

APOLLO GUIDANCE COMPUTER

Information Series

ISSUE 14

MODE SWITCHING AND MARK

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14-1. INTRODUCTION

14-2. This is the fourteenth issue of the AGCIS which is published to inform the technical staff at MIT/IL and Raytheon about the Apollo guidance computer (AGC) subsystem. One of the operations the AGC performs for the Guidance and Navigation System (figure 14-1) is automatic mode switching of the Inertial and Optics Subsystems. This issue contains a description of program section Mode Switching and Mark together with the Extended (List 2) Verbs associated with this program section which enable the AGC to perform the mode switching operation. (Issue 15 contains a general description of all Block I AGC programs and program sections in paragraph 15-98 through 15-203.)

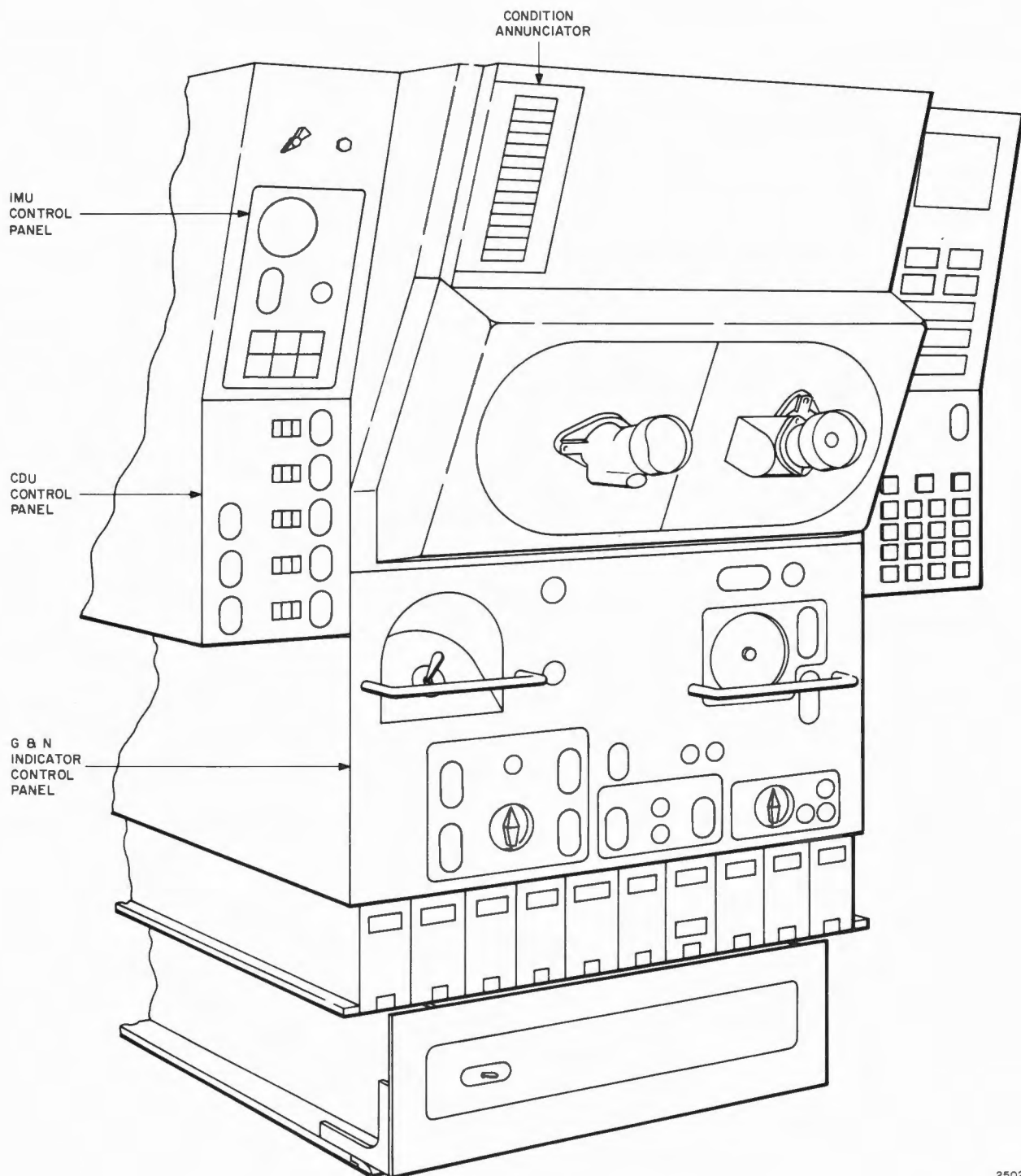
14-3. The Inertial Subsystem has six modes of operation:

- | | |
|-----------------|---------------------|
| a. Zero Encoder | d. Manual CDU |
| b. Coarse Align | e. Attitude Control |
| c. Fine Align | f. Reentry Control |

When the subsystem is under computer control (the TRANSFER switch on the IMU Control Panel, figure 14-2, in the COMPUTER position), Mode Switching and Mark accepts and processes requests for mode switching which are initiated by either Mission Functions (internal program requests) or the operator through the DSKY's. Such requests are then implemented by program section T4RUPT Output Control. The various modes, their calling sequences, and a brief description of each mode are contained in table 14-1.

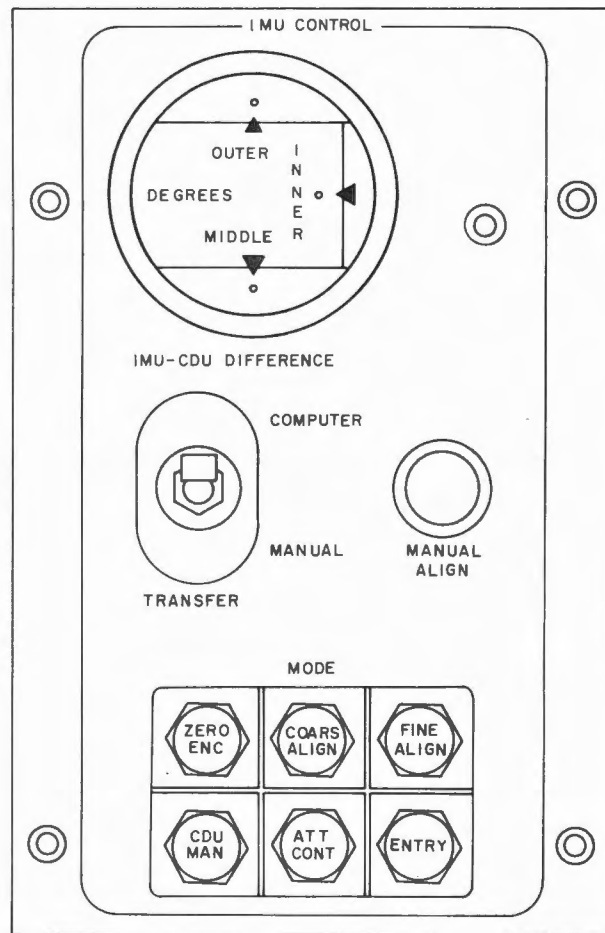
14-4. Mode switching requests can also be initiated manually by an operator via the six indicator switches on the IMU Control Panel (figure 14-2) providing the TRANSFER switch is in the MANUAL position. Each indicator switch contains an internal lamp which lights to indicate the mode of the Internal Subsystem when the switch is depressed or a computer-controlled mode switch is initiated.

14-5. The Optics Subsystem has three modes of operation: Zero Optics, Manual, and Computer. These modes are selected by the positioning of the OPTICS mode selector on the G and N Indicator Control Panel (figure 14-3). In the Zero Optics mode, the Optics CDU's are driven automatically to a zero position and the Optics follow the CDU's. In the Manual mode, the Optics are driven via the Optics hand controller.



2502

Figure 14-1. Guidance and Navigation System



2503

Figure 14-2. IMU Control Panel

Table 14-1
INERTIAL SUBSYSTEM MODES

Mode	Calling Sequence ⚠	Illuminated Indicator on IMU Control Panel	Description
Zero Encode	TC SETKANDC OCT 00051 OCT 40011	ZERO ENC	The CDU's are forced to electrical zero. A combination of this mode and the Fine Align and Attitude Control modes performs the Zero Encode Sequence which equates the CDU display dials with the actual gimbal angles.
Coarse Align	TC SETKANDC OCT 00042 OCT 40002	COARSE ALIGN	The gimbals are slaved to the CDU's (i.e., the gimbal angles are changed so as to repeat the CDU angles) Program Section T4RUPT Output Control drives the CDU's.
Fine Align	TC SETKANDC OCT 00050 OCT 40010	FINE ALIGN	The CDU's are slaved to the gimbals (i.e., the CDU's are changed to repeat the gimbal angles). Routine IMUPULSE drives the gimbals.
Manual CDU	TC SETKANDC OCT 00044 OCT 40004	CDU MAN	The gimbals are slaved to the CDU's. The operator aligns (drives) the CDU's via thumb-wheels on the CDU's.

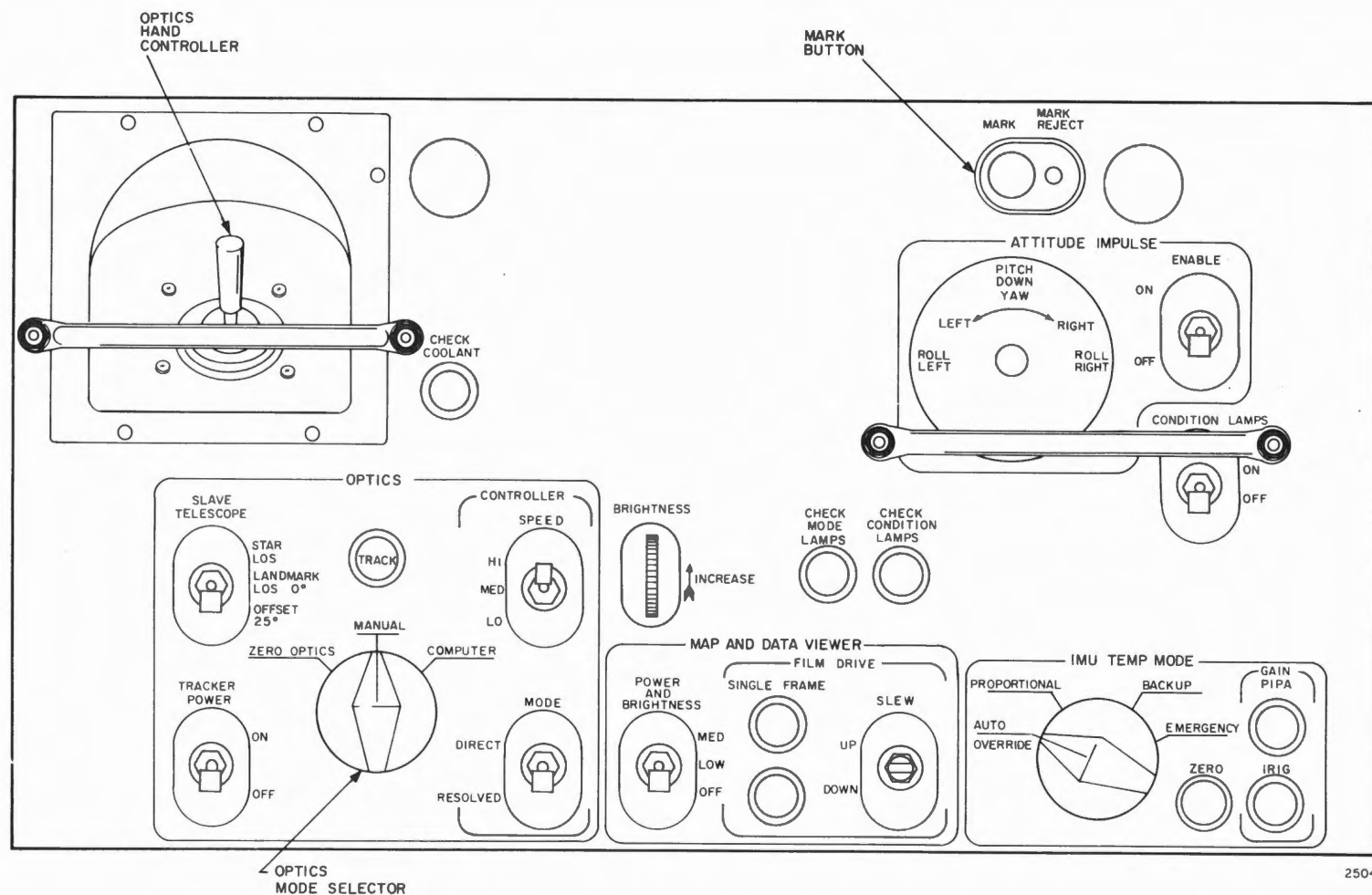
Table 14-1 (cont)
INERTIAL SUBSYSTEM MODES

Mode	Calling Sequence ①	Illuminated Indicator on IMU Control Panel	Description
Attitude Control	TC SETKANDC OCT 00060 OCT 41000	ATT CONT	Disagreement between the CDU angles and the gimbal angles causes error signals to be sent to the Stabilization and Control System (SCS) which may reactivate the Reaction Control System (RCS) and return the Spacecraft to the original attitude. The CDU angles determine the desired attitude of the spacecraft.
Reentry Control	TC SETKANDC OCT 00140 OCT 42000	ENTRY	Similar to the Attitude Control mode for differences between the gimbal angles on the Y and Z axis and the CDU Y and CDU Z angles. However, the difference between the gimbal angle on the X axis and the CDU X angle is an attitude error signal magnified by a factor of 16 to reduce the response time required for controlling the Spacecraft about the roll axis.

① The calling sequence for Routine SETKANDC is:

L	TC	SETKANDC
L+1	OCT	DDDDD
L+2	OCT	RRRRR

where DDDDD is the desired mode setting and RRRRR is the mode request.



2504

Figure 14-3. G and N Indicator Control Panel

In the Computer mode, the Optics are controlled by signals from the AGC.

14-6. In the Computer mode, an AGC Mission Function or Job will be able to request that the Optics CDU's be driven until they reflect the position of the shaft and trunnion axes. This is similar to the Zero Encode Sequence associated with the Inertial Subsystem. A Mission Function or Job will also be able to request that power be applied to the Optical Tracker (Star Tracker On) which allows the tracking of any star presently being sighted. Information pertaining to these two Optics "sub-modes" is not presently available; therefore, they are not discussed in this issue. In addition, a Mission Function or Job can request that the shaft and trunnion axes be driven to a special position by program section T4RUPT Output Control. This is similar to the Coarse Align mode associated with the Inertial Subsystem.

14-7. A Mark is an operator action taken to record time information, IMU angles and Optics angles. Whenever the operator depresses the MARK button on the G and N Indicator Control Panel, (figure 14-3) an interrupt is executed and the contents of the AGC Time counters, the IMU CDU counters, and the Optics CDU counters are read out and entered into an assigned Work Area (paragraph 12-11a). The assignment of a Work Area is a function of those routines executed to request that an operator take a Mark action.

14-8. A Mark action, unlike an IMU or Optics mode, is only requested by a Mission Function. However, if at any time the operator depresses the MARK button without first having received a Mark request, the current Time and Optics Mark information is displayed on the DSKY's.

14-9. Since there are many users of program section Mode Switching and Mark and it would be difficult to describe all of them, the only user described herein is the Extended Verbs which request a mode or an action peculiar to themselves via a keyboard action. The Extended Verbs are provided mainly for laboratory use since the Mission Functions duplicate the operations of the Extended Verbs automatically except for Verbs 70 and 71 which initiate System Tests (Issue 21).

14-10. MODE SWITCHING AND MARK ROUTINES

14-11. The routines called by the Mission Functions and the Extended Verbs to perform IMU moding are:

- | | | | |
|-------------|----------|----|----------|
| a. | IMUZERO | e. | IMUATTC |
| b. | IMUCOARS | f. | IMUREENT |
| c. | IMUFINE | g. | IMULOCK |
| d. | IMUPULSE | h. | IMURECOR |
| i. IMUSTALL | | | |

Each of the routines listed (with the exception of Routines IMUPULSE and IMUSTALL) schedules a Task to verify that the mode switch is successful. After a request to switch has been recognized, the time necessary for the K relays in the Inertial Subsystem to switch varies according to the specific mode requested. After a Mission Function has requested an IMU mode switch, control is transferred to Routine IMUSTALL to put the Mission Function Job into the dormant state until the K relays have had time to switch. In most cases instruction TC IMUSTALL is executed immediately after instruction TC IMUZERO, TC IMUCOARS, etc. The exceptions will be made clear as each Mission Function is described in its own issue.

14-12. The Routines called by the Mission Functions and by the Extended Verbs to perform Optics moding and the MARK requests are:

- | | | |
|----|----------|---|
| a. | OPTZERO | } (interface not available in SUNRISE 45) |
| b. | OPTCOARS | |
| c. | OPTTRKON | |
| d. | SCTMARK | |
| e. | SXTMARK | |
| f. | MKRELEAS | |
| g. | OPTSTALL | |

14-13. Program section Mode Switching and Mark also includes Routine KEYRUPT which is executed whenever the operator depresses a key on the DSKY's, the MARK button, or the ACC MARK button (when available). The actions taken by Routine KEYRUPT as a result of these operator entries are described in Issue 17, paragraphs 17-6 through 17-9 and 17-15 through 17-30 as part of the associated keyboard input process. The Job scheduled by Routine KEYRUPT if the MARK button is depressed without having been preceded by a request for marks is described in paragraph 14-135.

14-14. Routines READTIME and READIN 0, also part of program section Mode Switching and Mark, are described in this issue in paragraphs 14-139 and 14-142 respectively because (although used by several program sections) they are not closely associated with any particular program section.

14-15. The following paragraphs describe the IMU and Optics Routines listed in paragraphs 14-11 and 14-12. The Extended Verbs are described in paragraphs 14-144 through 14-236.

14-16. IMU MODING ROUTINES

14-17. ROUTINE IMUZERO

14-18. Routine IMUZERO implements the Zero Encode sequence for the IMU which equates the content of input counters CDUX, CDUY, and CDUZ and the IMU CDU display dials (figure 14-4) on the CDU's with the actual gimbal angles (the angles between the platform axes and the Spacecraft). During the execution of this sequence the ZERO ENCODER light on the Condition Annunciator Panel (figure 14-5) is illuminated. This indicator should not be confused with the ZERO ENC indicator switch on the IMU Control Panel which is illuminated when the Inertial Subsystem (IMU) is put into the Zero Encode mode.

14-19. During the execution of the Zero Encode sequence, the IMU is put into four different modes sequentially. The first mode requested is the Zero Encode mode which is in operation for 40 seconds. During the 40 second interval, the CDU display dials are forced to the zero position. Since, prior to the request for the Zero Encode Mode, computer control of the CDU loop was disabled by entering the quantity 77776 into register CDUIND, the gimbal angles are not changed. The CDU counters are then zeroed and the subsystem is put into the Fine Align mode for 10 sec. (IMU Control Panel indicator FINE ALIGN is turned on and indicator ZERO ENC is turned off by hardware.) During the 10 sec allowed for the Fine Align mode, the CDU's are slaved to the gyros and are driven such that they reflect the gimbal positions. Thus, not only will the CDU display dials reflect the gimbal angles, but also the CDU counters (CDUX, CDUY, and CDUZ) will reflect the gimbal angles.

14-20. Since it is possible that one of the display dials could be reading 00:00:00 while the actual gimbal angle is at 180° , the subsystem is switched to the Attitude Control mode for 2.2 sec. (When the system is in the Attitude Control mode, indicator ATT CONT on the IMU

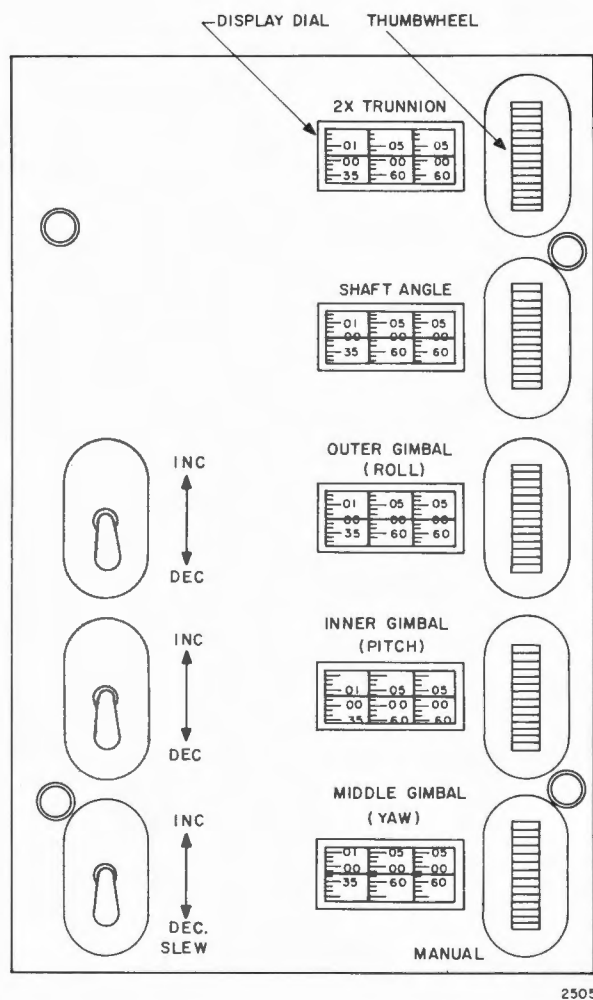
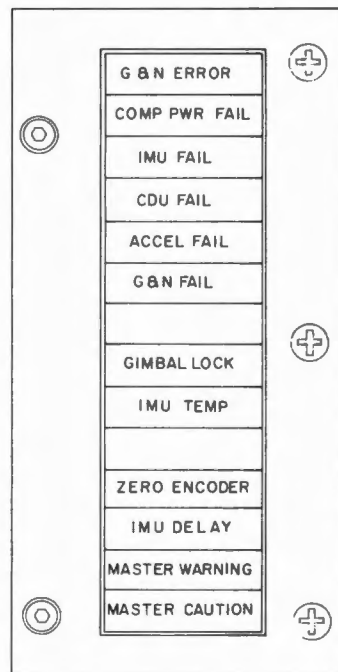


Figure 14-4. CDU Control Panel

Control Panel is illuminated and the previous indicator, which in this case is FINE ALIGN, is turned off.) After the request for the Attitude Control mode, the CDU drive loop is enabled for 2 sec and the THETAD registers are set so that, during the execution of program section T4RUPT Output Control, the CDU's will be driven off the zero position by about 10° . However, since the system is in the Attitude Control mode, the gimbal angles and thus the stable member will not be moved when the CDU's are driven. Finally, a request is made for the fourth mode which is the Fine Align mode. The Fine Align mode is maintained for 20 sec to allow the CDU's to reposition according to the gimbal angles. When the system is put into the Fine Align, mode indicator FINE ALIGN on the IMU Control Panel is illuminated and the previous indicator, which in this case is ATT CONT, is turned off. The system will remain in the Fine Align mode until a subsequent request is made for a mode switch.



2506

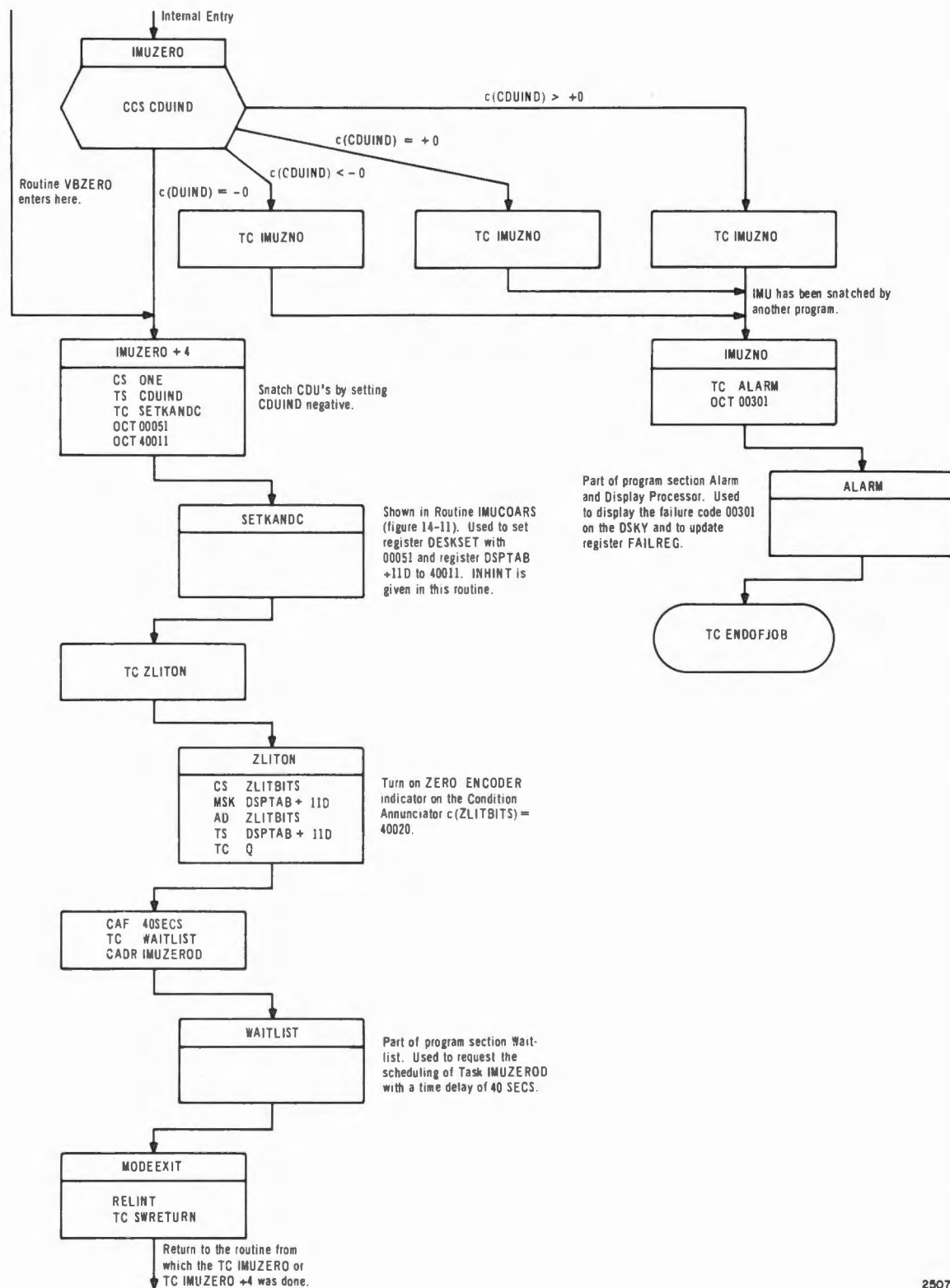
Figure 14-5. Condition Annunciator

14-21. Routine IMUZERO (figure 14-6) initiates the Zero Encode sequence by testing the content of register CDUIND to determine whether or not the CDU's have been reserved by another user. If register CDUIND contains a quantity other than 77777, indicating that another user has reserved the CDU's, program control is transferred to Routine ALARM where Job DOALARM is scheduled to display the failure code 00301 (two users trying to control the IMU simultaneously) to the operator in DSKY display register R1. Thereafter, the Job which requested Routine IMUZERO is terminated. If register CDUIND contains 77777, indicating that the CDU's are not reserved, program control is transferred to location IMUZERO+4 which is an entry point for Routine IMUZERO when a keyboard request is made for the Zero Encode sequence.

14-22. When program control is transferred to address IMUZERO+4, the quantity 77776 is entered into register CDUIND, which reserves the CDU's for the requested zeroing sequence. A request is made for the Zero Encode mode and this request is implemented by transferring program control to Routine SETKANDC with the octal quantities 00051 and 40011 contained in locations L+1 and L+2 respectively where L is the location from which the TC SETKANDC is done. Routine SETKANDC executes instruction INHINT and transfers the content of location L+1 to register DESKSET and the content of bit positions 15, 11, 10, 4, 3, 2, and 1 of the quantity contained in location L+2 to register DSPTAB+11D. Thereafter, program control is transferred to Routine ZLITON to enter a ONE into bit positions 15 and 5 of register DSPTAB+11D. After program section T4RUPT Output Control transfers the command from register DSPTAB+11D to register OUT0, both the ZERO ENC indicator switch on the IMU control panel and the ZERO ENCODER indicator on the Condition Annunciator will be illuminated. It may take up to 40 sec for the CDU's to be set to electrical zero; therefore, Task IMUZEROD is requested for execution with a time delay of 40 sec. Program control is transferred back to the routine from which the TC IMUZERO or TC IMUZERO+4 was done. In all likelihood this will result in the execution of Routine IMUSTALL, which will put the requesting Job into the dormant state. (Routine IMUSTALL is described in detail in paragraph 14-99.)

14-23. Task IMUZEROD

14-24. Task IMUZEROD, which begins execution at Routine IMUZEROD (figure 14-7), assumes the subsystem has been in the Zero Encode mode for 40 sec. Routine IMUZEROD enters the quantity 00000 into counters CDUX, CDUY, and CDUZ and then transfers program control to Routine KCHECK. Routine KCHECK tests the content of register WASKSET and



2507

Figure 14-6. Routine IMUZERO

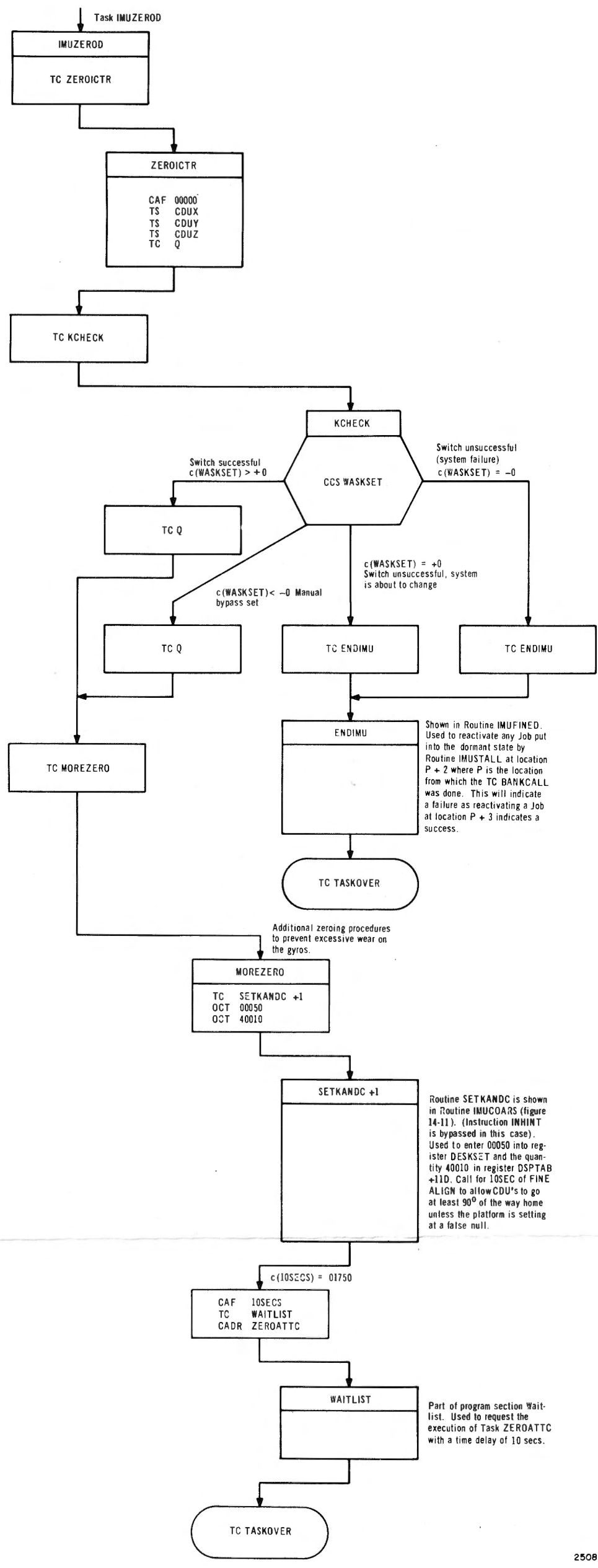


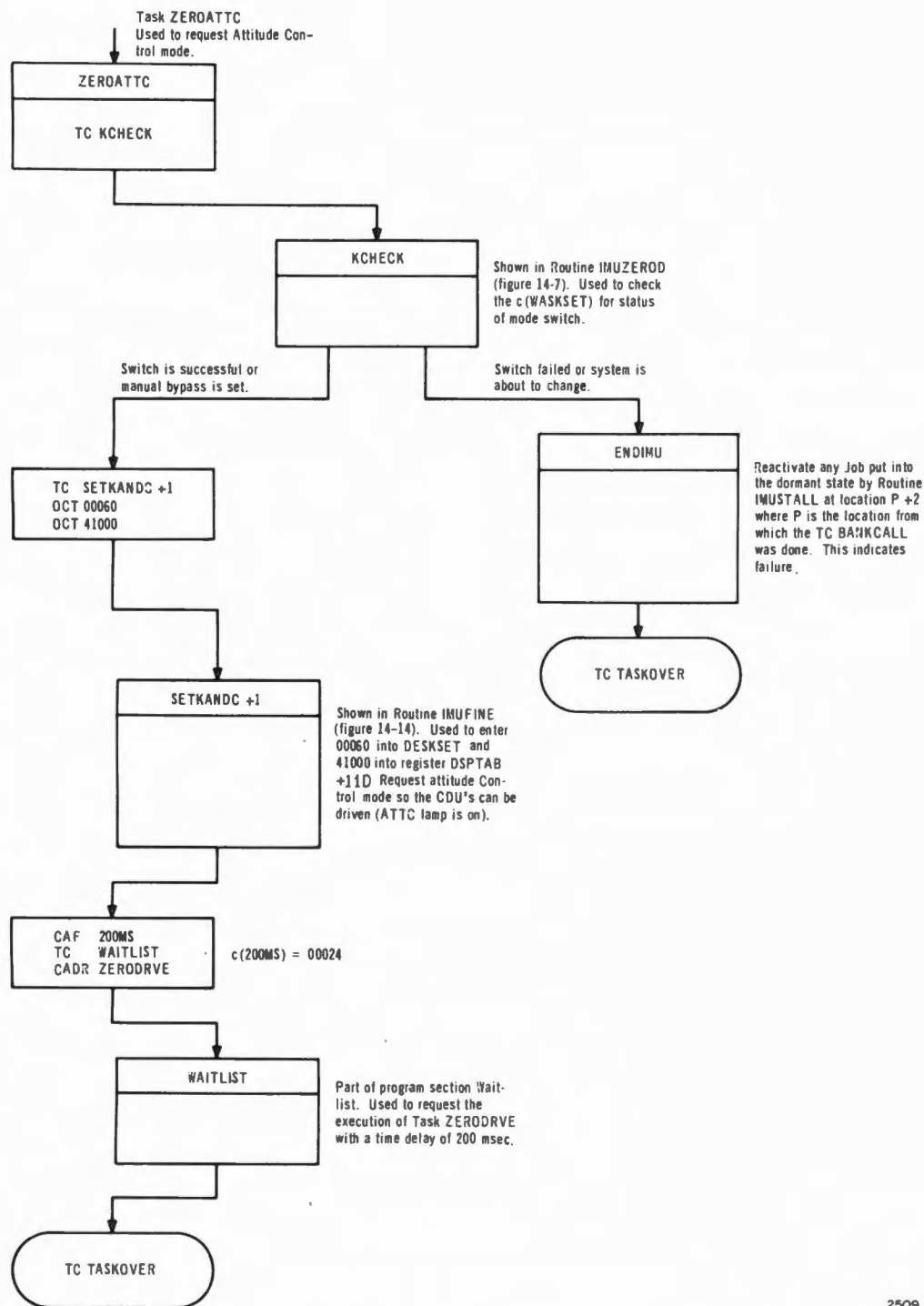
Figure 14-7. Task IMUZEROD

if WASKSET contains either of the octal quantities 77777 or 00000, control is transferred to Routine ENDIMU to indicate that either the switch was unsuccessful or that the system is about to change modes. Routine ENDIMU reactivates at location P+2 any Job put into the dormant state by Routine IMUSTALL where P is the location from which the TC BANKCALL was done. This indicates a failure as the Job would be reactivated at location P+3 if the switch had been successful. Routine ENDIMU then transfers program control to Routine FAILEND where the quantity 00000 is entered into register MODECADR if a Job was reactivated or 77777 is entered into register MODECADR if no Job was reactivated. Instruction TC TASKOVER is then executed. If register WASKSET contains a positive quantity or a negative quantity indicating that the switching was successful or that the manual bypass was set (i. e., a negative quantity entered into register WASKSET via a keyboard) program control is transferred to Routine MOREZERO.

14-25. Routine MOREZERO transfers program control to Routine SETKANDC+1 with the quantities 00050 and 40010 contained in locations L+1 and L+2 respectively where L is the location from which instruction TC SETKANDC+1 was done. The instruction bypassed by entry into the location SETKANDC+1 is an INHINT which is not necessary since this entry is made from a Task. After Routine SETKANDC enters the quantity 00050 into register DESKSET and a one into bit positions 15 and 4 of register DSPTAB+11D, Task ZEROATTC is scheduled for execution with a time delay of 10 sec and Task IMUZEROD is terminated. During the 10 sec allowed for T4RUPT to recognize the command contained in register DSPTAB+11D and for the proper relays to be set, indicator switch FINE ALIGN on the IMU control panel is illuminated. Also, the CDU's will be slaved to the IMU gimbals which causes the actual IMU gimbal angles to be reflected in the CDU display dials and counters CDUX, CDUY, and CDUZ to be updated.

14-26. Task ZEROATTC

14-27. Task ZEROATTC requests the Attitude Control mode via Routine ZEROATTC (figure 14-8). It is necessary to put the subsystem into the Attitude Control mode as it is possible that the CDU's could be reading 00:00:00 while the IMU CDU's are sitting at 180° (a false null). However, before requesting the Attitude Control mode, program control is transferred to Routine KCHECK to determine whether the previous request for the Fine Align mode was successful. If the switch was not successful, program control is transferred to Routine ENDIMU which was discussed in paragraph 14-24. If the switch was successful (or if the manual bypass is set), program control is again transferred to Routine SETKANDC at location SETKANDC+1. However, this time the



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Figure 14-8. Task ZEROATTC

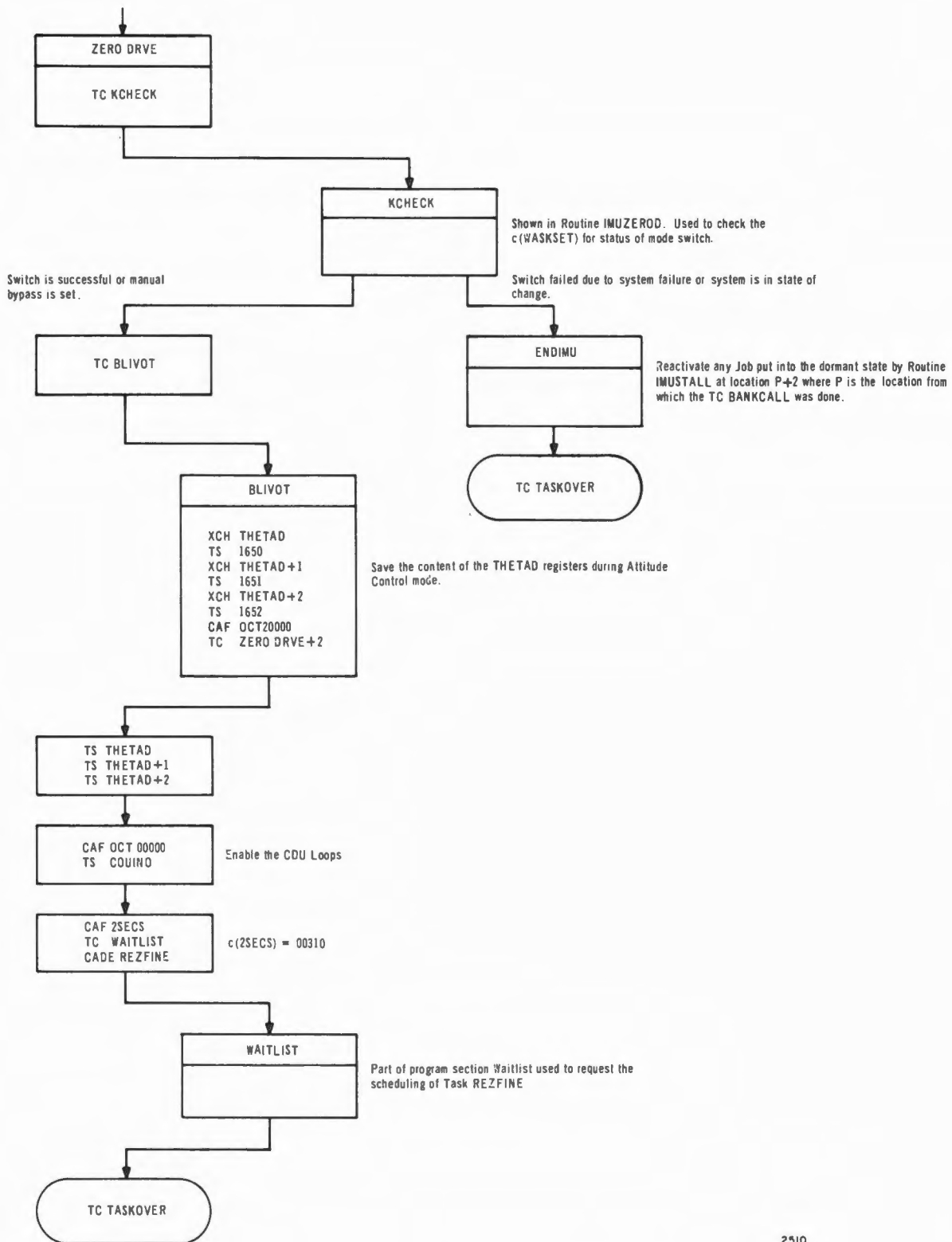
content of locations L+1 and L+2 is 00060 and 41000. After Routine SETKANDC enters the quantity 00060 into register DESKSET and a ONE into bit positions 15 and 10 of register DSPTAB+11D, Task ZERODRVE is requested to be executed with a time delay of 200 msec and Task ZEROATTC is terminated. During the 200 msec allowed for T4RUPT to recognize the command in register DSPTAB+11D and for the proper relays to be set, the ATT CONT indicator switch on the IMU Control Panel is illuminated.

14-28. Task ZERODRVE

14-29. Task ZERODRVE enables the CDU loops and enters a command into the THETAD registers to drive the CDU's off a possible false null. The command is honored during the next T4RUPT. However, before setting the content of the THETAD registers, Routine ZERODRVE (figure 14-9) transfers program control to Routine KCHECK to verify that the system is in the Attitude Control mode. In reality Routine KCHECK does not verify that the system is in the Attitude Control mode or in any other mode. However, it does check to determine if the last request for a mode switch was successful. Since requests for a mode switch are interlocked (refer to Routine IMUSTALL paragraph 14-99), the last request for a mode switch in this case would have been for the Attitude Control mode. Thus, it can be said that Routine KCHECK is executed to verify that the Inertial Subsystem is in the Attitude Control mode. It is necessary that the subsystem be in the Attitude Control mode since the gimbal angles should not be changed while the CDU's are being driven. If the subsystem is not in the Attitude Control mode, program control is transferred to Routine ENDIMU. If the system is in the Attitude Control mode, program control is transferred to Routine BLIVOT, which saves the content of registers THETAD, THETAD+1, and THETAD+2 in temporary storage locations. Routine BLIVOT then enters the octal quantity 20000 into register A and transfers program control back to Routine ZERODRVE where the content of register A is transferred to registers THETAD, THETAD+1, and THETAD+2. The CDU loops are then enabled by entering the octal quantity 00000 into register CDUIND. Next a request is made to program section WAITLIST to schedule Task REZFINE with a time delay of 2 sec and Task ZERODRVE is terminated. During the 2 sec allowed for driving the CDU's, they will be driven by about 10° .

14-30. Task REZFINE

14-31. TASK REZFINE is executed to disable the CDU loops, to restore the content of the THETAD registers, and to request that the subsystem be put into the Fine Align mode. However, before doing so,



2510

Figure 14-9. Task ZERO DRIVE

Routine REZFINE transfers program control to Routine KCHECK (figure 14-10) to verify that the subsystem is still in the Attitude Control mode. If the subsystem is not in the Attitude Control mode, program control is transferred to Routine ENDIMU which is discussed in paragraph 14-24. If the subsystem is in the Attitude Control mode, a request is made to put it in the Fine Align mode. This request is enabled by transferring program control to Routine SETKANDC at location SETKANDC+1 with the octal quantities 00050 and 40010 contained in locations L+1 and L+2 respectively where L is the location from which the TC SETKANDC+1 was done. After Routine SETKANDC enters the quantity 00050 into register DESKSET and enters a ONE into bit positions 15 and 4 of register DSPTAB+11D, the CDU loops are enabled by entering the octal quantity 00000 into register CDUIND. A request is then made to program section WAITLIST for the scheduling of Task IMUFINED with a time delay of 20 seconds. (Task IMUFINED is described in detail in paragraph 14-46.) Program control is then transferred to Routine BLIVOT2 where the content of the THETAD registers is restored and Task REZFINE is terminated.

14-32. During the 20 sec allowed before the execution of Task IMUFINED, the ATT CONT indicator switch on the IMU Control Panel is extinguished and indicator switch FINE ALIGN is illuminated. Task IMUFINED is executed to verify that the mode switch was successful and to reactivate any Job put into the dormant state by Routine IMUSTALL at location P+3 if the mode switch was successful or at location P+2 if the mode switch failed. Where P is the location from which the TC BANKCALL was done. When this reactivated Job is executed, indicator Zero Encoder on the Condition Annunciator will be turned off.

14-33. ROUTINE IMUCOARS

14-34. Routine IMUCOARS is executed to request that the Inertial Subsystem be put into the Coarse Align Mode. When the subsystem is in the Coarse Align mode, the IMU gimbals are slaved to the CDU's. Prior to executing this routine, registers THETAD, THETAD+1, and THETAD+2 must be preloaded with the desired CDU angles and registers KH and KG must be set with the desired CDU gains. When Routine IMUCOARS is executed, it is likely that the ZERO ENCODER indicator on the Condition Annunciator will be illuminated since the execution of Routine IMUCOARS is always preceded by the execution of Routine IMUZERO. (When the Zero Encode sequence was initiated via the keyboard, the ZERO ENCODER indicator is turned off prior to the completion of Job CHARIN.) Routine IMUCOARS turns off the ZERO ENCODER indicator (unless the Optics Subsystem is in the Zero Optics mode) and requests the scheduling of

Task BEGINCOM with a time delay of 200 msec. Program control is then transferred back to the routine from which the TC IMUCOARS was done. This usually results in program control being transferred to Routine IMUSTALL to put the requesting Job into the dormant state. After program section T4RUPT Output Control recognizes the request for a mode switch, indicator COARS ALIGN on the IMU Control Panel is illuminated.

14-35. Task BEGINCOM verifies that the subsystem is in the Coarse Align Mode. At this point it should be noted that Task BEGINCOM does not verify that the Inertial Subsystem is in the Coarse Align mode but that a request for a mode switch has been successful. Since requests for a mode switch are interlocked against each other (refer to Routine IMUSTALL paragraph 14-99) once a request is made via Routine IMUCOARS for the Coarse Align mode, there will be no additional request for a mode change until the execution of Task BEGINCOM. Thus, it can be said that Task BEGINCOM is executed to verify that the system is in the Coarse Align mode.

14-36. If the subsystem is not in Coarse Align mode, program control is transferred to Routine ENDIMU where any Job put into the dormant state by Routine IMUSTALL is reactivated at location P+2 where P is the location from which the TC BANKCALL was done. Reactivating a Job at location P+2 indicates that the switch has failed. If the subsystem is in the Coarse Align mode, the CDU loops are enabled and a request is made to schedule Task COARSDON with a time delay of 60 sec. During the 60 sec delay, the CDU's are driven by T4RUPT Output Control, the CDU counters are updated, and, since the IMU gimbals are slaved to the CDU's, the gimbal angles are changed. Because the CDU's are commanded at the rate of $4.5^{\circ}/\text{sec}$, 60 sec is enough time to ensure that the driving will be completed. When Task COARSDON is executed, any Job put into the dormant state by Routine IMUSTALL is reactivated at location P+2 if indicator CDU FAIL was turned on, or at location P+3 if the indicator was not turned on. The Inertial Subsystem remains in the Coarse Align mode.

14-37. Routine IMUCOARS (figure 14-11) requests that the Inertial Subsystem be put into the Coarse Align mode by transferring program control to routine SETKANDC with the quantities 00042 and 40002 in locations L+1 and L+2 respectively where L is the location from which the TC SETKANDC was done. Routine SETKANDC, operating under an INHINT, enters the quantity 00042 into register DESKSET (to indicate the computer is in control and to request the Coarse Align mode) and a ONE into bit positions 15 (to signal T4RUPT Output Control that new mode information is available), and 2 (to indicate the Coarse Align mode is requested) of register DSPTAB+11D. Program control is then

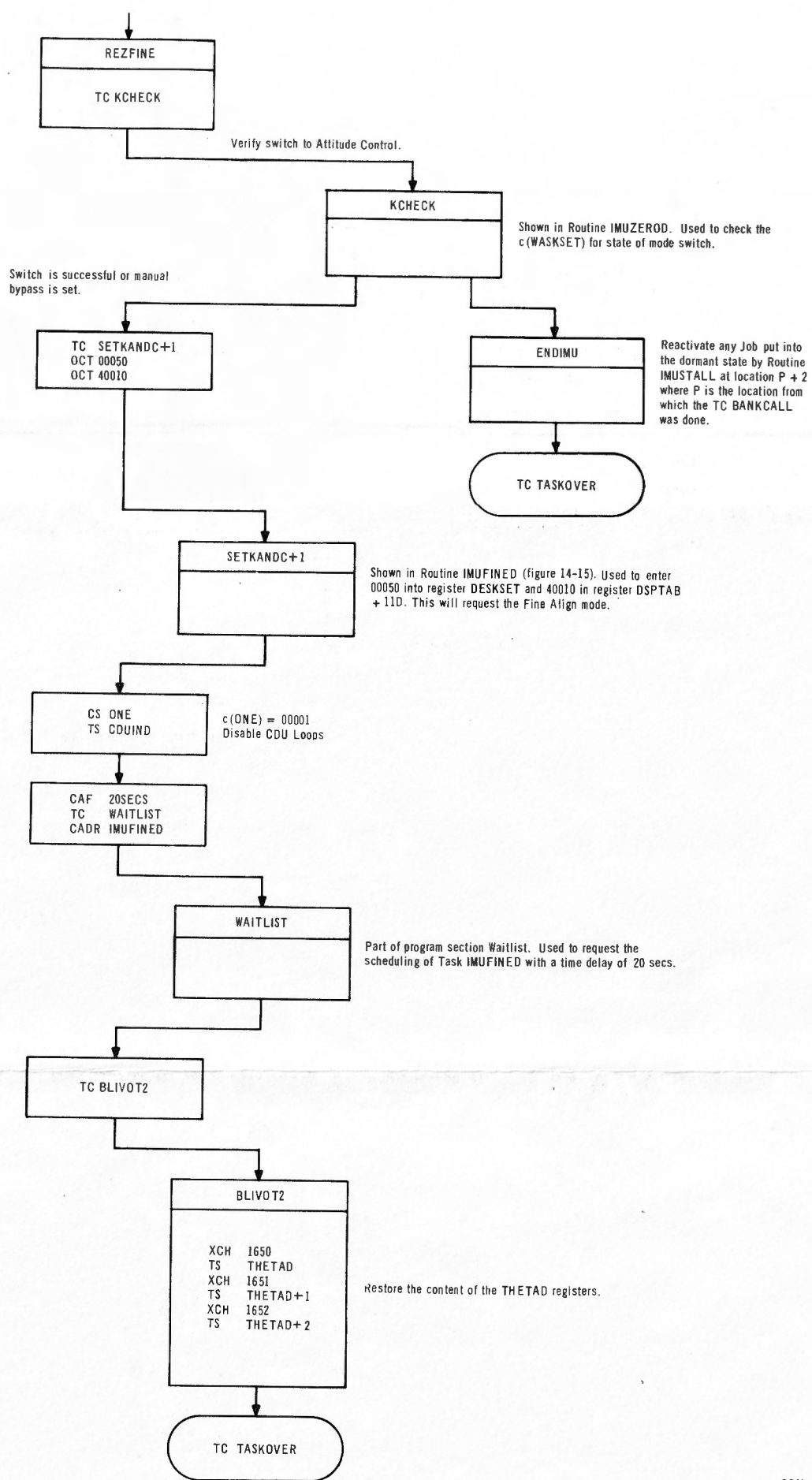


Figure 14-10. Task REZFINE

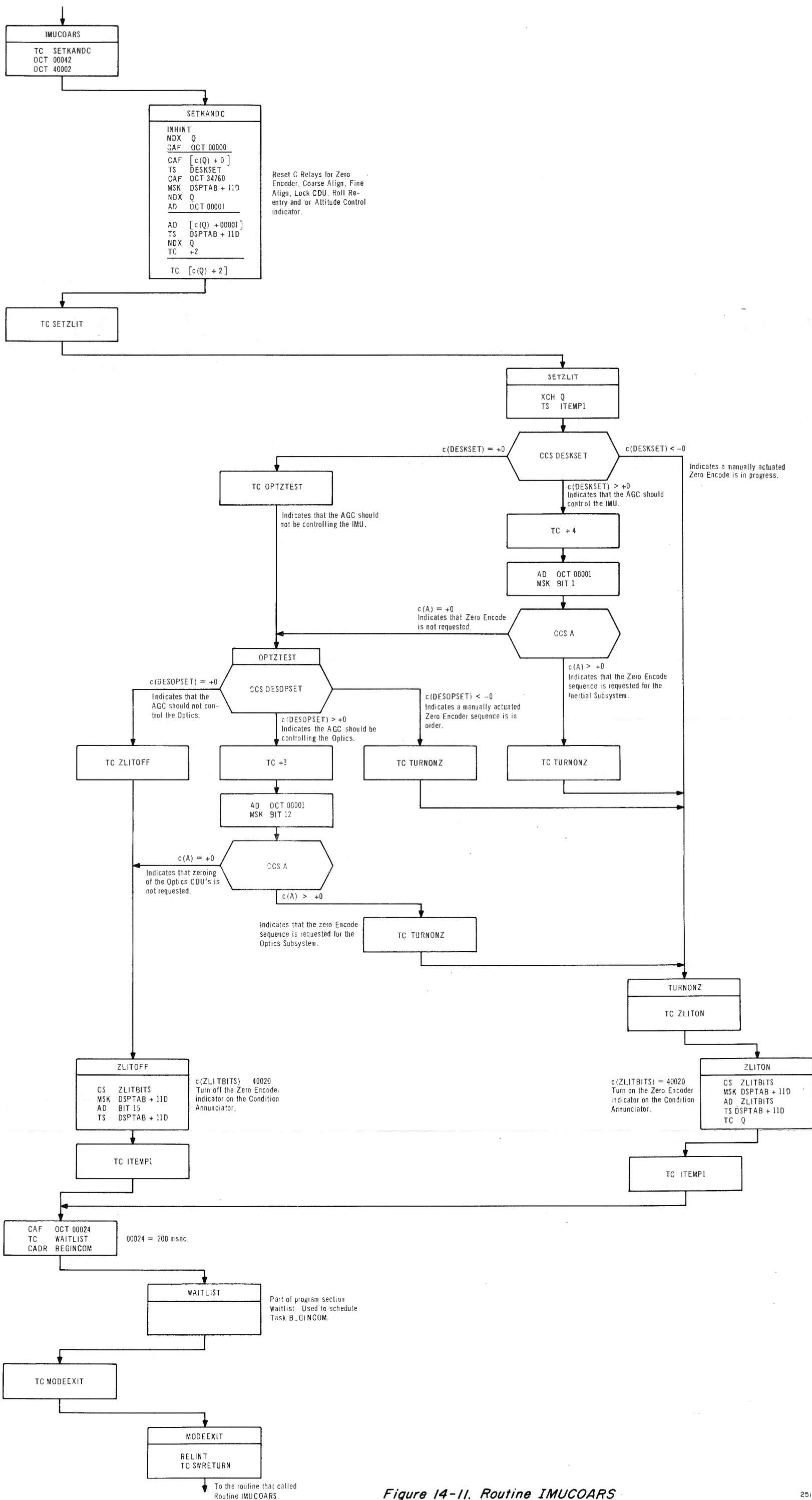


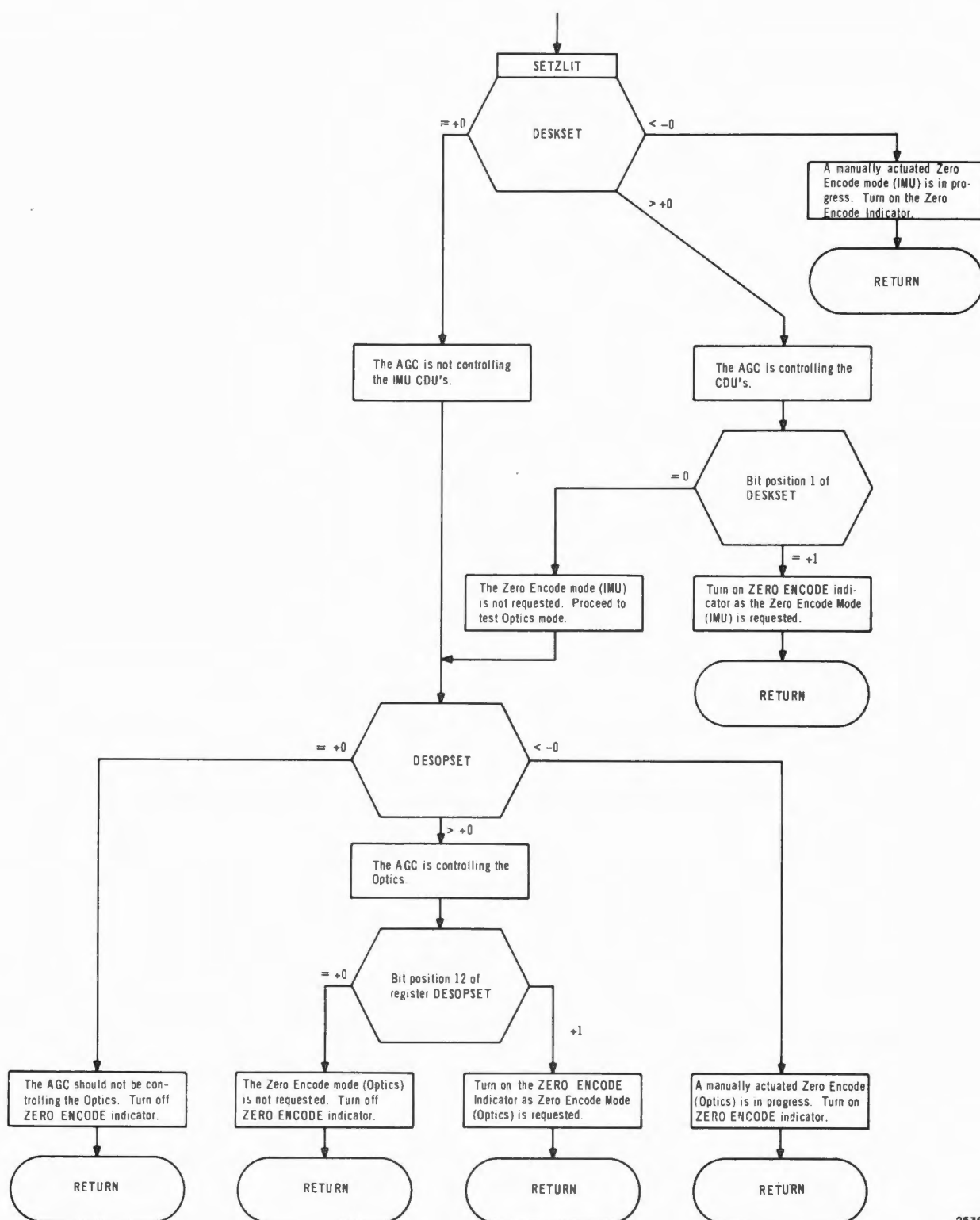
Figure 14-11. Routine IMUCOARS

transferred to Routine SETZLIT to turn off the ZERO ENCODER indicator on the Condition Annunciator provided the Optics Subsystem is not in the Zero Encode mode.

14-38. Routine SETZLIT controls the ZERO ENCODER indicator on the Condition Annunciator. If the indicator is to be turned off, a ONE is entered into bit position 15 and a ZERO is entered into bit position 1 of register DSPTAB+11D. If the indicator is to be illuminated, a ONE is entered into both bit positions 15 and 1 of register DSPTAB+11D. The specific action taken in regard to the ZERO ENCODER indicator depends upon the content of registers DESKSET and DESOPSET as illustrated in figure 14-12. After the ZERO ENCODER indicator has been set (either on or off), program control is transferred to program section WAITLIST to schedule Task BEGINCOM with a time delay of 200 msec. A RELINT is given and program control is transferred back to the routine from which the TC IMUCOARS was done. This results in program control being transferred to Routine IMUSTALL to put the requesting Job into the dormant state.

14-39. Task BEGINCOM

14-40. Task BEGINCOM (figure 14-13) verifies that the Inertial Subsystem is in the Coarse Align mode by testing the content of register WASKSET. If register WASKSET contains 00000 or 77777 indicating the subsystem is about to change or that the subsystem failed to achieve the desired mode respectively, program control is transferred to Routine ENDIMU (paragraph 14-46 through 14-51) to reactivate at location P+2 any Job put into the dormant state by Routine IMUSTALL where P is the location from which the TC BANKCALL was done. Reactivating a dormant Job at location P+2 indicates the requested mode was not achieved. Program control is then transferred to Routine FAILEND where the quantity 77777 is entered into register MODECADR if no Job was reactivated or the quantity 00000 if a Job was reactivated by Routine ENDIMU. If register WASKSET contains a positive quantity indicating the desired mode has been achieved, or a negative quantity, indicating the manual bypass is set, program control is transferred to Routine STARTCRS. (The manual bypass is set by keying in VERB, 01, NOUN, 01, ENTER, 00747, ENTER, 40000, ENTER via a keyboard.) Routine STARTCRS enables the CDU loops by entering the quantity 00000 into register CDUIND. (T4RUPT Output Control will drive the CDU's according to the differences between the contents of registers CDUZ and THETAD+2, CDUY and THETAD+1, and CDUX and THETAD. The THETAD registers must be set prior to the execution of Routine IMUCOARS.) Program control is transferred to program section WAITLIST to schedule Task COARSDON with a time delay of 60 seconds.



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Figure 14-12. Routine SETZLIT

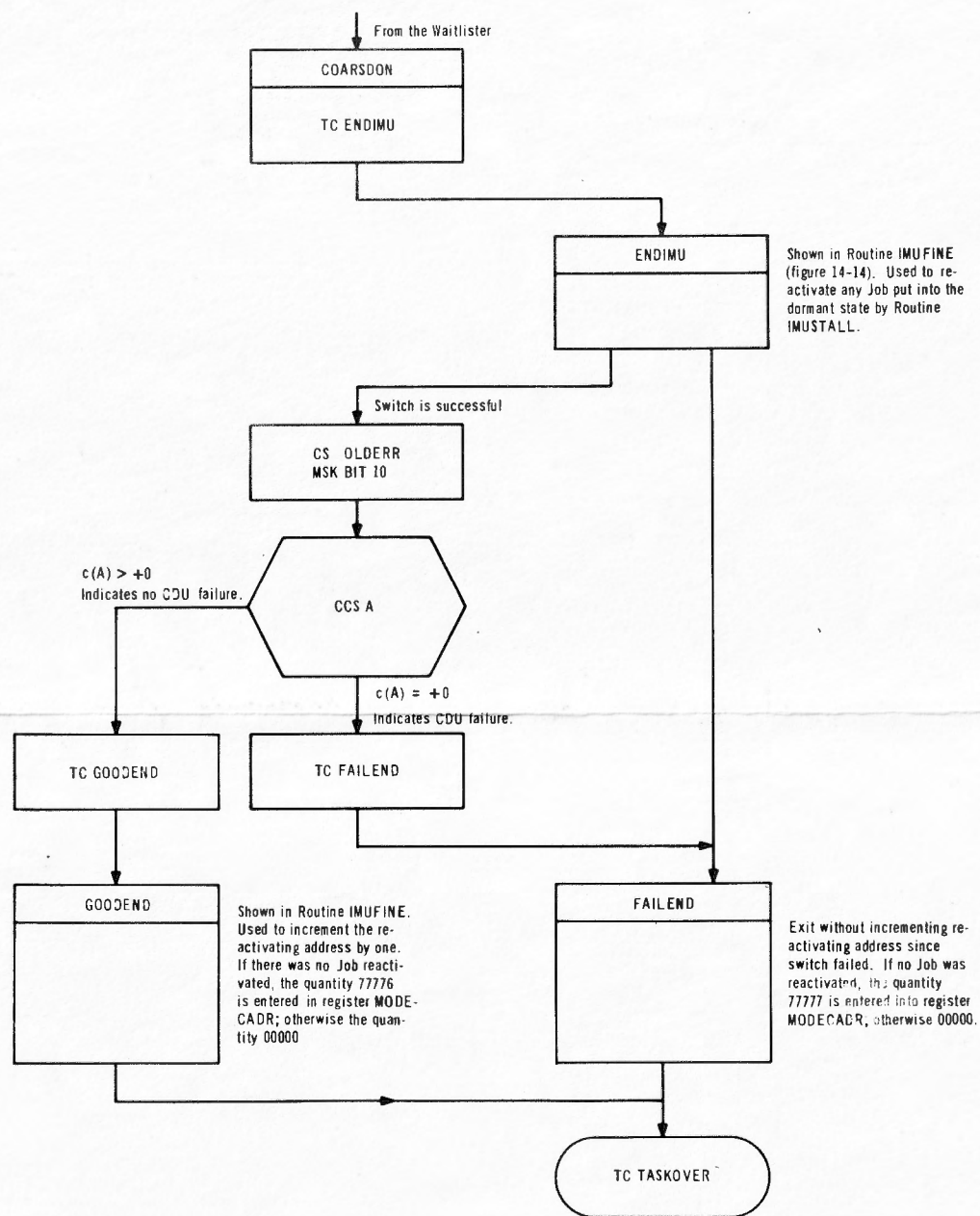
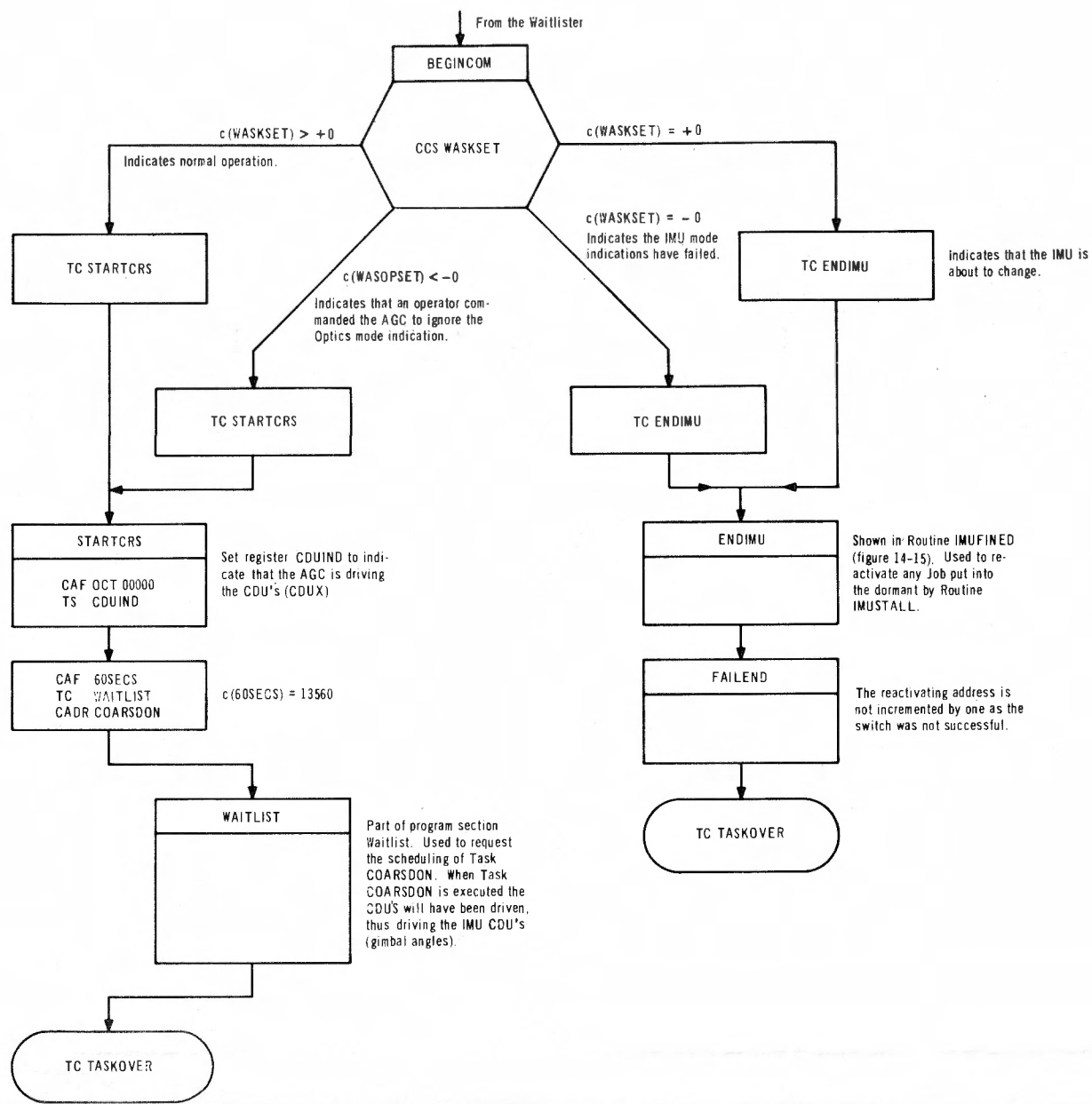


Figure 14-13. Tasks BEGINCOM and COARSDON

14-41. Task COARSDON

14-42. Task COARSDON (figure 14-13) transfers program control to Routine ENDIMU to reactivate any Job put into the dormant state by Routine IMUSTALL. (It is possible that there might not be one.) Routine ENDIMU (paragraph 14-46 through 14-51) also tests the content of register WASKSET which should not have been changed since it was tested during the execution of Task BEGINCOM. Thus, after reactivating any Job put into the dormant state by Routine IMUSTALL, program control is transferred back to Routine COARSDON where the content of bit position 10 of register OLDERR is tested. If bit position 10 contains a ZERO, the CDU FAIL indicator on the Condition Annunciator has been illuminated and program control is transferred to Routine FAILEND. Routine FAILEND enters the quantity 00000 or 77777 into register MODECADR if a Job was reactivated, or not reactivated respectively. If bit position 10 of register OLDERR contains a ZERO, the CDU FAIL indicator has not been turned on and program control is transferred to Routine GOODEND incrementing by one the awakening address of a Job reactivated by Routine ENDIMU and enters the quantity 00000 into register MODECADR. If no Job was reactivated by Routine ENDIMU, the quantity 77776 is entered into register MODECADR.

14-43. ROUTINE IMUFINE

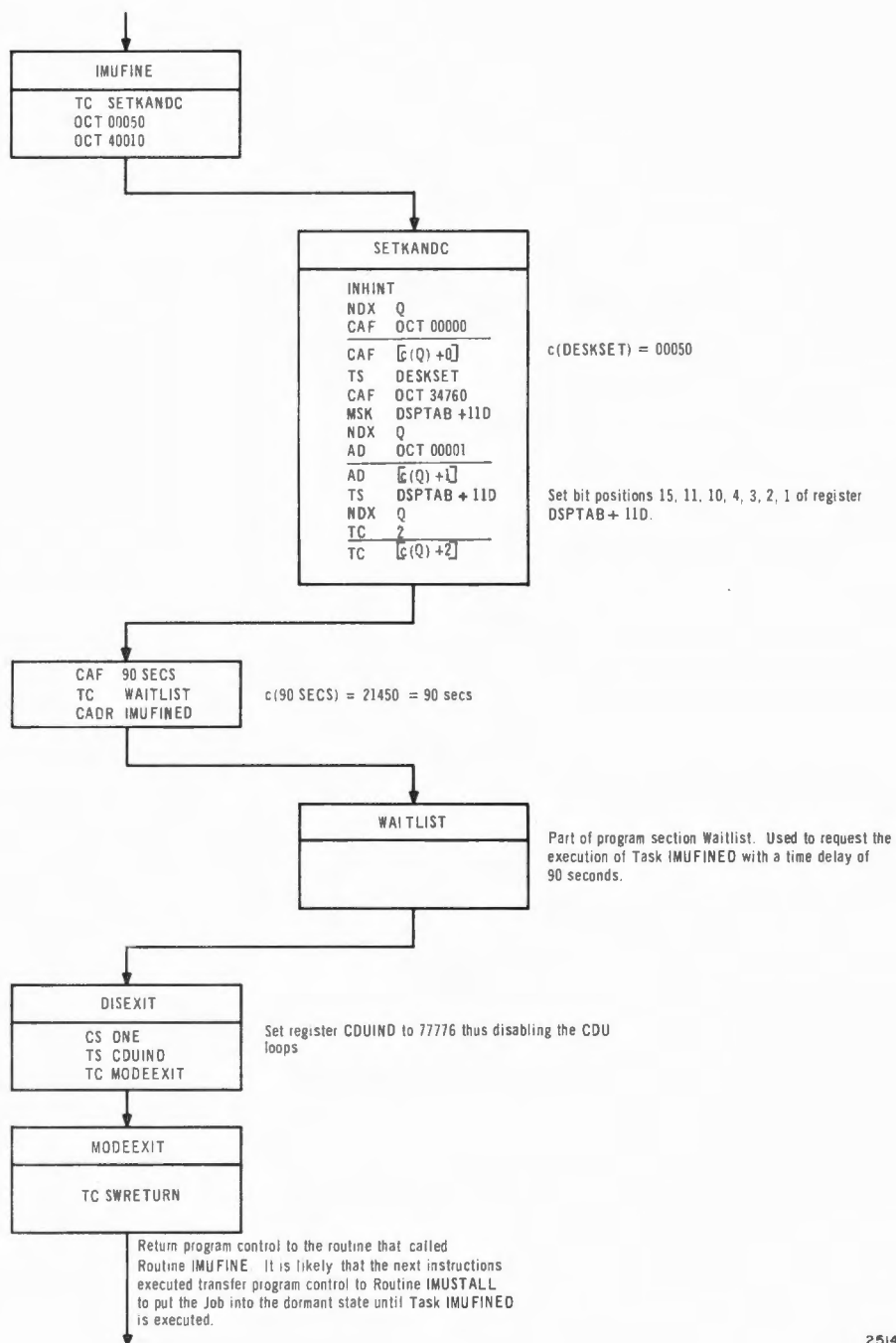
14-44. Routine IMUFINE requests that the Inertial Subsystem be put into the Fine Align mode. When the subsystem is in the Fine Align mode, the CDU's are slaved to the IMU gimbal angles and the gyros are pulsed by Routine IMUPULSE. Program control is transferred to Routine IMUFINE before executing Routine IMPULSE as the Inertial Subsystem must be in the Fine Align mode before the gyros can be pulsed. The Fine Align mode also disables the CDU loops and requests Task IMUFINED. After the execution of Routine IMUFINE, program control will be transferred to Routine IMUSTALL where the requesting Job is put into the dormant state until the subsystem is established in the requested mode. Task IMUFINED is executed to reactivate any Job put into the dormant state by Routine IMUSTALL and to verify that the system is indeed in the requested mode. At this point, it should be noted that Task IMUFINE does not verify that the Inertial Subsystem is in the Fine Align mode but that a request for a mode switch has been successful. Since by convention, routines that request a mode switch will never interfere with each other, once a request is made via Routine IMUFINE for the Fine Align mode, there will be no additional requests for a mode change until after the execution of Task IMUFINED. Thus, it can be said that Task IMUFINED is executed to verify that the subsystem is in the Fine Align mode.

14-45. Routine IMUFINE (figure 14-14) requests the Fine Align mode by transferring program control to Routine SETKANDC with the octal quantities 00050 and 40010 contained in locations L+1 and L+2 where L is the location from which the TC SETKANDC was done. After Routine SETKANDC enters the quantity 00050 into register DESKSET and enters a ONE into bit positions 15 (new mode information) and 4 (Fine Align mode) of register DSPTAB+11D, program control is transferred to program section WAITLIST to request the execution of Task IMUFINED with a time delay of 90 seconds. Then the CDU loops are disabled by entering the quantity 77776 into register CDUIND and program control is then transferred back to the routine from which the TC IMUFINE was done. This eventually results in program control being transferred to Routine IMUSTALL (paragraph 14-99) to put the Job into the dormant state. After program section T4RUPT Output Control recognizes the command contained in registers DSPTAB+11D, indicator switch FINE ALIGN on the IMU Control Panel is illuminated, the proper relays are set so that the CDU's are slaved to the IMU gimbal angles and the gyros are recentered. A time delay of 90 sec is allowed for these actions.

14-46. Task IMUFINED

14-47. Task IMUFINED (figure 14-15) begins execution at Routine IMUFINED which immediately transfers program control to Routine ENDIMU. Routine ENDIMU transfers the quantity 00000 to register A and on to register RUPTREG2. (Routine ENDOPT, the Optics equivalent for Routine ENDIMUO, transfers the quantity 00001 to register A before transferring program control to location ENDIMU+1 which contains TS RUPTREG2.) The content of register RUPTREG2 is used to index the address of registers MODECADR and WASKSET to obtain the content of the proper register. Register MODECADR contains the reactivating address of any Job put into the dormant state by Routine IMUSTALL while register OPTCADR at address MODECADR+1 contains the reactivating address of any Job put into the dormant state by Routine OPTSTALL. Register WASKSET contains information pertaining to the IMU CDU's and register WASOPSET at address WASKSET+1 contains information pertaining to the OPTICS. In this discussion, it is assumed the content of register RUPTREG2 contains 00000; therefore, indexing with the content of register RUPTREG2 yields registers MODECADR or WASKSET.

14-48. If register MODECADR contains a positive quantity, this indicates a Job was put into the dormant state by Routine IMUSTALL. The content of register MODECADR is then transferred to register A and program control is transferred to Routine JOBWAKE to reactivate this Job and program control is transferred to Routine ENDMODE. If register MODECADR contains 00000, indicating no Job was put into the



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Figure 14-14. Routine IMUFINE

dormant state by Routine IMUSTALL, program control is transferred directly to Routine ENDMODE where the content of register WASKSET is tested.

14-49. If register WASKSET contains 77777 (the mode switch failed) or 00000 (the system is in a state of change), program control is transferred to Routine FAILEND where the quantity 00000 is entered into register MODECADR if a Job was reactivated during the execution of Routine ENDIMU. The failure of the mode switch or the fact that indicators CDU FAIL or IMU FAIL are on is reflected in the fact that the reactivating address is not incremented. If no Job was reactivated during the execution of Routine ENDIMU, the quantity 77777 is entered into register MODECADR to indicate the switch failed or indicators CDU FAIL or IMU FAIL were turned on. Instruction TC TASKOVER is then executed.

14-50. If register WASKSET contains a positive quantity (mode switch successful) or a negative quantity (manual bypass set), program control is transferred back to the routine from which the TC ENDIMU (or the TC ENDIMU+1 in the case of Optics) was done. In this discussion, program control is transferred back to Routine IMUFINED for more checking. Routine IMUFINED tests the content of bit positions 10 and 12 of register OLDERR to determine whether the CDU FAIL or IMU FAIL indicator has been turned on. If either the CDU FAIL or the IMU FAIL indicator has been illuminated, program control is transferred to Routine FAILEND (paragraph 14-42). If neither indicator has been turned on, program control is transferred to Routine GOODEND where the reactivating address of the Job that was put into the dormant state by Routine IMUSTALL is incremented by one. (Since the reactivating address is stored in complement form, in reality, the $c(LOC_J)$ is decremented by one). The quantity 00000 is then transferred to register MODECADR to indicate a Job was reactivated during the execution of Routine ENDIMU. A successful mode switch is indicated by incrementing the reactivating address by one. If no Job was reactivated during the execution of Routine ENDIMU, Routine GOODEND transfers the quantity 77776 to register MODECADR to indicate a successful switch and instruction TC TASKOVER is executed.

14-51. The situation in which Routine ENDIMU does not find a Job to be reactivated occurs when a request for a mode switch is separated from a request for Routine IMUSTALL by a long computation. If the length of this computation is such that the mode switching operation has time to be completed, Routine IMUSTALL does not put the Job into the dormant state. If the switch was successful program control is transferred to location P+3 where P is the location from which the

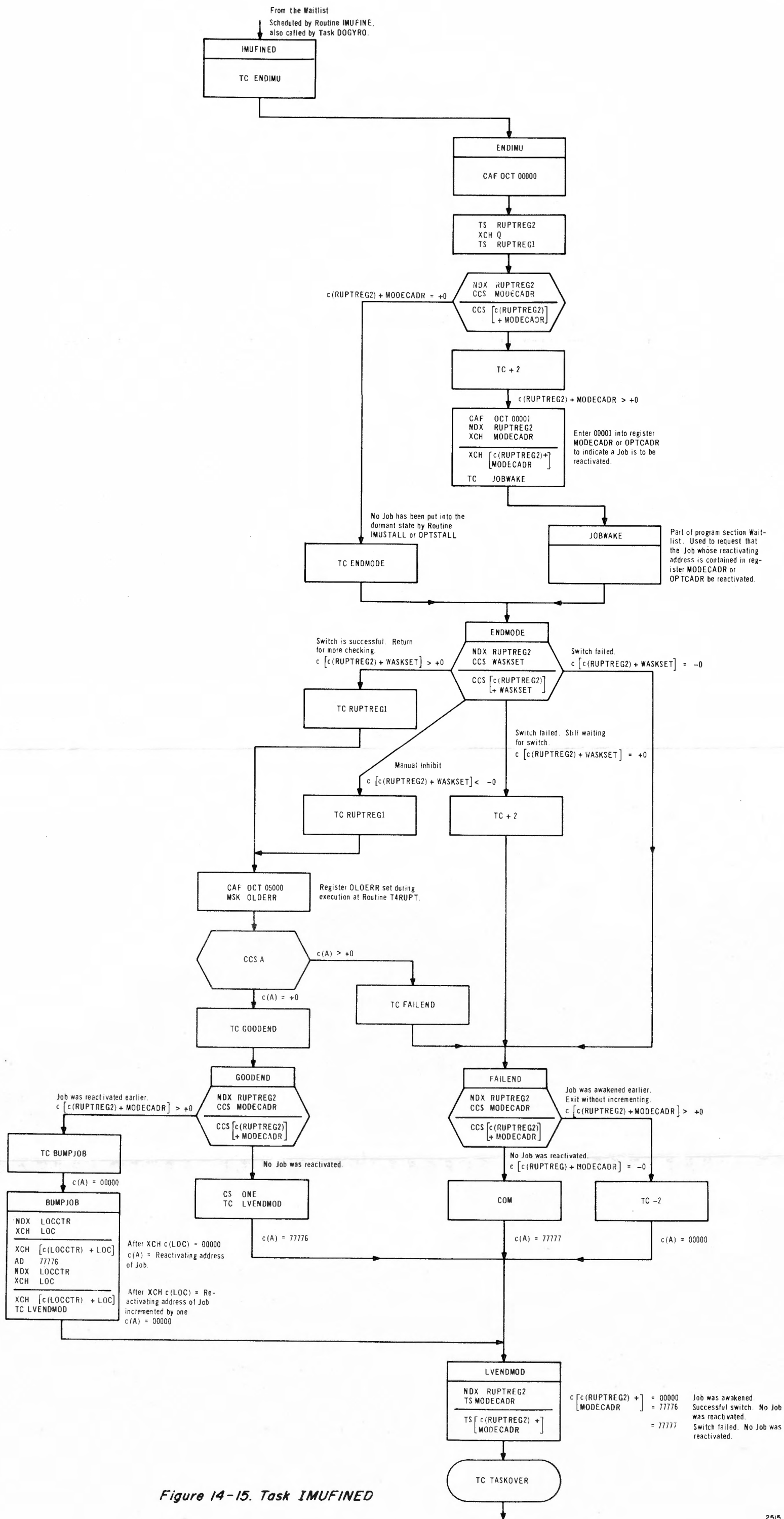


Figure 14-15. Task IMUFINED

TC BANKCALL, was done. If the switch was not successful program control is transferred to location P+2. (Routine IMUSTALL is described in detail in paragraph 14-99.)

14-52. ROUTINE IMUPULSE

14-53. A program section transfers control to Routine IMUPULSE to pulse-torque the IMU gyros according to commands contained in registers $GYROD+2n$ and $GYROD+2n+1$ where n equals 0, 1, or 2. Pulsing a gyro may be thought of as transferring a positive form of the command from a GYROD register to register OUTCR1 and the destination and direction of the command to a portion of register OUT2. Registers OUTCR1 and OUT2 are set under the auspices of a Task.

14-54. Assume it is desired to pulse the X-axis gyro in the positive direction 1000_{10} times. (One pulse equals 1.2345_{10} arc seconds; therefore, 1000_{10} pulses changes the angle between the X-axis of the stable platform and the spacecraft co-ordinate system by 1234.5 arc sec or approximately +0.34 arc deg.) The pulsing action is performed as follows:

- a. A ONE is entered into bit positions 14, 12, and 11, and a ZERO is entered into bit positions 15, 13, 10, and 9 of register OUT2. (Refer to Table 15-6 for bit assignments of register OUT2.)
- b. The quantity 36026 is entered into register OUTCR1 and each time the gyro is pulsed, the content of register OUTCR1 is incremented by ONE. When register OUTCR1 overflows (contents of OUTCR1 equals 40000_8), the pulsing is terminated and the corresponding section of register OUT2 is cleared. ($40000_8 - 36026_8 = 01752_8 = 01002_{10}$.) For this example, it was assumed that the desired number of pulses is 01000_{10} . The discrepancy of +2 is rectified by following the command to pulse the gyro on the X-axis in the positive direction 01002_{10} times with a command to pulse the same gyro in the negative direction two times.

14-55. Assuming the Inertial Subsystem is in the Fine Align mode when Routine IMUPULSE is executed, pulsing the gyros causes the IMU gimbal angles (angle between the stable platform and the Spacecraft) to change. Since the CDU's are slaved to the gimbal angles, this change is reflected in the CDU counters and the CDU display dials. The following paragraphs contain a discussion of the manner in which Routine IMUPULSE implements the function of pulsing each of the gyros.

14-56. Routine IMUPULSE (figure 14-16) enters the quantity 77774 into register CDUIND not only to reserve the CDU's but also to indicate the Y gyro is to be pulsed first. Routine IMUPULSE then translates the double-precision command contained in registers GYROD+2n and GYROD+2n+1 where n equals 0, 1, or 2 and enters this new command back into the GYROD registers. The translation is executed as follows:

- a. Routine TPAGREE forces sign agreement between registers GYROD and GYROD+1, GYROD+2 and GYROD+3, and GYROD+4 and GYROD+5.
- b. The content of register GYROD+1 is incremented or decremented by two depending upon whether the content of register GYROD is positive or negative. Similarly the content of register GYROD+3 is incremented or decremented by two depending upon the content of register GYROD+2; the content of register GYROD+5 is incremented or decremented by two depending upon the content of register GYROD+4.
- c. The content of register GYROD+2n is added to the content of register GYROD+2n+1. If overflow occurs as a result of either this addition or the operations in part b, the overflow or underflow is added to the content of the high order GYROD register. This addition is done as each bit in the high order part of the GYROD register specifies 2^{14} pulses (40000₈ pulses) and each bit in the low order command register specifies one pulse. The maximum number of positive or negative pulses that can be sent per command is 37777. The content of the high order GYROD register determines how many 37777-pulse commands are sent. Thus the extra pulses are added to the content of the low order GYROD register at this point.
- d. A Request is made to schedule Task DOGYRO with a time delay of 10 msec.
- e. The routine that called IMUPULSE regains program control. It is likely that the instructions executed next will transfer program control to Routine IMUSTALL to put the Job into the dormant state until the gyros have been pulsed.

14-57. Task DOGYRO

14-58. Task DOGYRO (via Routine DOGYRO) enters a command from one of the GYROD registers into register OUTCR1 and, dependent upon

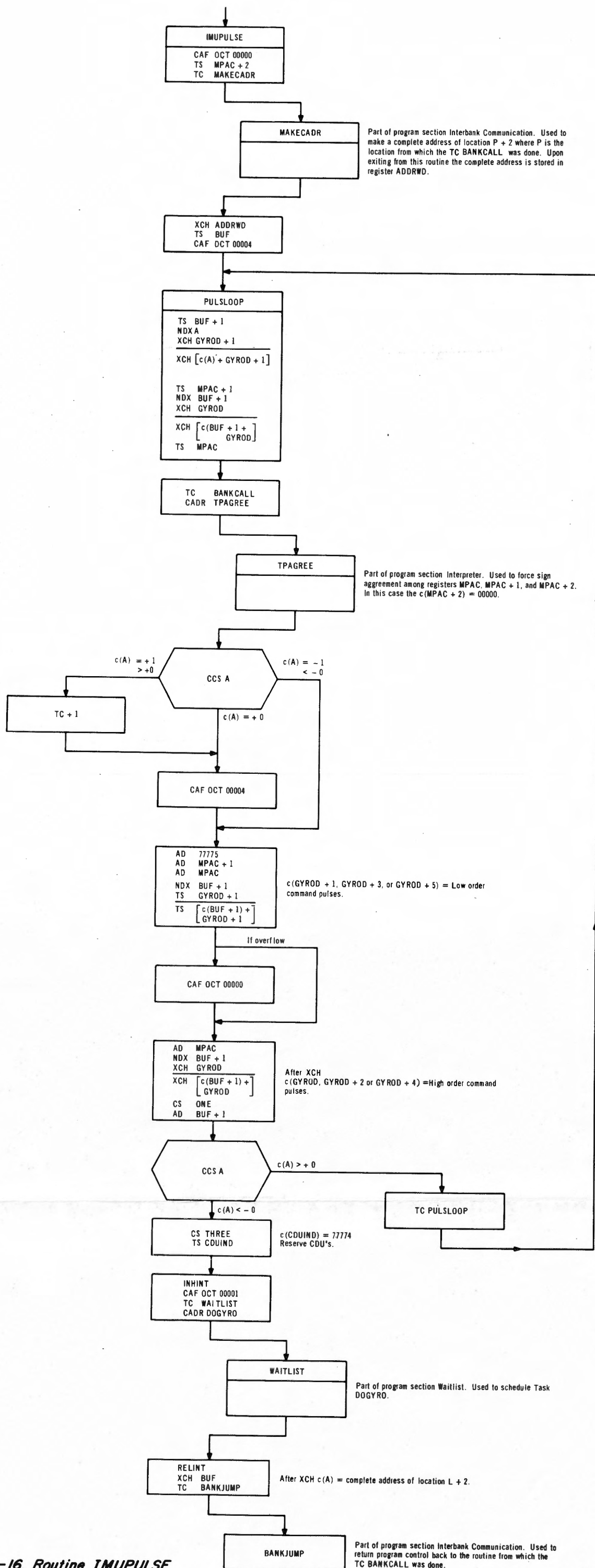


Figure 14-16. Routine IMUPULSE

the content of the specific GYROD register used, enters the destination of the command into register OUT2. Registers GYROD and GYROD+1, GYROD+2 and GYROD+3, and GYROD+4 and GYROD+5 contain commands to pulse the gyros on the X, Y, and Z axes respectively. The pulsing direction (either positive or negative) depends upon whether the high order GYROD register (GYROD, GYROD+2, or GYROD+4) contains a positive or a negative quantity. After the proper quantities are entered into registers OUTCR1 and OUT2, Routine DOGYRO calculates the time necessary for register OUTCR1 to overflow (i. e., the time it will take for the gyro to be pulsed according to the command in register OUTCR1). Routine DOGYRO then requests the scheduling of a Task (GYROADV, TWEAGY or DOGYRO) with a time delay 20 msec greater than the time just calculated to allow for a margin of safety.

14-59. When the scheduled Task is executed, it again executes Routine DOGYRO to pulse one of the gyros according to the command in a GYROD register. This Task in turn schedules another Task and this process is continued until all three gyros have been pulsed according to the commands contained in all the GYROD registers. The Z axis gyro is not pulsed until after the Y axis gyro has been pulsed according to the entire command in registers GYROD+2 and GYROD+3. Similarly, the X axis gyro is not pulsed until after the Z axis gyro has been pulsed according to the entire command in registers GYROD+4 and GYROD+5. The Task, scheduled after the low order part of the command to the X axis gyro has been sent, transfers program control to Routine IMUFINED (paragraph 14-46) to reactivate any Job put into the dormant state by Routine IMUSTALL.

14-60. The initial command to any gyro must be positive (the gyro must first be pulsed in a positive direction) and conversely the last command to any gyro must be negative. If the first command to be sent is negative, a command to pulse the gyros twice in the positive direction precedes the sending of the negative command. The content of a GYROD register that contains a negative command is decremented by two during the execution of Routine DOGYRO (paragraph 14-57). If the first command to be sent is positive, it is sent directly; however, it is followed by a command to pulse the gyros twice in the negative direction. Routine IMUPULSE increments by two the content of a GYROD register containing a positive quantity.

14-61. When Routine IMUPULSE requests the scheduling of Task DOGYRO, it sets the contents of register CDUIND to 77774 which reserves the CDU's and indicates that the first gyro to be pulsed is the Y gyro. Task DOGYRO (attachment 14-1), which begins execution at Routine DOGYRO, immediately transfers program control to Routine SETUPSUB.

14-62. Routine SETUPSUB enters the quantity 00000 into register RUPTREG2, and this quantity is used during the execution of Routine OUT2SUB to initialize register OUT2. The content of register CDUIND is then complemented and the content of the low three bit positions are transferred to register RUPTREG1. The content of register RUPTREG1 is utilized during the execution of Routine OUT2SUB to set register OUT2. Finally, Routine SETUPSUB fabricates an indexing quantity to obtain the specific GYROD register from which the pulsing command is to be taken. This quantity is obtained by doubling the quantity contained in register RUPTREG1 and entering this quantity into register RUPTREG3. Thus, the content of register RUPTREG3 is 00006, 00010, or 00004 depending upon whether the content of register RUPTREG1 is 00003, 00004, or 00002 respectively. The addresses of the proper high and low order registers are obtained by indexing location GYROD-4 and GYROD-3 with the content of register RUPTREG3.

14-63. Since register CDUIND contains 77774, the Y gyro is pulsed first and thus the description of Routine DOGYRO centers around the pulsing of the Y gyro. It should be kept in mind that after pulsing the Y gyro, the content of register CDUIND is updated and Routine DOGYRO is executed to pulse the Z and X gyros. The updating of register CDUIND is a function of Tasks TWEAKGY and GYROADV.

14-64. After the execution of Routine SETUPSUB, Routine DOGYRO transfers program control to one of three routines (DOPOSMAX, DONEGMAX, or DOMINOR) depending upon the content of the register specified by indexing the content of register RUPTREG3 with location GYROD-4. For ease of description, it is assumed that the above indexing operation yields register GYROD+2. In subsequent but not necessary consecutive executions of Routine DOGYRO, this indexing yields register GYROD+4 or GYROD. If register GYROD+2 contains a positive quantity (N), indicating the Y gyro should be pulsed N times in the positive direction, program control is transferred to Routine DOPOSMAX (paragraph 14-65). If register GYROD+2 contains a negative quantity (-N) indicating that the Y gyro should be pulsed N times in the negative direction, program control is transferred to Routine DONEGMAX (paragraph 14-66). If register GYROD+2 contains either 00000 or 77777 indicating no POSMAX or NEGMAX commands, program control is transferred to Routine DOMINOR (paragraph 14-68).

14-65. Routine DOPOSMAX decrements the content of register GYROD+2 by one and transfers the quantity 37777 to register A. Program control is then transferred to Routine OUT2SUB to send the POSMAX command (pulse the Y gyro 37777 times in the positive direction). Routine OUT2SUB implements this action by entering the quantity

00001 into register OUTCR1 and by setting the content of bit positions 14, 12, and 10 of register OUT2 to ONE and the content of bit positions 15, 13, 11, and 9 to ZERO. (If Routine DOGYRO is executed to pulse the Z gyro, the content of bit positions 14, 12, and 9 of register OUT2 is set to ONE and the content of bit positions 15, 13, 11, and 10 is set to ZERO. Similarly if Routine DOGYRO is executed to pulse the X gyro, the content of bit positions 14, 12, and 11 is set to ONE and the content of bit positions 15, 13, 10, and 9 is set to ZERO.) Since Routine OUT2SUB is a part of program section T4RUPT Output Control, it is not described here. Routine DOPOSMAX then requests the scheduling of Task DOGYRO with a time delay of 5.13 sec and instruction TC TASKOVER is executed. (Since the gyros are pulsed at a rate of 3200 pulses/sec, Task DOGYRO will not be executed again until after the gyros have been pulsed according to the command in register OUTCR1.)

14-66. Routine DONEGMAX increments the content of register GYROD+2 by one and, since the first command to a gyro must be positive, a command is sent to pulse the gyros twice in the positive direction. This command is implemented by transferring the quantity 00002 to register A and then transferring program control to Routine OUT2SUB. Bit position 14 of register CDUIND is set to ZERO to indicate that a command for two pulses in the positive direction has been sent. (The content of register CDUIND is always in complemented form during the pulsing of the gyros.) Bit position 14 of register CDUIND will not be set to ONE until the execution of Task TWEAKGY or Task GYROADV. If Routine DONEGMAX is executed again without first having executed Tasks TWEAKGY or GYROADV, indicating that the same gyro is still being pulsed, the command for two pulses in the positive direction is bypassed. Routine DONEGMAX waits for the pulses to be delivered, transfers the quantity 40000 to register A and then transfers program control to Routine OUT2SUB to send the NEGMAX command. Routine OUT2SUB accomplishes the sending of the NEGMAX command by entering the quantity 00001 into register OUTCR1 and by entering a ONE into bit positions 14, 13, 11, and 9 of register OUT2. Routine DONEGMAX then requests the scheduling of Task DOGYRO with a time delay of 5.13 sec. (Notice that the content of register OUTCR1 is set to the same quantity during the sending of either a POSMAX or NEGMAX command. The difference lies in the setting of register OUT2.)

14-67. Both Routines DOPOSMAX and DONEGMAX request the scheduling of Task DOGYRO. When task DOGYRO is executed, it is likely that program control will be transferred to Routine DOMINOR because the high order command registers seldom contain a quantity greater than 00001 or less than 77776. In fact, most often the high order command registers contain ZERO which forces program control immediately to

Routine DOMINOR. This is evident from the angle through which a POSMAX or NEGMAX command pulse torques a gyro.

14-68. Routine DOMINOR tests the content of the register specified by indexing location GYROD-3 with the content of register RUPTREG3. If no other gyros have been pulsed, this indexing yields register GYROD+3. Throughout the discussion of this routine it is assumed that the other gyros have not as yet been pulsed (i. e. Routine DOGYRO is being executed to pulse the gyro on the Y axis). Routine DOMINOR transfers program control to one of four routines depending upon the content of register GYROD+3. The four possible branches are shown in table 14-2.

TABLE 14-2
GYROD+3 BRANCHES

c(GYROD+3)	Routine Branched to
> +0	POSGOUT (paragraph 14-70)
= +0	TWEAKGY (paragraph 14-71)
= -0	GYROADV (paragraph 14-74)
< -0	NEGGOUT (paragraph 14-77)

14-69. Routine POSGOUT

14-70. Routine POSGOUT transfers the content of register GYROD+3 to register OVCTR and then transfers program control to Routine OUT2SUB to pulse the gyro on the Y axis in the positive direction, according to the command in register GYROD+3. Routine OUT2SUB enters the quantity $40000 - c(\text{GYROD}+3)$, obtained by decrementing the $c(\text{GYROD}+3)$ by one, into register OUTCR1. This quantity is formed by complementing this decremented quantity and then adding to this the quantity 37777. Thus, if register GYROD+3 contains 01752, the quantity 36026 is entered into register OUTCR1 (paragraph 14-54b). The content of bit positions 14, 12, and 10 of register OUT2 is set to ONE and the content of bit positions 15, 13, 11, and 9 of register OUT2 is set to ZERO. Routine POSGOUT then transfers program control to Routine GETDT to obtain the number of 10 msec intervals required to pulse the Y gyro according to the command in register OUTCR1. Routine GETDT divides the content of register OVCTR by 32_{10} , and the quotient is then incremented by two to round off uncertainties. (In reality this division is carried out by multiplying

the content of register OVCTR by 01000.) Routine POSGOUT then requests the scheduling of Task TWEAKGY with a time delay equal to the quotient obtained during the execution of Routine GETDT and Instruction TC TASKOVER is executed.

14-71. Routine TWEAKGY

14-72. Task TWEAKGY, which begins execution at Routine TWEAKGY, (attachment 14-1) is a special entrance to Routine DOGYRO. This entrance is used to send a command to pulse the Y gyro twice in the negative direction before attempting to pulse the Z gyro. In subsequent executions of Routine TWEAKGY (if there are any), the Routine pulses the Z gyro twice in the negative direction before attempting to initiate the pulsing of the X gyro or pulses the X gyro twice in the negative direction before terminating the gyro pulsing routines. Thus, the last command to the Y gyro is two pulses in the negative direction. Routine TWEAKGY also is entered at location TWEAKGY+1 in the special case when Routine DOMINOR is executed and the c(GYROD+3) is 00000. In this case, Routine TWEAKGY is executed under the auspices of Task DOGYRO. The instruction bypassed by entering Routine TWEAKGY at location TWEAKGY+1 is a TC SETUPSUB. Routine SETUPSUB (paragraph 14-62) sets registers RUPTREG1 and RUPTREG2 which are utilized during the execution of Routine OUT2SUB to specify the direction of the command that is entered into register OUTCR1. Routine SETUPSUB must be executed when Routine TWEAKGY is executed under the auspices of Task TWEAKGY as the content of these registers could have been changed during the time interval between the termination of Routine POSGOUT and the execution of Task TWEAKGY. If Routine TWEAKGY is executed under the auspices of Task DOGYRO, there is no need to execute Routine SETUPSUB as the content of registers RUPTREG1 and RUPTREG2 could not have changed.

14-73. Once registers RUPTREG1 and RUPTREG2 are set, the quantity 77775 is transferred to register A and program control is transferred to Routine OUT2SUB to send a command to pulse the Y gyro twice in the negative direction. Routine OUT2SUB enters the quantity 37776 into register OUTCR1, and enters a ONE into bit positions 15, 12, 10, and a ZERO into bit positions 14, 13, 11, and 9 of register OUT2. After executing Routine OUT2SUB to send a command to pulse the Y gyro twice in the negative direction, Routine TWEAKGY transfers program control to Routine GYROADV to update register CDUIND so that when Routine DOGYRO is executed the Z gyro will be pulsed.

14-74. Routine GYROADV

14-75. Routine GYROADV (attachment 14-1) is executed after the execution of Routine TWEAKGY, however, it is also executed under the auspices of Task GYROADV when it is necessary to update register CDUIND without preceding the updating of this register by sending a command to pulse the Y gyro twice in the negative direction. This is the case when the last command to the Y gyro was a command to pulse the gyro in the negative direction. Thus, Task GYROADV is scheduled during the execution of Routine NEGGOUT. In the special case when Routine DOMINOR is executed and the $c(\text{GYROD}+3)$ is -0, program control is transferred to Routine GYROADV.

14-76. Routine GYROADV enters the quantity 77773 or 77775 into register CDUIND depending upon whether the previous content of register CDUIND was 77774 or 77773 respectively and then transfers program control to Routine DOGYRO (paragraph 14-57). If the previous content of register CDUIND was 77775, program control is transferred to Routine IMUFINED (paragraph 14-46) to reactivate any Job put into the dormant state by Routine IMUSTALL and to terminate the gyro pulsing routines. Since it is assumed that the previous content of register CDUIND was 77774, the quantity 77773 is entered into register CDUIND and program control is transferred to Routine DOGYRO to pulse the Z gyro. The next time Routine GYROADV is executed, the quantity 77775 is entered into register CDUIND and program control is transferred to Routine DOGYRO to pulse the X gyro. The third time Routine GYROADV is executed, program control will be transferred to Routine IMUFINED.

14-77. Routine NEGGOUT

14-78. Routine NEGGOUT transfers the positive form of the content of register GYROD+3 to register OVCTR. The content of register OVCTR is utilized during the execution of Routine GETDT. The content of register CDUIND is then complemented and the content of bit position 14 is tested. If bit position 14 contains a ONE indicating that this is not the first command to pulse the Y gyro in a negative direction, program control is transferred to Routine NEGGOUT2 thus bypassing the command to pulse the Y gyro twice in the positive direction. As previously mentioned, the first command to pulse a gyro must be a command to pulse in the positive direction. Thus, if bit position 14 contains a ZERO, indicating that this is the first command to the Y gyro, a command to pulse the Y gyro twice in the positive direction is sent. Such a command is actuated by transferring the quantity 00002 to register A and then transferring program control to Routine OUT2SUB. After

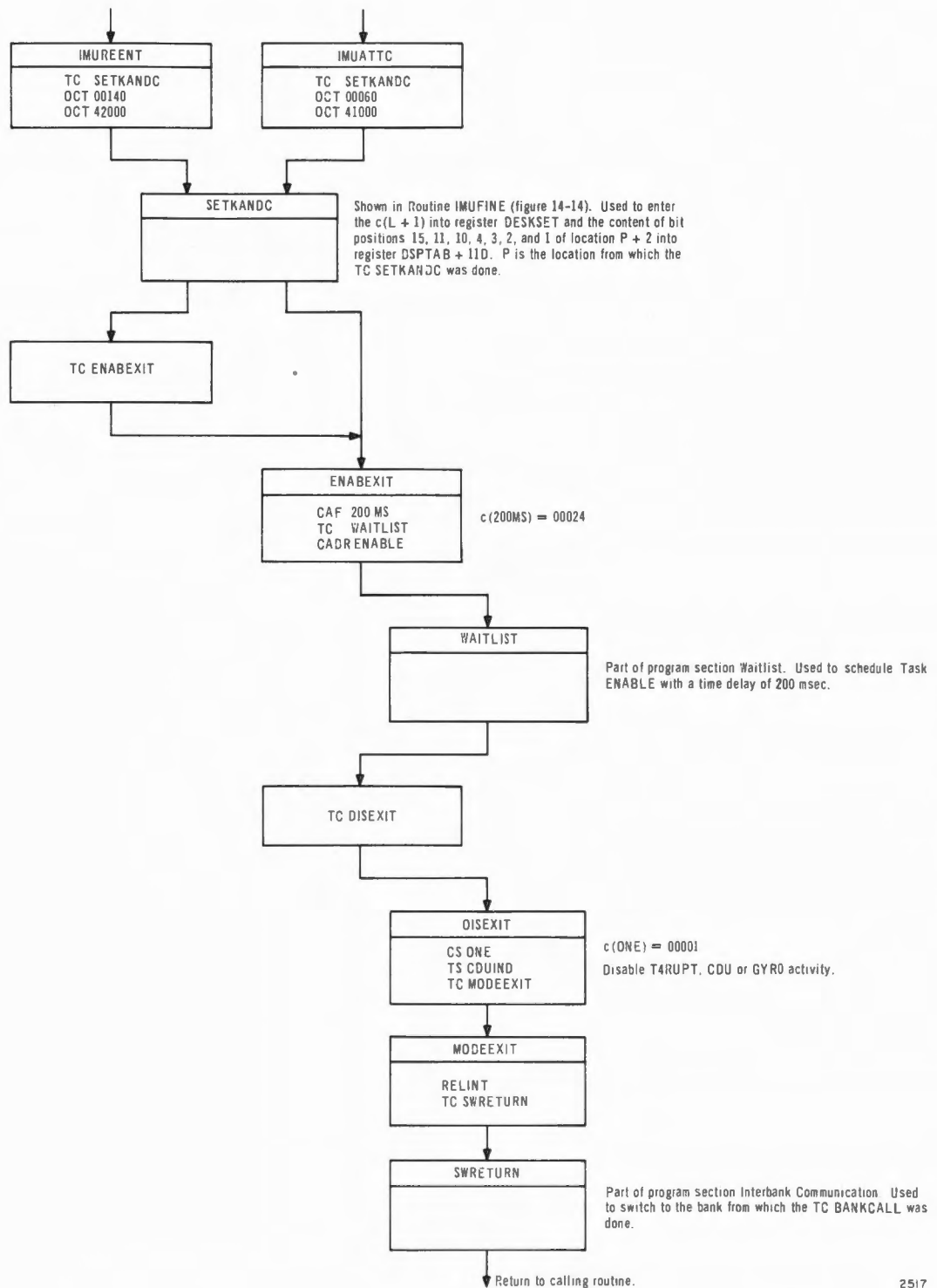
the positive command is sent, program control is transferred to Routine NEGGOUT2.

14-79. Routine NEGGOUT2 executes Routine GETDT to obtain the time necessary for the Y gyro to be pulsed according to the command in register OVCTR. This time is stored temporarily in register LRUPT. Then the content of register OVCTR, the positive form of the GYROD command, is complemented and transferred to register A. Program control is then transferred to Routine OUT2SUB to initiate the pulsing of the Y gyro according to the command in register A. Since register A contains a negative quantity, the Y gyro is pulsed in the negative direction. Then the content of register LPRUPT, the time necessary to pulse the gyro, is transferred to Routine WAITLIST to schedule Task GYROADV with the computed time delay, Instruction TC TASKOVER is then executed. Task GYROADV begins execution at Routine GYROADV. Since Routine GYROADV is also expected as a part of Task TWEAKGY, it has been discussed in paragraph 14-74.

14-80. ROUTINE IMUATTC

14-81. Routine IMUATTC is executed to request that the Inertial Subsystem be put into the Attitude Control mode, to disable the CDU loops, and to schedule Task ENABLE. Putting the system in the Attitude Control mode may be thought of as enabling a line of communication between the CDU's and the Stabilization and Control System (SCS). If there is non-agreement between the gimbal angles and the CDU's, error signals are sent to the SCS which, when the non-agreement is greater than a specified constant, activates the Reaction Control System (RCS) to return the Spacecraft to the specified attitude. Returning the Spacecraft to the specified attitude causes the gimbal angles to change but not the CDU's as they are Spacecraft-referenced. The RCS is deactivated when the gimbal angles equal the CDU angles. The error signal generated is given by $\sin(\theta_G - \theta_{CDU})$ where θ_G is the gimbal angle and θ_{CDU} is the CDU angle.

14-82. Prior to executing Routine IMUATTC, the desired CDU angles must be entered into the THETAD registers and the desired gains must be entered into registers KG and KH. Routine IMUATTC (figure 14-17) requests the Attitude Control mode by transferring program control to Routine SETKANDC with the quantities 00060 and 41000 contained in locations L+1 and L+2 respectively, where L is the location from which the TC SETKANDC was done. After Routine SETKANDC has entered the content of L+1 into the location of DESKSET and the content of bit positions 15, 11, 10, 4, 3, 2, and 1 of the quantity contained in the lo-



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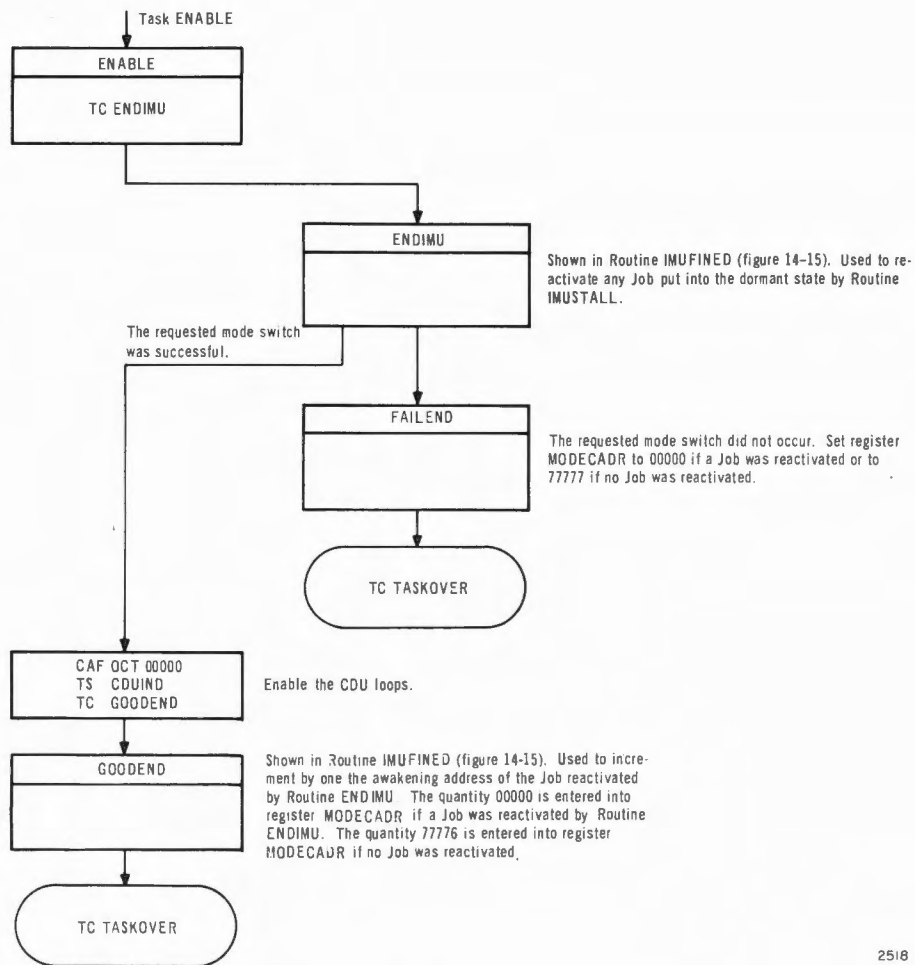
Figure 14-17. Routines IMUREENT and IMUATTC

cation L+2 into register DSPTAB+11D, a request is made to schedule Task ENABLE with a 200 msec delay. Thereafter, the CDU loops are disabled by entering 77776 into register CDUIND and program control is transferred back to the routine from which the TC IMUATTC was done. This results in program control being transferred eventually to Routine IMUSTALL. During the 200 msec interval before execution of Task ENABLE, the proper relays are set for the Attitude Control mode and indicator switch ATT CONT on the IMU Control Panel is illuminated.

14-83. Task ENABLE

14-84. Task ENABLE verifies that the Inertial Subsystem is in the Attitude Control mode, enables the CDU loops, and reactivates any Job put into the dormant state by Routine IMUSTALL. Enabling the CDU loops allows the CDU's to be driven by program section T4RUPT Output Control which causes disagreement between the CDU's and the gimbal angles. The resulting error signals are sent to the SCS which reactivates the RCS to turn the Spacecraft to the attitude specified by the CDU's. (The RCS functions as though it were returning the Spacecraft to the original attitude.)

14-85. Task ENABLE (figure 14-18) transfers program control to Routine ENDIMU (paragraphs 14-46 through 14-51) to verify that the system is in the Attitude Control mode and to reactivate any job put into the dormant state by Routine IMUSTALL. However, in reality, Routine ENDIMU is only checking to verify that the last request for a mode switch was successful. If the mode switch was not successful, register WASKSET contains 00000 or 77777 and program control is transferred to Routine FAILEND where the quantity 00000 is entered into register MODECADR if a Job was reactivated; or the quantity 77777 if no Job was reactivated. (The awakening address of any Job reactivated by Routine ENDIMU is not incremented.) Task ENABLE is then terminated. If the mode switch was successful, program control is transferred back to Routine ENABLE where the CDU loops are enabled by entering the quantity 00000 into register CDUIND. Program control is then transferred to Routine GOODEND where the awakening address of the Job reactivated by Routine ENDIMU is incremented by ONE. If no Job was reactivated by Routine ENDIMU, the quantity 77776 is entered into register MODECADR. If a Job was reactivated by Routine ENDIMU, the quantity 00000 is entered into register MODECADR. Task ENABLE is then terminated. Since the CDU loop has been enabled, program section T4RUPT Output Control drives the CDU's according to the commands in the THETAD registers and since the Inertial Subsystem is in the Attitude Control mode, the SCS and the RCS will reposition the



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Figure 14-18. Task ENABLE

Spacecraft to the desired attitude. (No check is made of IMU and CDU failure indications since in this mode the Mission Function or Job must check the status of these signals periodically.)

14-86. ROUTINE IMUREENT

14-87. Routine IMUREENT (figure 14-17) is executed to request that the Inertial Subsystem be put into the Reentry Control mode, to disable the CDU loops, and to schedule Task ENABLE. The Reentry Control mode is similar to the Attitude Control mode. The variance lies in the fact that the difference between the gimbal angle on the X axis and the CDU X angle is magnified by a factor of 16 to reduce the response time required to generate an attitude error signal. (This reduces the response time necessary to recognize commands pertaining to the roll of the Spacecraft during reentry.)

14-88. The only difference between Routines IMUREENT and IMUATTC is in the calling sequence to Routine SETKANDC. To request the Reentry Control mode, the quantities 00140 and 42000 are contained in locations L+1 and L+2 where L is the location from which the TC SETKANDC was done. After the calling sequence, Routine IMUREENT operates similar to Routine IMUATTC except that during the 200 msec before the execution of Task ENABLE, the ENTRY indicator on the IMU Control Panel is illuminated and Task ENABLE is executed to verify that the subsystem is in the Reentry Control mode. When Routine IMUATTC has been executed, program control is transferred back to the routine from which the TC IMUREENT was done and program control eventually is transferred to Routine IMUSTALL.

14-89. ROUTINE IMULOCK

14-90. Routine IMULOCK is executed to request that the Inertial Subsystem be put into the Manual CDU mode to disable the CDU loops, and to schedule Task IMULOCKD with a time delay of 200 msec. In the Manual CDU mode, the gimbals are slaved to the CDU's and the operator can manually position the CDU's via the thumbwheels on the CDU Control Panel (figure 14-4). Routine IMULOCK schedules Task IMULOCKD which when executed verifies that the system is in the Manual CDU mode and reactivates any Job put into the dormant state by Routine IMUSTALL.

14-91. Routine IMULOCK (figure 14-19) requests the Manual CDU mode by transferring program control to Routine SETKANDC with the quantities 00044 and 40004 contained in locations L+1 and L+2 where L

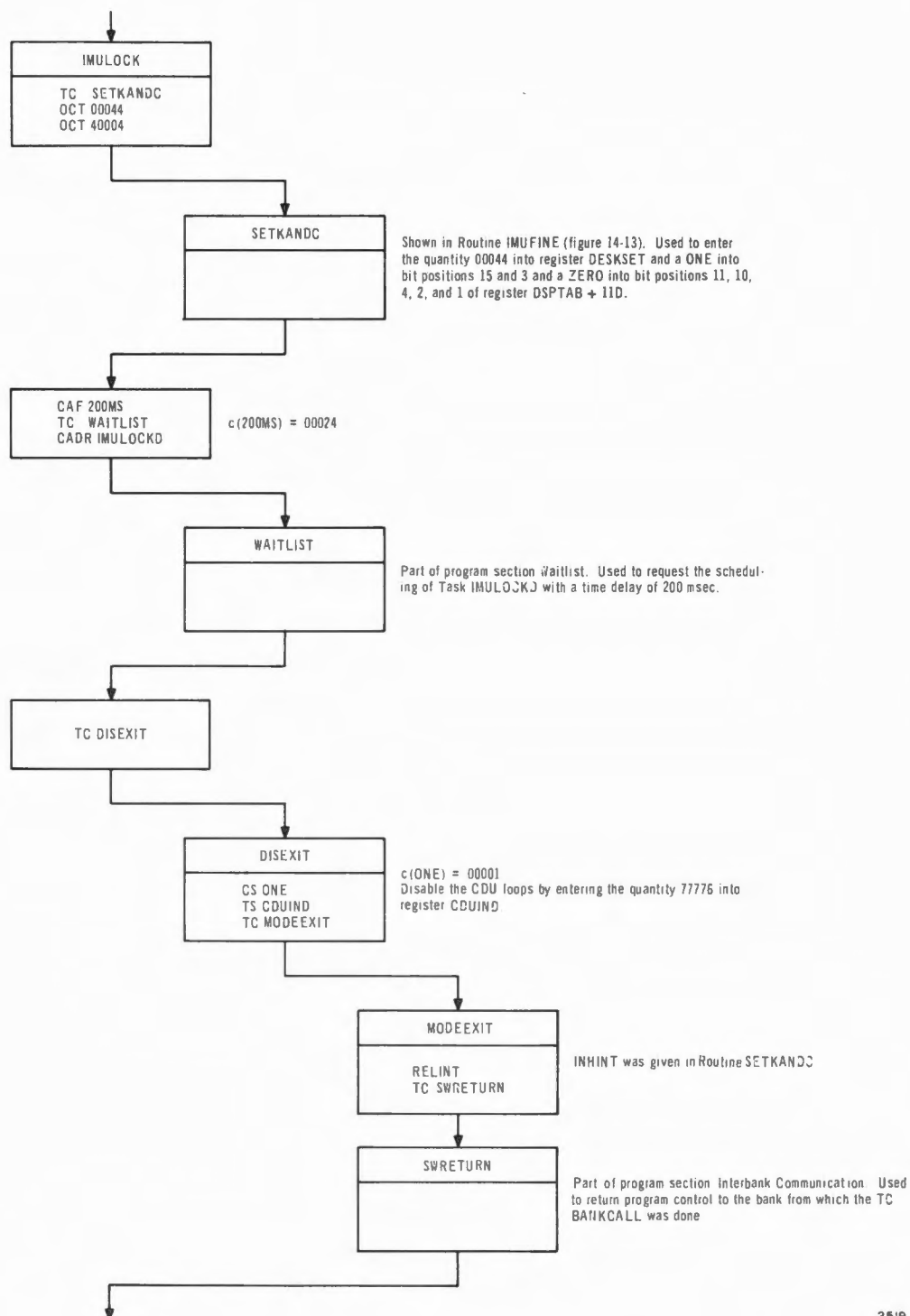


Figure 14-19. Routine IMULOCK

is the location from which the TC SETKANDC was done. After Routine SETKANDC enters the content of L+1 into register DESKSET and the content of bit positions 15, 11, 10, 4, 3, 2, and 1 of the quantity contained in the location L+2 into register DSPTAB+11D, a request is made to schedule Task IMULOCKD with a time delay of 200 msec. Then the CDU loops are disabled by entering the quantity 77776 into register CDUIND and program control is transferred back to the routine from which the TC IMULOCK was done. During the 200 msec allowed before the execution of Task IMULOCKD, the proper relays are set and the CDU MAN indicator on the IMU Control Panel is illuminated.

14-92. Task IMULOCKD

14-93. Task IMULOCKD (figure 14-20) transfers program control to Routine ENDIMU (paragraphs 14-46 through 14-51) to verify that the system is in the Manual CDU mode and to reactivate any Job put into the dormant state by Routine IMUSTALL. If the mode switch failed, program control is transferred to Routine FAILEND to set register MODECADR and to terminate Task IMULOCKD. If the switch is successful, program control is transferred to Routine GOODEND where the awakening address of any Job reactivated by Routine ENDIMU is incremented by ONE and register MODECADR is set as described previously. Task IMULOCKD is then terminated.

14-94. ROUTINE IMURECOR

14-95. Routine IMURECOR is executed to request that the Inertial Subsystem be returned to the Coarse Align mode to disable the CDU loops, and to schedule Task RECOARSD with a time delay of 200 msec. Task RECOARSD transfers the content of the CDU counters (registers CDUX, CDUY, CDUZ) into registers THETAD, THETAD+1, and THETAD+2. Program control is then transferred to Routine BEGINCOM which verifies that the subsystem is in the Coarse Align mode, enables the CDU drive loops for at least 60 seconds, and schedules a Task which when executed in 60 seconds will reactivate any Job put into the dormant state by Routine IMUSTALL.

14-96. Routine IMURECOR (figure 14-21) transfers program control to Routine SETKANDC with the quantities 00042 and 40002 contained in locations L+1 and L+2 where L is the location from which the TC SETKANDC was done. Routine SETKANDC enters the content of location L+1 into register DESKSET and the content of bit positions 15, 11, 10, 4, 3, 2, and 1 of the quantity contained in location L+2 into register DSPTAB+11D. Task RECOARSD is then requested for execution with a time delay of 200 msec and the CDU loops are disabled by entering the

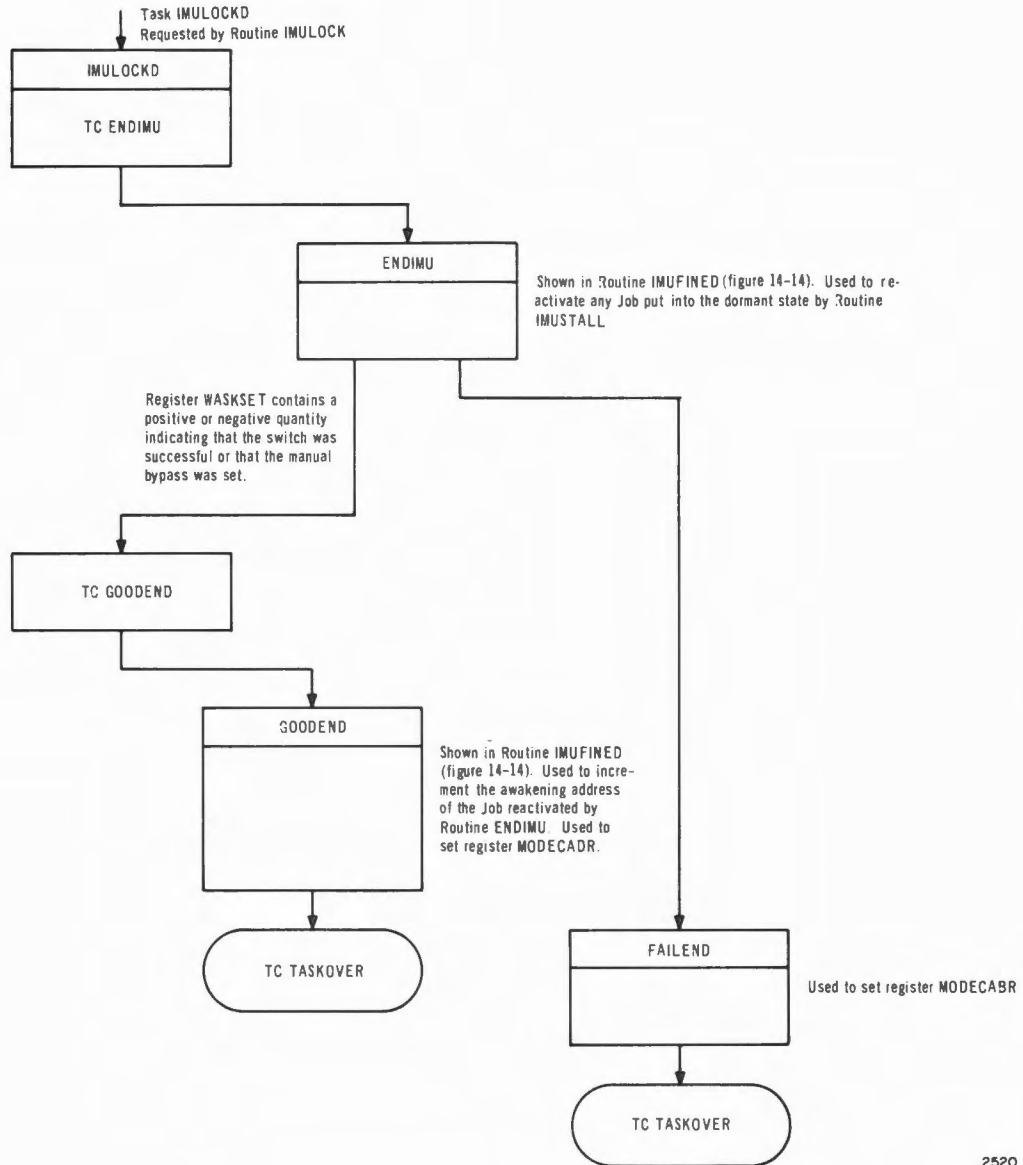
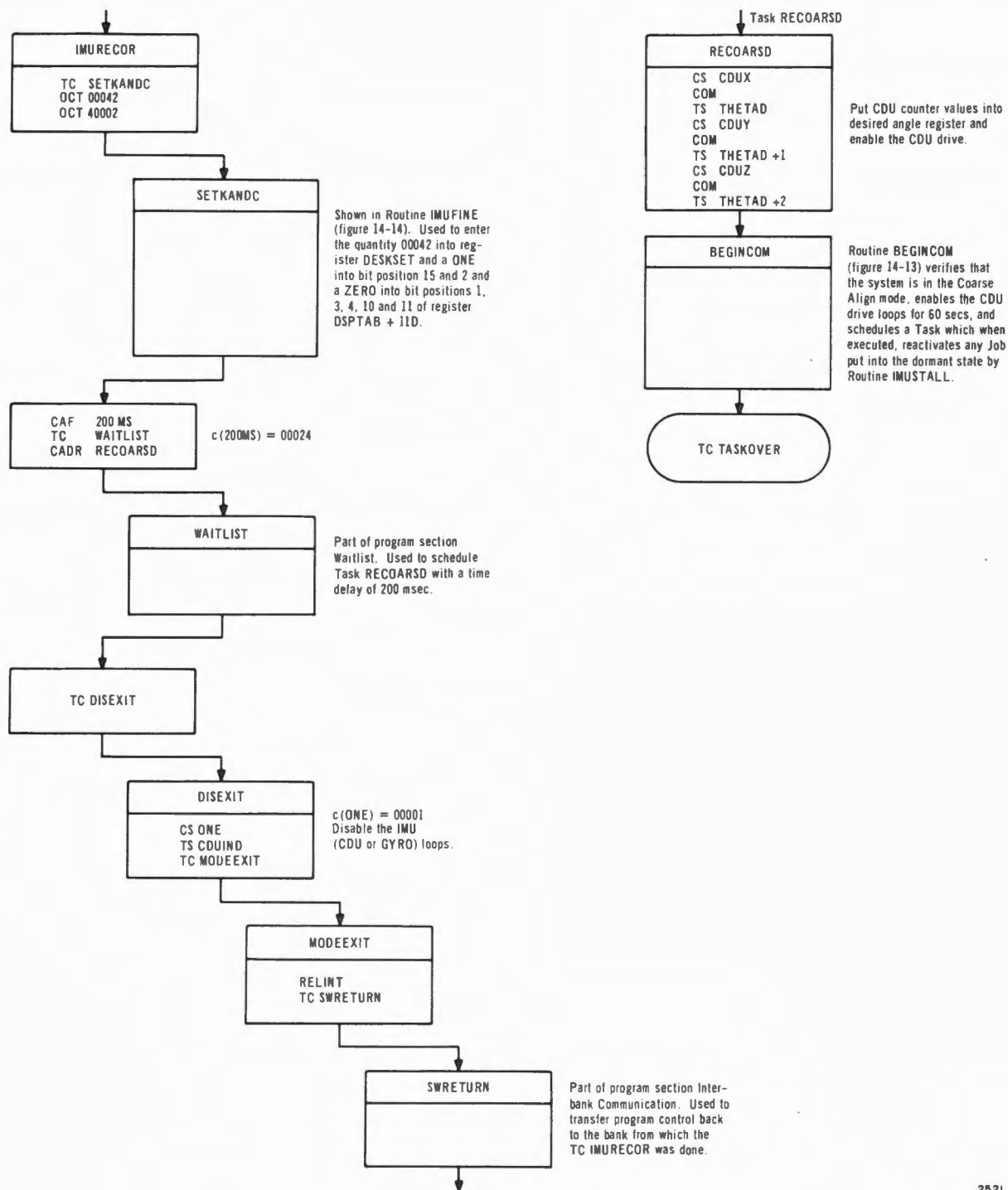


Figure 14-20. Task IMULOCKD



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Figure 14-21. Routine IMURECOR and Task RECOARSD

quantity 77776 into register CDUIND. Program control is then transferred back to the routine from which the TC IMURECOR was done. During the 200 msec allowed before the execution of Task RECOARSD, the proper relays are set and indicator COARS ALIGN on the IMU Control Panel is illuminated.

14-97. Task RECOARSD

14-98. Task RECOARSD (figure 14-21) transfers the content of counters CDUX, CDUY, CDUZ to registers THETAD, THETAD+1, and THETAD+2 respectively. Program control is then transferred to Routine BEGINCOM which is described in detail in paragraph 14-39.

14-99. ROUTINE IMUSTALL

14-100. By convention, any request for an IMU mode switch routine is always followed by a request for Routine IMUSTALL. In some cases, the two requests are separated by a long computation; however, the request for Routine IMUSTALL is usually so close to the request for the mode switch routine that the execution of Routine IMUSTALL precedes the completion of the mode switching operation (but not the execution of the mode switching routine requesting the switch) and the Task associated with the requested mode switch routine (Task IMUZEROD in the case of Routine IMUZERO).

14-101. When the request for Routine IMUSTALL occurs prior to the completion of the mode switch, Routine IMUSTALL puts the requesting Job (Mission Function) into the dormant state until the mode switch, or the execution of the associated Task is completed, whichever occurs first. (The requesting Job is awakened during the execution of the Task associated with the requested mode switch.)

14-102. Due to the possibility that the time interval between the request for the mode switch routine and the request for Routine IMUSTALL is such that the mode switching operation has been completed (as is the case if the two requests are greatly separated), Routine IMUSTALL tests whether or not the mode switch was successful. If the switch was successful, Routine IMUSTALL transfers program control to return address P+3 in the requesting routine (or Job) just as if it had been put into the dormant state and subsequently awakened. If the switch was not successful, Routine IMUSTALL transfers control to the return address P+2 in the requesting routine. The content of register MODECADR (IMUCADR at this point) indicates to Routine IMUSTALL the status of the mode change and the appropriate action to be taken. The content of this register is set by the sequence of routines starting with Routine

ENDIMU which was called during the execution of the Task associated with the particular mode switch routine in question.

14-103. Routine IMUSTALL (figure 14-22) is called to monitor the mode switching operation by a Job or a Mission Function, following the initiation of a request for a mode switch. This ensures that only one IMU mode switching request is honored at a time and that one such switch is completed before the next request is processed. Routine IMUSTALL has the capability of making the requesting Job or Mission Function inactive or dormant while the actual mode switch is effected by program section T4RUPT Output Control and the hardware. In addition, Routine IMUSTALL checks whether or not the request for a mode switch was successful. On successful completion of a mode switch, Routine IMUSTALL transfers control back to the return address P+3 in the requesting routine; if unsuccessful, return is to address P+2. Routine OPTSTALL is another entrance to Routine IMUSTALL which is used when the operation of the AGC is concerned with the Optics and not the IMU. It is possible for a request for an Optics mode switch to be processed while the AGC is processing a request for an IMU mode switch. The calling sequence in the requesting routine for Routine IMUSTALL is:

P	TC BANKCALL
P+1	CADR IMUSTALL (OPTSTALL)
P+2	Return address for failure
P+3	Return address for continuation

14-104. After the execution of instruction INHINT, Routine IMUSTALL checks the content of register MODECADR (IMUCADR) which indicates the status of the mode switching operation. Register MODECADR is set by various subroutines (ENDIMU, GOODEND, FAILEND, and IMUSTALL itself) encountered at different steps in the execution of a mode switch. If Routine IMUSTALL is entered prior to the completion of the requested mode switch, the content of register MODECADR could be:

- a. The complete address (CADR) at which the routine requesting a mode switch was put to sleep. This indicates that a new mode switch request has been made before the previous mode switch was completed. This CADR is stored in register MODECADR by Routine IMUSTALL just prior to putting the requesting routine to sleep.
- b. The quantity 00000 which indicates that there is no other Job awaiting the completion of a mode switch, and that

the system is ready to honor a new request. The quantity 00000 is stored in register MODECADR (IMUCADR) by Routine IMUSTALL, subroutine GOODEND or subroutine FAILEND.

14-105. If Routine IMUSTALL is entered after the mode switch has been completed, (i. e., the relays have had time to switch) the content of register MODECADR (IMUCADR) could be:

- a. The quantity 77777 indicates that the mode switch was completed but was unsuccessful due to a failure in the hardware. It also indicates that no Job was awakened because the requesting Job was not put into the dormant state. The contents of register IMUCADR was set by subroutine FAILEND.
- b. The quantity 77776 which indicates that the mode switch was successfully completed and that no Job was awakened. The contents of register MODECADR was set by subroutine GOODEND.

The following paragraphs contain a description of the actions taken by Routine IMUSTALL as a result of the various contents of register MODECADR (IMUCADR).

14-106. When Routine IMUSTALL is called by a Job or a Mission Function which has just requested a mode change, the contents of register MODECADR is 00000 which indicates there are no dormant Mission Functions or Jobs awaiting the completion of a mode switch and that the present request can be honored. Routine IMUSTALL calls Routine MAKECADR in program section Interbank Communication to make a CADR of the address P+2. (This address is changed in subroutine GOODEND to P+3, the continuation return address, if the switch is found to be successfully completed.) On returning to Routine IMUSTALL from Routine MAKECADR, the CADR P+2 (transmitted in A) is stored in register MODECADR. Program control is then transferred to Routine JOBSLEEP in program section Executive to make the requesting Mission Function or Job dormant. The computer is now free to process and execute other Jobs and Tasks until the Task (IMUZEROD, BEGINCOM, IMUFINE, etc.), scheduled by the requested mode switching routine (IMUZERO, IMUCOARS, IMUFINE, etc.), is due.

14-107. Should register MODECADR contain a complete address (CADR) when Routine IMUSTALL is entered, this indicates a second request for a mode change has been made before the previous request has been completed. (This CADR belongs to the Job or Mission Function which made

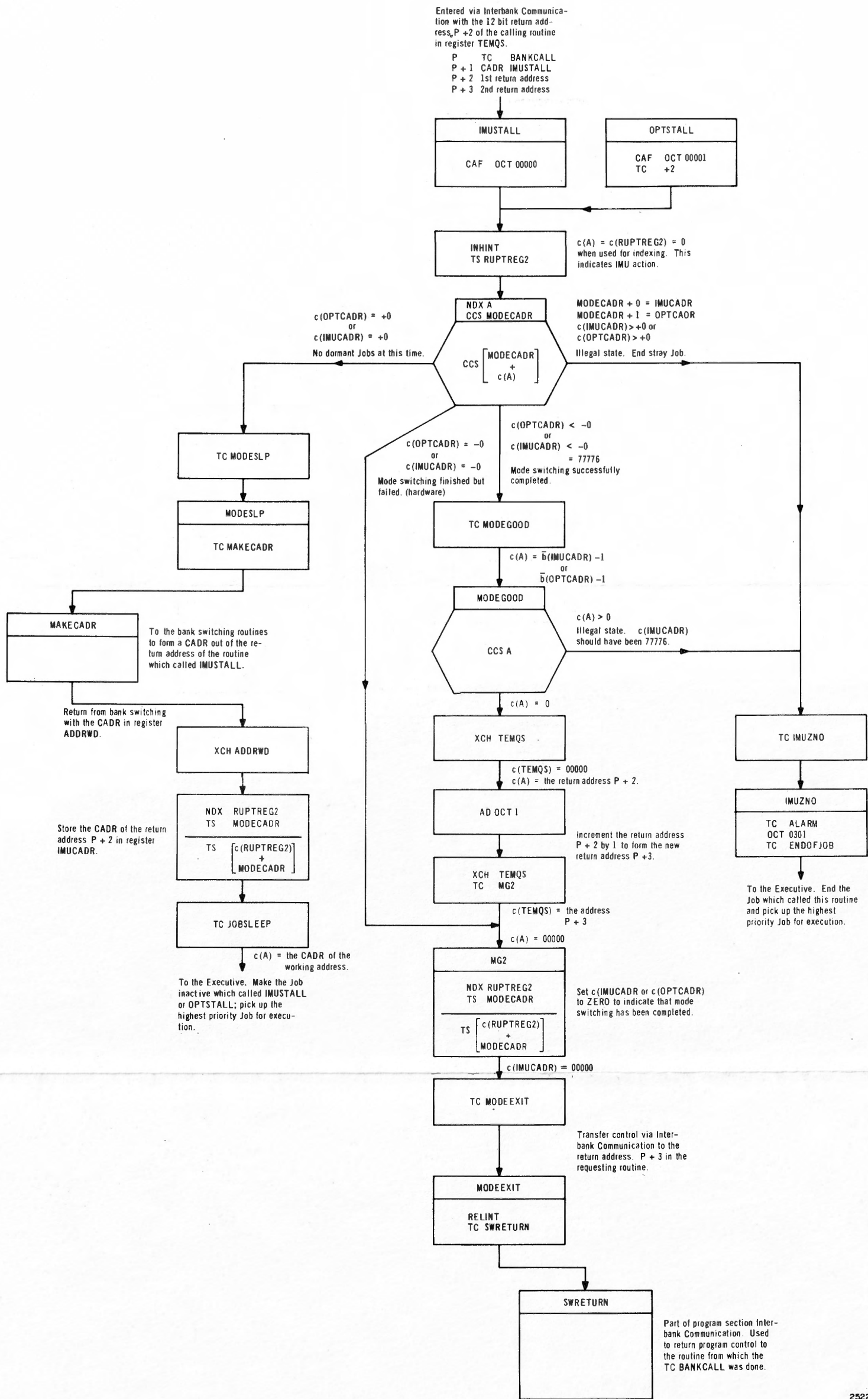


Figure 14-22. Routines IMUSTALL and OPTSTALL

the previous request.) Since the system can only be in one IMU mode at a time, the second request is assumed to be an error. Routine IMUSTALL executes the calling sequence:

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TC      ALARM
OCT     00301
TC      ENDOFJOB

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which terminates the Job or Mission Function which made the second request. (When the CADR is negative, a ONE in bit positions 16 and 15, it specifies a location in banks 21 through 34 and is processed in the same logic path as that when the contents of register MODECADR is 77776.)

14-108. The contents of register MODECADR can be 77776 only when Routine IMUSTALL is called following the completion of the mode switch operation when the requesting routine is not put into the dormant state. The reason being that the subroutine (GOODEND) which enters 77776 into register MODECADR, is only called as a result of the execution of the Task associated with the requested mode switch routine. The Task, in turn, is only executed after the mode switch has been completed. Moreover, the c(MODECADR) could never be 77776 if the routine requesting the mode switch has been made dormant because subroutine GOODEND would have stored the quantity 00000 into register MODECADR in this case. If Routine IMUSTALL detects a negative quantity in register MODECADR, this quantity, if not 77776 or 77777, can only be the CADR of a stray requesting routine located in some bank between 21 and 34 which was previously made dormant. This is an error as previously stated and an alarm sequence is executed. Ordinarily then, any negative quantity in register MODECADR at this time will be 77776 indicating a successfully completed mode switch. Routine IMUSTALL increments the return address P+2 by one yielding P+3. After entering the quantity 00000 into register MODECADR to indicate that the system can now honor new mode requests, Routine IMUSTALL transfers program control to the return address P+3 in the requesting Job or Mission Function via Routine SWRETURN in program section Interbank Communication.

14-109. Register MODECADR can only contain 77777 under the same condition as stated in paragraph 14-105a except that in this case it indicates the mode switch was unsuccessful (most likely due to a hardware failure). Routine IMUSTALL stores the quantity 00000 into register MODECADR and transfers program control via Routine SWRETURN to the return address P+2, which is the return address if a failure occurred.

14-110. OPTICS MODING ROUTINES

14-111. ROUTINE OPTZERO

14-112. Routine OPTZERO, which is not presently available in the Sunrise 45 listing, will be used to initiate the Zero Encode sequence for the Optics.

14-113. ROUTINE OPTCOARS

14-114. Routine OPTCOARS, which is not presently available in the Sunrise 45 listing, will be used to request that the Optics Subsystem be put into the Coarse Align mode.

14-115. ROUTINE OPTTRKON

14-116. Routine OPTTRKON, which is not presently available in the Sunrise 45 listing, will be used to request that the Subsystem be put into the Star Tracker On mode. In this mode, power is applied to the Optical Tracker with the result that any star being sighted will remain in the center of the reticle provided the perturbation of the Spacecraft is within specified limits.

14-117. MARK ROUTINES

14-118. ROUTINES SCTMARK AND SXTMARK

14-119. Routines SCTMARK and SXTMARK (figure 14-23) are used by the Mission Functions to request that the operator initiate a Mark action. An operator initiates a Mark action by depressing the MARK button on the G and N Indicator Control Panel. When this button is depressed, the Interrupt Transfer Routines initiate the execution of Routine KEYRUPT (paragraph 17-15). During the execution of Routine KEYRUPT, the contents of the Time Counters, the CDU counters, and the Optics counters are read out and entered into a Work Area that is assigned by the routine that requested that the operator initiate the Mark action (i. e., Routine SCTMARK or SXTMARK).

14-120. Routine SCTMARK is called by the sequence:

L	CAF	0000N
L+1	TC	BANKCALL
L+2	CADR	SCTMARK



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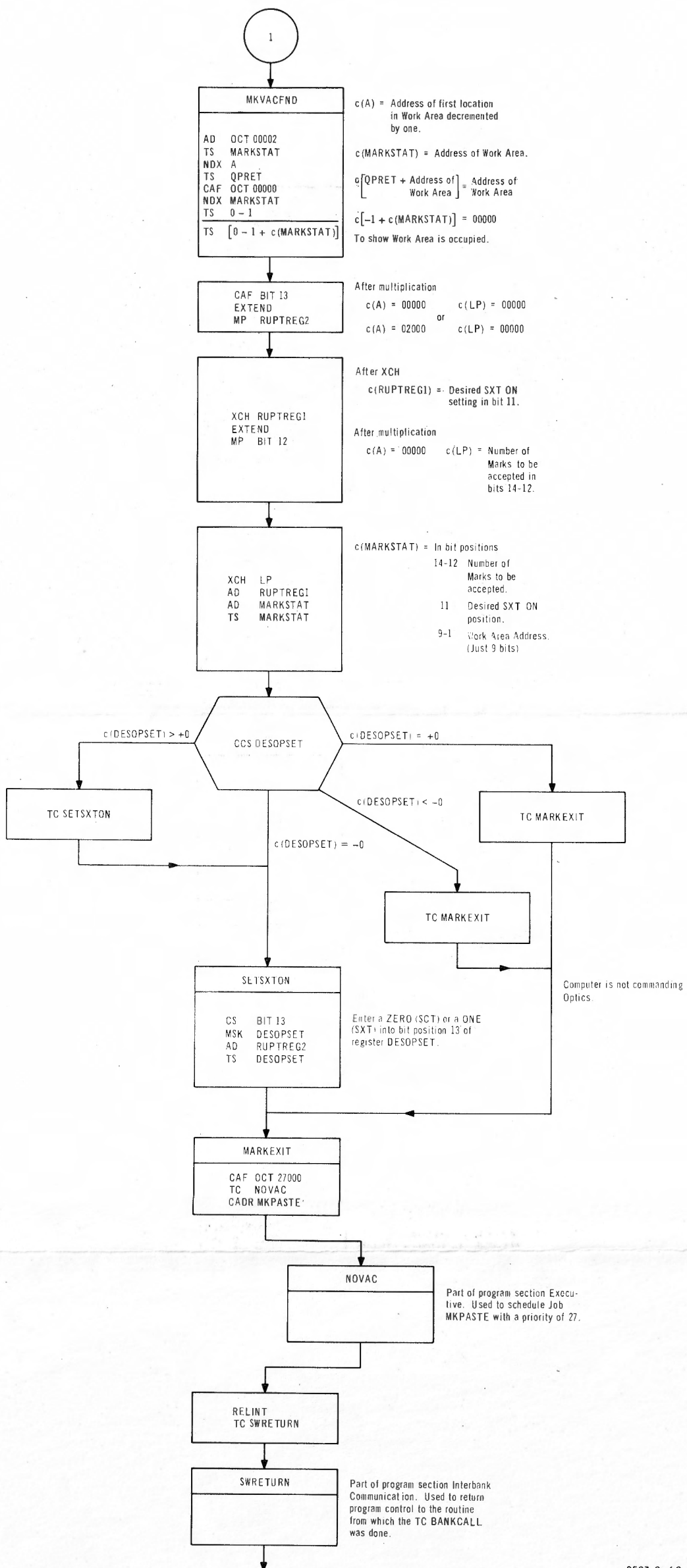


Figure 14-23. Routines SCTMARK and SXTMARK (Sheet 2 of 2)

where 0000N represents a number less than or equal to six which indicates the number of Marks that are to be accepted. It is possible for the operator to depress the MARK button more than N times but the AGC can only accept six Marks. Routine SCTMARK sets up a Work Area for storage of the Mark information (this work area is in addition to the one already assigned to the Job) and then initiates the flashing of digits 5, 1 in the VERB displays to advise the operator that he is to initiate Marks. Program control is then returned to the Job that requested Routine SCTMARK and the Job is put into the dormant state until all the requested mark information has been accepted. The following is the instruction sequence to make the Job dormant:

M	TC	BANKCALL
M+1	CADR	OPTSTALL

14-121. The information recorded by a Mark action is not accepted until the operator follows a Mark action with the Mark Accept action. Until the AGC MARK button is available, an operator must initiate a Mark Accept action by keying in VERB, 5, 2, ENTER. Upon the execution of Verb Routine DOMKACPT and Task MKACCEPT, which is scheduled by this Routine, the Work Area address into which the next Mark information is to be stored is incremented by seven. This ensures that the next time the MARK button is pressed, the Mark information will be stored into different locations in the Work area, thus preserving the previous Mark information. After all requested Mark information has been entered, Task MKACCEPT reactivates any Job put into the dormant state by Routine OPTSTALL. (For further details, refer to paragraph 17-27.) The requesting Job is reactivated at location M+3 after N Marks have been accepted. Unwanted Optics mode changes result in the Job being reactivated at location M+2. After the Mark information has been processed, program control is transferred via the calling sequence TC BANKCALL, to Routine MKRELEAS (paragraph 14-132) to release the Work area and the Mark system for other Jobs.

14-122. Routine SXTMARK is similar to Routine SCTMARK except that Routine SXTMARK requests that the Marks be taken with the Sextant while Routine SCTMARK requests that the Marks be taken with the Telescope. If Marks are to be taken with the Sextant and it is not operating (i. e. the Telescope is operating) program section T4RUPT Output Control executes Routine ALARM which schedules Job DOALARM to display the alarm code 00102 in DSKY display register R1. If this code appears, the operator should turn on the Sextant before beginning to Mark. Similarly if Marks are to be taken with the Telescope but the Telescope is not operating, the Alarm code 00102 is displayed indicating that the Telescope should be turned on.

14-123. Routine SCTMARK transfers program control to Routine MARKCOM with the quantity 00000 contained in location L+1 where L is the location from which the TC MARKCOM was done. Routine SXTMARK also transfers program control to Routine MARKCOM; however, the quantity transferred is 10000 which is contained in location P+1 where P is the location from which the TC MARKCOM was done.

14-124. Routine MARKCOM executes instruction INHINT and then transfers the content of register A which is the number of Marks to be accepted to register RUPTREG1 and the content of the location contained in register Q, the c(L+1) or the c(P+1) to register RUPTREG2. Then the c(MARKSTAT) is tested to determine if another Mission Function or Job has requested Mark information. If no other Job is awaiting Mark information (the contents of register MARKSTAT equals 00000) program control is transferred to Routine MARKOK. If there is a Mission Function or Job awaiting Mark information, this is an alarm condition and the calling sequence TC ALARM, OCT 00105 is executed. Routine ALARM (paragraph 19-36) schedules a Job to display alarm code 00105 on the DSKY's. Then the Mission Function or Job from which the TC SCTMARK or TC SXTMARK was done is terminated.

14-125. Routine MARKOK searches for a vacant Work Area by testing the content of registers VAC1USE, VAC2USE..., VAC5USE. When one of these registers is found to contain a quantity greater than zero, indicating that Work Area 1, 2, ... or 5 is vacant, program control is transferred to Routine MKVACFND. If registers VAC1USE through VAC5USE all contain zero, indicating that Work Areas 1 through 5 respectively are occupied, instructions TC ABORT and OCT 00104 are executed. Routine ABORT (paragraph 19-41) schedules Job DOALARM to display the abort code 00104 on the DSKY's and initiate a GOJAM sequence.

14-126. Routine MKVACFND enters the address of the first location in the selected Work Area into register MARKSTAT. This address is also stored in the location obtained by indexing the location of register QPRET with the address contained in register MARKSTAT. For example, assume the address of the first location of the Work area is 00271. This address is entered into register MARKSTAT and into location 00343. (Location 00343 is the QPRET location of Work Area 2.) Routine MKVACFND then enters the quantity 00000 into register VACrUSE (r = 1, 2, 3, 4, or 5) that was found to contain a positive quantity. Entering the quantity 00000 into this register indicates the associated Work Area is now occupied. Routine MKVACFND then enters a ONE into bit position 11 of register MARKSTAT if register RUPTREG2 contains 10000 or a ZERO into this bit position if register RUPTREG2

contains 00000. (Register RUPTREG2 contains 10000 if the Marks are to be taken with the Sextant or the quantity 00000 if the Marks are to be taken with the Telescope.) The content of bit positions 3 through 1 of register RUPTREG1, the number (N) of Marks to be accepted, is then transferred to bit positions 14 through 12 of register MARKSTAT. Thus the content of register MARKSTAT is as follows:

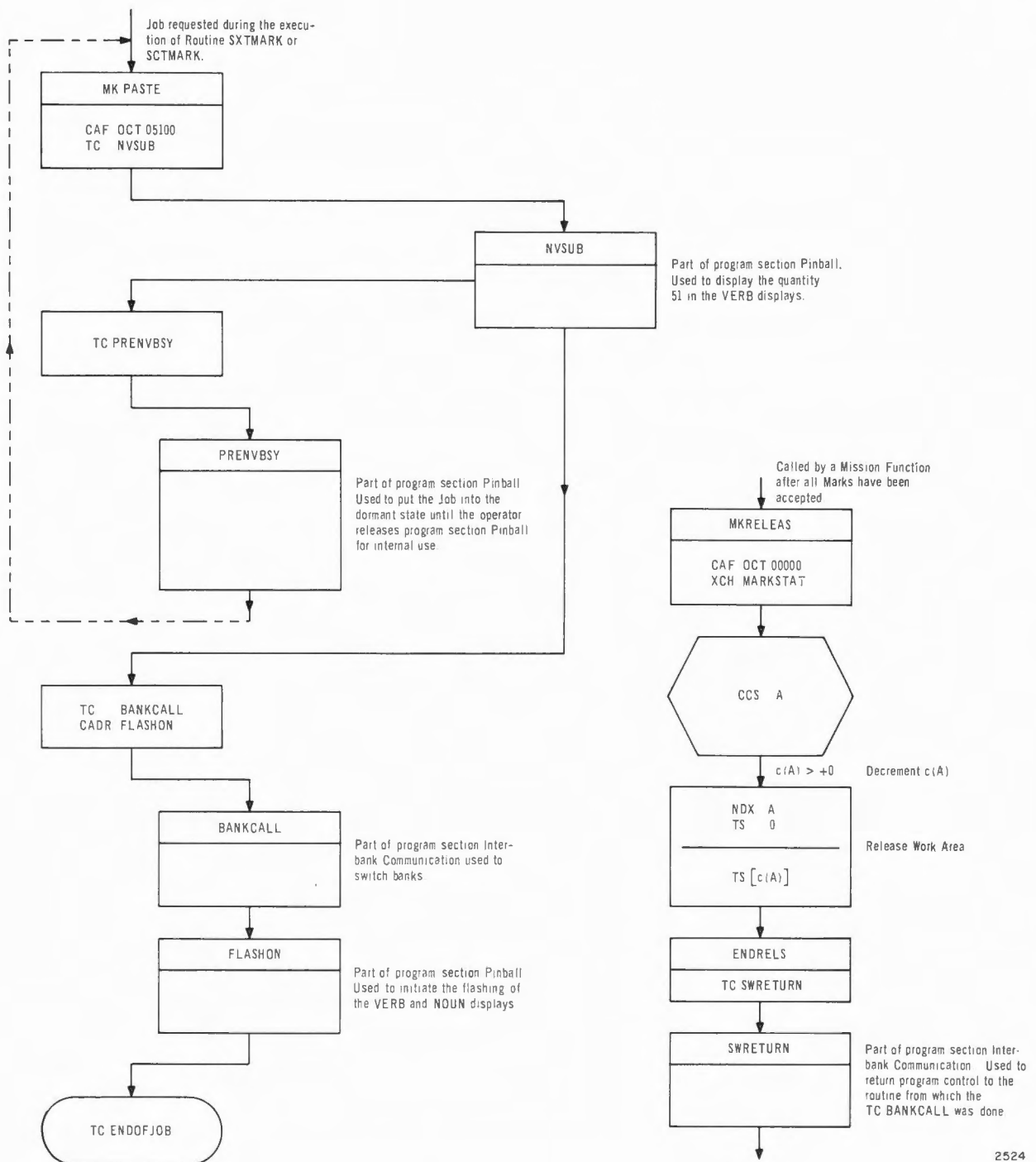
Bit Positions	Content
14 - 12	Number of Marks remaining to be accepted.
11	Desired setting of the sextant. (Contains a ONE if the sextant is on or a ZERO if the telescope is on.)
9 - 1	Work Area address.

14-127. The content of register DESOPSET is then tested. If it contains a negative quantity or the quantity 00000, indicating that the computer is not commanding the Optics, program control is transferred to Routine MARKEEXIT. If register DESOPSET contains a positive quantity, indicating that the AGC is controlling the Optics, program control is transferred to Routine SETSXTON. Routine SETSXTON enters a ONE into bit position 13 of register DESOPSET if the Marks are to be taken with the Sextant or a ZERO if the Marks are to be taken with the Telescope. Program control is then transferred to Routine MARKEEXIT. Usually the computer is controlling the Optics when Routine SXTMARK or SCTMARK is executed. If this is not the case, the Mark information could be obtained with the wrong instrument.

14-128. Routine MARKEEXIT transfers program control to program section Executive at Routine NOVAC to schedule Job MKPASTE with a priority of 27. Instruction RELINT is then executed and program control is transferred back to the routine from which the TC SXTMARK or TC SCTMARK was done. This eventually results in program control being transferred to Routine OPTSTALL (paragraph 14-133) to put the Mission Function into the dormant state until the requested number of Marks have been accepted.

14-129. Job MKPASTE

14-130. Job MKPASTE (figure 14-24) is executed to display the Verb code 51 (Please Mark) in the VERB displays on the DSKY's and to initiate



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Figure 14-24. Job MKPASTE and Routine MKRELEAS

the flashing of the VERB and NOUN displays. These actions could be executed under the auspices of Routine SXTMARK or SCTMARK but scheduling a special Job for this function prevents the necessity of putting the Mission Function into the dormant state if the operator has control over program section Pinball.

14-131. Routine MKPASTE transfers program control to Routine NVSUB in program section Pinball with the quantity 05100 in register A. Routine NVSUB (paragraph 17-217) tests the content of register DSPLOCK and, if the register contains a positive quantity indicating that the operator is using Pinball, program control is transferred back to Routine MKPASTE where instruction TC PRENVBSY is executed. Routine PRENVBSY, also in Pinball, puts the Job (Job MKPASTE) into the dormant state until the operator releases Pinball for internal use. If register DSPLOCK contains the quantity 00000, indicating that Pinball is available for internal use, Routine NVSUB sets the proper DSPTAB registers so that the quantity 51 is displayed in the DSKY VERB displays. (The NOUN displays are not changed.) Program control is then transferred via Routine MKPASTE to Routine FLASHON in Pinball where the flashing of the VERB and NOUN displays is initiated to notify the operator that he must initiate a Mark action. Job MKPASTE is then terminated. The flashing of the VERB and NOUN displays is terminated by Job MKFLSHOF which is scheduled for execution during the execution of Task MKACCEPT (paragraph 17-23) provided all the requested Mark information has been entered and accepted.

14-132. Routine MKRELEAS is called by the Mission Function or Job after it has been reactivated. (The Mission Function is not activated until the number of Mark actions specified in the request have been entered and accepted. Routine MKRELEAS enters the quantity 00000 into register MARKSTAT to free the Mark system for other users. The Work Area used by this Mission Function or System Test Job for Mark information is then released by entering the initial address of the Work Area into the appropriate VACrUSE register. (A Work Area is considered vacant when the appropriate VACrUSE register contains a positive quantity, its own address. Similarly, a Work Area is considered occupied when the appropriate VACrUSE register contains the quantity 00000.) Program control is then transferred back to the routine in the Mission Function or Job from which the TC BANKCALL, CADR MKRELEAS was done.

14-133. ROUTINE OPTSTALL

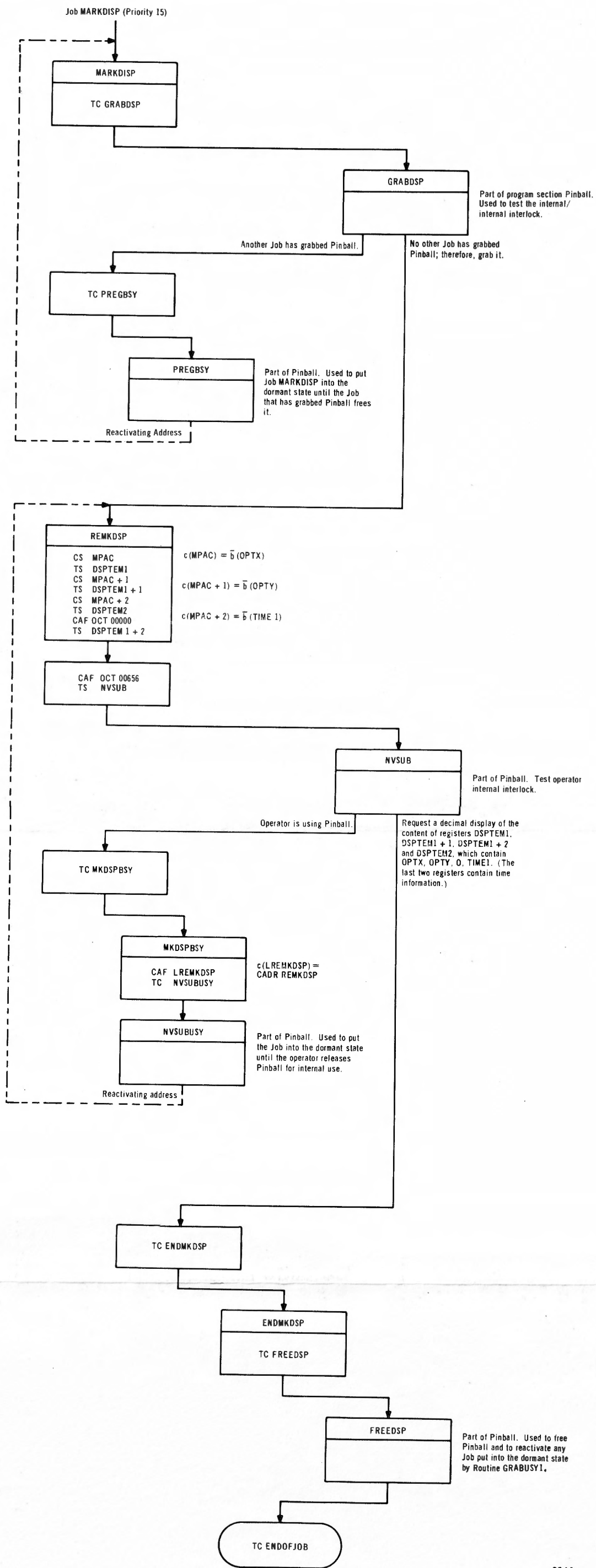
14-134. Routine OPTSTALL is a special entrance to Routine IMUSTALL which is described in paragraphs 14-99 through 14-109. Routine OPTSTALL differs from Routine IMUSTALL in that it sets an index register so that the content of register OPTCADR is tested instead of the content of register IMUCADR.

14-135. ROUTINE MARKDISP

14-136. Job MARKDISP, which begins execution at Routine MARKDISP (figure 14-25), is requested during the execution of Routine KEYRUPT if the operator, in the absence of a computer request for a MARK action, depresses the MARK button. Job MARKDISP requests a decimal display of the content of registers OPTX, OPTY and TIME1 as they were at the time the MARK button was depressed. After Routine KEYRUPT requests the execution of Job MARKDISP with a priority of 15, it transfers the content of registers OPTX, OPTY and TIME1 to the MPAC registers of the Job Area assigned to MARKDISP (refer to paragraph 17-19). When Job MARKDISP is executed, program control is transferred to Routine GRABDSP (paragraph 17-209) to test the internal/internal interlock. If another Job has grabbed program section Pinball, program control is transferred to Routine PREGBSY (17-212) to put Job MARKDISP into the dormant state until the Job that has grabbed Pinball frees it for other Jobs. If Job MARKDISP is able to grab Pinball, program control is transferred to Routine REMKDSP.

14-137. Routine REMKDSP transfers the content of the MPAC registers (i.e., the former content of registers (OPTX), (OPTY) and (TIME1) to registers DSPTEM1, DSPTEM1+1 and DSPTEM2 (0632) respectively. The quantity 00000 is transferred to register DSPTEM1+2 (0631). (When Routine NVSUB is used to request a decimal display of the content of the DSPTEM1 registers, the content of registers DSPTEM1+2 and DSPTEM2 is treated as a double precision quantity representing time information.) Next, a request is made to Routine NVSUB for the execution of Verb 06 Noun 56. If the operator has control over Pinball, program control is transferred to Routine MKDSPBSY which transfers the CADR (Complete Address) of Routine REMKDSP to register A and then transfers program control to Routine NVSUBUSY (17-222) to put Job MARKDISP into the dormant state until the operator releases Pinball for internal use. When Job MARKDISP is reactivated, it will begin execution at Routine REMKDSP. If the operator is not using program section Pinball, Routine NVSUB proceeds to decode the Verb code 06 and Noun 56. Thus, Routine NVSUB transfers program control to routine DECDSP (paragraph 17-306 and 17-312) to request that a decimal display be performed on the content of the DSPTEM1 registers. The content of registers DSPTEM1 and DSPTEM1+1 is scaled as Optics information pertaining to the shaft and trunnion angles. The content of registers DSPTEM1+2 and DSPTEM2 is treated as a double precision quantity representing time information.

14-138. After the execution of Routine NVSUB, program control is transferred to Routine ENDMKDSP. Routine ENDMKDSP transfers



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Figure 14-25. Routine MARKDISP

program control to Routine FREEDSP to free Pinball for other Jobs and to reactivate any Job put into the dormant state by Routine GRABUSY1. Instruction TC ENDOFJOB is then executed, terminating Job MARKDISP.

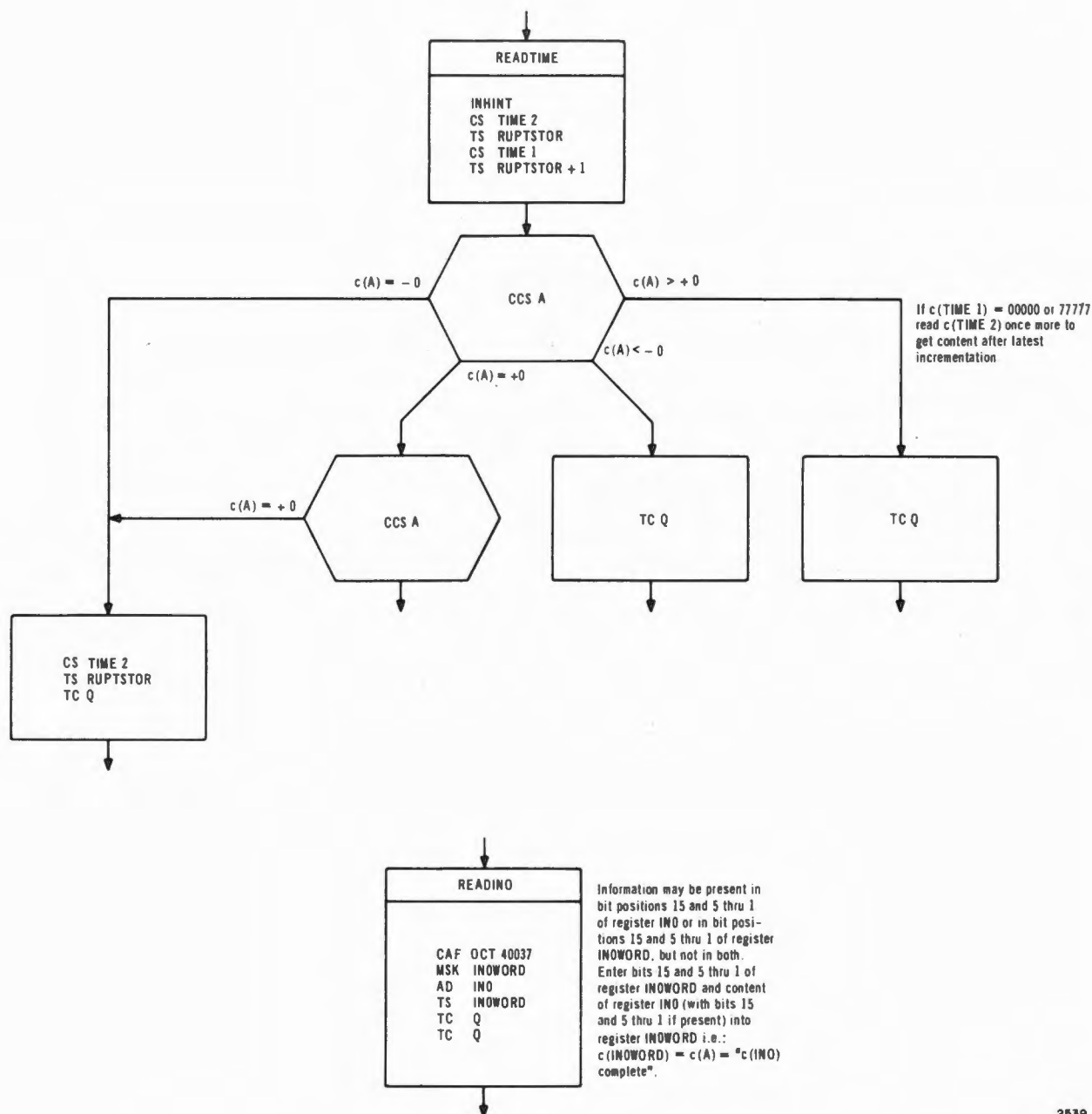
14-139. READ ROUTINES

14-140. ROUTINE READTIME

14-141. Routine READTIME (figure 14-26) is used to read the time counters. This routine executes instruction INHINT and transfers, in complement form, the c(TIME2) to register RUPTSTOR and the c(TIME1) to register RUPTSTOR+1. If input counter register TIME1 contains 00000, the content of input counter register TIME2 is read again to insure that register RUPTSTOR contains the current content of register TIME2.

14-142. ROUTINE READIN0

14-143. Routine READIN0 (figure 14-26) is used to read out the content of input register IN0 which has the property that whenever information is read from this register, the entire register is reset to 00000. Thus, information identifying the action that caused a KEYRUPT could be lost before the RUPT is executed. To prevent this from happening each time the content of register IN0 is read out, it is saved in register IN0WORD. Since the desired information could be in either register IN0 or in register IN0WORD (but not in both), Routine READIN0 first transfers the content of bit positions 15 and 5 through 1 of register IN0WORD to register A. This information is then added to the content of register IN0 and this sum is entered into register IN0WORD. Program control is then transferred to the routine from which the TC READIN0 was done.



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Figure 14-26. Routines READTIME and READINO

14-144. EXTENDED VERBS

14-145. A number of Verb-Noun combinations are provided in program section Mode Switching and Mark for requesting the moding of the IMU and Optics. When a request for a mode switch is initiated by the operator via a DSKY Verb-Noun combination, the appropriate routines in program section Mode Switching and Mark are executed under the auspices of Job CHARIN in program section Pinball. These Verbs, called the List 2 or Extended Verbs, are provided mainly for operator use in the laboratory since the Mission Functions do their own moding through direct use of the moding routines (not through NVSUB calls to these Extended Verbs). The Extended Verbs and the routines they initiate are listed in table 14-3. In general, the Verb routines are denoted by adding the suffix K to the moding routine requested. (For a discussion of the sequence of operations through which those DSKY Verb-Noun requests are processed, see Issue 17, paragraphs 17-84 through 17-95.)

14-146. VERB40 (ZERO)

14-147. ROUTINE VBZERO

14-148. Routine VBZERO, which is initiated by Verb 40, requests either the OPTZERO (paragraph 14-111) or the IMUZERO (paragraph 14-17) mode switching routine. Routine VBZERO (figure 14-27) transfers program control to Routine OP/INERT to determine the subsystem (Inertial or Optics) on which the zeroing sequence is to be performed. Routine OP/INERT compares the Noun code (content of register NOUNREG) with the quantity 00020. If the comparison indicates that the content of register NOUNREG is less than 20, program control is transferred to Routine ALM/END where indicator CHECK FAIL is turned on and Job CHARIN is terminated. If the Noun code is 20, program control is transferred to Routine IMUZERO. If the content of register NOUNREG is greater than 20, it is compared against the quantity 00055. If register NOUNREG does not contain 00055, program control is transferred to Routine ALM/END. If register NOUNREG contains 00055, program control is transferred to Routine ALM/END as the system interfaces necessary for the use of Routine OPTZERO are not available in present G&N Systems. However, Routine OPTZERO is described herein so that the reader may anticipate its availability.

TABLE 14-3
EXTENDED VERB ROUTINES

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
40	VERB 4, 0 NOUN 2, 0 or 5, 5 ENTER	VBZERO	The Noun Code is checked to verify that it is 20 or 55. Program control is then transferred to either Routine IMUZERO or Routine OPTZERO.	IMUZERO (if Noun Code is 20) OPTZERO (if Noun code is 55); however, the interfaces necessary for the execution of the Routine OPTZERO are not available in SUNRISE 45 IMUSTALL
41	VERB 4, 1 NOUN 2, 0 or 5, 5 ENTER	VBCOARK	The Noun Code is checked to verify that it is 20 or 55. If the Noun Code is 20, subsection NVSUB of program section Pinball is utilized to request loading of the THETAD Registers. If the operator keys in the requested data, registers KH and KG are set and program control is transferred to routine IMUCOARS. If the operator keys in Verb 33 (Verb Proceed), subsection NVSUB is used to request a data load of the DSPTEM2 register. If the operator keys	IMUCOARS CDUINC IMUCOARS

TABLE 14-3

EXTENDED VERB ROUTINES (cont)

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
			<p>in the requested data, the content of register DSPTEM2 is added to the content of the THETAD registers (during execution of Routine CDUINC), registers KH and KG are set, and program control is transferred to Routine IMUCOARS. If the operator again keys in Verb Proceed, program control is transferred to Routine IMUCOARS after registers KH and KG are set.</p> <p>If the Noun Code is 55, subsection NVSUB is executed to request a load of registers DESOPTX and DESOPTY. If the operator enters the requested data or keys in Verb Proceed, the Optics drive loop is enabled and Job CHARIN is terminated. If at any time the operator keys in Verb Terminate, Job CHARIN is terminated.</p>	<p>IMUSTALL</p> <p>None</p>

TABLE 14-3
EXTENDED VERB ROUTINES (cont)

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
42	VERB 4, 2, ENTER	IMUFINEK	Subsection NVSUB is utilized to request a data load of the GYROD registers. If the operator keys in either data or Verb Proceed, program control is transferred to Routine IMUFINE. If the operator keys in Verb Terminate, Job CHARIN is terminated.	IMUFINE IMUPULSE IMUSTALL
43	VERB 4, 3, ENTER	IMULOCKK	None	IMULOCK IMUSTALL
44	VERB 4, 4, ENTER	IMUATTCK	Subsection NVSUB is utilized to request that data be loaded into the DSPTEM2 registers. If the operator enters the requested data, the content of the DSPTEM2 registers is added to the content of the THETAD registers during the execution of Routine INCLOOP. Program Control is then transferred to Routine IMUATTC.	INCLOOP IMUATTC

TABLE 14-3
EXTENDED VERB ROUTINES (cont)

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
44	VERB 4, 4, ENTER	IMUATTCK	<p>If the operator keys in Verb Proceed, subsection NVSUB is used to request a data load of the THETAD registers. If the operator keys in either the requested data or Verb Proceed, program control is transferred to Routine IMUATTC.</p> <p>If at any time the operator keys in Verb Terminate, Job CHARIN is terminated.</p>	IMUATTC IMUSTALL
45	VERB 4, 5, ENTER	IMUREENT	<p>Subsection NVSUB is used to request a data load of the THETAD registers. If the operator keys in either the requested data or Verb Proceed, program control is transferred to Routine IMUREENT. If the operator keys in Verb Terminate, Job CHARIN is terminated.</p>	IMUREENT
46	VERB 4, 6, ENTER	IMUCORK	None	IMURECOR IMUSTALL
47	VERB 4, 7, ENTER	ALM/END	None	None

TABLE 14-3
EXTENDED VERB ROUTINES (cont)

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
50	ENTER (When the quantity 50 appears in the Verb displays)	GOLOADLV	<p>This Verb routine is executed only after the operator has performed the checklist item displayed. The flashing of the VERB and NOUN displays is terminated.</p> <p>Enters 77777 into register LOADSTAT and reactivates any Job put into the dormant state by Routine ENDIDLE at location P+3.</p>	None
51	Verb Code 51 is provided only for display purposes.	ALM/END	None	None
52	VERB 5, 2, ENTER	DOMKACPT	This Verb is used only until the ACC MARK button on the Optics is available. Requests the scheduling of Task MKACCEPT with a time delay of 10 msec.	None
53	VERB 5, 3, NOUN 2, 0, or 5, 5, ENTER	RELO/IK	The Noun code is checked to verify that it is either 20 or 55. If it is 20, the CDU drive	None

TABLE 14-3

EXTENDED VERB ROUTINES (cont)

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
			loop is enabled. If it is 55, the OPTICS drive loop is enabled. If it is neither, the CHECK FAIL indicator on the Navigation Panel is turned on.	
54	VERB 5, 4, ENTER	TORQGYRS	Subsection NVSUB is used to request a data load of the GYROD registers. If the operator keys in either data or Verb Proceed, program control is transferred to Routine IMUPULSE. If the operator keys in Verb Terminate, Job CHARIN is terminated.	IMUPULSE IMUSTALL
55-67	Illegal			
70	VERB 7, 0, ENTER	DOGDRIFT	The PROGRAM displays are updated and Program Control is transferred to the EXECUTIVE to request the execution of System Test Job LGNTEST1. The System Test Job utilizes the Mode Switching Routines.	SXTMARK IMUZERO IMUCOARS IMUSTALL IMUPULSE OPTSTALL
71	VERB 7, 1, ENTER	DOPIPTST	The PROGRAM displays are updated and program control	IMUZERO IMUPULSE

TABLE 14-3
EXTENDED VERB ROUTINES (cont)

Verb Code*	DSKY Key Sequence	Routine Initiated	Action Taken	Mode Switching Routines Utilized
			is transferred to the EXECUTIVE to request the execution of System Test Job PIPTEST 1. The System Test Job utilizes the mode switching and Mark Routines.	IMUSTALL SXTMARK
72-77	Illegal			

* Verb codes below 40 are included in list 1; see Issue 17, Table 17-6.

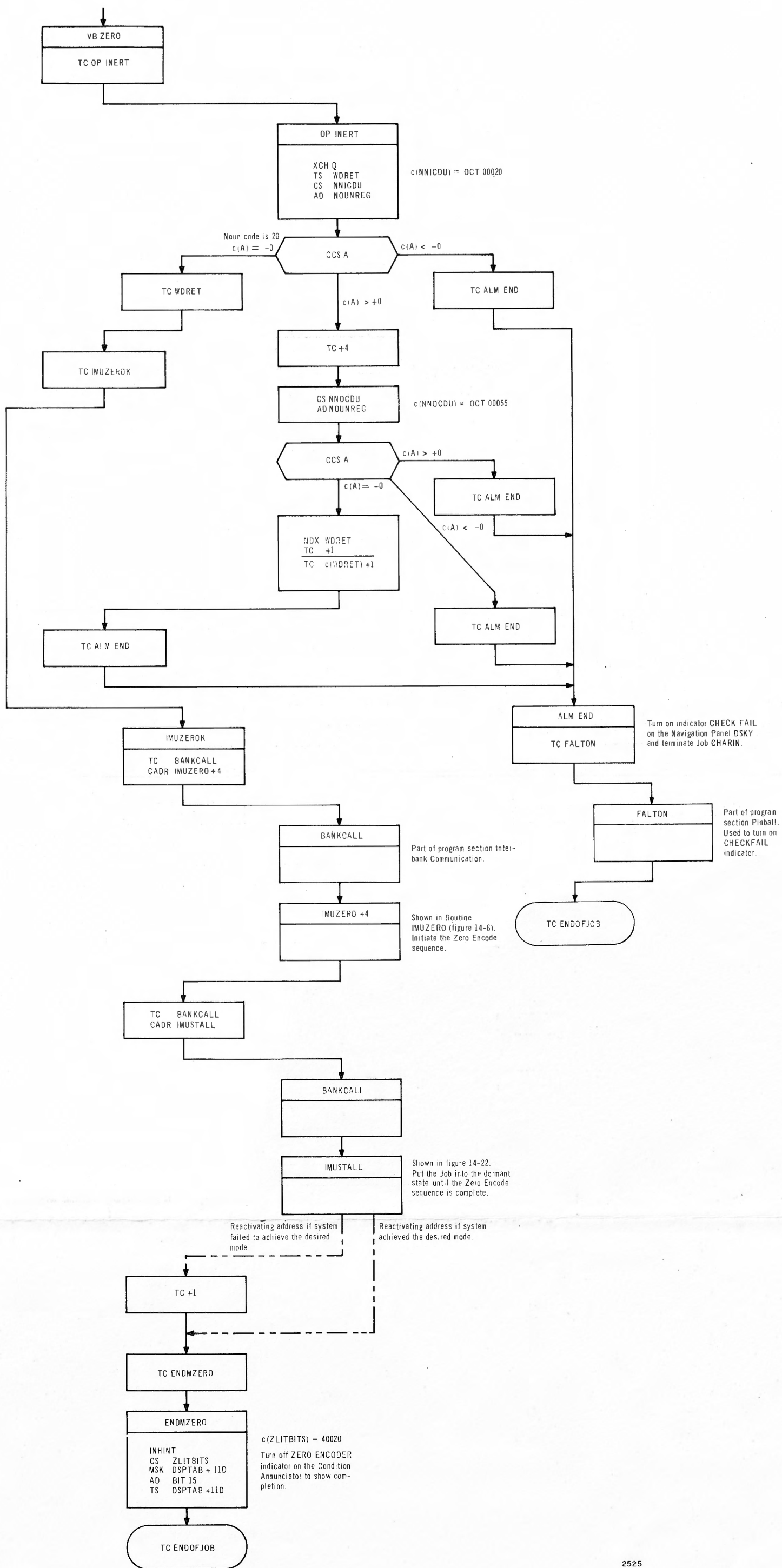


Figure 14-27. Routine VBZERO

14-149. ROUTINE IMUZEROK

14-150. Routine IMUZEROK transfers program control to Routine IMUZERO at location IMUZERO+4 to initiate the Zero Encode sequence (i. e., to equate the content of the IMU CDU's with the actual gimbal angles). The instructions bypassed by entering the routine at location IMUZERO+4 test register CDUIND to determine whether another program has reserved, or is allowing program section T4RUPT Output Control to drive the IMU CDU's. Since Routine VBZERO is only executed at the request of an operator in the laboratory, this test is unnecessary since the IMU CDU's can reasonably be presumed to be available. (Routine IMUZERO is described in detail in paragraph 14-17.) After Routine IMUZERO has been executed, program control is transferred to Routine IMUSTALL to put the Job (Job CHARIN) into the dormant state until the Zero Encode sequence is completed. (Routine IMUSTALL is described in paragraphs 14-99 through 14-109.) Regardless of whether the Job CHARIN is reactivated at a location indicating that a mode switch was unsuccessful or at a location indicating that all mode switches were successful, program control is transferred to Routine ENDMZERO where the ZERO ENCODER indicator on the Condition Annunciator is turned off. This is accomplished by entering a ZERO into bit position 5 of register DSPTAB+11D and a ONE into bit position 15 of this register to signal T4RUPT Output Control. Then the CHARIN Job is terminated.

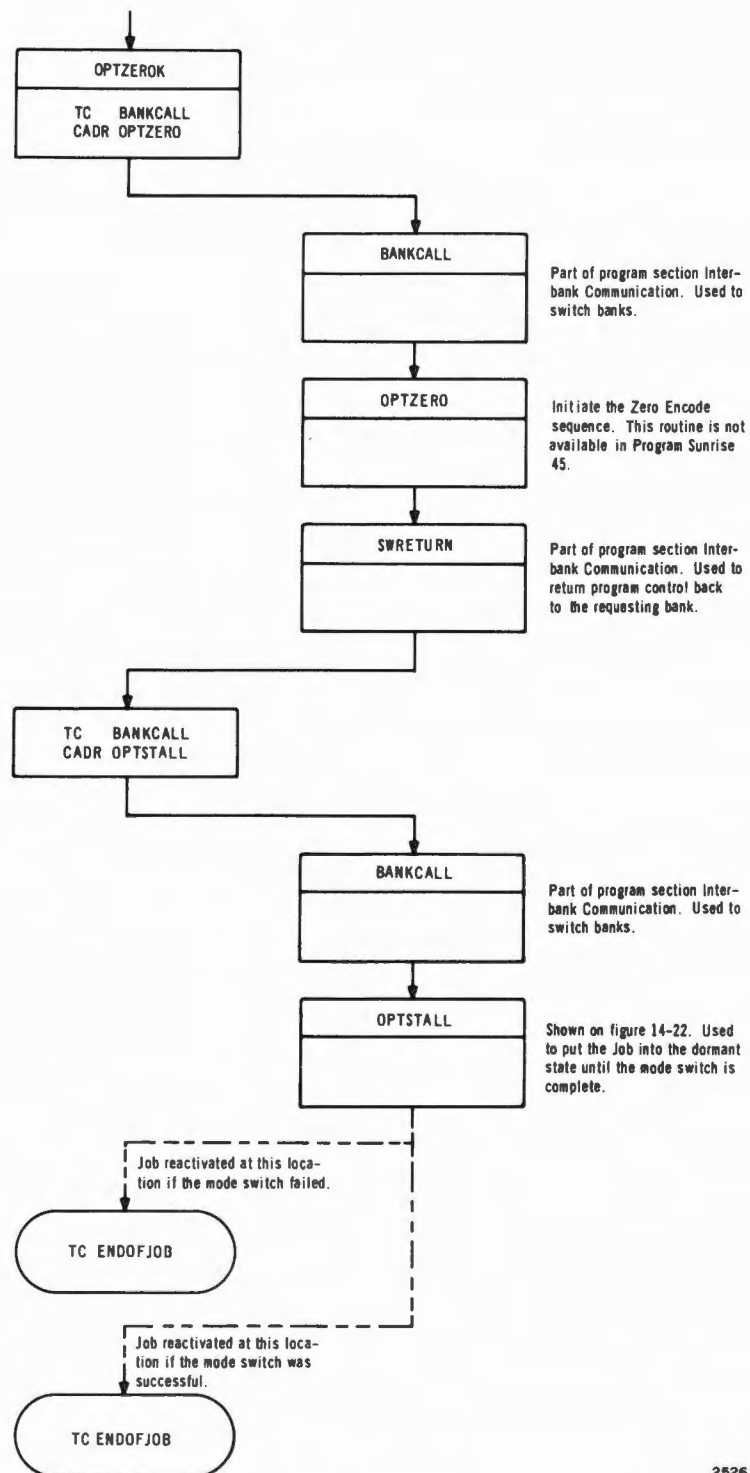
14-151. ROUTINE OPTZEROK

14-152. Although in revision 45 of program SUNRSE, program control is never transferred to Routine OPTZEROK, this routine is described here as it does appear in SUNRISE 45. Routine OPTZEROK (figure 14-28) transfers program control to Routine OPTZERO to initiate the Zero Encode sequence. (Routine OPTZERO is not available in the SUNRISE programs.) Program control is then transferred to Routine OPTSTALL to put Job CHARIN into the dormant state until the Zero Encode sequence has been executed. If at any time a mode switch fails, this Job will be reactivated at location P+2, where P is the location from which the TC BANKCALL was done. If all mode switches are successful, Job CHARIN is reactivated at location P+3 during the execution of the last Task associated with the Zero Encode sequence. Regardless at which location Job CHARIN is reactivated, instruction TC ENDOFJOB is executed.

14-153. VERB 41 (COARSE ALIGN)

14-154. ROUTINE VBCOARK

14-155. Routine VBCOARK is executed to perform one of two functions



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Figure 14-28. Routine OPTZEROK

depending upon the Noun code used with Verb 41. The two functions are as follows:

- a. If the Noun code is 20, Routine VBZERO is executed to allow the operator to enter the desired IMU CDU angles into the computer, and to force the gimbals to drive to this desired position. Routine VBCOARK implements this function by first requesting a data load of the desired IMU CDU angles. After the desired IMU CDU angles have been entered into the THETAD registers, Routine VBCOARK requests that the Inertial Subsystem be put into the Coarse Align mode. When the Inertial Subsystem is in the Coarse Align mode, Routine VBZERO enables the IMU CDU drive loop. Program section T4RUPT Output Control computes the drive command and transfers this command to registers OUTCR1 and OUT2. This causes the IMU CDU's to be driven and, since the system is in the Coarse Align mode, the gimbal angles follow. Prior to executing Routine VBCOARK, the Zero Encode sequence should have been executed to prevent the gimbals from possible severe transients when the coarse align mode switch occurs.
- b. If the Noun code is 55, Routine VBCOARK is executed to allow the operator to enter the desired Optics angles into the computer and to force the Optics to be driven to this position. Routine VBCOARK implements this function by requesting a data load of the desired Optics angles. After the operator keys in the requested data, this data is entered into registers DESOPTX and DESOPTX+1 (DESOPTY) and the Optics CDU drive loop is enabled. Program section T4RUPT Output Control computes the drive command and transfers this command to registers OUTCR2 and OUT2. When the Optics CDU's are driven, the position of the Sextant and the Telescope are changed accordingly.

14-156. Routine VBCOARK (attachment 14-2) transfers program control to Routine OP/INERT to test the Noun code used with Verb 41. If the Noun code is 20 or 55, program control is transferred to Routine IMUCOARK or to Routine OPTCOARK respectively. If the Noun code is neither 20 nor 55, program control is transferred to Routine ALM/END where a ONE is entered into bit position 5 of register OUT1 to illuminate indicator CHECK FAIL on the Navigation Panel DSKY. Job CHARIN is then terminated.

14-157. ROUTINE IMUCOARK

14-158. Routine IMUCOARK requests a data load of the THETAD regis-

ters by executing the standard calling sequence to Routine NVSUB which is described in paragraph 17-207. Routine IMUCOARK is executed under the auspices of Job CHARIN; however, Routine VERBFAN in subsection ENTER of program section Pinball (paragraph 17-276) executes Routine RELDSP to release Pinball for internal use. Thus, Routine IMUCOARK executes the standard calling sequence to Routine NVSUB as if this routine were executed under the auspices of a Job other than Job CHARIN.

14-159. Routine IMUCOARK transfers program control to Routine GRABDSP (in Pinball) to test the internal/internal interlock. If no other Job is using Pinball, the quantity 02522 is transferred to register A and program control is transferred to Routine NVSUB. If another Job is using Pinball, (i. e., the internal/internal interlock is set), program control is transferred to Routine PREGBSY to put Job CHARIN into the dormant state until the other Job that has grabbed Pinball frees it for other users by executing Routine FREEDSP. (Routine FREEDSP also activates any Job put into the dormant state by Routine PREGBSY.) Job CHARIN is reactivated at a location which contains instructions that transfer the quantity 02522 to register A and then transfers program control to Routine NVSUB.

14-160. When Routine IMUCOARK transfers program control to Routine NVSUB, the operator/internal interlock is tested. If the operator is not using Pinball, Routine NVSUB displays the quantity 22 in the NOUN displays. (Routine NVSUB requests that the quantity 25 be displayed in the VERB displays; however, it is unlikely that the operator will ever see the quantity 25 displayed since Routine ABCLOAD requests that the quantity 21 be displayed in the VERB displays.) Program control is then transferred to Routine ABCLOAD in Pinball (paragraph 17-387) to initiate a three-component data load request of the THETAD registers. After the data load request has been initiated, program control is transferred back to Routine IMUCOARK which transfers program control to Routine ENDIDLE to put the Job CHARIN into the dormant state until the operator responds to the load request. If the operator is using Pinball, Routine NVSUB transfers program control back to Routine IMUCOARK which then transfers program control to Routine PRENVBSY. Routine PRENVBSY puts Job CHARIN into the dormant state until the operator releases Pinball for internal use. This Job will be reactivated at a location which contains instructions that transfer the quantity 02522 to register A and then transfer program control to Routine NVSUB.

14-161. An operator has three different responses to a data load request (paragraph 17-372). These responses and actions taken by Routine

IMUCOARK are listed in table 14-4.

14-162. Routine INCLOOP (attachment 14-2) enters the address of register THETAD+2 into register BUF and then sets up a loop so that Routine INCLOOP2 will be executed three times. Routine INCLOOP2 transfers the content of register DSPTEM+2 to register TEM2 and then transfers program control via calling sequence (TC BANKCALL, CADR CDUINC) to Routine CDUINC. The second and third time Routine INCLOOP2 is executed, the content of register DSPTEM2+1 and DSPTEM2 respectively are transferred to register TEM2 before program control is transferred to Routine CDUINC.

14-163. Routine CDUINC tests the content of registers THETAD+2, THETAD+1, and THETAD during the first, second, and third passes respectively through the routine. If register THETAD+2, THETAD+1, or THETAD contains a positive quantity or the quantity 00000 (the quantity 77777 is changed to 00000) the content of register TEM2 is added to the content of register THETAD+2, THETAD+1, or THETAD. If register THETAD+2, THETAD+1, or THETAD, contains a negative quantity, the quantity is decremented by one before the content of register TEM2 is added to it. This compensates for the fact that the addition is done in ONE's complement while the operands are in TWO's complement. If this addition of the contents of registers THETAD+2 and TEM2 results in a negative quantity, the quantity 77776 is added to the content of the THETAD registers to compensate for the fact that the addition is done in ONE's complement while the data represents information in TWO's complement. If the addition results in a positive quantity, there is no need for compensation. If no overflow occurs as a result of the addition, the sum is entered into register THETAD+2, THETAD+1, or THETAD, and program control is transferred back to the calling routine via Routine SWRETURN. In this case, program control is transferred back to Routine INCLOOP2 at a location such that it can be executed again if it has not been executed three times or program control can be transferred to Routine ICORK2 if Routine INCLOOP has been executed three times. If overflow or underflow occurs as a result of the addition, the quantity 37777 or 40000 respectively is entered into register THETAD+2, THETAD+1, or THETAD before program control is transferred to either Routine INCLOOP2 again or to Routine ICORK2.

14-164. Routine ICORK2 is executed after the desired IMU CDU angles (total or incremental) have been entered into the proper THETAD registers. This routine enters the quantity 04100 into register A and then transfers program control to Routine NVSUB. If the operator is not using program section Pinball, Routine NVSUB sets the proper DSPTAB

TABLE 14-4
ROUTINE IMUCOARK ACTIONS

Operator Response	Action Taken
Operator keys in the three requested data words, each followed by ENTER	Program control is transferred to Routine ICORK2 (paragraph 14-164).
Operator keys in VERB 3, 3, Proceed, ENTER	Program control is transferred to Routine ICSDEL (attachment 14-2) where the quantity 02523 is transferred to register A and program control is transferred to Routine NVSUB to request a data load of the DSPTEMP1 registers. The operator must think of this load request as an incremental load request since the data entered is added to the content of the THETAD registers. Routine NVSUB operates as described in paragraph 14-160 with the exception that the quantity 23 is displayed in the NOUN displays. The three possible operator responses and the action taken by Routine ICSDEL are listed in Table 14-5.
Operator keys in VERB 3, 4, Terminate and ENTER	Program control is transferred to Routine ENDMKDSP (attachment 14-2) which transfers program control to Routine FREEDSP (paragraph 17-227) to reactivate any Job put into the dormant state by Routine GRABUSY1 and to free program section Pinball for other internal programs. Job CHARIN is then terminated.

TABLE 14-5
ROUTINE ICSDEL ACTIONS

Operator Response	Action Taken
Operator keys in the three requested data words, each followed by ENTER	Program control is transferred to Routine CDUINC via Routine INCLoop which is described in paragraphs 14-162 and 14-163.
Operator keys in VERB 3, 3, (Proceed), ENTER	Program control is transferred to Routine ICORK2 which is described in paragraph 14-164.
Operator keys in VERB 3, 4, (Terminate) ENTER	Program control is transferred to Routine ENDMKDSP which transfers program control to Routine FREEDSP (paragraph 17-227) to reactivate any Job put into the dormant state by Routine GRABUSY1 and to program section Pinball for other internal programs. Job CHARIN is then terminated.

register so that the quantity 41 is redisplayed in the VERB displays (the quantity currently displayed in the VERB display is 23.) If the operator is using Pinball, program control is transferred via Routine ICORK2 to Routine PRENVBSY to put the Job CHARIN into the dormant state until the operator releases Pinball for internal use. When Job CHARIN is reactivated, program control is transferred to Routine NVSUB to display the quantity 41 in the VERB displays.

14-165. After Routine NVSUB is executed to display the quantity 41 in the VERB display, program control is transferred to Routine FREEDSP to free Pinball for other Jobs and to reactivate any Job put into the dormant state by Routine GRABUSY1. Then, the quantity 05605 is entered into register KG and the quantity 00000 is entered into register KH. After the desired gains have been entered into registers KG and KH (utilized during the execution of program section T4RUPT Output Control), program control is transferred to Routine IMUCOARS via Routine BANKJUMP. Routine IMUCOARS (paragraph 14-33) requests that the Inertial Subsystem be put into the Coarse Align mode, schedules Task BEGINCOM to verify the mode switch, and to enable the IMU CDU drive loop, and then transfers program control back to the routine which requested Routine IMUCOARS (i. e., in this case, Routine ICORK2). Routine ICORK2 transfers program control to Routine IMUSTALL (paragraphs 14-99 through 14-109) to put the Job into the dormant state until it is reactivated by Task COARSDON. Task COARSDON is scheduled for execution during the execution of Task BEGINCOM. (If the mode switch fails, the Job will be reactivated during the execution of Routine BEGINCOM.) When this Job is reactivated, instruction TC ENDOFJOB is executed.

14-166. ROUTINE OPTCOARK

14-167. Routine OPTCOARK (attachment 14-2) is executed when Routine VBCOARK (paragraph 14-154) is executed and the NOUN code is 55 to request a data load of registers DESOPTX and DESOPTY. The routine implements this action by executing the standard calling sequence to Routine NVSUB. Thus, if the internal/internal interlock is not set when it is tested during the execution of Routine GRABDSP, the quantity 02457 is transferred to register A and program control is transferred to Routine NVSUB. If the operator/internal interlock is not set (i. e., the operator does not have control over program section Pinball), Routine NVSUB requests a display of the Verb code 24 in the VERB displays and the NOUN code 57 in the NOUN displays. (It is unlikely that the operator will ever see the quantity 24 appear in the VERB displays as Routine NVSUB transfers program control to Routine ABLOAD where the Verb code is changed to 21 and a display is requested. In the worst

case, the 24 is displayed for only 20 msec.) Routine ABLOAD (paragraph 17-385) initiates a two-component load request and after the load request has been initiated, program control is transferred via Routine OPTCOARK to Routine ENDIDLE to put the Job into the dormant state until the operator responds to the load request. If the internal/internal interlock or the operator/internal interlock is set, program control is transferred to Routine PREGBSY or to Routine PRENVBSY to put Job CHARIN into the dormant state until the operator frees or releases program section Pinball for internal use.

14-168. If the operator keys in either the requested data or VERB 3, 3, (Proceed) ENTER, the quantity 04100 is transferred to register A and program control is transferred to Routine NVSUB. If the operator is not using Pinball, Routine NVSUB redisplay the Verb code 41 in the VERB displays. If the operator is using Pinball, Routine NVSUB transfers program control via Routine OPTCOARK to Routine PRENVBSY to put the Job into the dormant state until the operator releases Pinball for internal use. When this Job is reactivated and executed, it transfers program control to Routine NVSUB to redisplay the Verb code 41.

14-169. After Routine NVSUB redisplay the Verb code 41, program control is transferred to Routine FREEDSP to reactivate any Job put into the dormant state by Routine GRABUSY1 and to free Pinball for other Jobs. Next, the content of register OPTIND is tested and it will most likely contain the quantity 77777 as the Extended Verbs are provided mainly for laboratory use and it is unlikely that another Job would either have reserved the Optics driving function for itself or have enabled the Optics drive loop. If register OPTIND contains 77777 indicating that no other Job has enabled the Optics drive loop and that no other Job has reserved the Optics driving function for itself, the quantity 00000 is entered into register OPTIND to enable the Optics drive loop and instruction TC ENDOFJOB is executed. When T4RUPT Output Control is executed, the difference between register DESOPTX and CDU counter OPTX and the difference between register DESOPTY and CDU input counter OPTY are translated into a command. The Optics are driven until this difference approaches zero. If register OPTIND does not contain 77777, instruction TC ENDOFJOB is executed immediately.

14-170. VERB 42 (FINE ALIGN IMU)

14-171. ROUTINE IMUFINEK

14-172. Routine IMUFINEK is executed to allow the operator to enter the desired gimbal angles into the computer and to torque the stable member gyros to the desired position. Routine IMUFINEK implements

this action by first requesting a data load of the GYROD (desired gimbal angle) registers and then requesting that the Inertial Subsystem be put into the Fine Align mode. When the subsystem is in the Fine Align mode, program control is transferred to Routine IMUPULSE to drive the gyros until the gimbal angles reach the desired position. Since the subsystem is in the Fine Align mode, the IMU CDU's will reflect the change in the gimbal angles.

14-173. Routine IMUFINEK, (attachment 14-3) which is executed under the auspices of Job CHARIN, since it is initiated via a DSKY request, requests a data load of the GYROD registers by executing the standard calling sequence to Routine NVSUB. Thus, Routine IMUFINEK transfers program control to Routine GRABDSP to test the internal/internal interlock. If the internal/internal interlock is set, program control is transferred via Routine IMUFINEK to Routine PREGBSY to put Job CHARIN into the dormant state until the Job that has grabbed program section Pinball frees it for internal use. The awakening address of a Job put into the dormant state by Routine PREGBSY is set so that when the Job is reactivated and is executed, the quantity 02567 is transferred to register A and then program control is transferred to Routine NVSUB. If the internal/internal interlock is not set, Routine GRABDSP transfers program control back to Routine IMUFINEK where the quantity 02567 is transferred to register A and program control is transferred to Routine NVSUB.

14-174. Routine NVSUB tests the operator/internal interlock and if the operator is using Pinball (i. e., the operator/internal interlock is set), program control is transferred to Routine PRENVBSY where the Job is put into the dormant state until the operator releases Pinball for internal use. The awakening address of this Job is set so that when the Job is reactivated and then executed, the quantity 02567 is transferred to register A and program control is transferred to Routine NVSUB. If the operator is not using Pinball (i. e., the operator/internal interlock is not set), Routine NVSUB displays the quantity 67 in the NOUN displays. Program control is then transferred to Routine ABCLOAD where the quantity 21 is displayed in the VERB displays and a request for a three-component load is initiated. After the load request has been initiated, program control is transferred back to Routine IMUFINEK which in turn transfers program control to Routine ENDIDLE to put Job CHARIN into the dormant state until the operator responds to the load request. The operator can respond to a load request in one of three different ways: enter the request data, proceed or terminate.

14-175. If the operator keys in VERB, 3, 4, (Terminate) ENTER the

Job is reactivated and the awakening address is set so that when the Job is executed, Routine IMUFINEK causes program control to be transferred to Routine ENDMKDSP. Routine ENDMKDSP executes Routine FREEDSP which frees Pinball for other Jobs, reactivates any Job put into the dormant state by Routine GRABUSY1, and then transfers program control back to the routine from which the TC FREEDSP was done. In this case, program control is transferred back to Routine ENDMKDSP where instruction TC ENDOFJOB is executed.

14-176. If the operator keys in either the requested gimbal angle data or VERB, 3, 3, (Proceed) ENTER the Job is reactivated and the awakening address is set so that when the Job is executed, Routine IMUFINEK transfers the quantity 04200 to register A and then transfers program control to Routine NVSUB. If the operator is not using Pinball, Routine NVSUB displays the quantity 42 in the VERB displays. (If the operator is using Pinball, program control is transferred to Routine PRENVBSY to put the Job into the dormant state until the operator releases Pinball for internal use.) After Routine NVSUB causes the quantity 42 to be redisplayed in the VERB displays, program control is transferred by Routine IMUFINEK to Routine FREEDSP to free Pinball for other internal Jobs and then reactivate any Job put into the dormant state by Routine GRABUSY1.

14-177. Routine IMUFINEK then transfers program control via the calling sequence TC BANKCALL, CADR IMUFINE to Routine IMUFINE to request that the Inertial Subsystem be put into the Fine Align mode. Routine IMUFINE (paragraph 14-43) not only requests the Fine Align mode, but also disables the IMU CDU loops and requests the execution of Task IMUFINED. Thereafter, program control is transferred back to that routine (in this instance, Job CHARIN) from which program control was transferred to Routine IMUFINE. Thus, program control is transferred back to Routine IMUFINEK at a location that causes program control to be transferred to Routine IMUSTALL to put the Job into the dormant state until the system is established in the Fine Align mode. This Job is reactivated by Task IMUFINED. If the mode switch is not successful, the Job is reactivated at a location that causes the execution of instruction TC ENDOFJOB. If the mode switch is successful, the Job is reactivated at a location that causes program control to be transferred to Routine IMUPULSE via Routine BANKCALL. Thus, when the reactivated Job is executed, program control is transferred to Routine IMUPULSE (paragraph 14-52) to initiate the pulse torquing of the IMU gyros according to commands contained in the GYROD registers. (The GYROD registers were loaded at the beginning of Routine IMUFINEK.) After initiating the command to pulse torque the gyros, Routine IMUPULSE transfers control back to Routine IMUFINEK where program control is

transferred to Routine IMUSTALL. Routine IMUSTALL puts the Job into the dormant state until the pulsing of the gyros is completed. Regardless of whether the Job is reactivated at the location pertaining to a failure or at the location pertaining to a successful mode switch, instruction TC ENDOFJOB is executed.

14-178. VERB 43 (LOCK IMU)

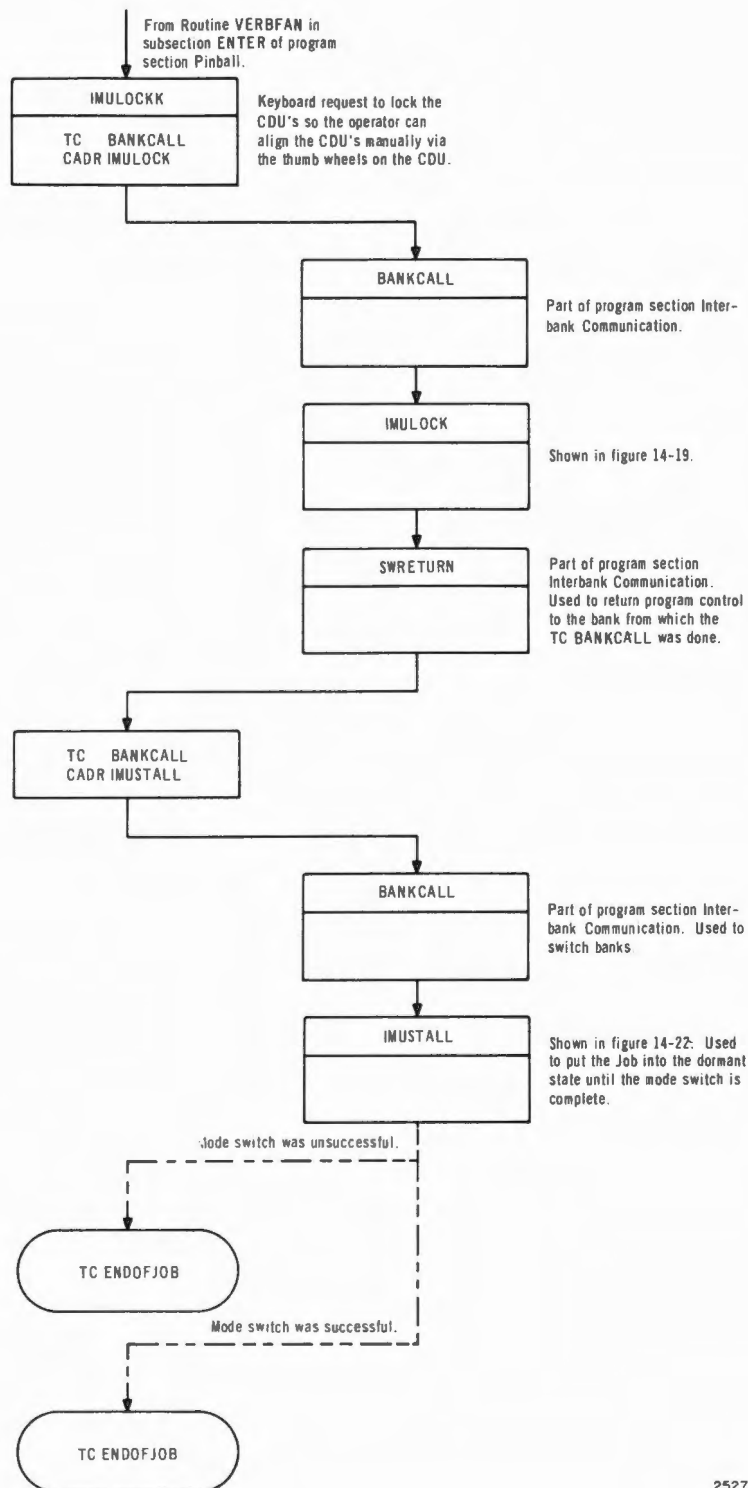
14-179. ROUTINE IMULOCKK

14-180. Routine IMULOCKK, (figure 14-29), requests that the Inertial Subsystem be put in the Manual CDU mode by transferring program control to Routine IMULOCK via Routine BANKCALL. Routine IMULOCK (paragraph 14-89) not only requests that the subsystem be put into the Manual CDU mode but also disables the IMU CDU loops and schedules Task IMULOCKD with a time delay of 200 msec. Thereafter, program control is transferred back to Routine IMULOCKK where program control is transferred to Routine IMUSTALL via Routine BANKCALL to put Job CHARIN, under which Routine IMULOCKK was initiated, into the dormant state until the Inertial Subsystem is established in the Manual CDU mode. Job CHARIN is later reactivated by Task IMULOCKD. Regardless of whether the Job is reactivated at the location pertaining to an unsuccessful mode switch or at the location pertaining to a successful mode switch, instruction TC ENDOFJOB is executed, terminating the Job.

14-181. VERB 44 (SET IMU TO ATTITUDE CONTROL)

14-182. ROUTINE IMUATTCK

14-183. Routine IMUATTCK is executed to allow the operator to enter the desired spacecraft attitude into the THETAD registers and then to command the attitude of the spacecraft to be changed according to the angles contained in the THETAD registers. This operation is implemented by requesting an incremental data load of the DSPTEM2 registers and then, if the data is entered, adding the data to the content of the THETAD registers. Then Routine IMUATTCK requests that the Inertial Subsystem be put into the Attitude Control mode. If the operator does not wish to enter an incremental load, he can key in VERB Proceed which gives him an option to enter an absolute load of the THETAD registers. When the system is in the Attitude Control mode, the difference between the THETAD registers and the CDU counters causes T4RUPT Output Control to drive the CDU's (the gimbals will not follow as the subsystem is not in the Coarse Align mode). Since the subsystem is in the Attitude Control mode, the difference between the CDU's and the actual gimbal angles causes the pulses to be sent to the stabilization and Control System (SCS) and to the Reaction Control System (RCS) which reposition the spacecraft to the desired attitude.



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Figure 14-29. Routine IMULOCKK

14-184. Routine IMUATTCK (attachment 14-4) executes the calling sequence to subsection NVSUB of program section Pinball to request a data load of the DSPTEM2 registers. Thus, Routine IMUATTCK transfers program control to Routine GRABDSP to test the internal/internal interlock. If this interlock is set, program control is transferred to Routine PREGBSY via Routine IMUATTCK to put the requesting Job into the dormant state until the Job that has grabbed Pinball releases it for internal use. If the internal/internal interlock is not set, Routine GRABDSP transfers program control back to Routine IMUATTCK where the quantity 02523 is transferred to register A and program control is transferred to Routine NVSUB. Routine NVSUB tests the operator/internal interlock and, if the operator is not using Pinball, requests that the quantity 25 be displayed in the VERB displays and the quantity 23 be displayed in the NOUN displays. Program control is then transferred to Routine ABCLOAD (paragraph 17-387) to initiate a three-component load request and to request a display of the quantity 21 in the VERB displays. (The VERB displays may briefly indicate the 25 before the 21 appears if the execution of program section T4RUPT Output Control occurs between the two requests.) After the load request has been initiated, program control is transferred back to Routine IMUATTCK which in turn transfers program control to Routine ENDDIDLE to put Job CHARIN into the dormant state until the operator responds to the load request. If Routine NVSUB finds that the operator/internal interlock is set, program control is transferred to Routine PRENVBSY via Routine IMUATTCK to put Job CHARIN into the dormant state until the operator releases Pinball for internal use. When this Job is reactivated, the awakening address is set such that when the Job is executed, the quantity 02523 is transferred to register A and program control is transferred to Subsection NVSUB to initiate the three-component load request.

14-185. The operator can respond in one of three ways to a data load request: enter the requested data, proceed or terminate. If the operator chooses to enter the three incremental data words, each word representing a quantity to be added to the current content of registers THETAD, THETAD+1, and THETAD+2 respectively, program control is transferred to Routine INCLOOP. Routine INCLOOP, (paragraph 14-162), increments the THETAD registers and then transfers program control to Routine ATTCK2. If the operator elects to key in VERB, 3, 3, (Proceed) ENTER program control is transferred immediately to Routine ATTCABS. If the operator keys in VERB, 3, 4, (Terminate) ENTER, program control is transferred to Routine ENDMKDSP to free Pinball for other Jobs and to terminate this Job.

14-186. Routine ATTCABS, which is initiated by the Proceed option, transfers the quantity 02522 to register A and then transfers program control to Routine NVSUB. If the operator/internal interlock is not set, Routine NVSUB displays the quantity 25 in the VERB displays and the quantity 22 in the NOUN displays. Program control is then transferred to Routine ABCLOAD to initiate a second request for a three-component load of the THETAD registers. When this request is initiated, the quantity 21 is displayed in the VERB displays. (It is likely that the operator will never see the quantity 25 appear in the VERB displays due to the speed of requesting actions.) After the request for a data load has been initiated, program control is transferred back to Routine IMUATTCK which transfers program control to Routine ENDIDLE to put the Job into the dormant state until the operator responds to the load request. The Job is reactivated at one of three locations, depending upon how the operator responds to the load request. If the internal/internal interlock or the operator/internal interlock is set, program control is transferred to Routine PREGBSY or Routine PRENVBSY respectively to put the Job CHARIN into the dormant state until Pinball has been freed or released for internal use.

14-187. The operator must respond to this second data load request in one of three ways: enter requested data, proceed, or terminate. If the operator keys in VERB, 3, 4, (Terminate) ENTER, the Job CHARIN, under which Routine IMUATTCK is executed, is reactivated by that Job CHARIN requested by depressing key ENTER. The Job is reactivated at a location that transfers program control to Routine ENDMKDSP. Routine ENDMKDSP executes Routine FREEDSP and then terminates the Job under which Routine ENDMKDSP is executed. Routine FREEDSP (paragraph 17-227) is executed to reactivate any Job put into the dormant state by Routine GRABUSY1 and to free Pinball for other Jobs.

14-188. If the operator enters the three absolute data words requested, the Job is reactivated at the first location of Routine ATTCK2. If the operator keys in VERB, 3, 3, (Proceed) ENTER, the Job CHARIN under which Routine IMUATTCK is executed is reactivated by that Job CHARIN requested by depressing key ENTER. The Job is reactivated at a location that transfers program control to Routine ATTCK2.

14-189. Routine ATTCK2 is executed after the operator has entered the requested data (either incremental data or absolute data) into the computer, or has elected to proceed without data. This routine transfers the quantity 04400 to register A and then transfers program control to Routine NVSUB. If the operator/internal interlock is not set, Routine NVSUB redispays the Verb code 44 in the VERB displays. The quantity 23 or 22 remains displayed in the NOUN displays depending upon

whether the operator keyed in data pertaining to an incremental load or an absolute load respectively. If the operator/internal interlock is set, Routine NVSUB transfers program control to Routine PRENVBSY via Routine IMUATTCK to put the Job into the dormant state until the operator releases Pinball for internal use. The Job will be reactivated when the operator takes a VERB, 3, 5, (Release Display) ENTER keyboard action at a location that contains an instruction to transfer the quantity 04400 to register A and then transfers program control to Routine NVSUB.

14-190. After Routine NVSUB is executed to redisplay the quantity 44 in the VERB displays, program control is transferred to Routine FREEDSP (paragraph 17-227) via Routine IMUATTCK to release Pinball for other Jobs. Finally, since in all three cases the THETAD registers now contain the desired Spacecraft attitude, program control is transferred to Routine IMUATTC via Routine BANKCALL to request that the Inertial Subsystem be put into the Attitude Control mode. (In the SUNRISE listings, registers KH and KG are not set by Routine IMUATTCK. This will be corrected in later programs.) Routine IMUATTC (paragraph 14-80) also schedules a Task which, when executed, enables the IMU CDU drive loop. Thus, T4RUPT Output Control will drive the IMU CDU's and cause error signals to be sent to the SCS which will activate the RCS to turn the Spacecraft to the attitude specified by the IMU CDU's.

14-191. After Routine IMUATTC is executed, program control is transferred to Routine IMUSTALL via Routine IMUATTCK to put the Job into the dormant state until the Inertial Subsystem has been established in the desired mode. This Job is reactivated during the Task associated with Routine IMUATTC. Regardless of whether the Job is reactivated at a location indicating that the mode switch was successful or unsuccessful, instruction TC ENDOFJOB is executed.

14-192. VERB 45 (SET IMU TO RE-ENTRY CONTROL)

14-193. ROUTINE IMUREENK

14-194. Routine IMUREENK is executed to allow the operator to change the attitude of the Spacecraft by keying in angular information pertaining to the desired attitude of the Spacecraft. This routine differs from Routine IMUATTCK (paragraph 14-182) in two specific ways:

- a. The operator does not have the option of keying in an incremental load versus an absolute load. He may only key in absolute data.

- b. Routine IMUREENK requests that the Inertial Subsystem be established in the Re-entry Control mode unlike Routine IMUATTCK which requests that the Inertial Subsystem be established in the Attitude Control mode.

14-195. Routine IMUREENK (attachment 14-4) requests a data load of the THETAD registers by executing the standard calling sequence to Routine NVSUB. Thus, if the internal/internal interlock is not set when it is tested during the execution of Routine GRABDSP, the quantity 02522 is transferred to register A and program control is transferred to Routine NVSUB. If the internal/internal interlock is set, program control is transferred to Routine PREGBSY to put the Job into the dormant state until the routine that has grabbed program section Pinball frees it for internal use by executing Routine FREEDSP. When this Job CHARIN is reactivated and executed, the quantity 02522 is transferred to register A and program control is transferred to Routine NVSUB.

14-196. Routine NVSUB tests operator/internal interlock and, if the operator is not using Pinball, displays the quantity 22 in the NOUN displays, indicating that an absolute load to register THETAD has been requested. Routine NVSUB requests that the quantity 25 be displayed in the VERB displays but it is unlikely that the request will ever be recognized because program control is immediately transferred to Routine ABCLOAD to request the display of the quantity 21 in the VERB displays. (The operator sees only the quantity 21 appear in the VERB displays.) Routine ABCLOAD (paragraph 17-387) initiates a request for a three component Load. If the operator/internal interlock is set, program control is transferred to Routine PRENVBSY via Routine IMUREENK to put the Job into the dormant state until the operator releases Pinball for internal use by taking a VERB, 3, 5, ENTER keyboard action. Job CHARIN is reactivated at a location that transfers the quantity 02522 to register A and then transfers program control to Routine NVSUB.

14-197. After the data load request has been initiated, program control is transferred to Routine ENDIDLE via Routine IMUREENK to put the Job into the dormant state until the operator responds to the data load request. The operator can execute one of three possible responses to a data load request: enter the requested data, proceed or terminate. If the operator keys in either the requested absolute data or else VERB, 3, 3 (Proceed,) ENTER, the Job is reactivated during the execution of Routine LOADLV or Routine VBPROC respectively. When the reactivated Job is executed, the quantity 04500 is transferred to register A and program control is transferred to Routine NVSUB to redisplay the Verb code in the VERB displays. Of course, if the operator is using Pinball, this Job is put into the dormant state by Routine PRENVBSY. If the operator

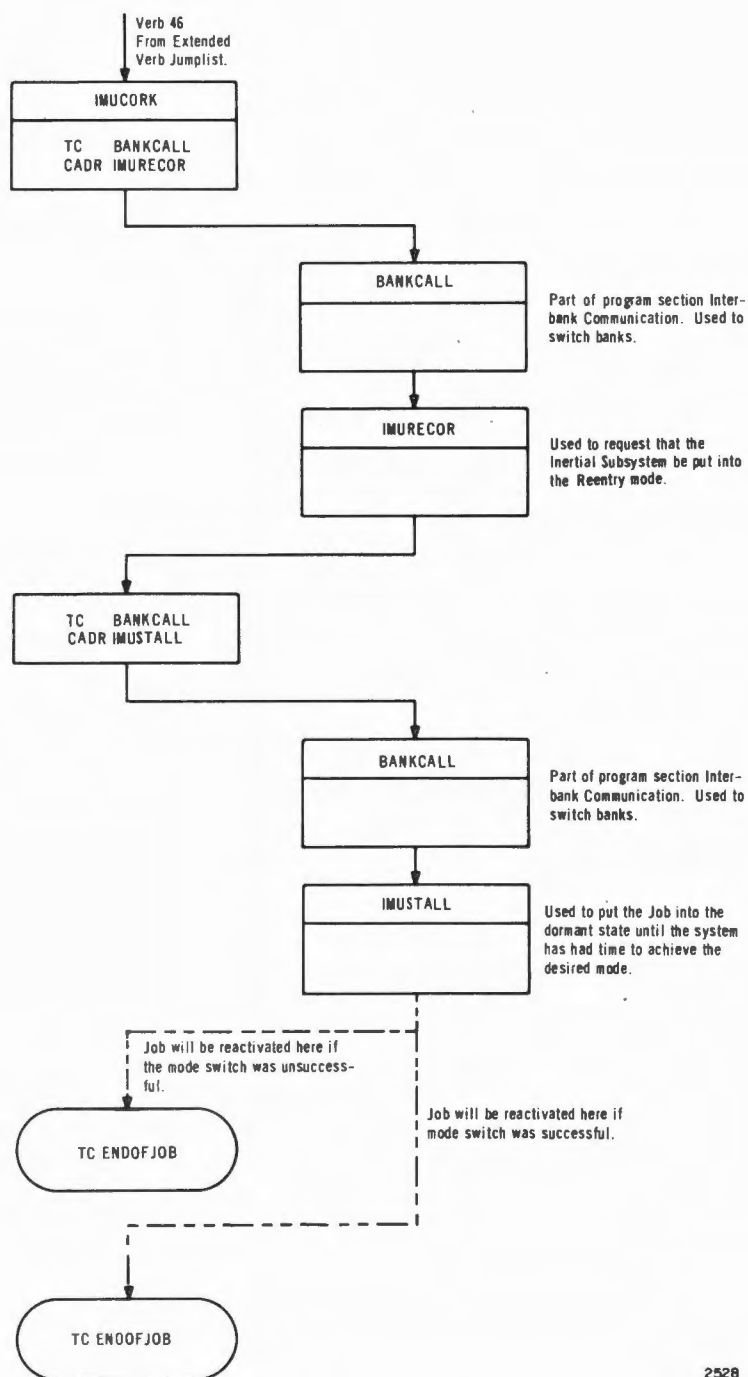
keys in VERB, 3, 4, ENTER, the Job is reactivated during the execution of Routine VBTERM. When the reactivated Job is executed, program control is transferred to Routine ENDMKDSP which transfers program control to Routine FREEDSP to free Pinball for other Jobs. Thereafter, this Job is terminated.

14-198. After Routine NVSUB requests that the quantity 45 be redisplayed in the VERB displays, program control is transferred to Routine IMUREENT (paragraph 14-86) via Routine BANKCALL to request that the Inertial Subsystem be put into the Reentry mode. (The angular information pertaining to the desired attitude is contained in the THETAD registers.) Routine IMUREENT also requests the execution of Task ENABLE to enable the IMU CDU drive loop. Program control is then transferred to Routine IMUSTALL to put the Job into the dormant state until the Inertial Subsystem has had time to achieve the desired mode. Regardless of whether this Job is reactivated at a location indicating that the mode switch was unsuccessful or at a location indicating the mode switch was successful, instruction TC ENDOFJOB is executed.

14-199. VERB 46 (RETURN IMU TO COARSE ALIGN)

14-200. ROUTINE IMUCORK

14-201. Routine IMUCORK (figure 14-30) is executed to return the Inertial Subsystem to the Coarse Align mode from the Fine Align mode. This action is initiated by transferring program control to Routine IMURECOR via Routine BANKCALL. Routine IMURECOR (paragraph 14-94) requests that the subsystem be put into the Coarse Align mode and then requests the scheduling of Task RECOARSD (paragraph 14-97) with a time delay of 200 msec. Program control is then transferred back to Routine IMUCORK which in turn transfers program control to Routine IMUSTALL (paragraph 14-99) to put the Job into the dormant state until the Inertial Subsystem has been established in the Coarse Align mode. In this case, this action involves transferring the content of counters CDUX, CDUY, and CDUZ to the corresponding THETAD registers, and enabling the CDU drive loop for at least 60 seconds. The CDU's will not be driven as there is no difference between the content of the THETAD registers and the corresponding CDU-input register. However, this action is necessary to assure that the subsystem is established in the Coarse Align mode. (This is done under the auspices of Task RECOARSD.) When the Job is reactivated and executed, instruction TC ENDOFJOB is executed.



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Figure 14-30. Routine IMUCORK

14-202. VERB 47 (OPTICAL TRACKER ON)

14-203. ROUTINE OPTTRONK

14-204. In program Sunrise 45, a request for Routine OPTTRONK is illegal and results in indicator CHECK FAIL being turned on and Job CHARIN being terminated. In a subsequent revision to Sunrise 45, program control will be transferred to Routine OPTTRONK to request that the Optics Subsystem be put into the Star Tracker On mode. Routine OPTTRONK (figure 14-31) requests that the Optics Subsystem be put into the Star Tracker On mode by transferring program control to Routine OPTTRKON via Routine BANKCALL. After Routine OPTTRKON is executed, program control is transferred to Routine OPTSTALL to put the Job into the dormant state until the Optics Subsystem is established in the Star Tracker On mode. When this Job is reactivated (by a Task scheduled by Routine OPTTRKON) and executed, Job CHARIN (and hence Routine OPTTRONK) will be terminated.

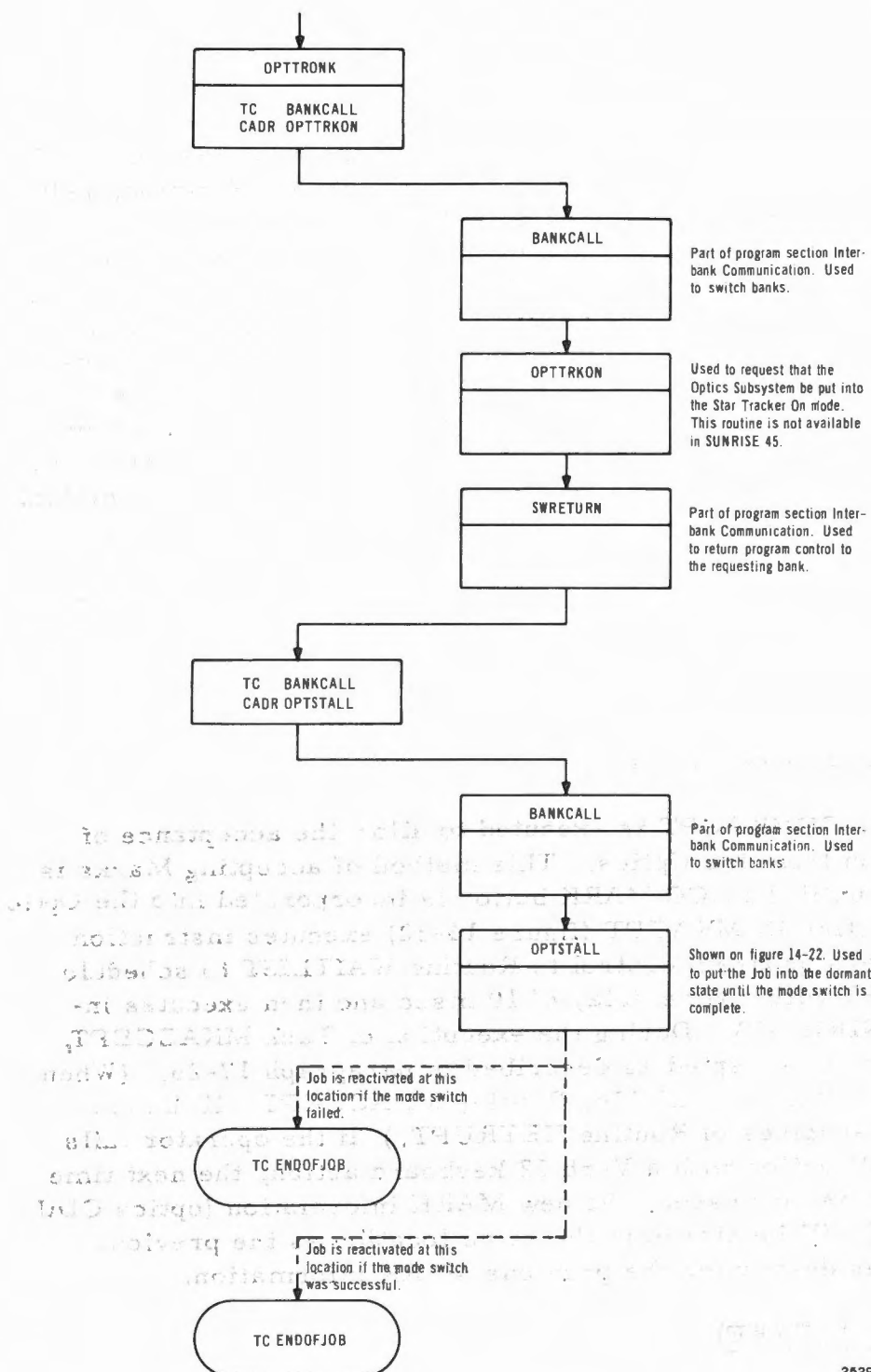
14-205. VERB 50 (PLEASE PERFORM)

14-206. PLEASE PERFORM VERB

14-207. Verb 50 is for internal use only. A Job wishing to use Verb 50 must preload register DSPTEM1 with a code referring to the Checklist item to be performed. The Job must then execute an NVSUB call to request (via a Verb 01 Noun 25) an octal display of the Checklist item code in R1. Flashing of the Verb and Noun displays must be initiated. A second call is made to routine NVSUB requesting that the quantity 50 be flashed in the VERB displays. In all likelihood, after the second execution of routine NVSUB, routine ENDIDLE will be executed to request that the Job be put into the dormant state until the operator responds to the flashing Verb 50, Noun 25 displays. The operator indicates that he has accomplished the requested Checklist item by depressing key ENTER.

14-208. Depressing key ENTER when Verb 50 is displayed initiates the execution of Routine GOLOADLV which transfers program control to Routine FLASHOFF to terminate the flashing of the VERB and NOUN displays. Thereafter, program control is transferred to Routine LOADLV (paragraph 17-431) to reactivate the Job that requested Verb 50 and was put into the dormant state by Routine ENDIDLE while awaiting the operator's response. The requesting Job is reactivated at a location indicating that the operator has accomplished the requested Checklist item. Then Job CHARIN (initiated by the ENTER action) is terminated.

14-208a. If the operator elects not to perform the requested Checklist item he must key in VERB, 3, 3, (Proceed) ENTER. The requesting Job is reactivated (by Routine VBPROC, paragraph 17-441) at a location indicating that the operator has not accomplished the requested Checklist item. Job CHARIN is then terminated.



2529

Figure 14-31. Routine OPTTRONK

14-209. VERB 51 (PLEASE MARK)

14-210. PLEASE MARK VERB

14-211. Verb 51, Please Mark, is for internal program use only. (If an operator were to take a VERB, 5, 1, ENTER keyboard action, indicator CHECK FAIL on the DSKY would be illuminated and the Job CHARIN would be terminated.) This quantity 51 is displayed in the VERB displays whenever Job MKPASTE is executed. Besides executing Routine NVSUB to display the quantity 51 in the VERB displays, Job MKPASTE also initiates the flashing of the VERB and NOUN displays to alert the operator. Job MKPASTE (paragraph 14-129) is requested for execution during the execution of Routine SCTMARK or SXTMARK (paragraph 14-118). When the operator sees the quantity 51 appear in the VERB displays, he should perform the appropriate optical sighting and depress the Mark button thus causing execution of function KEYRUPT (paragraph 17-6). The flashing of the VERB and NOUN displays is terminated after the last requested Mark information has been accepted.

14-212. VERB 52 (MARK ACCEPT)

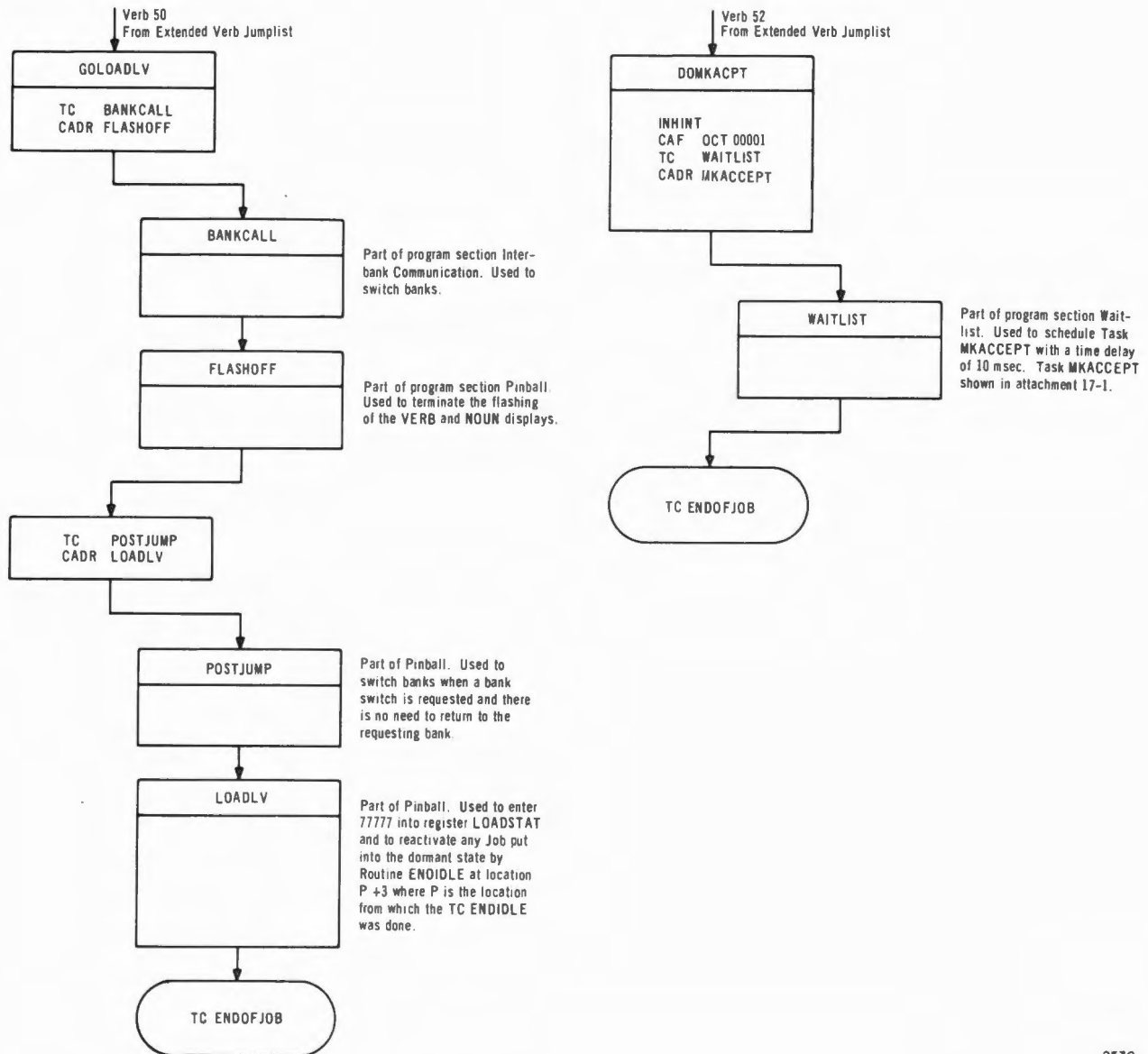
14-213. ROUTINE DOMKACPT

14-214. Routine DOMKACPT is executed to allow the acceptance of Mark information from the Optics. This method of accepting Marks is only temporary until the ACC MARK button is incorporated into the Optics Subsystem. Routine DOMKACPT (figure 14-32) executes instruction INHINT, transfers program control to Routine WAITLIST to schedule Task MKACCEPT with a time delay of 10 msec and then executes instruction TC ENDOFJOB. During the execution of Task MKACCEPT, Mark information is accepted as described in paragraph 17-25. (When the ACC MARK button is available, Routine MKACCEPT will be executed under the auspices of Routine KEYRUPT.) If the operator fails to follow a MARK action with a Verb 52 keyboard action, the next time the MARK button is depressed, the new MARK information (optics CDU angles and time) will be stored in the same location as the previous information, thus destroying the previous MARK information.

14-215. VERB 53 (FREE)

14-216. ROUTINE RELO/IK

14-217. An operator takes a VERB, 5, 3, NOUN, 2, 0, or 55, ENTER keyboard action which causes the execution of Routine RELO/IK to make



2530

Figure 14-32. Routines GOLOADLV AND DOMKACPT

the Inertial or the Optics Subsystem available for use. For example, if alarm code 00301 appears in DSKY display register R1, this indicates that the Inertial Subsystem has been reserved or is currently being used by another Job. The operator can take a VERB, 5, 3, NOUN, 2, 0, ENTER keyboard action to free the subsystem for use by another user; Verb 53 is not intended for internal use.

14-218. Routine RELO/IK (figure 14-33) transfers program control to Routine OP/INERT (paragraph 14-148) to test the Noun code used with this Verb. If the Noun code is 20, program control is transferred to Routine IMURELK via Routine RELO/IK where the quantity 77777 is entered into Register CDUIND to make the Inertial Subsystem available and then instruction TC ENDOFJOB is executed. If the Noun code is 55, program control is transferred back to Routine RELO/IK where the quantity 77777 is entered into register OPTIND to make the Optics Subsystem available and the instruction TC ENDOFJOB is executed. If the Noun code used with this Verb is neither 20 nor 55, program control is transferred to Routine ALM/END where indicator CHECKFAIL on the Navigation Panel DSKY is turned on before instruction TC ENDOFJOB is executed.

14-219. VERB 54 (PULSE TORQUE GYROS)

14-220. ROUTINE TORQGYRS

14-221. Routine TORQGYRS is provided to allow the operator to enter a command into the computer to pulse torque the gyros. The Inertial Subsystem should be in the Fine Align mode so that any changes in the gimbal-angles are reflected in the CDU display dials and in the CDU counters.

14-222. Routine TORQGYRS (figure 14-34) executes the standard calling sequence to Routine NVSUB to request an absolute data load of the GYROD registers. Thus, program control is first transferred to Routine GRABDSP to test the internal/internal interlock. If the internal/internal interlock is set, program control is transferred to Routine PREGBSY via Routine TORQGYRS to put the Job CHARIN into the dormant state until the Job that has grabbed program section Pinball releases it for internal use. If the internal/internal interlock is not set, program control is transferred back to Routine TORQGYRS where the quantity 02567 is transferred to register A and program control is transferred to Routine NVSUB.

14-223. Routine NVSUB first tests the operator/internal interlock and, if it is set, program control is transferred to Routine PRENVBSY via

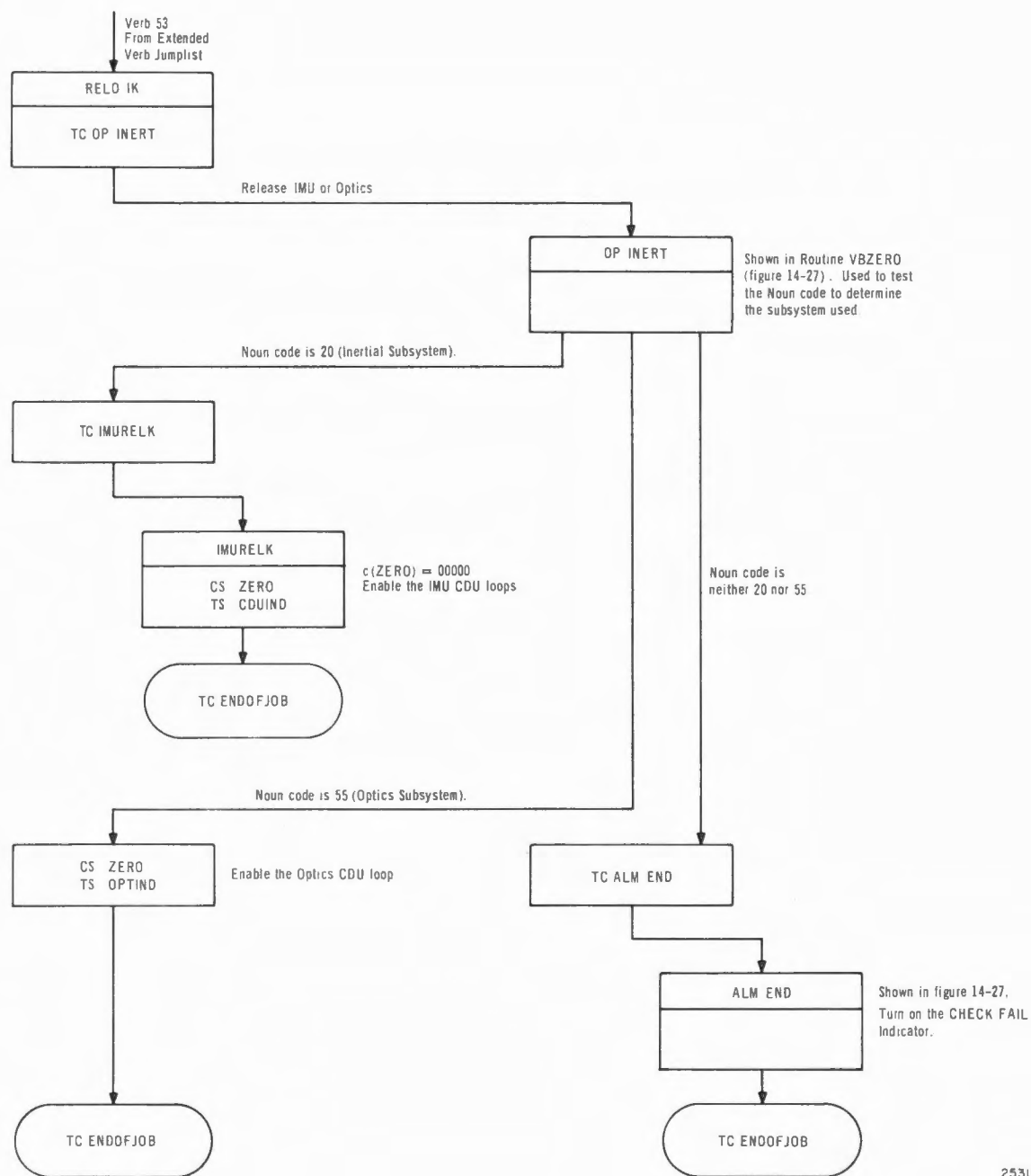


Figure 14-33. Routine RELO/IK

Routine TORQGYRS to put the Job into the dormant state until the operator releases Pinball for internal use. If the operator/internal interlock is not set, Routine NVSUB displays the Noun Code 67 in the NOUN displays and sets the proper DSPTAB registers so that the quantity 25 is displayed in the VERB displays. After Routine NVSUB transfers program control to Routine ABCLOAD, the DSPTAB registers are reset to display the quantity 21 in the VERB displays. Thus, the operator will probably not see the quantity 25 displayed in the VERB display. Program control is then transferred to Routine ENDDLE to put the Job into the dormant state until the operator enters the requested data or else keys in Verb Proceed or Verb Terminate.

14-224. If the operator initiates a VERB, 3, 4, (Terminate) ENTER keyboard action, the reactivating address is set so that when the Job is executed, program control is transferred to Routine ENDMKDSP. Routine ENDMKDSP executes Routine FREEDSP to free Pinball for internal use. Thereafter, the Job is terminated.

14-225. If the operator keys in either the three requested data words or VERB, 3, 3, (Proceed) ENTER the reactivating address is set so that when the Job is executed, the quantity 05400 is transferred to register A and program control is transferred to Routine NVSUB. If the operator/internal interlock is not set, Routine NVSUB redisplay the quantity 54 in the VERB displays. If the operator/internal interlock is set, program control is transferred to Routine PRENVBSY via Routine TORQGYRS to put the Job into the dormant state until the operator releases Pinball for internal use. When this Job is reactivated and executed, Routine NVSUB is executed to redisplay the Verb code 54 in the VERB displays.

14-226. After Routine NVSUB is executed to redisplay the quantity 54 in the VERB displays, program control is transferred to Routine FREEDSP to free Pinball for other Jobs. Program control is then transferred to Routine IMUPULSE via Routine BANKCALL to initiate the pulse torquing of the gyros according to commands in the GYROD registers. After the execution of Routine IMUPULSE, program control is transferred back to Routine TORQGYRS where program control is transferred to Routine IMUSTALL via Routine BANKCALL to put the Job into the dormant state until the pulse torquing of the gyros is completed. When this Job is reactivated (by a task associated with Routine IMUPULSE) activated and executed, instruction TC ENDOFJOB is executed.

14-227. VERB 70 (DO GYRO DRIFT TEST)

14-228. ROUTINE DOGDRIFT

14-229. Routine DOGDRIFT is executed to request the execution of the

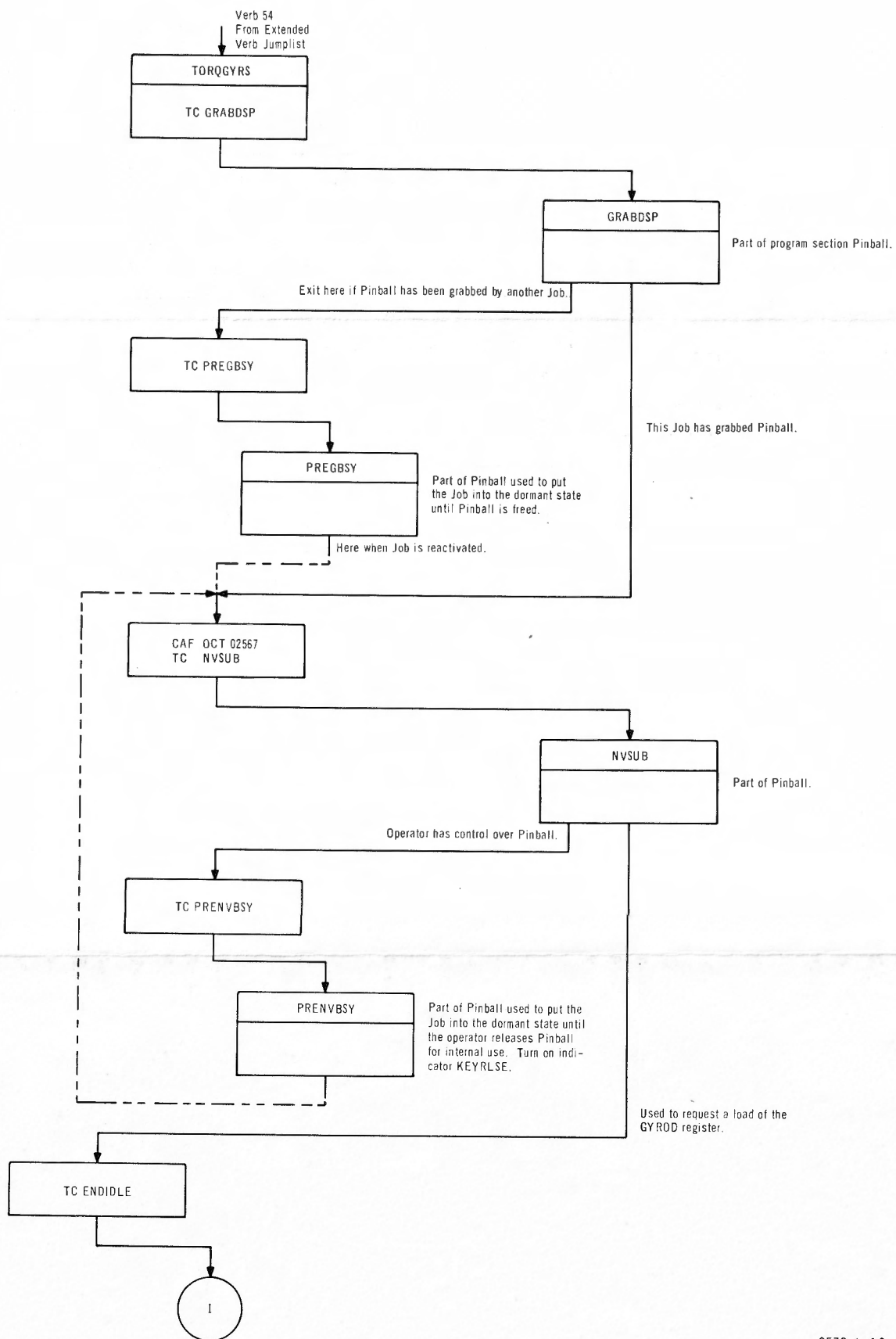


Figure 14-34. Routine TORQGYRS (Sheet 1 of 2)

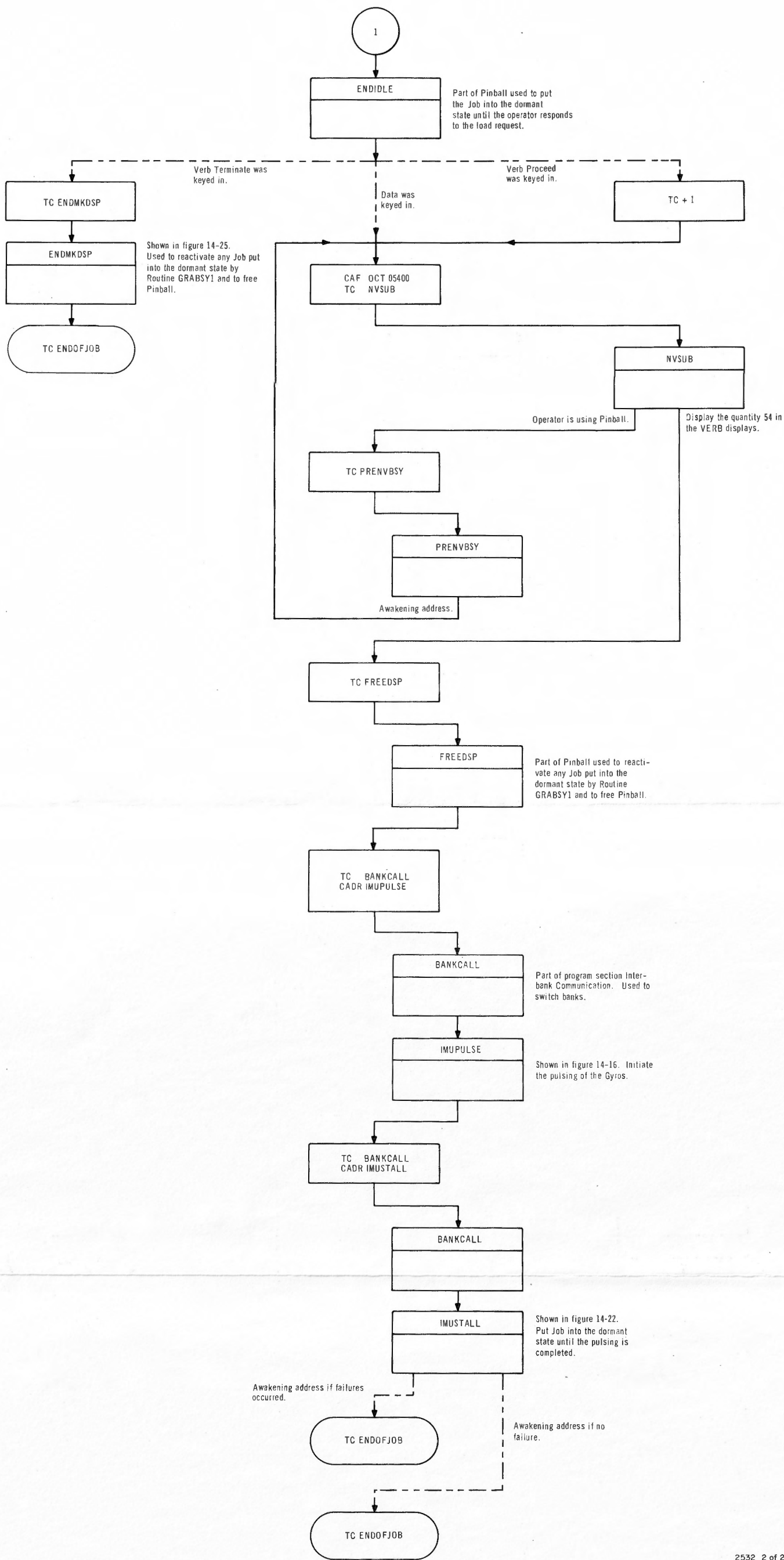


Figure 14-34. Routine TORQYRS (Sheet 2 of 2)

System Test Job LGNTEST1. Job LGNTEST1, which begins at Routine LGNTEST1, aligns the IMU stable member to one of nine different positions. Every 10 sec within a 30 sec interval, earth rate torquing is applied to the stable member. The PIPA counters corresponding to the PIPA's in the horizontal plane are read as are the time counters. Every 10 sec within a 300 sec interval (5 min) earth rate torquing is applied to the azimuth (vertical gyro). The PIPA (on the horizontal) and time counters are read and again every 10 sec within a 300 sec interval the earth rate torquing is applied to the azimuth. The PIPA's (on the horizontal) and time counters are read. After a second reading of the PIPA's and time counters, the ΔV of the PIPA's and the Δt of the time counters is computed and displayed on the DSKY's. From the information displayed, the operator can calculate certain significant IRIG performance parameters such as the non-compensated bias drift of the nth IRIG (i. e., the drift which is not dependent on g, NBD, the drift of the nth IRIG due to 1 g acceleration along the positive input axis (ADIA_n), and the drift of the nth IRIG due to 1 g acceleration along the positive spin reference axis (ADSRA_n). Prior to requesting the display, Job LGNTEST1 initiates the flashing of the VERB and NOUN displays to alert the operator of the fact that he must take a keyboard action. Thus, after the operator records the quantities displayed, he takes a VERB, 3, 3, (Proceed) ENTER keyboard action if he wishes Job LGNTEST1 to continue or a VERB, 3, 4, ENTER (Terminate) keyboard action if he wishes Job LGNTEST1 to terminate.

14-230. Job LGNTEST1 (Issue 21) differs from a Mission Function Job such as Pre-launch Alignment or Free Fall Integration as there is no cell in the Phase Tables associated with it. Thus Job LGNTEST1 does not have the restart capability which is characteristic of Mission Functions. However, Job LGNTEST1 is similar to a Mission Function in that, when it is requested for execution, the DSKY PROGRAM displays are updated.

14-231. Routine DOGDRIIFT (figure 14-35) is executed when the operator takes a VERB, 7, 0, ENTER keyboard action. This routine transfers program control to Routine TESTMODE which tests the content of bit positions 1 and 3 of register MODREG. If either or both of these bit positions contains a ONE, indicating that Mission Function Pre-launch and/or another system test routine is active, indicator CHECK FAIL is illuminated and Job CHARIN is terminated without requesting the execution of Job LGNTEST1. This check serves as an interlock to prevent the attempted execution of more than one routine at a time which initiates IMU moding and torquing requests. If neither bit position 1 or 3 of register MODREG contains a ONE, Routine TESTMODE enters a ONE into bit position 3 to indicate that a system test routine is active and

then transfers program control to Routine DSPMM (described in detail in 17-471) to request a display of the updated content of register MODREG in the PROGRAM displays. After the request is recognized, the content of the PROGRAM displays is either 04 or 06, depending upon whether Mission Function Orbital Integration is inactive or active respectively. Routine DOGDRIFT then enters the quantity 23000 into register A and then transfers program control to Routine FINDVAC to request the execution of Job LGNTEST1 with a priority of 23. Instruction TC ENDOFJOB is then executed to terminate Job CHARIN.

14-232. VERB 71 (DO PIPA SCALE TEST)

14-233. ROUTINE DOPIPTST

14-234. An operator may take a VERB, 7, 1, ENTER keyboard action causing execution of Routine DOPIPTST to request system test Job PIPTEST1. Job PIPTEST1, which begins execution at Routine PIPTEST1, aligns the stable member to one of six different positions so that each accelerometer (PIPA) input axis is aligned in both a positive and a negative direction with respect to the local vertical. After the stable member is aligned to each position, the acceleration due to gravity is calculated and displayed to the operator who must then compare this value with a known value to determine the accuracy of the accelerometer. When the operator notes the acceleration displayed, he must key in VERB, 3, 3, (Proceed) ENTER if he wishes Job DOPIPTST to continue. If he wishes the Job to terminate, he keys in VERB, 3, 4, (Terminate) ENTER. (Prior to requesting a display of the acceleration due to gravity, Job PIPTEST would have initiated the flashing of the VERB and NOUN displays to alert the operator to the fact that he must take a keyboard action.) Job PIPTEST1 (described in Issue 21) differs from a Mission Function Job such as Pre-launch alignment or Orbital Integration since there is no cell in the Phase Table associated with it. Thus Job PIPTEST1 does not have the restart capability which is characteristic of Mission Function. However, Job PIPTEST1 is similar to a Mission Function Job in that, when it is requested for execution, the DSKY PROGRAM displays are updated.

14-235. As mentioned in the preceding paragraph, Routine DOPIPTST is executed when the operator takes a VERB, 7, 1, ENTER keyboard action. Routine DOPIPTST (figure 14-35) transfers program control to Routine TESTMODE to update register MODREG and to display the updated content of register MODREG in the PROGRAM displays. Before register MODREG is updated, the content of bit positions 1 and 3 of this register is tested to determine whether Pre-launch Alignment or another system test routine respectively is active. If either of these are

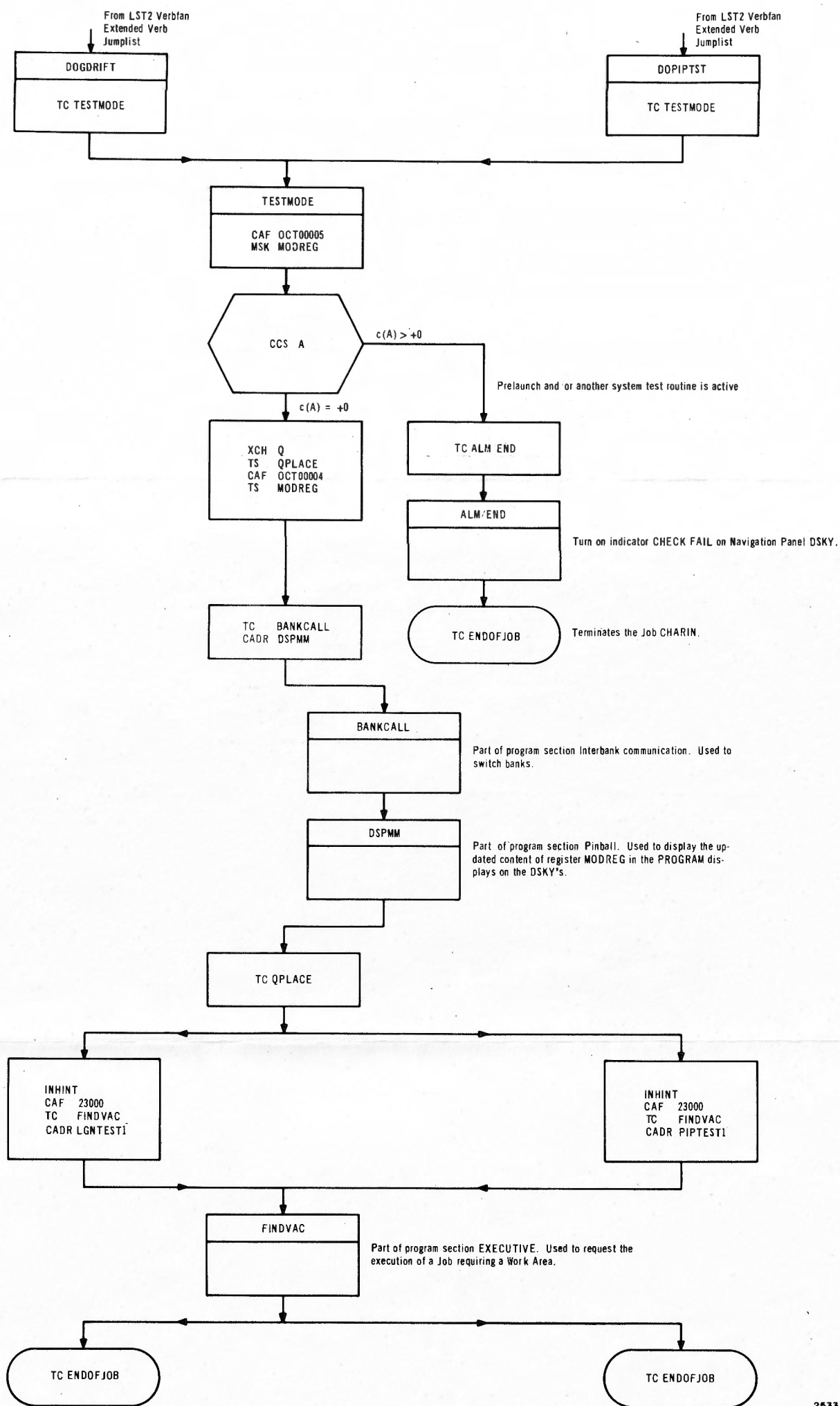


Figure 14-35. Routines DOGDRIFT and DOPIPTST

active (i. e. , bit position 1 or 3 contains a ONE), indicator CHECK-FAIL is illuminated and Job CHARIN is terminated. This check serves as an interlock to prevent the attempted execution of more than one routine at a time which initiates IMU moding and torquing requests. If both of these are inactive, (i. e. , bit positions 1 and 3 contain a ZERO) a ONE is entered into bit position 3 of register MODREG and program control is transferred to Routine DSPMM to display the updated content of register MODREG to the operator.

14-236. Routine DOPIPTST then transfers the quantity 23000 to register A and then transfers program control to Routine FINDVAC to request the execution of Job PIPTEST1 with a priority of 23. The Job CHARIN is then terminated.