APOLLO GUIDANCE AND NAVIGATION PROGRAMED INSTRUCTION SERIES

VOLUME VII

CM/LM PGNCS COMPUTER SUBSYSTEM FAMILIARIZATION

TEXT 1

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PROGRAMED INSTRUCTION MATERIALS

prepared by: FIELD SERVICE TRAINING
AC ELECTRONICS DIVISION
GENERAL MOTORS CORP.

TITLE PAGE

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prepared by: AC ELECTRONICS DIVISION
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in response to: NASA CONTRACT NAS 9-497

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TABLE OF CONTENTS

STUDENT PREREQUISITES

You must have successfully completed either the "CM PGNCS Optical Subsystem Familiarization" or the "LM PGNCS Optical Subsystem Familiarization" programed instruction booklet or acquired equivalent knowledge.

LEARNING OBJECTIVES

Upon completion of this text, you will be able to demonstrate a knowledge of DSKY keys and displays by:

1. Listing the keystrokes necessary to enter any given Verb, Noun, or piece of data.

2. Analyzing a given situation, determining what error has been made, and listing the keystrokes necessary to correct the error.

3. Determining from a given display what keystrokes would constitute a correct astronaut response, then indicating what would occur as a result of that response.

DIRECTIONS FOR USING TEXT

This text utilizes a programed instructional technique. This technique lets you learn material at your own pace.

The material in this text has been divided into small steps called frames. Each frame is numbered. Within each frame is the frame material and, in the majority of cases, one or more questions. The frame material is the information you are supposed to learn. The questions test your comprehension of the frame material. Each frame begins with the answers to the questions in the previous frame. The corresponding questions and answers are number matched.

Many frames are supported by illustrations. These illustrations appear on left hand pages and support the text which appears on the appropriate right hand page.

Follow the procedure below in proceeding through this text.

1) STUDY THE ILLUSTRATION ON THE LEFT HAND PAGE IF PROVIDED

2) READ THE FRAME MATERIAL

3) ANSWER THE QUESTIONS IN THAT FRAME

4) CONFIRM YOUR ANSWER AND REVIEW THE FRAME MATERIAL IF NECESSARY

5) REPEAT STEPS 1, 2, 3 AND 4 UNTIL A SECTION IS COMPLETED

6) ANSWER ALL REVIEW QUESTIONS

7) CONFIRM REVIEW QUESTION ANSWERS

8) REVIEW THE ITEMS YOU HAVE INCORRECTLY ANSWERED UNTIL YOU HAVE MASTERED THE MATERIAL IN THAT SECTION

9) PROCEED TO THE NEXT SECTION

SECTION I

FUNCTIONS OF THE DISPLAY AND KEYBOARD

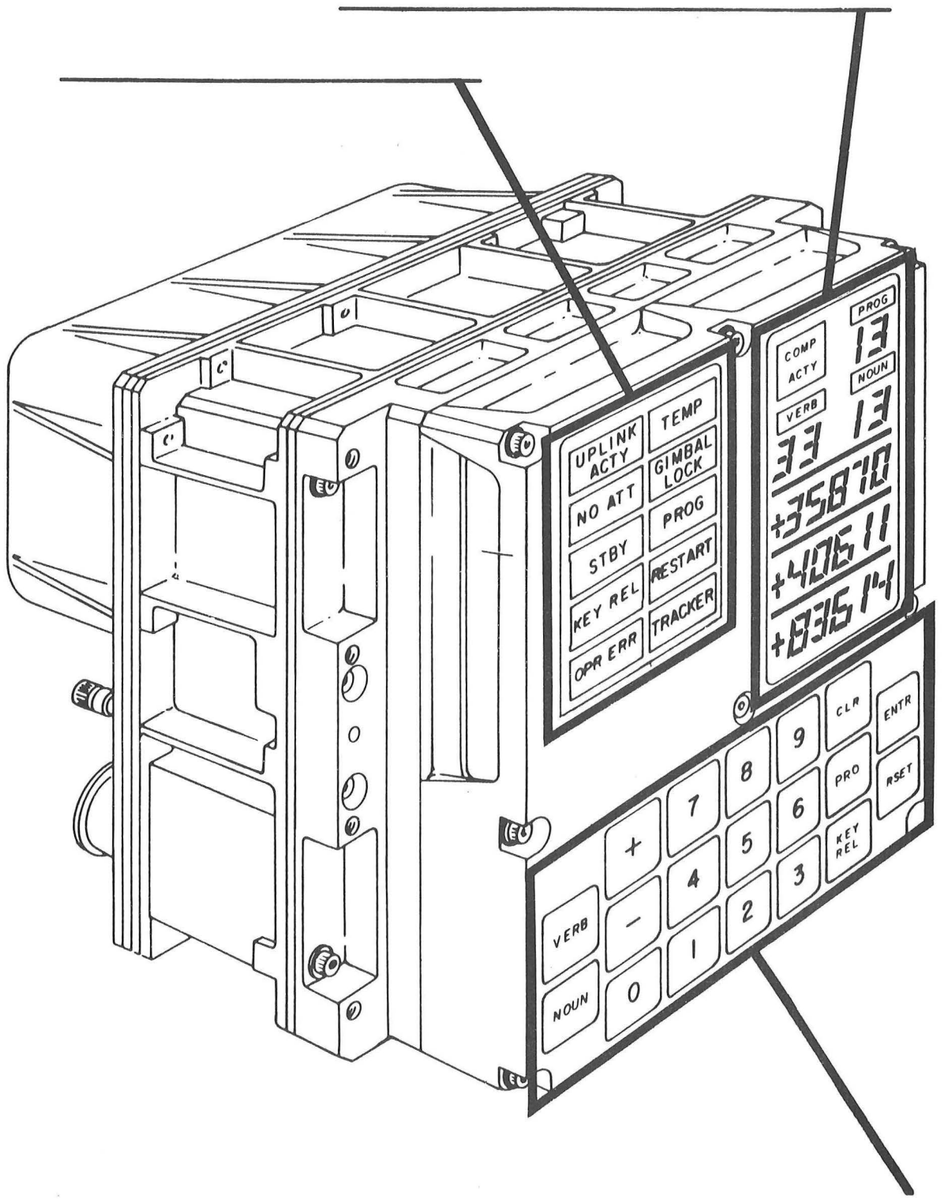

FIGURE 1-1.

The Computer Subsystem (CSS) consists of the computer itself and the Display and Keyboard assembly (DSKY). The DSKY, shown in figure 1-1, is the communication link between the astronaut and the computer.

Three functional areas on the face of the DSKY will be considered. These are:

1. Keyboard
2. Data display
3. Status/condition indicators

1. In figure 1-1, write in the names of these three functional areas in the appropriate blanks.

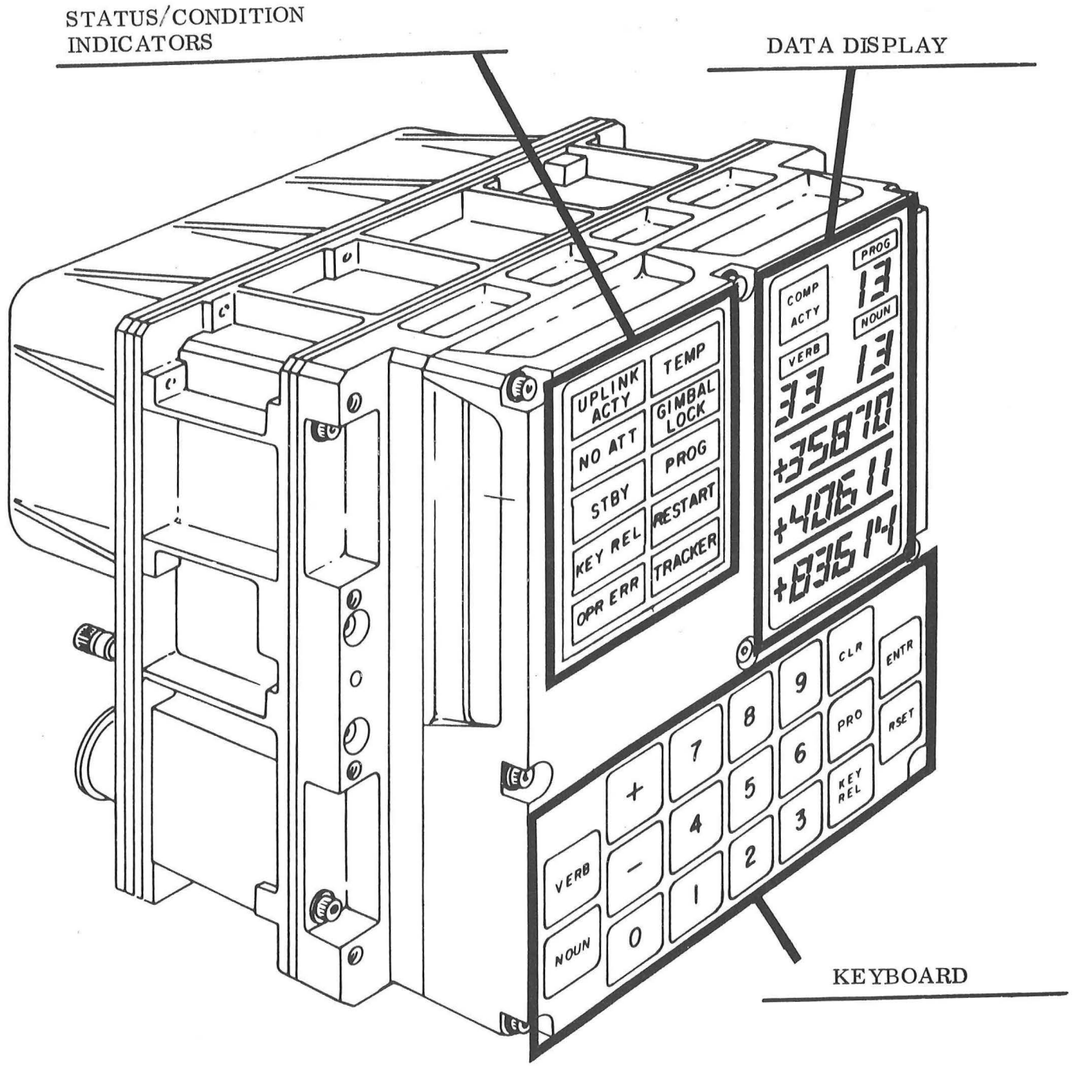

FIGURE 1-2.

1-2

ANS-1: See figure 1-2.

2. Which of the DSKY functional areas do you think is used by the astronaut for communicating instructions or data to the computer? _____ .

1-3

ANS-2: Keyboard

3. Which of the DSKY functional areas do you think is used for displaying data as it is keyed in by the astronaut?

_____ .

1-4

ANS-3: Data display

4. Which of the DSKY functional areas would be used for displaying malfunction indications? _____ .

1-5

ANS-4: Status/condition indicators

As the name implies, this group of lights is used to display various states or conditions that may exist within the CSS. As you progress through this text, the significance of each of these lights will be explained.

SECTION II

FUNCTIONS OF THE COMPUTER

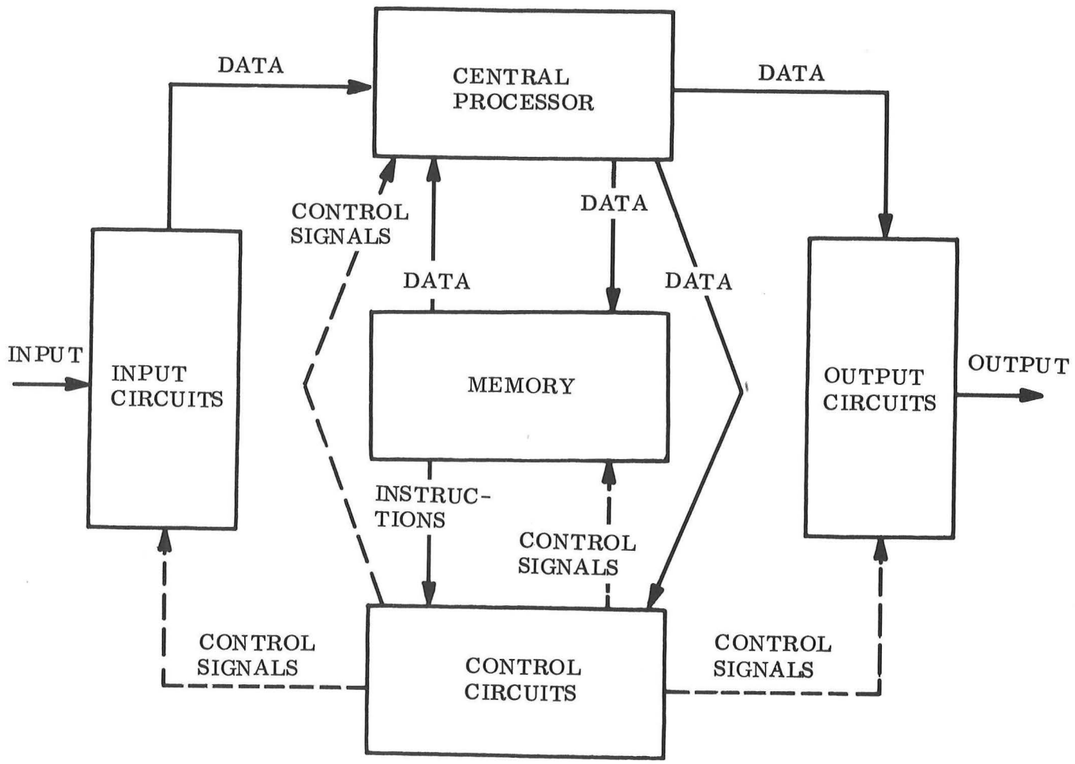

FIGURE 2-1.

2-1

Figure 2-1 shows a somewhat simplified block diagram of the computer.

If you can answer the following questions correctly, skip this section and proceed to Section 3.

Which of the computer functional areas shown in figure 2-1 is associated with each of the following descriptive phrases?

_____ A. Performs logical and arithmetic operations.

_____ B. Storage area for instructions, constants, and variables.

_____ C. Circuits which accept data from other systems.

_____ D. Co-ordinates activities of all areas.

_____ E. Circuits which dispense data to other systems.

2-2

ANS: Central Processor A.

Memory B.

Input Circuits C.

Control Circuits D.

Output Circuits E.

Electrical signals are sent to the computer by the DSKY, PGNCS subsystems, and other spacecraft systems.

1. In your own words, describe the function of the computer's input circuits.

2-3

ANS-1: Any sentence that expresses the idea "provides capability of accepting inputs"

There are three general types of input signal: data, commands, and condition indications.

2. Indicate whether each of the signals listed below would be considered as data, command, a condition indication, or none of these.

___ A. CAGE signal generated by cage switch

___ B. IMU temperature out of limits

___ C. Optics (or Rendezvous Radar) shaft angle

___ D. Numeral "9" generated by DSKY

___ E. +28VDC power from Electrical Subsystem

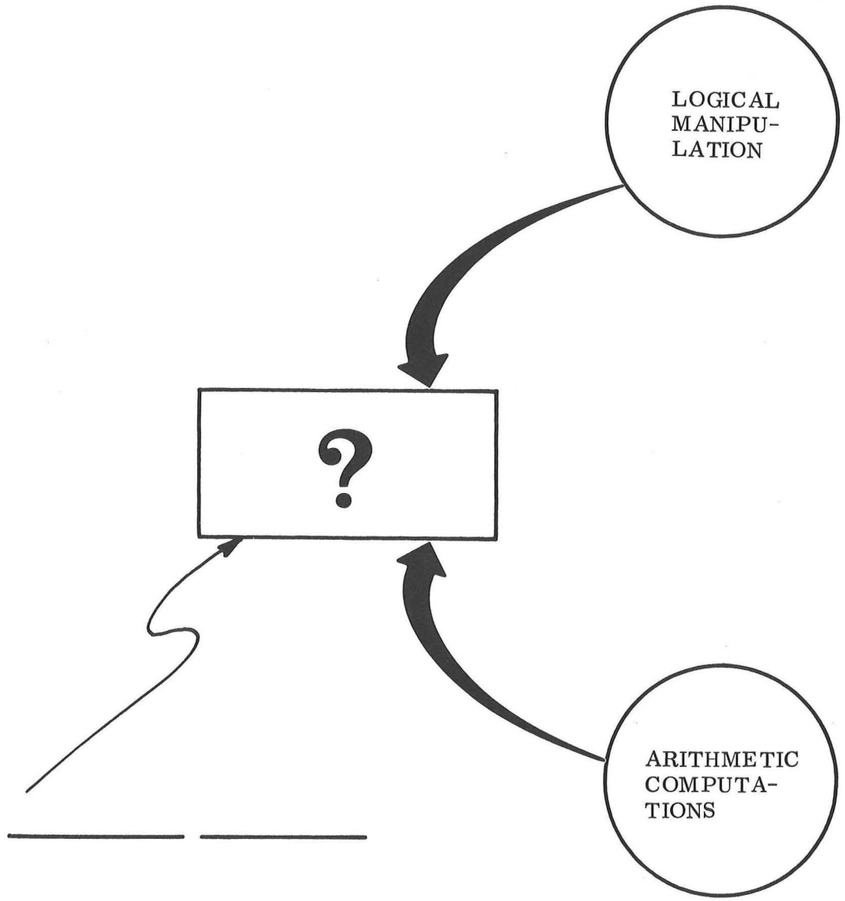

FIGURE 2-2.

2-4	

ANS-2: A. command
B. condition indication
C. data
D. data ("command" is acceptable)
E. none of these

Once the inputs are accepted by the computer, processing occurs. This involves logical manipulation and arithmetic computations.

3. Write in the space provided in figure 2-2 the name of the functional area of the computer that you would expect to perform logical and arithmetic operations. (Refer to figure 2-1 if necessary.)

2-5	

ANS-3: Central processor

A few of the operations that may be performed by the Central Processor are:

Arithmetic:
Add
Subtract
Multiply
Divide

Logic:
And
Or

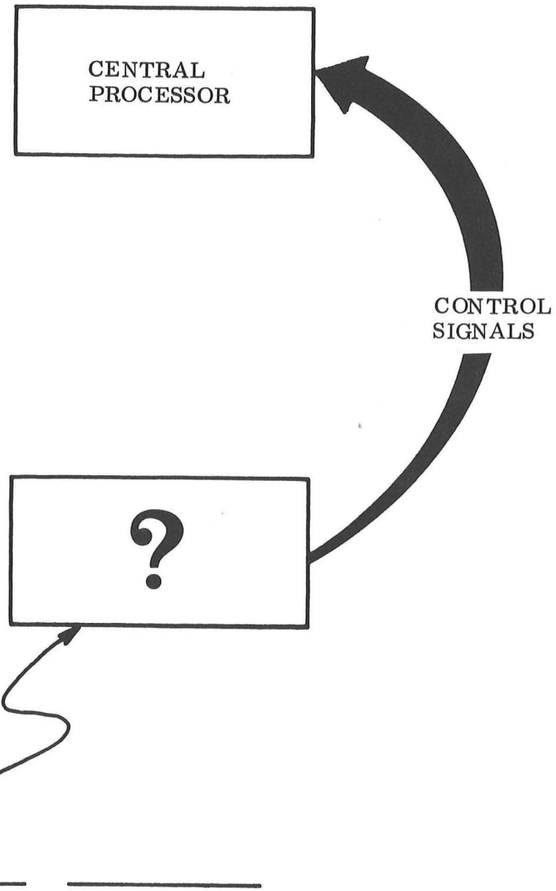

FIGURE 2-3.

Since the Central Processor can perform many different operations, a block of circuits is needed to supply it with signals that specify which operation is to be performed.

4. Write in the space provided in figure 2-3 the name of the functional area of the computer that supplies these signals.

ANS-4: Control circuits

The control circuits also supply control signals to all the other functional areas of the computer.

5. The purpose of the control circuits is to:

   A. perform logical and arithmetic operations

   B. accept data, commands and condition indications

   C. determine the sequence of operations performed by the computer.

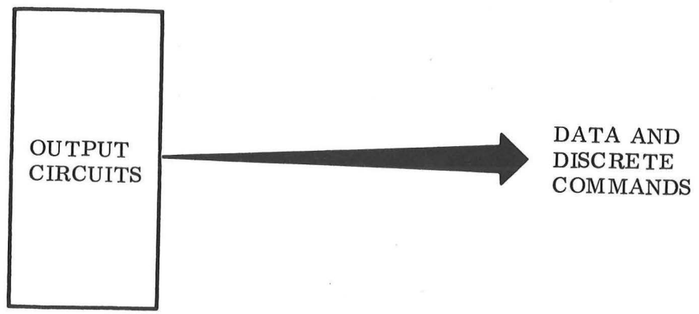

FIGURE 2-4.

ANS-5: c.

The computer must also be able to supply signals to other equipment. This capability is provided by the computer output circuits, shown in figure 2-4.

6. Which one of the items of data listed below would you expect to be dispensed by the computer through its output circuits?

_____ A. the present value of the IMU's outer gimbal angle

_____ B. the spacecraft's roll attitude error

_____ C. the radius of the earth

ANS-6: B.

Outputs provided by the computer consist of data and discrete commands to other spacecraft equipment. The output circuits are loaded under the control of the control circuits.

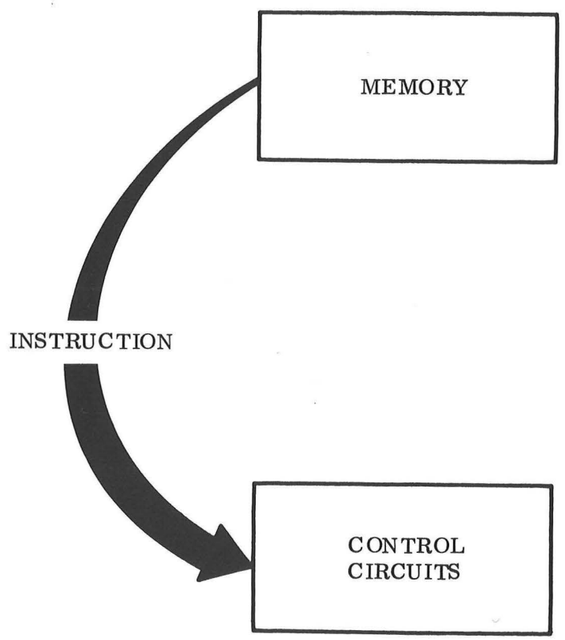

FIGURE 2-5.

2-10

The sequence of operations which the computer performs to process inputs and supply outputs is determined by the computer's program. The program is built into the computer at the time of manufacture in the form of a group of circuits called the Memory.

2-11

During operation, an increment of the program called an instruction is supplied to the control circuits by the Memory at the proper time. (See figure 2-5.) After this instruction has been performed, the next one is supplied by Memory and so on.

7. The control circuits decode the instructions and supply the proper _____ _____ to the other circuits.

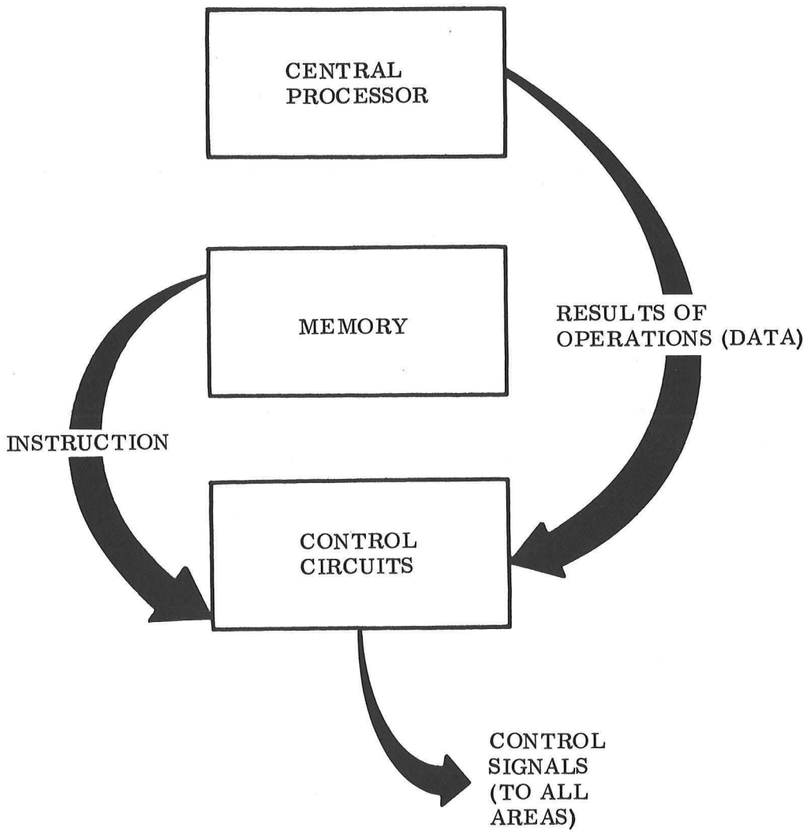

FIGURE 2-6.

ANS-7: control signals

Sometimes, a particular instruction requires the control circuits to consider the results of the previous operation performed by the Central Processor. (See figure 2-6.) By including instructions of this type in the program, the computer acquires the capability of adjusting its operation to fit almost any situation.

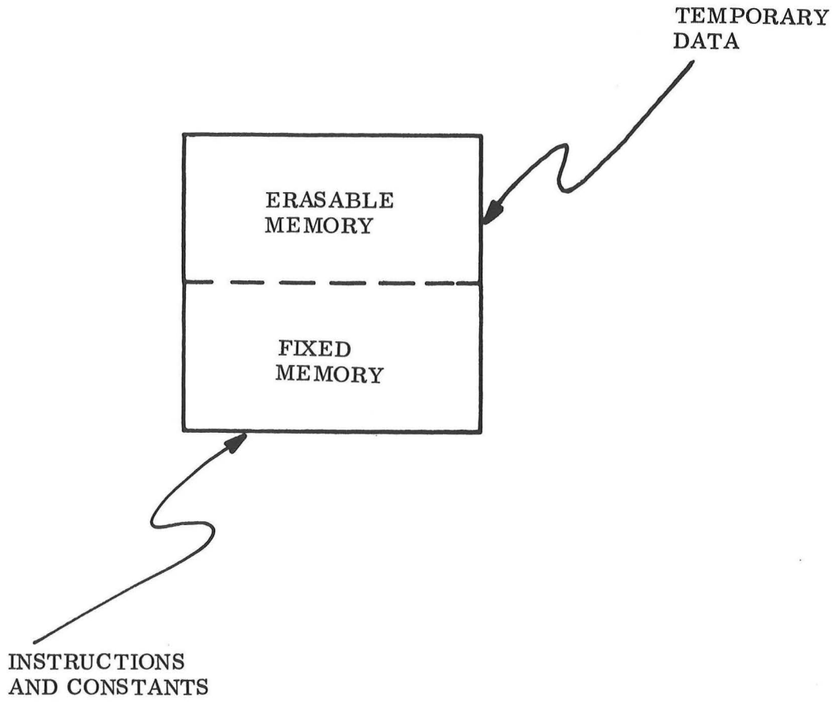

FIGURE 2-7.

In addition to operating instructions, the Memory also contains numerical constants and temporary data. (See figure 2-7.)

Program instructions and constants are stored in a portion of the Memory called Fixed Memory. It is called this because the data is built-in during manufacture and cannot be altered.

Temporary data is stored in a portion called Erasable Memory. The central processor can read any item of data stored in Erasable Memory and can also alter any item of this data.

8. Describe briefly, in your own words, the function of the computer's memory circuits.

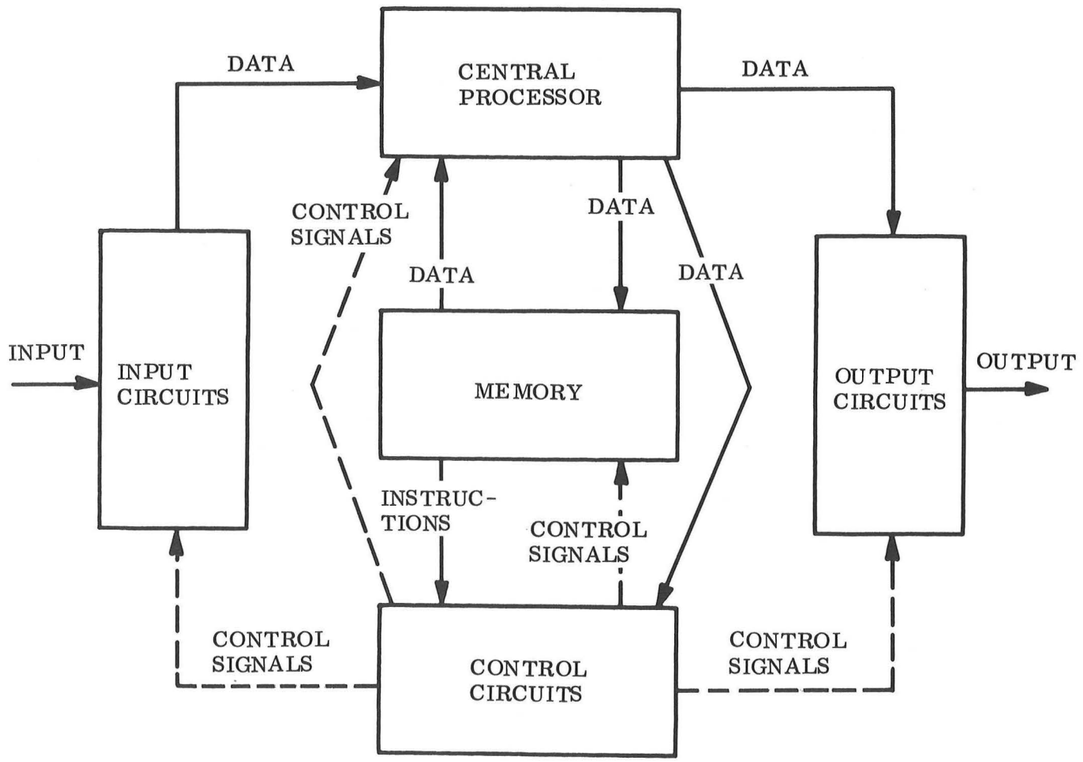

FIGURE 2-8.

2-14

ANS-8: Your answer should express the idea that the memory functions as a storage area for instructions, constants, and variables.

The entire flow of signals within the computer is shown in this illustration. In order to process a particular input, the computer may have to perform hundreds or even thousands of instructions. These will be performed one after the other until the processing is complete. Since the computer can perform about 40,000 instructions per second, most processing sequences require only a short time to perform.

2-15 REVIEW QUESTIONS

Which of the computer functional areas, shown in figure 2-8, is associated with each of the descriptive phrases given below?

_____ 9. performs logical and arithmetic operations

_____ 10. storage area for instructions, constants and variables

_____ 11. circuits which accept data from other systems

_____ 12. co-ordinates activities of all areas

_____ 13. circuits which dispense data to other systems

ANS-9: Central Processor

ANS-10: Memory

ANS-11: Input circuits

ANS-12: Control circuits

ANS-13: Output circuits

SECTION III

ASTRONAUT/CSS INTERFACE

3-1

As we said in Section 1, communication between the astronaut and the computer is through the DSKY. In this section you will see how the keys, the Data Display lights, and certain of the Status/Condition indicators are related to the communication function.

3-2

The communication is two-way, astronaut-to-computer and computer-to-astronaut. The astronaut-to-computer communication could be broken down into two basic categories, commands and data. The computer-to-astronaut communication, on the other hand, consists primarily of requests, either for additional data or some other action.

We will start with the astronaut-to-computer commands. These commands are made by means of numerical codes, classified as Verbs and Nouns.

1. A code indicating an action to be performed by the computer would be designated by a _____ code.

2. A code indicating a parameter to be acted upon would be designated by a _____ code.

3-3

ANS-1: Verb

ANS-2: Noun

3. A few Verb and Noun phrases are listed below. Indicate whether each is a Verb or a Noun.

_____ A. Display octal component 1 in R1

_____ B. ICDU angles

_____ C. Target codes

_____ D. Load component 2 into R2

_____ E. Monitor decimal in R1 or R1, R2 or R1, R2, R3

_____ F. This vehicle weight ~ other vehicle weight

3-4

ANS-3: A. Verb
B. Noun
C. Noun
D. Verb
E. Verb
F. Noun

Because of certain restrictions, only a limited number of Verb-Noun combinations are permitted. For example, a Noun described as "Decimal Only" could never be used with a Verb which specifies "Display octal component". In spite of such restrictions, however, a complete list of permissible combinations is too long to present here. (Complete Verb-Noun lists are available through the Flight Control Division.)

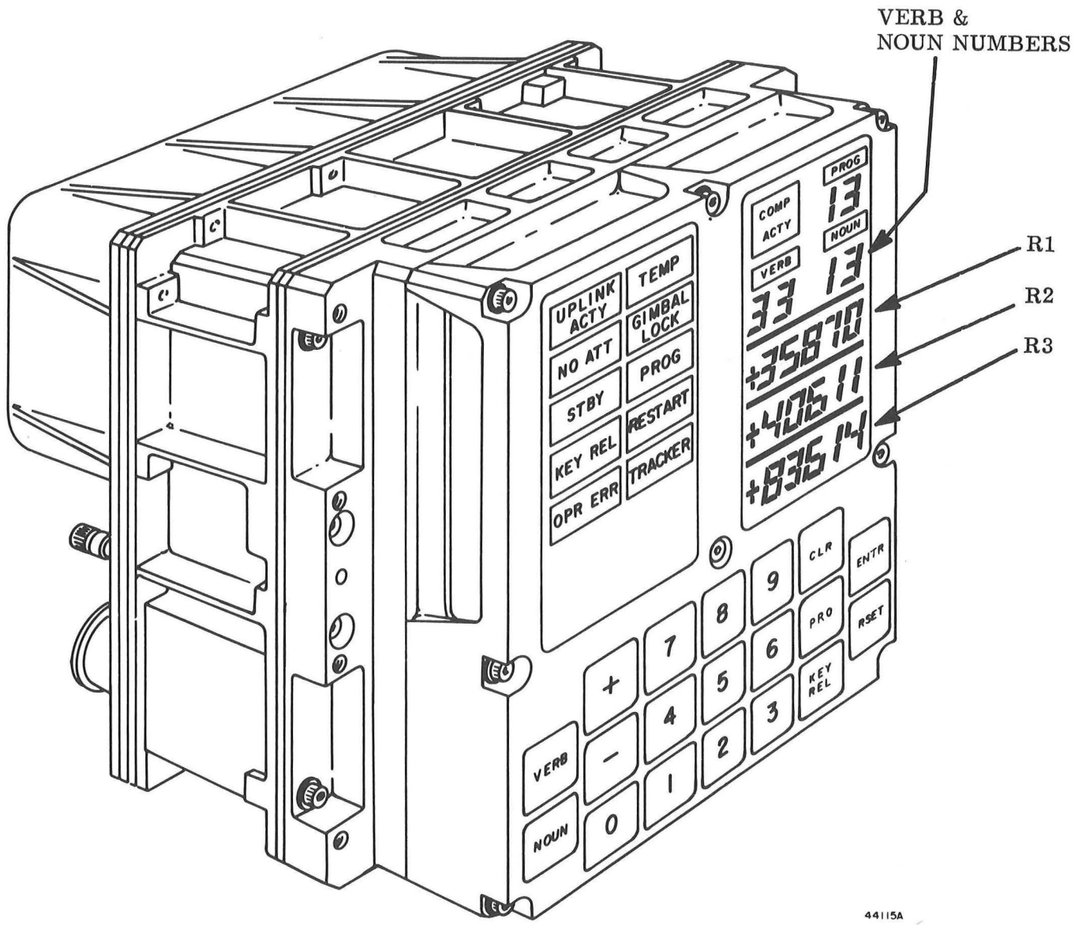

FIGURE 3-1.

NOTE: The DSKY is illustrated in figure 3-1. This illustration can be removed and used as a reference throughout the discussion in this section.

In order to present a meaningful discussion of Verbs, Nouns and Verb-Noun combinations, we will cite several examples. Before we do, though, a few words of explanation about Verbs and Nouns in general are in order.

The most commonly used Verbs are those that specify either Display, Monitor, or Load. There are others, of course, but in the examples used we will limit ourselves to these three major classes. Display, Monitor and Load Verbs always specify the number of components and the DSKY display registers associated with them. For example:

Verb 01 = Display in octal Component 1 in R1 (Register 1)

Verb 02 = Display in octal Component 2 in R2

Verb 06 = Display in decimal Components 1, 2, 3 in R1, R2, R3, respectively.

Nouns are made up of one or more components, and it is these components to which the component numbers in the Verb codes above refer. For example:

Noun 29 = X_{SM} Launch Azimuth (1 component)

Noun 47 = CSM mass
LM mass } (2 components)

Noun 20 = Outer gimbal angle (CDUX)
Inner gimbal angle (CDUY)
Middle gimbal angle (CDUZ) } (3 components)

Now, if the astronaut keys in Verb 01 Noun 47, only the first component of Noun 47 (CSM mass) will be displayed. On the other hand, if he keyed in Verb 06 Noun 20, all three components of Noun 20 will be displayed simultaneously in the three registers.

The procedure to be used in communicating a particular Verb-Noun combination to the computer is as follows: (Verb 01 Noun 20 is taken as an example).

a. Depress the VERB key in the keyboard. This causes the existing number in the Verb lights to be turned off.

b. Depress the proper numeral keys on the keyboard for the two Verb digits, most significant digit first (i.e. "0", "1"). These numerals will appear in the Verb lights.

c. Depress the Noun key. The old Noun number is blanked.

d. Key in the two Noun digits which then appear in the Noun lights.

e. Verify that the Verb and Noun codes displayed are correct, then depress the ENTR key. This signals the computer to execute the action specified by the Verb-Noun combination.

4. According to the procedure listed above, which sequence of key depressions should be used?

A. "VERB", "0", "1", "NOUN", "0", "2", "ENTR"

B. "VERB", "0", "1", "NOUN", "2", "0", "ENTR"

C. "VERB", "NOUN", "0", "1", "2", "0", "ENTR"

D. "VERB", "1", "0", "NOUN", "2", "0", "ENTR"

E. "VERB", "1", "0", "NOUN", "0", "2", "ENTR"

F. Either B or D.

ANS-4: B.

The computer's program is set up so that certain exceptions to the sequence given in the previous frame are allowed. The exceptions are:

1. The Noun may be keyed in before the Verb. That is, NOUN, 2, 0, VERB 0, 1, ENTR works just as well as VERB, 0, 1, NOUN, 2, 0, ENTR

2. If the VERB lights presently show the desired Verb it need not be blanked and rekeyed. The same applies to the Noun. That is, supposing we want Verb 01 Noun 20 and the VERB lights have 01 showing, we only have to key NOUN, 2, 0, ENTR

3. If the desired Verb-Noun combination is presently shown in the lights, it is only necessary to depress the ENTR key.

5. Suppose we want Verb 04 Noun 46. Write out the shortest sequence of key-strokes we would use in each case below assuming the VERB-NOUN lights show the numbers given.

	Presently displayed		Keystrokes
	VERB	NOUN	
A.	Blank	Blank	
B.	04	12	
C.	01	46	
D.	01	01	
E.	04	46	

3-8

ANS-5: A. VERB, 0, 4, NOUN, 4, 6, ENTR OR
NOUN, 4, 6, VERB, 0, 4, ENTR
B. NOUN, 4, 6, ENTR
C. VERB, 0, 4, ENTR
D. VERB, 0, 4, NOUN, 4, 6, ENTR OR
NOUN, 4, 6, VERB, 0, 4, ENTR
E. ENTR

6. Take a close look at the answers given above. Can you find two rules that are observed in all sequences of keystrokes? _____

_____

3-9

ANS-6: (1) Two digits must be keyed in for each Verb or Noun code.

(2) ENTR is always the last keystroke

The Verbs used in the preceding examples (01 and 04) are Display Verbs. That is, these Verbs are used to initiate a one-time display of data.

Monitor Verbs are also used for data display. The only difference is that Monitor Verbs operate continuously to provide an updated display every one second. One application of this might be to monitor the time-to-ignition for a thrusting maneuver.

3-10

Up to this point, all the Verb-Noun combinations used as examples have completely defined the action required of the computer.

Many times, however, the computer needs additional data or some other form of response from the astronaut. When this is the case, the VERB and NOUN lights will flash on and off at a 1.5 Hz rate (1/3 second on - 1/3 second off). For example, assume the astronaut has keyed in Verb 01, Noun 01, ENTR (Noun 01 signifies "Address to be specified"). The computer now needs the address of the data storage location before it can proceed so the VERB-NOUN FLASH will start.

Suppose that the octal address desired is 01111_8. The astronaut therefore keys in 1, 1, 1, 1, ENTR. After this additional data is received the computer is able to proceed, so the VERB-NOUN FLASH is turned off and the desired data is displayed.

7. Suppose you have keyed in Verb 01, Noun 10 ENTR and the VERB and NOUN lights start to flash. What does this mean to you?

_____

_____

ANS-7: The computer needs more data before it can continue.

Actually, the Verb-Noun flash isn't always a request for data but it is always a request for astronaut action of some kind. The other kinds of requests and responses will be covered later in this section.

8. Now let's take a minute for review.

A. Verb-Noun combinations are keyed in when the astronaut wishes to give the computer _____ (data/commands).

B. A Verb code specifies a/an _____.

C. A Noun code specifies a/an _____.

D. The usual keystroke sequence is: Verb, two numerals, Noun, two numerals, ENTR. What other sequence would work in every case?

_____

E. Any Verb or Noun code requires _____ (1/2/3/4/5) numerals to be keyed in.

F. The final keystroke in any sequence is always _____.

G. If more data is needed by the computer, the Verb and Noun lights will _____ (go out/start flashing/glow steadily).

ANS-8: A. commands
B. action to be performed
C. parameter to be acted upon
D. Noun, two numerals, Verb, two numerals, ENTR
E. 2
F. ENTR
G. start flashing.

In the example just discussed, data was supplied to the computer as a positive octal quantity. Let's investigate the procedures used in supplying data to the computer in more detail.

Whenever we want to indicate that a quantity is expressed as an octal number, a subscript 8 will be shown, i.e., 01111_8.

Similarly, for decimal notation, we will show a subscript 10, i.e., 10187_{10}.

Study the rules given below for keying in octal quantities.

1. Do not strike either the + or - sign key. These keys are reserved for use with decimal quantities.

2. Key in the numerals starting with the most significant digit.

3. All quantities are assumed to consist of five digits; however, zeroes in the most significant digit positions need not be keyed in.

4. For negative octal quantities subtract the number from 77777 and key in the difference. That is, form the 7's complement and key that in.*

9. Use the rules given above to determine the series of key strokes for the following octal quantities. The first one has been filled in to give you a start.

A. $+00100_8$: 1,0,0,ENTR

B. $+37000_8$: _____

C. -00001_8: _____

D. $+00012_8$: _____

E. $+30401_8$: _____

F. -12000_8: _____

* So that the computer can tell the difference between positive octal numbers and 7's complements representing negative octal numbers, it has been designed to assume that any octal number equal to or less than 37777 is positive and that any number greater than that is a 7's complement. Thus, the largest octal number the computer can handle -- either positive or negative -- is 37777.

ANS-9: A. 1,0,0,ENTR
B. 3,7,0,0,0,ENTR
C. 7,7,7,7,6,ENTR
D. 1,2,ENTR
E. 3,0,4,0,1,ENTR
F. 6,5,7,7,7,ENTR

The computer is programed to recognize decimal data by the presence of a + or - sign keyed in prior to the first digit. The following rules apply when keying in decimal data.

1. Key in the sign (+ or -) before the first digit

2. Key in five digits in all cases starting with the most significant. Include all leading zeroes.

3. Contrary to the manner of loading negative octal data, do not complement negative decimal numbers.

4. Strike the ENTR key last.

10. Show in the space provided the correct sequence of keystrokes for the following decimal numbers.

A. $+00359_{10}$ _____

B. -10187_{10} _____

C. $+00000_{10}$ _____

ANS-10: A. + 0, 0, 3, 5, 9, ENTR
B. - 1, 0, 1, 8, 7, ENTR
C. + 0, 0, 0, 0, 0, ENTR

Now that you have a feel for the procedures used in supplying data quantities to the computer we are ready to begin a discussion of the situations in which these procedures will be used.

We mentioned earlier that the most commonly used Verbs belong to classes called Display, Monitor, and Load.

Display and Monitor Verbs, as you have learned, command the computer to display the current value of a parameter stored in its memory.

Load Verbs, on the other hand, are used to change or to supply a new value of a parameter for use by the computer. That is, Load Verbs are used to load new data into the computer's memory.

Let's suppose the astronaut wants to change the value of CSM mass being used by the computer. He starts by specifying an action and a parameter, thus:

VERB, 2, 1, NOUN, 4, 7, ENTR

where Verb 21 = Load Component 1 into R1

and Noun 47 = CSM Mass (Component 1)

LM Mass (Component 2)

Two things happen as the ENTR key is struck. First, the data registers (R1, R2, and R3) are all blanked. That is, any data previously displayed is removed to make way for the new data. Second, the Verb-Noun display starts flashing, indicating that the astronaut can now key in the new data. Suppose this is 64100_{10} lb. He will now key in +, 6, 4, 1, 0, 0, ENTR. As he strikes the keys, the character appears in the proper position in R1. When he strikes ENTR, the Verb-Noun flash stops, indicating the load sequence is complete. The new CSM Mass value is now stored in the applicable memory location and the old value no longer exists.

11. Verb 22 can now be used to "Load Component 2 into R2." Show below the complete sequence of keystrokes needed to change the LM Mass to 32000_{10} lb.

ANS-11: VERB, 2, 2, ENTR
+ 3, 2, 0, 0, 0, ENTR

An alternate method of entering the same information would be to enter Verb 24, Noun 47. Verb 24 is an instruction to "Load components 1, 2 into R1, R2". It initiates the following sequence:

1. VERB 24, NOUN 47 show in the lights as we key them in.
2. When we strike ENTR the Verb changes to VERB 21 and we now have Verb 21, Noun 47 flashing.
3. As we key in the CSM Mass (64100_{10} lb) it appears in R1.
4. When we strike ENTR for CSM Mass the Verb changes to 22 and we now have Verb 22, Noun 47 flashing.
5. As we key in the LM Mass (32000_{10} lb) it appears in R2.
6. When we strike ENTR for LM Mass the Verb-Noun flash stops leaving VERB 22, NOUN 47 showing along with the values just loaded.

12. Before proceeding further, let's pause a moment to review the procedure for loading data.

A. Strike the + or - key only when loading _____ components.

B. Five digits are always keyed in when loading _____ components.

C. Key in the 7's complement to load _____ _____components.

D. Non-significant zeroes may be omitted when loading _____ components

NOTE: We haven't mentioned it recently, but specific Verbs and Nouns are being brought into this discussion only to illustrate the concepts, so if you have noticed that many Verbs and Nouns haven't been mentioned, remember, we aren't trying to teach them to you.

ANS-12: A. decimal
B. decimal
C. negative octal
D. octal

In case the operator makes an error while loading data, the method of correction depends on the type of error and the time at which it is detected. If the error is detected prior to the final ENTR, it can be corrected as follows:

a. If a Verb or Noun code has been keyed incorrectly, strike the VERB or NOUN key, as applicable, and then key in the correct numbers. If any data has been keyed in before the error is detected, it, too, will have to be re-keyed. (Remember from frame 3-16 that striking the ENTR key in order to enter a Verb-Noun combination also blanks the data register.)

b. If data has been keyed into the register incorrectly, strike the CLR (Clear) key. Doing this will blank the data display register currently being loaded, and the correct numbers can then be keyed in.

13. Assume the astronaut is attempting to key in VERB, 2, 1, NOUN, 4,7, ENTR, +, 6, 4, 1, 0, 0, ENTR.

A. If he mistakenly strikes the 3 key instead of the 2 in the VERB and detects the error after having struck NOUN, 4, 7, but before the first ENTR, he could correct the error and complete the entry by use of what keystrokes?

_____

B. With the same conditions as in part A, the error is detected only after +, 6, 4, 1 have been keyed in. What keystrokes would be required to correct the error and complete the entry? _____

C. If he mistakenly keys in +, 9, 4, 1, 0, 0, and notices the error before striking the second ENTR, what keystrokes are required to correct the error and complete the entry? _____

ANS-13: A. VERB, 2, 1, ENTR, +, 6, 4, 1, 0, 0, ENTR
B. VERB, 2, 1, ENTR, +, 6, 4, 1, 0, 0, ENTR
C. CLR, +, 6, 4, 1, 0, 0, ENTR

Striking the final ENTR enters the data into the computer memory. This means that it can no longer be corrected simply by clearing the register. (Besides, the CLR key is disabled by the final ENTR and therefore is incapable of clearing the register.) Thus, if an error is not detected until after the final ENTR, it can be corrected only by going through all the necessary parts of the sequence again.

14. Assume the same conditions as in part C of question 13, except that the error was not detected until after the final ENTR was struck. That is, Noun and Verb were entered correctly, the data incorrectly. What keystrokes would be required to correct the error and enter the correct data?

_____

A. +, 6, 4, 1, 0, 0, ENTR

B. CLR, +, 6, 4, 1, 0, 0, ENTR

C. ENTR, +, 6, 4, 1, 0, 0, ENTR

D. VERB, 2, 1, NOUN, 4, 7, ENTR, +, 6, 4, 1, 0, 0, ENTR

ANS-14: C. ENTR, +, 6, 4, 1, 0, 0, ENTR

Actually, D would also work, but the Verb and Noun need not be keyed in this time because they were keyed in correctly the time before. All that is necessary is to re-enter them by pressing ENTR. At that point, the Verb-Noun display will start flashing and the data register will be blanked, ready for the correct data to be keyed in.

Sometimes the computer itself detects an error by the astronaut. In these cases, it rejects the erroneous input and turns on the OPR ERR (Operator Error) light.

15. In which of the following situations do you think the computer would turn the OPR ERR light on?

_____ A. CLR key struck too many times

_____ B. Octal Verb and decimal Noun keyed in together

_____ C. Unassigned Verb or Noun keyed in

_____ D. Noun keyed in before Verb

_____ E. Less than five digits keyed in for decimal data load

_____ F. + or - sign omitted when keying in decimal data

_____ G. Numeral 3 accidentally struck instead of 6 when keying data into R1

_____ H. Numeral 8 or 9 struck when loading octal data

ANS-15: B, C, E, F, H

The following is a complete list of errors that cause the OPR ERR light to be turned on.

a. Numeral 8 or 9 struck while loading octal data (remember, the computer will assume the data is octal if the + or - sign is omitted or if the associated Verb or Noun was designated octal only).

b. Five numerals not loaded for decimal data. (The computer assumes the data is decimal if it is preceded by a + or - sign or if the associated Verb or Noun was designated decimal only.)

c. Octal data loaded for decimal-only Noun.

d. Decimal and octal data mixed in 2 or 3 component load.

e. Unassigned or illegal Verb or Noun keyed in.

f. Two numerals not loaded for major mode (PROG) number.

g. Unassigned major mode number loaded.

h. Octal display Verb specified with decimal-only Noun.

i. Fewer components associated with Noun than with specified Verb.

An error which has caused the OPR ERR light to be turned on can be corrected in the same way other errors are corrected. The only difference is the OPR ERR light must be turned off. This is accomplished by pressing the RSET (reset) key.

16. Assume a decimal-only Noun has been keyed in along with a load Verb. The astronaut then keys in +, 1, 1, 0, 0, ENTR. The OPR ERR light comes on. Why? _____

3-23

ANS-16: Not enough digits. (Five required for any decimal entry)

An error which has caused the OPR ERR light to be turned on is corrected in the same way other errors are corrected. The only difference is that the OPR ERR light must also be put out. This is accomplished by pressing the RSET (reset) key, which turns out the OPR ERR light but has no effect on the existing Verb-Noun combination or on the data being displayed.

17. You would expect the RSET key to be struck _____ (before/after) the new entry was made. (Keep in mind that, if the computer detects a new error while the correction is being made, it would be a good idea if the computer were able to indicate this to the astronaut.)

3-24

ANS-17: before

If the RSET key were struck after the new entry, the OPR ERR light would have remained on throughout the new sequence of keystrokes. Thus, even if the computer had detected a new error, it would have had no way of indicating this to the astronaut.

The RSET key is used not only to turn off the OPR ERR light but the following lights as well:

PROG

RESTART

TRACKER

UPLINK ACTY

NOTE: PROG and RESTART will be discussed later in this section; TRACKER and UPLINK ACTY will be covered in the interface sections.

3-25

Certain other types of errors need not be corrected so the computer merely ignores the input without turning on the OPR ERR light. This type of error includes:

a. more than five numerals keyed in for a single data register

b. sign key struck after the first numeral has been struck

c. sign key struck more than once for a single data register

d. more than two numerals keyed in for a Verb or Noun

e. CLR key struck too many times or after loading sequence is complete

f. sign or numeral key struck at wrong time

18. True Or False? If the computer completely ignores a keystroke it indicates a computer malfunction. _____

ANS-18: False

Up to this point, the only computer-to-astronaut communication we have discussed is the simple request for data. Now we will look at the other "requests" the computer can make of the astronaut.

Whenever the computer initiates a flashing display it will suspend further processing until the astronaut supplies a response. Three main types of response are usually permitted. These are:

1. Proceed
2. Terminate
3. Recycle

The Proceed response is the one used most often. It indicates that the astronaut accepts the data being displayed. The astronaut tells the computer to proceed by pressing the PRO key or by keying in Verb 33 ENTR. Since it is simpler, pressing the PRO key is the method normally used.

19. Would the computer take any action if the PRO key is struck when there is no internally initiated flashing display up? _____

ANS-19: No, not normally, but there is one exception to this rule, explained below.

As we said, the PRO key is usually struck to signify acceptance of the data the computer has displayed. However, if the proper Verb-Noun combination is flashing, striking the PRO key will place the computer in a STANDBY (low power consumption) mode. This function will never interfere with the prime function of the PRO key.

The astronaut indicates a Terminate response by keying in Verb 34 ENTR. Recycle is indicated by keying in Verb 32 ENTR or, in some cases, by simply striking the ENTR key.

20. Assume Verb 06 Noun 47 is flashing. What would the astronaut do if he wanted to:

_____A. be sure that the data in the display is still correct and has not been changed internally since the display was initiated.

_____B. turn the display off.

_____C. approve the data as shown.

3-29

ANS-20: A. Recycle
B. Terminate
C. Proceed

Astronaut-initiated communication always takes precedence over computer-initiated communication. That is, the astronaut can take over the DSKY at any time, but the computer can use it only if the astronaut is not using it. The computer, however, is not totally helpless. If a situation arises in which the computer wants to use the DSKY but is prevented from doing so, it will signal the astronaut by flashing the KEY REL (Key Release) lamp. That is, if the computer wishes to interrupt the astronaut or if the astronaut has interrupted the computer and the computer doesn't like it, the KEY REL light will begin flashing and will continue until the astronaut presses the KEY REL key, thereby turning the DSKY over to the computer.

21. Assume the computer has a flashing Verb 06 Noun 47 showing on the DSKY and the astronaut ignores it and keys in Verb 01 Noun 20 ENTR. What Verb-Noun combination will be lit on the DSKY? _____

Does the KEY REL light start flashing? _____

3-30

ANS-21: Verb 01 Noun 20

yes

Suppose the astronaut now presses the KEY REL key. The KEY REL light, of course, will go out, but what will happen to the Verb-Noun display?

22. Since the computer was displaying a flashing Verb 06 Noun 47 when the astronaut interrupted it, you would expect the DSKY now to _____.

A. revert to the flashing Verb 06 Noun 47

B. continue displaying Verb 01 Noun 20

C. blank out the Verb-Noun display

3-31

ANS-22: A. revert to the flashing Verb 06 Noun 47

The procedure will be similar if the other situation occurs, i.e., if the computer wishes to interrupt the astronaut. If, for example, the astronaut is using the DSKY to monitor the IMU Gimbal Angles (Verb 16 Noun 20), and the computer decides it wants to display something, the KEY REL light will start flashing.

23. If the astronaut pushes the KEY REL key, the KEY REL light will go out and the Verb-Noun display will _____.

A. continue to display Verb 16 Noun 20

B. not display anything

C. display a new Verb-Noun combination

3-32

ANS-23: C. display a new Verb-Noun combination

Previously, you learned that if the astronaut makes an error the computer may turn on the OPR ERR light. If the computer makes an error, it will turn on either the PROG (Program Caution) or the RESTART light, depending on how serious the error is.

3-33

If the computer detects a discrepancy which does not present an immediate problem but which the astronaut should know about, it will turn on the PROG (Program Caution) light and continue its processing. For example, if the ground station begins telemetering data to the spacecraft faster than the computer can handle it, the PROG light will come on. As a result, the astronaut would probably contact the ground station and instruct it to retransmit the data. As noted earlier, the PROG light can be turned off by pressing the RSET key.

3-34

Whenever the computer detects an internal discrepancy which requires that processing be reperformed it will turn on the RESTART light and re-initialize the processing routine that went bad. For example, if the computer misreads a number from its memory during the course of a calculation, the computer will detect its own error and light the RESTART light. In many routines, the computer will also return to some point in its program prior to the error, then pick up the calculation again from that point. Like the OPR ERR and PROG lights, the RESTART light can be turned off by pressing the RSET key.

3-35

Now, to summarize all the DSKY controls and indicators, match the terms in List I with the phrases in List II, then match the key depressions in List III with the phrases in List IV.

I

_____ 24. Flashing KEY REL light

_____ 25. PROG light

_____ 26. RESTART light

_____ 27. STBY light

_____ 28. OPR ERR light

_____ 29. Flashing Verb-Noun

II

A. The computer has re-initialized due to a serious discrepancy.

B. The computer is not operating.

C. The astronaut is requested to perform some action.

D. The astronaut has made an illegal keystroke.

E. The computer has encountered a discrepancy.

F. The computer would like to replace the astronaut's display with its own.

III

_____ 30. VERB

_____ 31. NOUN

_____ 32. ENTR

_____ 33. CLR

_____ 34. RSET

_____ 35. PRO

_____ 36. (+) or (-)

_____ 37. 0, 1, 2....9

_____ 38. KEYREL

IV

A. The astronaut display may be replaced by the computer

B. Turn off caution indicators.

C. Next two numerals are an action code.

D. Continue with processing sequence

E. Next five numerals are decimal coded data.

F. Begin processing sequence.

G. Next two numerals are the subject of an action.

H. Correct erroneous data.

I. Data or numerical code.

3-36

ANS-24: F.
ANS-25: E.
ANS-26: A.
ANS-27: B.
ANS-28: D.
ANS-29: C.
ANS-30: C.
ANS-31: G.
ANS-32: F.
ANS-33: H.
ANS-34: B.
ANS-35: D.
ANS-36: E.
ANS-37: I.
ANS-38: A.

3-37

Now let's apply the definitions and rules we have discussed.

39. Assume the astronaut is in the process of keying in VERB, 2, 2, NOUN, 4, 7, ENTR, +, 9, 6, 1, 0, 0, ENTR and that he accidentally keys in Verb 21 instead of Verb 22. If he notices the error before the second ENTR is struck, what keystrokes would be required to enter the correct Verb-Noun combination?

_____

3-38

ANS-39: VERB, 2, 2, ENTR

Noun 47 would not have to be re-keyed since it would still be displayed in the NOUN lights. (See frame 3-7.)

40. Assume the astronaut is in the process of keying in VERB, 2, 2, NOUN, 4, 7, ENTR, +, 8, 7, 0, 1, 0, ENTR and that he accidentally strikes a 5 instead of an 8 in the data.

A. If he notices it before striking the second ENTR, he could correct it by what keystrokes? _____

B. If he notices it after striking ENTR, the OPR ERR light _____ (would/would not) come on and he would have to perform what series of keystrokes to correct the error? _____

ANS-40: A. CLR, 8, 7, 0, 1, 0, ENTR

B. would not
ENTR, +, 8, 7, 0, 1, 0, ENTR

In part A, striking the CLR key would blank the data register, allowing the data to be re-keyed. There would have been no effect on the Verb-Noun combination so they would not need to be either re-keyed or re-entered.

In part B, the mistake was one which did not violate any of the computer's built-in rules (frame 3-22), which means it could not detect the error and turn on the OPR ERR light. Since the final ENTR has been struck, the entire sequence, including the Verb-Noun combination, would have to be gone through again. However, since the correct Verb-Noun combination was still displayed, striking ENTR would be sufficient to re-enter it. (See frame 3-7.)

41. Assume the astronaut is keying in VERB, 2, 2, NOUN, 4, 6, ENTR, 9, 1, 1, 1, 3. As he strikes the 3, he notices that the OPR ERR light is on. (Verb 21 = Load component 1 into R1; Component 1 of Noun 46 = Octal code identifying program configuration.)

A. Why is the OPR ERR light on? _____

B. Assuming the correct number is 31113, what sequence of keystrokes would the astronaut now use as he entered the correct data? _____

ANS-41: A. 9 struck in loading octal-only noun

B. RSET, CLR, 3, 1, 1, 1, 3, ENTR

In part A, the error was one that could be detected by the computer (frame 3-22).

In part B, RSET was struck because the OPR ERR light was on, and CLR was struck because the final ENTR had not been struck. If ENTR had been struck, the sequence to correct the error would have been RSET, ENTR, then the correct octal number.

42. Assume the astronaut has keyed in VERB, 0, 6, NOUN, 6, 5, ENTR in order to check ground elapsed time. (Verb 06 = Display decimal in R1, R2, and R3; Noun 65 = Ground elapsed time as determined by the computer.) Ground elapsed time is displayed in the DSKY registers and the astronaut is satisfied with the display.

A. What would the astronaut do if the KEYREL light started flashing?

_____

B. What would happen to the display following the astronaut's action in part A?

_____

ANS-42: A. Press KEY REL key

B. It would change.

The KEYREL light simply means that the computer has some information it wishes to display. Since the astronaut does not have anything urgent to do with the DSKY, he releases it to the computer by pressing the KEY REL key. Once this is done, the computer will put up its own display on the DSKY. (See frames 3-29 through 3-31.)

43. Assume the computer initiates a flashing Verb 04, Noun 46, and displays 31112 in R1 and 11111 in R2. (Verb 04 = Display octal component 1 and 2 in R1 and R2: Noun 46 = Octal codes identifying existing program configurations.)

A. What keystroke(s) would be required if the astronaut wished to accept the data as displayed? _____

B. What keystroke(s) would be required if the astronaut wished to change the code in R1 to 31001? _____

(NOTE: The Load Verbs are: 21 = Load component 1 into R1; 22 = Load component 2 into R2; 23 = Load component 3 into R3; 24 = Load component 1, 2 into R1, R2: 25 = Load component 1, 2, 3 into R1, R2, R3.)

ANS-43: A. PRO

B. VERB, 2, 1, ENTR, 3, 1, 0, 0, 1, ENTR

To change any data in the computer, the new data must be loaded by means of one or more of the Load Verbs. In this case, since the data to be changed is displayed in R1, Verb 21 (Load component 1 into R1) would be used. Noun 46 need not be re-keyed since it is already displayed.

44. Assume the astronaut has keyed in NOUN, 4, 7, VERB, 2, 1, ENTR, 6, 4, 1, 0, 0, ENTR, and the OPR ERR light comes on. (Verb 21 = Load first component into R1; Component 1 of Noun 47 = Vehicle weight, decimal only.)

A. Assuming the Verb-Noun combination to be legal and correct, what caused the OPR ERR light to come on? _____

B. What sequence of keystrokes must be made to correct the error?

_____

C. If the astronaut had detected the error before the final ENTR in the sequence had been struck, what sequence of keystrokes could have been used to correct the error? (In this case, the OPR ERR light would not have come on.)

_____

ANS-44: A. No "+" or "-", which would be needed for decimal data.
B. RSET, ENTR, +, 6, 4, 1, 0, 0, ENTR
C. CLR, +, 6, 4, 1, 0, 0, ENTR

The error was one that the computer could detect (frame 3-22). In part B, RSET puts the OPR ERR light out, ENTR re-enters the necessary Verb-Noun combination (which is already displayed and therefore need not be re-keyed).

In part C, the OPR ERR light had not come on, so RSET was not necessary. Neither had the final ENTR been struck, so CLR would clear the data from R1 and allow the correct data to be keyed in.

45. Assume the astronaut has keyed in NOUN, 4, 7, VERB, 2, 1, ENTR, +, 9, 7, 8, ENTR, and the OPR ERR light comes on. (Verb 21 = Load component 1 into R1; Component 1 of Noun 47 = Vehicle weight, decimal only.)

A. Why did the OPR ERR light come on? _____

B. Assuming the correct weight is 9,780 pounds, what sequence of keystrokes would the astronaut use to correct his error? _____

ANS-45: A. Any decimal entry requires 5 digits.
B. RSET, ENTR, +, 0, 9, 7, 8, 0, ENTR

In part B, since the OPR ERR light had come on, RSET must be struck, and, since the final ENTR had been struck, all data must be re-entered, including the Verb-Noun combination (which was still displayed and therefore need not be re-keyed but only entered by striking ENTR). As mentioned in answer A, a decimal entry requires 5 digits, which means that all zeroes, including any that precede the most significant digit. +10, for instance, would be +, 0, 0, 0, 1, 0, ENTR.

46. Assume the astronaut is in the process of keying in NOUN, 2, 2, VERB, 2, 5, ENTR, but accidentally strikes the 8 key instead of the 5.

A. If he noticed the error immediately, before striking the ENTR key, what keystrokes would be required to correct the error and finish keying in the desired Verb-Noun combination? _____

B. If he noticed the error only after striking ENTR, what keystrokes would be required? _____

3-45	

ANS-46: A. VERB, 2, 5, ENTR
B. VERB, 2, 5, ENTR

Any error in keying in a Verb or a Noun is corrected simply by re-keying and re-entering the Verb or Noun in which the mistake was made. No other strokes are necessary because striking the VERB or NOUN key automatically clears the associated display and makes way for the new Verb or Noun to be keyed in. The only time another stroke would be needed would be if the erroneous Verb or Noun entry resulted in an illegal Verb-Noun combination. In this case, the OPR ERR light would come on and the RSET key would have to be struck.