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GUIDANCE AND NAVIGATION

Approved Milton B. Trageser Date 8/12/64
Milton B. Trageser, Director
Apollo Guidance and Navigation Program

Approved Roger B. Woodbury Date 8/13/64
Roger B. Woodbury, Deputy Director
Instrumentation Laboratory

E-1574
KEYBOARD AND DISPLAY
SYSTEM PROGRAM FOR AGC
(PROGRAM SUNRISE)

by

Alan I. Green and Joseph J. Rocchio

August 1964



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E-1574

KEYBOARD AND DISPLAY SYSTEM
PROGRAM FOR AGC
(PROGRAM SUNRISE)

ABSTRACT

The Keyboard and Display System Program described in this report is included in Program SUNRISE, the first mission-oriented program for the AGC. This Keyboard and Display Program evolved from early versions for AGC 3, and from AGC 4 Programs ECLIPSE and MOONGLOW.

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and
Joseph J. Rocchio
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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 is caused primarily by operator action, but information exchange can be initiated 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 with neither loading nor 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. 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.

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, ERROR LIGHT 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 input register IN0.

Each depression of a Keyboard button activates INTERRUPT #4 (KEYRUPT), as well as places the key code into IN0. This 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 #5 (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). 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 MARK Button.

When the MARK button is depressed, a "1" is placed in bit 15 of IN0 and KEYRUPT is activated. The MARK part of KEYRUPT picks up and stores seven quantities: three IMU angles, two Optics angles, and double precision time. The KEYRUPT is then terminated with a RESUME.

1.4 The Display Panel.

1.4.1 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.

The Major Mode 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.

1.4.2 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 I.

All the information necessary to operate the Display Panel is transmitted from the computer through the output register OUT0. Two Display Panel characters are activated by OUT0 at a time. Bits 1-5 (bit 1 is the low order bit) of OUT0 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, flash, etc. 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.

1.4.3 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 T4RUPT (INTERRUPT #3). T4RUPT is activated approximately once every 60 milliseconds. Every second T4RUPT (or approximately 120 milliseconds) calls DSPOUT. Thus a new group of Display Panel relays can be selected approximately every 0.12 seconds.

1.4.4 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.

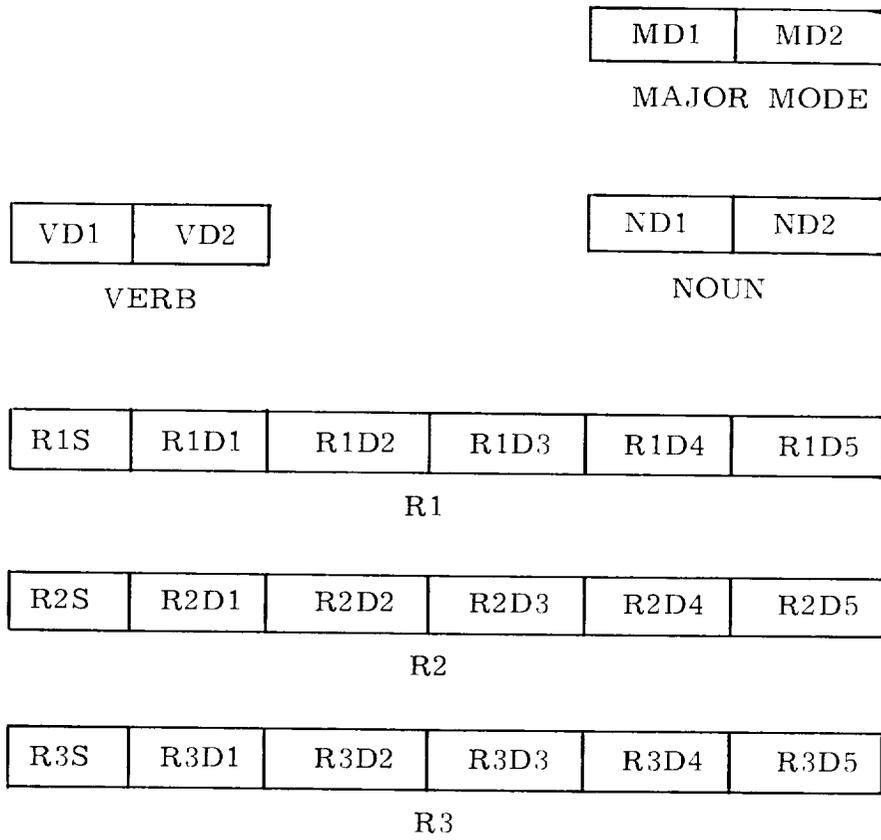


Fig. I -1. Display Panel

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. The emphasis of this chapter will be on Keyboard use.

2.1 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 octal 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.

2.1.1 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	N_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 octal). 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.

2.1.2 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); 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.

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. 1. 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, Error Light 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 more than two numerical characters are punched in while loading the Verb, Noun, or Major Mode code, or more than five numerical characters, while loading a data word, the excess characters are not accepted.

2. 1. 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 Error Light 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 data 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. (Verb 35, Release Display System, is included for early Display Panels which had no Key Release button.) For more details, see Chapter 3.

2.2 General Verb, Noun Conventions.

2.2.1 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. The group of registers to which a Noun code refers may be a group of 1, 2, or 3 members. These are generally referred to as 1-, 2-, or 3-component Nouns. The component is understood as a component member of the register group to which the Noun refers, and not necessarily in the sense of components of a vector or multi-precision number, although this may be the case; the meaning of component should be clear for any particular Noun. 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 Chapter 4.

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. They are not normally loaded, but the capability exists and may be useful in special applications. 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.

2.2.2 Verb Conventions.

As discussed in Section 2.2.1, 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 group 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 therein; 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. A similar component format is used in the Display and Monitor Verbs.

2.2.3 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. 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 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 Verb is the only 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.

2.3 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 Check Fail Light is turned on.

As data is loaded, it is temporarily stored in intermediate buffers. It is not placed into its final destination, as spec-

ified by the Noun code, until the final ENTER of the load sequence is punched in.

2.3.1 The CLEAR Button.

The CLEAR Button is used to remove errors in loading data as it is displayed in R1, R2, or R3. It does nothing to the Major Mode, 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 the 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.

2.3.2 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", 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.

Case II. Change Major Mode

To change Major Mode, the sequence is: VERB 37 ENTER. This causes the Noun display register to be blanked and the Verb code to be flashed. The 2-octal-character Major Mode Code should then be loaded. For verification purposes, it is displayed as it is loaded in the Noun display register. The ENTER causes 1) the flash to be turned off, 2) a request for the new Major Mode to be entered, and 3) a new Major Mode Code to be displayed in the Major Mode display register. This new Major Mode display is usually the logical "OR" of the old and new Major Mode Codes. (See a forthcoming report by C. A. Muntz for details on Major Modes.)

2.3.3 Conclusion of Loading.

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.

2.4 Program Initiation.

There is a class of programs of larger scope than the data loading and display programs which the Keyboard can call.

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 40-77. The pertinent programs are called directly upon ENTER as part of the Keyboard and Display Program Executive Job, 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 ENTRET. 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 ENTRET. The Keyboard and Display System is released before the Extended Verbs (codes 40-77) are called, so that they may use the Keyboard and Display System Program.

2.5 Data Monitor.

There is a class of Verbs called Monitor Verbs which displays data every one-half 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), 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 Error Reset. 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.

CHAPTER 3

INTERNAL USE OF KEYBOARD AND DISPLAY SYSTEM PROGRAM

The Keyboard and Display System Program is available to other internal computer programs in its entirety 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. Any Verb-Noun combination available to the Keyboard can be called by internal routines.

3.1 Interlocks 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.

The two interlocks are: an operator/internal interlock, and an internal/internal interlock.

The operator/internal interlock (called DSPLOCK) is made busy to internal routines by any keyboard activity (except Error Light Reset). It remains busy until it is "released" by the Key Release button or by certain special Verbs. See Section 3.32.

The internal/internal interlock (called GRABLOCK) is made busy to other internal routines once any internal routine has "grabbed" the Display System. It remains busy until 10 seconds after the grabbing routine has "freed" it. These procedures will be described in detail in Section 3.3.

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

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

L,	TC GRABDSP
L+1,	Return here if Display System is already grabbed.
L+2,	Return here means you have Display System grabbed.

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.

	NVSUB may be used more than once while Display System is grabbed.

	TC FREEDSP

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 "GRABBING" the Display System (GRABDSP)

Any internal routine that wishes to use the Keyboard and Display Program must first "GRAB" the Display System by executing a TC GRABDSP. (This routine is in directly accessible fixed memory.) If the TC GRABDSP was done at location L, the return is to L+1 if the System is already grabbed (GRABLOCK is busy). If GRABLOCK shows that the Keyboard and Display System is free, the return is to L+2, indicating that the calling routine now has the System "grabbed."

The decision for what to do if the Keyboard and Display System is found already grabbed is left to the calling routine. It may use an optional routine called GRABUSY, which enters it into a list waiting for the Keyboard and Display System to be freed, or it may prefer to continue and attempt the TC GRABDSP again later.

The calling sequence for the optional GRABUSY is:

```
CAF WAKECADR
TC GRABUSY
```

GRABUSY is in directly accessible fixed memory. It puts the calling JOB to sleep, and enters the specified CADR into a waiting list. This CADR is the location at which you wish your JOB to wake up when the Display System is freed. The list is searched and the CADR's are called in the sequence they were inserted according to the following convention. After a TC FREEDSP, the internal/internal interlock (GRABLOCK) is kept busy for 10 seconds, after which a CADR is called from the list and the JOB waked up. This 10-second delay insures that all internally initiated information for display will be visible.

There is a special entrance to GRABUSY called PREGBSY for routines in banks that wish the CADR of 1+ (Location from which the TC PREGBSY was done) to be entered in the list.

3.3.2 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. Any Verb-Noun combination available to the Keyboard can be called by NVSUB. The format is to place a word in the A register with the 6-bit Verb code in bits 7-12 and the 6-bit Noun code in bits 1-6. 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 6 bits are all zero. Thus to display the Verb code only, bits 1-6 are set to 0, and the Verb code is placed into bits 7-12. To display the Noun code only, bits 7-12 are set to 0, and the Noun code is placed into bits 1-6. 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 only 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 Error Light Reset). It remains busy until it is released by the Key Release button or by the following Verbs: Release Display System (35), which is included for early versions of the Keyboard which have no Key Release button; Proceed Without Data (33); Terminate (34); Fresh Start (36); Request Executive (20); Request Waitlist (10); also by all the Verbs with codes 40-77 (these

are the so-called (Extended Verbs).

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. If the Keyboard and Display System is available, but in the execution of the Verb-Noun combination some alarm condition is found (such as use of an undefined Verb or Noun code, or certain other situations impossible during normal operation-- see Section 5.1), then the return is to M+1, indicating that the execution of the Verb-Noun combination could not be completed. Thus return to M+1 indicates that the Verb-Noun was not executed to completion, while return to M+2 indicates that the Verb-Noun was fully 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 NVSUBSY, which enters it into a list 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 NVSUBSY is:

```
CAF WAKECADR
TC NVSUBSY
```

NVSUBSY is in directly accessible fixed memory. It puts the calling JOB to sleep, enters the specified CADR on the top of the waiting list, 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.

The waiting list is searched by all internal occurrences of the "Free" Display System but only by those external occurrences of the "Release" Display System which are in response to use of the NVSUBSY routine.

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 entered in the list.

3.3.3 "FREEING" the Display System (FREEDSP)

An internal routine that has successfully "grabbed" the Keyboard and Display System may execute an unlimited number of calls to NVSUB before "freeing" the System to other internal users by executing a TC FREEDSP. (This routine is in directly accessible fixed memory.) If the TC FREEDSP was done at location N, the return is to N+1.

After a TC FREEDSP, GRABLOCK is kept busy for 10 seconds, after which a CADR is called from the list and the corresponding JOB waked up. The CADR's are called in the order they were inserted, except that any CADR that may have been placed in the list by NVSUBUSY is called first. This is done to ensure that a routine which has "grabbed" the System, but has found NVSUB busy (due to keyboard action by the operator) and has used NVSUBUSY will be called before other routines that find the system already grabbed.

3.4 Keyboard and Display System Release

The "Key Release" Light (also known as Release Display System) 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 (or by performing Verb 35 on those early keyboards which have no Key Release button).

Note that the waiting list associated with GRABUSY and NVSUBUSY is searched by those occurrences of the "Release" Display System which are in response to the use of the NVSUBUSY routine. If the Display System is released at any time other than

following an internal use of NVSUBUSY, the list is not searched even if there are some CADR's in the list due to the use of GRABUSY. These will be called after the routine that has the System grabbed performs a Free Display System.

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 M+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. There are essentially two courses of action.

3.5.1 Initiating Programs that Keep Control

Some programs that place requests through NVSUB for data to be loaded will wish to retain control of the computer while the operator loads the data. These can inspect the contents of an erasable register called LOADSTAT to determine when the data is complete. The conditions of LOADSTAT are:

- + 0 Waiting for data.
- +NZ The Verb "Proceed Without Data" has been keyed in.
- NZ The Verb "Terminate" has been keyed in.
- 0 The data load has been completed.

3.5.2 Initiating Programs that Relinquish Control

Some 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). It also makes NVSUB busy to other internal programs. This 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.

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 as assembled under the name SUNRISE contains a significant amount of documentary information and is regarded as the prime reference for the program's description. This chapter and the accompanying flow charts (Appendix V) attempt 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 principle 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, ERROR RESET, +, -, and KEY RELEASE.

The flow of control of this part of the program is illustrated in Fig. V-4.

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 ERROR 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 request 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 (see Fig. V-7). 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 codes 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 flow chart for the Octal Display Verbs is given in Fig. V-5, and that for the Decimal Display Verb is given in Fig. V-9.

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 (Fig. V-12) 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 1/2 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.

A flow chart of the three-component Load Verb is given in Fig. V-13. The other Load Verbs are very similar. Basically the flow of control 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. "Go To" Verbs.

The "Go To" 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 to be loaded into erasable memory. 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 Bump, Proceed, Terminate, etc. These programs are straightforward and will not be described in detail here.

4.3 Subroutine Use.

An entry routine NVSUB (see Fig. V-15) 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, and the routines ENDIDLE and RECALTST are shown in Figs. V-16 and V-17, respectively.

4.4 Display Output Routines.

The electroluminescent Display Panel is periodically updated by INTERRUPT #3 (T4RUPT) to the DSPOUT routine. This routine (Fig. V-8) maintains a correspondence between an internal buffer (DSPTAB) and the lights by driving the controlling relays via OUT0 whenever the states of the buffer and 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 DSPTAB 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 OUT0, 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. GRABDSP, GRABUSY (Fig. V-18)
2. NVSUBUSY (Fig. V-19)
3. FREEDSP, FREEWAIT, FREDSPDO (Fig. V-20)
4. RELDSP (Fig. V-21)

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

Logically the interlocking is accomplished by controlling the states of 2 registers. DSPLOCK is the operator/internal interlock and has 2 states: external activity or no external activity. GRABLOCK is the internal/internal interlock and has 3 states:

1. +0 no internal control (system is available).
2. +1 internal control assumed by some routine.
Others must wait.
3. +2 internal control assumed by some routine, but pre-empted by external activity. When external user releases the Display System, the internal routine is re-activated (JOBWAKE) and GRABLOCK is reset to +1. See Fig. V-21.

CHAPTER 5

ALARMS AND SPECIAL CONTROLS

The Keyboard and Display System Program makes use of the Program Check Fail Light (also known as Illegal Order). It is also concerned with the Key Release Light (also known as Release Display System), the Key Release Button (also known as Release Display System), the Flash, and the Error Light Reset Button. This chapter will describe the way the Keyboard and Display System Program makes use of these alarms and controls.

5.1 Program Check Fail Light (Illegal Order).

The Program Check Fail Light is turned on by the Keyboard and Display Program when it encounters some improper operating condition. If the Keyboard and Display Program had been initiated by internal computer program (through NVSUB), it returns to M+1 (where M is the location from which the TC NVSUB was performed). If the Keyboard was the initiator, it does a TC ENDOFJOB.

The conditions which cause the Keyboard and Display Program to turn on the Program Check Fail Light are:

1. An input code other than those listed in Appendix I is received from the Keyboard.
2. The contents of the register used to determine which Display Panel character is to be lighted has exceeded its limit.
3. An 8 or 9 was punched in while loading a word that was not preceded by a plus or minus sign.

4. An undefined Verb or Noun code has been used. The Verb 00 or Noun 00 are always illegal if punched into the Keyboard.
5. A decimal number which is numerically too large for the scale factor assigned to the current Noun has been loaded through the Keyboard.
6. An attempt has been made to load a decimal number into a register whose scale factor is specified by the Noun as time in hours. (Note that time in seconds is a permissible load.)
7. The dp decimal display Verb has been used with a Mixed Noun.

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. The operator should press the Key Release button (or execute Verb 35 in those keyboards which have no Key Release button).

5.3 The Verb, Noun Flash.

The Verb and Noun lights are flashed to indicate that the operator should load data. It is turned off by any of the usual load sequence conclusions:

1. Finishing the load sequence.
2. Punching in Verb 33, Proceed Without Data.
3. Punching in Verb 34, Terminate.

5.4 Error Light Reset.

The Error Light Reset button serves two functions. By direct wire, it turns off the non-program computer alarm lights on the Display Panel. By program action, it takes the following action related to the Display Panel: the Program Check Fail light is turned off, the UPLINK Activity light is turned off, the Telemetry Fail light is turned off, the Program Alarm light is turned off, the DSPTAB buffer is checked for proper format and corrected if necessary. Also, the following program action not related to the Display Panel is taken: Endpulses are unblocked; the Errupt lock is reset; the C Relays corresponding to IMU Fail, CDU Fail, and PIPA Fail are reset.

5.5 Fresh Start.

The Fresh Start Program is initiated either by the automatic restart circuitry or by Verb 36. 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), frees the Display System (GRABLOCK), and terminates the Monitor. It also initializes much of the program control software. (See a memo by C. A. Muntz for these details.)

APPENDIX I
INPUT/OUTPUT CODES

I.1 Keyboard Input Codes.

These codes enter the computer through bits 1-5 of IN0.
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
ERROR 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

I.2 5 Bit Relay Output Codes for Display Panel.

These codes are placed in OUT0. 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	

I.3 Relayword Format for OUT0.

<u>Bits 15-12</u>	<u>Bit 11</u>	<u>Bits 10-6</u>	<u>Bits 5-1</u>
1 0 1 1		MD1	MD2
1 0 1 0	FLASH	VD1	VD2
1 0 0 1		ND1	ND2
1 0 0 0	UPACT		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

II.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
10	Enter Request to Waitlist	
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
20	Enter Request to Executive	
21	Write 1st component into:	R1

<u>Verb Code</u>	<u>Function</u>	<u>Display Location</u>
22	Write 2nd component into:	R2
23	Write 3rd component into:	R3
24	Write 1st and 2nd components into:	R1, R2
25	Write 1st, 2nd, and 3rd components into:	R1, R2, R3
26	Spare	
27	Spare	
30	Spare	
31	Bank Display	R1
32	Bump displays [c(R2) into R3, c(R1) into R2]	
33	Proceed without Data	
34	Terminate	
35	Release Display System	
36	Fresh Start	
37	Change Major Mode to:	

II. 1. 2	<u>Extended Verbs</u>
40	Zero (used with noun ICDU or OCDU only)
41	Coarse Align (used with noun ICDU or OCDU only)
42	Fine align IMU
43	Lock IMU
44	Set IMU to Attitude Control
45	Set IMU to Re-entry Control
46	Return IMU to Coarse Align
47	Turn Optical Tracker On (not in use yet)
50	Please Perform
51	Please Mark
52	MARK Accept (until button is available)
53	Free (used with Noun ICDU or OCDU only)
54	Pulse Torque GYRO's
55	Spare
56	Spare
57	Spare
60	Spare
61	Spare
62	Spare
63	Spare
64	Spare
65	Spare
66	Spare
67	Spare
70	Perform GYRO Drift Test
71	Perform PIPA Scale Test
72	Spare
73	Spare

74	Spare
75	Spare
76	Spare
77	Spare

II. 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.
- Verb 10 Enters request to Waitlist Routine for any machine address with any delay. This Verb assumes that the desired number of 10 millisecond units of delay has been loaded into the low order bits of the Prio/Delay register (Noun 26). This Verb is used with the "Machine Address to be Specified" Noun. The complete address of the desired location is then punched in. See Section 2. 3. 2, Case I.
- Verbs 11-17 Update data displays every one-half second.

- Verb 20 Enters request to Executive Routine for any machine address with any priority. This Verb assumes that the desired priority has been loaded into bits 10-14 of the Prio/Delay register (Noun 26). This Verb is used with the Noun "Machine Address to be Specified." The complete address of the desired location is then punched in. See Section 2.3.2, Case I.
- Verbs 21-25 Perform data load. Octal quantities are unsigned. Decimal quantities are preceded by a + or - sign.
- Verb 31 Bank Display. This Verb is included to permit displaying the contents of fixed memory in any bank. Its intended use is for checking program ropes and the BANK position of program ropes.
- Verb 32 Display Shift. Useful for preserving an existing display of a quantity while displaying another quantity.
- Verb 33 Proceed Without Data. Informs routine requesting data to be loaded that the operator chooses not to load fresh data, but wishes the routine to continue as best it can with old data. Final decision for what action should be taken is left to requesting routine.
- Verb 34 Terminate. Informs routine requesting data to be loaded that the operator chooses not to load fresh data, and wishes the routine

to terminate. Final decision for what action should be taken is left to requesting routine. If Monitor is on, it is turned off.

- Verb 35 Releases Keyboard and Display System for internally initiated use. Performs the same function as the Key Release button. It is included for use with those early keyboards which have no Key Release button.
- 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. See Section 2.3.2, Case II for details.

II. 2. 2 Extended Verbs

- Verb 40 Must be used with Noun 20 (ICDU) or Noun 55 (OCDU) only.
- Verb 41 Must be used with Noun 20 (ICDU) or Noun 55 (OCDU) only.
- Verbs 42-47 Call programs that perform the indicated G&N System procedure.
- Verb 50 This verb is used only by internal routines that wish the operator to perform a certain task. It should never be keyed in by the operator. It is usually used with Noun 25 (Checklist). The coded number for the Checklist Item to be performed is displayed in register R1 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."

- Verbs 51, 52 Verb 51 is used only by internal routines that wish the operator to MARK. It should never be keyed in by the operator. It is usually used with Noun 30 (Star Numbers). The numbers of the stars to be marked are displayed in registers R1, R2, R3 by the requesting routine. The operator should indicate completion of each valid mark by Verb 52 (Mark Accept)

or by pressing the Mark Accept button when it is available. He may do several MARK's until he gets what he considers a good one before doing Mark Accept. He should never press ENTER with Verb 51.

Verbs 53-54 Call programs that perform the indicated G&N System procedure.

Verbs 70-71 Call programs that perform the indicated G&N System Test.

APPENDIX III

NOUNS

III. 1 Noun List

III. 1.1 Normal Nouns

<u>Noun Code</u>	<u>Function</u>
00	Not in Use
01	Specify Machine Address (Fractional)
02	Specify Machine Address (Whole)
03	Specify Machine Address (Degrees)
04	Specify Machine Address (Hours)
05	Specify Machine Address (Seconds)
06	Specify Machine Address (GYRO Degrees)
07	Specify Machine Address (Y OPTICS Degrees)
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Increment Machine Address
16	Time Seconds
17	Time Hours
20	ICDU
21	PIPA's
22	New Angles I
23	Delta Angles I
24	Delta Time (Seconds)
25	Checklist
26	Prio/Delay
27	Self Test On/Off Switch
30	Star Numbers

<u>Noun Code</u>	<u>Function</u>
31	Failreg
32	Spare
33	Spare
34	Spare
35	Spare
36	Spare
37	Spare
40	Spare
41	Spare
42	Spare
43	Spare
44	Spare
45	Spare
46	Spare
47	Spare
50	Spare
51	Spare
52	Spare
53	Spare
54	Spare

III. 1.2 Mixed Nouns

<u>Noun Code</u>	<u>Function</u>
55	OCDU
56	Uncalled Mark Data (OCDU & Time (Seconds))
57	New Angles OCDU
60	ICDUX and Time (Seconds)
61	ICDUY and Time (Seconds)
62	ICDUZ and Time (Seconds)
63	OCDUX and Time (Seconds)
64	OCDUY and Time (Seconds)
65	Time (Hours and Seconds)

<u>Noun Code</u>	<u>Function</u>
66	System Test Results
67	Delta GYRO Angles
70	Spare
71	Spare
72	Spare
73	Spare
74	Spare
75	Spare
76	Spare
77	Spare

III. 2 Noun Scale Factors

The Keyboard and Display Routines are able to handle decimal/binary and binary/decimal scale factoring for the following situations:

- 1) fractional
- 2) whole
- 3) degrees (maximum ± 359.99)
- 4) time in seconds (maximum +999.99)
- 5) time in hours (maximum +745.65). This may be used for display only. Loading of time in hours is not allowed.
- 6) GYRO degrees (maximum +9.9999)
- 7) Y OPTICS degrees. There are two different ranges, selected according to bit 13 of register WASOPSET.
 Bit 13 = 0 for range I; bit 13 = 1 for Range II.
 Range I maximum +179.99 degrees
 Range II maximum +89.999 degrees
 (In range II a bias of 19.775 degrees is added for display; subtracted for loads.)

In all cases, a single precision (5 decimal character) word is handled.

III. 3 Noun Descriptions

III. 3.1 Normal Nouns

Noun 00 Not in use.

Nouns 01-07 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. Seven different "Machine Address to be Specified" nouns are provided so that any of the decimal scale factors may be applied to the contents of any machine address.

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.

Nouns 16-17 These nouns refer to the time counters TIME1, TIME2, and are not normally loaded. If decimal is desired, Noun 16 gives seconds modulo 1000 (maximum +999.99 seconds); Noun 17 gives hours up to a machine maximum of 745.65 hours.*

* Since this noun refers to counter registers, it is not normally loaded. However, the capability exists and loading may be useful in special applications.

- Noun 20 This refers to the 3 ICPU counters. They are not normally loaded. If decimal is desired, the form is XXX.XX degrees (maximum of ± 359.99). *
- Noun 21 This refers to the 3 PIPA counters, and is not normally loaded. In decimal, register contents are presented as whole decimal, representing the number of PIPA counts (maximum $\pm 16,383$). *
- Noun 22 This refers to the desired platform angle registers (THETAD). (Decimal scale, ± 359.99 degrees maximum.)
- Noun 23 This refers to the Temporary Data Buffer. (Decimal scale ± 359.99 degrees maximum.)
- Noun 24 This refers to the Temporary Data Buffer. (Decimal scale, ± 999.99 seconds maximum.)
- Noun 25 Usually used with Verb 50, described in Section II. 2.2. Refers to Temporary Data Buffer. (If decimal is desired, whole scale is used.)
- Noun 26 This Noun is to be preloaded with the desired PRIORITY for use with VERB 20 (REQUEST EXECUTIVE); with the desired DELAY, when used with VERB 10 (REQUEST WAITLIST). OCTAL is to be used for the PRIORITY; decimal whole scaling is provided for the DELAY.

* Since this noun refers to counter registers, it is not normally loaded. However, the capability exists and loading may be useful in special applications.

- Noun 27 +0 loaded into this Noun causes the idle job to be done for Executive Backup.
- NZ loaded into this Noun causes the AGC Self Check routine to be done for the Executive Backup indefinitely.
- +NZ loaded into this Noun causes the AGC Self Check routine to be done for the Executive Backup N times, where N is the number loaded. (If decimal is used, whole number scale.)
- Noun 30 Refers to the Temporary Data Buffer. Intended for star identification numbers. The decimal scale for each is whole. This Noun is usually used with Verb 51, described in Section II. 2. 2.
- Noun 31 Used to display system failure conditions. A coded number to identify the failure is displayed in R 1. (Octal only)

III. 3. 2 Mixed Nouns

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

- Noun 55 Refers to the OCDU counters. (Decimal scale: X OPTICS scale is +359. 99 degrees maximum. Y OPTICS scale is either +179. 99 degrees maximum, or +89. 999 degrees maximum. See Section III. 2)*

* Since this noun refers to counter registers, it is not normally loaded. However, the capability exists and loading may be useful in special applications.

- Noun 56 Refers to Temporary Data Buffer. Noun is used by internal routines to display the OCDU angles and time (seconds) when an unrequested Mark is performed. (Optics decimal scale is same as Noun 55.)
- Noun 57 Refers to the desired optics angle registers (DESOPTX, DESOPTY). (Optics decimal scale is same as Noun 55.)
- Nouns 60-64 Refers to each of the ICDU and OCDU counters separately, and time counter (in seconds). The ICDU decimal scales are ± 359.99 degrees maximum. (Optics decimal scales are same as Noun 55.)*
- Noun 65 Refers to TIME1, TIME2 counters. (Decimal scales: hours scale, +745.65 maximum; seconds scale, +999.99 maximum.)*
- Noun 66 Refers to Temporary Data Buffer. Decimal scales are whole, fractional, whole.
- Noun 67 Refers to the desired delta GYRO angle registers (GYROD). Decimal scale is ± 9.9999 degrees maximum.

* Since this noun refers to counter registers, it is not normally loaded. However, the capability exists and loading may be useful in special application.

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 tells the Decimal Display Verb or the Decimal Monitor Verb how many component members belong to the given Noun; a 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

0 0 0 0 0	1 component
0 0 0 0 1	2 components (each single precision)
0 0 0 1 0	3 components (each single precision)

Scale Factor Routine Code Number

0 0 0 0 0	Fractional
0 0 0 0 1	Degrees (XXX.XX)
0 0 0 1 0	Arithmetic Scale Factor
0 0 0 1 1	Arithmetic Double Precision (multiplies by 2^{14} at end)
0 0 1 0 0	Arithmetic Double Precision
0 0 1 0 1	Y Optics Degrees

Scale Factor Constant Code Number

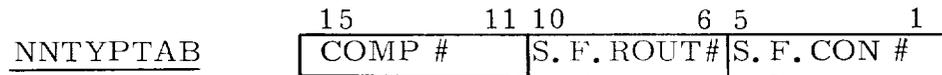
0 0 0 0 0	Whole
	Time in Seconds (XXX.XX)
0 0 0 0 1	Time in Hours (XXX,XX)
0 0 0 1 0	Degrees
0 0 0 1 1	Gyro Degrees

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

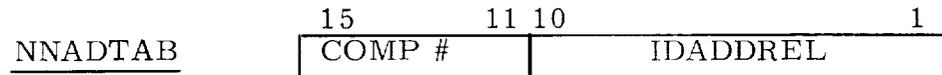
IV.2 Noun Tables--Normal Nouns.



- +0, Not in use
- NZ, Specify Machine Address
- 0, Increment Machine Address

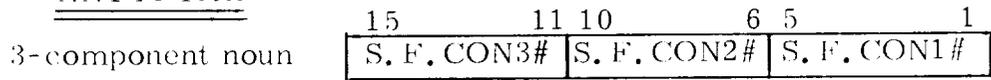


IV.3 Noun Tables--Mixed Nouns.



- +0, Not in use

NNTYPTAB



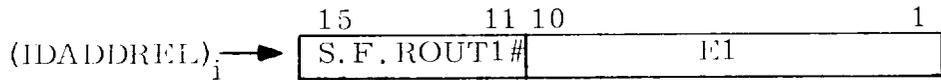
or



or



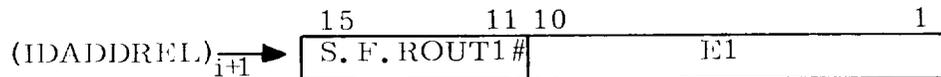
IDADDTAB



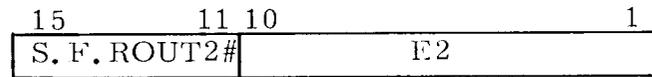
3-component



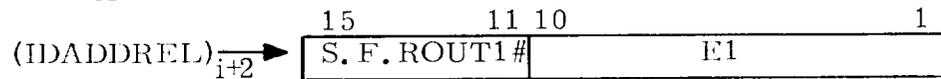
or



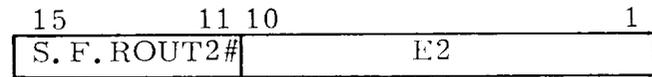
2-component



or



3-component



APPENDIX V
PROGRAM FLOW DIAGRAMS

A group of program flow diagrams for the Keyboard and Display System Program is given in Figures V-1 through V-21.

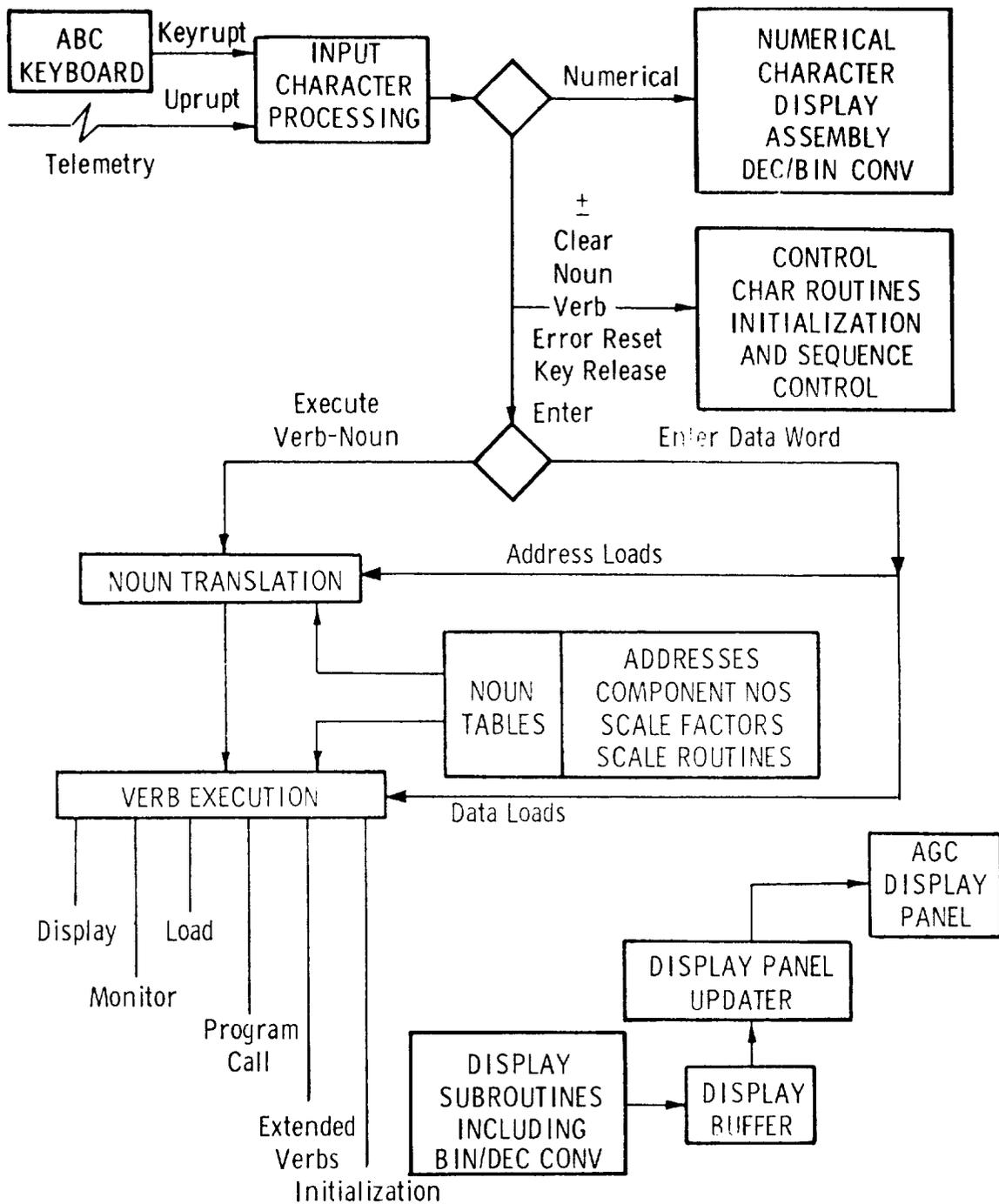


Fig. V-1 Keyboard and display block diagram.

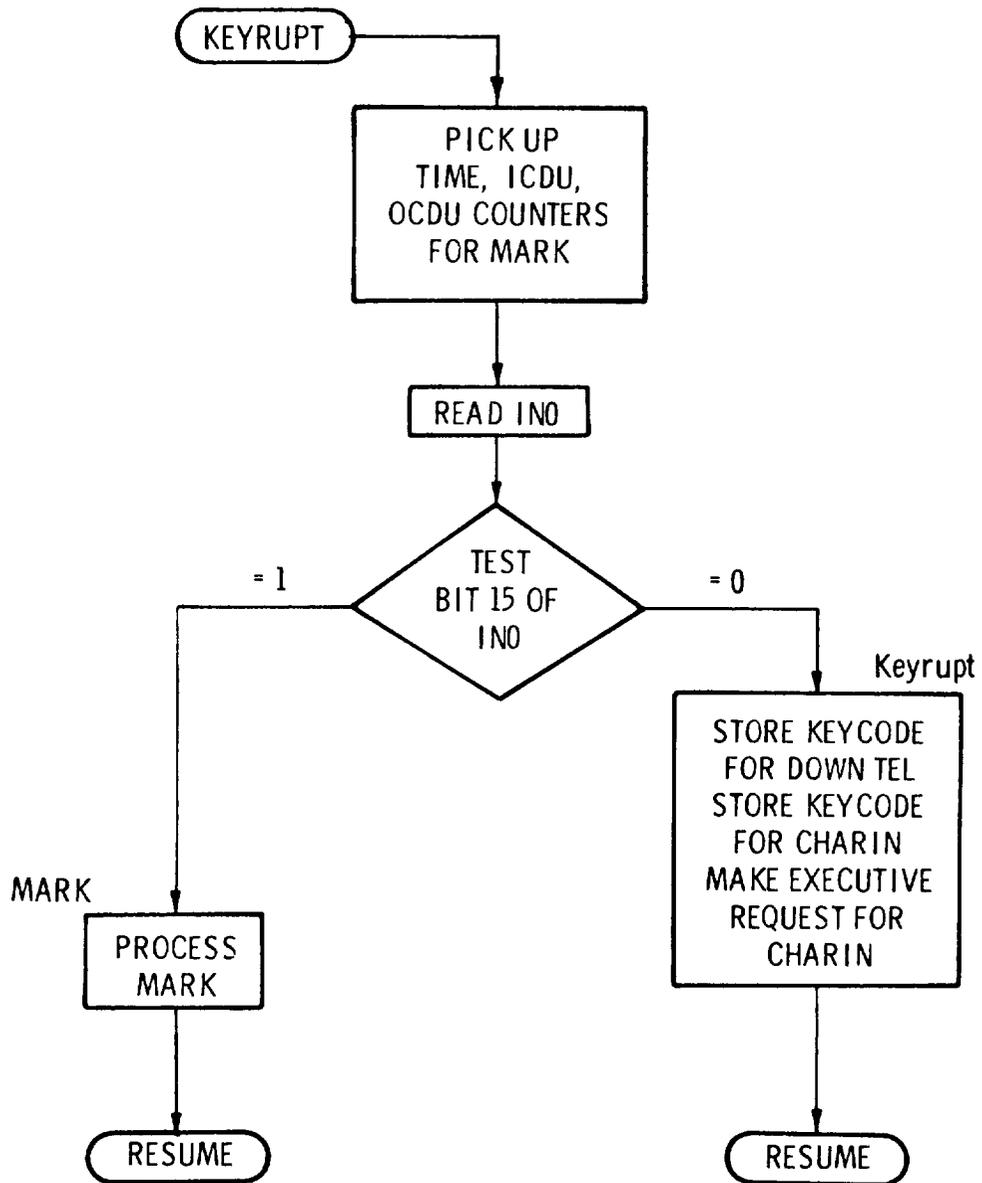


Fig. V-2 Keyboard flow diagram.

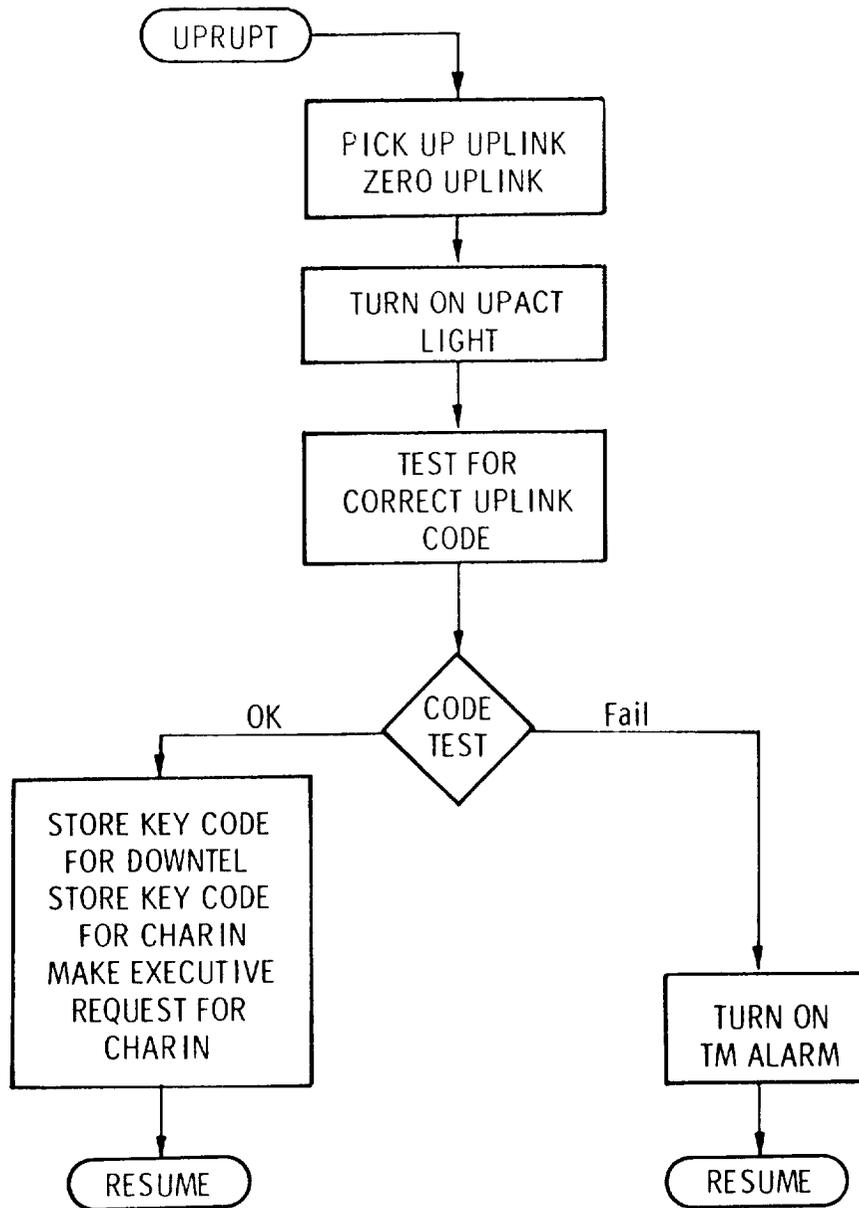


Fig. V-3 Uprupt flow diagram.

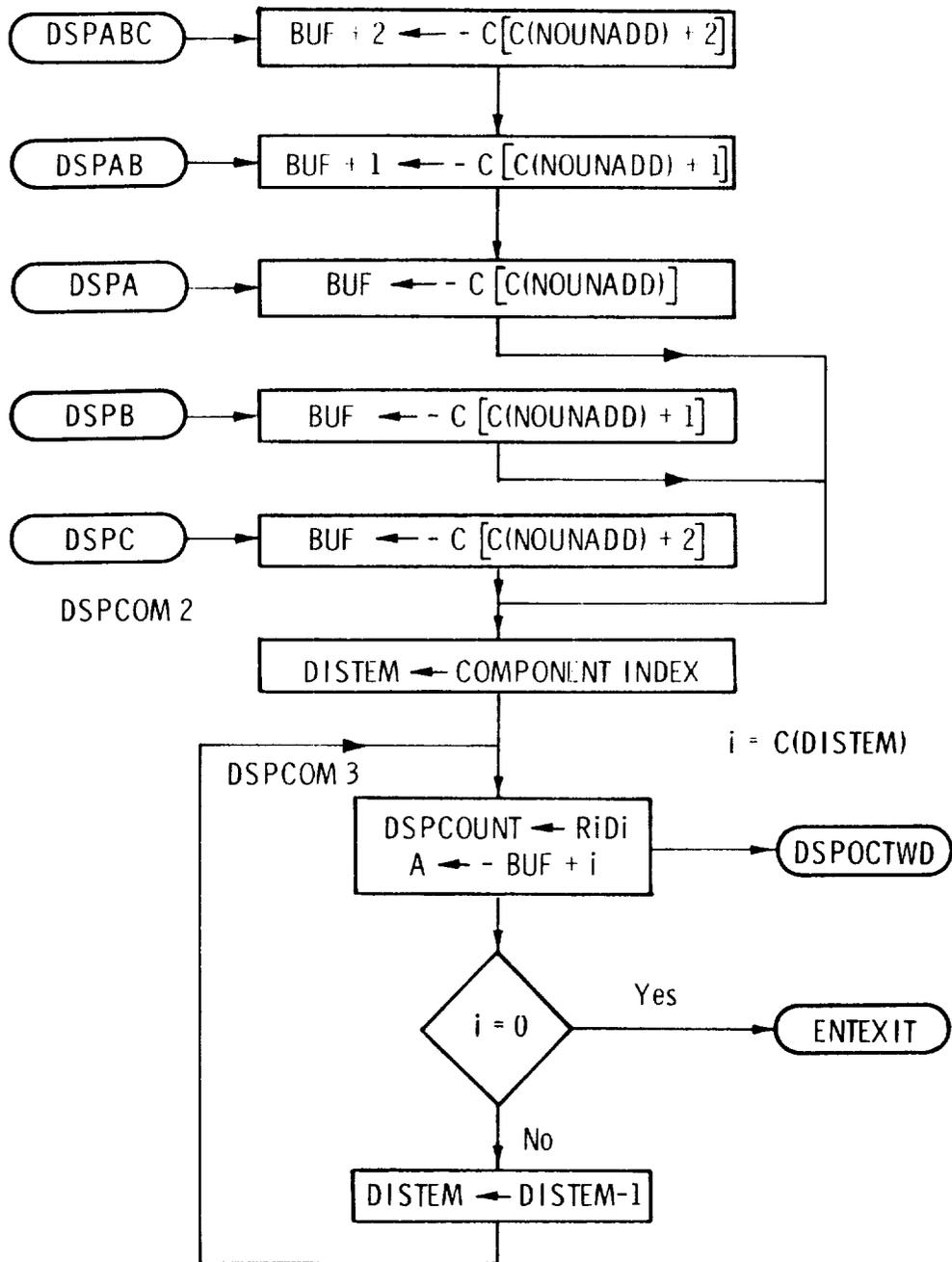


Fig. V-5 Octal display verbs flow diagram.

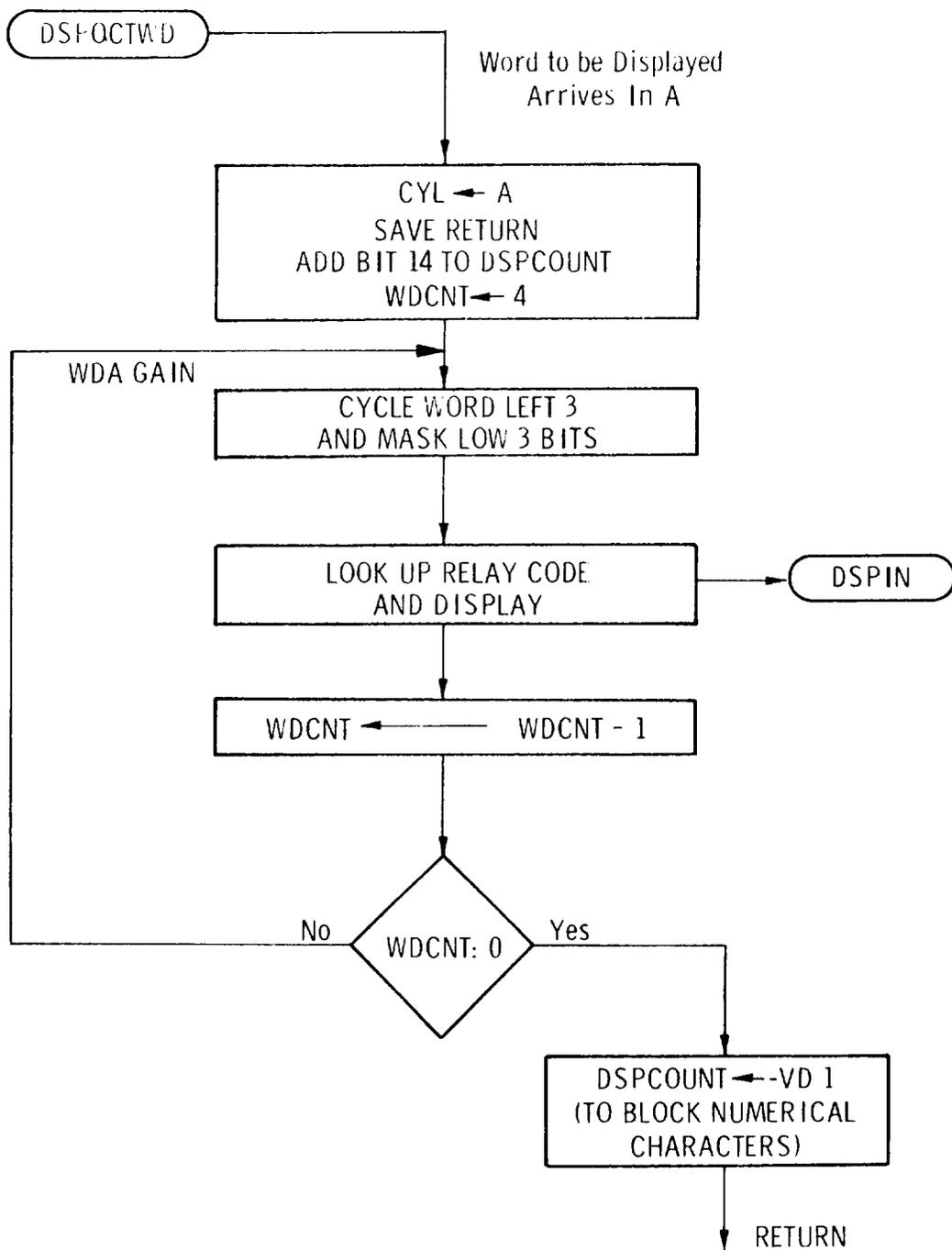


Fig. V-6 DSPOCTWD flow diagram.

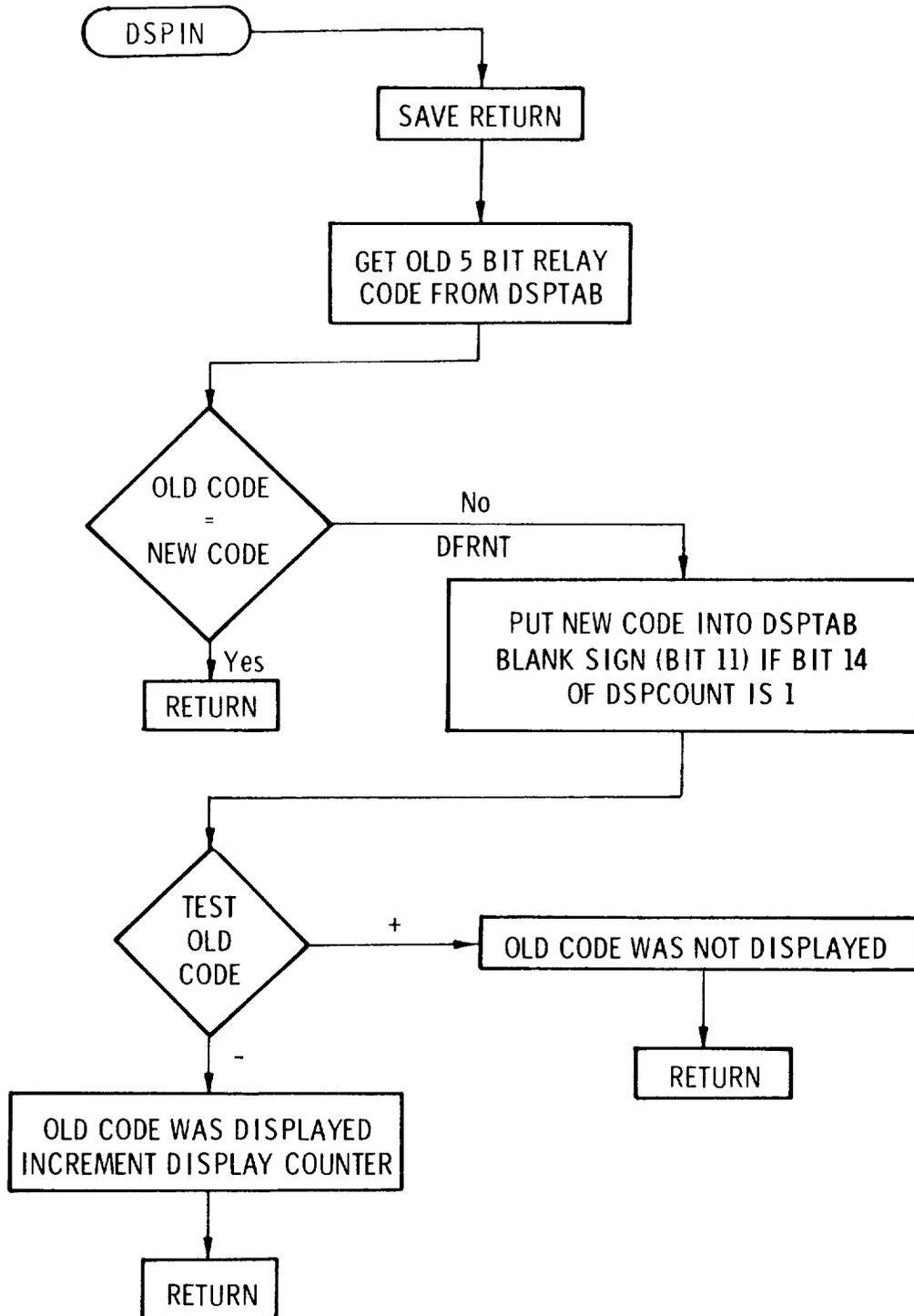


Fig. V-7 DSPIN flow diagram.

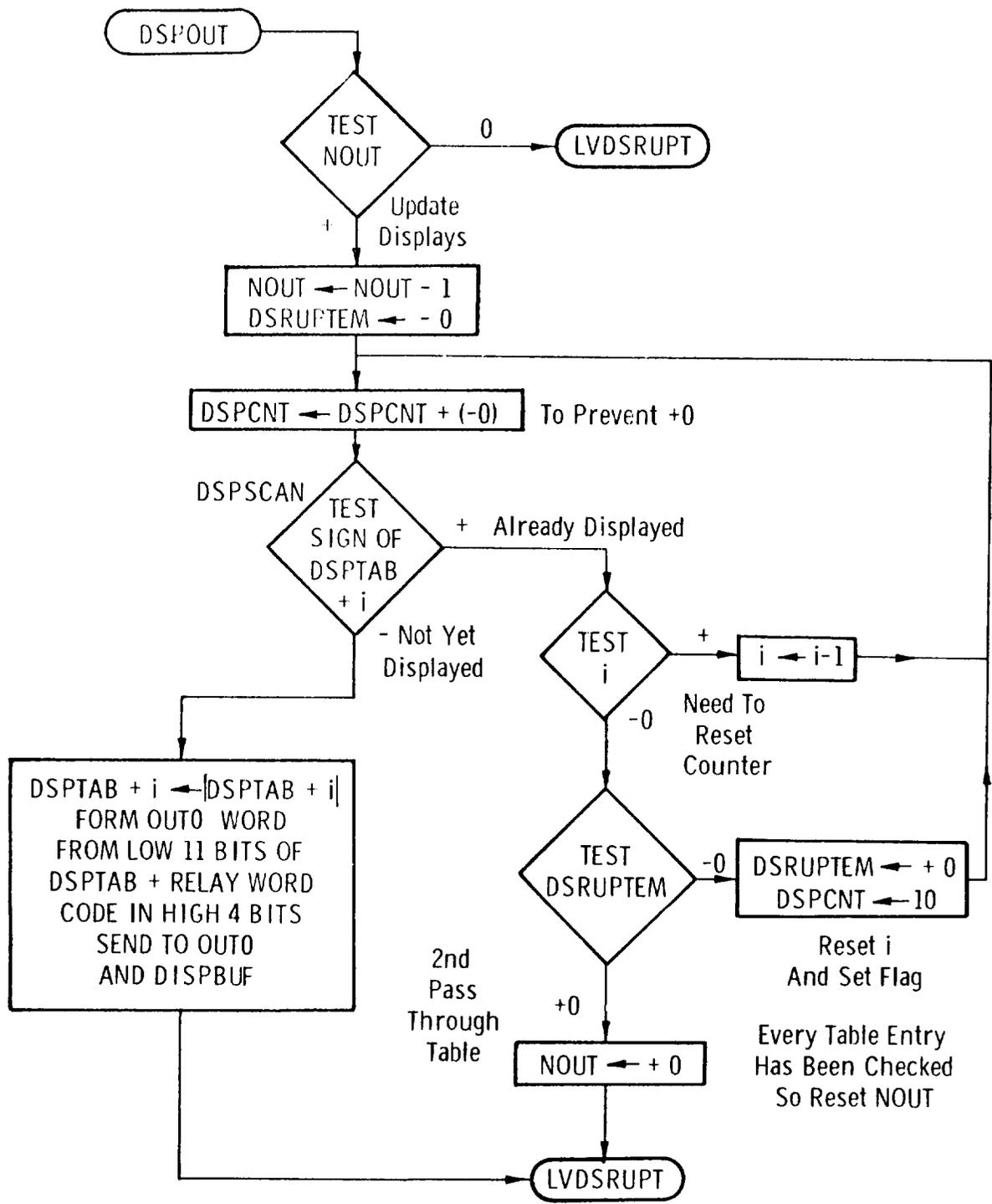


Fig. V-8 DSPOUT flow diagram.

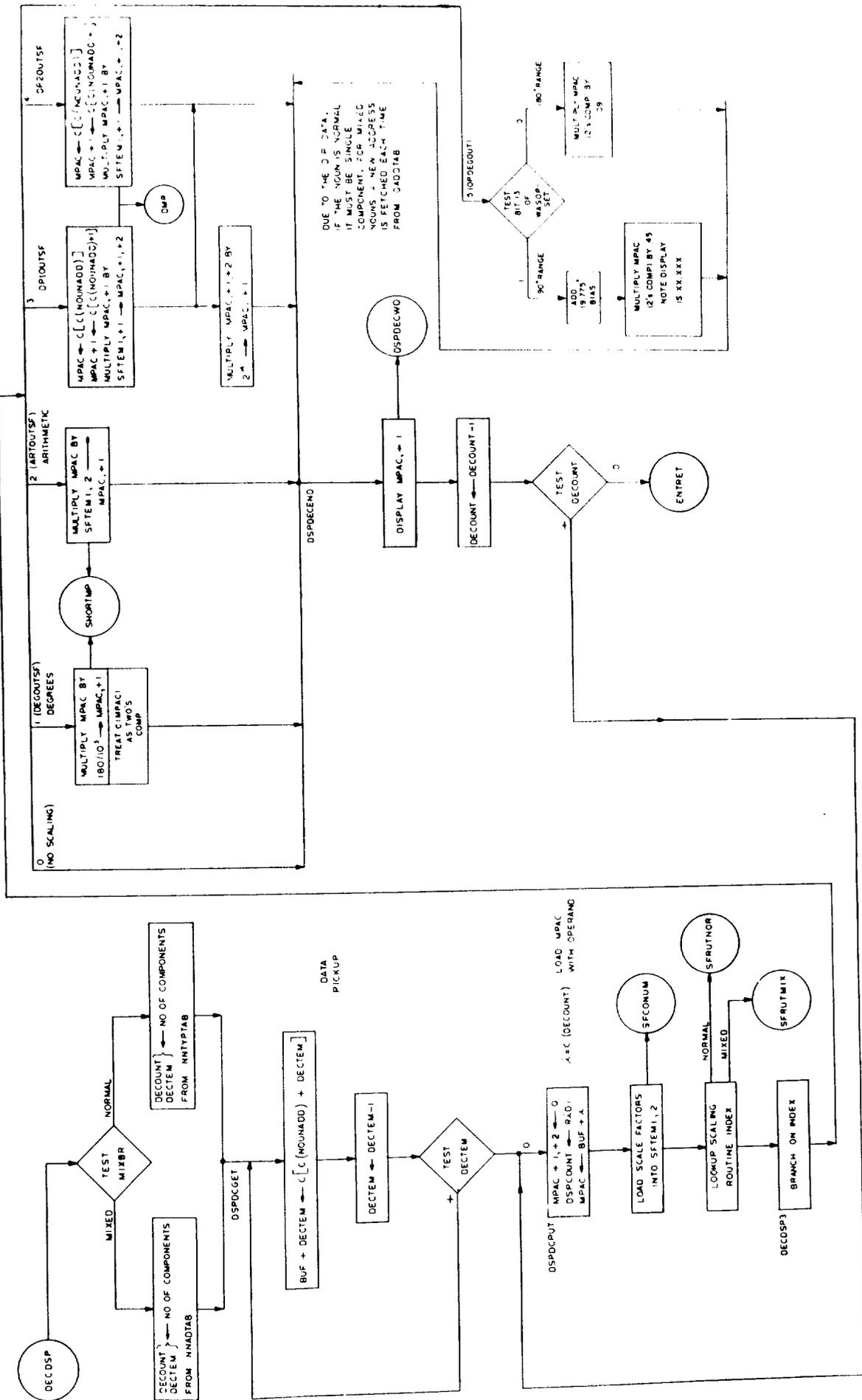


Fig. V-9 Decimal display verb flow diagram.

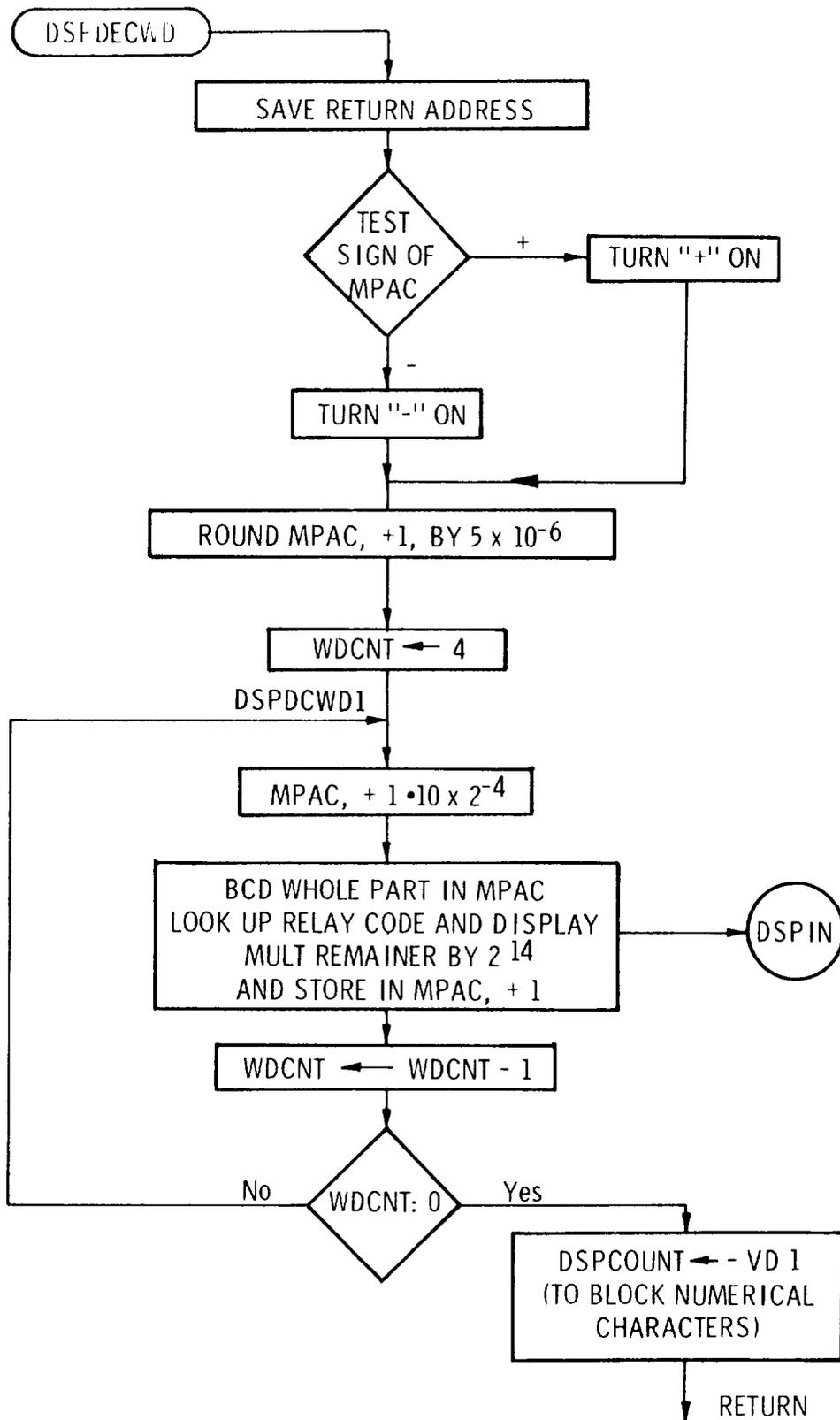


Fig. V-10 DSPDECWD flow diagram.

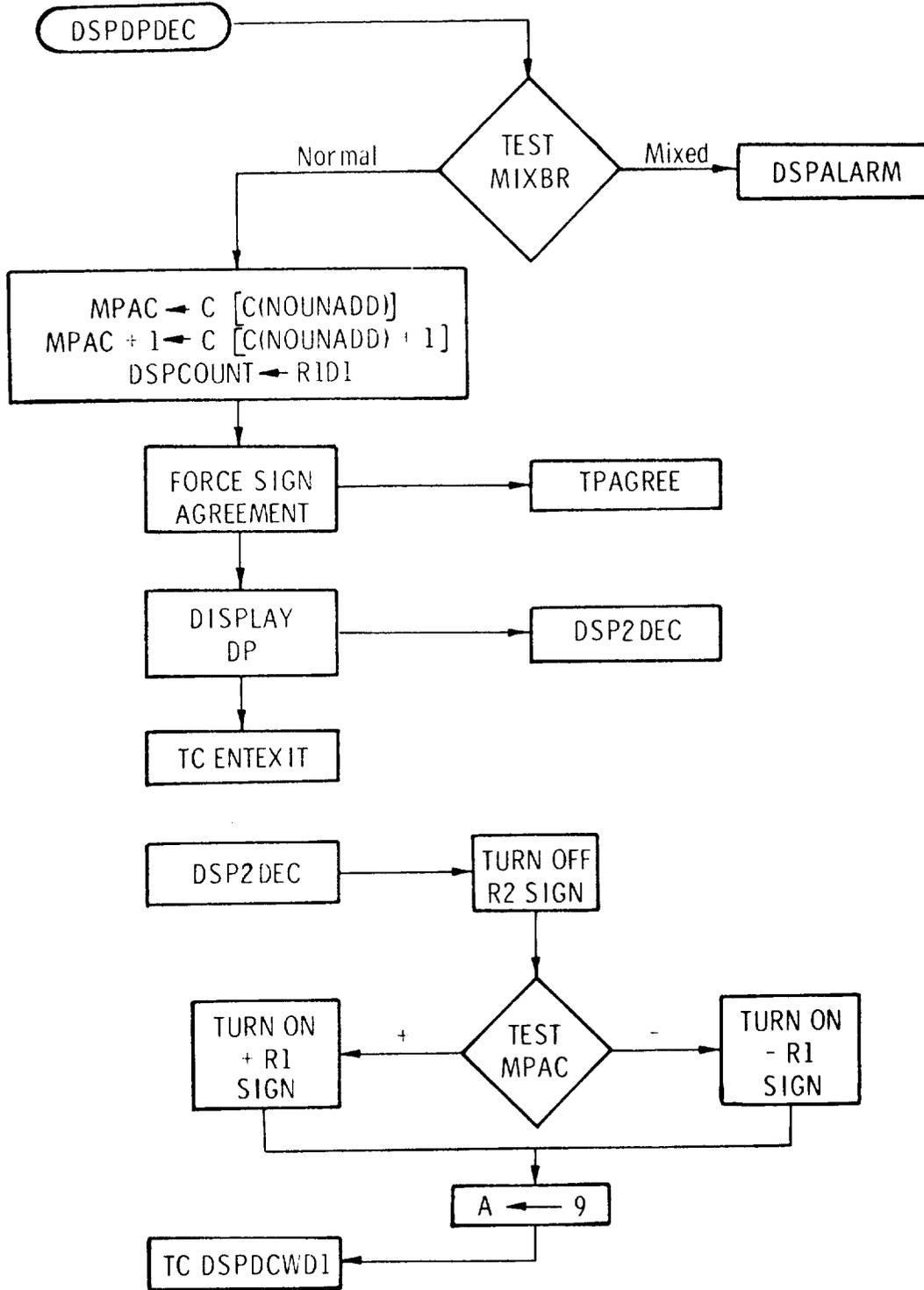


Fig. V-11 DP decimal display verb flow diagram.

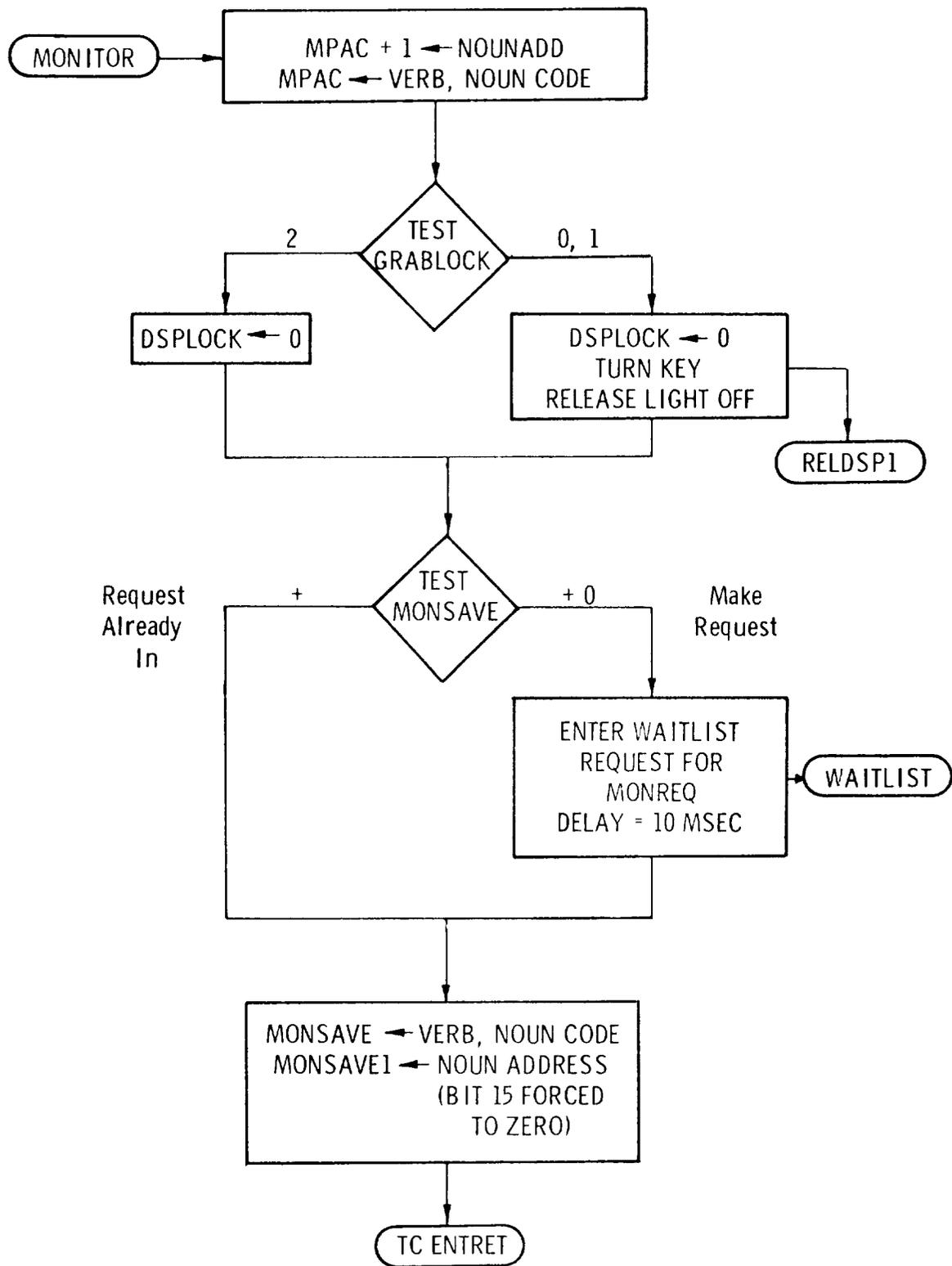


Fig. V-12a Monitor verbs flow diagram.

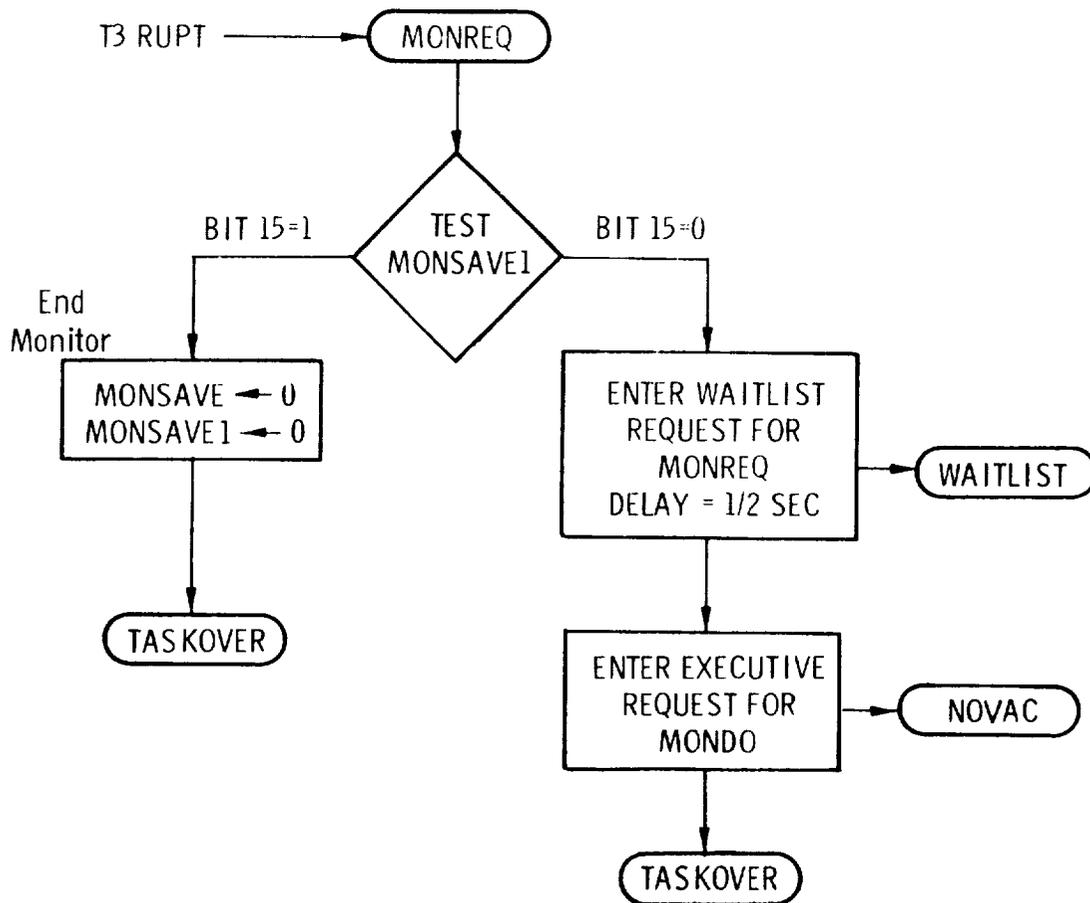


Fig. V-12b Monitor verbs flow diagram.

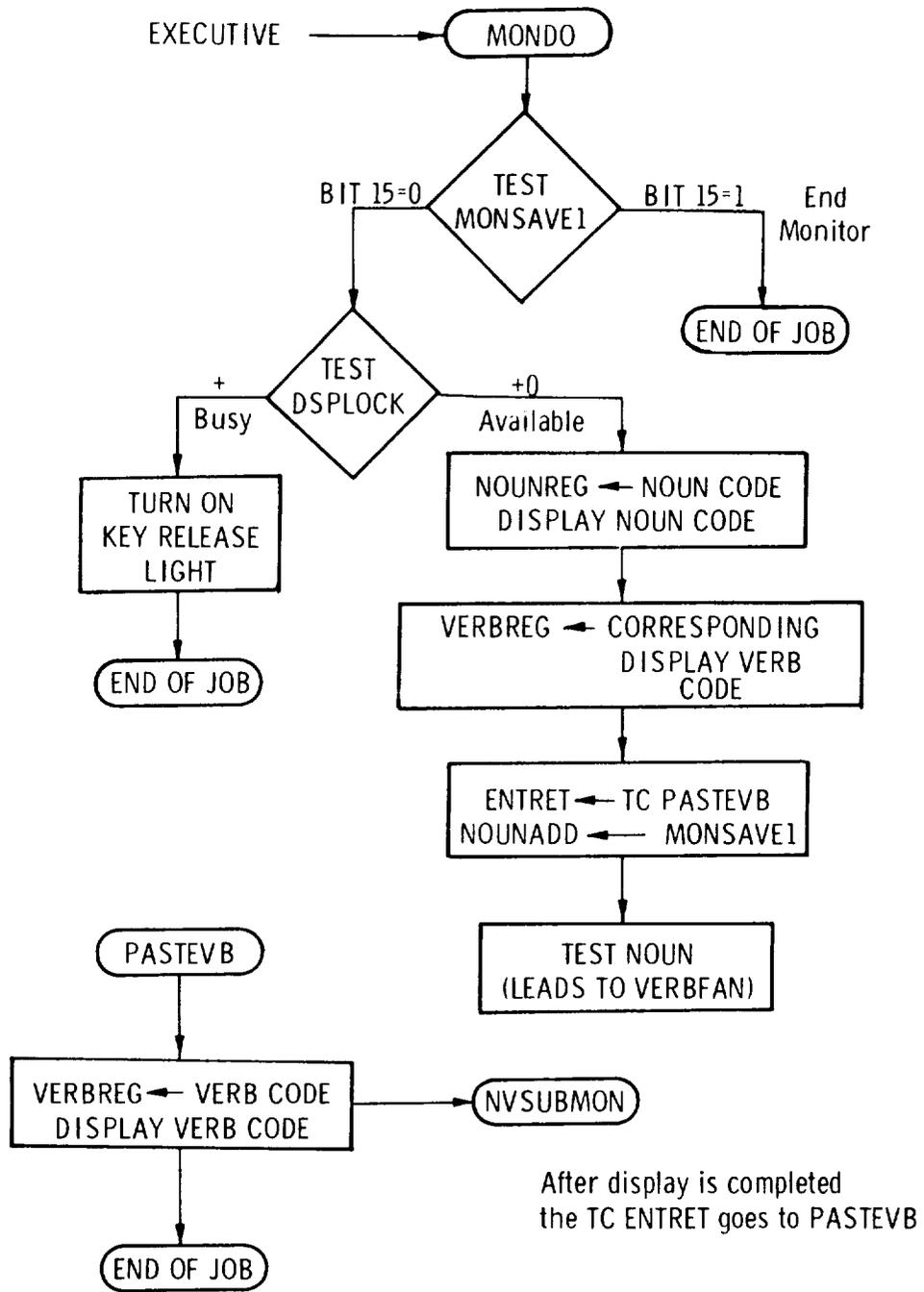


Fig. V-12c Monitor verbs flow diagram.

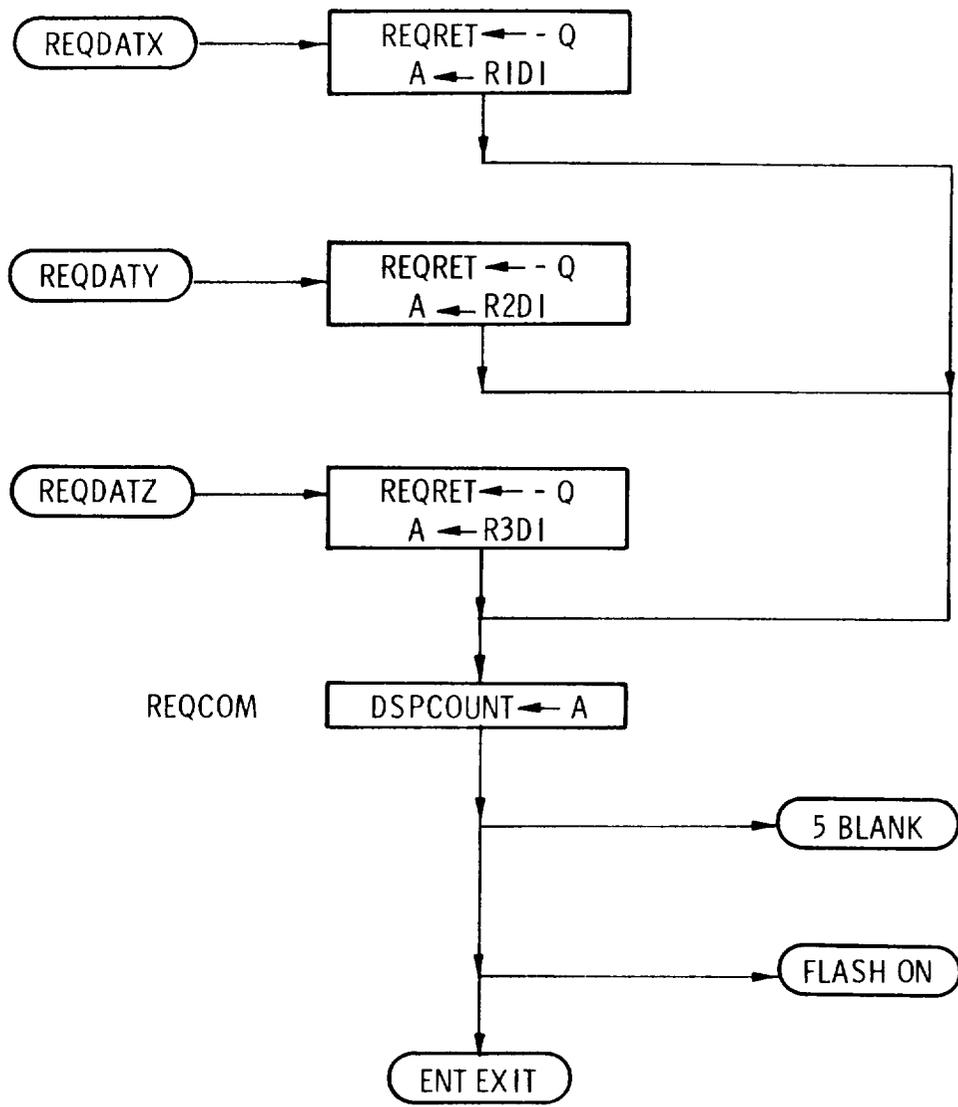


Fig. V-14 Request data routines flow diagram.

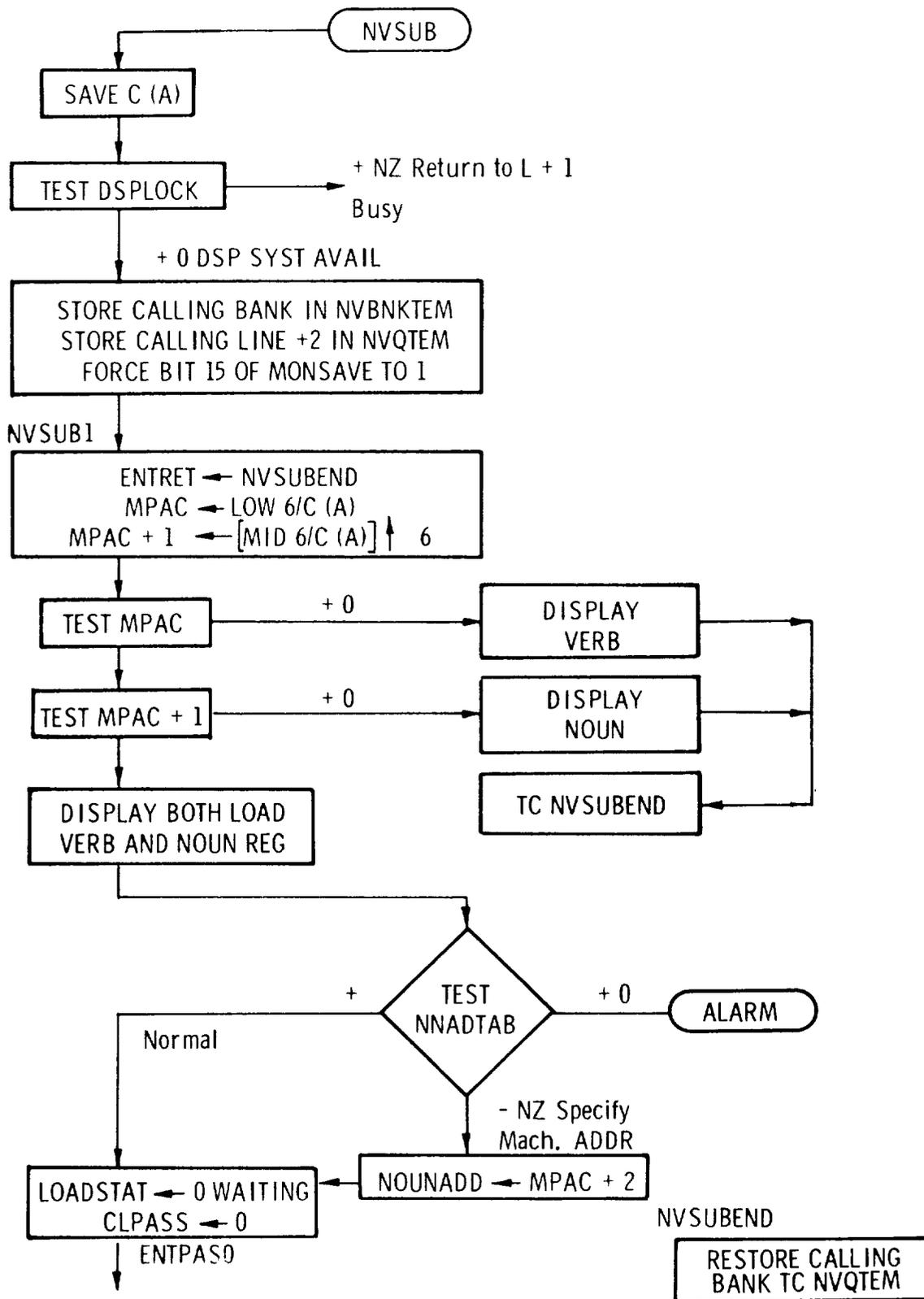


Fig. V-15 NVSUB flow diagram.

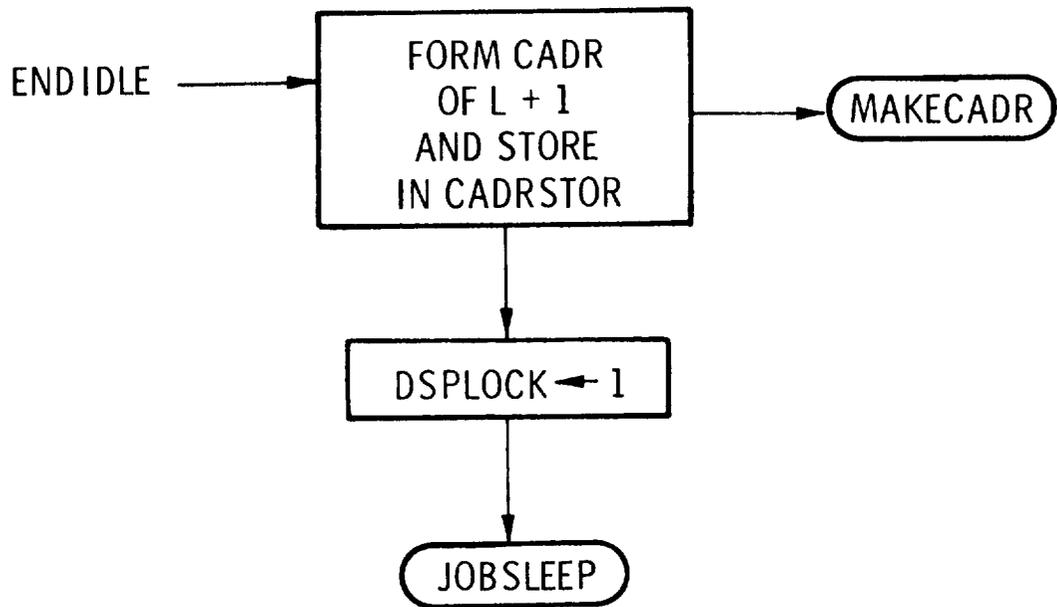


Fig. V-16 ENDIDLE flow diagram.

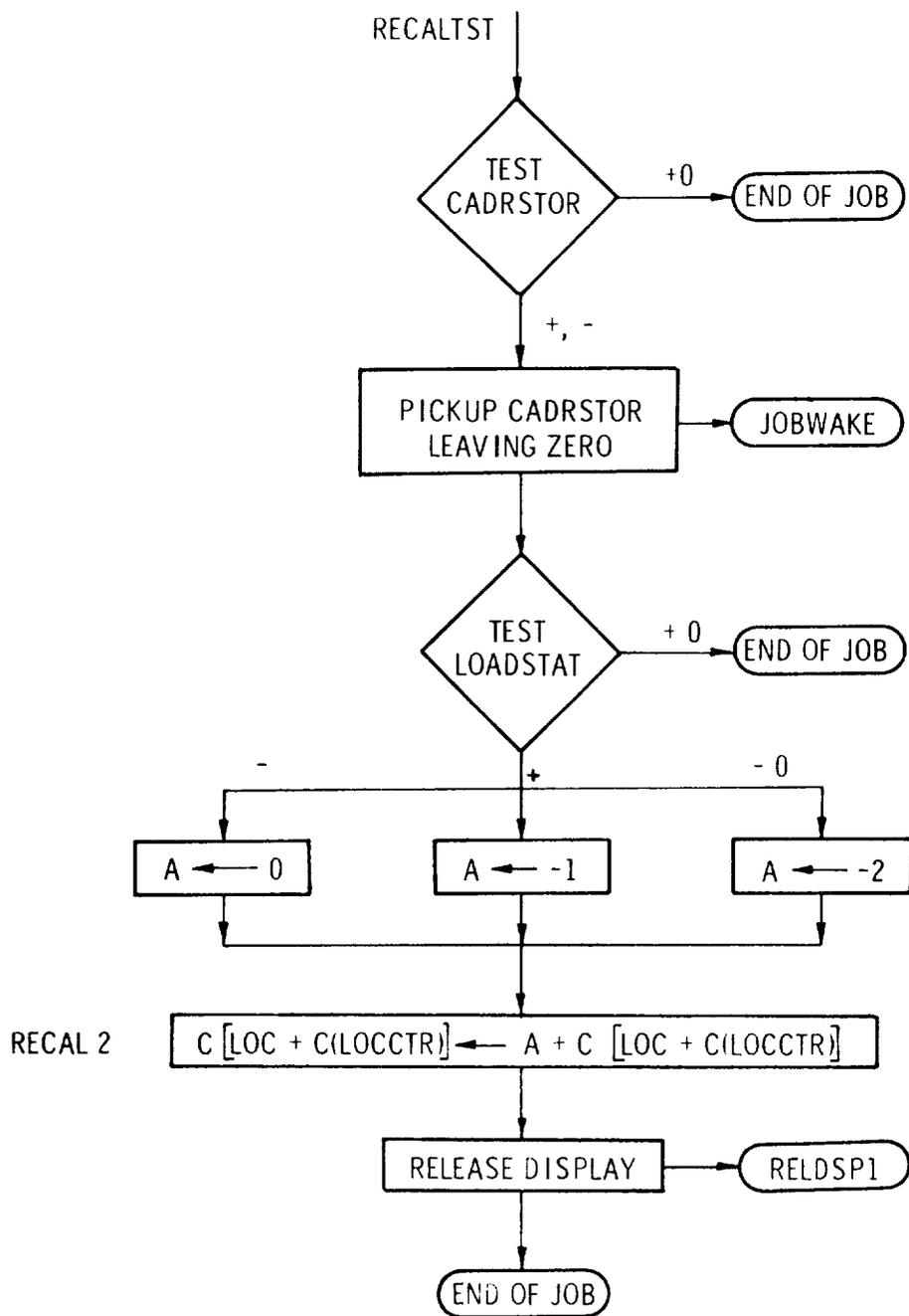


Fig. V-17 RECALTST flow diagram.

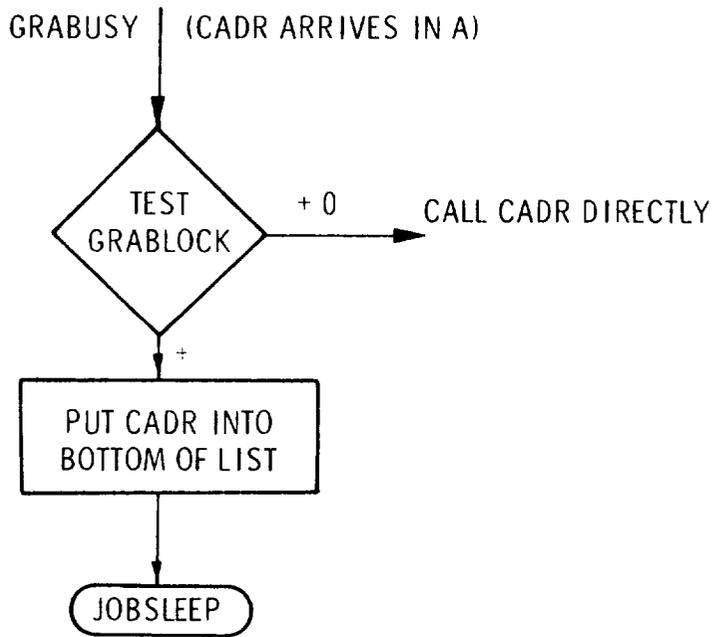
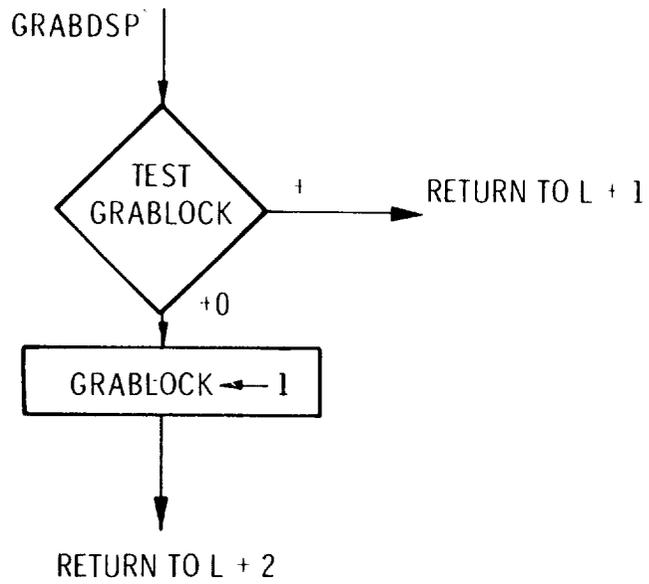


Fig. V-18 GRAB display flow diagrams.

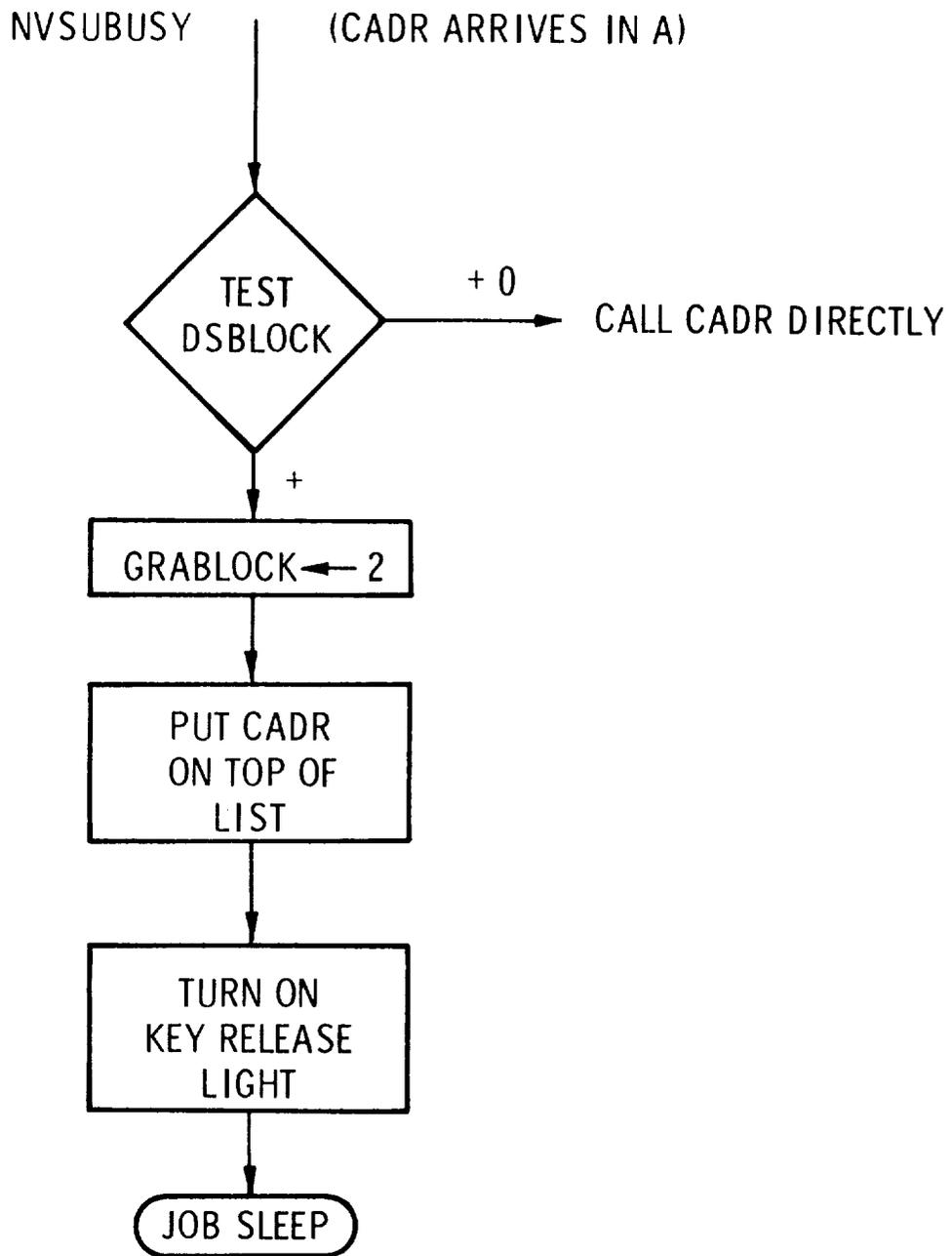


Fig. V-19 NVSUBUSY flow diagram.

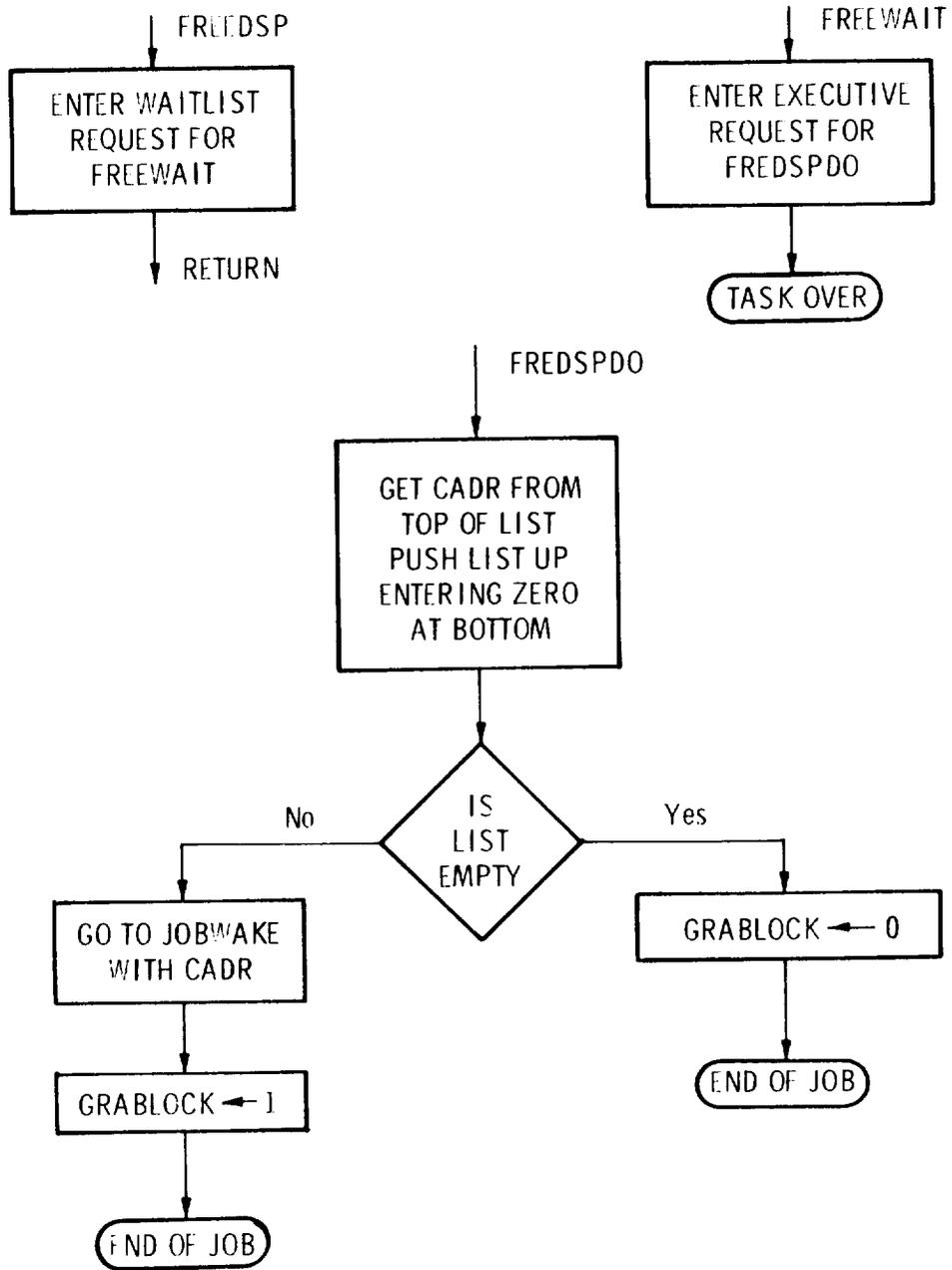


Fig. V-20 FREE display flow diagrams.

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