

APOLLO

GUIDANCE, NAVIGATION AND CONTROL

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KEYBOARD AND DISPLAY
PROGRAM AND OPERATION

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KEYBOARD AND DISPLAY
PROGRAM AND OPERATION

ABSTRACT

The Keyboard and Display program described in this report is included in the Flight 278 Programs (originally called SUNDISK and SUNDXNCE).

The lists of nouns and extended verbs are incomplete. They differ somewhat in CSM and LM and are subject to frequent change. The most complete and up to date information for these is best obtained from the latest revision of MIT/IL "Flight 278 Memo 17", or from the "Assembly and Operation Information" log section at the beginning of the program listing itself.

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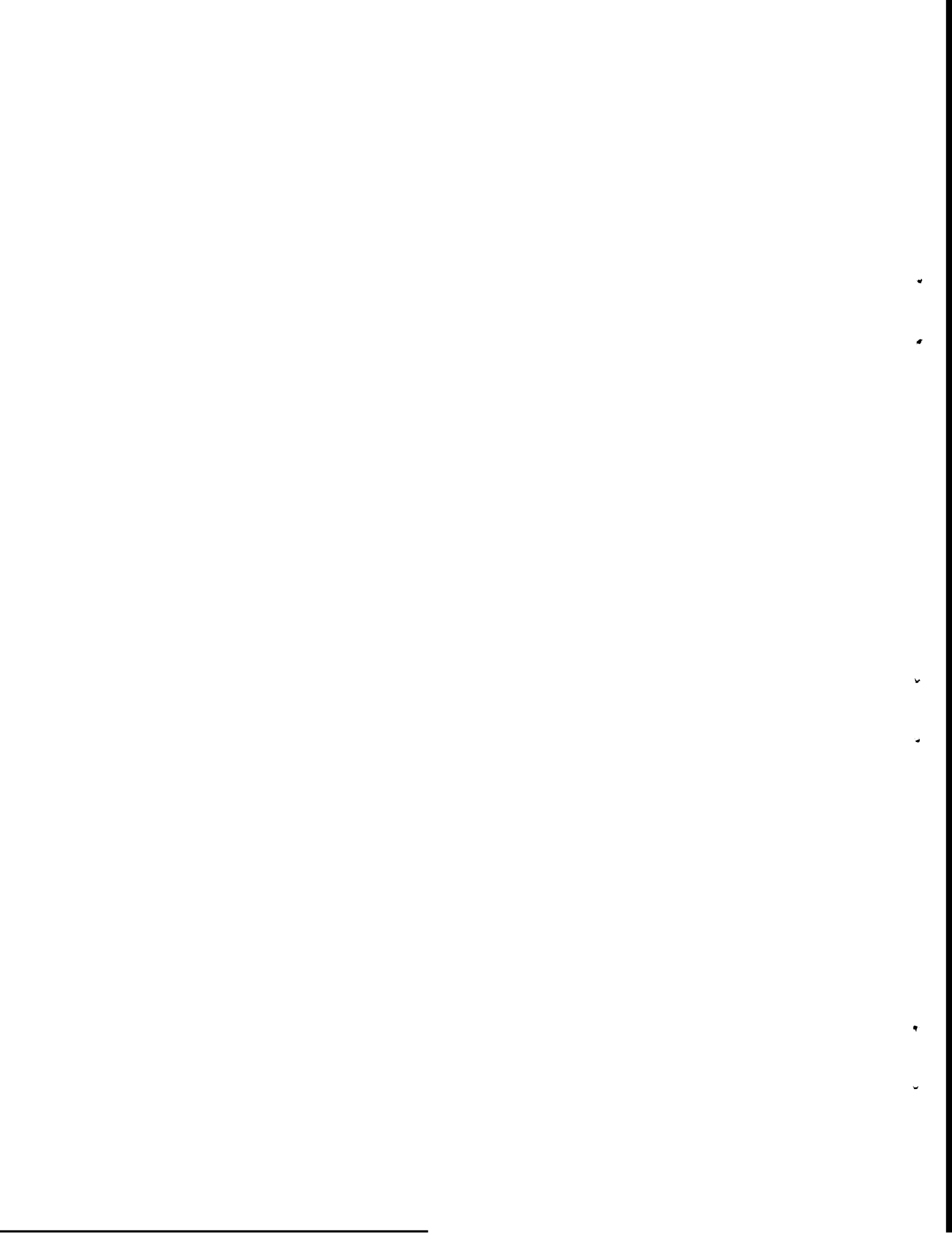


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INTRODUCTION

The Keyboard and Display System Program processes digital information exchanged between the Apollo Guidance Computer (AGC) and the computer operator. The initiation for these exchanges can be caused by operator action or by internal computer programs.

The modes of operation are as follows:

1. Display of Internal Data. Both a one-shot display and a periodically updating display (called monitor) are provided.
2. Loading External Data. As each numerical character is punched in, it is displayed in the appropriate Display Panel location.

The data involved in both loading and display can be presented in either octal or decimal form, as the operator indicates. If decimal is chosen, the appropriate scale factors are supplied by the program.

3. Program Calling and Control. The Keyboard System is used to initiate a class of routines which are concerned not only with loading or display. Typical of this class are test routines and system routines. Certain of these require instructions from the operator to determine whether to stop or continue at a given point.
4. Changing Major Mode (Program). The initiation of large scale mission phases can be commanded by the operator.

The inputs to the Keyboard and Display Program are from the direct-wire keyboard and the remote keyboard which transmits via Uplink. Both of these inputs are accomplished character-by-character. In addition, there are internal machine program requests of the Keyboard and Display Program.

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CHAPTER 1

INPUT/OUTPUT INTERFACES OF THE KEYBOARD AND DISPLAY SYSTEM PROGRAM

The external inputs to the Keyboard and Display System Program are the direct-wire Keyboard and the Uplink. The output is the Electroluminescent Display Panel.

1.1 Direct-wire Keyboard.

The Keyboard contains the following characters: VERB, NOUN, +, -, the numerical characters from 0 through 9, CLEAR, ENTER, RESET, and KEY RELEASE. Each of the characters is represented by a 5-bit binary code (see Appendix I). The Keyboard code is transmitted to the computer over a 5-wire link and is placed into bits 1 - 5 of the appropriate input channel.

CSM Each depression of a button on the Main Keyboard activates INTERRUPT KEYRUPT1, and places the key code into Channel 15. The Navigation Keyboard activates INTERRUPT KEYRUPT2, and places the key code into Channel 16.

LM Each depression of a Keyboard button activates INTERRUPT KEYRUPT1, and places the key code into Channel 15.

The appropriate Keyrupt program picks up the key code and enters a request to the Executive Routine for the program which decodes and digests the key code (CHARIN). Then a RESUME is executed, terminating the KEYRUPT.

1.2 UPLINK Inputs.

The Uplink is the digital telemetry system which sends information from the ground to the airborne computer. Each time a word is received by the Uplink, INTERRUPT UPRUPT is activated. UPRUPT picks up the transmitted code (these codes are the same as key codes) and enters a request to the Executive Routine for

the program which decodes and digests the key code (CHARIN). (See Appendix VI.) Then a RESUME is executed, terminating the UPRUPT. Note that CHARIN makes no distinction between inputs from the Keyboard and inputs from the Uplink.

There is a toggle switch which is used either to accept Uplink inputs, or to block the Uplink. In the blocked position, the operator has chosen not to accept any keyboard type of input from the ground.

1.3 The Display Panel.

1.3.1 Description,

The Display Panel consists of **24** electroluminescent sections arranged as in Fig. 1-1. Each section is capable of displaying any decimal character or remaining blank, except the **3** sign sections (R1S, R2S, R3S). These display a plus sign, a minus sign, or a blank. The numerical sections are grouped to form **3** data display registers, each of 5 numerical characters; and **3** control display registers, each of 2 numerical characters. The data display registers are referred to as R1, R2, R3. The control display registers are known as Verb, Noun, and Major Mode (Program).

The Major Mode (Program) display register is used to indicate which phase of the mission or large system program is operating. The Verb and Noun display registers are used to indicate the activity of a smaller class of programs, such as displays, loads, etc. These may be initiated by keyboard action, or from within the computer by program action.

1.3.2 Activation.

Each Display Panel character is controlled by a group of 5 latching relays. Once these relays are activated, the appropriate character remains visible on the Display Panel until the state of these relays is changed. The 5-bit relay codes for each numerical character are listed in Appendix 1.

All the information necessary to operate the Display Panel is transmitted from the computer through output channel 10 (OUTO). Two Display Panel characters are activated by OUTO at a time. Bits 1 - 5 (bit 1 is the low order bit) of OUTO operate the right character of the selected pair; bits 6-10 operate the left character of the pair. Bit 11 is used for special one-bit functions, such as signs. Bits 12-15 (bit 15 is the high order bit), which are known as the Relayword code, select the appropriate pair of Display Panel characters. See Appendix I for details.

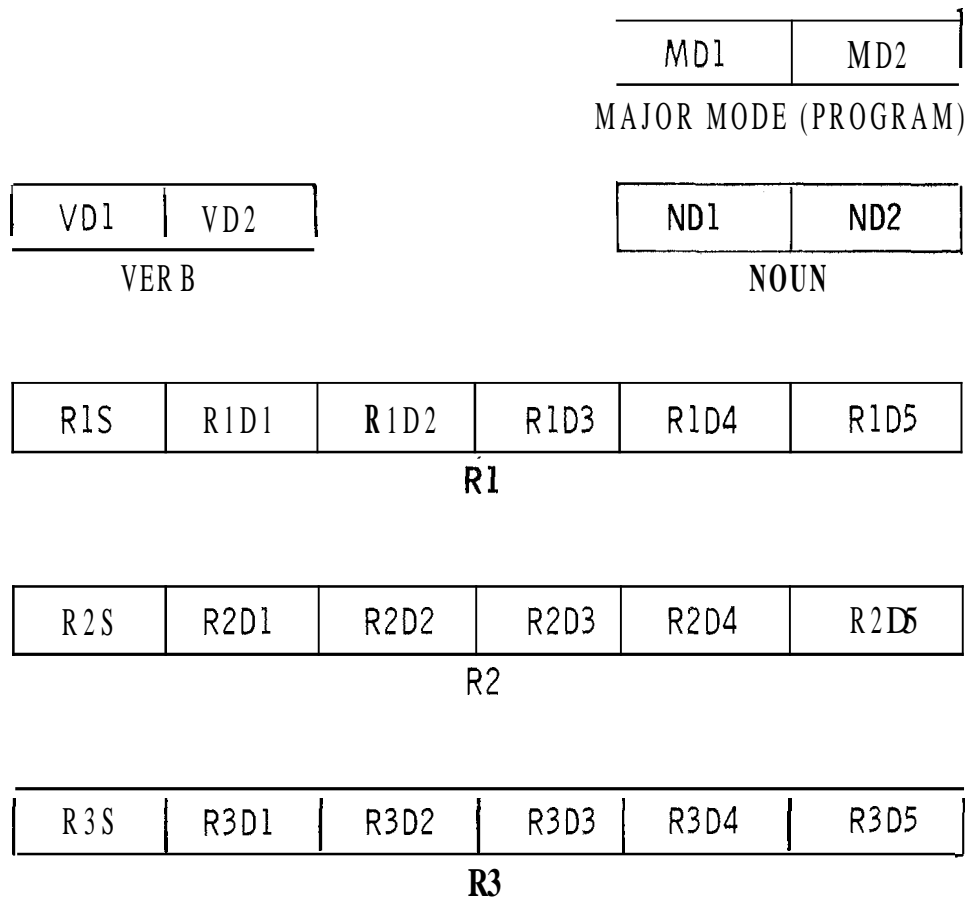


Figure 1-1. Display Panel

1.3.3 Timing.

The 15-bit word which activates a pair of characters in the Display Panel is placed into OUT0 by DSPOUT, a program operating in the Interrupt mode, DSPOUT is part of a larger Interrupt program called T4RUPPT. DSPOUT is activated approximately once every 120 milliseconds, Thus, at maximum activity, two numerical characters and a sign may be updated on the Display Panel every 0.12 seconds,

1.3.4 Display Panel Buffer,

DSPOUT obtains the 15-bit word to be placed in OUT0 from an 11-register buffer called DSPTAB. Each DSPTAB register contains the information to activate a pair of numerical characters (and perhaps a special single bit function, such as sign) in the Display Panel. By retaining this information, the DSPTAB reflects the present state of the entire Display Panel. Thus it is possible to compare new information with that already displayed and to place new data in OUT0 only when they differ.

1.3.5 Other Indicators,

The Key Release light is controlled by bit 5 of channel 11.

The Verb/Noun flash is controlled by bit 6 of channel 11.

The Operator Error Alarm light is controlled by bit 7 of channel 11.

CHAPTER 2

KEYBOARD USE OF THE KEYBOARD AND DISPLAY SYSTEM

The Keyboard and Display System Program can be initiated either by external manipulation of the Keyboard or by internal computer program action.

2.1 Functions of Keyboard Buttons and Display Panel Lights

The numerical buttons 0 through 9, +, - are obvious.

The VERB button indicates that the next 2 numerical characters punched in are to be interpreted as the Verb Code. Further information is found in Section 2.2.

The NOUN button indicates that the next 2 numerical characters punched in are to be interpreted as the Noun Code. Further information is found in Section 2.2.

The RESET button turns off the alarm lights on the DSKY panel. If any of these alarm lights remains on, it indicates that the condition causing the alarm persists. Further information is found in Section 5.4.

The ENTER button is used two ways

1. To execute the Verb/Noun combination appearing in the Verb and Noun lights.
2. To accept the data word just loaded.

Further information is found in Section 2.2.

The CLEAR button is used during a data loading sequence to blank the data display register (R1, R2, or R3) being used. It allows the operator to begin loading the data word again. Further information is found in Section 2.4.1.

The KEY RELEASE light is turned on when an internal program attempts to use the Keyboard and Display Panel but finds that the operator has not released it for internal use. Pressing the KEY RELEASE button performs this release.

The KEY RELEASE button: If no internally initiated request is awaiting the operator's response, hitting the KEY RELEASE button simply gives the operator's permission for internal programs to use the Keyboard and Display Panel Program.

If some internally initiated request is awaiting the operator's response (indicated by a flashing Verb/Noun), hitting the KEY RELEASE button re-establishes the Display Panel to the state it was in when the operator's response was requested. See Sections 2.2.4, 2.5 for further information.

The OPERATOR ERROR light is turned on when the operator performs some improper sequence of key depressions. A common example is an attempt to execute an undefined (spare) Verb or Noun code. Further information is found in Sections 2.8 and 5.1.

The Verb/Noun Flash turns the Verb and Noun lights on and off about once per second. It is used to indicate that some action is required of the operator (usually the loading of data). Further information is found in Section 2.4, 2.5, and 5.3.

2.2 Keyboard Operating Format.

The basic language of communication between the operator and the Keyboard and Display System is a pair of words known as Verb and Noun. Each of these is represented by a 2 character decimal number. The Verb code indicates what action is to be taken (operation); the Noun code indicates to what this action is applied (operand). Typical Verbs are those for displaying, loading, etc. Nouns usually refer to a group of erasable registers within the computer memory. The Verb codes are listed in Appendix II; the Noun codes in Appendix III. (These lists are incomplete. For the latest complete lists, see the latest revision of MIT/IL "Flight 278 Memo 17".)

2.2.1 Standard Verb-Noun Activation Procedure

The standard procedure for the execution of a keyboard operation consists of a sequence of 7 key depressions.

VERB V_1V_2 NOUN ${}_1N_2$ ENTER

The VERB key depression blanks the Verb lights on the Display Panel (VD1 and VD2), and clears the Verb code register within the computer. The next two numerical characters punched in are interpreted as the Verb code (V_1, V_2 in decimal). Each of these characters is displayed in the Verb lights on the Display Panel as it is punched in. The NOUN key operates similarly for the NOUN lights and Noun code register.

The depression of the ENTER key causes the performance of the Verb-Noun combination appearing in the lights at the time of depression. Thus it is not necessary to follow any order in punching in the Verb or Noun code. They may be done in reverse order, or an old Verb or old Noun may be used without repunching it.

No action is ever taken in performing the Verb-Noun combination until ENTER is pressed. If an error is noticed in either the Verb code or the Noun code before the ENTER is pressed, correction is simple. Merely press the VERB or NOUN key and repunch the originally intended code, without necessarily changing the other. Only when the operator has verified that the desired Verb and Noun codes are in the lights should he press the ENTER key and execute the Verb-Noun combination.

2.2.2 Further Procedure for Data Loading.

If the Verb-Noun combination being executed requires data to be loaded by the operator, the flash will be turned on after the Enter which initiated the Verb-Noun execution. This flash turns the Verb and Noun lights off and on about once per second. Data is loaded in 5-character words and is displayed character-by-character in one of the 5-position data display registers R1, R2, or R3 as it is keyed in. Numerical data is assumed to be octal, unless the 5-character data word is preceded by a plus or minus sign, in which case it is considered decimal. Decimal data must be loaded in full 5-numerical-character words (no zeros may be suppressed). If this is violated, the Operator Error Alarm is turned on. Octal data may be loaded with high order zeros suppressed. If decimal is used for any component of a multi-component Load Verb, it must be used for all components of that Verb. No mixing of octal and decimal data is permitted for different components of the same Load Verb. (If this is violated, the Operator Error Alarm is turned on.)

The ENTER key must be pressed after each data word. This tells the program that the numerical word being punched in is complete. The flash is turned off after the last ENTER of a loading sequence is pressed.

2.2.3 Acceptance of Keys.

The numerical keys, the CLEAR key, and the sign keys are rejected if struck after completion (final ENTER) of a data display or data load Verb. At such time, only the Verb, Noun, Enter, Reset, or Key Release are accepted. Thus the data keys are accepted only after the control keys have instructed the program to accept them.

Similarly the plus (+) and minus (-) keys are accepted just before the first numerical character of R1, R2, or R3 is punched in, and at no other time.

The 8 or 9 key is accepted only while loading a data word into R1, R2, or R3 which was preceded by a plus or minus sign. (If this is violated, the Operator Error Alarm is turned on.)

If more than two numerical characters are punched in while loading the Verb, Noun or Major Mode (Program) code, or more than five numerical characters, while loading a data word, the excess characters are not accepted.

2.2.4 Release of Keyboard and Display System.

The Keyboard and Display System Program can be used by internal computer programs as a subroutine (see Chapter 3). However, any operator keyboard action (except Reset) makes the Keyboard and Display System Program busy to internal routines. The operator has control of the Keyboard and Display System until he wishes to release it. Thus he is assured that data he wishes to observe will not be replaced by internally initiated displays. In general, it is recommended that the operator release the Keyboard and Display System for internal use when he has temporarily finished with it. This is done by pressing the Key Release button, For more information, see Chapter 3.

If an internal program attempts to use the Keyboard and Display System, but finds that the Operator has used it and not yet released it, the Key Release light is turned on. When the operator finds it convenient, he should strike the Key Release button to allow the internal program to use the Keyboard and Display Panel,

The Key Release button always causes release of the Keyboard and Display System, as described above. In addition, the Key Release button has a second auxiliary function: to re-establish the Display Panel to the state it was in when the operator's response was requested by some internal program. If the Key Release button is hit when either the Key Release light is *On*, or no internally initiated request is awaiting the operator's response, or both, then a simple release of the Keyboard and Display System is performed as above. If the Key Release button is hit when both the Key Release light is off and some internally initiated request request is awaiting the operator's response (indicated by a flashing Verb/Noun), then the re-establish Display Panel is performed. Also, just prior to the re-establish, a release of the Keyboard and Display System is performed.

This re-establish feature is intended for use when the operator has been requested to respond to some internally initiated request but has obscured the information on the Display Panel by some Keyboard activity of his own initiation

which does not serve as a response. Hitting the Key Release button will re-establish the Display Panel to the state it was in before he obscured it, so that he can again see the information pertinent to the waiting request. See also Sections 2.5, 3.5.1.

2.3 General Verb and Noun Conventions.

2.3.1 Noun Conventions,

A Noun code can refer to a device, a group of computer erasable registers, a group of counter registers, or may serve merely as a label. A label Noun refers to no particular computer register, but conveys information by its Noun code number only. A Noun code refers to a group of 1, 2, or 3 component members each of which is associated with certain computer registers. Nouns are generally considered 1-, 2-, or 3- component Nouns. The machine addresses for the registers to which a Noun refers are stored within the computer in Noun Tables. This will be described in more detail in Appendix IV.

There are two classes of Nouns: Normal and Mixed, A Normal Noun is one whose component members refer to computer registers which have consecutive addresses, and whose Component members all use the same scale factor when converted to decimal. A Mixed Noun is one whose component members refer to non-consecutive machine addresses, or whose component members require different scale factors when converted to decimal, or both.

The Nouns which refer to counter registers are primarily intended to be used with Display Verbs, but may be loaded if desired. Some Nouns refer to registers intended for command numbers (i.e., a desired new angle command). These are intended primarily to be used with Load Verbs, but may be displayed if desired.

Certain nouns are restricted to be "decimal only"; others to be "octal only" (see Appendix III). If any attempt is made to associate decimal data with an "octal only" noun or octal data with a "decimal only" noun, the Operator Error Alarm is turned on.

Another restrictive category for nouns is to be "no load". If any attempt is made to load any data into this type of noun, the Operator Error Alarm is turned on.

2.3.2 Verb Conventions.

As discussed in Section 2.3.1, a single Noun code refers to a group of 1-, 2-, or 3-component members. It is the Verb code that determines which component

member of the Noun is operated on. Thus, for instance, there are 5 different Load Verbs (see Appendix II). Verb 21 is required for loading the first component of whatever Noun is used therewith; Verb 22 loads the second component of the Noun; Verb 23, the third component; Verb 24, the first and second components of the Noun; and Verb 25 loads all three components of the Noun,

2.3.3 Decimal Conversion.

When decimal is used in loading or displaying data, conversion is done by interpreting the number as a fraction. For other than fractional representations, scale factors are applied after the fractional conversion to binary when loading and before the fractional conversion to decimal when displaying. The scale factors for Nouns that are to handle decimal data are kept in Noun Tables within the computer. A list of some available scale factors is given in Appendix III.2. These Noun Tables also keep information on how many component members are associated with each Noun that handles decimal data. The details for these Noun Tables are found in Appendix IV.

When the Decimal Display (or Decimal Monitor) Verb is employed, all the component members of the Noun being used are scaled as appropriate, converted to decimal, and displayed in the data display registers. This Decimal Display (or Decimal Monitor) Verb is an exception to the component selection feature of Verbs.

If decimal is used for loading data of any component of a multi-component Load Verb, it must be used for all components of that Verb. Thus no mixture of decimal and octal data is permitted for different components of the same Load Verb. (If this is violated, the Operator Error Alarm is turned on.)

2.4 Data Loading.

Whenever any data is to be loaded by the operator, the Verb and Noun lights flash. This flashing occurs when the loading of data is required by procedures initiated either by operator keyboard action or by internal program action. Also, the appropriate data display register (R1, R2, or R3) is blanked, and the internal computer storage register is cleared in anticipation of data loading. Each numerical character is displayed in the proper data display register position as it is punched in. Each of the data display registers (R1, R2, R3) can handle 5 numerical characters (sign is optional). If an attempt is made to key in more than 5 numerical characters in sequence, the sixth and subsequent characters are simply rejected. They do not write over the last valid character.

The plus (+) and minus (-) keys are accepted only when they precede the first numerical character of R1, R2, or R3. The signs are simply rejected if punched at any other time. If the 8 or 9 key is punched at any time other than while loading a data word which was preceded by a plus or minus sign, it is rejected and the Operator Error, Light is turned on.

As data is loaded, it is temporarily stored in intermediate buffers. It is not placed into its final destination, as specified by the Noun code, until the final ENTER of the load sequence is punched in.

2.4.1 The CLEAR Button

The CLEAR Button is used during data loading to remove errors in R1, R2, or R3. It allows the operator to begin loading the data word again. It does nothing to the Major Mode (Program), Noun, or Verb lights. (The Noun lights are blanked by the NOUN key; the Verb lights, by the VERB key.) In the following discussions, the term Clearing Function will be used to mean: blanking data display register of interest and placing +0 into the internal storage register associated with that display register.

For single component Load Verbs or "Machine Address to be Specified" Nouns, the CLEAR button depression performs the Clearing Function on whichever register is being loaded, provided that the CLEAR is punched before the data ENTER. Once the ENTER is depressed, the CLEAR does nothing. The only way to correct an error after the data ENTER for a single component Load Verb is to begin the Load Verb again.

For the 2- or 3-component Load Verbs, there is a backing-up feature of CLEAR. The first depression of the CLEAR key performs the Clearing Function on whichever register is being loaded. (The CLEAR may be pressed after any character, but before its ENTER.) Consecutive depressions of CLEAR perform the Clearing Function on the data display register above the current one, until R1 is cleared. Any attempts to back-up beyond R1 are simply ignored.

The backing-up function of Clear operates only on whatever data is pertinent to the Load Verb which initiated the loading sequence. For example, if the initiating Load Verb was a load second component only, no backing-up action is possible.

2.4.2 Loading Sequence

The normal use of the flash is with a Load Verb. In multi-component load situations, the appropriate single component Load Verbs are flashed one at a time.

Thus the computer always instructs the operator through a loading sequence. For example, consider a three-component loading sequence. The operator (or the internal program, for that matter) initiates the sequence by punching in VERB = 25, "load 3 components of:" (any noun will do). The Verb code is changed to 21, "load first component of:", and the flash is turned on. Verb 21 continues to be flashed as the operator punches in the first word of data. When the ENTER is pressed, the Verb code is changed to 22. Flashing continues while the operator punches in the second data word. When ENTER is pressed, the Verb code is changed to 23 "load third component of", and again the flash continues while the third data word is punched in. When ENTER is pressed, the flash is turned off, and all three data words are placed in the locations specified by the Noun. Notice that throughout the changing of the Verb codes, the Noun code was left unchanged.

There are two special cases when the flash is used with Verbs other than Load Verbs.

Case I. Machine Address to be Specified.

There is a class of Noun available to allow any machine address to be used. These are called "Machine Address to be Specified" Nouns. When the ENTER which causes the Verb-Noun combination to be executed senses a Noun of this type, the flash is immediately turned on. The Verb code is left unchanged. The operator should load the 5-octal-character complete machine address of interest. It is displayed in R3 as it is punched in. If an error is made in loading the address, the CLEAR may be used to remove it. Pressing ENTER causes continuation in executing the Verb.

In normal use, it is the ECADR of the desired register that is supplied by the operator. However, with Verb 27 (Fixed Memory Display), it is the FCADR of the desired location that is supplied by the operator. See Appendix 11.2 for further details.

Case II. Change Major Mode (Program)

To change Major Mode (Program), the sequence is: VERB 37 ENTER. This causes the Noun display register to be blanked and the Verb code to be flashed. The 2-decimal-character Major Mode Code should then be loaded. For verification purposes, it is displayed as it is loaded in the Noun display register. Next the ENTER should be pressed. If fewer than two numerical characters were supplied for the Major Mode Code, the Operator Error Alarm is turned on and the sequence is recycled to request the Major Mode Code again (that is, the flash is left on and the Noun display register is blanked).

If two numerical characters have been supplied, the final ENTER turns off the flash, enters a request for the new Major Mode, and causes a new Major Mode Code to be displayed in the Major Mode display register. See Mission Plan for further details.

2.4.3 Conclusion of Loading

During data loading sequences, the flash is turned off only by three events: 1) the final ENTER of a load sequence, 2) the VERB = Terminate, 3) the VERB = Proceed Without Data. It is important to conclude every Load Verb by one of the above three, especially if the load was initiated by program action within the computer. If an internally initiated load is not concluded validly, the program that initiated it may never be recalled.

The "Proceed Without Data" Verb is used to indicate that the operator is unable or wishes not to supply the data requested, but wishes the initiating program to continue as best it can with old data. The "Terminate" Verb is used to indicate that the operator chooses not to load the requested data, and also wishes the requesting routine to cease operation. See Chapter 3 for further explanation. The decision for what to do is left to the internal program.

2.5 Required Operator Responses to Internally Requested Action

Whenever an internal program requests operator action, the flash is turned on to indicate this fact. It is very important that the operator perform one of the legitimate responses, for the internal program may be in an idling condition while awaiting operator's response. If he does not respond properly, the internal program may never be recalled.

If an internal program requests operator response, but the operator obscures the information on the Display Panel by some Keyboard activity of his own initiation which does not serve as a response, the operator can re-establish the Display Panel to the state it was in at the time of the internally initiated request for his response. He does this by striking the Key Release button. If both the Key Release light is *off* and the internally initiated request is still awaiting the operator's response (indicated by a flashing Verb/Noun), then the re-establish Display Panel is performed. Also, just prior to the re-establish, a release of the Keyboard and Display System is performed. [Note: if the Key Release light is on, or no internally initiated request is awaiting the operator's response, or both, then only a simple release of the Keyboard and Display System is performed (See Section 2.2.4).] Also see Section 3.5.1.

2.5.1 Response to Internally Initiated Load Request

This is the most usual event in this class, It has been thoroughly discussed in Section 2.4.3. The load verb situation is the model upon which the other situations in this section have been based.

2.5.2 Response to Internally Initiated Display (or Monitor) with Flash

The initiating program wishes the operator to indicate his acceptance of the displayed data. The operator may:

- A) Correct the data. He performs the appropriate load verb sequence. Upon the final ENTER, the requesting program is recalled.

Perform V32E (Resquence). This indicates his desire for the requesting program to resequence back to some earlier point in the internal routine that led up to the request for his response, Often a recomputation is desired in an attempt to show more acceptable data. The decision for what to do is left to the requesting program. Note: Use of this Verb is limited to Flashing Display (or Monitor) requests in which it is improper for the

operator to load fresh data if he does not approve the data he is shown. More details may be found in Appendix 11.2. Consult the Mission plan for exactly when this Verb may be used.

- B) Perform V33E (Proceed Without Data). This indicates his acceptance of the displayed data, and his desire for the initiating program to continue without further information from him.
- C) Perform V34E (Terminate). The operator wishes the requesting program to cease operation. The decision for what to do is left to the requesting program.

2.5.3 Response to Internally Initiated "Please Perform" with Flash

This is usually used with the Noun "Checklist" and coded number(s) for the requested action are displayed in the data display register(s).

- A) Striking ENTER indicates that the requested action has been performed (similar to data in, under a load situation).
- B) V33E (Proceed Without Data). The operator chooses not to perform the requested action, but desires the requesting program to proceed as best it can without further activity from him.
- C) V34E (Terminate). The operator chooses not to perform the requested action and desires the requesting program to cease operation. The decision for what to do is left to the requesting program.

(Details of how an internal routine sets up the "Please Perform" case are given in Section 3.6.2.)

2.5.4 Response to Internally Initiated "Please Mark" with Flash

This is very similar to the "Please Perform" case.

More detail on MARK and "Please Mark" Verb is best obtained from the Mission Plan.

2.6 Data Monitor

There is a class of Verbs called Monitor Verbs which displays data every one second. Once a Monitor Verb is executed, the data in the Display Panel continues to be updated until the Monitor is turned off.

The Monitor is turned off by: Verb 34 (Terminate), Verb 33 (Proceed Without Data), Verb 32 (Resequence), an internal program initiation of the Keyboard and Display System Program (a NVSUB call that finds the Keyboard and Display System available), and by Fresh Start.

Monitor action is suspended (but not ended) by the depression of any key except Reset, and the Key Release light is turned on. Monitor action continues after the Keyboard and Display System is released. Thus it is possible to suspend a monitor while the operator loads some data, or requests another display; and to return to the original monitor when his intervention is concluded.

If a second monitor is requested by the operator while an earlier monitor is still active, the second monitor takes over the first, which ends. Thus multiple monitors cannot occur.

2.7 Extended Verbs

There is a class of programs of larger scope than the data loading and display programs which the Keyboard can call by Verb/Noun. This class is typically concerned with system testing and operation. Of course, some of these programs will need to display data or request the loading of data or commands by means of the Keyboard and Display Program. The details of this will be described in Chapter 3.

The group of Verbs that perform this general program calling is called the Extended Verbs. Their verb codes are in the range 40-99. The pertinent programs are called directly upon ENTER as part of the Keyboard and Display Program Executive Job (NOVAC), and with its same priority. The Verbs that call programs of relatively short duration should be executed directly and then should end the Keyboard and Display Program with a TC ENDOFJOB. Those of longer duration should place a request to the Executive Routine for the main body of the program and end the Keyboard and Display Program with a TC ENDOFJOB. The Keyboard and Display System is released before the Extended Verbs (codes 40-99) are called, so that they may use the Keyboard and Display System Program.

2.8 Alarm Philosophy

The Operator Error Alarm light is turned on by the Keyboard and Display Program when the operator performs some improper sequence of key depressions. A detailed list of conditions which cause the Operator Error Alarm to be turned on is found in Chapter 5. This section describes the general categories of improper operation.

2.8.1 Illegal Verbs, Nouns, and Combinations

The simplest alarm situation is an attempt to use an undefined (or spare) Verb Code or Noun Code. The Alarm light is turned on when the ENTER is pressed that attempts to execute the Verb/Noun combination. No further action is taken.

It is possible to choose a Verb that is defined and a Noun that is defined, but have the combination of Verb and Noun be illegal (for example, the "decimal display" Verb used with a Noun which is restricted to be "octal only"). The alarm light is turned on at the ENTER that attempts to execute the Verb/Noun combination. No further action is taken.

2.8.2 Illegal Data and Recycle

Many legal Verb/Noun combinations require the loading of additional data (either numerical or machine address). It is possible that the data supplied may itself be improper for the Noun selected. Examples are: (1) the numerical data exceeds the maximum value allowed by the scale factor associated with the Noun (see Appendix III,2) , and (2) decimal data is loaded into an "octal only" noun.

In general, the offense is detected at the final ENTER of the loading sequence. The alarm is turned on and a recycle is performed back to the beginning of the loading sequence. The flash is left on, and the data display register associated with the first data word in the sequence is blanked again. It is necessary for the operator only to supply the data again; he need not attempt to re-execute the Verb/Noun combination. (Note, if decimal data is supplied for the address of a "machine address to be specified" noun, the alarm and recycle are performed at the ENTER immediately following the address word.)

2.8.3 Alarm and Key Rejection

There are two situations which cause the Operator Error Alarm light to be turned on and the offending key depression to be simply rejected, These are:

- 1) An attempt to ENTER a decimal data word having fewer than 5 numerical characters. The ENTER is simply rejected. The flash is left on and the Verb Code is not advanced. Thus it is possible to supply the remaining numerical characters and to press ENTER again for the same data word. Or the CLEAR key may be used if the operator wishes to begin loading the offending data word again.

- 2) An 8 or 9 is punched while loading a word which was not preceded by a plus or minus sign. The 8 or 9 is simply rejected. The remaining characters may then be supplied or the offending word removed and its loading begun again,

CHAPTER 3

INTERNAL USE OF KEYBOARD AND DISPLAY SYSTEM PROGRAM

The Keyboard and Display System Program is available to other internal computer programs for subroutine use. Use is limited to routines operating under Executive Routine control. Routines operating in the Interrupt Mode may not use the Keyboard and Display Program as a subroutine,

The Verb and Noun Codes themselves are used as the language for communicating between other internal programs and the Keyboard and Display System Program. The combination of any display, load, or monitor Verb together with any Noun available to the keyboard can be called by internal routines.

3.1 Interlock for Internal Use of Keyboard and Display Program

It is necessary to place certain limits on when an internal routine may use the Keyboard and Display Program. This is necessary to prevent the situation in which an internally initiated procedure might write over data in the Display Panel that the operator has not had time to digest. Thus, an operator/internal interlock is provided.

The operator/internal interlock (called DSPLOCK) is made busy to internal routines by any keyboard activity (except Reset). It remains busy until it is "released" by the Key Release button or by certain special Verbs. See Section 3.3.1.

The old internal/internal interlock (called GRABLOCK) has been removed. This used to provide the feature that once one internal program had "grabbed" the Display System, other internal programs found the Display System unavailable. The responsibility for avoiding conflict in the use of the Display System by several internal programs is now born by the Mission sequencing.

A group of programs known as the "Display Interface Routines" provides buffering between Mission Programs and the Keyboard and Display System Program. Most of the Mission Program internal use of the Keyboard and Display System Program is now handled through these Display Interface Routines. These have been written by Margaret Hamilton of MIT/IL, and details on their use are best obtained from her documentation.

3.2 Typical Calling Sequence for Internal Use of Keyboard and Display System

A calling sequence for typical internal use of the Keyboard and Display System Program is:

- M, TC NVSUB (with Verb-Noun code in A register)
- M+1, Return here if Display System is busy (operator)
- M+2, Return here after execution of Verb/Noun

3.3 Details of Calling Keyboard and Display Program for Internal Use

The details of the Calling sequence shown in Section 3.2 will be described here. Also the formats and return option will be explained.

3.3.1 Internal Calling of a Verb/Noun Combination (NVSUB)

The communicator for calling the Keyboard and Display Program is called NVSUB. It is in directly accessible fixed memory. The Combination of any display, load, or monitor Verb together with any noun available to the Keyboard can be called by NVSUB. The format is to place a word in the A register with the 7-bit Verb code in bits 8-14 and the 7-bit Noun code in bits 1-7. The TC NVSUB causes the Verb code to be displayed in the Verb lights, the Noun code to be displayed in the Noun lights, and the Verb-Noun combination to be executed. Notice that the Verb 00 and Noun 00 are both illegal codes, if punched in by the operator. Advantage is made of this fact in the following situation. If the program calling NVSUB wishes to display a Verb code without executing it, or to display a Noun code without executing it, the contents of A should be set so that the other 7 bits are all zero. Thus to display the Verb code only, bits 1-7 are set to 0 and the Verb code is placed into bits 8-14. To display the Noun code only, bits 8-14 are set to 0 and the Noun code is placed into bits 1-7. The entire action of NVSUB is taken as a subroutine of the program that called NVSUB. Thus NVSUB is run as part of the same Executive Job that called NVSUB, and with the same priority.

If the calling routine wishes to use one of the "Machine Address to be Specified" Nouns, it is necessary to preload MPAC + 2 with the appropriate Machine Address before the TC NVSUB.

The Keyboard and Display System is made busy (DSPLOCK) to internal users when there is any Keyboard activity (except Reset). It remains busy until it is released by the Key Release button or by the following Verbs: Proceed Without Data

(33); Terminate (34); Fresh Start (36); Request Executive (30); Request Waitlist (31); Resequene (32); also by all the Verbs with codes 40-99 (these are the so-called Extended Verbs); recall from ENDIDLE; start of a Monitor Verb.

If the TC NVSUB was done at location M, the return is to M+1 if the Keyboard and Display System is busy (DSPLOCK is busy). If DSPLOCK shows that the System is available, the return is to M+2, after the Verb-Noun combination has been executed.

The decision for what to do if the Keyboard and Display System is found busy is left to the calling routine. It may use an optional routine called NVSUBUSY, which puts it to sleep waiting for the Keyboard and Display System to be released, Or it may prefer to continue and attempt the TC NVSUB again later.

The calling sequence for the optional NVSUBUSY is:

CAF WAKECADR
TC NVSUBUSY

NVSUBUSY is in directly accesible fixed memory. It puts the calling JOB to sleep, saves its CADR for later waking, and turns on the "Key Release" light, telling the operator to release the Display System for internal use. This CADR is the location at which you wish your JOB to wake up when the Display System is released. Note that the Verb/Noun code is not saved. The user must take care to have the desired Verb/Noun code in A when NVSUB is called again after wake-up.

Jobs that were put to sleep by NVSUBUSY are waked up by: the Key Release button; Proceed Without Data (V33); Terminate (V34); Request Executive (V30); Request Waitlist (V31); Resequene (V32); all Extended Verbs (40-99).

There is a special entrance to NVSUBUSY called PRENVBSY for routines in banks that wish the CADR of (location from which the TC PRENVBSY was done) - 2 to be saved for later waking. Note that the Verb/Noun code is not saved. The CADR of (location from which the TC PRENVBSY was done) - 2 should refer to the instruction that places the desired Verb/Noun code into A, before calling NVSUB again after wake up.

3.3.2 NVSBWAIT.

NVSBWAIT is a special entrance for routines in banks only that wish to combine the functions of NVSUB and PRENVRSY into one call. It is located in F/F memory. It is called with the desired Verb/Noun code in A.

If the Keyboard and Display System is not busy, it executes the Verb/Noun combination and returns to L+1 (L is the location from which the TC NVSBWAIT was done).

If the System is busy, it turns on the Key Release light and puts the calling job to sleep with (L-1) being saved for eventual waking when the Keyboard and Display System is released. Note that the Verb/Noun code is not saved. (L-1) should refer to the instruction that places the desired Verb/Noun code into A, before calling NVSUB again after wake up.

3.3.3 NVSUB Requests for Illegal Verb/Noun Combinations

If the Keyboard and Display System is available, but the routine that calls NVSUB specifies an illegal Verb/Noun combination, then an ABORT is caused (with code 01501 displayed). The philosophy of what causes a Verb/Noun combination to be illegal is given in Section 2.8.1. A complete list of the illegal situations is given in Section 5.1.1. Notice that recycles caused by bad data being loaded do not fall into this category.

3.4 Keyboard and Display System Release

The "Key Release" Light is turned on to indicate to the operator that some internal program has attempted to use NVSUB, and found the Keyboard and Display System busy. Thus the operator should release the Keyboard and Display System by pressing the Key Release button.

The Key Release button always causes release of the Keyboard and Display System, as described above. In addition, the Key Release button has a second auxiliary function: to re-establish the Display Panel to the state it was in when the operator's response was requested by some internal program. If the Key Release button is hit when ~~either~~ the Key Release light is on, or no internally initiated request is awaiting the operator's response, or both, then a simple release of the Keyboard and Display System is performed as above. If the Key Release button is hit when both the Key Release light is off and some internally initiated request is awaiting the operator's response (indicated by a flashing Verb/Noun), then the re-establish Display Panel is performed. Also, just prior to the re-establish, a release of the Keyboard and Display System is performed.

This re-establish feature is intended for use when the operator has been requested to respond to some internally initiated request but has obscured the

information on the Display Panel by some Keyboard activity of his own initiation which does not serve as a response. Hitting the Key Release button will re-establish the Display Panel to the state it was in before he obscured it, so that he can again see the information pertinent to the waiting request. See also Section 3.5.1.

3.5 Internally Initiated Loads

If a loading operation is called by NVSUB, some additional facts should be pointed out. If the Keyboard and Display System is available, the Load Verb is displayed along with the Noun and the flash is turned on. When everything is set up to receive data from the operator, NVSUB returns to Mi-2 of the calling routine. Now there is a relatively long time until the completion of the load. The option of what to do at this point is left to the calling routine.

Most programs that place requests through NVSUB for data to be loaded will desire to give up control of the computer until the data has been loaded. These will be recalled as soon as the data load is completed, if they follow the procedure outlined below.

A routine called ENDIDLE is provided in directly accessible fixed storage. It puts the current Executive Job to sleep, and stores away the location from which the initiating routine did a TC ENDIDLE; (call this location P), Use of ENDIDLE allows other Executive Jobs to be run while the actual data loading is taking place.

Recall to the routine that called ENDIDLE is made at the end of the loading sequence, when the Verb "Terminate" is keyed in, or when the Verb "Proceed Without Data" is keyed in. The recall is to:

P+1	For "Terminate"
P+2	For "Proceed Without Data"
P+3	For Data In

The recall is made by way of an Executive Routine request to wake up the routine that did the TC ENDIDLE. NVSUB is made available just before recall. The Verb and Noun codes that were current when the request to wake the job was placed are available to that job. The Verb is found in the waked-up job's MPAC; the Noun, in MPAC+1. This information may be useful for testing .

3.5.1 Re-Establish Displays (Key Release Button)

If the Key Release button is pressed when either the Key Release light is on or ENDIDLE is inactive (CADRSTDR = + 0), or both, then a simple release of the Keyboard and Display System is performed (see Section 3.4).

If the Key Release button is pressed when both the Key Release light is off and ENDIDLE is active (CADRSTOR not = + 0), then the Display Panel is re-established to the state it was in when operator response was requested (that is, when GNDIDLE was called). Also, just prior to the re-establish, a release of the Keyboard and Display System is performed. The re-establish is performed by going to PINBRNCH in the "Display Interface Routines". The details for just how this is accomplished are best obtained from the Display Interface Routines documentation by Margaret Hamilton of MIT/IL.

This re-establish feature is intended for use when the operator has been requested to respond to some internal request (ENDIDLE was used), but he has obscured the information on the Display Panel by some Keyboard activity of his own initiation which does not serve as a response. Hitting the Key Release button will re-establish the Display Panel to the state it was in before he obscured it, *so* that he can again see the information pertinent to the waiting request. This re-establish feature works only for internal requests for operator response that used ENDIDLE through the Display Interface Routines, and not those that used ENDIDLE directly. See Section 3.4 also.

3.6 Other Uses of ENDIDLE

As discussed in Section 3.5, the primary use of ENDIDLE is while an internal program is waiting for data that it requested to be loaded (with an actual load verb). Experience has shown that there are several situations in which internal programs wish to wait for certain operator actions before continuing in their solution. These programs may use ENDIDLE, but they must turn the flash on to indicate to the operator that he must respond (a TC FLASHON will accomplish this).

The Key Release button may be used to re-establish the Display Panel to the state it was in at the time ENDIDLE was used. See Section 3.5.1 for details.

3.6.1 Use of ENDIDLE with Display (or Monitor) Verbs

A routine going to NVSUB with a display (or monitor) verb may then turn on the flash, and go to ENDIDLE. This is done when the program wishes the operator to indicate his acceptance of the displayed data.

- A) If the operator wishes to correct the data, he may perform the appropriate load verb sequence, Upon the final ENTER, the requesting program is recalled at Pi-3.

In some situations, it is improper for the operator to load fresh data if he does not approve the data he is shown. If the operator wishes the requesting routine to resequence back to some earlier point in the internal routine that led up to the request for his response, he strikes V32E (Resequence). The requesting program is recalled at P+3. The decision for what to do is decided by the program itself at this point. Often a recomputation is desired in an attempt to show more acceptable data. Use of this Verb is limited. See Appendix 11.2 for more detail. Consult the Mission Plan for exactly when V32 may be used.

The requesting program can resolve any ambiguity about what caused the recall to P+3 by examining MPAC after recall. This contains the Verb code that was current when the request for recall was performed.

- B) If the operator wishes to accept the displayed data, he strikes V33E (Proceed Without Data). This indicates his desire for the initiating program to continue without further information from him. The requesting program is recalled at P+2.
- C) If the operator may wish the requesting program to cease operation, he strikes V34E (Terminate). The requesting program is recalled at P+1. Whether or not it ceases to operate is decided by the program itself at this point.

3.6.2 Use of ENDIDLE with "Please Perform"

The normal sequence for a routine to request the operator's response in a "Please Perform" case is:

1. Place coded number(s) into the register(s) that the "Checklist" Noun refers to. The coded information indicates what action is requested of the operator.
2. Go to NVSUB with a display Verb and the Noun "Checklist". This shows the code for Noun "Checklist" in the Noun lights, and the coded information in the Data Display Register(s). It also momentarily attempts to show the Display Verb in the Verb lights,
3. Go to NVSUB with the "Please Perform" Verb and zeros in the low 7 bits. This will paste up the "Please Perform" Verb code in the Verb lights. Usually the display Verb of (2) will never be visible to the operator.

4. Turn on the Verb/Noun flash (TC FLASHON).
5. Go to ENDIDLE.

The operator responses are:

- A) ENTER to indicate the requested action has been taken. Recall is to P+3 (similar to data in, under a load situation).
- B) V33E (Proceed Without Data). The operator chooses not to perform requested action, but wishes the requesting program to continue as best it can without further activity from him. Recall is to P+2.
- C) V34E (Terminate). The operator chooses not to perform the requested action, and wishes the requesting program to cease operation. The decision for what to do is left to the requesting program. Recall is to P+1.

3.6.3 Use of ENDIDLE with "Please Mark"

This is very similar to the "Please Perform" case. For details, see the Mission Plan.

3.6.4 Summary of Recalls to ENDIDLE

P = location from which the TC ENDIDLE was performed. The recalls are to:

P+1 for Terminate (V34E).

P+2 for Proceed Without Data (V33E).

P+3 for Data In (final E of a load Verb sequence).
 Or for E under the Please Perform or Please Mark Verb.
 Or for Re-sequence (V32E). This should be used only with those flashing display situations that allow Re-sequence as a response.

3.7 Limitations to Internal Use of Keyboard and Display System

As described in Sections 3.3.1, 3.5, and 3.6, there are two ways that an internal program may be put to sleep by the Keyboard and Display Program while awaiting action by the operator. One is by means of NVSUBUSY (or PRENVBSY, or NVSEWAIT) while waiting for the operator to release the Keyboard and Display System. The other is by means of ENDIDLE while waiting for the operator to load data or indicate his acceptance or rejection of other situations.

A groundrule has been established that only one internal program may be asleep by means of the Keyboard and Display Program (either NVSUBUSY or ENDIDLE) at any time. Violations of this rule will result in an ABORT (with code 01206 displayed). The philosophy here is similar to that used in other list overflows in System Programs (examples: Executive, Waitlist). The ways this groundrule can be violated are:

- 1) Second use of ENDIDLE before response to the first one.
- 2) Second use of NVSUBUSY before response to the first one.
- 3) Use of ENDIDLE after an earlier use of NVSUBUSY, but before response to use of NVSUBUSY.
- 4) Use of NVSUBUSY after an earlier use of ENDIDLE, but before response to use of ENDIDLE.

The Display Interface Routines described in Section 3.1 perform some buffering which may get around these restrictions in certain cases. See the "Display Interface Routines" documentation for particulars. The point being made in this section is that only one internal program may be asleep at any time by means of the Keyboard and Display System Program,

3.8 JAMTERM, JAMPROC

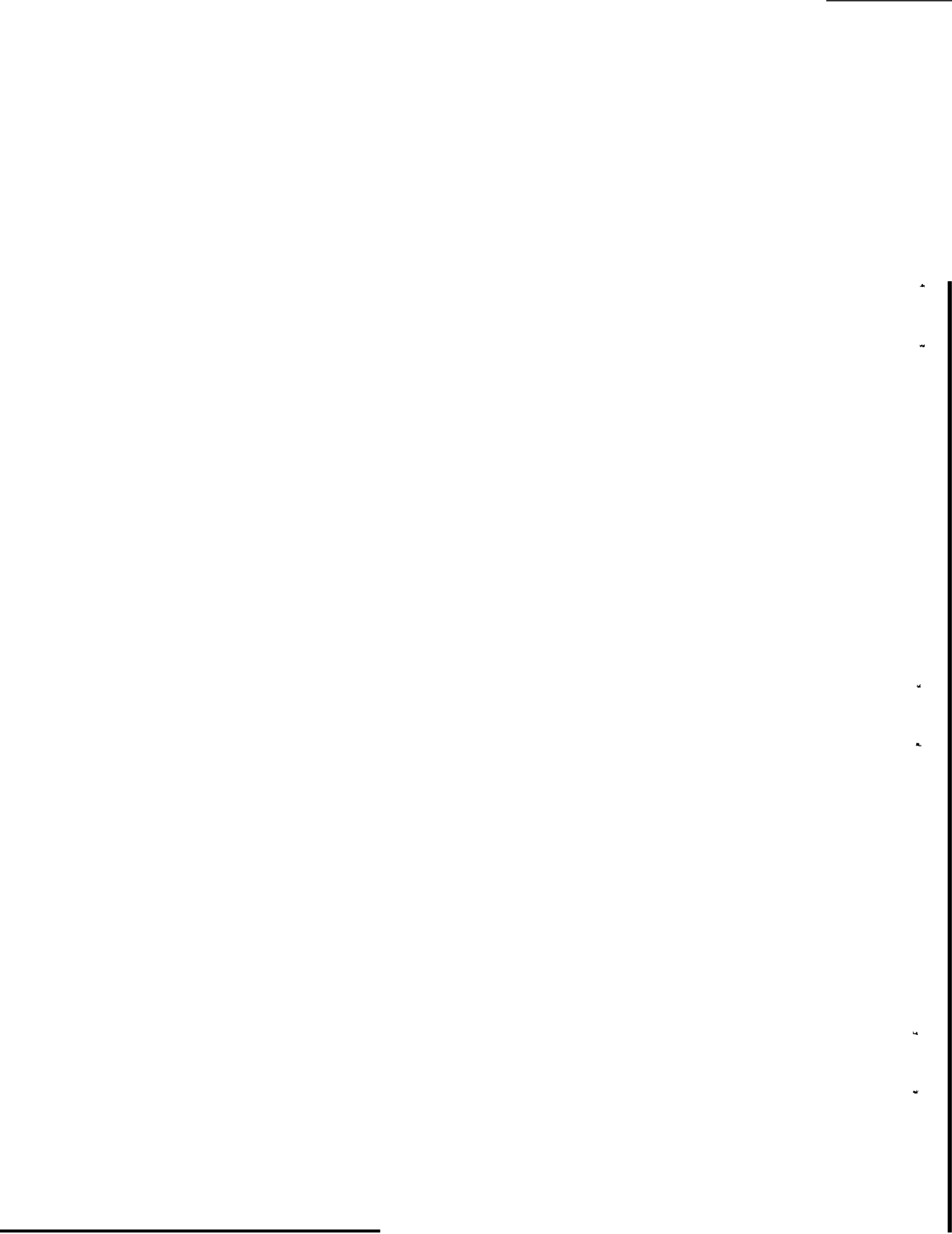
Internal programs may perform the Terminate function (as V34E would have done) or the Proceed function (as V33E would have done). JAMTERM displays **34** in the Verb lights and then executes the entire Terminate function (see Appendix II.2), ending with an ENDOFJOB. JAMPROC displays **33** in the Verb lights and executes the Proceed function (see Appendix II.2), ending with an ENDOFJOB. Both routines are in F/F memory.

3.9 BLANKSUB

Routine BLANKSUB is provided to allow an internal program to blank data display registers R1, R2, or R3 (or any combination of these). It is intended for use after an internal program has gone to NVSUB and then wishes to blank some of the data just displayed.

BLANKSUB is located in F/F memory. It is called with the blanking code in A BIT1 = 1 blanks R1; BIT2 = 1 blanks R2; BIT3 = 1 blanks R3. Any combination of these is accepted. If L is the location from which the TC BLANKSUB was done, the return is to L+1 if the Display System is busy; return to L+2 with the blanking performed if the Display System is available. These returns are similar to those for NVSUB (see Section 3.2, 3.3).

If the user of BLANKSUB finds the Keyboard and Display System is busy, it should not go to PRENVBSY or NVSUBUSY for itself. Rather it should use NVSUBUSY so as to wake and go to NVSUB again before attempting the BLANKSUB again. The intention is that BLANKSUB should not be used except immediately after NVSUB so that the internal user is banking his own display data and not perhaps some externally initiated display data.



CHAPTER 4

PROGRAM DESCRIPTION

The AGC Keyboard and Display Program, as currently implemented, comprises nearly 2,000 words and occupies the majority of two banks of AGC fixed memory. The listing of the program contains a significant amount of documentary information and is regarded as the prime reference for the program's description. This chapter attempts to give a broad functional description of the program flow and logic to aid in the understanding and use of the routine,

Figure V-1 gives a functional block diagram and illustrates the three principal divisions of the program:

1. Input Character Processing
2. Command Execution.
3. Display.

4.1 Input Character Processing

The parts of the program which process input characters are:

1. KEYRUPT. The routine triggered by the Keyboard Interrupt which reads the input character and activates the Executive Routine part of the Keyboard Routine (CHARIN).
2. NUM. The part of the routine which processes numerical characters.
3. The various control character processors including: NOUN, VERB, CLEAR, RESET, +, -, and KEY RELEASE.

Descriptively the NOUN and VERB keys indicate that new command parameters are to be entered and the program initializes the proper registers to accept these parameters.

The + and - keys are used to set register DECBRNCH, which directs NUM how to accept input numerical characters.

The function of CLEAR has been described in Chapter 2. This function is implemented by using the state of register CLPASS as a one-pass gate. Initially CLPASS is +0, as set by an ENTER. When CLEAR is actuated, the "blank current register" path is taken and CLPASS is incremented. A second CLEAR then will take the other branch (CLPASSHI) and do the backing up. If, however, a sign or numeric character intervened, CLPASS would have been reset to +0. A special case is required for the single-component loads since these can not be allowed to back up. These verbs then set CLPASS to a large negative number which prevents the backing up path from being entered.

The function of RESET is clear from the flow chart.

The ENTER key is used in two distinct ways:

1. As an execute signal implying that the operator wants the current noun-verb command to be executed. This occurs when REQRET is positive and is the normal ENTER function,
2. As a data-entered signal implying that the operator has completed a numerical input word. This occurs when REQRET is negative. Since data is entered only in response to a data request, the routines which do this requesting (e.g., REQDATZ) set REQRET negative. The Enter routine, when it takes the "data in" path (ENTPASSHI), leaves REQRET positive so that succeeding ENTER's will be interpreted in the first category unless another load has occurred.

Numerical input is processed by the NUM routine, which assembles input characters in one of 5 possible buffer registers, NOUNREG, VERBREG, X, Y, or ZREG, depending on the previous control characters or the load command. The buffer register used is determined by the state of DSPCOUNT, so that there is a 1-1 correspondence between the input buffers and the displays. As numerical data is accepted, it is also displayed via the DSPIN subroutine. NUM accepts either octal or decimal input. Octal input is assembled by cycling so that leading zeros are not required. Decimal input is accepted as if the decimal point were to the far right until overflow or the fifth character is in; this is then converted to fractional form and stored to double precision. Five characters must be punched in for decimal.

4.2 Command Execution

Whenever an "execute Verb-Noun" ENTER occurs, the particular command routine implied by the Verb-Noun coded is executed. This process takes place in two stages:

1. Noun Translation
2. Verb Execution

The Noun translation phase decides whether the Noun is Normal or Mixed, looks up the machine address for the given Noun and stores it in NOUNADD, tests if the Noun address is to be entered or incremented, and does as much preliminary processing as possible before branching on the Verb code.

After the Noun translation phase, a full fan on the Verb code is executed and a particular Verb routine is entered. These fall into three general categories:

1. Display and Monitor Commands
2. Load Commands
3. "Go To" Commands (or Routine Initialization).

4.2.1 Display and Monitor Verbs

The basic flow of control for decimal display is:

1. All component data pick up from referenced registers into a temporary buffer.
2. For each component in turn:
 - a. Scale factor look up.
 - b. Scaling routine look up.
 - c. Scale and display.

The logic is complicated by the difference between Mixed and Normal Nouns, since the Noun Tables for each are of different formats (Appendix IV).

The monitoring function is implemented by providing a Monitor Verb corresponding to each Display Verb. The Monitor execution consists of three basic parts:

1. The MONITOR routine, entered via the verbfan, saves the Noun and Verb codes and the machine address corresponding to the Noun (in case it was a "Machine Address to be Specified" Noun) and makes a Waitlist request for MONREQ.
2. The MONREQ routine is merely a scheduling routine which produces an Executive call to MONDO every 1 sec.
3. The MONDO routine causes execution of the equivalent Display Verb and Noun combination whenever it is called. It first tests DSPLOCK (the operator/internal interlock) to enable keyboard activity to suspend (but not end) monitoring action.

The ability to handle externally specified addresses is gained by always preloading the address register NOUNADD. For other than "Machine Address to be Specified" Nouns, this register is reloaded from the Noun Tables by the TESTNOUN routine.

4.2.2 Load Verbs

The flow of control for a Load Verb is:

1. Input data for each component is requested in turn by the display of the proper "load single component" Verb and the flash. When all input data is received, signified by the last ENTER, then the following occurs for each component in turn:
 2. a. Address look up.
 - b. Octal or Decimal Test.
 - c. Store if octal; scale factor look up if decimal.
 - d. Scaling routine look up if decimal.
 - e. Scale and store if decimal,

4.2.3 Extended Verbs

The Extended Verbs provide a means of calling specialized routines from the Keyboard. These have been provided for such functions as testing and facilitating

the running of programs. The called routines have the option of using the Noun code as a parameter if desired.

4.2.4 Miscellaneous Verbs

There are several miscellaneous verbs such as Proceed, Terminate, etc. These programs are straightforward and will not be described in detail here.

4.3 Subroutine Use

An entry routine NVSUB has been provided to make the routines of the Keyboard and Display System available to programs as well as the Keyboard. The use and philosophy has been previously described. The structure of the program is straightforward and in effect depends on having an erasable register ENTRET as the exit instruction for all Keyboard and Display routines. When they are initiated by the Keyboard, this register is preset to TC ENDOFJOB; when they are initiated by NVSUB, it is set to NVSUBEND where a return is made to the calling routine.

The mechanism for handling internally requested loads has been previously described.

4.4 Display Output Routines

The electroluminescent Display Panel is periodically updated by INTERRUPT T4RUP T to the DSPOUT routine. This routine (Fig. V-2) maintains a correspondence between an internal buffer (DSPTAB) and the lights by driving the controlling relays via Output Channel 10 (OUTO) whenever the states of the buffer and the lights differ.

To conserve Interrupt time, the programs which make entries to the DSPTAB (e.g., DSPIN) always test that:

1. The new entry represents a change from the previous entry.
2. The previous entry had already been displayed (as opposed to awaiting display).

Only if both conditions are satisfied is the DSPOUT counter (NOUT) incremented. Hence c(NOUT) is the number of DSPTAB entries which must be sent out to make the Display Panel correspond to the buffer.

The differentiation between a DSPTAR entry which has been displayed and one waiting to be displayed is maintained by the sign of the entry. Positive entries have already been displayed, while their complements represent new information waiting to be displayed. When DSPOUT sends a word to OUTO, it changes the DSPTAB entry sign from negative to positive to indicate this.

As can be seen by following the flow chart, a safety play is incorporated to guard against looping. When the counter (DSPCNT) which is used to step through the display table reaches zero the second time, then there must be no negative entries in DSPTAB so NOUT is set to zero and the program exits,

4.5 Interlock Control

Interlock between external (keyboard) and internal routine use of the Keyboard and Display System is controlled by the following routines:

1. NVSUBUSY
2. RELDSP

The effect and use of these programs has been described in Chapter 3.

Logically the interlocking is accomplished by controlling the states of DSPLOCK, the operator/internal interlock, having 2 states: external activity or no external activity.

1. +0 no external activity (system available for internal use).
2. +1 external activity (system unavailable for internal use).

CHAPTER 5

ALARMS AND SPECIAL CONTROLS

The Keyboard and Display System Program makes use of the Operator Error Light. It is also concerned with the Key Release Light (also known as Release Display System), the Flash, and the Reset Button. This chapter summarizes the way the Keyboard and Display System Program makes use of these alarms and controls. Much of the reasoning is discussed in Chapter 2.

5.1 Operator Error Alarm Conditions

The categories of improper operation which cause the Operator Error Alarm light to be turned on are described in Section 2.8. A detailed list of these conditions is given below.

5.1.1 Operator Error Alarm and No Further Action

Violation of the following principles causes the Operator Error Alarm to be turned on. No further action is taken (see Section 2.8.1).

- 1) An undefined (or spare) Verb must not be used.
- 2) An undefined (or spare) Noun must not be used.
- 3) In octal display and monitor verbs and all load verbs, the component number of the verb must not exceed the number of components in the noun.
- 4) The octal display and monitor verbs must not be used with a "decimal only" noun.
- 5) The decimal display and monitor verbs must not be used with an "octal only" noun.
- 6) The dp decimal display and monitor verbs (07, 17) must not be used with mixed nouns (codes 40-99).

- 7) No load verb may be used with a noun restricted to be "no load". All nouns having the split MIN/SEC scale (see Appendix 111.2 item L) for any component are "no load" for the entire noun.
- 8) (An input code other than those listed in Appendix I is received from the Keyboard.)
- 9) (The contents of the register used to determine which Display Panel character is to be lighted has exceeded its limit.)

5.1.2 Operator Error Alarm and Recycle

Violation of the following principles causes the Operator Error Alarm to be turned on, and a recycle to be performed (see Section 2.8.2).

- 1) The address keyed in for a "machine address to be specified" noun must be octal.
- 2) In multi-component load verbs, no mixing of octal and decimal data is permitted, All the data words loaded for a given noun must be either all octal or all decimal.
- 3) Octal data must not be loaded into a "decimal only" noun.
- 4) Decimal data must not be loaded into an "octal only" noun,
- 5) Decimal data loaded must not numerically exceed the maximum permitted by the scale factor associated with the appropriate component of the noun (see Appendix III.2).
- 6) Negative decimal data must not be loaded using the *Y* optics scale,
- 7) All 3 words must be loaded for the Hours, Minutes, Seconds scale (see Appendix III.2 item K).
- 8) When loading with the Hours, Minutes, Seconds scale, the minutes must not exceed 59; the seconds must not exceed 59.99; the total number must not exceed 745 hours, 39 minutes, 14.55 seconds.

- 9) Two numerical characters must be supplied for the Major Mode (Program) Code under V37 (see Section 2.4.2 case II).

5.1.3 Operator Error Alarm and Key Rejection

The following cause the Operator Error Alarm to be turned **on** and the appropriate key depression to be rejected (see Section 2.8.3).

- 1) An attempt to ENTER a decimal data word with fewer than 5 numerical characters. The ENTER is rejected.
- 2) An 8 or 9 is punched while loading a word which was not preceded by a plus or minus sign. The 8 or 9 is rejected.

5.2 Key Release (Release Display System)

The illumination of the Key Release light indicates that some internal program has attempted to use the Keyboard and Display System Program and found it busy due to operator action. The operator should press the Key Release button when convenient.

The Key Release button always causes release of the Keyboard and Display System, as described above. In addition, the Key Release button has a second auxiliary function: to re-establish the Display Panel to the state it was in when the operator's response was requested by some internal program. See Sections 2.2.4, 2.5, and 3.5.1 for details.

5.3 The Verb , Noun Flash

The Verb and Noun lights are flashed to indicate that some action is required of the operator (often the loading of data). It is turned off by any of the responses to requests for operator response,

1. Finishing the load sequence, or punching in V32E (Resequence). Use of V32 is limited. See Section 2.5.
2. Punching in Verb 33E (Proceed Without Data).
3. Punching in Verb 34E (Terminate).

5.4 RESET Button Action

This button is furnished to turn off Alarm lights on the Display Panel. Under program control, the following action related to the Display Panel is taken: the Operator Error light, the Uplink Activity light, the Standby light, the Restart light, the Program Alarm light, the Auto light, the Hold light, the Free light, and the Tracker light are all turned off; the DSPTAB buffer is checked for proper format and corrected if necessary.

5.5 Fresh Start

The Fresh Start Program is initiated by Verb 36E. It takes the following action in regard to the Keyboard and Display System: turns off the Display Panel Alarm lights, turns off the Key Release light, blanks the Display Panel Data and Control Registers, releases the Display System (DSPLOCK), and terminates the Monitor. It also initializes much of the program control software.

APPENDIX I

INPUT/OUTPUT CODES

I.1 Keyboard Input Codes

These codes enter the computer through bits 1—5 of either channel 15 or 16 (see Section 1.1). The MSB is placed in bit 5; the LSB, in bit 1.

	MSB	LSB
0	1	0 0 0 0
1	0	0 0 0 1
2	0	0 0 1 0
3	0	0 0 1 1
4	0	0 1 0 0
5	0	0 1 0 1
6	0	0 1 1 0
7	0	0 1 1 1
8	0	1 0 0 0
9	0	1 0 0 1
VERB	1	0 0 0 1
RESET	1	0 0 1 0
KEY RELEASE	1	1 0 0 1
+	1	1 0 1 0
-	1	1 0 1 1
ENTER	1	1 1 0 0
CLEAR	1	1 1 1 0
NOUN	1	1 1 1 1

1.2 5 Bit Relay Output Codes for Display Panel

These codes are placed in Channel 10. There are two possible orientations. For the right character of a pair, the MSB is placed in bit 5; the LSB, in bit 1. For the left character of a pair, the MSB is placed in bit 10; the LSB, in bit 6.

	MSB	LSB
Blank	0 0 0 0 0	
0	1 0 1 0 1	
1	0 0 0 1 1	
2	1 1 0 0 1	
3	1 1 0 1 1	
4	0 1 1 1 1	
5	1 1 1 1 0	
6	1 1 1 0 0	
7	1 0 0 1 1	
8	1 1 1 0 1	
9	1 1 1 1 1	

1.3 Relayword Format for OUTO

Bits 15-12	Bit 11	Bits 10-6	Bits 5-1
1 0 1 1		MD1	MD2
1 0 1 0		VD1	VD2
1 0 0 1		ND1	ND2
1 0 0 0			R1D1
0 1 1 1	+R1S	R1D2	R1D3
0 1 1 0	-R1S	R1D4	R1D5
0 1 0 1	+R2S	R2D1	R2D2
0 1 0 0	-R2S	R2D3	R2D4
0 0 1 1		R2D5	R3D1
0 0 1 0	+R3S	R3D2	R3D3
0 0 0 1	-R3S	R3D4	R3D5

The Display Panel Output Buffer (DSPTAB) follows this same format with respect to the low order 11 bits.

APPENDIX II

VERBS

11.1 Verb List

II.1.1 Ordinary Verbs

<u>Verb Code</u>	<u>Function</u>	<u>Display Location</u>
00	Illegal	
01	Display (in octal) 1st component of:	R1
02	Display (in octal) 2nd component of:	R1
03	Display (in octal) 3rd component of:	R1
04	Display (in octal) 1st and 2nd components of:	R1, R2
05	Display (in octal) 1st, 2nd, and 3rd components of:	R1, R2, R3
06	Display (in decimal) all component(s) of:	As appropriate
07	DP decimal display	R1, R2
08	Spare	
09	Spare	
10	Spare	
11	Monitor (in octal) 1st component of:	R1
12	Monitor (in octal) 2nd component of:	R1
13	Monitor (in octal) 3rd component of:	R1
14	Monitor (in octal) 1st and 2nd components of:	R1, R2
15	Monitor (in octal) 1st, 2nd, and 3rd components of:	R1, R2, R3
16	Monitor (in decimal) all component(s) of:	As appropriate
17	Monitor DP Decimal	R1, R2
18	Spare	
19	Spare	
20	Spare	
21	Load 1st component of:	R1
22	Load 2nd component of:	R2
23	Load 3rd component of:	R3

24	Load 1st and 2nd components of:	R1, R2
25	Load 1st, 2nd, and 3rd components of:	R1, R2, R3
26	Spare	
27	Fixed Memory Display	R1
28	Spare	
29	Spare	
30	Enter Request to Executive	
31	Enter Request to Waitlist	
32	Resequence	
33	Proceed Without Data	
34	Terminate	
35	Test Lights	All Panel Lights
36	Fresh Start	
37	Change Major Mode (Program) to:	
38	Spare	
39	Spare	

II.1.2 Extended Verbs (Not Complete)

As discussed in Section 2.7, the Keyboard and Display System Program merely serves as a dispatcher for the extended verbs (40-99); that is, it transfers control to a TC table having one entry for each extended verb and fans out to the appropriate program. This table is found in the "Extended Verbs" log section in the program listing. The actual programs are written by a variety of different people who make the appropriate entries in this table.

The correct list of extended verbs is best obtained from the latest version of MIT/IL "Flight 278 Memo 17", or from the "Assembly and Operation Information" log section at the beginning of the program listing itself. Note that there are differences in the CSM and LM lists.

Only a few extended verbs are listed below:

- 50 Please Perform
- 51 Please Mark (CSM only)
- 52 Please Mark X Reticle (LM only)
- 53 Please Mark Y Reticle (LM only)
- 54 Please Mark X or Y Reticle (LM only)
- 55 Align Time (Increment AGC Time in Decimal)
- 91 Perform Banksum

11.2 Verb Descriptions

II.2.1 Ordinary Verbs

Verbs 01-05 Perform octal displays of data.

Verb 06 Performs decimal display of data. The scale factors, types of scale factor routines, and component information are stored within the machine for each Noun which is required to display in decimal.

Verb 07 Performs a double precision decimal display of data. It does no scale factoring. It merely performs a 10 character fractional decimal conversion of two consecutive erasable registers using R1 and R2 (the sign is placed in the R1 sign position; the R2 sign position is blank). It cannot be used with Mixed Nouns. Its intended use is primarily with "Machine Address to be Specified" Nouns.

Verbs 11-17 Update data displays every second.

Verbs 21-25 Perform data load. Octal quantities are unsigned. Decimal quantities are preceded by a + or - sign.

Verb 27 Fixed Memory Display. This verb is included to permit displaying in octal the contents of any fixed memory register. It can be used to check program ropes and the BANK position of program ropes. It is used with the Noun "Machine Address to be Specified". The FCADR of the desired location is then punched in, (For FIXED/FIXED, use FCADR in range 4000-7777.)

For banks less than or equal 27, this is enough.

For banks greater than or equal to 30, the third component of Noun 26 (PRIO, ADRES, BBCON) must be preloaded with the desired Superbank Bits (bits 5,6,7). V23N26 should be used.

Summary

For banks	L/E	27	V27N01E(FCADR)E
For banks	G/E	30	V23N26E(SUPERBITS)E V27N01E(FCADR)E

- Verb 30 Request Executive. Enters request to Executive Routine for any machine address with any priority. This Verb assumes that the desired PRIORITY, ADRES (12 bit), and BBCON (both F bank and E bank) have been preloaded into Noun 26. V30E then places the request into the Executive Routine.
- Verb 31 Request Waitlist. Enters request to Waitlist Routine for any machine address with any delay. This verb assumes that the desired DELAY, ADRES (12 bit), and BBCON (both F bank and E bank) have been preloaded into Noun 26. V31E then places the request into the Waitlist Routine.
- Verb 32 Resequence. Informs routine requesting operator's response that the operator wishes the requesting routine to resequence back to some earlier point in the internal routine that led up to the request for his response. Often a recomputation is desired in an attempt to show more acceptable data. The final decision for what action should be taken is left to the requesting routine. Also, the Flash is turned off, the Monitor is turned off, the Display System is released.
- Use of this Verb is limited to Display-with-flash situations in which it is improper for the operator to load fresh data if he does not approve the data he is shown. It should not be used in Please Perform, Please Mark, or Load Verb situations. See Sections 2.5.2, 3.6.1.
- Consult the Mission Plan for exactly when this Verb may be used.
- Verb 33 Proceed Without Data. Informs routine requesting the operator's response that the operator wishes the requesting routine to proceed without further inputs from the operator. Final decision for what action should be taken is left to the requesting routine. Also, the Flash is turned off, the Monitor is turned off, the Display System is released.
- Verb 34 Terminate. Informs routine requesting the operator's response that the operator wishes the requesting routine to terminate, Final decision for what action should be taken is left to requesting

routine. Also, the Flash is turned off, the Monitor is turned off, the Display System is released.

- Verb 35 Turns on all display panel lights. After five seconds, it turns off the Caution and Status lights.
- Verb 36 Initializes the program control software and the Keyboard and Display System Program. See Section 5.5 for details.
- Verb 37 Changes to New Major Mode (Program). See Section 2.4.2, Case II for details.

II.2.2 Extended Verbs (Not Complete)

The following is incomplete. It describes only those Extended Verbs listed in Appendix II.1.2.

- Verb 50 This verb is used only by internal routines that wish the operator to perform a certain action. It should never be keyed in by the operator. It is usually used with Noun 25 (Checklist). The coded number(s) for the Checklist Item(s) to be performed are displayed in the Data Display Register(s) by the requesting routine.

Once the operator has performed the requested action he should press ENTER to indicate that the Checklist Item has been performed. If he wishes not to perform the requested action, he should key in the Verb "Proceed Without Data". (See Section 2.5.3, for operational details. See Section 3.6.2 for details of how an internal routine uses Verb 50.)

- Verb 51-54 Use is similar to Verb 50. Used only by internal routines that wish the operator to MARK, They should never be keyed in by the operator. See Mission Plan for further details.

- Verb 55 Requests the loading of AT (in Hours, Minutes, and Seconds. See Appendix 111.2, item K). When this data has been entered, the contents of the time counters are updated.

In order to align time, it is necessary to be able to display time as of a given command with a minimum of uncertainty in fetching

the timecounters. Noun 65 has been altered so that it displays a Sampled Time. The time counters are sampled for this noun in Keyrupt, Uprupt and in the interrupt section of the monitor.

Verb 91 Causes the Self Check Program to perform the sum check of the fixed memory.

APPENDIX III

NOUNS

III. 1 NOUN LIST (Incomplete)

The following list is incomplete and is intended only for examples of typical nouns. The Noun Lists differ in CSM and ^{LM}, and are subject to frequent change. The latest noun information is best obtained from the latest revision of MIT/IL "Flight 278 Memo 17," or from the "Assembly and Operation Information" log section at the beginning of the program listing itself.

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NORMAL NOUNS	COMPONENTS	SCALE AND DECIMAL POINT	RESTRICTIONS
00 Not in use			
01 Specify Machine Address (Fractional)	3 Comp	.XXXXXX For Each	
02 Specify Machine Address (Whole)	3 Comp	XXXXX. For Each	
03 Specify Machine Address (Degrees)	3 Comp	XXX. XX Deg For Each	
04 Spare			
05 Angular Error/ Difference	1 Comp	XXX. XX Deg	
06 Option Code	2 Comp	Octal Only For Each	
07 Change of Program (Used with Please Perform Only)	1 Comp	XXXXX.	DEC Only
08 Alarm Data	3 Comp	Octal Only For Each	
09 Alarm Codes	3 Comp	Octal Only For Each	
10 Channel to be Specified	1 Comp	Octal only	
11 Spare			
12 Spare			
13 Spare			
14 Inbit Message	3 Comp	Octal Only For Each	
15 Increment Machine Address	1 Comp	Octal Only	
16 Spare			
17 Spare			
18 Spare			
19 Trim Enable	3 Comp	XXX. XX Deg For Each	
20 ICDU Angles	3 Comp	XXX. XX Deg For Each	
21 PIPAS	3 Comp	XXXXX. Pulses For Each	
22 New ICDU Angles	3 Comp	XXX. XX Deg For Each	

23 Delta ICDU Angles	3 Comp	XXX,XX Deg For Each	
24 Delta Time For AGC Clock	3 Comp	OOXXX Hrs OOXXX Min 0XX,XX Sec XXXXX. For Each	DEC Only Must Load 3 Comps
25 Checklist (Used with Please Perform Only)	3 Comp		
26 Priority/Delay, ADRES, BBCON	3 Comp	Octal Only For Each	
27 Self Test On/Off Switch	1 Comp	XXXXX.	
28 Spare			
29 Spare			
30 Spare			
31 Spare			
32 Spare			
33 Time of Ignition	3 Comp	OOXXX Hrs OOXXX Min 0XX,XX Sec	DEC Only Must Load 3 Comps
34 Time of Event	3 Comp	OOXXX Hrs OOXXX Min OXX,XX Sec	DEC Only Must Load 3 Comps
35 Time to go to Event	3 Comp	OOXXX Hrs OOXXX Min OXX,XX Sec	DEC Only Must Load 3 Comps
36 Time of AGC Clock	3 Comp	OOXXX Hrs OOXXX Min OXX,XX Sec	DEC Only Must Load 3 Comps
37 TIG of TPI	3 Comp	OOXXX Hrs 000XX Min OXX,XX Sec	DEC Only Must Load 3 Comps
38 TIG of MID	3 Comp	OOXXX Hrs OOXXX Min OXX,XX Sec	DEC Only Must Load 3 Comps
39 Delta Time to Transfer	3 Comp	OOXXX Hrs 000XX, Min OXX,XX Sec	DEC Only Must Load 3 Comps
Mixed Nouns			
40 Time to Ignition/Cutoff, VG, Delta V (Accumulated)	3 Comp	XXBXX Min/sec XXXX, X Ft/sec XXXX, X Ft/sec	No Load, DEC Only

65 Sampled AGC Time
(Fetched in Interrupt)

00XXX. Hrs
000XX. Min
0XX. XX Sec

3 Comp

DEC Only
Must Load 3 Comp

NOTE: B indicates Blank

III.2 NOUN SCALE FACTORS (Not Complete)

The following list is not complete. It lists only those scale factors referred to in Appendix III. 1. For a complete list of scale factors available, see the latest revision of MIT/IL "Flight 278 Memo 17" Appendix 5.

Scale Type	units	Decimal Format	Precision	AGC Format
A)	OCTAL	XXXXX	SP	OCTAL
B)	FRACTIONAL	.XXXXX (max. 99996)	SP	Bit 1 = 2^{-14} Units
C)	WHOLE	XXXXX. (max 16383.)	SP	Bit 1 = 1 Unit
D)	CDU DEGREES	XXX.XX DEGREES (max 359.99)	SP	Bit 1 = $360/2^{15}$ DEGREES (Uses 15 bits for magnitude and 2's comp.)
E)	ELEVATION DEGREES	XX.XXX DEGREES (max 89.999)	SP	Bit 1 = $90/2^{14}$ DEGREES
F)	DEGREES (180)	XXX.XX DEGREES (max 179.99)	SP	Bit 1 = $180/2^{14}$ DEGREES
G)	DP DEGREES (90)	XX.XXX DEGREES (max 89.999)	DP	Bit 1 of low register = $360/2^{28}$ DEGREES
H)	D P DEGREES (360)	XXX.XX DEGREES (max 359.99)	DP	Bit 1 of low register = $360/2^{28}$ DEGREES
J)	Y OPTICS DEGREES	XX.XXX DEGREES (bias of 19.775 degrees added for display; subtracted for load.)	SP	Bit 1 = $90/2^{15}$ DEGREES (Uses 15 bits for magnitude and 2's comp.)
NOTE: Negative numbers cannot be loaded.				
K)	TIME (HR, MIN, SEC)	OOXXX. HR OOXX. MIN OXX. XX SEC (decimal only max MIN component 59, max SEC component 59.99; max capacity 745 HR, 39 MIN, 14.55 SEC; when loading, all 3 components must be supplied.)	DP	Bit 1 of low register = 10^{-2} SEC
L)	TIME (MIN/SEC)	XXBXX MIN/SEC (B is a blank position; decimal only, display on monitor only; cannot be loaded; max MIN component 59, max SEC component 59; values greater than 59 MIN 59 SEC are displayed as 59 MIN 59 SEC.)	DP	Bit 1 of low register = 10^{-2} SEC

P)	VELOCITY 2	XXXXX. FEET/SEC (max 41994.)	DP	Bit 1 of <u>high</u> register = 2^{-7} METERS/CENTI-SEC
Q)	POSITION 4	XXXX.X NAUTICAL MILES	DP	Bit 1 of low register = 2 METERS
S)	VELOCITY 3	XXXX.X FT/SEC	DP	Bit 1 of <u>high</u> register = 2^{-7} METERS/CENTI-SEC

III.2.1 Use of DP Scale Factors

The DP scale factor situations deal only with one 5 character (and sign, of course) decimal number; but with two octal registers: that is, two consecutive erasable registers are involved in the decimal scale factoring. The numerically greater address is treated as the minor part; the numerically smaller address, as the major part. Note that this is not a full double precision operation where 10 decimal characters would have to be handled.

Octal load verbs place 00000 into the major part register, and place the octal word loaded into the minor part register. Octal display verbs show only the minor part. Admittedly, use of octal load and display verbs with DP scale factor situations is limited and should be used only for very special applications. To get at both the major and minor parts in octal, Noun 01 must be used.

III.3 Noun Register Assignments (Not Complete)

The following list is not complete. It lists only those nouns listed in Appendix III.1. For a complete list of noun register assignments, see the latest revision of MIT/IL "Flight 278 Memo 17".

Normal Nouns

Noun	Scale	Comp.	Registers
01	B	3	As Specified, +1, +2
02	C	3	As Specified, +1, +2
03	D	3	As Specified, +1, +2
04	Spare		
05	F	1	DSPTM1
06	A	2	OPTION1, +1
07	C	1	DSPTM1
08	A	3	ALMCADR,ALMCADR+1, ERCOUNT
09	A	3	FAILREG, +1, +2
10	A	1	As Specified
11	Spare		
12	Spare		
13	Spare		
14	A	3	DSPTM1, +1, +2
15	A	1	
16	Spare		
17	Spare		
18	Spare		
19	D	3	CPHI, +1, +2
20	D	3	CDUX, CDUY, CDUZ
21	C	3	PIPAX, PIPAY, PIPAZ
22	D	3	CPHI, +1, +2
23	D	3	DSPTM2, +1, +2
24	K	3	DSPTM1, +1
25	C	3	DSPTM1, +1, +2
26	A	3	DSPTM1, +1, +2
27	C	1	SMODE
28	Spare		
29	Spare		
30	Spare		

31	Spare		
32	Spare		
33	K	3	TIG, +1
34	K	3	DSPTM 1, +1
35	K	3	TTOGO, +1
36	K	3	TIME2, +1
37	K	3	TTPI, +1
38	K	3	TMID, +1
39	K	3	T3T0T4, +1

111.4 Noun Descriptions (Not Complete)

Only the Nouns listed in Appendix III.1 are described here,

111.4.1 Normal Nouns

Noun 00 Not in use.

Noun **01-03** The machine address for these nouns is not stored within the machine, but is supplied by the operator. This allows any address to be loaded, displayed, or monitored. When ENTER is pressed with one of these nouns, the Flash is activated, but the Verb is left unchanged. This indicates to the operator that he should type in the 5 character OCTAL address, followed by an ENTER. It is displayed in R3, and the Flash is turned off. Thereafter, the execution of the Verb continues, just as in the case of any other noun.

In normal use, it is the ECADR of the desired register that is supplied by the operator. However, with Verb 27 (Fixed Memory Display), it is the FCADR of the desired location that is supplied by the operator. (For further details on Fixed Memory Display, see remarks in Section II.2.1 under Verb 27).

Noun 07 Used to request the operator to initiate a change of Program (Major Mode). The desired Program Code is displayed in R1.

Noun **08** Used to display system failure conditions. The address of the most recent failure is displayed in R1; the BBCON of the most recent failure is displayed R2; the number of times the SELF-CHECK Program has detected a malfunction (if appropriate) is displayed in R3. (Octal only.)

- Noun 09 Used to display system failure conditions. Coded numbers to identify the failures are displayed in R1, R2, and R3. R1 refers to the first failure since the RESET button was last pressed; R2 refers to the second most recent failure; R3 refers to the most recent failure. (Octal only.)
- Noun 10 Use is similar to Nouns 01-03, but a channel address is supplied by the operator. This noun allows any input channel to be displayed or monitored; any output channel to be loaded, displayed, or monitored. (Octal only.)
- Noun 15 This is used to increment the machine address already specified. It is useful for loading or displaying a group of consecutive addresses. (Octal only.)
- Noun 24 Format is Hours ($\pm 00XXX$, in R1), Minutes ($\pm 000XX$, in R2, MAX = 59), Seconds ($\pm 0XX.XX$ in R3, MAX = 59.99). Overall maximum value is 745 H, 39 M, 14.55 S. Decimal only, When loading, all 3 words must be supplied. (See Appendix 11.2, item K.)
- Noun 25 Usually used with Verb 50, described in Appendix 11.2.2.
- Noun 26 This Noun must be preloaded with the desired PRIORITY, ADRES (12 Bit), and BBCON (both F bank and E bank) constant for use with Verb 30 (REQUEST EXECUTIVE).
- This Noun must be preloaded with the desired DELAY, ADRES (12 Bit), and BBCON for use with Verb 31 (REQUEST WAITLIST).
- The third component of this Noun must be preloaded with the desired Superbank Bits (bits 5,6, 7) for use with Verb 27 (Fixed Memory Display) when the fixed bank to be displayed is greater than or equal to 30. V23N26 should be used. See comments under Verb 27 in Appendix 11.2. OCTAL only.
- Noun 27 + 0 loaded into this Noun causes the idle job to be run as the Executive backup.

+NZ loaded into this Noun causes the AGC Self Check to be run as the Executive backup until an error is detected.

-0 loaded into this Noun causes the AGC Self Check to be run as the Executive backup, continuing if an error is detected.

-NZ loaded into this Noun causes the AGC Self Check to be run as the Executive backup, recycling to the beginning if an error is detected.

Noun 33-39 See format comments under Noun 24. Note that Noun 36 refers to time counters TIME1, TIME2 directly,

III.4.2 Mixed Nouns

Mixed Nouns are those whose components refer to non-consecutive addresses or have different scale factors. Nouns 40-99 are Mixed.

Sometimes a noun which really should be Normal is defined in the Mixed Noun range (40-99) only for convenience. For example, it may be desired to have a Noun's code adjacent to another Noun which really must be Mixed. This is slightly wasteful in that the full power of the Mixed Noun capability is not utilized, but there is nothing wrong with it.

Noun 40 Format for first component is $\pm XXBXX$. The left 2 characters are whole minutes (MAX = 59); the B is a blank; the right 2 characters are whole seconds (MAX = 59). Decimal only, Display or monitor only. Cannot be loaded. Values greater than 59 M 59 S are displayed as 59 M 59 S. (See Appendix III.2, item L.)

This component makes it illegal to load entire noun.

Noun 65 Refers to the SAMPTIME registers. During Keyrupt, Urupt, and the interrupt section of monitor, TIME1 and TIME2 are read into the SAMPTIME registers. Thus AGC clock time may be displayed by means of this noun with a minimum of uncertainty about when the snapshot was performed. See Format comments under Noun 24.

APPENDIX IV

NOUN TABLE FORMAT

IV.1 Code Numbers

The Noun Tables contain the information necessary to perform scale factoring of decimal data in loading and display. There is a Component Code Number, which indicates how many component members belong to the given Noun; an Scale Factor Routine Code Number, which indicates what Scale Factoring Routine should be used with this Noun; and a Scale Factor Constant Code Number, which indicates what scaling constant should be applied for this Noun. Of course, Mixed Nouns require a separate Scale Factor Routine Code and a separate Scale Factor Constant Code for each component.

Component Code Number

00000	1 component
00001	2 components
00010	3 components
xlxxx	Decimal only
lxxxx	No load

Scale Factor Routine Code Number

00000	Octal only
00001	Fractional
00010	CDU Degrees (XXX.XX)
00011	Arithmetic Scale Factor (multiplies by 2^{14} at end, for load)
00100	Arithmetic Double Precision 1 (multiplies by 2^{14} at end, for display)
00101	Arithmetic Double Precision 2 (shifts left by 7 at end, for load)
00110	Y Optics Degrees
00111	Arithmetic Double Precision 3 (shifts left by 7 at end, for display)
01000	Whole hours in R1, whole minutes (mod 60) in R2, seconds (mod 60) 0XX.XX in R3.

01001 Minutes (mod 60) in D1 D2, D3 blank, seconds (mod 60) in D4 D5.
 01010 Arithmetic Double Precision 4 (shifts left by 3 at end for load).
 01011 Arithmetic 1 Scale Factor (multiplies by 2^{14} at end, for display)

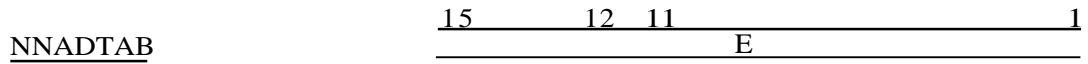
Scale Factor Constant Code Number (Not Complete)

The following list is not complete and is intended only for examples of typical Scale Factor Constant Codes. The Scale Factor Constant Codes differ somewhat in CSM and LM. The latest information is best obtained from the "Pinball Noun Tables" log section in the program listing itself.

00000 Whole (XXXXX.Units)
 00001 Spare
 00010 CDU Degrees (XXX.XX deg.)
 00010 Y Optics Degrees (XX.XXX deg.)
 00011 DP Degrees (90) (XX.XXX deg.)
 00100 DP Degrees (360) (XXX.XX deg.)
 00101 Degrees (180) (XXX.XX deg.)
 00110 Spare
 00111 Spare
 01000 Position 4 (XXXX.X nautical miles)
 01001 Velocity 2 (XXXXX. feet/sec.)
 01010 Velocity 3 (XXXX.X feet/sec.)
 01011 Elevation degrees (XX.XXX deg.)

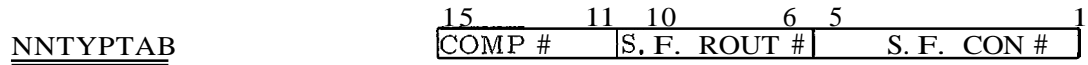
These Code Numbers, together with the machine addresses pertinent to each Noun, are combined in the Noun Tables: NNADTAB; NNTYPTAB; IDADDTAB and RUTMXTAB (the last two are necessary for Mixed Nouns only).

IV. 2 Noun Tables--Normal Nouns



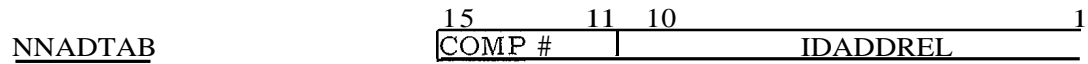
NNADTAB

- +0, Not in Use
- NZ, Specify Machine Address
- 1, Specify Channel
- 0, Increment Machine Address



NNTYPTAB

IV. 3 Noun Tables--Mixed Nouns



NNADTAB

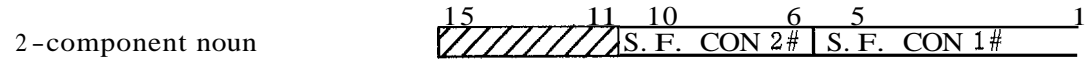
- +0, Not in Use



NNTYPTAB

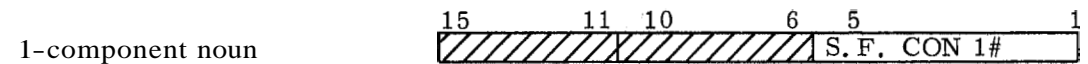
3-component noun

or



2-component noun

or

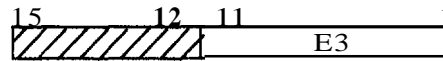
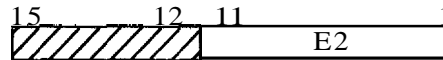


1-component noun

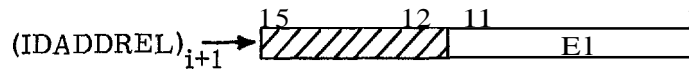
IDADDTAB



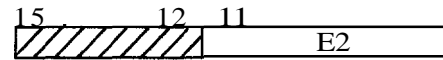
3-component



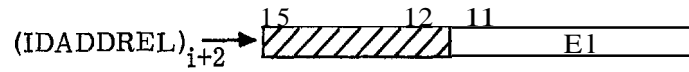
or



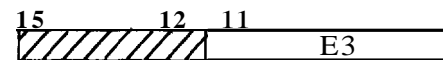
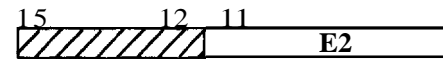
2-component



or

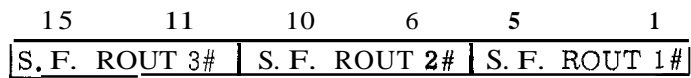


3-component



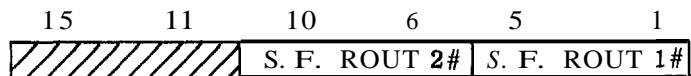
RUTMXTAB

3-component noun



or

2-component noun



APPENDIX V
PROGRAM FLOW DIAGRAMS

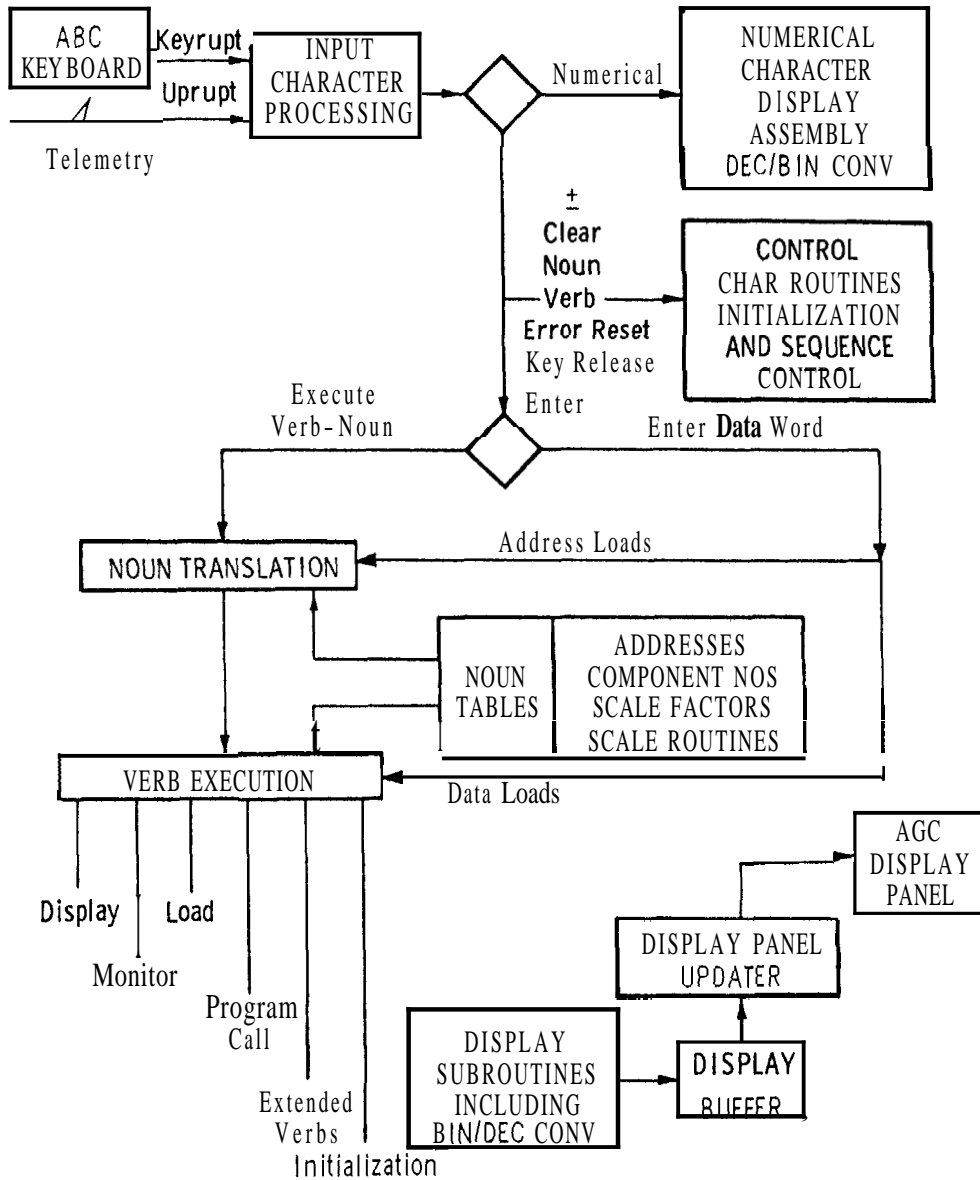


Fig. V-1 Keyboard and display block diagram.

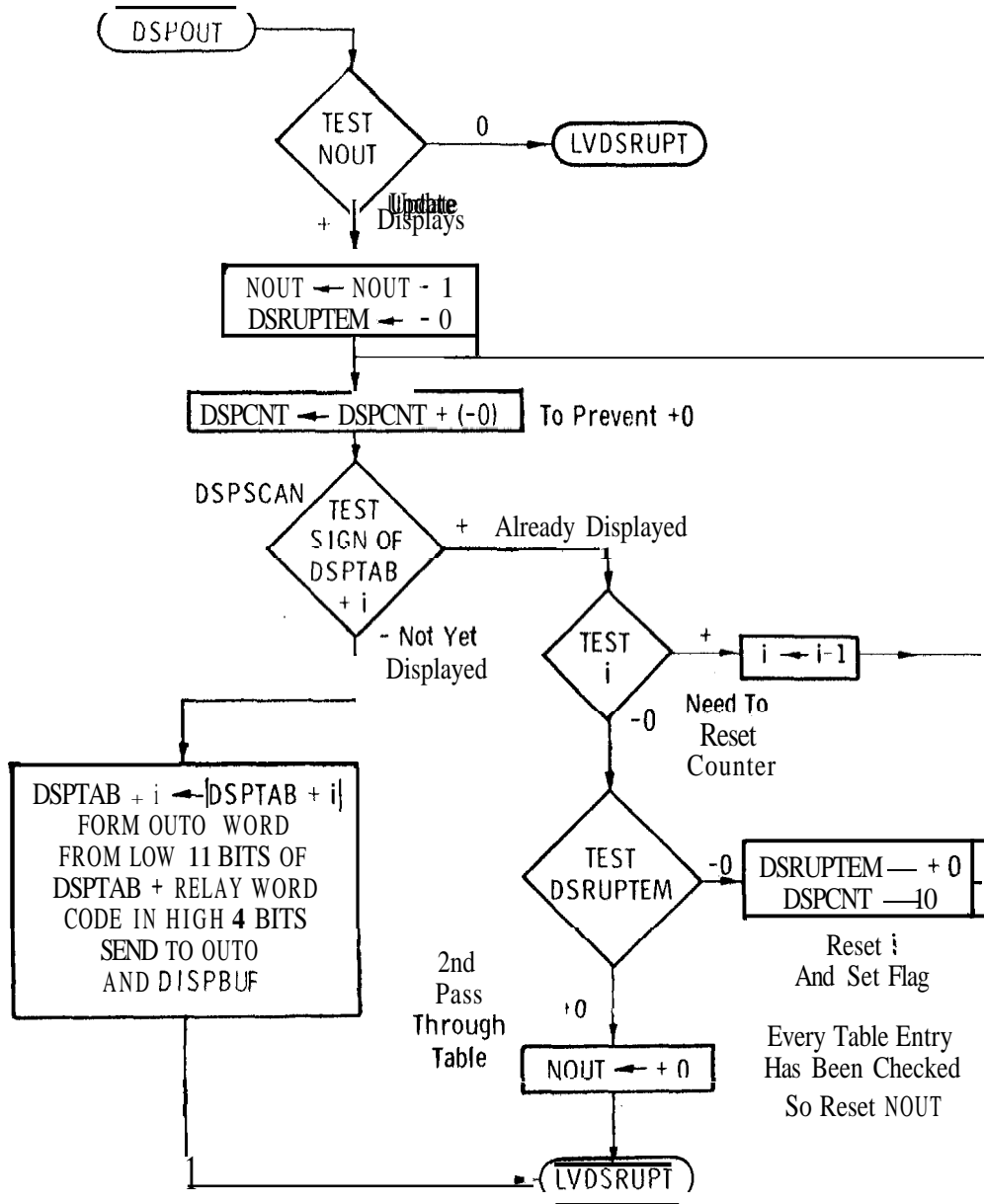


Fig. V-2 DSPOUT flow diagram.



APPENDIX VI

UPRUPT OPERATION

An UPRUPT is executed when a 15-bit Uplink message is assembled in register UPLINK. The UPRUPT program reads this 15-bit word and tests for $\overline{W}\overline{W}$ format. (This is a 5-bit keycode message, its complement in the middle 5 bits, and the original in the high 5 bits,)

If the $\overline{W}\overline{W}$ test is passed, an executive request is placed for CHARIN to digest the 5 bit key code. If the $\overline{W}\overline{W}$ test is failed, a program interlock is activated to block further acceptance of Uplink messages. This interlock is freed by sending the Reset code through the UPLINK. It is important to send a string of at least 15 zeroes before the Reset to clear out any "ones" that might be left in UPLINK due to falling out of synch.

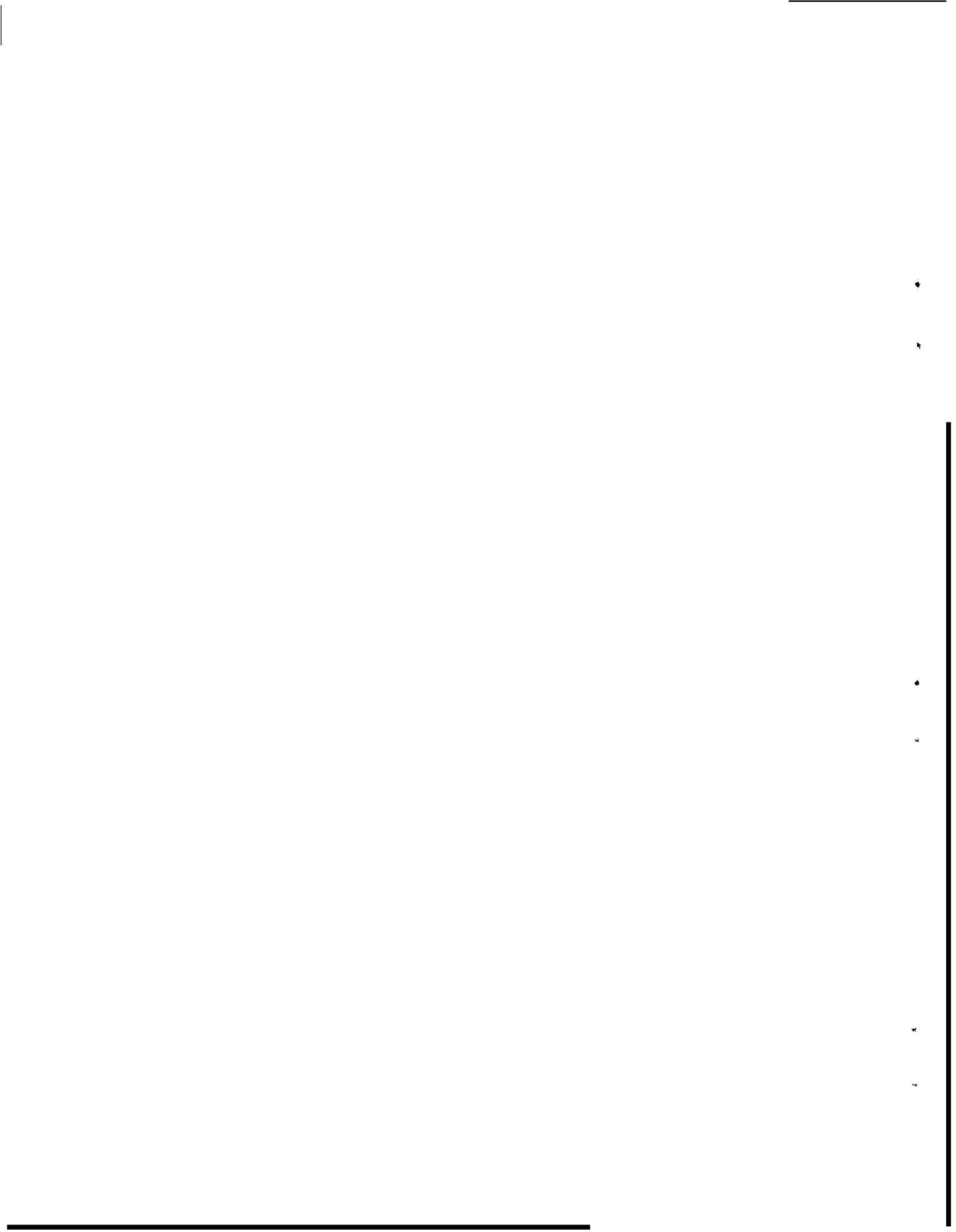
The UPLINK ACTIVITY light is turned on by all UPRUPTs. It is turned off by Key Release. Therefore, it is good practice to send the Key Release code at the end of a sequence of UPLINK transmissions.



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