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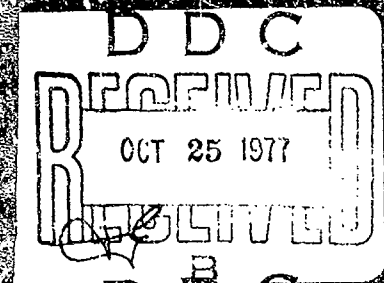
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6 TAP II BEAMFORMING SYSTEM SOFTWARE
FINAL REPORT [U].

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FOREWORD

This final report is submitted by the Electronic Systems Division of the Bunker Ramo Corporation to the Office of Naval Research, Long Range Acoustic Propagation Project, in compliance with Contract No. N00014-77-C-0143, CDRL Item No. A003. *new*

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1.0 (U) INTRODUCTION (U)

1.1 (U) SOFTWARE FEATURES (U)

The major software blocks for the TAP-II system are depicted in Figure 1-1. They are beamforming, calibration, and editing. At the highest level, all analyses are initiated through an executive routine which receives direction through an interactive question-and-answer interchange with the operator. All analyses return to this executive after completion to request further operator direction.

1.1.1 (U) Beamforming. (U) The primary function of the system is beamforming and spectral analysis. The various computational techniques utilized by TAP-II result in an extremely versatile capability. A selection between three different time domain windows allows the operator to make on-line tradeoffs between spectral line bandwidths and rolloff characteristics. Three different stored element shading coefficient tables allow the effects of different array tapers to be investigated and also allow any combination of array elements to be zeroed out, effectively forming arrays with a reduced number of elements. Automatically generated calibration tables are used during the analysis to eliminate channel amplitude and phase tracking errors. Both simple and exponential data averaging are provided.

1.1.2 (U) Calibration. (U) For the automatic calibration routine, a common signal is injected simultaneously into all array channels and Fourier techniques are used to compute normalized channel-to-channel gain and phase response variances.

1.1.3 (U) On-line Editing. (U) The editing feature allows seldom varied constants to be changed on-line by the operator if desired. Values changed in this manner include the date, three different 64-element shading coefficient tables, all plot format variables, element-element spacing for three different arrays, the speed of sound, and three prestored sample rates to be used for three different arrays.

1.2 (U) COMMUNICATION INTERCHANGE. (U) As in TAP-I, a significant system feature is the method used for communication with the operator. All analyses are directed by an executive routine through a conversational question and answer interchange. As all questions are asked, the previously input answer is displayed in parentheses, and the operator can select this answer with a simple carriage return. A rubout character instructs the computer to ignore the newly input answer (in case of input error), and to re-ask the question.

Where logical, entire groups of questions can be skipped if no answers are to be changed. Answers to questions are immediately error-checked, and the question re-asked if an error is discovered.

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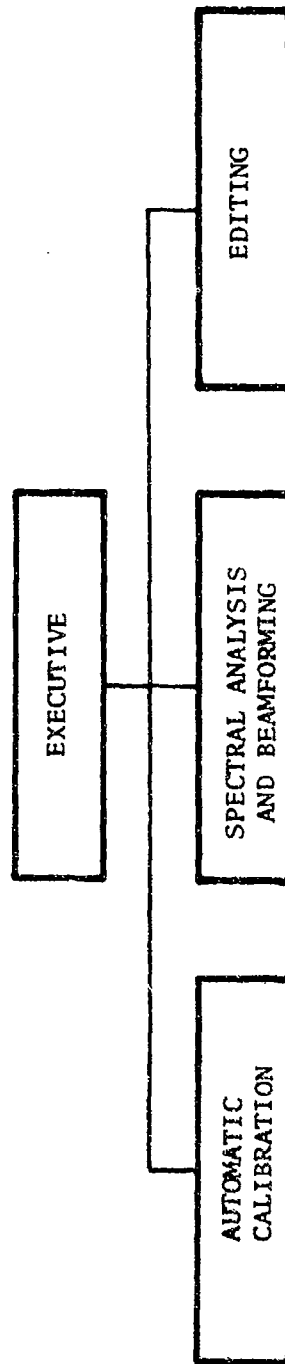


Figure 1-1. Software Organization

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1.3 (U) SOFTWARE CONFIGURATION. (U) The TAP-II system is implemented on a Hewlett Packard 21MX computer, using the HP BCS operating system. The system is disc based, with the separate analysis programs residing on disc. The programs are loaded (as entire coreloads) as required. The system software falls into the following categories:

1) FORTRAN Analysis Routines. All analysis routines and the executive are written in FORTRAN. Communication with the disc, input data source, and an external array processor is effected through FORTRAN calls.

2) Assembly Language Disc and Interface Handling Routines. These routines, written in HP assembly language, handle all control of the disc and data input interfaces. They are FORTRAN-callable.

3) Coreload Transfer Routines. Special software was developed to transfer program coreloads to and from disc. These routines, written in HP assembly language, are FORTRAN-callable.

4) Array Processor Software. All actual computation is done in a Floating Point Systems AP120B array processor which is controlled by the 21MX computer. All communication with the processor is handled through FORTRAN calls, using manufacturer-supplied routines.

1.4 (U) REPORT CONTENTS. (U) Details of all the software developed for TAP-II follow in this report. System operating instructions are also included. A description of the hardware, and the mathematical theory of operation are in a companion volume.

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2.0 (C) OPERATING INSTRUCTIONS (U)

2.1 (U) INTRODUCTION (U)

Operation of the TAP II System is through the CRT keyboard and the sense switches on the 2IMX front panel.

2.1.1 (U) Conventions. (U) Certain conventions apply to all keyboard entries, as follows:

1) For numeric inputs, a permissible range is usually printed within parentheses: (0-100). Any value outside this range will result in a repeated request to enter the number. The same will occur if an illegal character is entered.

2) For numeric inputs, the current value is also printed within parentheses. This value will remain unchanged if RETURN is pressed (no characters entered).

3) All numeric inputs are integers (i.e., no fractional part) unless a decimal point appears in the range of current value printouts. For integers, the decimal point must be omitted; for other numbers, the decimal point may be omitted if there is no fractional part (tenths, hundredths, etc.).

4) For all numeric inputs, leading zeros, trailing zeros, and the sign, if positive, may be omitted.

5) All inputs are completed by pressing RETURN. The use of the RETURN key is assumed and will not be repeated in the operating instructions.

6) An error recognized before pressing RETURN may be corrected by pressing RUBOUT, then making the proper entry.

7) Entering 12345 in place of most numeric inputs will result in control being returned to the Executive.

2.1.2 (U) System Hardware. (U) A block diagram of the TAP-II computer system is given in Figure 2.1-1. Turn on and operation of the HP-2IMX computer and the High-Density Digital Recorder are described elsewhere. Table 2.1-1 is an operator check-list describing the normal switch settings for the remaining components of the system. The switches should be set to the recommended positions prior to attempting a beamforming operation.

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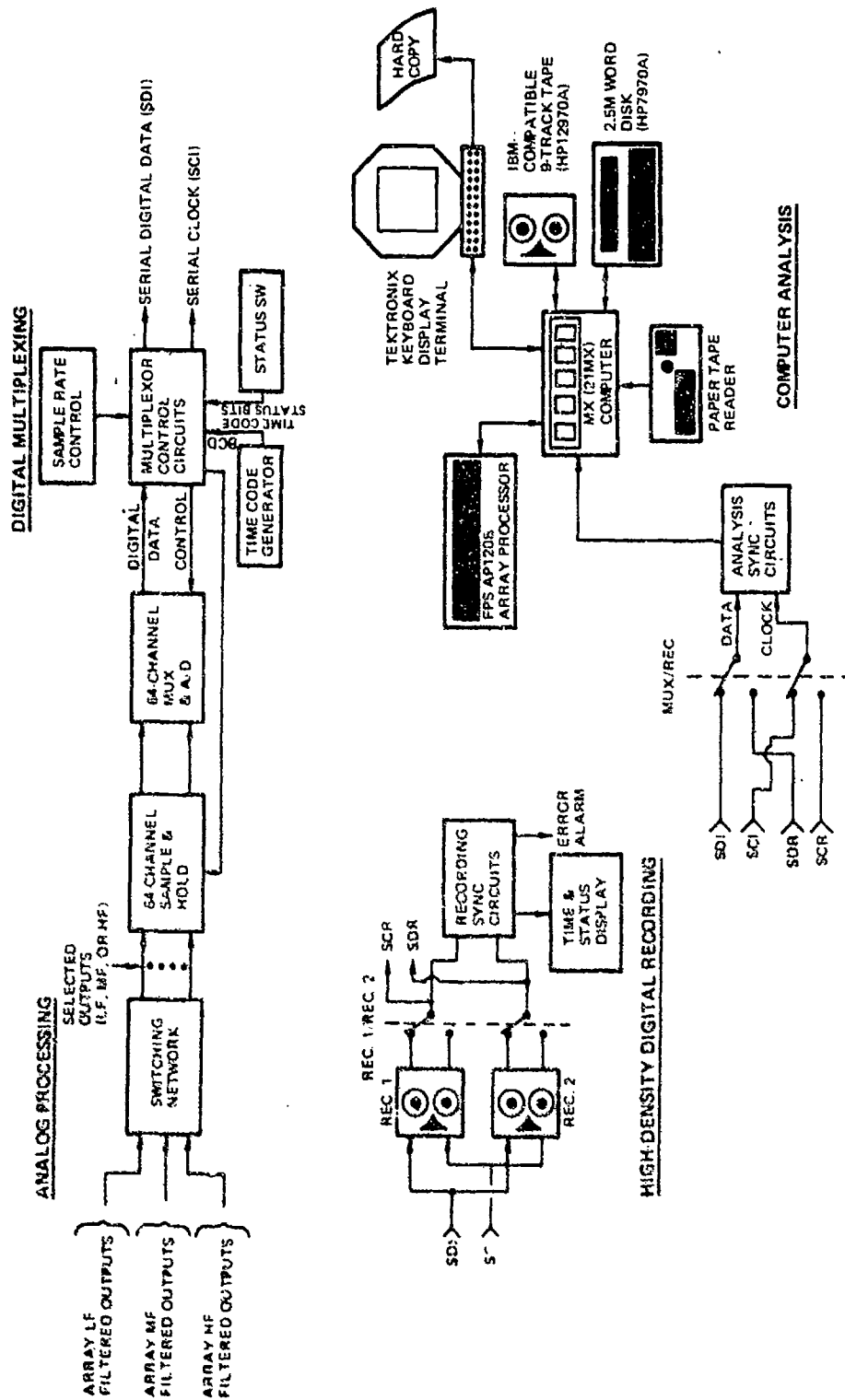


Figure 2.1-1 (U) Hardware Block Diagram

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TABLE 2.1-1 (U) EQUIPMENT CHECK LIST

1. Sample and Hold Assembly (rack 12)
 - a) Power switch - ON
 - b) Hold/not hold - HOLD position
2. Status Panel (rack 12)
 - a) Display - ON
 - b) Status toggle switches - The 12 toggle switches may be used to identify blocks of data on the HDDR magnetic tape. The indicators above the toggle switches show the status bit configuration from the data currently appearing on the HDDR transport read lines.
 - c) Time display - The time display on the status panel displays the time field from the data currently appearing on the HDDR transport read lines.
3. Digital Controller (rack 12)
 - a) Run/stop switches - set to RUN
 - b) Input Select - set to MUX for real time data; set to RBC for HDDR data.
 - c) Alarm switch - set to ON. Internal circuitry will activate the alarm if a fault is detected in the serial digital data currently appearing on the HDDR transport read lines.
4. A/D Converter (rack 12)
 - a) Power switch - ON
 - b) Last channel - set to 77
5. Counter/Timer (rack 12)

The Counter/Timer is primarily used to monitor the hydrophone sample rate. When used for this purpose, set up as shown below.

 - a) Power switch - ON
 - b) Storage - OFF
 - c) Clock - internal
 - d) FREQ/TIME/MULT - Hz/s/10⁶

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TABLE 2.1-1 (U) EQUIPMENT CHECK LIST (Continued)

e) Function - Freq A

f) Input A - Multiplexer FP (red) and ground (black) on the Digital Controller

g) A Sync - adjust as necessary

6. Clock (rack 12)

a) Power - ON

b) Set to correct time

7. Sample Rate Clock (rack 12)

The basic timing source for controlling sample rate may be either the HP-3320 Frequency Synthesizer or the Sample Rate panel, depending upon which is cabled into the system. Set the active clock source as shown below.

a) Sample Rate Panel - select the standard sample rate (53, 136, or 848) appropriate for the calculations, or

b) Frequency Synthesizer - Power ON, signal level to +26 db, frequency dial as directed in Beamforming INPUT NEW PARAMETER prompt (see Figure 2.4-2)

8. Power Supply (rack 12)

a) Power - ON

b) Voltages - adjust to level specified on labels

9. AC Regulator (rack 12)

a) Power - ON

b) Meter - nominal 118 VAC

10. AP-120B (rack 13)

a) Power - ON

b) +5V indicator ON

c) +12V indicator ON

d) -5V indicator ON

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2.2 (U) EXECUTIVE (U)

The Executive is the starting point for all programs and functions. After completion of any function, control is automatically returned to the Executive. However, when the computer or other components of the system have been turned off, it is necessary to "BOOT" the system as follows:

1. Ensure that power is on at all applicable units (computer, I/O extender, CRT terminal, line printer, Digital Controller, AP-120B). Ensure that TAP II System disc is loaded and DISC READY is illuminated.
2. At the computer, set the S register to 041201 and press STORE.
3. At the computer, press PRESET, IBL, RUN, RUN. The system should be loaded from the disc and the following message should be displayed:

TAP II EXECUTIVE

ENTER OPERATION TO BE PERFORMED:
B=BEAM FORMING
C=CALIBRATION
E=EDITING
L=DISPLAY STORED DATA

This message will be displayed at the completion of any of the listed functions.

To start any of these functions, enter the indicated letter.

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2.3 (C) CALIBRATION ANALYSIS (U)

The calibration analysis routine is used to normalize channel-to-channel gain and phase response variances. Execution of the array calibration analysis is required prior to attempting beamforming. The calibration analysis should be repeated whenever a change in the characteristics of the array may have taken place.

The calibration mode is called by entering a C when in the Executive routine. The options listed below are displayed on the CRT when the calibration routine is entered.

- 1 BEAMFORMER CALIBRATION
- 2 NOISE ANALYSIS
- 3 FORCE CAL TABLE TO UNITY

The operator should select the option appropriate for the activity desired. Selection of BEAMFORMER CALIBRATION results in alteration of the calibration tables used to normalize channel amplitude and phase information during beamforming. It also prints the absolute and/or normalized array channel responses at four frequencies within the array band width. Selection of NOISE ANALYSIS allows the operator to obtain the calibration analysis line printer tabulation without altering the internal beamforming calibration tables. The FORCE CAL TABLE TO UNITY option sets the normalization factors for each channel to unity which results in the signal from each array channel being accepted by the beamforming analysis program without correction.

2.3.1 (C) Beamformer Calibration. (U) This mode updates calibration tables for the array selected. Hydrophone channel calibration mathematically eliminates channel-to-channel variations in the analog signal path. The recommended procedure for calibration is to inject a white noise signal at the input point common to the array preamplifiers and to run the BEAMFORMER CALIBRATION program once for each array. The white noise should be band limited before injection at the highest frequency capability of the array being calibrated or limited by the array filters, to prevent aliasing errors. The injected signal amplitude should be such that a 3-5 volt peak signal is applied to the A/D converter.

To exercise the BEAMFORMER CALIBRATION from the EXECUTIVE program, type C. See Figure 2.3-1 for a typical calibration analysis input display. Select BEAMFORMER CALIBRATION by typing 1. The operator should respond to the prompts displayed to select:

ARRAY TYPE

REFERENCE CHANNEL NO.

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***** TAP-II CALIBRATION ANALYSIS *****
5:45:33 16 APR 1977

ENTER CAL TYPE:

1 = BEAMFORMER CALIBRATION
2 = NOISE ANALYSIS
3 = FORCE CHL TABLE TO UNITY

(3)

2

ARRAY TYPE: (1=LF, 2=MF, 3=HF)

(3)

REFERENCE CHANNEL NO.: (1-64)

(32)

NUMBER OF AVERAGING INTERVALS: (1-128)

(64)

TYPE OF WEIGHTING WINDOW: (1=RECT, 2=HANNING, 3=RECT.)

(2)

TYPE OF OUTPUT (0=PARTIAL, 1=FULL):

(0)

Figure 2.3-1 Calibration Analysis Input Display

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NUMBER OF AVERAGING INTERVALS

TYPE OF WEIGHTING WINDOW

TYPE OF OUTPUT

2.3.1.1 (C) ARRAY TYPE selection allows a new calibration table to be generated for either the low frequency, medium frequency or high frequency array.

2.3.1.2 (U) The REFERENCE CHANNEL NO. selection is chosen from any channel known to be normal. Other factors being equal, channel 32 is recommended for the reference channel.

2.3.1.3 (U) Increasing NUMBER OF AVERAGING INTERVALS removes the influence of sample-to-sample variations. For calibration on noise, 64 averages are recommended. Ten averages may be sufficient for some wave studies.

2.3.1.4 (U) The TYPE OF WEIGHTING WINDOW is selected according to the characteristics desired. Normally Hanning would be selected.

2.3.1.5 (U) The TYPE OF OUTPUT may be either full or partial. The full printout prints both the absolute and relative response of each channel at 16 frequencies appropriate for the array chosen. The partial printout eliminates the absolute response lines giving only the response relative to the reference channel in amplitude (decibels) and phase (degrees) at four frequencies.

To insure that a good calibration has been obtained, the absolute levels printed for the reference channel should be in excess of -30 db in every frequency cell.

The CALIBRATION ANALYSIS mode exits to the Executive Program upon completion.

2.3.2 (C) Noise Analysis. (U) The NOISE ANALYSIS mode of the calibration routine allows the operator to determine the response of each hydrophone channel to the present input signal without altering the calibration table. A partial or full tabular output may be obtained on the line printer. Examination of the printout will reveal the amplitude and phase response of each channel at frequencies which are appropriate for the array type selected. The NOISE ANALYSIS mode may be used by the operator for testing purposes when a calibration table which is known to be valid is stored in the computer and should not be disturbed. Except for the calibration table storage, the results of the NOISE ANALYSIS mode are identical to the BEAMFORMER CALIBRATION mode. This mode exits to the Executive program upon completion.

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2.3.3 (C) Force CAL Table to Unity. (U) This mode of operation eliminates the effect of calibration corrections for the array selected when the array is used in beamforming analysis. It is used to initialize the array calibration table if, for some reason, the BEAMFORMER CALIBRATION mode cannot be exercised. This mode exits to the Executive upon completion.

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2.4 (C) BEAMFORMING (U)

The BEAMFORMING PROGRAM is called by entering B while in the Executive program. Prior to starting the first beamforming operation the following steps must be taken:

- 1) The array to be used must be calibrated using the BEAMFORMER CALIBRATION program.
- 2) The sound velocity, the array shading table, sample rate and other parameters must be initialized using the EDITOR program.
- 3) The sample rate timing source must be set to the proper frequency.
- 4) The INPUT NEW PARAMETERS mode of the BEAMFORMING program must be entered to establish the operation to be performed.

Subsequent beamforming operations may bypass the above steps if no change is desired.

Upon entering the BEAMFORMING program, the operator has five entry options:

ENTER

- 1 TO INPUT NEW PARAMETERS
- 2 TO START IMMEDIATELY
- 3 TO HOLD UNTIL START TIME
- 4 TO DISPLAY EXISTING TABLE DATA
- 12345 TO RETURN TO EXEC

See Figures 2.4-1, 2.4-2 and 2.4-3 for typical prompt and operator response for Beamforming.

2.4.1 (C) To Input New Parameters. (U) This mode is entered upon start up or when parameter changes are required. After the parameters have been updated, the program exits to the beamforming calculations. While in the INPUT NEW PARAMETERS mode, the operator may return to the Executive program without modifying any parameters by typing 12345. The parameters which may be changed are:

- 1) (C) Analysis Parameters (see Fig. 2.4-1)

ARRAY TYPE

TIME-FREQUENCY TRANSFORM LENGTH (normal entry is 1024)

SHADING TABLE NO. (normal shading table is Hanning)

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***** TAP-II BEAMFORMING PROGRAM *****
15:47: 5 16 APR 1977

ENTER 1 TO INPUT NEW PARAMETERS
2 TO START IMMEDIATELY
3 TO HOLD UNTIL START TIME
4 TO DISPLAY EXISTING TABLE DATA
12345 TO RETURN TO EXEC
(0)
1
ENTER ARRAY TYPE (1=LF, 2=MF, 3=HF)
(3)
ENTER TIME-FREQUENCY TRANSFORM LENGTH (1024,2048,4096)
(1024)
ENTER SHADING TABLE NO. (1, 2, OR 3)
(1)
ENTER TYPE OF TIME WEIGHTING WINDOW (1=RECT, 2=HANNING, 3=RECT)
(2)
ENTER TYPE OF AVERAGING (1=SINGLE, 2=EXPONENTIAL)
(1)
2
ENTER EXPONENTIAL AVERAGING TIME IN SECONDS(1 0-500.0
(000)
1
ENTER NUMBER OF AVERAGING INTERVALS: (1 - 999)
(1)

Figure 2.4.-1 (U) Beamforming, Analysis Parameters

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LINE GROUP FREQUENCY RANGES ARE: (NO. MIN F MAX F)
1 0 105.2 2 106.0 211.2 3 212.0 317.2 4 318.0 423.2

HOW MANY LINE GROUPS FOR ANALYSIS? (1- 4)
(2)

THE CURRENT LINE GROUP NO(S) = 2 3
CHANGE DESIRED? (1 = YES, 0 = NO)
(0)

1
ENTER 2 NO(S). SEPARATED BY SPACES: (1- 4)
NO'S MUST BE IN ASCENDING ORDER
2 3

ENTER TAPE FLAG NO. 1: (1 TO WRITE COM. COEFF. TO TAPE, 0 IF NOT.)
(0)

ENTER TAPE FLAG NO. 2: (1 TO WRITE MI AC. TBL. TO TAPE 0 IF NOT)
(0)

SET THE FOLLOWING SENSE SWITCHES:
SS 0 TO OUTPUT LINE GROUP NO 2
SS 1 TO OUTPUT LINE GROUP NO 3
CLEAR SWITCH 8 TO PLOT LINE GROUP DATA, SET TO LIST
CLEAR SWITCH 9 FOR FULL LISTING. SET FOR PARTIAL
CLEAR SWITCH 10 FOR NORMAL END, SET TO LOOP AROUND

CURRENT SAMPLE RATE = 848 0 HZ.
SET FREQ. SYNT. TO 1455168 HZ AND HIT RETURN

Figure 2.4-2 (U) Beamforming, Output Parameters

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ENTER START FLAG: (1 = HOLD UNTIL START TIME, 0 = NO HOLD
(0)

1
ENTER DESIRED START TIME (HR, MIN, SEC)
(IF ON OTHER SIDE OF 2400 HOURS, MAKE GREATER THAN 24,00,00)
10 12 33

Figure 2.4-3 (U) Hold Until Start Time

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TIME WEIGHTING WINDOW (normal weighting window is Hanning)

TYPE OF AVERAGING (normal averaging is simple)

EXPONENTIAL AVERAGING TIME IN SECONDS

NUMBER OF AVERAGING INTERVALS

2) (U) Output Parameters (see Figure 2.4-2)

HOW MANY LINE GROUPS FOR ANALYSIS

ENTER THE LINE GROUP NUMBERS

WRITE COM COEF TO TAPE

WRITE MINOR ACC TBL TO TAPE

SELECT PLOT AND PRINT GROUPS

Sample Rate Timing - The sample rate of the array signals is set by the operator using either the HP 3320B Frequency Synthesizer or the Sample Rate panel. Instructions for setting the sample rate clock are given after the output parameters are set. See Figure 2.4-2 for typical instructions. The active clock source must be determined by the operator.

Upon depressing RETURN the beamforming analysis will begin.

2.4.2 (U) To Start Immediately. (U) This option allows the operator to start the BEAMFORMING analysis by depressing 2. If the control parameters are correct, this path may be taken at any time.

2.4.3 (U) To Hold Until Start Time. (U) This option allows the operator to delay the start of the BEAMFORMING analysis until a preset time of day. Figure 2.4-3 shows a typical CRT display when this option is chosen.

2.4.4 (U) To Display Existing Table Data. (U) This option allows previously-analyzed data to be printed and/or plotted with the same or new plot variables. For example, it may be desirable to change the scale, range, plot angle, etc. to emphasize features of interest. At the completion of the BEAMFORMING analysis, control is returned to the Executive program. If plot changes are desired, the operator should enter the Edit routine, call Plot Format Variables, and make the changes desired. Upon reentering the BEAMFORMING program, via the Executive program, the operator enters 4 and RETURN to output the previously-analyzed data. Sense switches should be set to the configuration for the output desired prior to depressing RETURN.

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Sense Switch options are explained in detail in Table 2.4-1. A prompt to set the sense switches is given in the INPUT NEW PARAMETERS mode; but, if in mode START IMMEDIATELY or HOLD UNTIL START TIME, the operator must remember to set the sense switches.

2.4.5 (U) 12345 To Return to EXEC. (U) While in the BEAMFORMING program initializing phase, the operator may return to the Executive program by typing 12345 in response to any prompt message. This action terminates the new parameter input and uses old parameters in subsequent analysis.

TABLE 2.4-1 (U) SENSE SWITCH OPTIONS (U)

SS No.	Option
0	The first eight switches determine which line groups are plotted or listed if a complete listing is selected (see switch 9). The computer prints out a message informing the operator which line group each of these switches controls.
1	
2	
3	
4	
5	
6	
7	
8	If switch 8 is cleared, the line groups selected by switches 0-7 are plotted on the CRT. If set, the data is printed on the line printer.
9	If listing is selected by switch 8, switch 9 determines the type of listing. If switch 9 is clear, the line groups selected by switches 0-7 are listed in their entirety (128 frequency lines, 64 steer angles for each line). If switch 9 is set, the operator is requested to enter the frequency of interest via the CRT, and 44 lines around this frequency are listed on the line printer (64 steer angles for each line).
10	If switch 10 is clear, the beamforming program returns to the Executive after the analysis. If set, a loop is set up where beamforming is automatically restarted after each completion, using the originally input parameters. Output to the line printer and CRT are inhibited, but the IBM tapes are written.

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2.5 (C) EDITING (U)

Editing allows the modification of certain infrequently changed parameters. This function is selected by entering an E when in the Executive.

The Editing program will display the following on the CRT:

PARAMETER EDITING PHASE

ENTER DATA SET TO BE MODIFIED:

- 1=ARRAY SHADING TABLES
- 2=ARRAY SPACING
- 3=ARRAY SAMPLING RATES
- 4=PLOT FORMAT VARIABLES
- 5=SOUND VELOCITY
- 6=DATE
- 7=LIST DEVICE
- 8=RETURN TO EXECUTIVE

The operator may select any of these functions in any order. The only requirement is that after he is through, he must select function 8 (Return to Executive) so that the modified data will be stored on disc.

The operator entries for each option are fairly self-explanatory. The following discussion refers to illustrations of typical displays for the particular option being described.

2.5.1 (C) Array Shading Tables. (U) (See Figure 2.5-1): For each of the three arrays, there are three shading tables. The first two entries specify which of the nine tables is to be modified. It should be noted that there is no entry for the second request. This indicates that the operator selected the number in parentheses (1). The program then displays the current content of the table, and asks how the table is to be modified. If the option for individual changes is requested, as is shown, the program will request location and new value until 65 is entered for location. If the option for setting the entire table to one value is selected, the program will request that value and store it throughout the table. If the option for Hanning weightings is chosen, the Hanning weighting curve will be stored.

2.5.2 (C) Array Spacing. (U) (See Figure 2.5-2): For each of the three arrays, there is a storage location for the element spacing. The two requests are for array number and element spacing in meters.

2.5.3 (C) Array Sampling Rates. (U) (See Figures 2.5-3 and 2.5-4): For each of the three arrays, there is a storage location for the sampling rate. The first request is for array number. The second request

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ENTER ARRAY NUMBER: (1=LF, 2=MF, 3=HF)
(1)

ENTER TABLE TO BE MODIFIED (1-3)
(1)

1:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
17:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
25:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
33:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
41:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
49:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
57:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

ENTER CHANGE MODE (1-4):
1=SET ENTIRE TABLE TO SAME VALUE
2=SET TABLE TO HANNING WEIGHTINGS
3=MODIFY INDIVIDUAL VALUES
4=NO CHANGE

(4)

3

ENTER TABLE LOCATION TO BE CHANGED (65=EXIT)
(1)

ENTER NEW VALUE (0.0-100.0)
(1.000)

0

ENTER TABLE LOCATION TO BE CHANGED (65=EXIT)
(1)

65

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Figure 2.5-1 (C) Sample Array Shading Table Dialog

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ENTER DATA SET TO BE MODIFIED:

- 1=ARRAY SHADING TABLES
- 2=ARRAY SPACING
- 3=ARRAY SAMPLING RATES
- 4=PLOT FORMAT VARIABLES
- 5=SOUND VELOCITY
- 6=DATE
- 7=LIST DEVICE
- 8=RETURN TO EXECUTIVE

2
ENTER ARRAY NUMBER. (1=LF, 2=MF, 3=HF)
(1)

ENTER NEW SPACING IN METERS (0.0-150.0)
(37.500)

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Figure 2.5-2 (C) Sample Array Spacing Dialog

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ENTER ARRAY NUMBER: (1=LF, 2=MF, 3=HF)
(1)

RECORDER USED FOR INPUT? (Y OR N)

N

ENTER NEW SAMPLING RATE IN HERTZ (10.0-1000.0)
53.000)

NEW FREQ. SYNTHESIZER SETTING IS 90.948 KHZ

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Figure 2.5-3 (C) Sample Array Sampling Rates Dialog (No Recorder)

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ENTER ARRAY NUMBER: (1=LF, 2=MF, 3=HF)
(1)

RECORDER USED FOR INPUT? (Y OR N)

Y

ENTER SAMPLING RATE NUMBER (0-15):

0=848.0	4=169.6	8= 94.2	12= 65.2
1=424.0	5=141.3	9= 84.9	13= 60.6
2=282.7	6=121.1	10= 77.1	14= 56.5
3=212.0	7=106.0	11= 70.7	15= 53.0

(15)

NEW FREQ. SYNTHESIZER SETTING IS 1.305 KHZ

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Figure 2.5-4 (C) Sample Array Sampling Rates Dialog (with Recorder)

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(RECORDER USED FOR INPUT?) is significant because only certain predetermined sampling rates are allowed if the recorder is used. In this case, a list of rates is displayed and the operator must enter the number of the desired rate. When the recorder is not used, the actual sampling rate is entered. In either case, the required frequency synthesizer setting for the specified sampling rate is computed and displayed. The operator must adjust the sample rate source as requested.

2.5.4 (C) Plot Format Variables. (U) (See Figure 2.5-5): The Plot Format Variables editing section allows modification of a series of numbers which specify the dimensions of the plot made by the BEAMFORMING program and what the plot represents. Most of the specifications are dimensioned in plot points. The CRT screen is 1000 plot points wide and 800 plot points high. 100 plot points are therefore one tenth of the screen width. Taking the plot format requests in order, the X and Y offsets of axis origin are the distance of the lower left hand corner of the plot from the left side and bottom of the CRT, respectively. X increment is the horizontal spacing of each of the 128 frequency bins which make up the horizontal axis. The width of the plot, therefore is this number times 128. Plot height is the size of the Y axis. Delta X and delta Y plot-to-plot are the offset from one beam to the next. Varying them will change the apparent angle the Z axis makes with the X and Y axes. (The Z axis is the diagonal line at the right of the plot which is actually perpendicular to the XY plane). Lowest plot value is the lowest value on the Y axis, in decibels. Range plotted is the range of signals represented by the distance specified by the plot height. Therefore, if the plot height is 304, the lowest plot value is -35 and the range plotted is 40, a level of 5 db, which is 40 above -35 db, will be 304 plot points higher than the -35 db level, or the bottom of the plot. The number of frequency lines to "OR" may be a 1 or 4. If 1 is selected, a normal plot results. If 4 is selected, only the highest within each group of four points is plotted, resulting in a much faster plot. The number of beams to skip at the beginning and end of plot, if other than 0, cuts off sections at the front or rear, respectively, of the plot. This prevents "mountains" at the front of the plot from hiding an important feature, or noise at the rear of the plot from obscuring one. An entry of zero provides a full plot.

2.5.5 (U) Sound Velocity. (U) (See Figure 2.5-6): Sound velocity is entered in meters per second.

2.5.6 (U) Date. (U) (See Figure 2.5-7): Any 12 characters representing date may be entered. If the CHANGE DATE? question is answered with N (no), the current date is not modified.

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PLOT FORMAT VARIABLES

X OFFSET OF AXIS ORIGIN (IN PLOT POINTS, 0-1000)
(50)

Y OFFSET OF AXIS ORIGIN (IN PLOT POINTS, 0-1000)
(60)

X INCREMENT (IN PLOT POINTS, 0-1000)
(3)

PLOT HEIGHT (IN PLOT POINTS, MUST BE A MULTIPLE OF 8, 0-800)
(304)

DELTA X PLOT-TO-PLOT (IN MULTIPLES OF INCRX, 0-1000)
(1)

DELTA Y PLOT-TO-PLOT (IN PLOT POINTS, 0-100)
(6)

LOWEST PLOT VALUE IN DB (-100.0 - +100.0)
(-35.000)

RANGE PLOTTED IN DB (MUST BE A MULTIPLE OF 4, 0.0-200.0)
(40.000)

NUMBER OF FREQUENCY LINES TO 'OR' FOR PLOT (1 OR 4)
(4)

NUMBER OF BEAMS TO SKIP AT BEGINNING OF PLOT (0-65)
(15)

0
NUMBER OF BEAMS TO SKIP AT END OF PLOT (0-65)
(25)
0

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Figure 2.5-5 (C) Sample Plot Format Variables Dialog

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ENTER DATA SET TO BE MODIFIED:

1=ARRAY SHADING TABLES

2=ARRAY SPACING

3=ARRAY SAMPLING RATES

4=PLOT FORMAT VARIABLES

5=SOUND VELOCITY

6=DATE

7=LIST DEVICE

8=RETURN TO EXECUTIVE

5

ENTER SOUND VELOCITY IN METERS/SEC (0.0-3000.0)

(1500.000)

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Figure 2.5-6 (U) Sample Sound Velocity Dialog

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ENTER DATA SET TO BE MODIFIED.

- 1=ARRAY SHADING TABLES
- 2=ARRAY SPACING
- 3=ARRAY SAMPLING RATES
- 4=PLOT FORMAT VARIABLES
- 5=SOUND VELOCITY
- 6=DATE
- 7=LIST DEVICE
- 8=RETURN TO EXECUTIVE

6

<15 APR 1977 >

CHANGE DATE? (Y OR N)

Y

ENTER DATE <12 CHARACTERS MAX.>

16 APR 1977

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2.5.7 (U) List Device. (U) (See Figure 2.5-8): Either the CRT or the Teletype may be used as an alternate output device for messages which usually go to the line printer. This is generally only used as a backup in the event of a line printer failure. When the CRT is used, the computer must be halted at the bottom of each page and PAGE pressed if overwriting of the CRT screen is not desired. In the message, LP indicates line printer and TTY indicates Teletype.

2.5.8 (U) Return to Executive. (U) After modifying any data, it is required that option 8 be selected to return control to the Executive, so that the new data will be written on the disc. Any other path back to the Executive will not save the new data.

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ENTER DATA SET TO BE MODIFIED:

- 1=ARRAY SHADING TABLES
- 2=ARRAY SPACING
- 3=ARRAY SAMPLING RATES
- 4=PLOT FORMAT VARIABLES
- 5=SOUND VELOCITY
- 6=DATE
- 7=LIST DEVICE
- 8=RETURN TO EXECUTIVE

7
ENTER LIST DEVICE: (1=CRT, 6=LP, 12=TTY)
(1)
6

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Figure 2.5-9 (U) Sample List Device Dialog

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2.6 (C) DISPLAY STORED DATA (U)

The display stored data option allows listing of certain variables stored on the disc. In addition, the aliasing frequency for each of three array spacings at the current sound velocity is computed and printed. The standard steer angles for the interpolated beams are also listed. A choice of listing device is offered to the operator. An example of the printout is shown in Figure 2.6-1.

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TAP II STORED DATA
DATE 16 APR 1977 TIME 5:46:17

ARRAY NO	SAMPLE RATE (HZ)	SPACING (METERS)	ARRAY ALIASING FREQ. (HZ)
1	53.00	37.500	20.00
2	135.68	12.500	60.00
3	848.00	2.344	319.97

SOUND VELOCITY = 1500.0

TAP II STANDARD STEER ANGLES (DEGREES)

1: -75.47	2: -69.55	3: -64.96	4: -61.04
5: -57.46	6: -54.29	7: -51.35	8: -48.59
9: -45.99	10: -43.39	11: -41.00	12: -38.68
13: -36.57	14: -34.19	15: -32.07	16: -30.00
17: -27.90	18: -25.91	19: -23.95	20: -22.02
21: -20.06	22: -18.18	23: -16.32	24: -14.48
25: -12.59	26: -10.78	27: -8.97	28: -7.18
29: -5.34	30: -3.55	31: -1.78	32: .00
33: 1.78	34: 3.55	35: 5.34	36: 7.18
37: 8.97	38: 10.78	39: 12.59	40: 14.48
41: 16.32	42: 18.18	43: 20.06	44: 22.02
45: 23.95	46: 25.91	47: 27.90	48: 30.00
49: 32.07	50: 34.19	51: 36.37	52: 38.68
53: 41.00	54: 43.39	55: 45.89	56: 48.59
57: 51.35	58: 54.29	59: 57.46	60: 61.04
61: 64.96	62: 69.55	63: 75.47	64: 90.00

PRESS RETURN TO CONTINUE

Figure 2.6-1 (C) Sample Display Stored Data Printout

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2.7 (U) ERROR HALTS (U)

During the operation of the TAP-II software certain conditions can occur due to operator error or equipment malfunction which make it impossible for the computer to continue to produce meaningful data. Upon detection of an irrecoverable error the computer will halt and display an error code in the S register. The error codes displayed are shown in Table 2.7-1. If an error halt occurs, the operator should analyze the failure, take corrective action, and reboot the system as described in paragraph 2.2.

TABLE 2.7-1. (U) ERROR HALTS (U)

CODE	MEANING
102001	Operator input error
102002	No input completion interrupt
102003	Disc too slow or sample rate too fast
102004	Disc interface delay
102005	Not defined
102006	Disc call error
102007	Storage exceeded
102010	Disc status bad, track in B register

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2.8 (U) DISC COPYING (U)

For purposes of providing disc backup copies, discs may be copied to and from magnetic tape, and from disc to disc. MADIU is a stand-alone program which performs these functions. MADIU is designed to work with a variety of discs and magnetic tape drives; however, only its use as it applies to this system (7900/7970) will be discussed here. Some of the characteristics of MADIU are:

- 1) Multiple tape files
- 2) Tape-disc verification
- 3) Defective cylinders are copied to/from magnetic tape as defective
- 4) Protected cylinders are copied as protected
- 5) All 204 cylinders are copied
- 6) During loading or disc copy, the destination disc is always initialized. It is therefore unnecessary to pre-initialize the disc with the disc diagnostic, RTGEN, etc.

2.8.1 (U) Program Description. (U) No program details are available.

2.8.2 (U) Outputs. (U) Magnetic tape format:

1st word = number of words in the record (SIO characteristic)
2nd word = 16-bit disc status after reading track
rest of record = disc track data

2.8.3 (U) Operating Instructions. (U)

- 1) Operation consists of configuration and application modes. If a configured MADIU tape is available, load it with BBL (002100 in S register, press STORE, PRESET, IBL, RUN) and skip to step 8. If it is necessary to configure MADIU begin at step 2; an unconfigured MADIU tape must be used; a configured MADIU cannot be reconfigured.
- 2) Load the unconfigured MADIU tape using BBL.
- 3) Set starting address 2.
- 4) Set switch register bits 0-5 to the disc higher priority select code. Set all other switches off.
- 5) Press PRESET and RUN.

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- 6) Load the Configured SIO Module, or load and configure the SIO drivers in the following order:

46K SIO TTY Driver
16K SIO Punch Driver (if configured tape is to be punched)
16K SIO 9-Track Magnetic Tape Driver

- 7) If a Configured MADIU tape is to be punched, load and execute the 16K SIO System Dump. Label the resulting tape Configured MADIU. Date it.

- 8) Ready all equipment. Turn the PROTECT/OVERRIDE switch on the disc drive to the appropriate position. Set the magnetic tape to unit 0 and the proper density. Make certain that the disc or mag tape about to be written on is the right one and that the other is protected. For disc-to-disc copying, neither disc may be protected.

- 9) Set starting address 100. Press RUN. The computer will print

(FOR 7900) TYPE "LO" "DU" "VE" "CO" OR "TE"

- 10) Enter one of the following (followed by RETURN):

LO - load disc from mag tape
DU - dump disc to mag tape
VE - verify disc versus mag tape
CO - copy disc to disc (with auto verify)
TE - terminate

- 11) Some of the following additional requests will be received:

SUBCHANNEL #

Meaning: enter disc subchannel to be used. The lower (fixed) disc is 0, and the upper disc is 1.

SOURCE SUBCHANNEL #

Meaning: enter source disc subchannel to be used for disc-to-disc copy.

DESTINATION SUBCHANNEL #

Meaning: enter destination disc subchannel to be used for disc-to-disc copy.

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TAPE FILE #

Meaning: enter mag tape disc file to be used. The first physical file is 1. The program assumes that there are already N-1 files on the tape. Dumping to file N will destroy all files greater than N.

12) When operation is complete, the message in step 9 will be received.

13) The following error halts may be received:

- HLT 00B Disc not ready (bits 2 or 6 set).
- HLT 03B Time out on disc data flag. Press RUN to get status in A register.
- HLT 04B Power failure.
- HLT 05B Time out on disc command flag. Press RUN to get status in A register.
- HLT 07B Disc seek error or data protect (bits 8, 9, or 10 set). Press RUN to get status in A register.
- HLT 10B Any disc status bit set except 3 and 4 after a read or write (check PROTECT/OVERRIDE switch). Press RUN to get status in A register.
- HLT 11B SIO mag tape driver halt (no write ring).
- HLT 13B Illegal cylinder status (2nd word on mag tape or during copy).
- HLT 16B Bad cylinder status during load verify [mag tape status (word 2) and disc readback status disagree].
- HLT 17B EOF and EOT on mag tape.
- HLT 20B Mag tape error.
- HLT 21B Bad data verify.
- HLT 33B Mag tape record length wrong; i.e., wrong format for a load.
- HLT 35B Cylinder count unequal to 203.

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HLT 36B Incomplete data transfer for disc current cylinder.

HLT 40E Mag tape SIO driver not loaded.

HLT 44B Mag tape SIO driver halt.

HLT 55B The current cylinder is and will be flagged as bad. The track number (octal) is in the A register. Press RUN to continue.

HLT 77B End. Press RUN to continue.

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2.9 (U) SYSTEM GENERATION PROCEDURES (U)

All of the TAP II software is generated with the Fourier Cross Loader (FXL) and the RTE File Manager (FMGR). Each coreload has a transfer file which directs dumping of a predetermined set of relocatable modules into a file used by FXL. The modules which make up a given coreload can be determined by listing the transfer file for that coreload. Once a change is made to a program or subroutine in a certain coreload, the operator must transfer control to that coreload's transfer file, then to a transfer file which controls FXL, then run COPYF, a program which actually stores the coreload on the disc. The coreloads and their transfer files are listed in Table 2.9-1.

TABLE 2.9-1 (U) SYSTEM GENERATION TRANSFER FILES (U)

CORELOAD	MAIN PROGRAM NAME	MAIN TRANSFER FILE	FXL TRANSFER FILE
0	Y0000	CL0TR	RFTR
1	BFORM	CL1TR	RFTR
2	Y0002	CL2TR	RTTR
3	Y0003	CL3TR	RTTR
4	Y0004	CL4TR	RTTR
5	CAL	CL5TR	RFTR
6	Y0006	CL6TR	RFTR

The procedure for producing a new coreload is as follows:

1) Boot lower disc (RTE) system

2) Enter RU,FMGR

TR,(main transfer file name)

TR,(FXL transfer file name)

RU,COPYF

3) Answer the COPYF questions as follows:

TARGET SYSTEM CORE SIZE? 32

CORELOAD NUMBER? (enter appropriate number)

TARGET DISC LU NUMBER? 13

SYSTEM FILE NAME? BCSJOB

OVERLAY FILE USED? NO

LU #13 WILL BE MODIFIED, CAN WE PROCEED? YE

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- 4) The error message INCORRECT RECORD COUNT-FILE READ will be displayed when done. This is normal and should be ignored. Any other message is an error.

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3.0 (C) IBM TAPE FORMATS (U)

3.1 (U) GENERAL FORMATS (U)

Two types of tape records are written by TAP-II: records containing either the Accumulation Table data or the complex coefficients data. Both types contain a 4480 integer word block written in one record. The record type is determined by the contents of Word 100. If Word 100 = 1, the record contains complex coefficient data; if 2, the record contains Accumulation Table data.

To read the data, it is suggested that the tape read statement input the entire record into an array, IBUF, dimensioned to 4480. If the dimension and equivalence statements shown in Figure 3.1-1 are employed, the information contained in the record is conveniently accessible. In both Figure 3.1-1 and the following Figure 3.1-2, FORTRAN data type conventions are followed, with the first letter defining whether the variable is integer or floating point.

The first 128 words in both types of records contain header information. Figure 3.1-2 summarizes the information useful to a program reading the tapes. Variable names used make use of the equivalence conventions given in Figure 3.1-1.

The second 128 words in either type of 4480-word record contains non-acoustic data. This data is identical in format to the form in which it was originally received from the batch computer. This format will be defined by Systems Integrated software, and is not included here.

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DIMENSION	IBUF(4480)
DIMENSION	ICOM(128), INADAT(128), IDAT(4096)
DIMENSION	IDATE(6), SR(3), LGRP(8), ITIM(3), SP(3)
EQUIVALENCE	(ICOM(1),IBUF(1)), (INADAT(1),IBUF(129)), (IDAT(1),IBUF(257))
EQUIVALENCE	(NSAMP(1),ICOM(1)), (IDATE(1),ICOM(6)), (NINT,ICOM(39))
EQUIVALENCE	(KK,ICOM(3)), (BW,ICOM(15)), (SR(1),ICOM(27))
EQUIVALENCE	(ITYP,ICOM(33)), (ISHD,ICOM(34)), (IW,ICOM(35))
EQUIVALENCE	(IAV,ICOM(36)), (AUTM,ICOM(37)), (NGRPS,ICOM(40))
EQUIVALENCE	(LGRP(1)<ICOM(41)), (IHDR,ICOM(100)), (ITIM(1),ICOM(61))
EQUIVALENCE	(JJ1,ICOM(101)), (KHALF,ICOM(102)),(KCC,ICOM(103))
EQUIVALENCE	(SP(1),ICOM(51)), (SVEL,ICOM(83))

Figure 3.1-1 (U) DIMENSION and EQUIVALENCE Conventions (U)

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INFORMATION

LOCATION

- | | |
|---|---|
| 1. Length of tape | All records are 4480 words long, with 16-bit integer words |
| 2. Type of tape record | Defined by IHDR: 1 = Complex Coefficients
2 = Accumulation Table
(averaged powers) |
| 3. Date | Contained in Array IDATE. IDATE is a 6-element integer array containing ASCII information in a 6 A2 format |
| 4. Time | Contained in array ITIM:
ITIM(1) = hours (integer format)
ITIM(2) = minutes (integer format)
ITIM(3) = seconds (integer format)
The time is that read from the time code generator at the start of a TAP II analysis. Time is read only once per analysis, so several succeeding records might have identical time headers. |
| 6. Number of Averaging Intervals in current TAP II Analysis | Defined in NINT |
| 7. Current value of Averaging Loop Counter | Defined in KK |
| 8. Number of 128-point frequency line groups being analyzed | Defined in NGRPS |
| 9. Lambda Array Type | Defined in ITYP: 1 = LF
2 = MF
3 = HF |
| 10. Hydrophone Channel Sample rate | Defined in SR (ITYP). Units are Hz |
| 11. Time-Frequency Transform length | Defined in NSAMP. Will be either 1024, 2048 or 4096 |
| 12. FFT frequency line spacing | Defined in BW. BW = SR(ITYP)/NSAMP |
| 13. Type of Time Weighting Window | Defined in IW. 1 = Rectangular
2 = Hanning |

Figure 3.1-2 (C) HEADER INFORMATION (U)

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INFORMATION

LOCATION

14. Array Shading Table

Defined in ISHD (will be 1, 2, or 3). Consult logs to find out what type of shading was put into shading table ISHD

15. Type of averaging

Defined in IAV (1 = simple, 2 = exponential). This affects the power data being stored in the Accumulation Table. For simple averaging, the new powers computed in each averaging cycle are simply summed to the table (the table is cleared at the start of every new analysis). Then at the completion of the last averaging cycle the table is divided by NINT. For exponential averaging, each newly computed power is summed to the current table contents using the formula:

$$\text{New Table Value} = \text{New Sample} + e^{-t/\text{AVTM}} (\text{old table value} - \text{new sample})$$

16. Exponential Averaging Time

Defined in AVTM. Units are seconds.

17. Time to collect the data sample for one average

Calculated using the formula:
 $t = \text{NSAMP}/\text{SR}(\text{ITYP})$

18. The frequency of the first FFT line in a tape record of IHDR Type 1 (complex coefficients)

Calculated using the formula:
 $F = \text{BW} * (128. * (\text{LGRP}(\text{JJ1}) - 1.) + 64. * \text{KHALF} + 32. * \text{KCC})$

19. The frequency of the first FFT line in a tape record of IHDR Type 2 (powers in Accumulation Table)

Calculated using the formula:
 $F = \text{BW} * (128. * (\text{LGRP}(\text{JJ1}) - 1.) + 64. * \text{KHALF})$

18. Lambda array element-element spacing

Defined in SP(ITYP). Units are meters.

20. Sound velocity

Defined in SVEL. Units are meters/sec.

Figure 3.1-2 (C) HEADER INFORMATION (U)

2 of 2

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3.2 (C) COMPLEX COEFFICIENTS (U)

If the contents of IHDR (the 100th word of the input record) equals 1, the record contains 4096 words of complex coefficient data, which will be in array IDAT using the conventions of Figure 3.1-1.

Each consecutive 128-word section of IDAT contains 64 complex numbers, in integer form, representing the beamformer output vs steer angle for one frequency cell. A total of 32 frequency cells are included in any one record. The frequency of the first cell is given by the equation listed in line 18 of Figure 3.1-2. The succeeding frequencies follow in order, spaced in increments of BW Hz.

Both the real and imaginary parts of the complex numbers are in scaled voltage units. When the integer numbers are divided by 64, the result reads directly in volts (rms). The maximum rms voltage for any hydrophone is 7.07, consequently the maximum array output is $64 (7.07) = 452.55$ volts (rms).

The complex numbers (an intermediate output of TAP II) are the direct results of the second FFT. The steer angles representing the 64 complex results are functions of frequency. These steer angles are given by the relation:

$$\theta_r = \sin^{-1} [-r/32 \cdot (F/FM)]$$

where r = an index varying between -31 to +32

F = The frequency of the FFT line

FM = The array aliasing frequency (= $SVEL/(2 \cdot SP(ITYP))$)

In each group of 64 complex numbers (128 consecutive elements of array IDAT), the numbers are stored in order of $r = 0$ to +32, then -31 to -1.

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3.3 (C) ACCUMULATION TABLE (U)

If the contents of IHDR (the 100th word of the input record) equal 2, the record contains 4096 words of Accumulation Table data, which will be stored in array IDAT if using the conventions of Figure 3.1-2.

The Accumulation Table contains array output power as a function of frequency and steer angle. Each consecutive 64-word section of IDAT contains the power for 64 separate directions at one frequency line. The frequency of the first line is given by the equation listed in line 19 of Figure 3.1-2. The succeeding frequencies follow in order in increments of BW Hz. One record contains a maximum of 64 frequencies.

The powers are in scaled voltage squared units. The scale factor is the same for all 4096 IDAT values, and is contained in IBUF (4353). The correct value in volts squared (rms) can be obtained by dividing the table values by $2^{**}(15-IBUF(4353))$.

The Lambda array aliasing frequency is given by:

$$FM = SVEL/(2.*SP(ITYP)) \quad (\text{See Figure 3.1-2.})$$

If the FFT line frequency is below this aliasing frequency, the 64 steer angles are the 64 TAP II steer angles, shown in Figure 3.3-1. The data is in the same order, the first value in a group of 64 numbers representing the most rearward steer angle (-75.47°), and the last number the most forward ($+90^\circ$).

If the FFT line frequency is above the array aliasing frequency, the steer angles are not standard. In this case the steer angles are given by the relation:

$$\theta = \sin^{-1} [r/32(F/FM)]$$

where F = FFT line frequency

FM = array aliasing frequency

r = index varying between -31 and +32.

The order of storing r in the Accumulation Table starts at -31 and increments upwards to 32, for 64 total angles per frequency line.

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1: -75.47	2: -69.55	3: -64.96	4: -61.04
5: -57.46	6: -54.29	7: -51.35	8: -48.59
9: -45.89	10: -43.39	11: -41.00	12: -38.68
13: -36.37	14: -34.19	15: -32.07	16: -30.00
17: -27.90	18: -25.91	19: -23.95	20: -22.02
21: -20.06	22: -18.18	23: -16.32	24: -14.48
25: -12.59	26: -10.78	27: -8.97	28: -7.18
29: -5.34	30: -3.55	31: -1.78	32: .00
33: 1.78	34: 3.55	35: 5.34	36: 7.18
37: 8.97	38: 10.78	39: 12.59	40: 14.48
41: 16.32	42: 18.18	43: 20.06	44: 22.02
45: 23.95	46: 25.91	47: 27.90	48: 30.00
49: 32.07	50: 34.19	51: 36.37	52: 38.68
53: 41.00	54: 43.39	55: 45.89	56: 48.59
57: 51.35	58: 54.29	59: 57.46	60: 61.04
61: 64.96	62: 69.55	63: 75.47	64: 90.00

Figure 3.3-1 (C) TAP II Standard Steer Angles (Degrees) (U)

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4.0 (U) SOFTWARE DOCUMENTATION (U)

4.1 (U) SOFTWARE OVERVIEW (U)

The TAP II system of programs resides on the upper (removable) disc. There are several complete coreloads on this disc, each occupying six consecutive tracks. When the system is booted, the internal binary loader (IBL) loads a secondary bootstrap which in turn loads in a complete 32K coreload (up to address 77577) and starts execution of the program. This secondary bootstrap resides on track 0 sector 0 of the disc. The coreloads begin at track 1. The various coreloads, starting track numbers, and functions are as follows:

Coreload	Track	Function
0	1	Executive
1	7	Beamforming
2	13	Data Collection (Low Speed)
3	19	Data Collection (High Speed)
4	25	High Speed Data Reformatting
5	31	Calibration
6	37	Beam Interpolation
7	43	(spare)
8	49	(spare)

Operation always starts with the Executive, which passes control to other coreloads as directed by operator action. The various coreloads also loads in and transfer control to other coreloads.

Because the core loading process affects all of core, any data required by a program for passing to the next program or to be saved for its later execution will be lost. Therefore, a common data track is reserved to hold this data. This data is read into a buffer (ICOM) at the beginning of each program and is written back (if modified) at the end of each program. (This data is not to be confused with data in a FORTRAN COMMON statement.) The common data occupies only the first sector (128 words) of the common track. Table 4.1-1 shows the location of each data element within the common track and ICOM. The next nine sectors hold the shading tables, one per sector.

Beyond the coreloads are data tracks, including the common track, which start at track 55. The assignments of these tracks are given in Table 4.1-2. In this table, track numbers are relative to track 55.

The operating system used by TAP II is Basic Control System, BCS. The use of BCS is required because the high I/O processing overhead of other operating systems would be prohibitive. The programs are loaded onto disc with the Fourier Cross Loader (FXL) as described in section 2.9 in this manual. The use of FXL eliminates the paper tape handling usually required by BCS.

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TABLE 4.1-1. (U) DISC COMMON ASSIGNMENTS (128 words available) (U)

1. NSAMP - Number of samples
2. IRET - Return pointer
3. IFAST - High speed flag
4. NCYC - No. coll/anal. cycles
5. LD - List device number
6. IDATE - Date (in 12 characters)
7. IDATE (Two characters per word)
8. IDATE (Two characters per word)
9. IDATE (Two characters per word)
10. IDATE (Two characters per word)
11. IDATE (Two characters per word)
12. NUPDAT - No. of updates
13. KK - Averaging loop counter
14. IRCYCL - Ret. track for collection
15. BW - Bandwidth
16. BW - Bandwidth
17. IDEC(1) Decimation numbers
18. IDEC(2) Decimation numbers
19. IDEC(3) Decimation numbers
20. IDEC Decimation numbers
21. ICALTP - Calibration type
22. IR - Reference channel no.
23. NA - No. of averaging intervals
24. IW - Type weighting window
25. IOI - Type output
26. Spare
27. SR(1) - Sample rate
28. SR(1)
29. SR(2) - Sample rate
30. SE(2)
31. SR(3) - Sample rate
32. SR(3)
33. ITYP - Array type (1,2,3)
34. ISHD - Shading table number
35. IN - Type of time window
36. IAV - Averaging type (1 = simple)
37. AVTM - Averaging time (1-600)
38. AVTM - Averaging time (1-600)
39. NINT - No. of averaging intervals
40. NCRPS - No. of 128-line group
41. LGRP(1) - Group no. of 1st group
42. LGRP(2) - Group no. of 2nd group
43. LGRP(3) - Group no. of 3rd group
44. LGRP(4) - Group no. of 4th group
45. LGRP(5) - Group no. of 5th group
46. LGRP(6) - Group no. of 6th group
47. LGRP(7) - Group no. of 7th group
48. LGRP(8) - Group no. of 8th group

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TABLE 4.1-1. (U) DISC COMMON ASSIGNMENTS (U) (Continued)

49. MT2 - Flag for output to MT2
50. MT1 - Flag for output to MT1
51. SP(1) - Array spacing (ft.)
52. SP
53. SP(2) - Array spacing (ft.)
54. SP
55. SP(3) - Array spacing (ft.)
56. SP
57. TAU1 - Corrected exp. avg. time
58. TAU1 - Corrected exp. avg. time
59. Spare
60. IG - Group counter
61. ITIM(1) - Time of sample - hr.
62. ITIM(2) - Time of sample - min.
63. ITIM(3) - Time of sample - sec.
64. IOUT - No. of output words
65. IXORG - X-origin initial offset
66. IYORG - Y-origin initial offset
67. INCRX - X-increment of plot
68. IHI - Height of Y axis (in plot points)
69. IDELX - Delta-X for each plot line
70. IDELY - Delta-Y for each plot line
71. YMIN - Lowest value plotted (in db)
72. YMIN - Lowest value plotted (in db)
73. SCF - Range plotted (in db)
74. SCF - Range plotted (in db)
75. CALS(1) - Calib. sample rate
76. CALS(1)
77. CALS(2) - Calib. sample rate
78. CALS(2)
79. CALS(3) - Calib. sample rate
80. CALS(3)
81. ICL - Coreload (HS or LS)
82. IIOR - No. of plot pts. to 'or'
83. SVEL - Sound Velocity (m/sec)
84. SVEL - Sound Velocity (m/sec)
85. Spare
86. Spare
87. Spare
88. Spare
89. Spare
90. NSOLD - Previous NSAMP
91. IWOLD - Previous IW
92. Spare
93. Spare
94. Spare
95. Spare
96. Spare

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TABLE 4.1-1. (U) DISC COMMON ASSIGNMENTS (U) (Continued)

97. INTP - Inhibit TYPE flag
98. Spare
99. Spare
100. IHDR - Magnetic tape header
101. JJI - Line group counter
102. KHALF - Line group half-counter
103. KCC - Magnetic tape counter
104. Spare
105. NBSKP - No. plots to skip at beginning
106. NESKP - No. plots to skip at end
107. Spare
.
.
.
128. Spare

TABLE 4.1-2 (U) DISC TRACK ALLOCATIONS (U)

<u>Track</u>	<u>Name</u>	<u>Function</u>
0-42	ITEMPO	Temporary storage and high speed data
43-106	IDATO	Time domain data from Y0002 or Y0004
107-122	IMIFO	Minor accumulation table
123-126	IBUFO	Temporary storage buffer
127	ICOMO	Coreload common
128-130	ICALO	Calibration shading tables
147	IPHAO	Phasor table
148-149	IWINO	Time weighting window

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4.2 (C) BEAMFORMING OVERVIEW (U)

4.2.1 (U) Function. (U) The primary function of the TAP-II system is to resolve the output of a towed array in both the frequency and spatial domains. This is done in the Beamforming software. Several computational techniques are employed to implement all the features of this system, with a two-dimensional FFT being the heart of the computational mechanism. This technique, mathematically described in a companion volume to this report, first uses the FFT to transform sampled length variable from 1024 to 4096 points. A second FFT transform, taken across the 64-sensor frequency domain outputs, is used to simultaneously form 64 directional beams.

The manner in which these features will be implemented in the TAP-II system can be seen in the flow diagram of the Spectral Analysis and Beamforming Operation, shown in Figure 4.2.-1.

4.2.2 (C) Initiating Analysis. (U) To initialize the operation, the on-line operator first enters the analysis parameters to the computer in the TAP-II conversational input format. (If the analysis is to be the same as the one previously run, the questions can be skipped and the computer will use the previously stored directions.) The following parameters are entered at this time:

- 1) Array type (LF, MF, or HF)
- 2) Table number of sensor shading coefficients to be used (1, 2, or 3).
- 3) Type of time domain windowing (rectangular or Hanning).
- 4) Time to frequency FFT size (1024, 2048, or 4096).
- 5) Type of averaging (simple or exponential averaging time is requested if exponential averaging is selected).
- 6) Number and range of frequency lines to be utilized in beamforming (64 to 1024 lines (in groups of 128)).
- 7) Number of analysis intervals.

4.2.3 (U) Preliminary Computations. (U) After these parameters are entered, and before the actual analysis is started, a channel correction phasor array is computed for each sensor channel. These arrays, which are in the frequency domain, are computed from two factors: (1) the stored channel calibration array, computed during the most recent calibration analysis, and (2) the shading coefficient table. The resultant channel correction phasor arrays are used later in the flow.

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4.2.4 (U) Plot Data Table. (U) The last step before performing the actual data analysis is the clearing of the Plot Data Table. This table is generated during each separate analysis period and accumulates the computed results.

4.2.5 (C) Analysis Loops. (U) The basic analysis pattern is to collect a block of data simultaneously from each array sensor, storing the data on disc. The data is then transformed into the frequency and spatial domains using two FFTs. The plot data table is updated, and the computed array output versus frequency and direction is output in graphical form. The basic loop is repeated II times, II being the number of analysis intervals directed by the operator. At the end of the II loops, the Master Accumulator Table is updated and the final data is output in both graphical and tabular form.

These processes are shown in steps (2), (3) and (4) of the flow diagram. In step (2) the sample interval loop is initiated to collect data and store it on disc. N sampled time data points (N=1024, 2048, or 4096) are collected for each of 64 array sensors. Then the operations in step (3) of the flow diagram are performed on each of the 64 data blocks. First, the N points for a single channel are read from the disc. This array is then multiplied by a "window" array, which implements the time domain window function (such as Hanning). The resultant time-weighted array is then transformed to the frequency domain using the FFT transform. It is then multiplied by the precomputed phasor array, and written back to the disc. At this point, the data represents the array sensor output in the frequency domain, as corrected by the element shading coefficient, calibration, and sample skew correction factors.

Spatial resolution is achieved in step (4) of the flow diagram. The indices of this frequency-to-spatial loop are set up accordingly to the initial operator inputs as to the desired frequency lines of analysis. As many lines as desired, in multiples of 128, can be selected: up to 1024 lines in the case of a 2048- or 4096-point time-to-frequency transform. For any individual frequency line, beamforming is accomplished by forming a 64-element cross array. This array consists of the 64 complex frequency domain output of the 64 sensors at the line frequency. A 64-point FFT is the final step in the spatial resolution. The resulting complex coefficients are then written to IBM-compatible 9-track tape. The Plot Data Table is updated by taking the vector magnitude of the complex coefficients and using either exponential or true averaging. At step (5), an interpolation algorithm is used to compute beam power versus frequency for a standard set of look angles. After all the desired lines are completed, the updated plot table is output in both graphical and tabular form, and is stored on magnetic tape.

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4.2.6 (U) Processing Details. (U) The BFORM program, which is written in FORTRAN, is described in detail later in this section.

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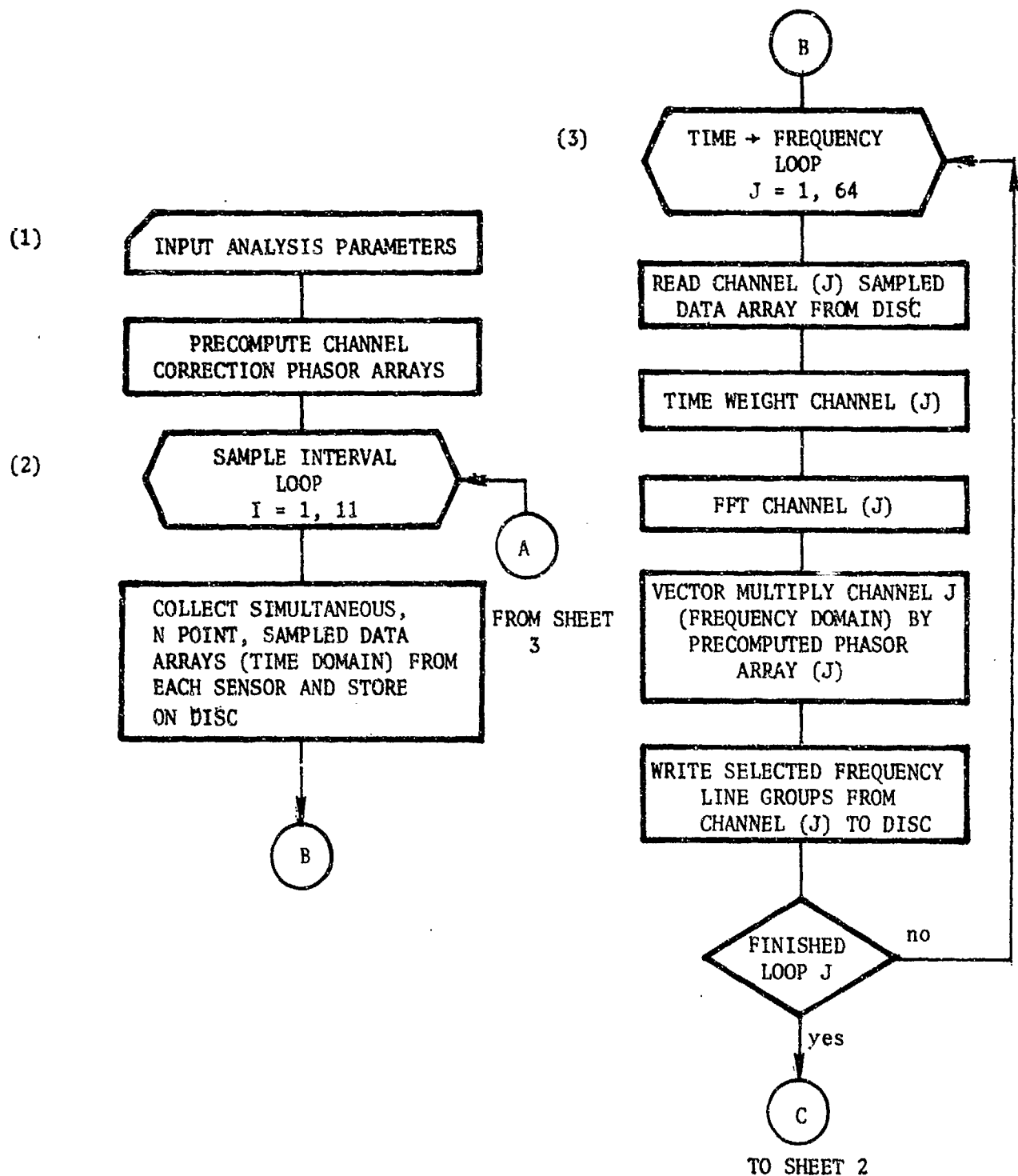


Figure 4.2-1 (U) Spectral Analysis and Beamforming Flow Diagram Sheet 1 of 3

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FROM SHEET 1

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(4)

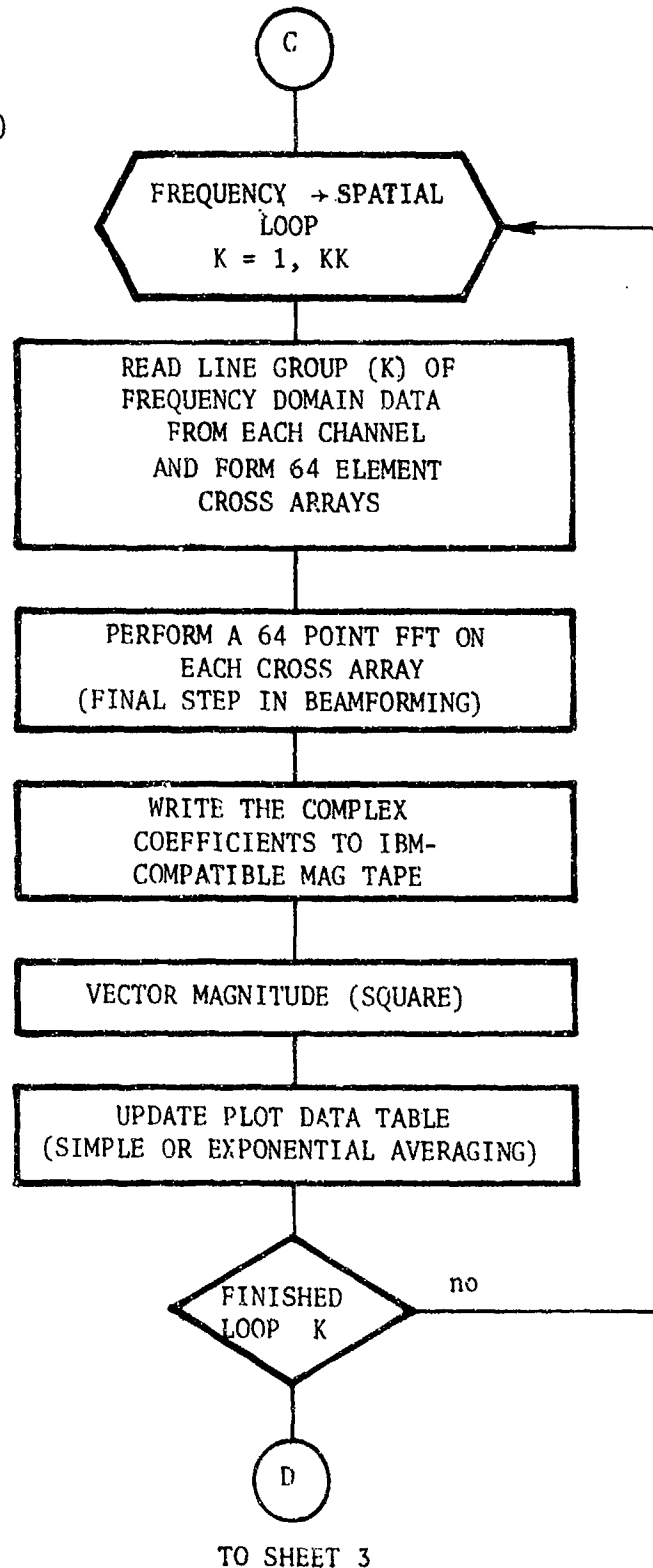


Figure 4.2-1 (U) Spectral Analysis and Beamforming Flow Diagram

Sheet 2 of 3

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FROM SHEET 2

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(4) Continued.

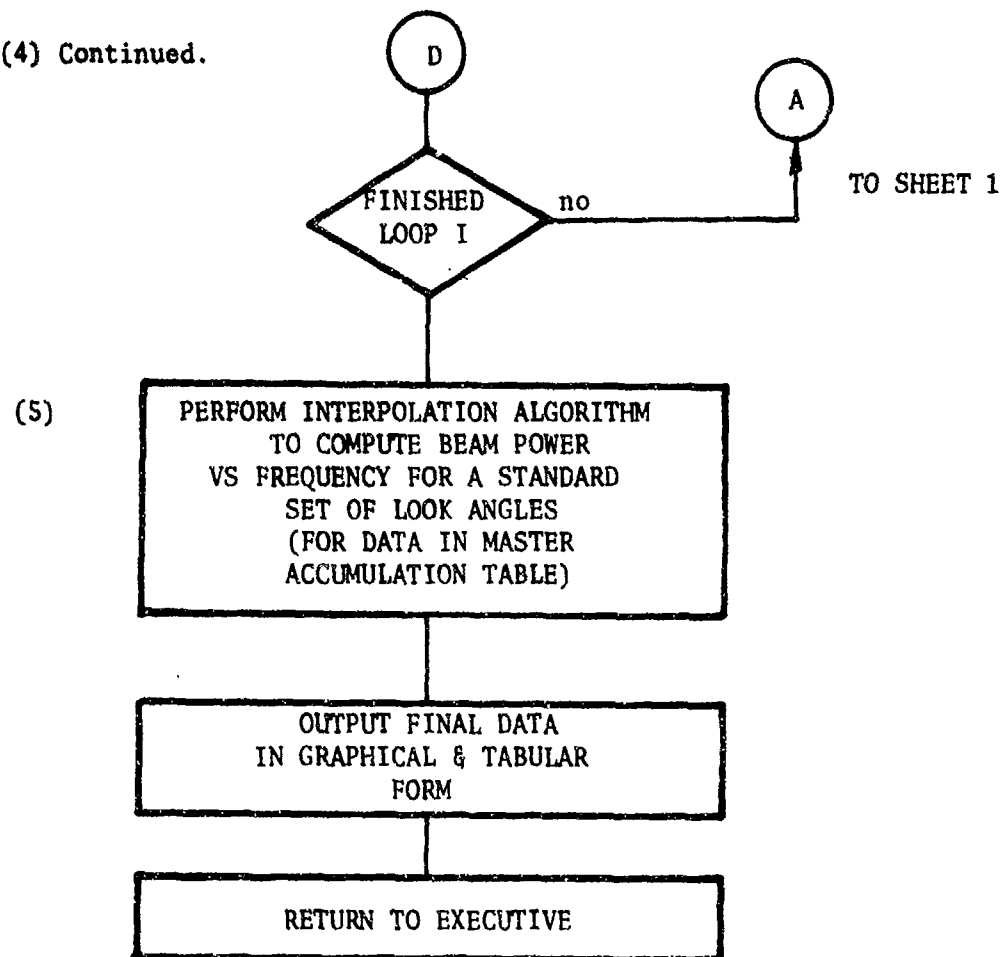


Figure 4.2-1 (U) Spectral Analysis and Beamforming Flow Diagram Sheet 3 of 3

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4.3 (U) CALIBRATION OVERVIEW (U)

Automatic system self-calibration is provided using Fourier techniques. In this mode, the output of a white noise generator is simultaneously entered into every channel. The channel outputs are then simultaneously sampled and the resulting calculated normalized amplitude and phase information are computed, printed out and internally stored to be used in the correction phasor arrays during the beam-forming analysis.

At-sea array monitoring will be accomplished in the same manner, except that actual hydrophone inputs to the system will be used, with long-term averaging employed to give reliable estimates of channel-to-channel variances.

Mathematically, the normalized channel-to-channel transfer functions are defined as:

$$\begin{array}{l} \text{Normalized transfer function} \\ \text{for the } i\text{th channel} \end{array} = \frac{\text{Fourier transform of } i\text{th channel}}{\text{Fourier transform of reference channel}}$$

or, equivalently,

$$\text{Transfer function} = \frac{\text{Averaged cross power spectrum of } i\text{th and reference channels}}{\text{Average power spectrum of reference channel}}$$

Since averaging gives a more reliable transfer function, the latter technique is used. The averaging time and reference channel are selectable on-line by the operator. A 32-point time-to-frequency transform is used here, effectively dividing the frequency spectrum into 16 segments for phase and amplitude correction purposes.

An overview flow diagram of the calibration software is in Figure 4.3-1. First, operator entered parameters are accepted. These parameters are summarized in Table 4.3-1.

If the parameter ICALTP equals 3, the program simply stores all 1's in the calibration table on disc. This has the effect of forcing the TAP-II system to assume all channels are identical, a choice that is best if the calibration electronics are inoperative.

When the choice for ICALTP is 1, a normal calibration analysis is done. When ICALTP is 2, a noise analysis is performed to calculate only relative channel amplitude, instead of a complete transfer function calculation.

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TABLE 4.3-1 (U) Calibration Variables Input by Operator

<u>Variable Name</u>	<u>Range</u>	<u>Function</u>
1) ICALTP	1-3	1=Normal Calibration (write output tables to disc] 2=Noise Analysis (inhibit disc output) 3=Force CAL Table to Unity
2) ITYP	1-3	Array Type (1=LF, 2=MF, 3=HF)
3) IR	1-64	Channel to be used as the reference in the ΔA and $\Delta \phi$ calculations.
4) NA	1-128	Number of Averaging Intervals
5) IW	1-3	Type of Time Weighting Window (1=rectangular, 2=Hanning, 3=rectangular)
6) IO1	0, 1	Type of Output 0=partial output (channel ΔA s and $\Delta \phi$ s are listed at four frequencies) 1=full output (the information is printed out for 16 frequencies)

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Before beginning the analysis loops, a time weighting window is calculated (step 4 on the flow diagram). This is a 32-point data weighting array containing either a rectangular or Hanning window function. The input parameter IW determines which type.

To start the analysis, data is collected simultaneously from all 64 hydrophone channels and stored on disc. The amount of data collected depends on the number of averages, NA, requested by the operator.

Step 6 in the flow diagram is the beginning of the channel loop. The 64 channels are analyzed sequentially; for each channel an averaged transfer function between that channel and the reference channel IR is computed.

The averaging starts in Step 7 where two 32-point summing tables are cleared to zero. These tables are stored in data blocks 2 and 3 in the 120B array processor. Steps 8 through 15 form the averaging loop. In this loop, successive 32-point data blocks from both channel I and the reference channel are read from disc, time weighted, and Fourier transformed to the frequency domain. In the case of calibration (IXALTP=1), both the reference channel auto power spectrum and the transfer function are computed (steps 11 and 13). For a noise analysis (ICALTP=2), the auto power spectrums for both the reference channel and the Ith channel are computed (steps 12 and 13). The averaging loop ends with computed power spectrums summed to the accumulation tables (step 14).

Steps 16, 17, 18, and 19 compute the final averaged transfer function, and also the inverse of the transfer function which forms the correction array. The correction array data for each channel is thus sequentially calculated and stored in memory. Step 21 completes the channel loop, with the printing of the completed results. Two output options are implemented. A partial output prints the transfer function in four frequency cells only. The full output selection prints the results for all 16 frequency calls.

If a noise analysis is being performed, steps 16, 17 and 20 are executed. This computes the power spectrum only, for both the Ith and reference channels.

To complete calibration, the computed correction array is stored away on disc, to be used later in Beamforming. The output to disc is skipped if a noise analysis is being performed.

The main calibration program, CAL, is described in detail later in this section.

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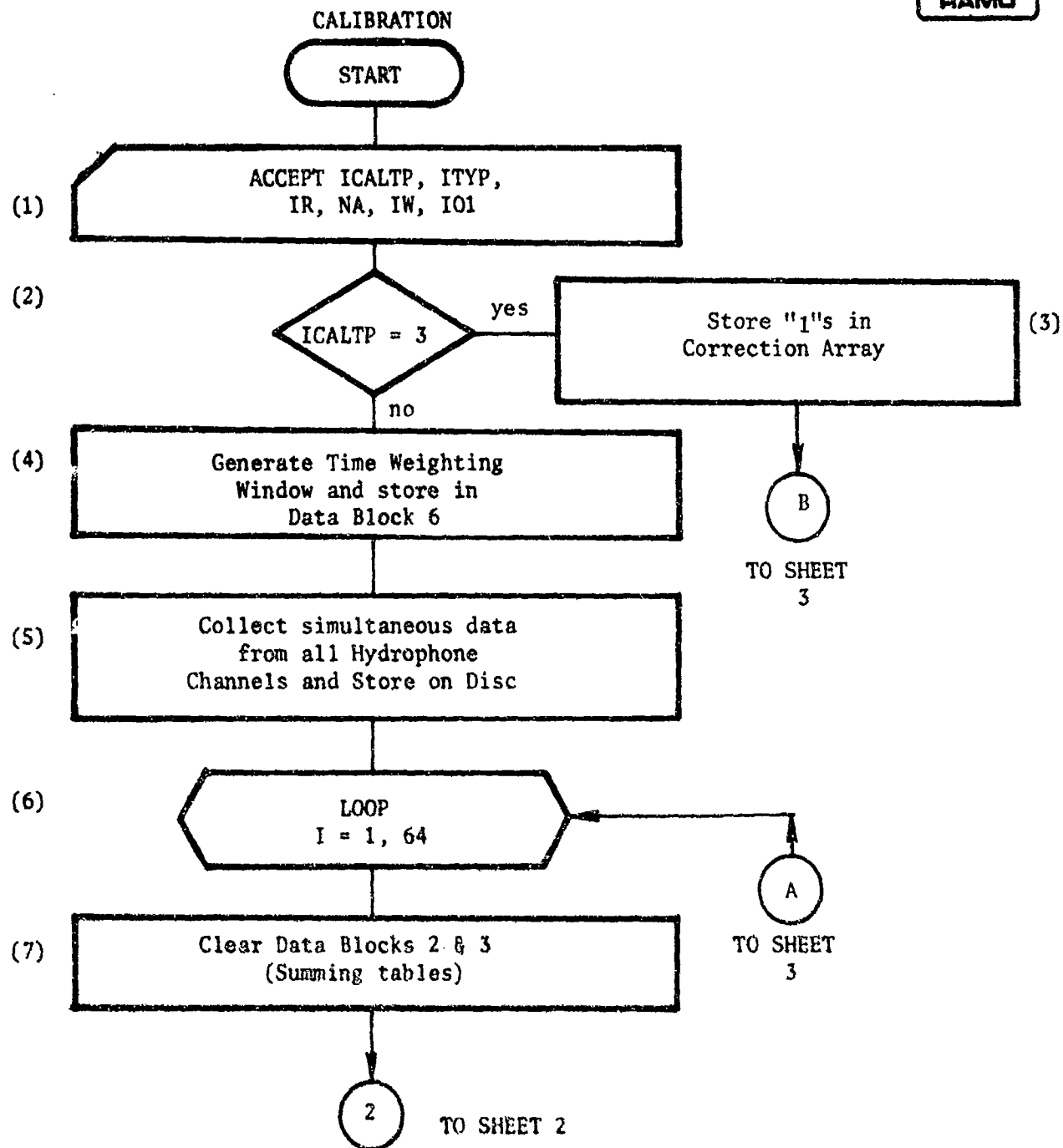


Figure 4.3-1 (U) Calibration Overview

Sheet 1 of 3

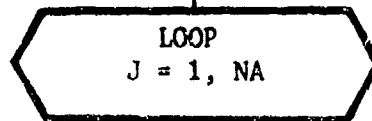
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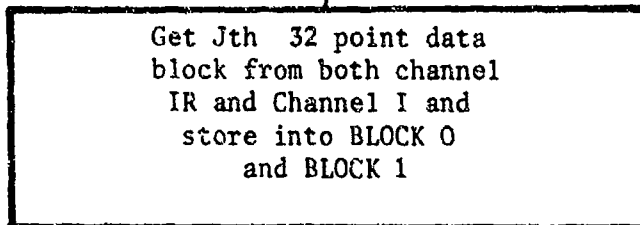
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2 FROM SHEET 1

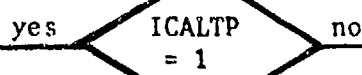
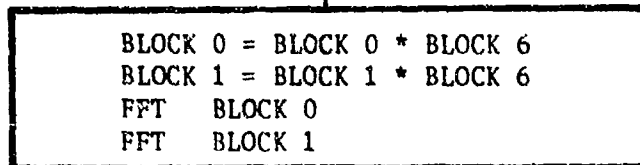
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(9)



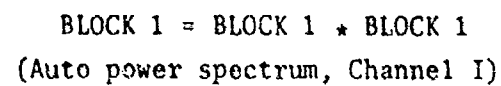
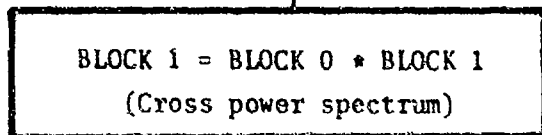
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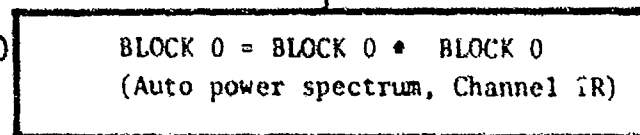
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(11)

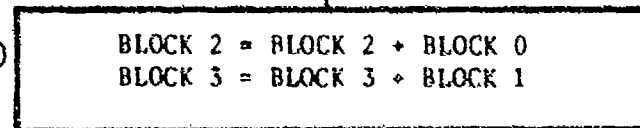


(12)

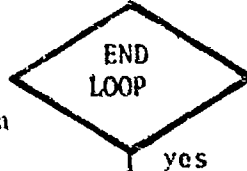
(13)



(14)



(15)



no

yes

3 TO SHEET 3

Figure 4.3-1 (U) Calibration
Overview

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FROM SHEET 2

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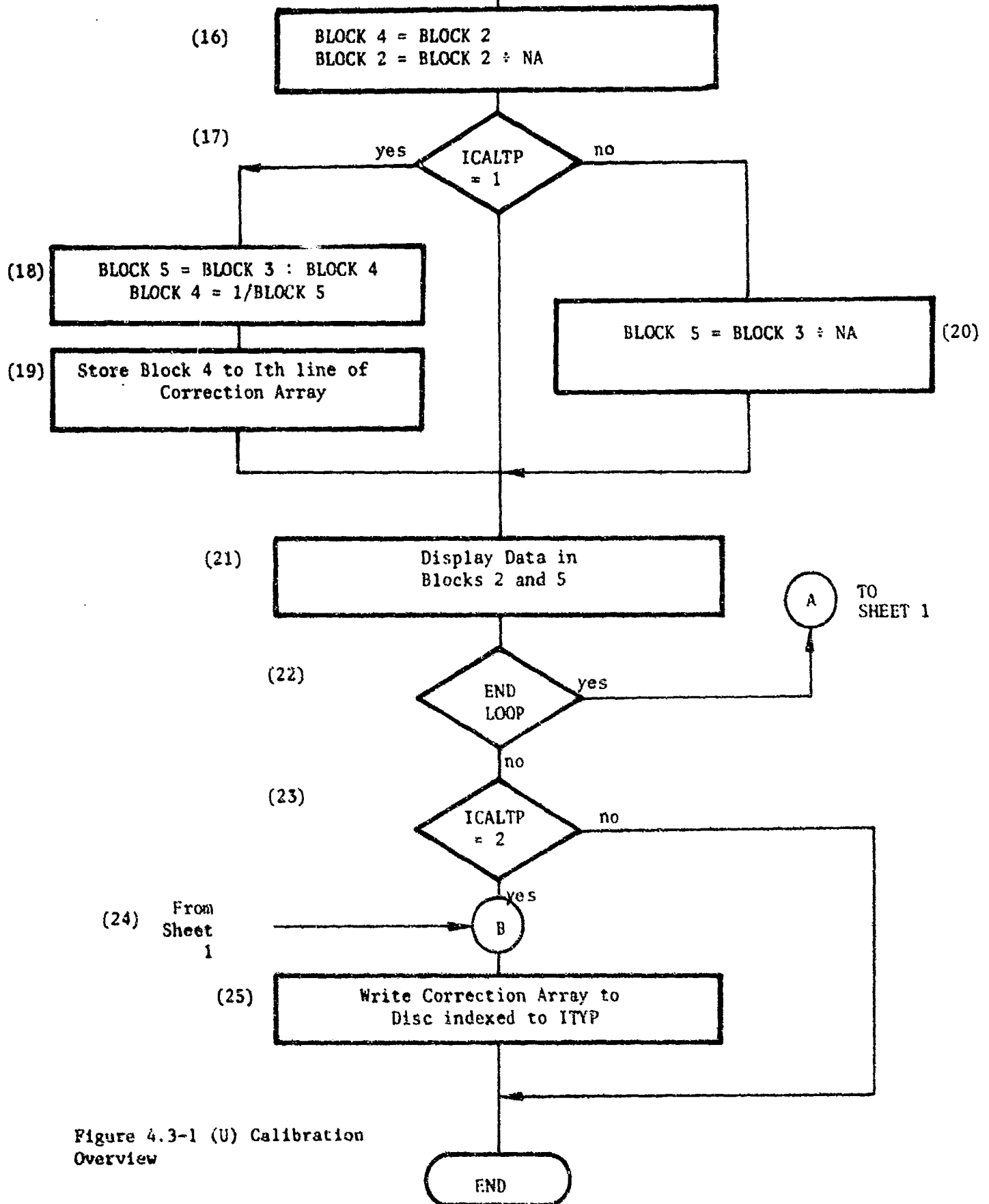


Figure 4.3-1 (U) Calibration
Overview

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4.4 (U) AP-120B SOFTWARE OVERVIEW (U)

The AP-120B, called the AP, is a high speed processor with an internal structure which is well suited to array manipulations. All operations are directed by programs resident in the 21MX computer. There are two basic types of operations: transfer of data to and from the AP, and operations within the AP. One operation from each of these two groups can take place simultaneously. To accomplish these functions, including the overlapping of operations, with the maximum degree of transparency, a large part of the software is 21MX software. The subroutines within the 21MX handle checking for last operation done, transferring the AP program to the AP, starting the program, and manipulating the interface.

Most of the machine-manipulating subroutines are never called directly by the user program. The exceptions are APCLR, which initializes both hardware and software, and several status checking subroutines. These reside in several library files on the File Manager disc, and are loaded automatically by FXL. The array manipulation subroutines, however, must undergo a linking process before they can be loaded by FXL. This involves the Linker, APLINK, which is a program which resides in the RTE (lower disc) system. APLINK produces a paper tape which is a number of FORTRAN source statements. When this source code is compiled by the HP Fortran IV compiler, the object code generated contains the AP-120B code plus the 21MX instructions necessary to transfer it to the AP and start its execution. The file #APLIB contains the linked object code for all of the array manipulation subroutines used by the TAP II system. The remainder of the (unlinked) AP programs exist on a magnetic tape labeled APLIB in the form used by APLINK.

All of the AP support programs except the Linker reside in absolute form on a separate disc labeled AP-120B SUPPORT SOFTWARE, along with an executive, called APE. This executive is similar to the TAP II Executive, Y0000, in that it offers the operator a choice of programs and reads in a coreload specified by the operator. The programs on this disc are the diagnostics (APTST, APPATH, APARTH, and FIFPT), the AP source code assembler (APAL), the AP Simulator (APSIM), and the AP software Debug program (HWDEBUG).

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4.5 (U) PROGRAM DESCRIPTIONS AND FLOW DIAGRAMS (U)

This section contains descriptions and detailed flow diagrams of the application routines and subroutines used in the TAP II software. These programs are listed below.

<u>Para.</u>	<u>Symbol</u>	<u>Program Name</u>
4.5.1	BFORM	Beamforming and Spectral Analysis Program
4.5.2	CAL	Calibration Program
4.5.3	Y0000	Tap II Executive Program
4.5.4	Y0002	Data Collection Program
4.5.5	Y0003	Data Collection Program (High Speed)
4.5.6	Y0004	High Speed Data Reformatting Program
4.5.7	Y0006	Steer Angle Interpolation Subroutine
4.5.8	DISC, IDISC, DWAIT	Disc Read/Write Subroutine
4.5.9	TIME	Tape II Time Input
4.5.10	INPT, INPTF	Typewriter Input and Limit Check
4.5.11	TYPI, TYPF, TYP A	Direct Typewriter Input Routine
4.5.12	PEDIT	Parameter Edit Subroutine
4.5.13	CLOAD	Core Load Subroutine
4.5.14	TAT	Track Allocation Table
4.5.15	PUT	Convert Line Group Data Subroutine
4.5.16	AXIS	Draw Axis Subroutine
4.5.17	PLOT	Plot Points Subroutine
4.5.18	LGPRI	Print Table Subroutine
4.5.19	LGPLT	Plot Line Group Subroutine

NOTE: Program descriptions are in BR standard format.

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PROGRAM: (C) BEAMFORMING AND SPECTRAL ANALYSIS, BFORM 4.5.1

1. (C) FUNCTION. The Beamforming and Spectral Analysis program uses FFT techniques to resolve output from a towed hydrophone array into both frequency and spatial domains. Normalized, corrected, and unskewed data in the form of polar log amplitudes are obtained.
2. (U) CONSTRAINTS. N/A.
3. (U) CALLING SEQUENCE. BFORM is called by the Executive; and recalled by Data Collection Program. The Executive calls program CAL, then Editor is used to enter options and parameters. The BFORM program is selected as an option by striking the B key and carriage return.
4. (U) DESCRIPTION OF INPUT. Operator-entered options and parameters are entered in the Editor main program. Data from the collection program are obtained from the disc, as is the common area containing the selection parameters. Output options are entered in a similar manner in the BFORM Program.
5. (U) DESCRIPTION OF OUTPUT. Partial or full printouts, isometric hidden-line plots for one or two selected line-groups, and output matrices stored on disc are output in response to operator-selected options.
6. (U) FILES USED. Files and their record sizes are: ABUF (4096), EBUF (64), INBUF (8704), IOBUF (4096), ICOM (128).
7. (U) ERRORS. Operator selections (in the Editor) are range-checked and re-accepted if inconsistent.
8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A.
9. (U) DESCRIPTION OF PROCESSING. BFORM is a highly complex program which makes heavy use of the AP-120B array processor calls, and uses several BR application programs and a few Tektronix plot routines, with over 600 lines of FORTRAN. Refer to the detailed flow diagram, Figure 4.5.1-1 for an understanding of the processing. Data from the coreload are multiplied by the elements of the correction array shading table; the appropriate time-weighted window is used, and the results combined with previous data until the specified number of tables have been averaged, scaled and fixed and the results stored on disc. Real FFT processing is used to obtain frequency line group resolution, and complex FFT produces the spatial beamforming. A variety of options may be used to select print, plot, and store the data.

The subroutines called by BFORM are itemized in Table 4.5.1-1.

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TABLE 4.5.1-1 (U) SUBROUTINES CALLED BY BFORM (CORELOAD 1) (U)

APCLR	A	Clear AP-120B hardware status (must precede all other calls to 120)
APGET	A	Transfer data to HP computer from AP-120B
APPUT	A	Transfer data from HP computer to AP-120-B
APWAI	A	Wait for completion of AP-120B execution, then proceed
APWD	A	Wait for completion of data transfer to or from AP-120B, then proceed
APWR	A	Wait for completion of program execution by AP-120B, then proceed
AXIS	B	Draws tick-marks and labels three axis for isometric plot
CFFT	A	Complex fast Fourier transform
CHOUT	T	Output a character or control code to CRT display
CLOAD	B	Read in specified coreload from disc and run
CVMAG	A	Complex vector magnitude (square)
CVMUL	A	Complex vector multiply
DISC	B	Read from, or write to, disc the vector specified
DWAIT	B	Wait for completion of last disc call before proceeding
D750	B	Wait 750 msec. (used following CRT screen erase command)
ENDIO	B	Used just before end of program for updating common disc files
IDISC	B	Initialize parameters for disc access (used at beginning of program)
INPT	B	Input an integer within specified limits, test against limits
INPTF	B	Input a floating number or leave same. Test input against limits
LGPLT	B	Line group plot subroutine
LPHDR	B	Prints header data for LGPRI Routine
LPPRI	B	Prints out frequency/azimuth table in 12 pages, or a partial print
PLOT	B	Plot one line of data points in isometric hidden-line family
PUT	B	Gets line group data, converts to log magnitude, stores on disc
RFFT	A	Fast Fourier transform (real)
TIME	B	Read current time of day and store hours, minutes and seconds
TPLOT	T	Plot one line segment or move cursor to designated location
TYPI	B	Input a string of integer values, check against limits
VADD	A	Vector add
VFIX	A	Vector fix
VFLT	A	Vector float
VLOG	A	Vector logarithm (base 10)
VMAX	A	Vector maximum (of two vectors)
VMOV	A	Vector move
VMUL	A	Vector multiply
VSCSC	A	Vector scan and scale (fix)
VSMUL	A	Vector-scalar multiply
VCLR	A	Vector clear
	A	AP-120B FORTRAN-callable routine - see Math Library Manual (7288-02)
	B	Bunker Ramo application routine
	T	TEKTRONIX Plot Package Subroutine

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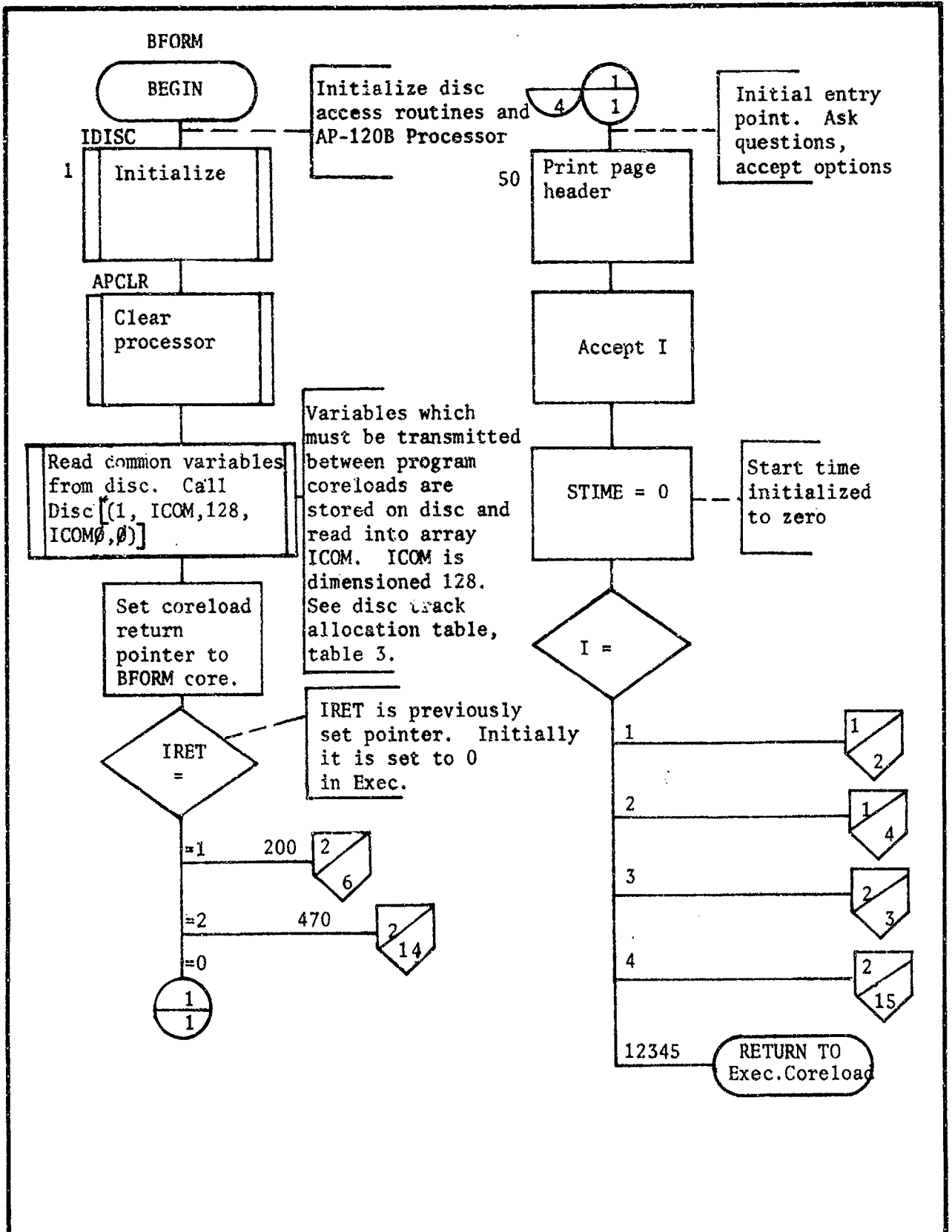


Figure 4.5.1-1 (U)

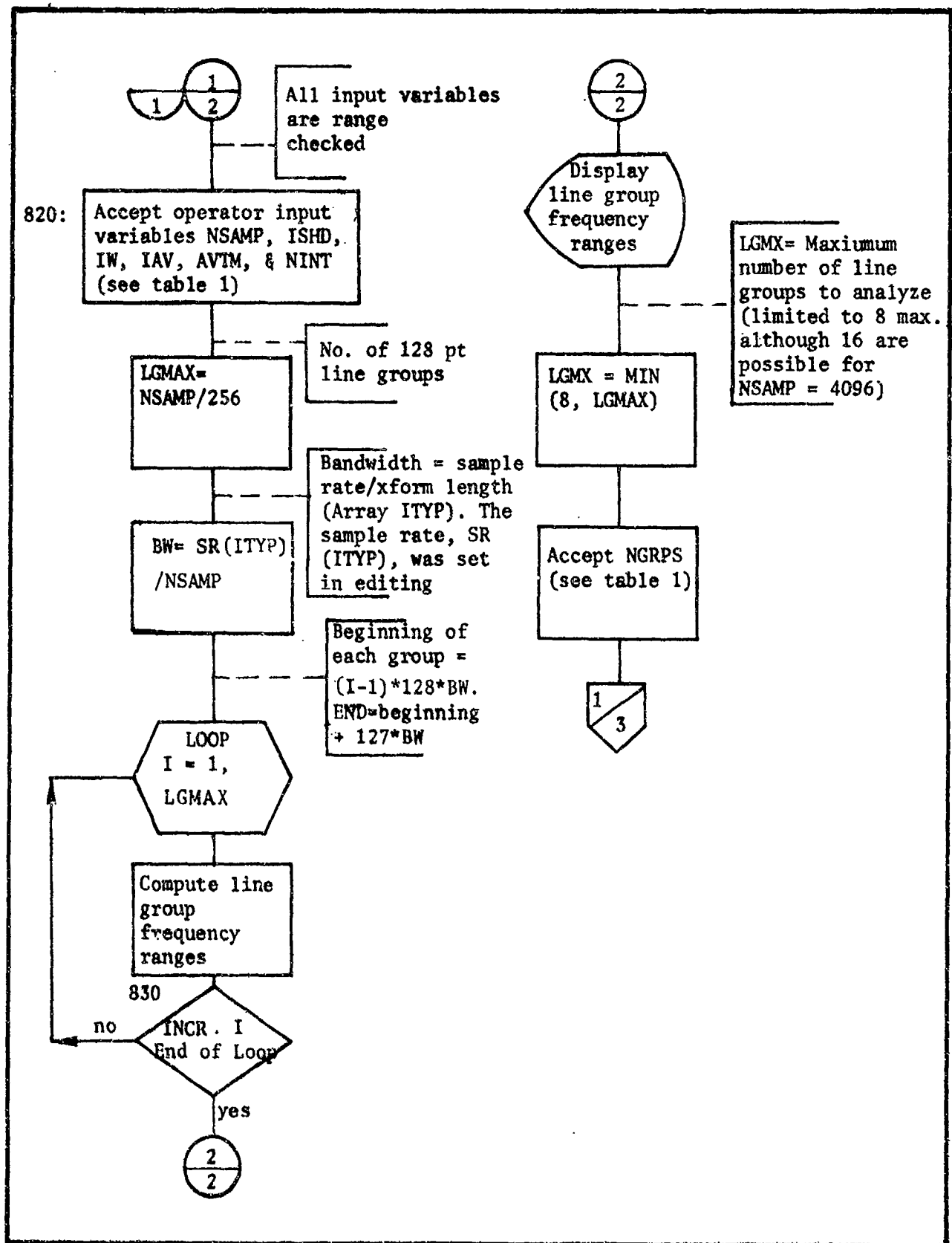


Figure 4.5.1-1 (U)

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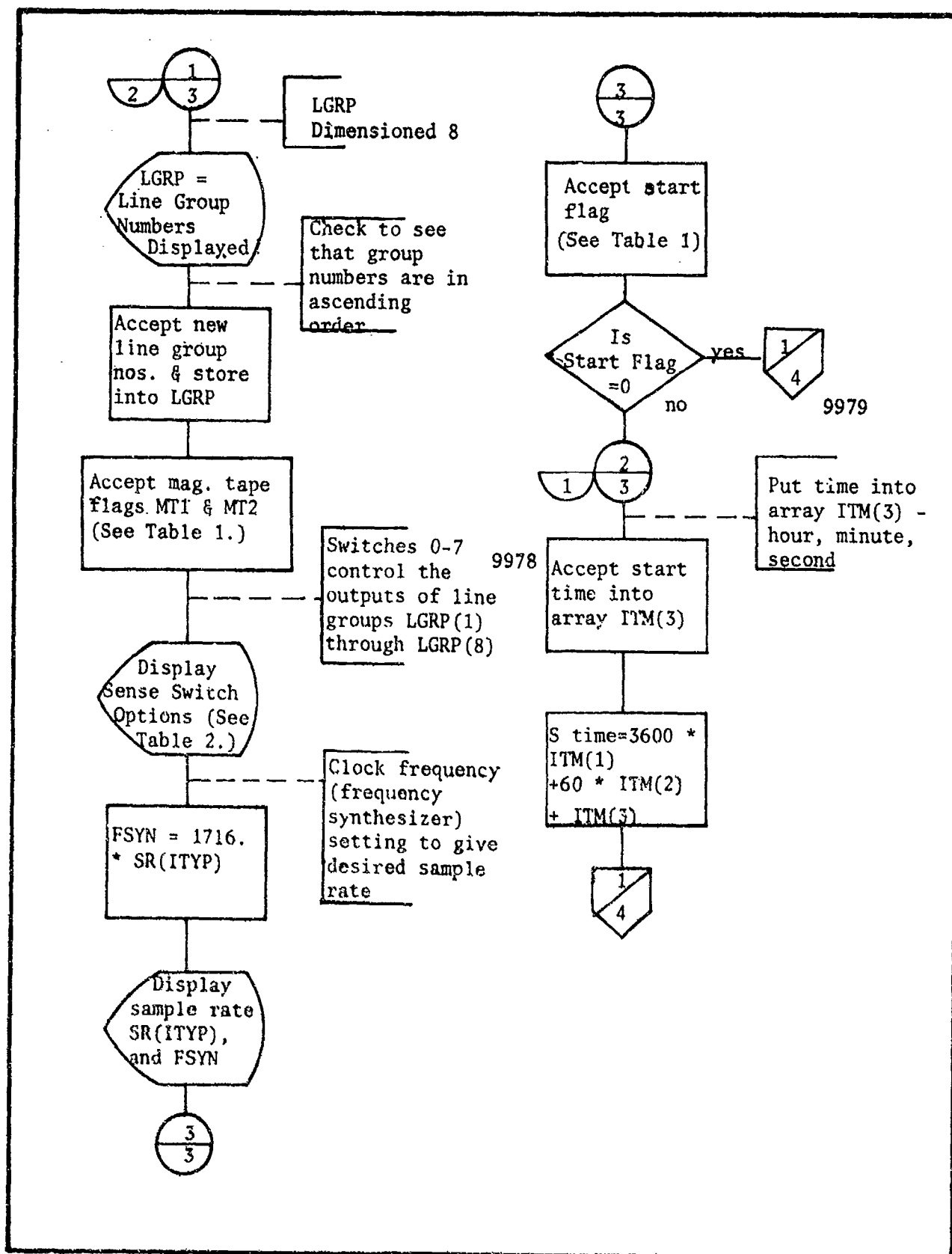


Figure 4.5.1-1 (U)

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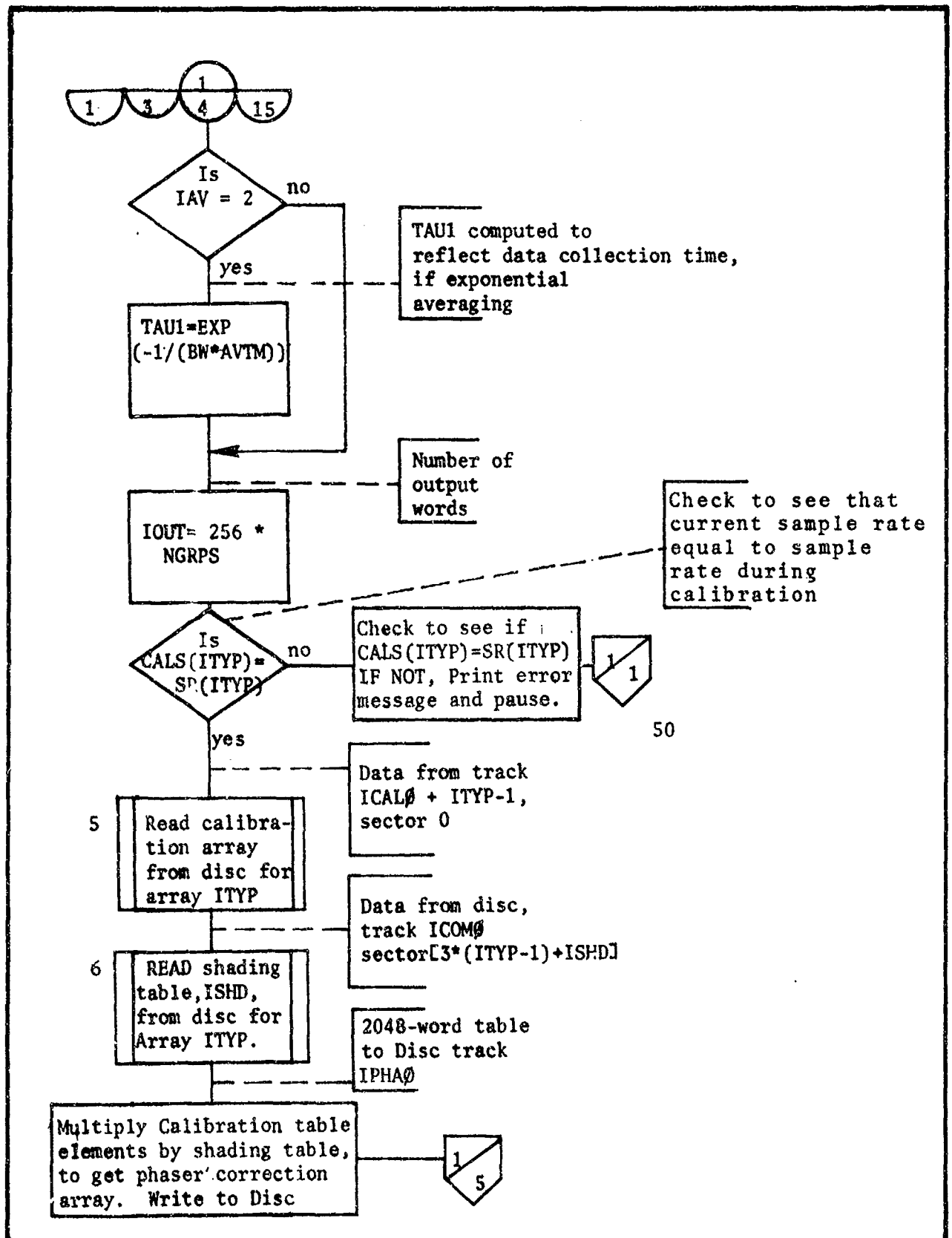


Figure 4.5.1-1 (U)

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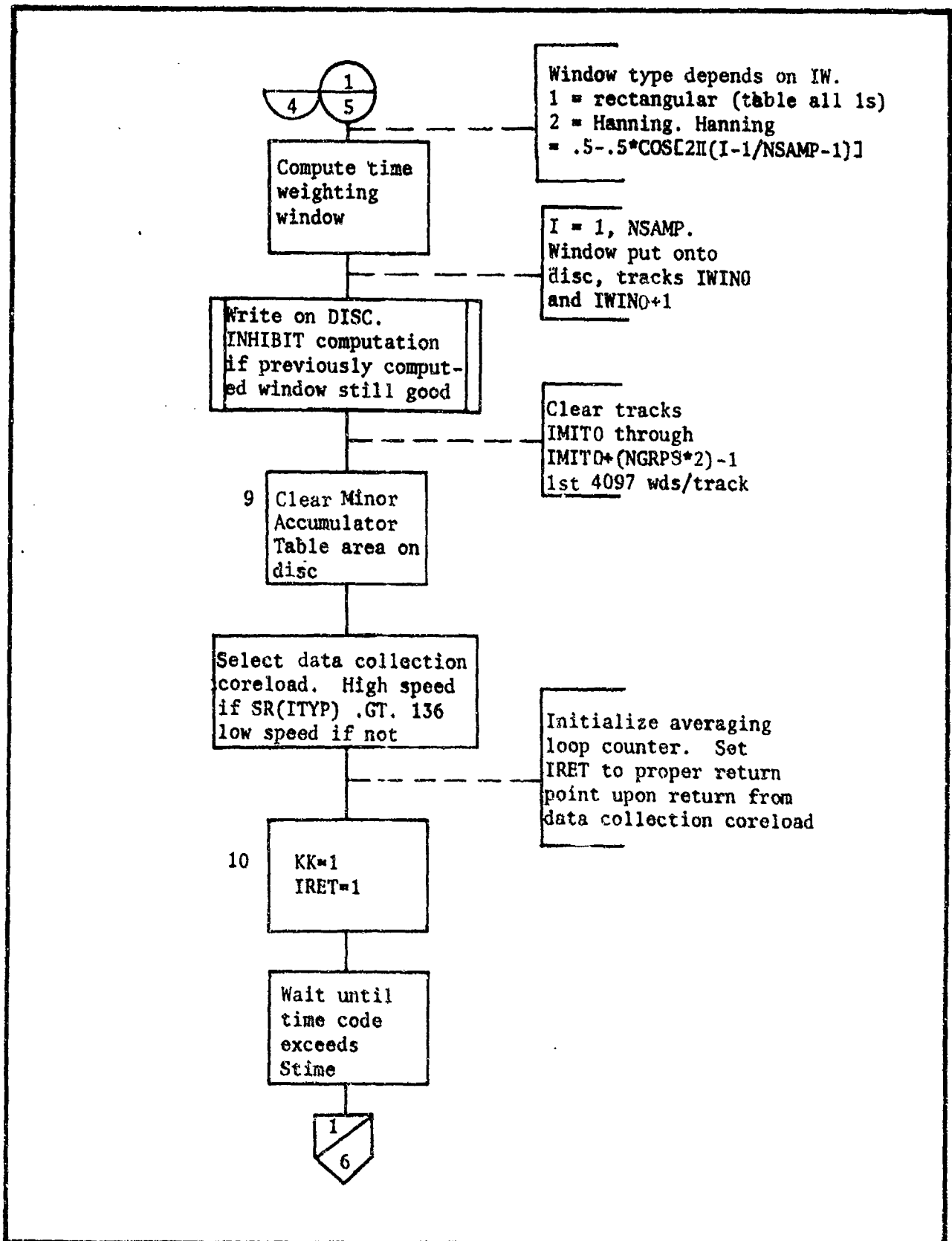


Figure 4.5.1-1 (U)

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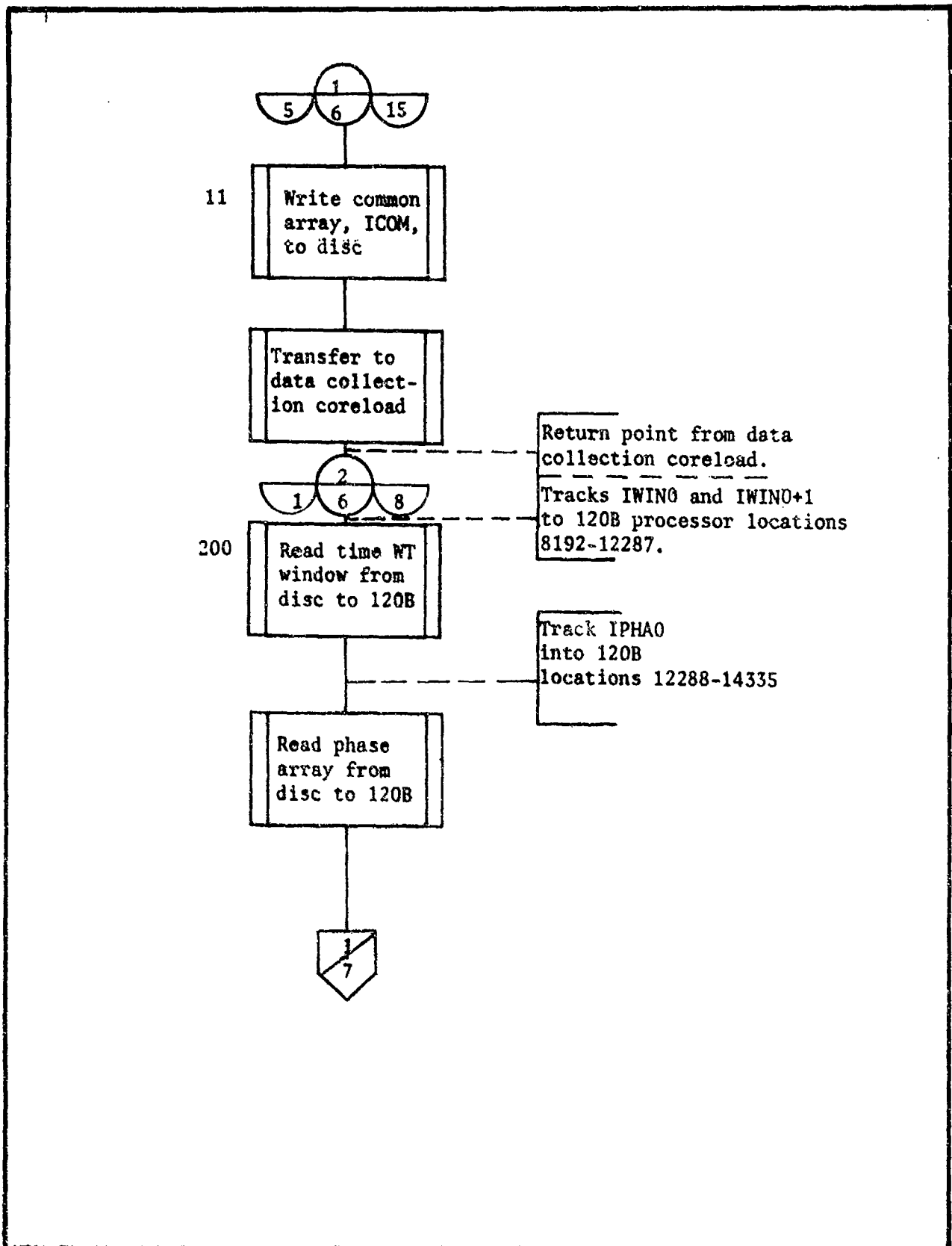


Figure 4.5.1.-1 (U)

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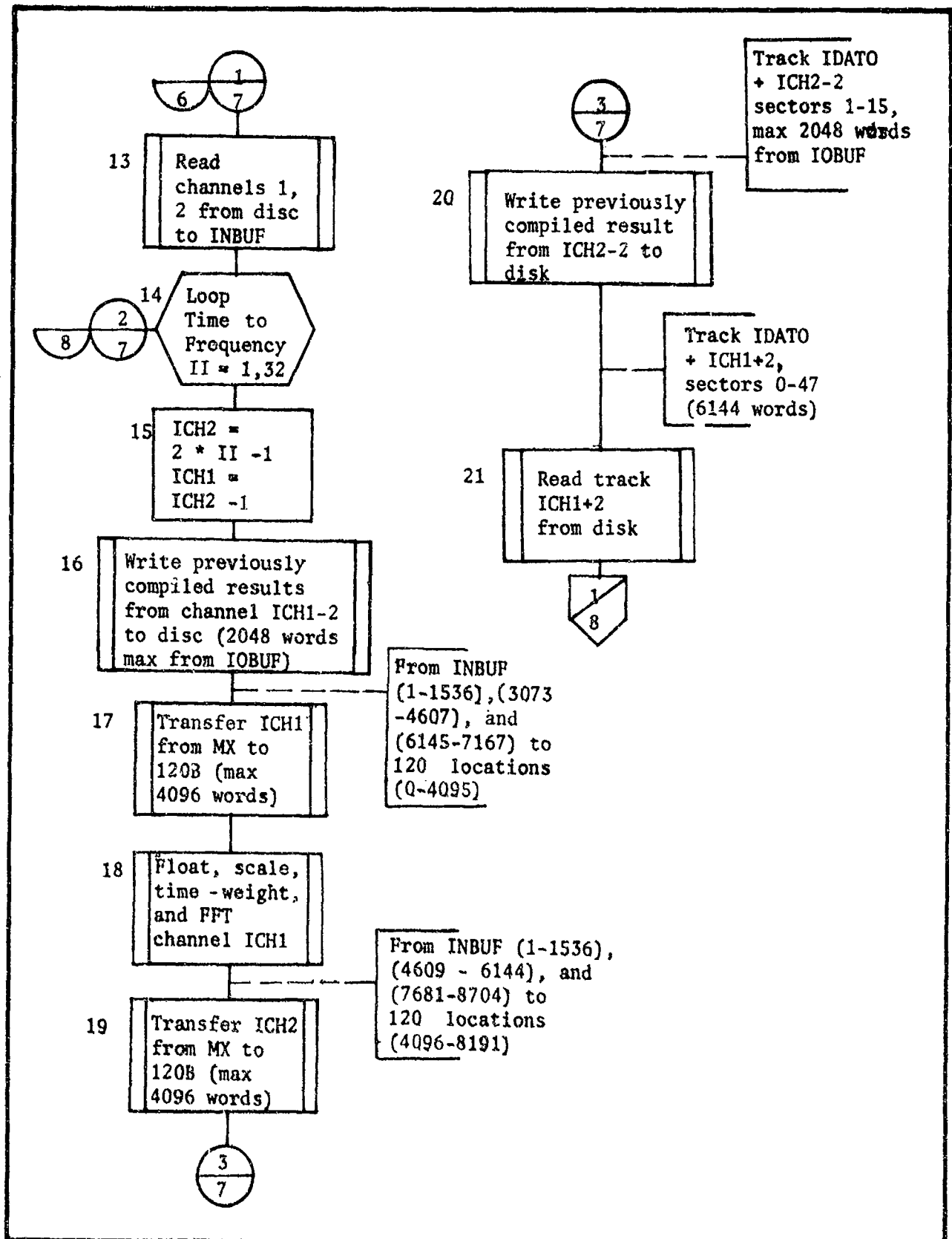


Figure 4.5.1-1 (U)

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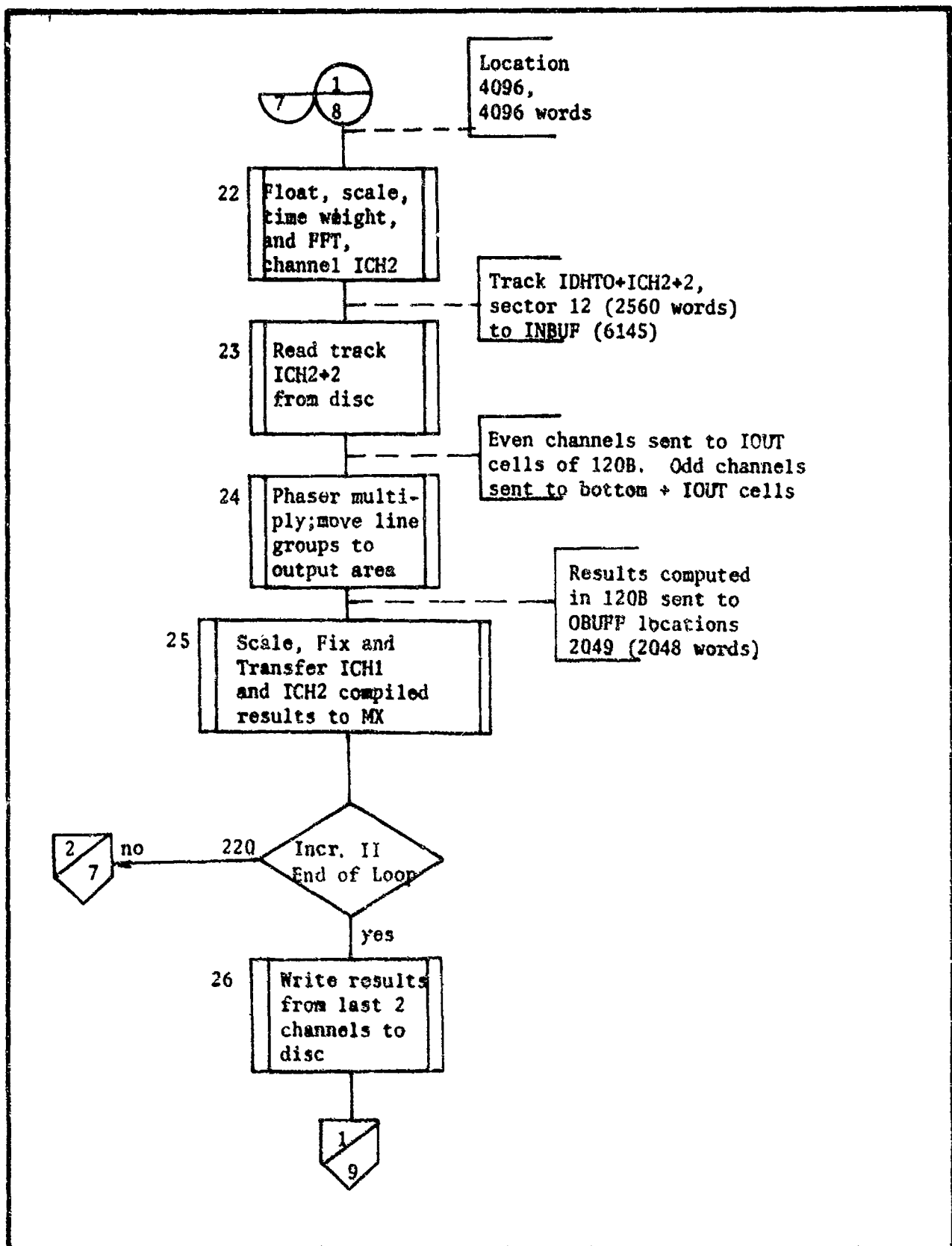


Figure 4.5.1-1 (U)

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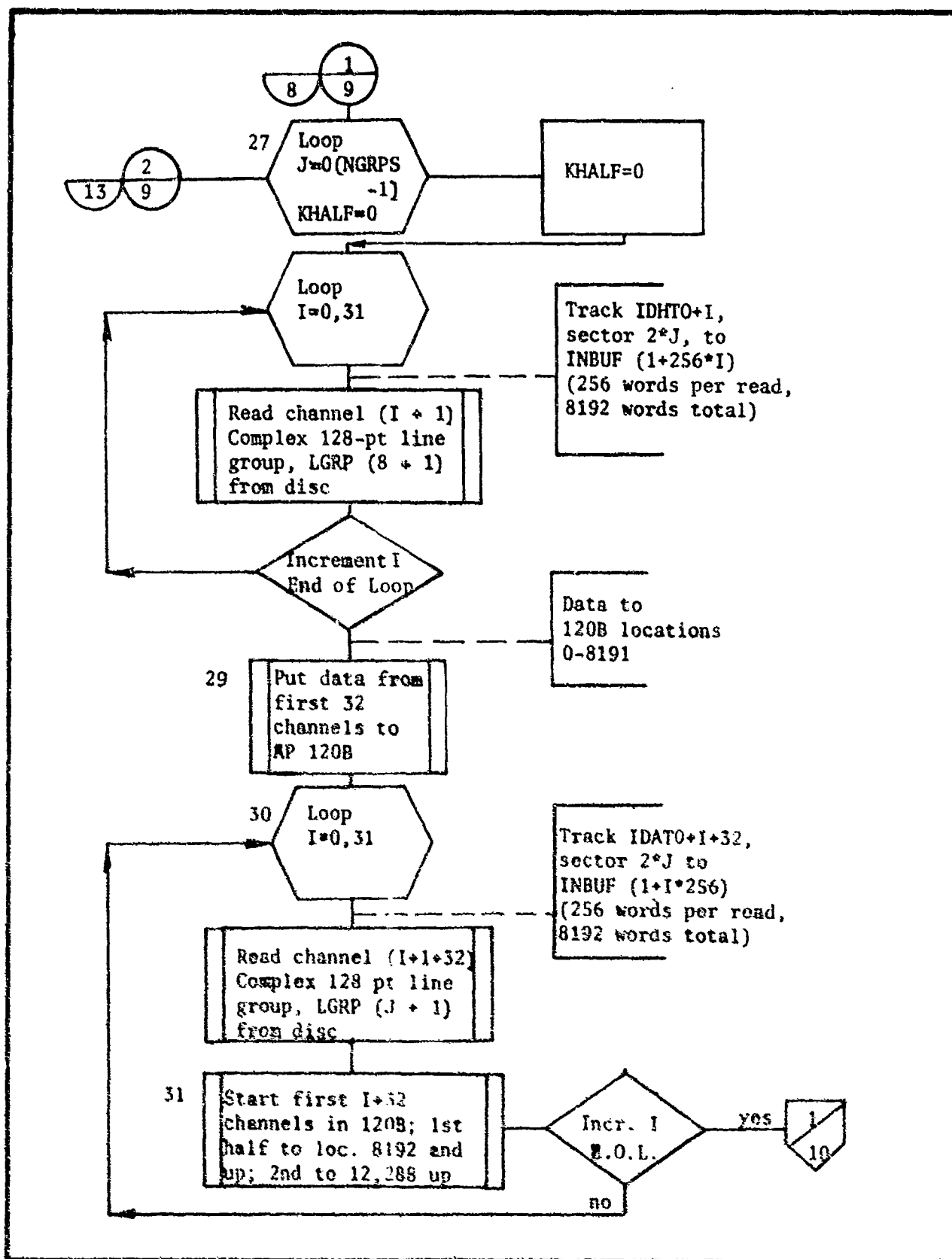


Figure 4.5.1-1 (U)

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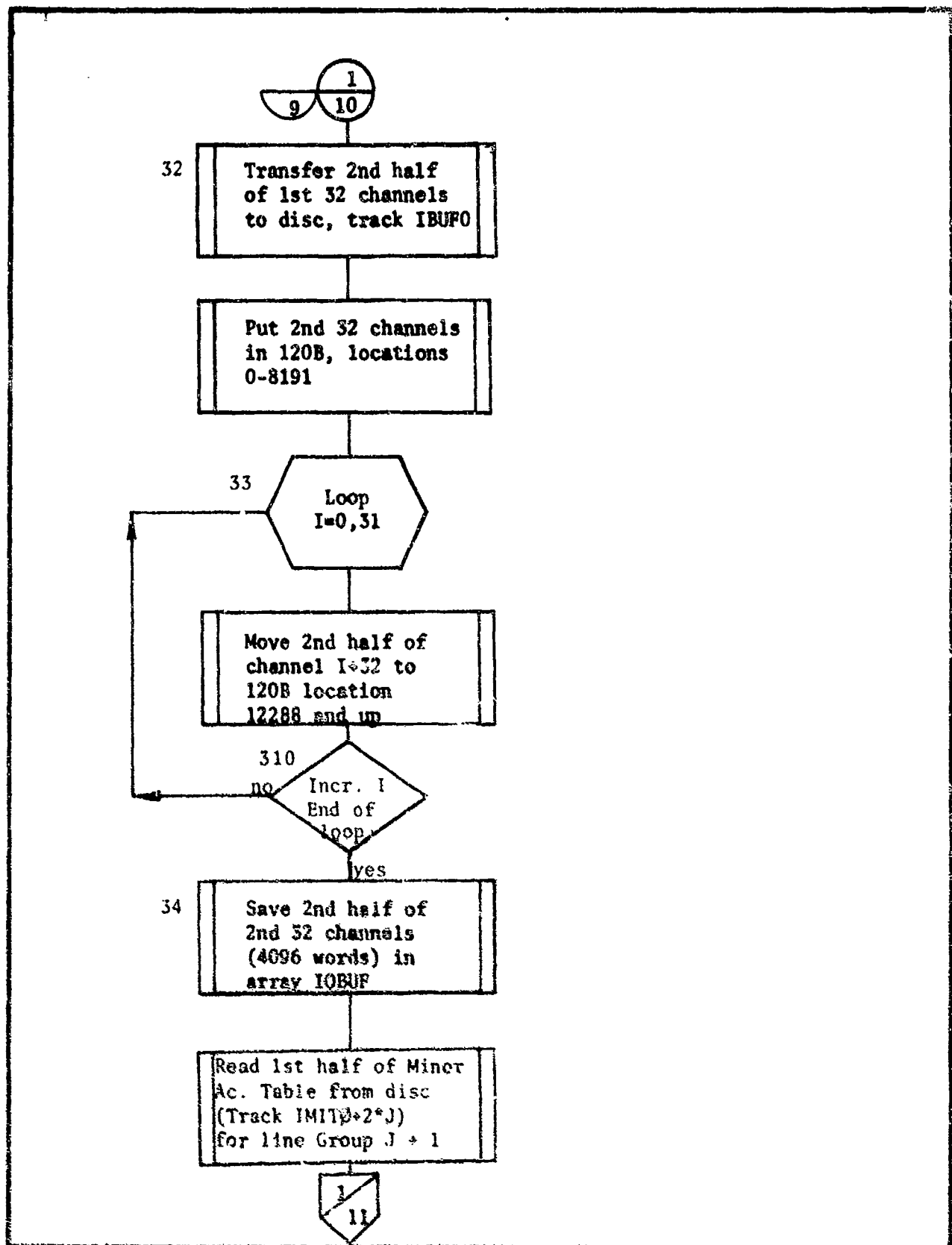


Figure 4.5.1-1 (U)

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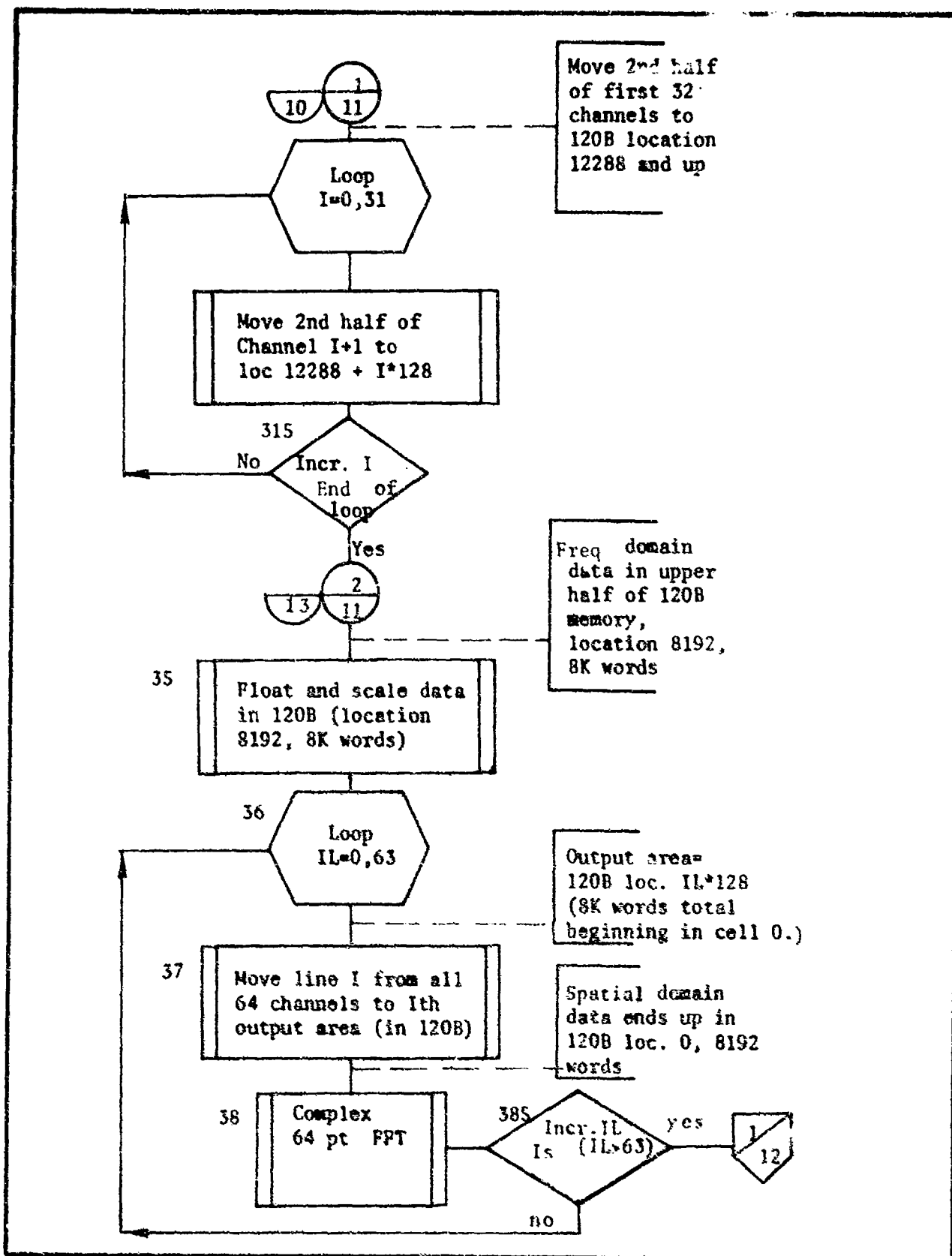


Figure 4.5.1-1 (U)

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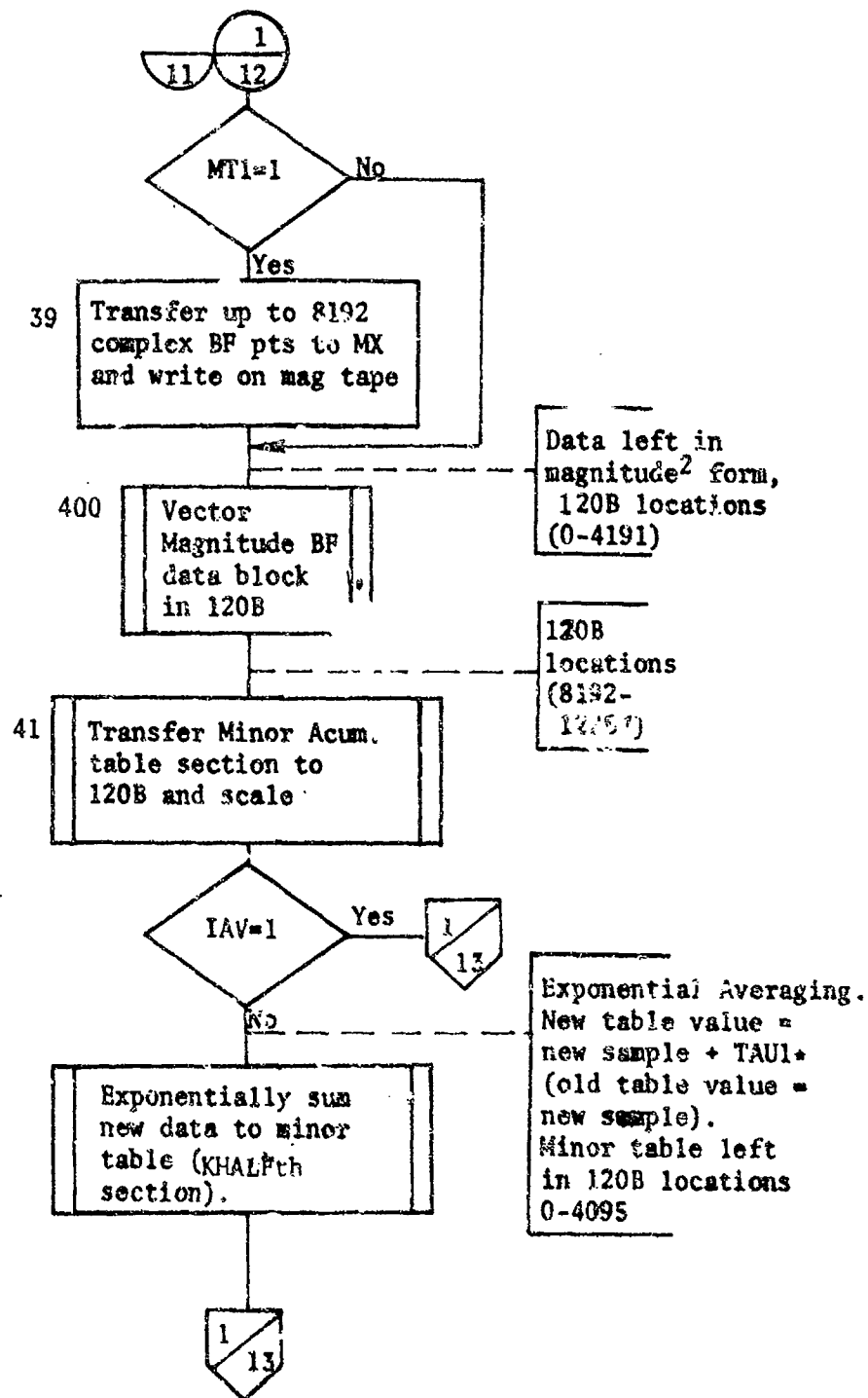


Figure 4.5.1-1 (U)

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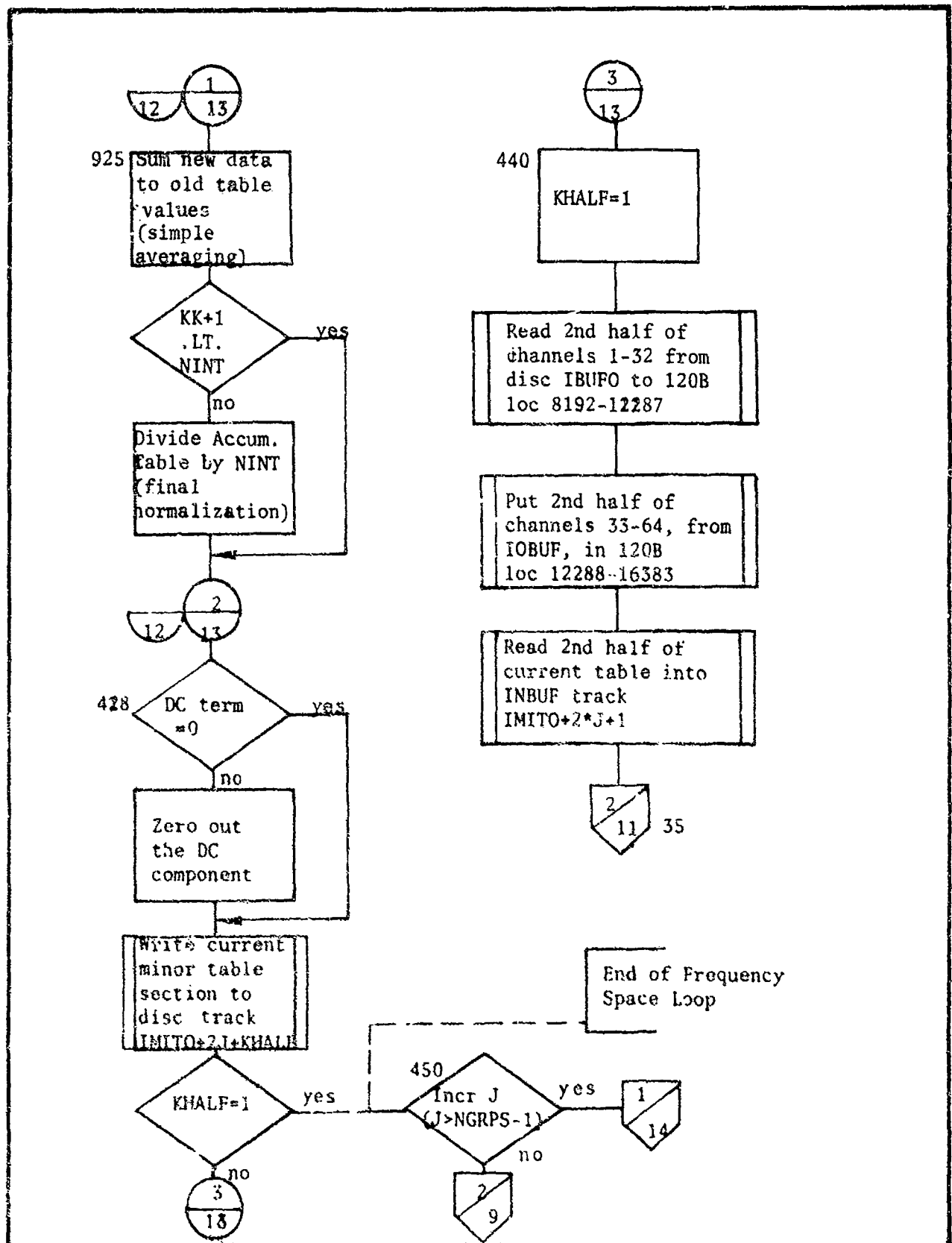


Figure 4.5.1-1 (U)

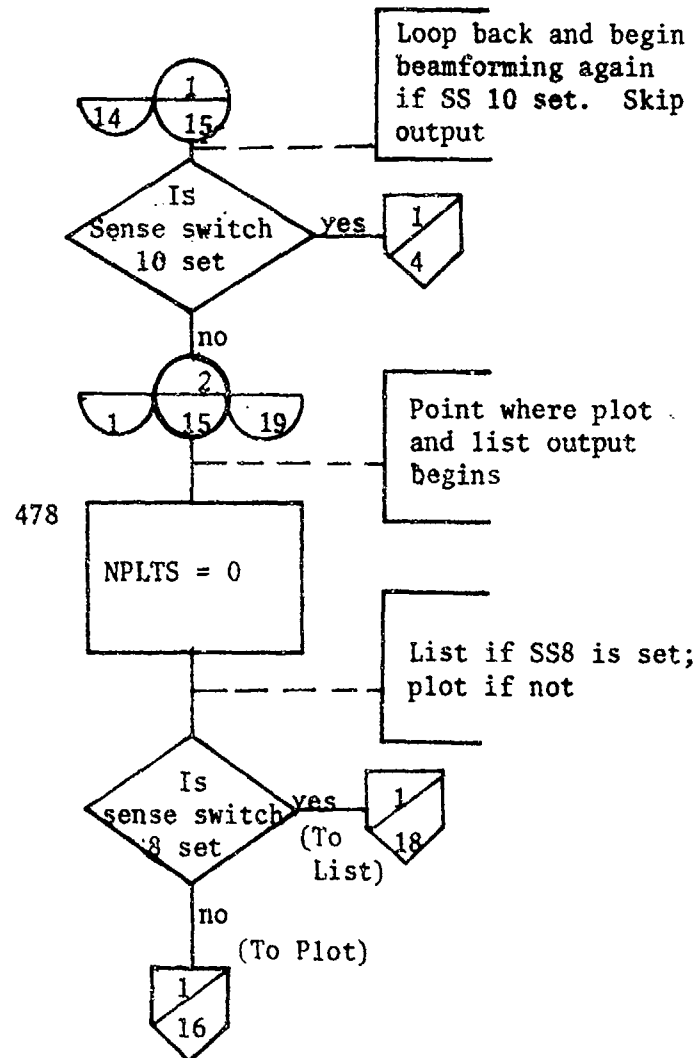
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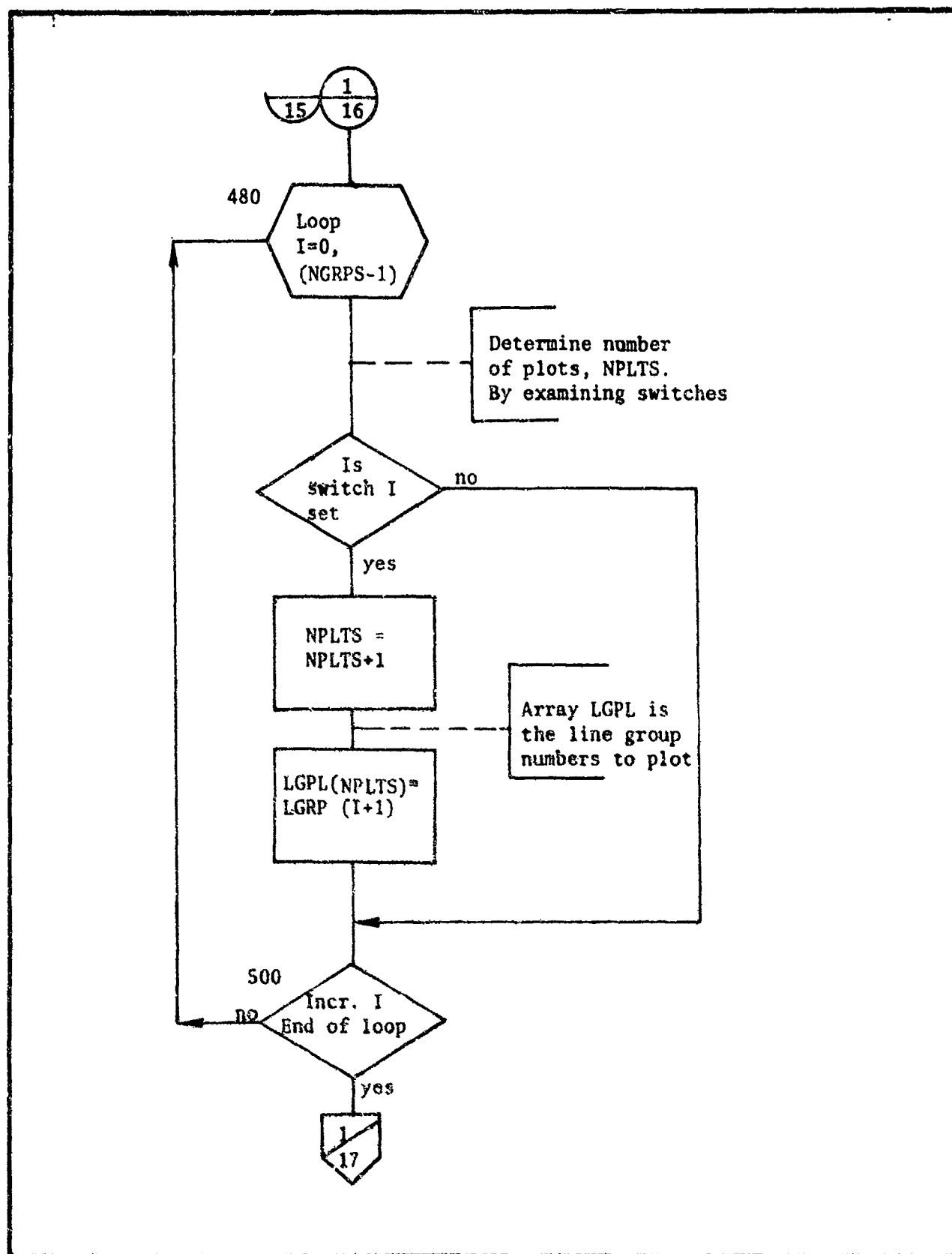


Figure 4.5.1-1 (U)

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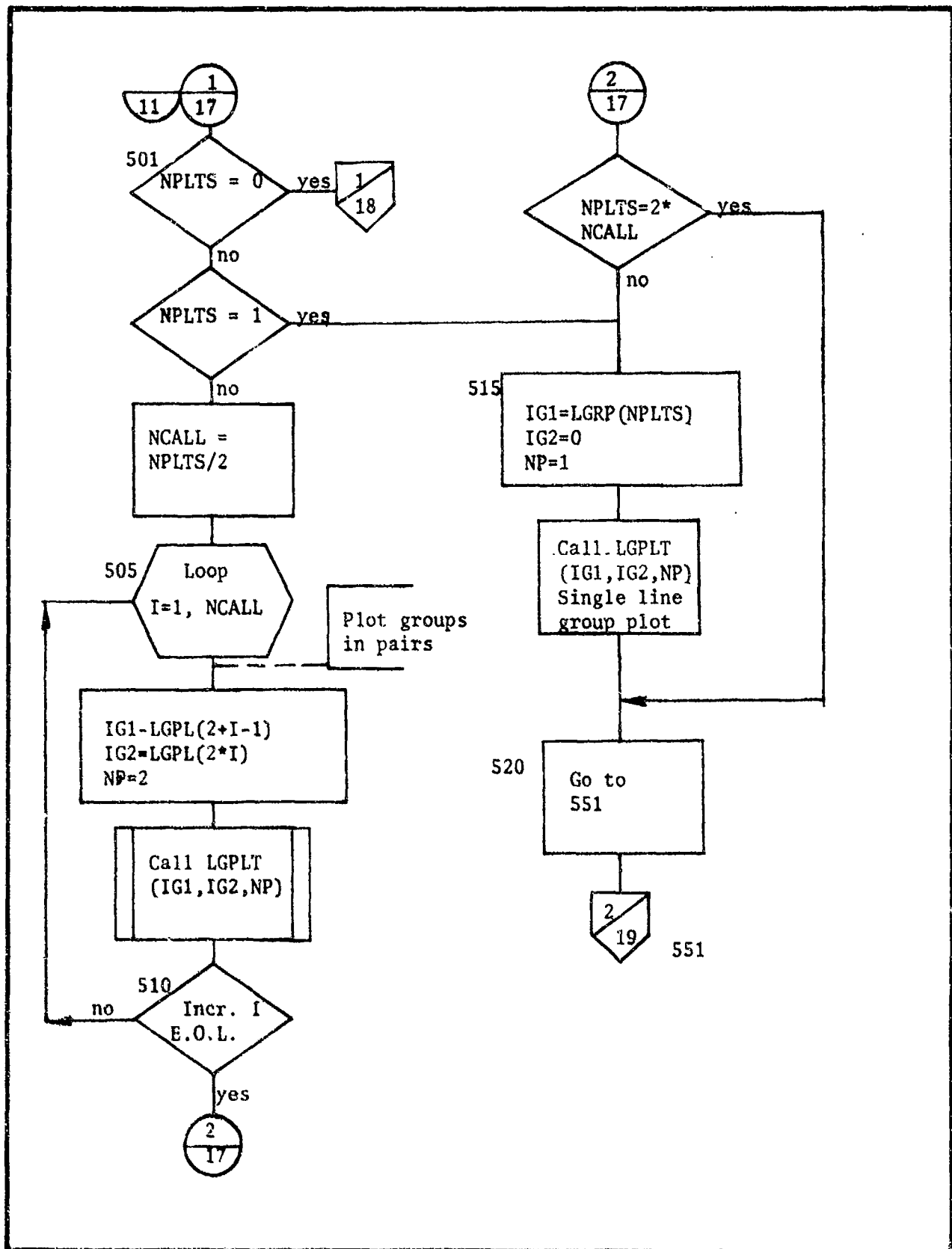


Figure 4.5.1-1 (U)

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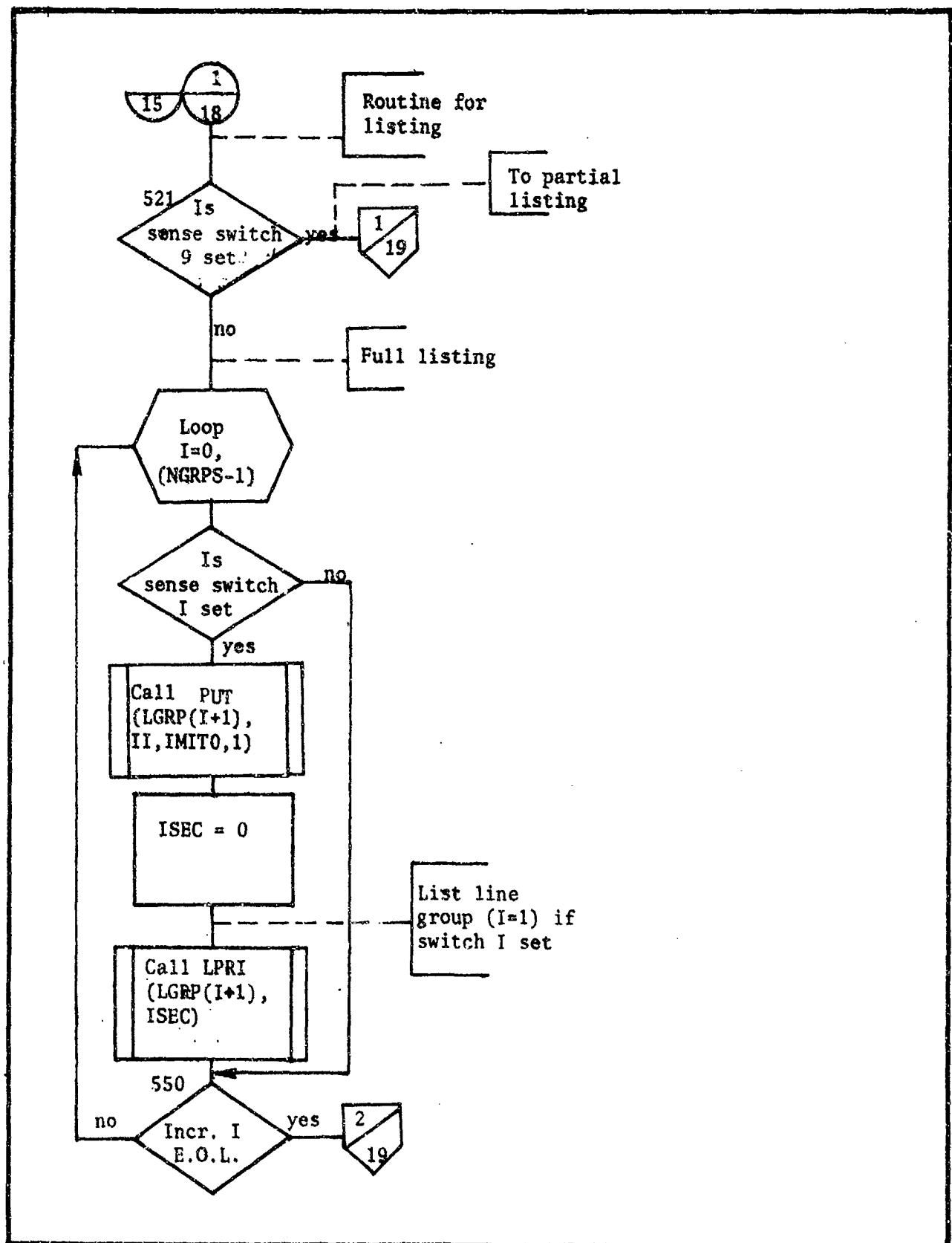


Figure 4.5.1-1 (U)

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BFORM Sheet 18 or 19

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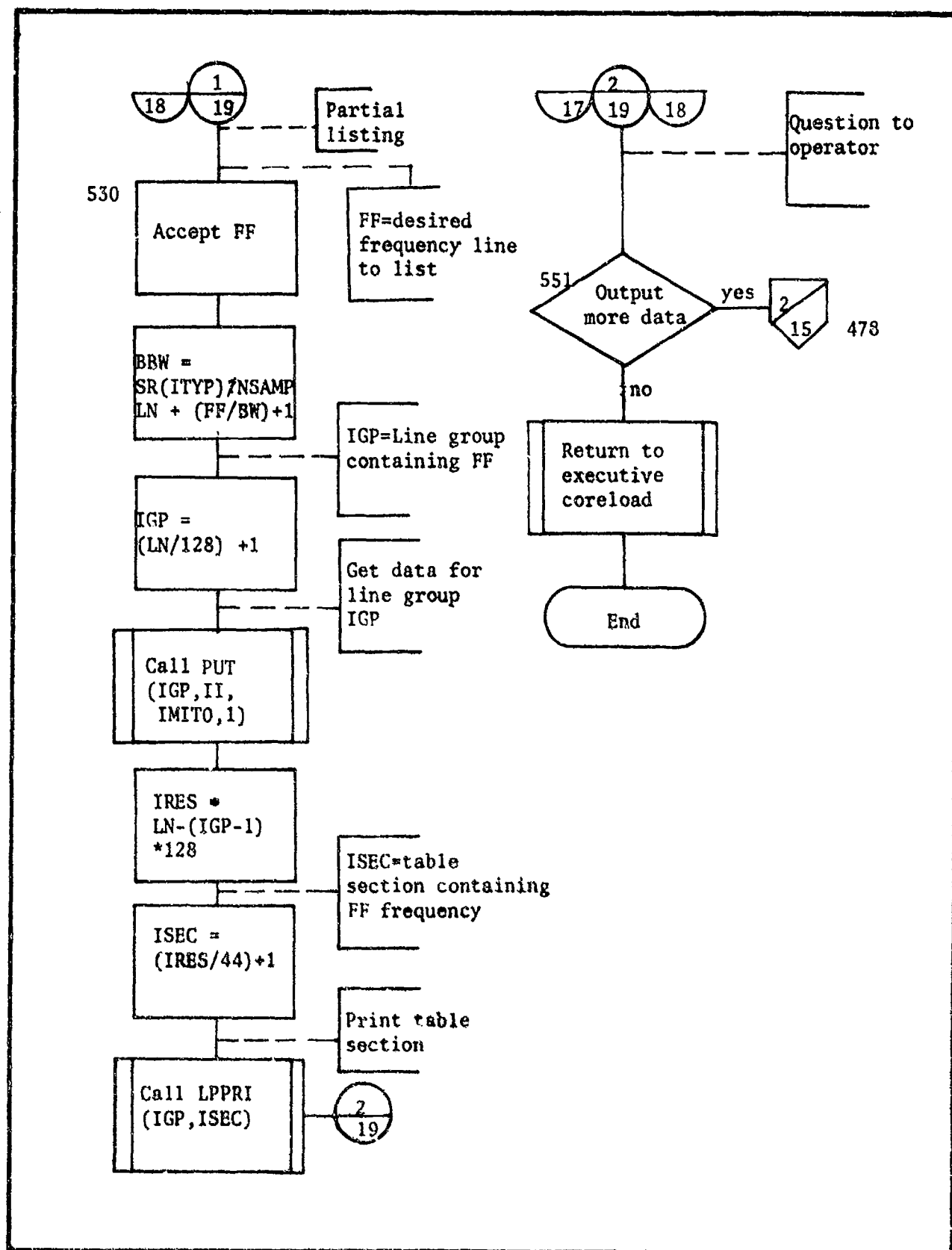


Figure 4.5.1-1 (U)

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PROGRAM: (U) CALIBRATION, CAL

4.5.2.

1. (U) FUNCTION. The Calibration Program performs automatic system self-calibration. A common signal is injected simultaneously into all channels and Fourier techniques are used to compute normalized channel-to-channel gain and phase response variances.
2. (U) CONSTRAINTS. N/A.
3. (U) CALLING SEQUENCE. The CAL Program is called by the Executive main program. When the operator selects the option, C, and enters a carriage return, CAL will be loaded and executed.
4. (U) DESCRIPTION OF INPUT. Specifications and options are queued, previous entries may be retained by carriage-return, and entered values are range-checked. Data obtained by the Collection program is retrieved from the disc from preassigned locations.
5. (U) DESCRIPTION OF OUTPUT. Partial or full printout of the normalized amplitude and phase and the reference channel data. The correction array is stored on disc.
6. (U) FILES USED. File names and sizes are: ACOR (2048), ICOM (128), IBLK1 (128), IBLK2 (128), IBLK3 (64), AWIN (32), BWIN (32), CWIN (32). These are arrays in the main memory. ACOR and ICOM are also on disc.
7. (U) ERRORS. Operator input selections are range-checked. An error will be indicated if the entry is outside the specified range.
8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A.
9. (U) DESCRIPTION OF PROCESSING. This is a moderately complex program which utilizes the AP-120B array processor. For detailed description of the process, study of the flow diagram, Figure 4.5.2-1, is recommended. The data collection program is loaded to collect data from the 64 channels, then a 32 point FFT is performed on the weighted data (window weighting may be a rectangular or Hanning). The normalized amplitude in Band phase with respect to a selected reference channel is printed. The correction array is the complex reciprocal of the rectangular representation of the unnormalized unskewed DFT analysis coefficients; it is saved on a disc for use by the Beamforming and Analysis program. Time of day is read from the system clock and saved on disc at the beginning of the program.

Subroutines used by CAL are listed in Table 4.5.2-1.

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TABLE 4.5.2-1 (U) SUBROUTINES CALLED BY CAL (CORELOAD 5) (U)

APCLR	A	Clear AP-120B hardware status (must precede all other calls to 120)
APGET	A	Transfer data to HP computer from AP-120B
APPUT	A	Transfer data from HP computer to AP-120B
APWAI	A	Wait for completion of AP-120B execution, then proceed
APWD	A	Wait for completion of data transfer to or from AP-120B, then proceed
APWR	A	Wait for completion of program execution by AP-120B, then proceed
CLHDR	B	Header for Calibration Program print-out
CLOAD	B	Read in specified coreload from disc and run
CVMUL	A	Complex vector multiply
CVRCI	A	Complex vector reciprocal
DISC	B	Read from, or write to, disc the vector specified
DWAIT	B	Wait for completion of last disc call before proceeding
D750	B	Wait 750 msec. (used following CRT screen erase command)
ENDIO	B	Used just before end of program for updating common disc files
IDISC	B	Initialize parameters for disc access (used at beginning of program)
INPT	B	Input an integer within specified limits, test against specifications
POLAR	A	Rectangular to polar conversion
RFFT	A	Fast Fourier transform (real)
TIME	B	Read current time of day and store hours, minutes and seconds
VADD	A	Vector add
VCLR	A	Vector clear
VDIV	A	Vector divide
VFLT	A	Vector float
VLOG	A	Vector logarithm (base 10)
VMOV	A	Vector move
VMUL	A	Vector multiply
VSMUL	A	Vector-scalar multiply

A AF-120B FORTRAN Callable Routine - see Math Library Manual (7288-02)

B Bunker Ramo Application Routine

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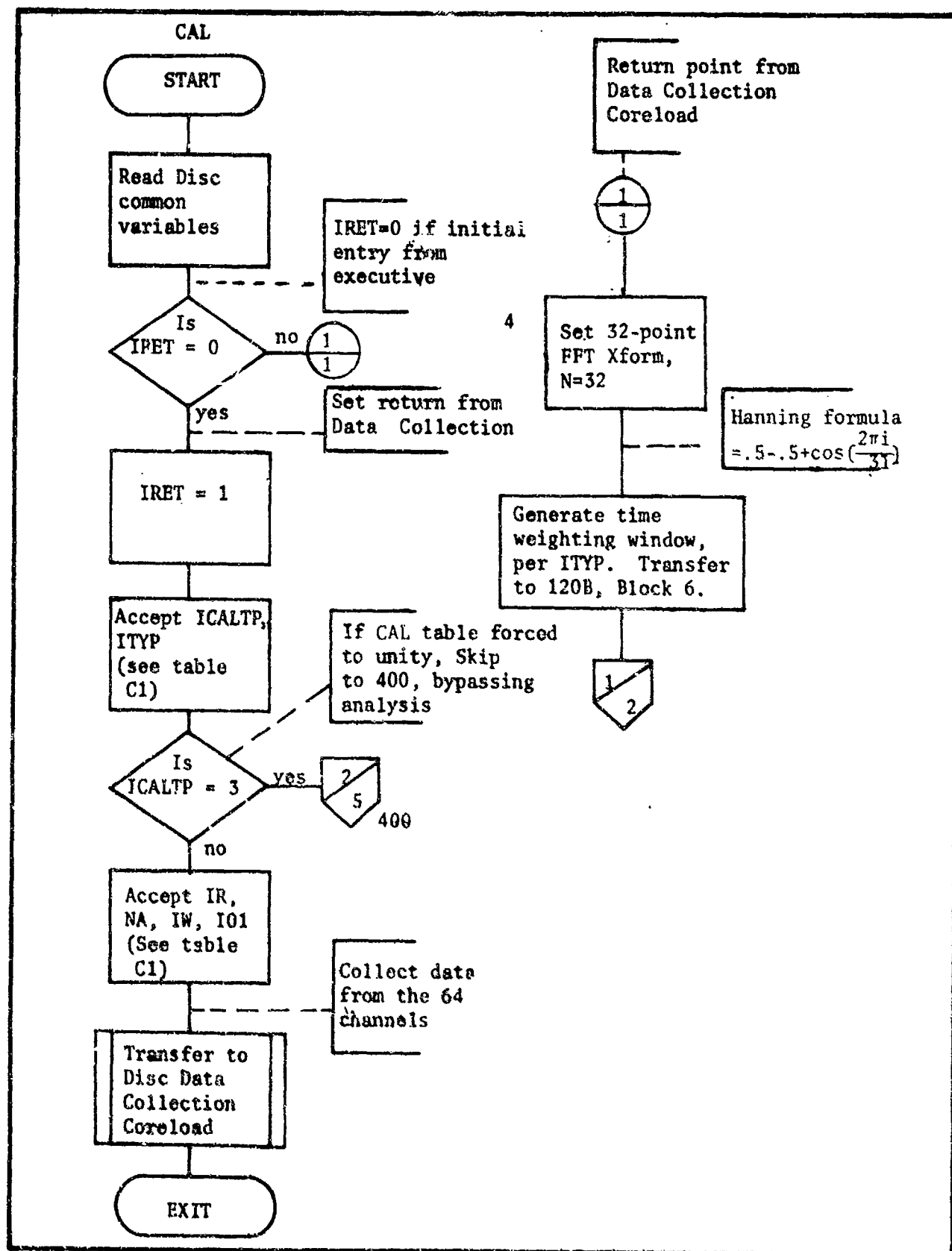


Figure 4.5.2-1 (U)

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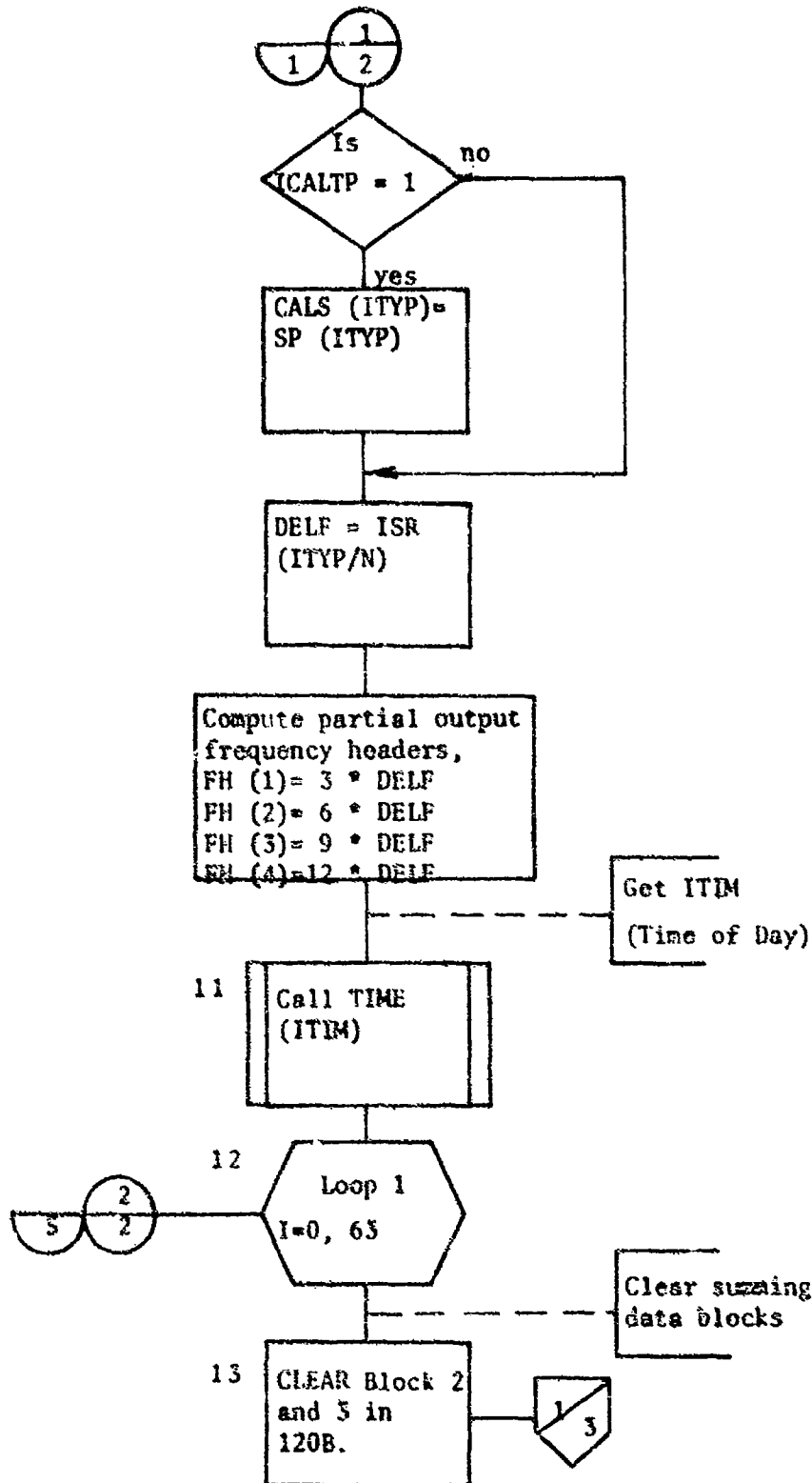


Figure 4.5.2-1 (U)

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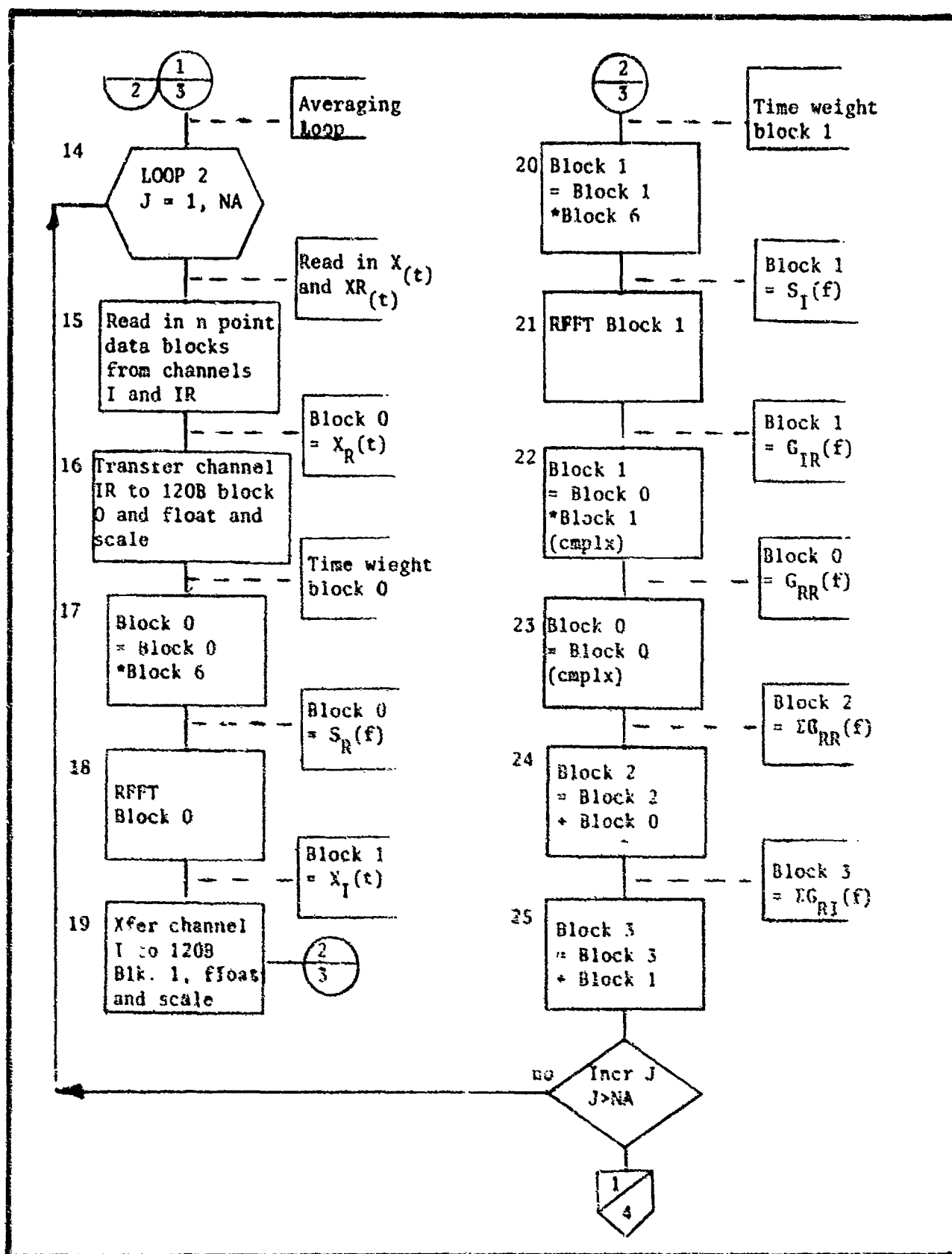


Figure 4.5.2-1 (U)

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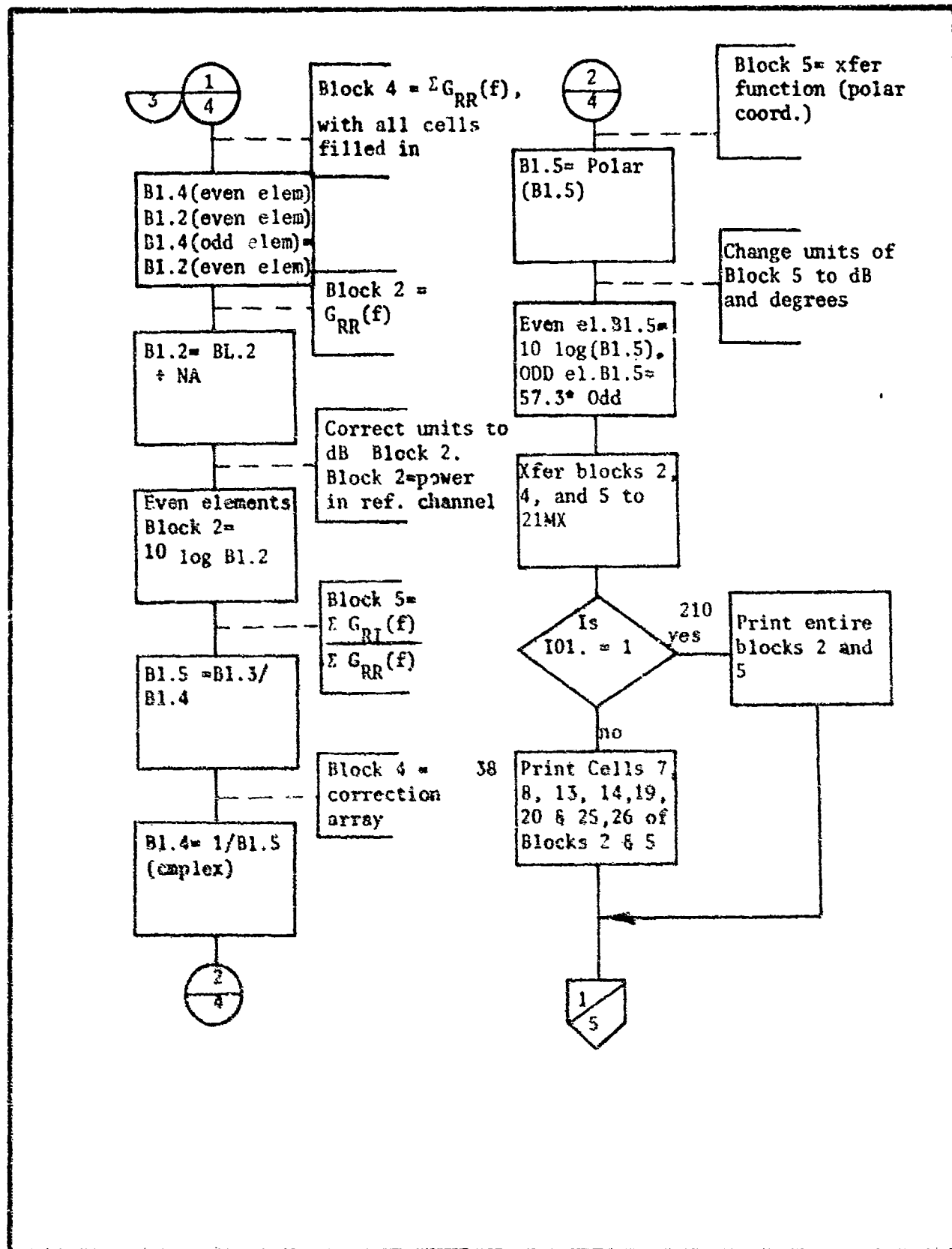


Figure 4.5.2-1 (U)

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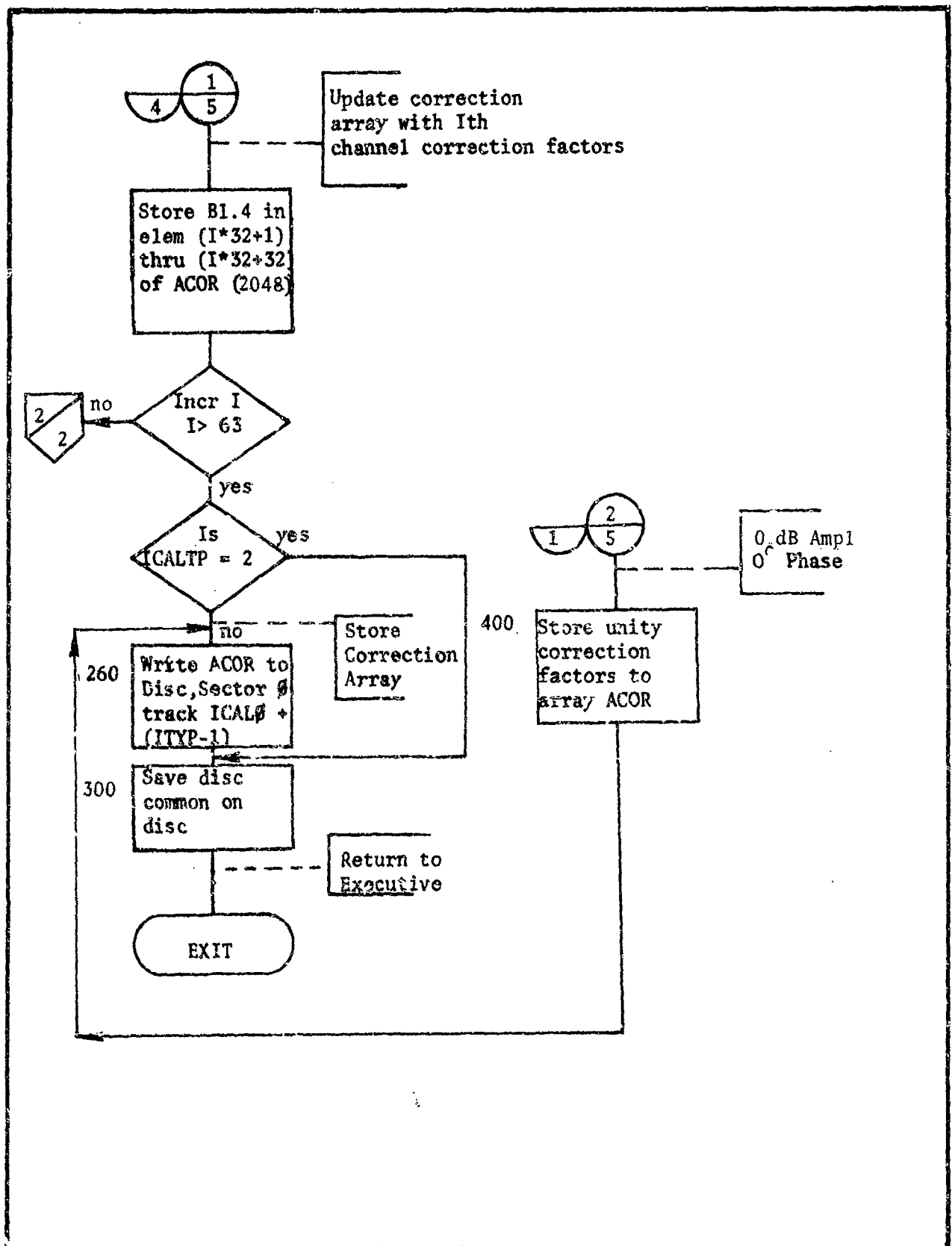


Figure 4.5.2-1 (U)

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PROGRAM: (U) TAP II EXECUTIVE, Y0000

4.5.3

1. (U) FUNCTION. Y0000 lists the operator options, inputs a single character command from the operator, and transfers control to the indicated coreload or subroutine.
2. (U) CONSTRAINTS. None
3. (U) CALLING SEQUENCE. N/A
4. (U) DESCRIPTION OF INPUTS. N/A
5. (U) DESCRIPTION OF OUTPUT. Y0000 sets IRET (a first time indicator on the disc common track) to zero.
6. (U) FILES USED. Sector 0 of the disc common track is read and modified as described above.
7. (U) ERRORS. None
8. (U) COMPUTER OPERATOR INSTRUCTIONS. See general system operating instructions.
9. (U) DESCRIPTION OF PROCESSING. Figure 4.5.3-1. Y0000 is entered directly from the bootstrap procedure. The program reads the disc common track (sector 0), clears IRET as an indication to programs called that they are being entered from the Executive, and writes the modified data back on the disc. The operator options are printed. The operator's response determines whether to read in another coreload or transfer control to a subroutine located within the Executive coreload. Coreloads accessed by Y0000 are 1 (beamforming) and 5 (calibration). Subroutines within the current coreload are PEDIT (parameter editing) and DSDAT (display stored data).

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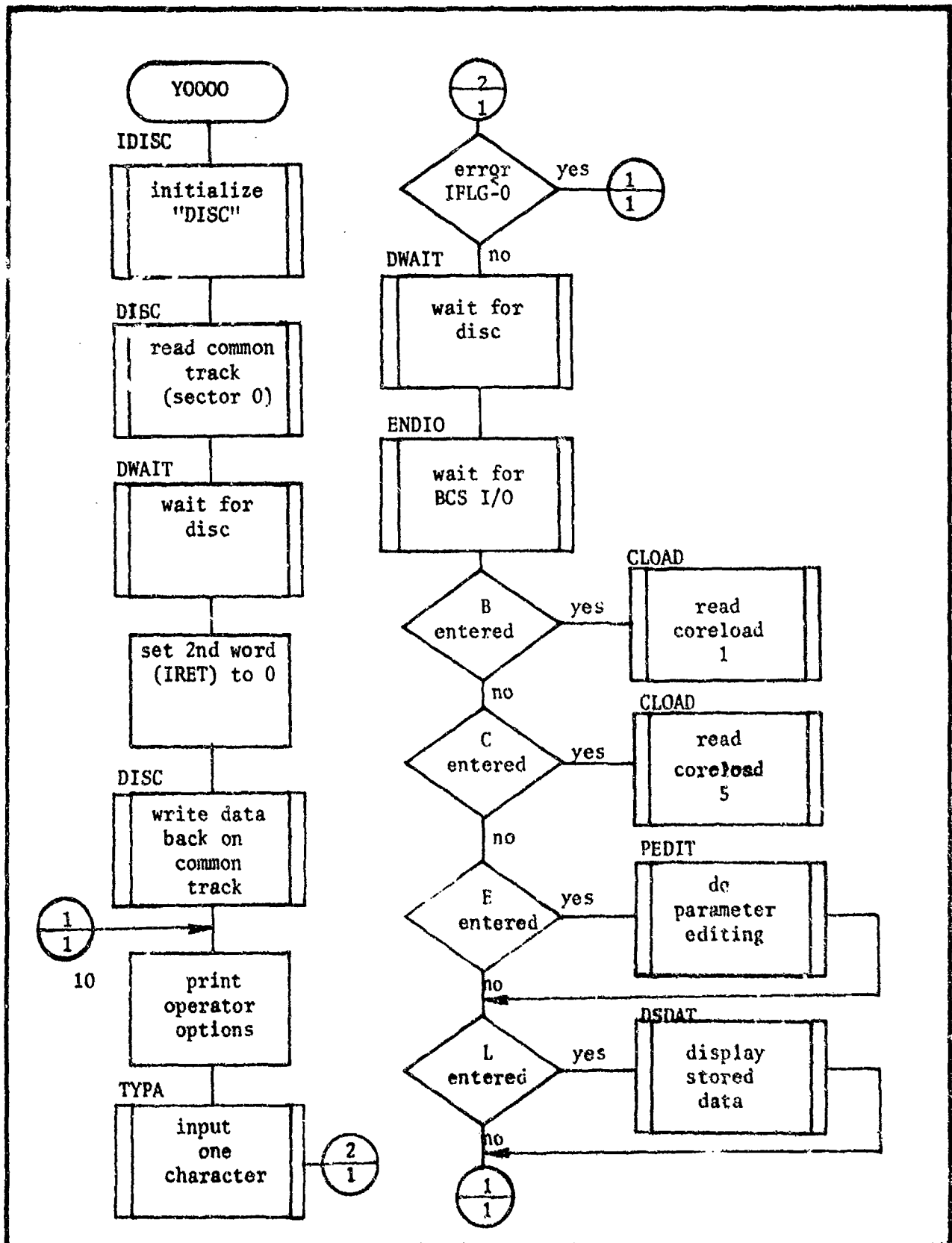


Figure 4.5.3-1 (U)

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PROGRAM: (U) DATA COLLECTION, Y0002

4.5.4

1. (U) FUNCTION. Y0002 collects, demultiplexes, and stores the Digital Controller data on the disc.
2. (U) CONSTRAINTS. The maximum sample rate is approximately 149 Hz and is limited by the disc access time. This is equivalent to a data rate (including header words) of 9834 Hz.
3. (U) CALLING SEQUENCE. N/A
4. (U) DESCRIPTION OF INPUT. See Figure 4.5.4-1 for description of Digital Controller input and method. The interface is always used in the no header mode.
5. (U) DESCRIPTION OF OUTPUT. All output is to the disc. See Figure 4.5.4-2 for format.
6. (U) FILES USED. The ICOMO track (sector 0) is used for number of samples (NSAMP) starting track of the next core load (IRCYL), and data decimation count (IDEC(ITYP)). Error codes are output to the display. See Table 2.7-1 Error Halts.
7. (U) ERRORS. None
8. (U) COMPUTER OPERATOR INSTRUCTIONS. See general system operation instructions.
9. (U) DESCRIPTION OF PROCESSING. Processing steps are keyed to the flowchart, Figure 4.5.4-3.

(1) The common track is read to obtain number of samples and the return program's starting cylinder. The number of samples is converted to the number of 128-word blocks (one sector), the two's complement of which is stored in BCTR. BLK, the number of the current block, is initialized to zero. BLK will be used to compute storage location for the disc.

(2) The control words for the interface and DMA are formed, so that there will be no time consumed in their computation at the start of each new DMA transfer. Part of the interface control word is the decimation count, which is taken from the common data read from the disc. There are three decimation counts, and the proper one must be used depending upon whether ITYP (also from the common track) is a 1, 2, or 3. Other control bits are the start bit (5) and the eliminate header word bit (4). The header is not input to allow two additional word times between DMA transfers to switch buffers and set up DMA for the next transfer.

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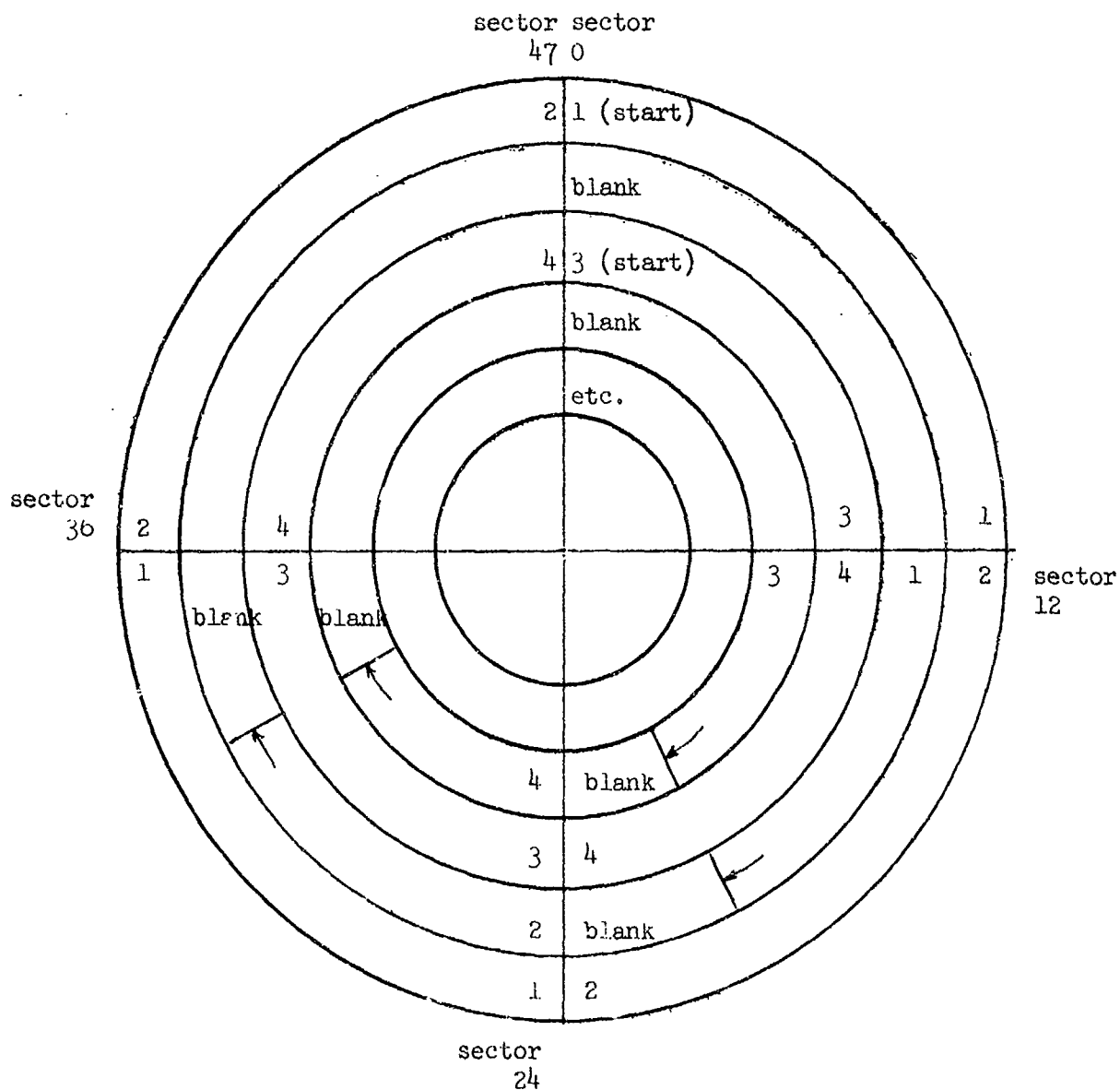
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2216	major frame sync word
time	4 bit BCD code: minutes, 10 seconds, seconds
channel 1	} 64 12-bit 2's complement samples (bits 15-12 are tied to bit 11)
channel 2	
channel 3	
channel 64	
2217	minor frame sync word
time	4 bit BCD code: 10 hours, hours, 10 minutes
channel 1	
channel 2	
channel 3	
channel 64	
2217	minor frame sync word
status	front panel status switches
channel 1	
channel 2	
channel 3	
channel 64	
2215	major frame sync word
etc.	
	Control bits to interface:
	bits 3-0 specify no. of minor frames to skip (decimation)
	bit 4, when set true starts input at first word of major frame
	bit 5, when set true suppresses header words (2 per minor frame)

Figure 4.5.4-1 (U) Digital Controller Input Format

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- NOTES:
1. The numbers within the circles represent channel numbers.
 2. One circle represents one complete disc rotation. Sector 24 lies directly over sector 0 (different head but no head repositioning).

Figure 4.5.4-2 (U) Low Speed Disc Data Format (Time Domain Format)

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(3) It has been found that after core loading, there is an unprocessed DMA interrupt request which will cause trouble the first time interrupts are enabled. Processing at (3) takes care of this by storing a NOP at location 6 (the DMA 6 trap cell), enabling interrupts, waiting a few microseconds, then disabling interrupts again. During this time, the interrupt will occur and be processed (by the NOP). The input buffer pointers are switched to set them up properly for the initial transfer. A JSB BFIT through a base page link is set up in the DMA 6 trap cell (location 6) so that control will be transferred to location BFIT at the completion of an input DMA transfer. It was necessary to make the link instruction (the JSB) a separate program module so that it will reference BFIT through a base page link. An undesirable feature of using the cross loader is that sometimes it generates current page links for external references. It is therefore essential that the link instruction (program module LINK6) be forced to be loaded in a different page than the main program, so that a base page link is generated by the loader. No interrupt should be created by the interface, so a HLT 30 is stored in its trap cell to stop the program if this occurs.

(4) The data input is started. BFIN, the subroutine which does this, returns control as soon as the DMA transfer is initiated.

(5) A delay of 13 seconds is started. If the end of this delay is reached, the input data was not received in the time required at the lowest sample rate, and this is an error. Normally, an interrupt will occur which will transfer control to BFIT as discussed earlier. BFIT will return control to the "done" exit of BFIN, which will transfer control to location BFDUN, at (6).

(6) The input buffer pointers are switched. BCTR is incremented and if not zero, BFIN is called again to start the next 8192 words of input. If BCTR is zero, BFHLT is called to stop input. In either case, remembering that BFIN returns control immediately, interrupts are turned off and demultiplexing (formatting) begins.

(7) Formatting, beginning at (7), places 128 words of each channel on the disc at different locations. 128 words was chosen because it is one disc sector and the smallest amount of data which can be written. 128 words each of 64 channels is 8192 words, which is the number of words in the input buffer, and the reason for that number being chosen.

(8) Two channels (sectors) are written per track, on alternate tracks, so that the time for writing all 64 channels (rotational delay plus head movement delay) will be less than the time required for the next 8192 words to be read in. The disc format was also chosen so that contiguous blocks of any given channel would be as long as possible (12 sectors) within the constraints of storage time.

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(9) After all 128 words of any given channel are picked out of the input buffer and stored in the output buffer, the track and sector corresponding to that channel (FMTB) and block (sequence number : BLK) are computed. The track which is computed has a base of 0, whereas the actual disc cylinder which will be used has a base of FTUD+IDATO, parameters which are set up in the track allocation table (program module TAT) prior to load time. Therefore, these two numbers are added in. The 128 words are written onto the appropriate sector by calling WDISC.

(10) The channel number (FMTB) and counter (FBCTR) are incremented. If the latter is not zero, all 64 channels have not been done, so control is returned to (8) to continue. Otherwise, block (BLK) is incremented (because storage will be on the next sector the next time). A check is made on whether the input DMA completion interrupt is waiting (by checking for flag set). If it is, the formatting and writing process took too long and consequently sync has been lost, so an error exit is taken. Otherwise, interrupts are turned on. BCTR is checked. If non-zero, control is transferred back to (5) to wait for input completion. If BCTR is zero, all requested data has been collected and the interface has already been turned off. The beamforming program core load is read back in.

(11) Subroutine WDISC writes data as a sequential access file on the disc. It assumes that TRAK, SECT, and HEADB are set to specify the starting location on the disc. HEADB will always show the lower head for the disc in use; SECT varies from 0-47 to cover both surfaces. WDISC sets the core address and count into WPTR and WCTR from the calling parameters. At WDIS1 it computes AA, the number of words to be written on the current track. This will be the minimum of WCTR or the number of words remaining on the track. WRITD is called and will write AA words starting at TRAK and SECT. Next, SECT is updated. Since all write requests must be a multiple of 128 words (one sector), all that is required is to add AA/128 to SECT. If AA/128 is not an integer, an error path is taken. If the result is 48, SECT is reset to zero and TRAK is incremented by one. SECT+AA/128 will not be greater than 48 because AA was chosen to write only to the end of the current track. If TRAK is updated, it is compared to 202. If greater, storage has been exceeded and an error exit is taken. At WDIS2, WPTR and WCTR are updated by the number of words written, AA. If WCTR is non-zero, all data has not been written and control is transferred to WDIS1 to update AA and write additional data. This continues until WCTR is zero and then control is returned to the caller. Upon return, TRAK, SECT, and HEADB are properly set to continue writing from the point at which writing was discontinued. Program Y0002 does not use WDISC in the sequential access mode, but instead sets TRAK and SECT each time before calling WDISC.

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(12) WRITD, called by WDISC, first converts SECT (range 0-47) and HEADB to HDSEC, the control word for head and sector which uses sector in the range 0-23. The conversion consists of using head and sector as is, if sector is less than 24, and if otherwise, head plus one and sector less 24. This is then shifted into the bit positions used by the disc controller. DMA is set up to write AA words starting at the location in WPTR. The remainder of the disc processing is as specified in the disc interface manual except that DMA 7 is used. DMA 7 is used because DMA 6 is in use for input during disc output. If status following the write is bad, an error path is taken.

(13) Subroutine BFIN starts Digital Controller input. DMA 6 is initialized for input of the number of words given in the calling sequence, the interface is enabled, DMA is started, and the Digital Controller is started by outputting a control word containing bit 5 equal to 1. This order of events is important, as otherwise the input does not dependably start with channel 1. Other bits contained in the control word are bit 4 to disable the header, and bits 3-0 which specify the decimation. This control word was set up by the calling program in location BCW. Once input is started, control is returned to the caller. One of the calling parameters is the location to which control is to be transferred when input is complete. The immediate return to the caller is what allows the double buffering of input. As there are only about 101 microseconds between input words at the maximum data rate, and it is essential not to miss any, it would otherwise not be possible to do the formatting and output between BFIN calls. As it is, there is just enough time after a completion interrupt to start the next input request before the next word arrives.

The maximum data rate for this program is approximately 9834 Hz, which corresponds to a sample rate of 149 Hz. The limiting factor on speed in this program is the time required for disc access. The formatting time is brief enough to allow two channels to be written in every disc rotation.

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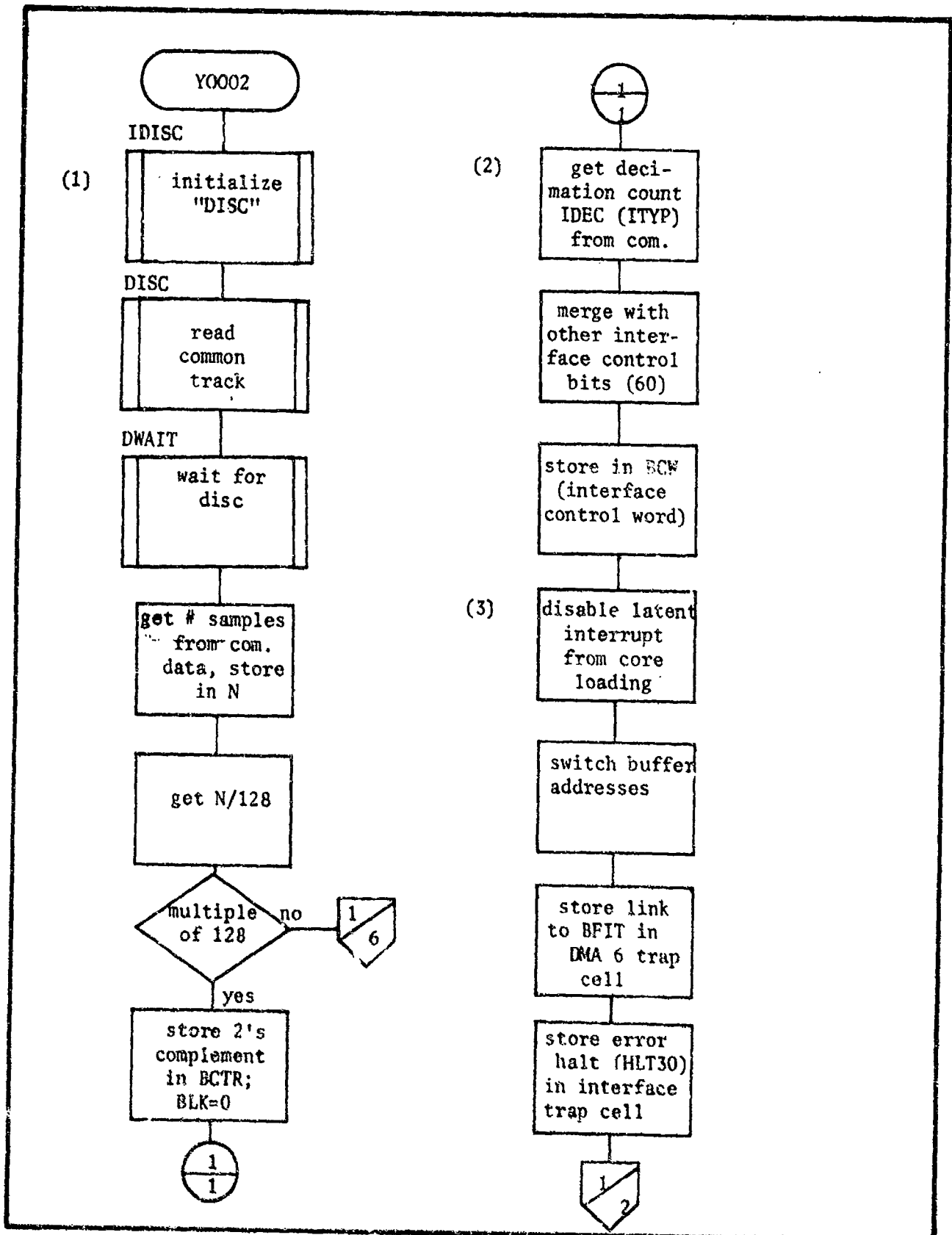


Figure 4.5.4-3 (U)

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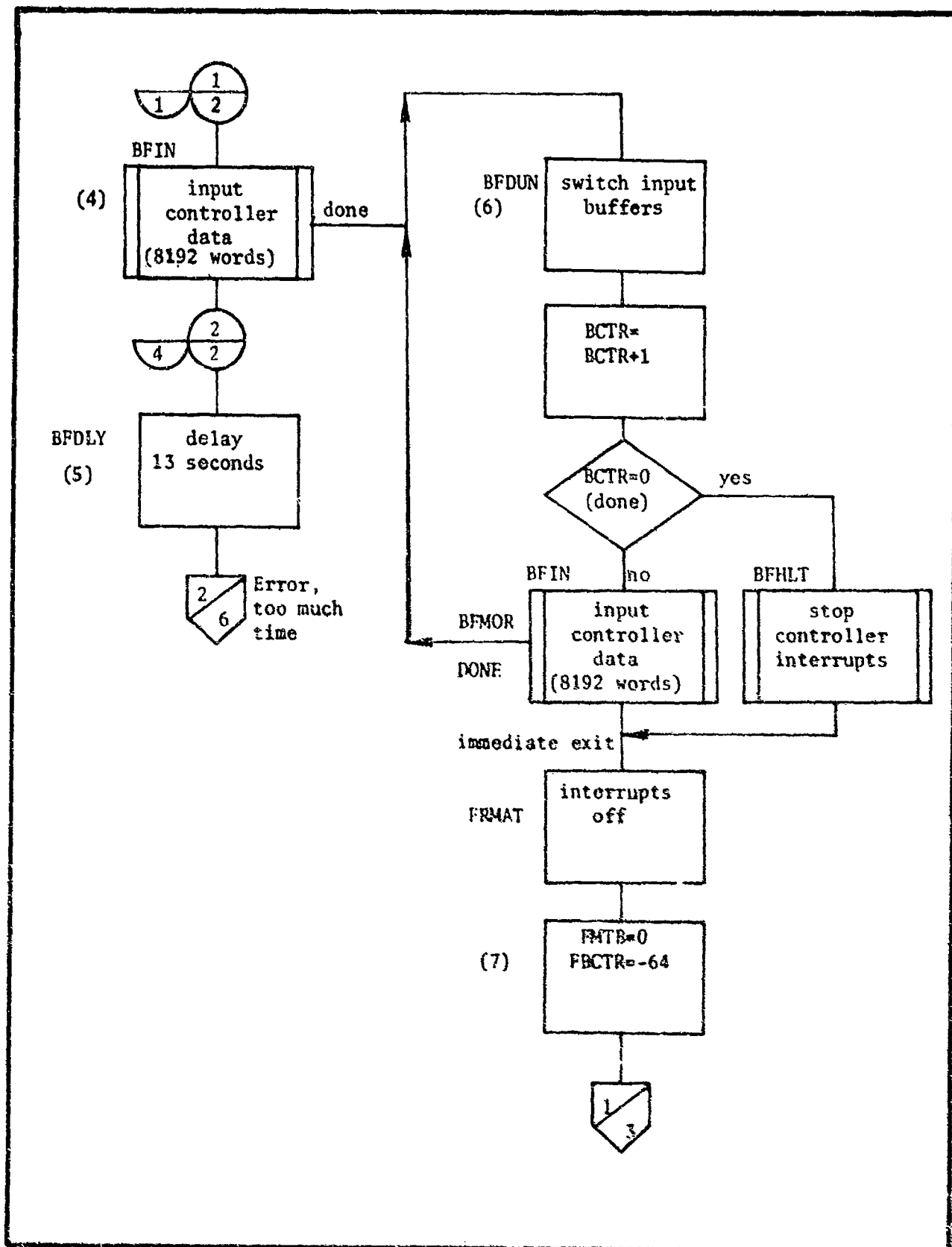


Figure 4.5.4-3 (U)

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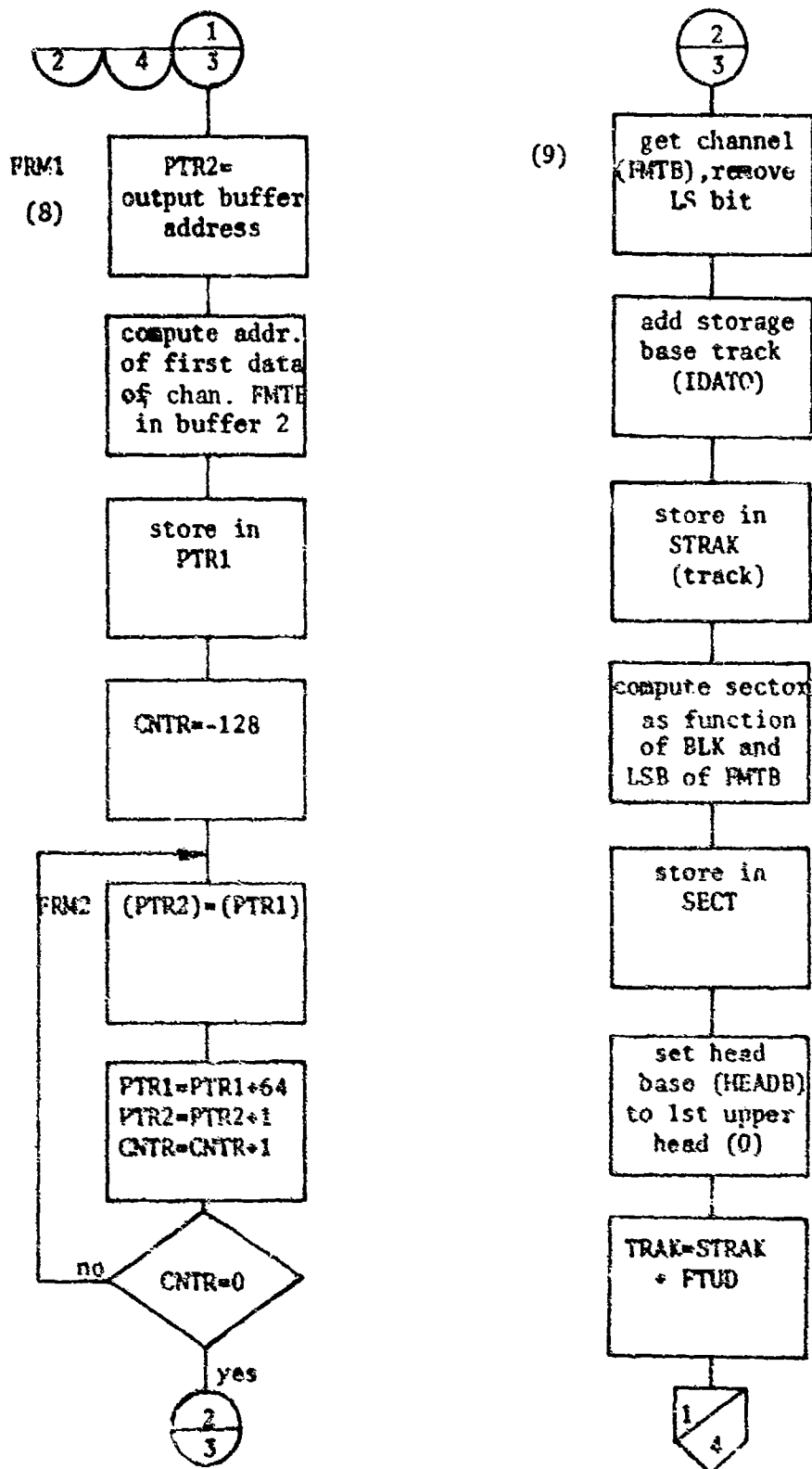


Figure 4.5.4-3 (U)

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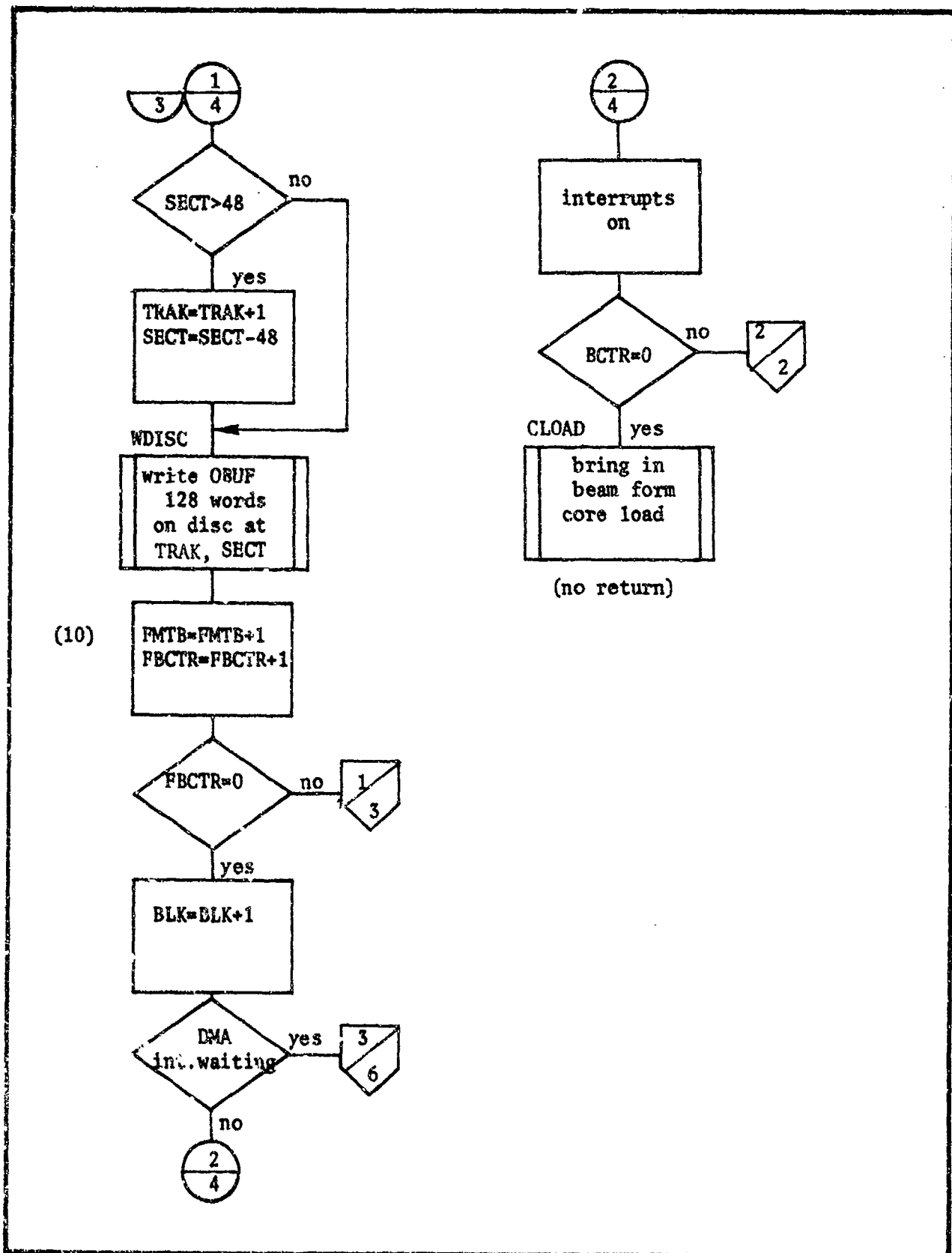


Figure 4.5.4-3 (U)

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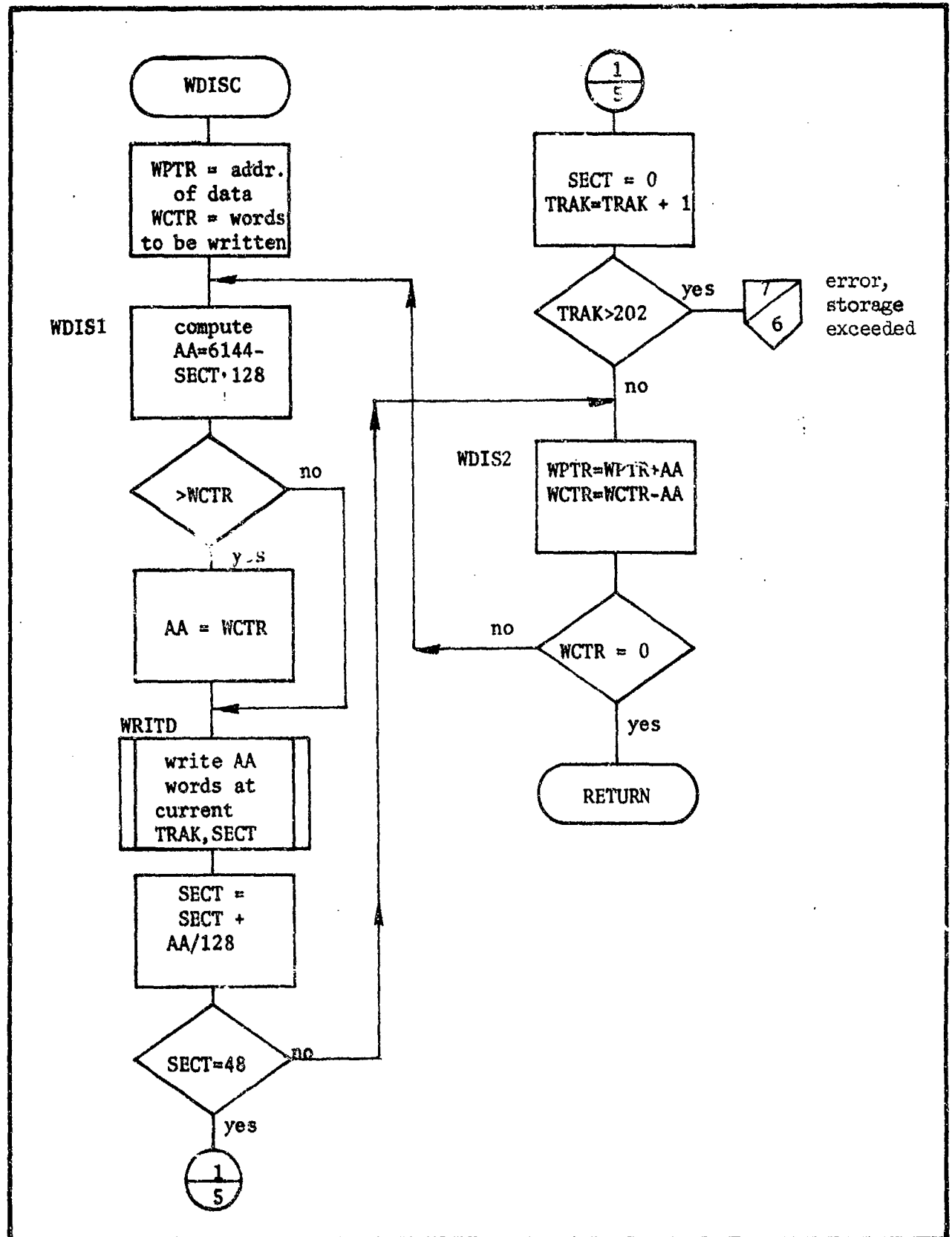


Figure 4.5.4-3 (U)

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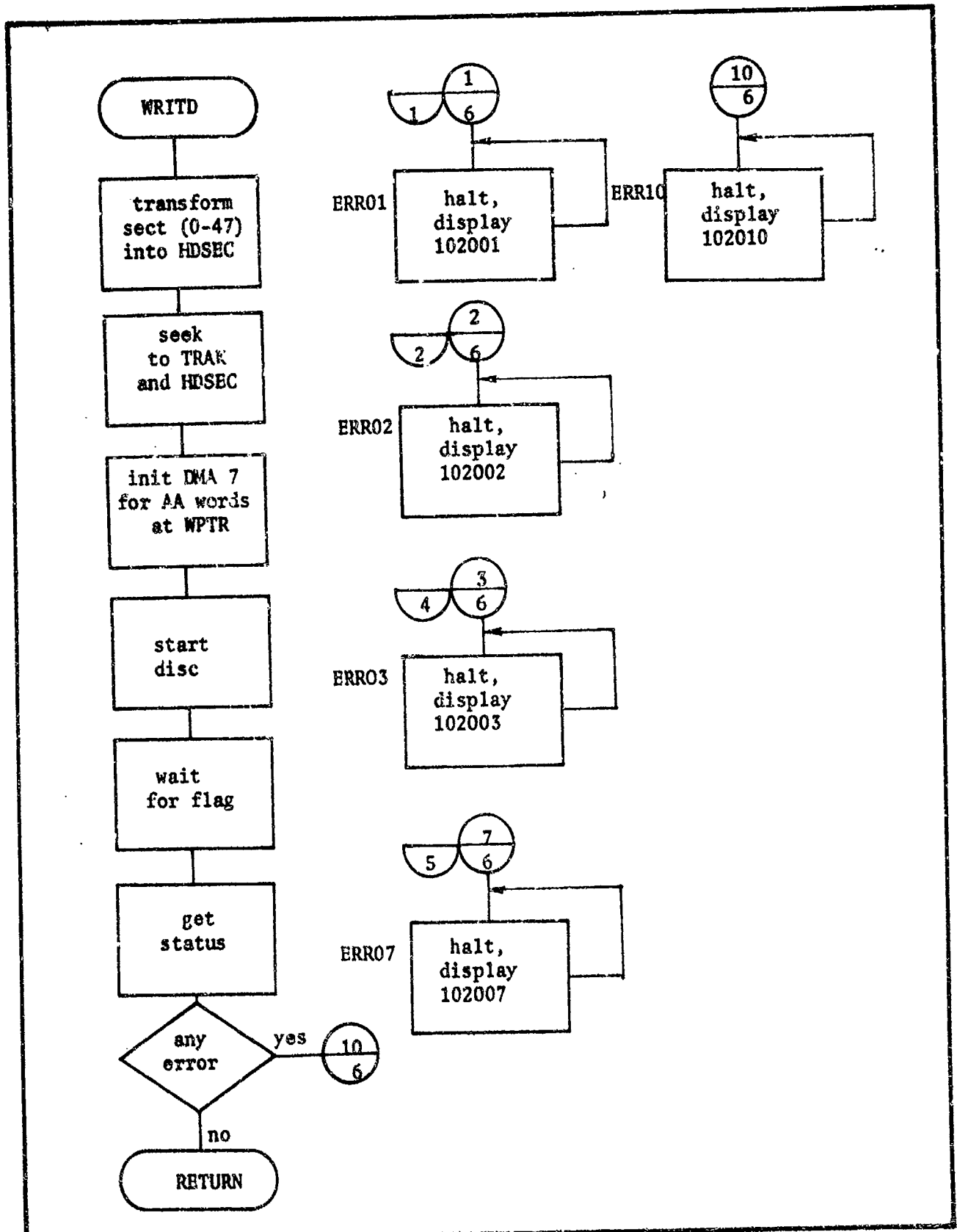
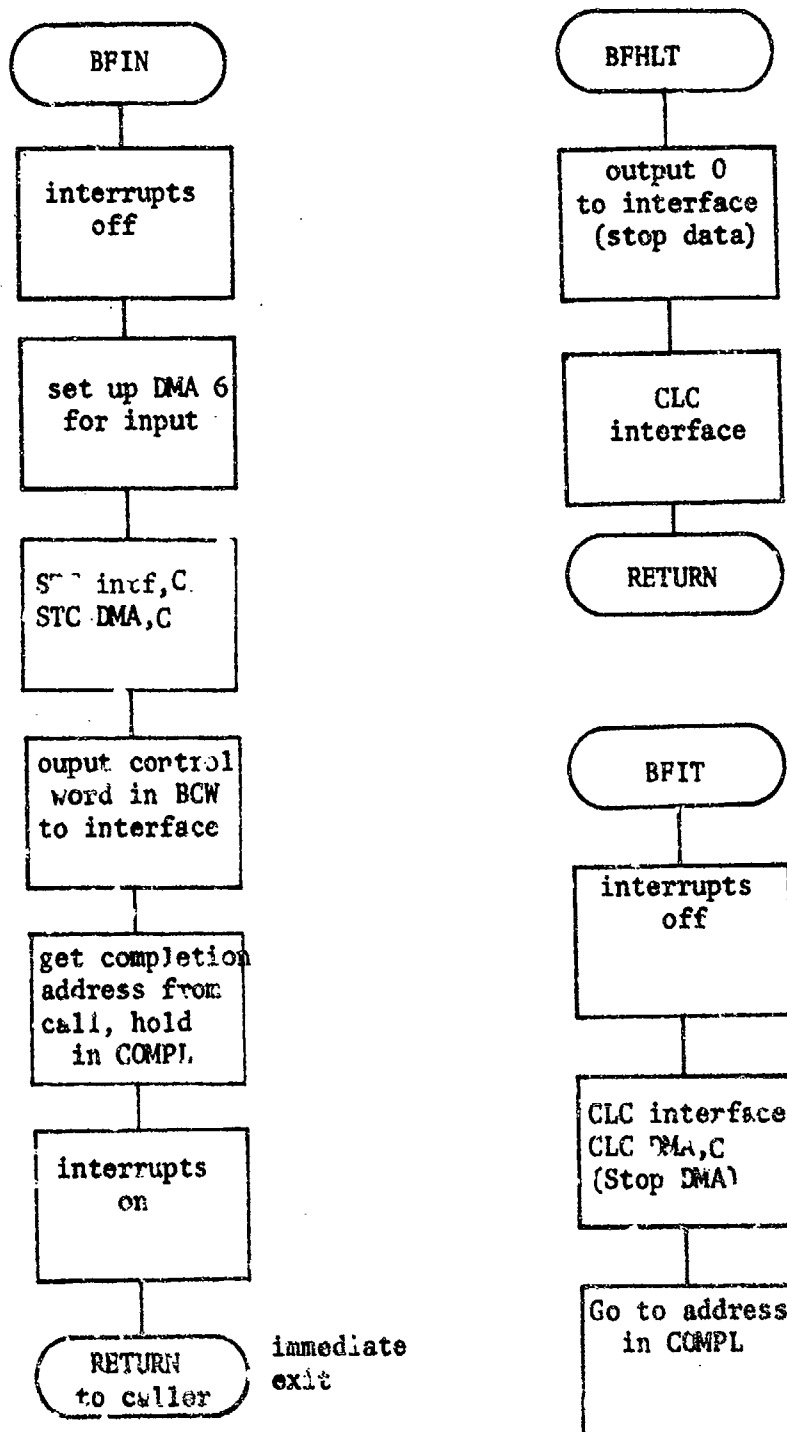


Figure 4.5.4-3 (U)

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DMA 6
INTERRUPT

Figure A.5.4-3 (U)

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PROGRAM: (U) DATA COLLECTION PROGRAM (HIGH SPEED), Y0003 4.5.5

1. (U) FUNCTION. Y0003 collects and stores the Digital Controller data on the disc.
2. (U) CONSTRAINTS. The maximum sample rate is approximately 1000 Hz and is limited by input transfer DMA step time. This is equivalent to a data rate (including header words) of 66 kHz.
3. (U) CALLING SEQUENCE. N/A
4. (U) DESCRIPTION OF INPUT. See Figure 4.5.4-1 (Y0002) for description of Digital Controller input and method. The interface is always used in the no-header mode.
5. (U) DESCRIPTION OF OUTPUT. All output is to the disc. Output data is not demultiplexed and demultiplexing must be done by program Y0004. Output is a continuous sequence of samples of channels 1-64, occupying each track completely, to a maximum of $42\frac{2}{3}$ tracks for 4096 samples. Each sector starts at channel 1 with two groups of 64 channels per 128-word sector.
6. (U) FILES USED. The ICOMO track (sector 0) is used for number of samples (NSAMP) and data decimation count (IDEC(ITYP)).
7. (U) ERRORS. None
8. (U) COMPUTER OPERATOR INSTRUCTIONS. See general system operating instructions.
9. (U) DESCRIPTION OF PROCESSING, Figure 4.5.5-1. Processing is generally the same as Y0002 with the following exceptions. DMA and interface control words are set up during initialization (once only) because the limiting factor is the processing time from occurrence of a DMA interrupt to the starting of the next transfer. For the same reason, DMA control word 1 is output to DMA only once, as it remains unchanged in the control word 1 register. Every possible unnecessary instruction in the critical timing area has been removed or moved to another area of the program to maximize speed. For this reason, BFIT (the completion interrupt processor) flows directly into the DMA setup code (without a jump instruction), the switching of input buffers is done after input is started, and changeable DMA control words are set up for next time after input is started. Because disc access time is the limiting factor in program Y0002, no demultiplexing is done in Y0003. Instead, data is written on the disc in the order received, a full track at a time. Data is stored in the ITMPO tracks. When data collection is complete, coreload 4 (program Y0004) is read in to do the demultiplexing.

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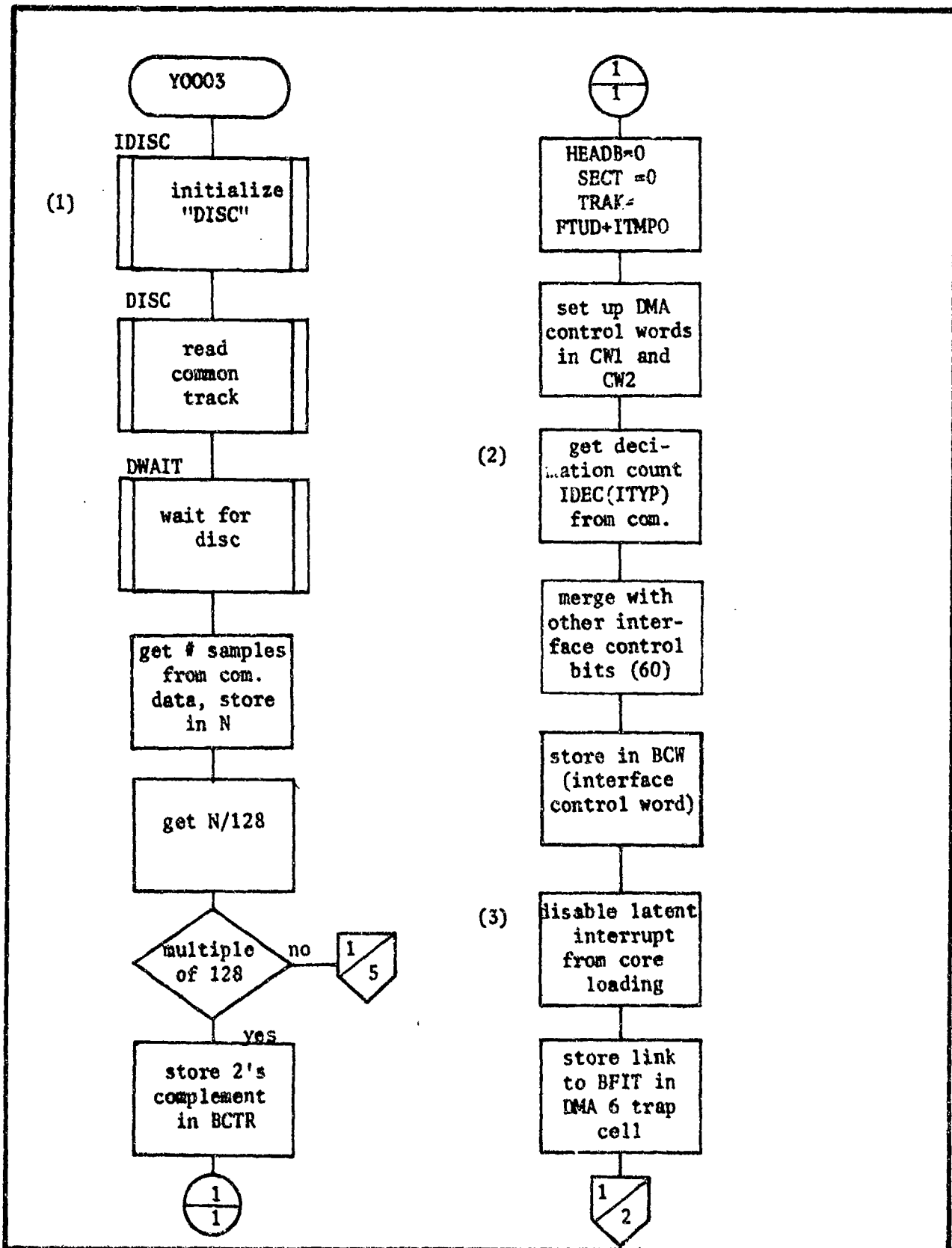


Figure 4.5.5-1 (U)

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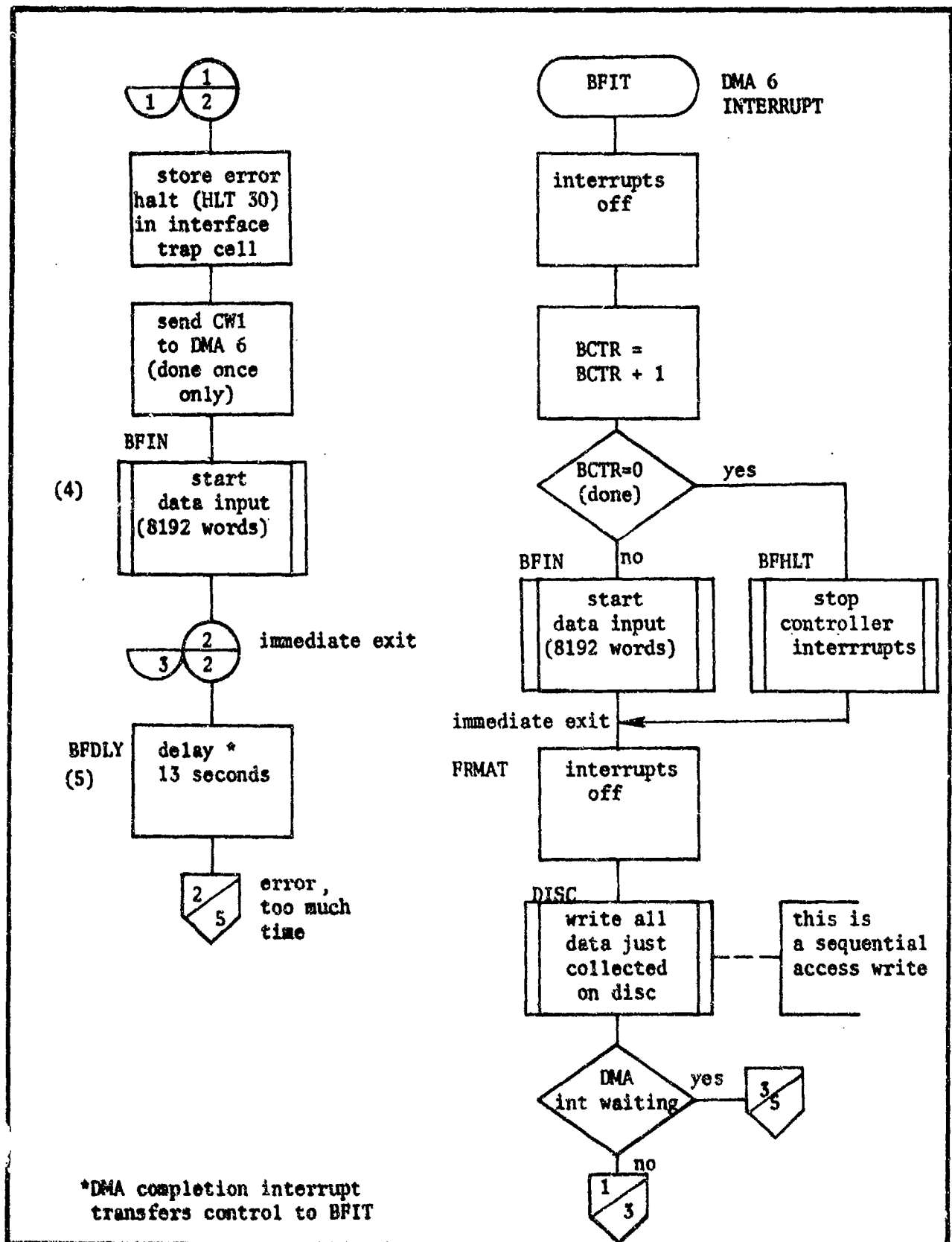
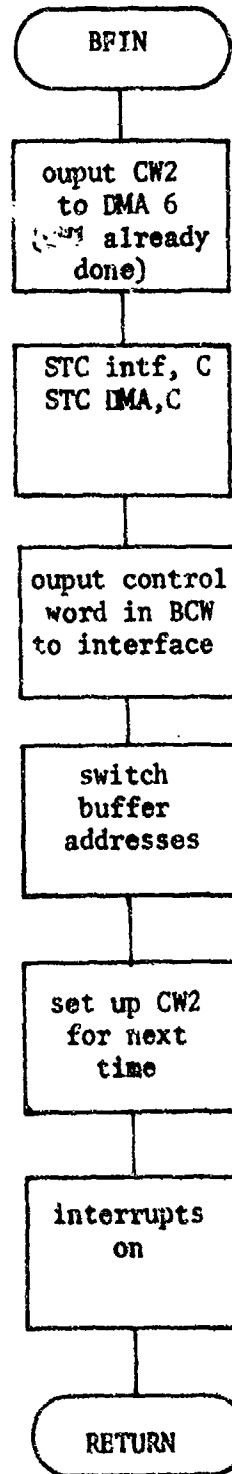
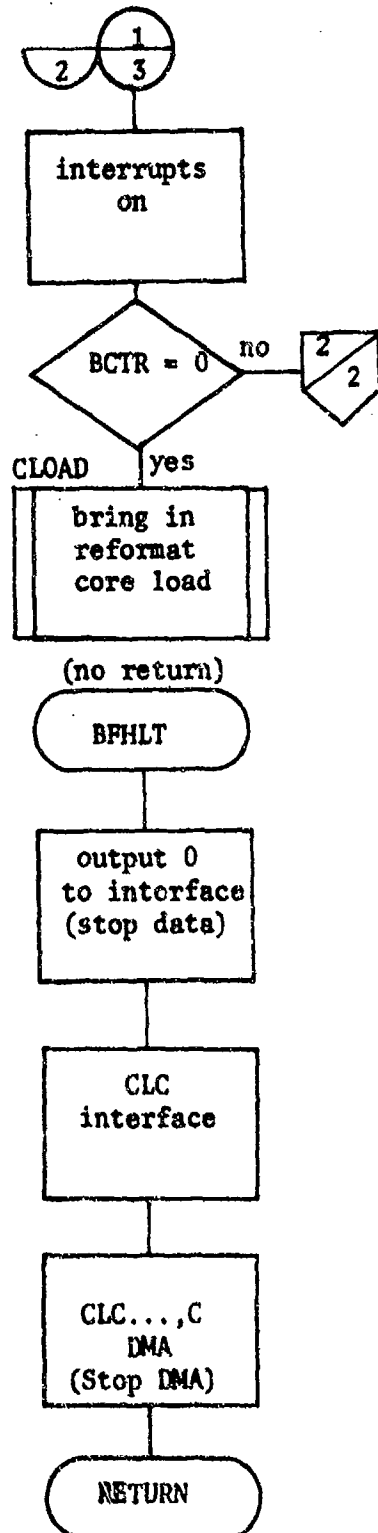


Figure 4.5.5-1 (U)

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immediate exit

Figure 4.5.5-1(U)

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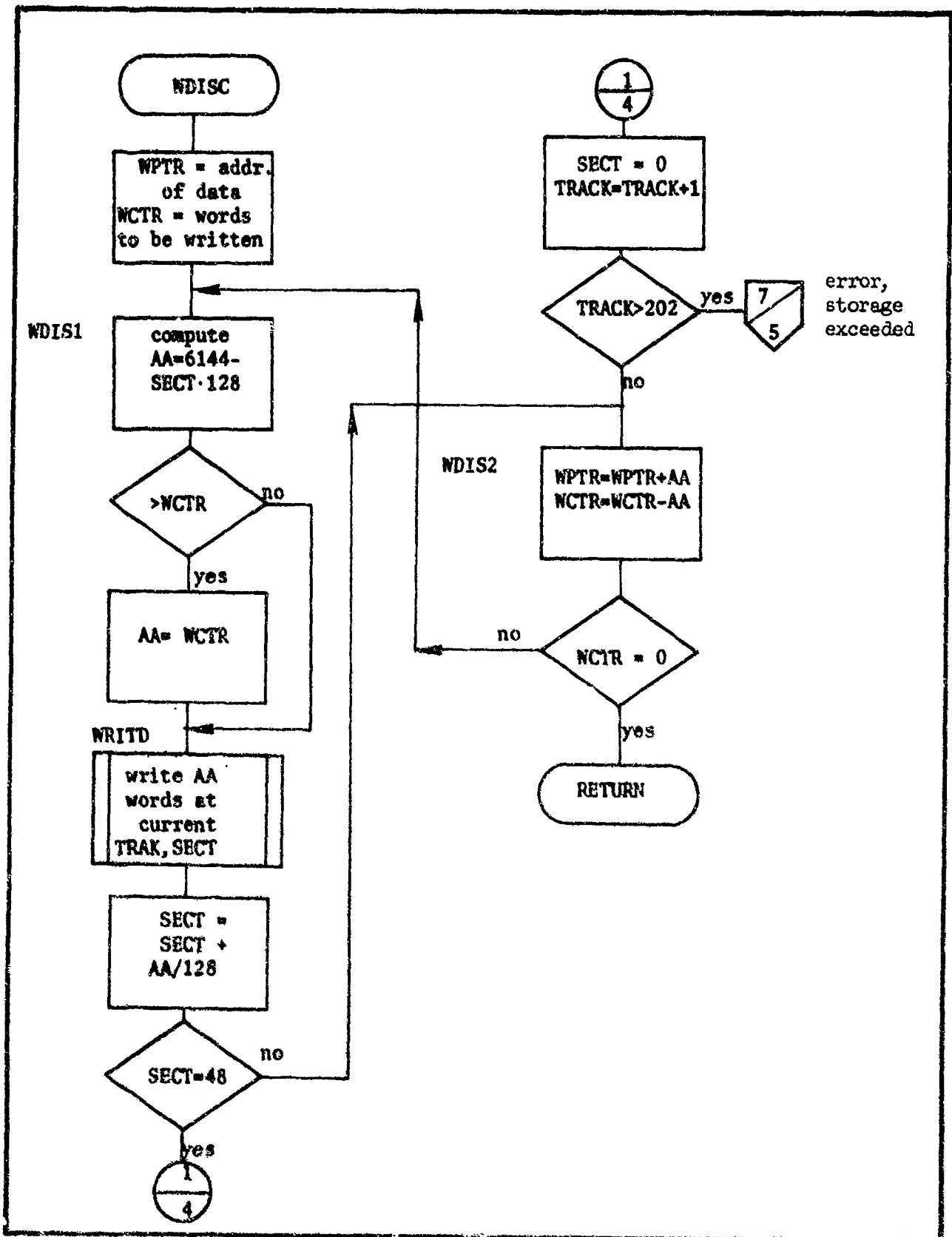


Figure 4.5.5-1 (U)

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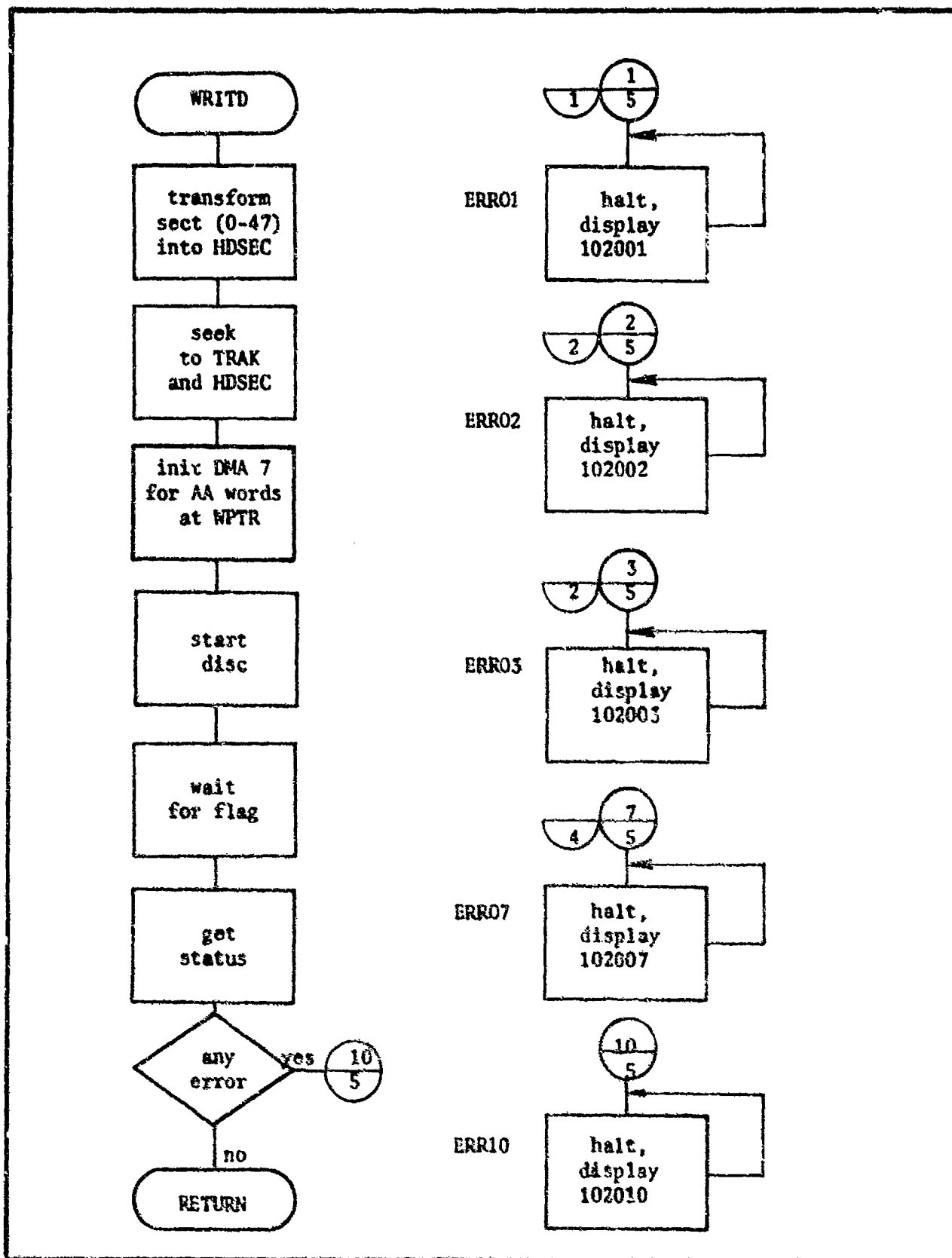


Figure 4.5.5-1 (U)

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PROGRAM: (U) HIGH SPEED DATA REFORMATTING, Y0004

4.5.6

1. (U) FUNCTION. Y0004 reads the data collected by program Y0003 (in ITMPO tracks) and reformats it to be identical to the data collected by Y0002 (in IDATO tracks)
2. (U) CONSTRAINTS. None
3. (U) CALLING SEQUENCE. N/A
4. (U) DESCRIPTION OF INPUT. See program Y0003 output description for description of input.
5. (U) DESCRIPTION OF OUTPUT. See Figure 4.5.4-2 (Y0002) for description of output.
6. (U) FILES USED. The ICOMO track (section 0) is used for number of samples (NSAMP), and starting track of the next core load (IRCYL).
7. (U) ERRORS. None
8. (U) COMPUTER OPERATOR INSTRUCTIONS. See general system operating instructions.
9. (U) DESCRIPTION OF PROCESSING Figure 4.5.6-1. Processing is similar to program Y0002 except that the calls to BFIN (digital controller input) are replaced with calls to RDISC, which provides sequential access capabilities, and there is no overlap of input and output. Reformatting is the same except that 256 words at a time are demultiplexed to reduce processing time by half. Writing is done by calling DISC. When processing is complete, control is returned to the coreload whose starting cylinder is in IRCYL.

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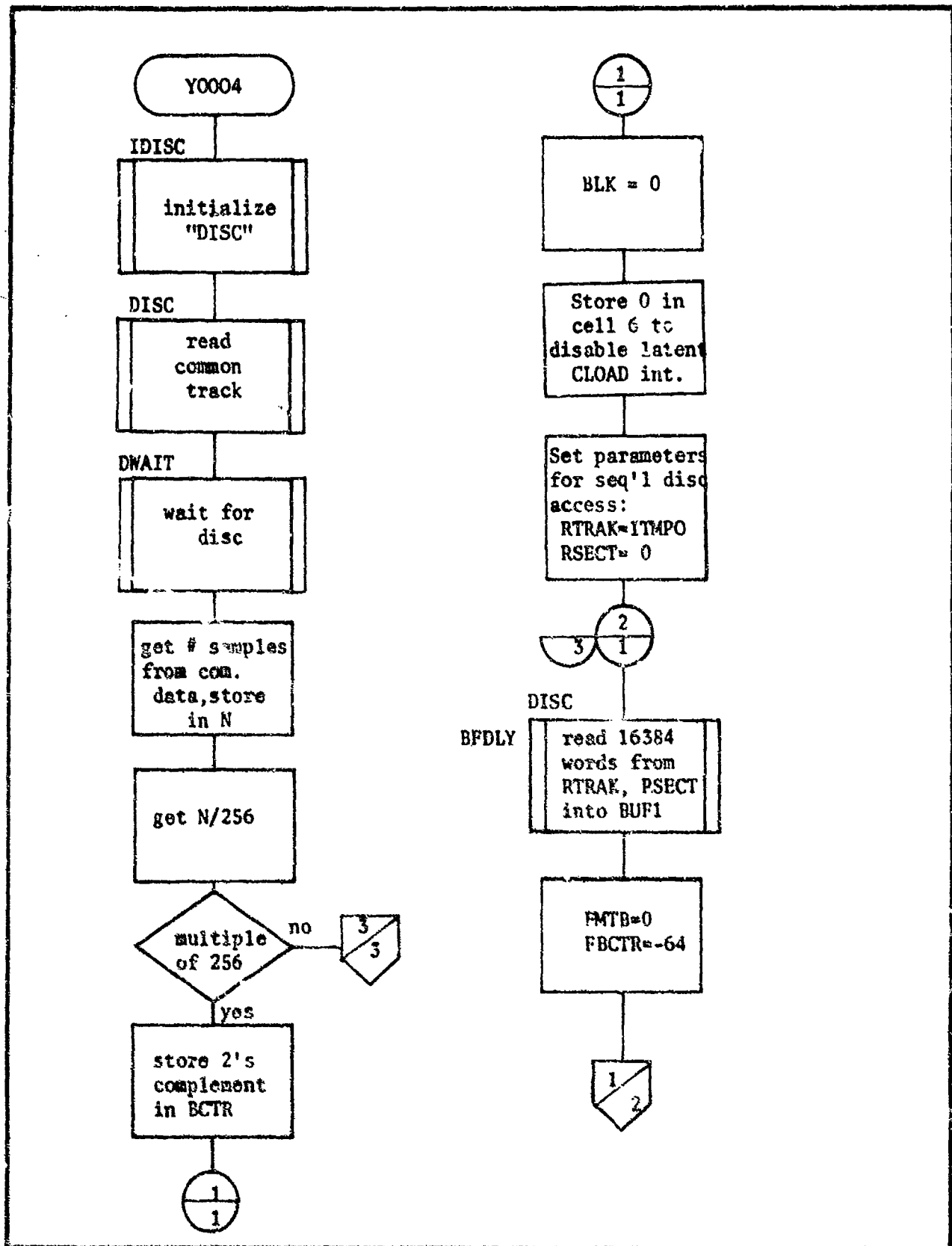


Figure 4.5.6-1 (U)

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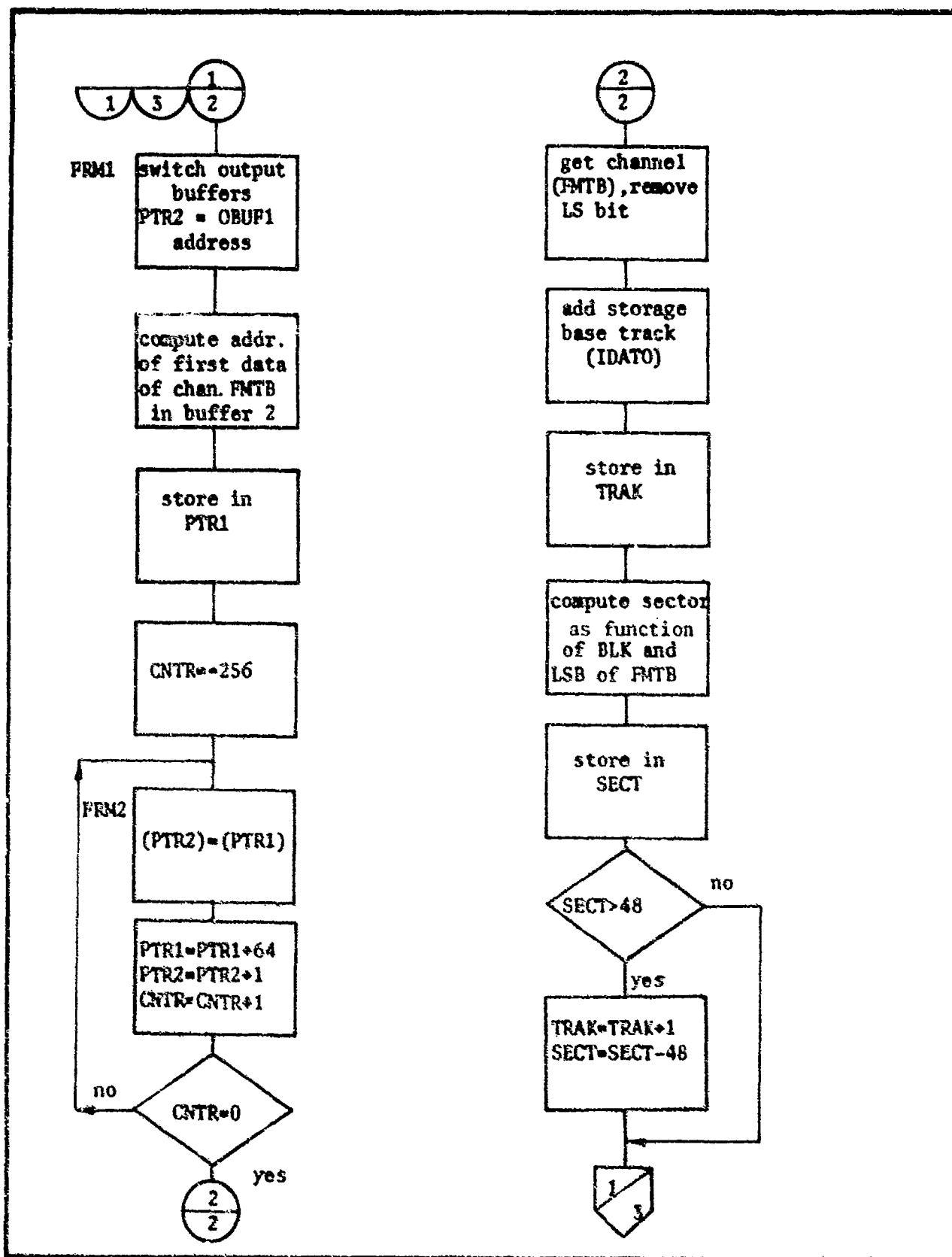


Figure 4.5.6-1 (U)

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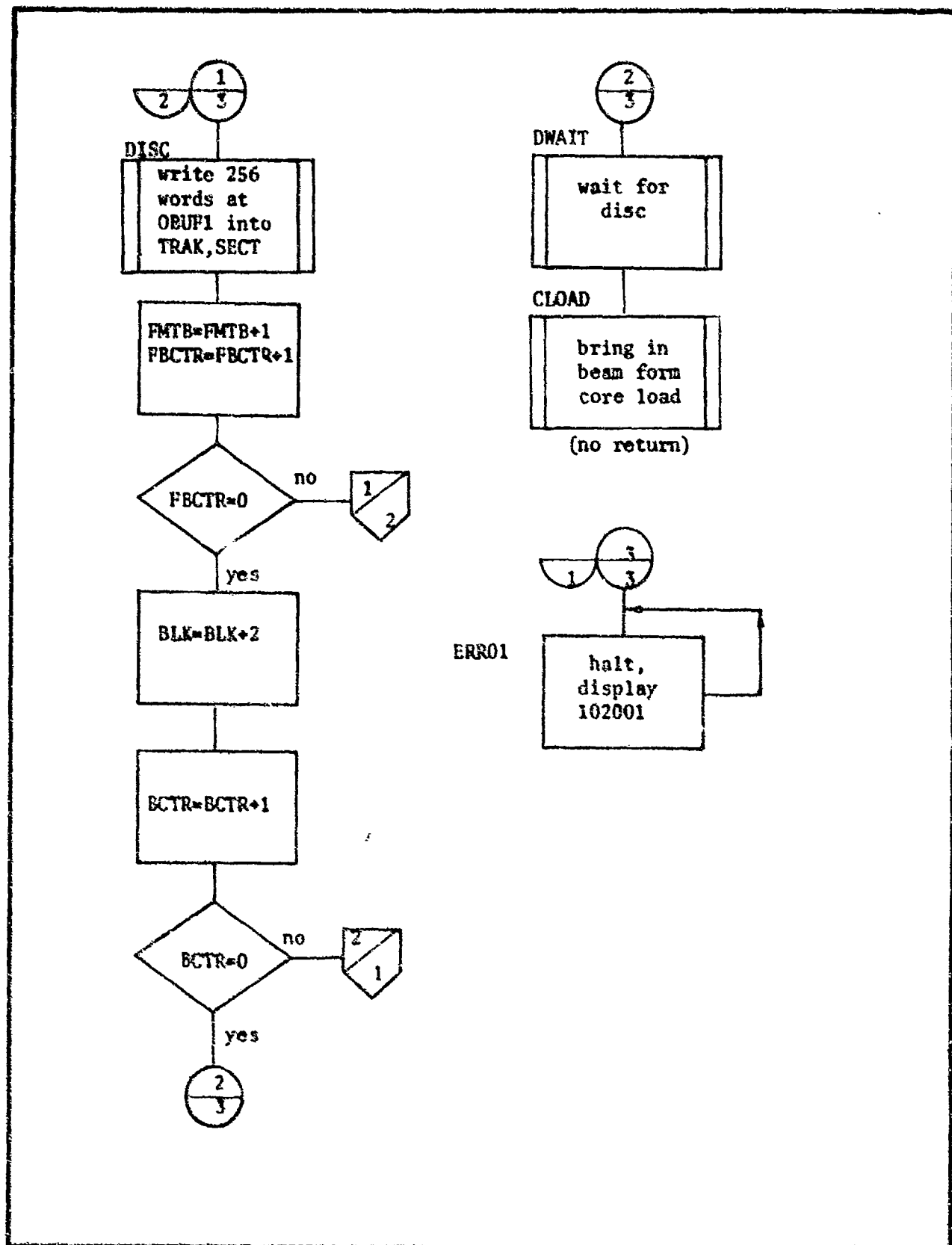


Figure 4.5.6-1 (U)

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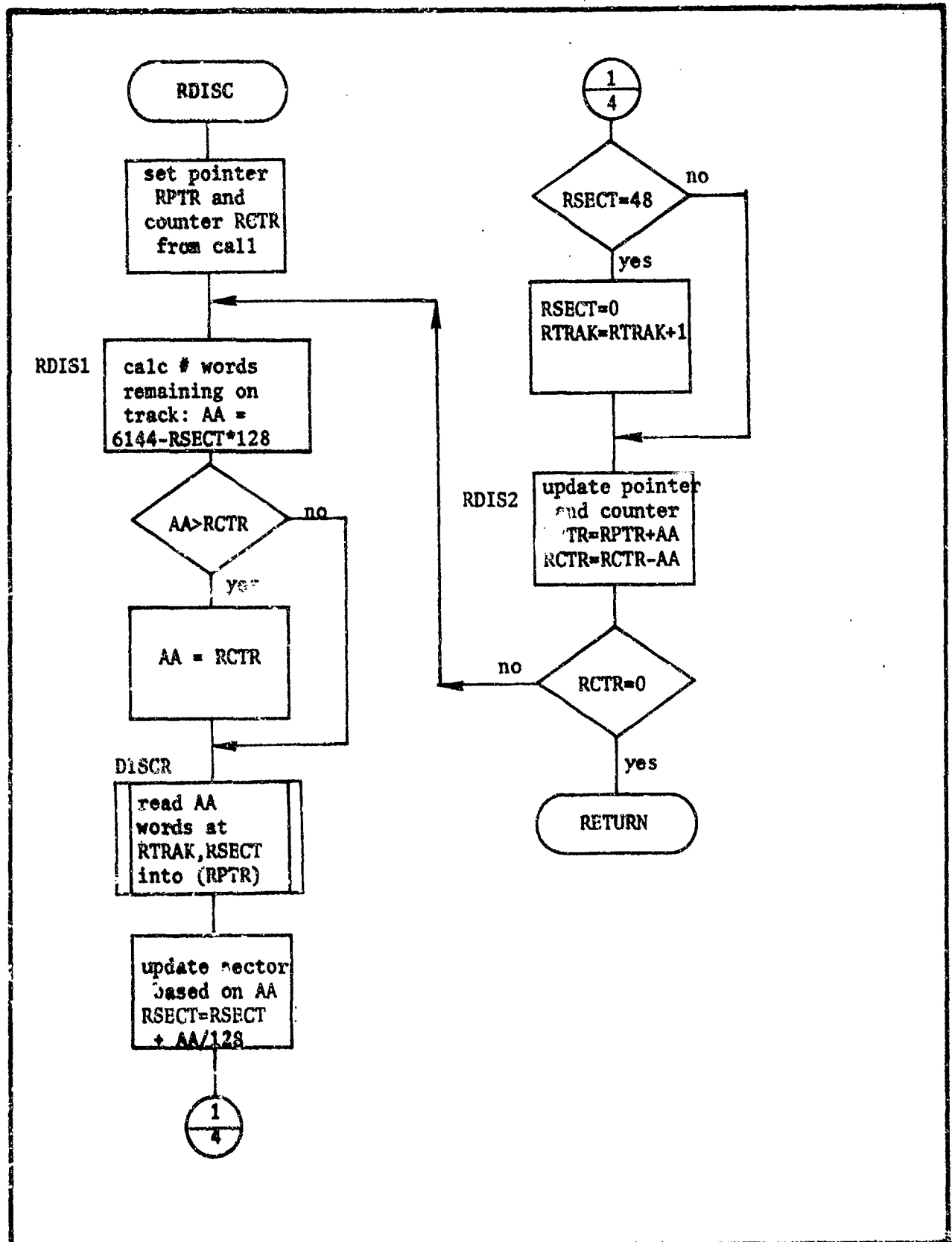


Figure 4.5.6-1 (U)

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PROGRAM: (U) STEER ANGLE INTERPOLATION, Y0006

4.5.7

1. (U) FUNCTION. The beam data produced by the beam forming program BFORM is at steer angles which vary according to sample rate. Y0006 produces data at standard steer angles by interpolation.
2. (U) CONSTRAINTS. None
3. (U) CALLING SEQUENCE. N/A
4. (U) DESCRIPTION OF INPUT. See Files Used.
5. (U) DESCRIPTION OF OUTPUT. See Files Used.
6. (U) FILES USED. The Minor Accumulator Table (the IMITO tracks) is used and modified. The ICOMO track (sector 0) is used.
7. (U) ERRORS. None
8. (U) COMPUTER OPERATOR INSTRUCTIONS. None
9. (U) DESCRIPTION OF PROCESSING. Refer to the flowchart, Figure 4.5.7-1. The program first computes a table of 1000 angles whose sines are evenly spaced over 90 degrees. The data is next interpolated to 64 standard steer angles using this table of arcsines and using the AP-120B to re-order the data so that the final data is continuous from directly aft (-90°) to directly forward (+90°). The interpolation computations are performed in the 21MX computer. After each half-group is interpolated, the data is written back on the disc in the original position, but representing different steer angles. After all groups have been processed (as determined from NGRPS in the common track) the coreload specified by IRCYL (set by the calling coreload) is read back in.

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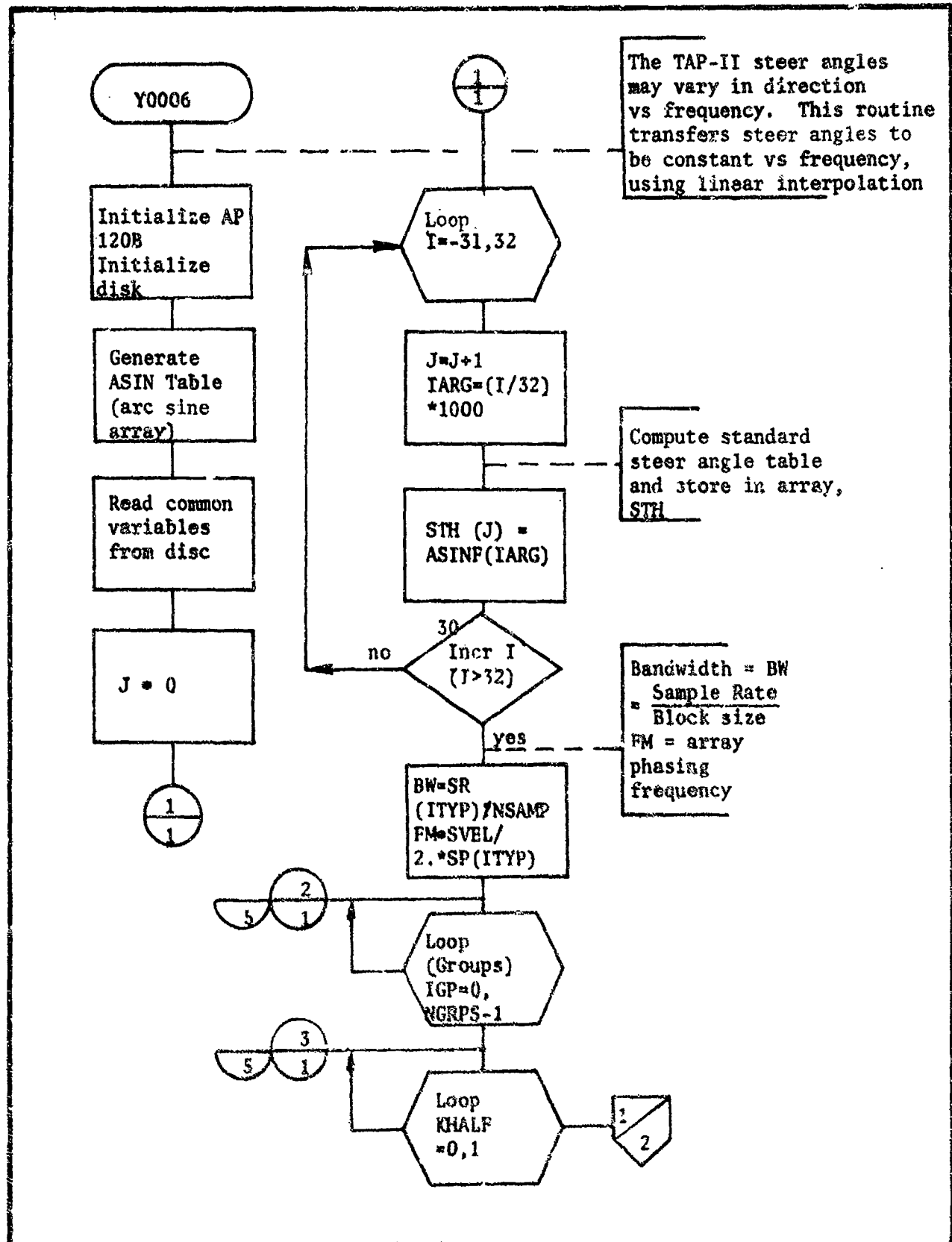


Figure 4.5.7-1 (U)

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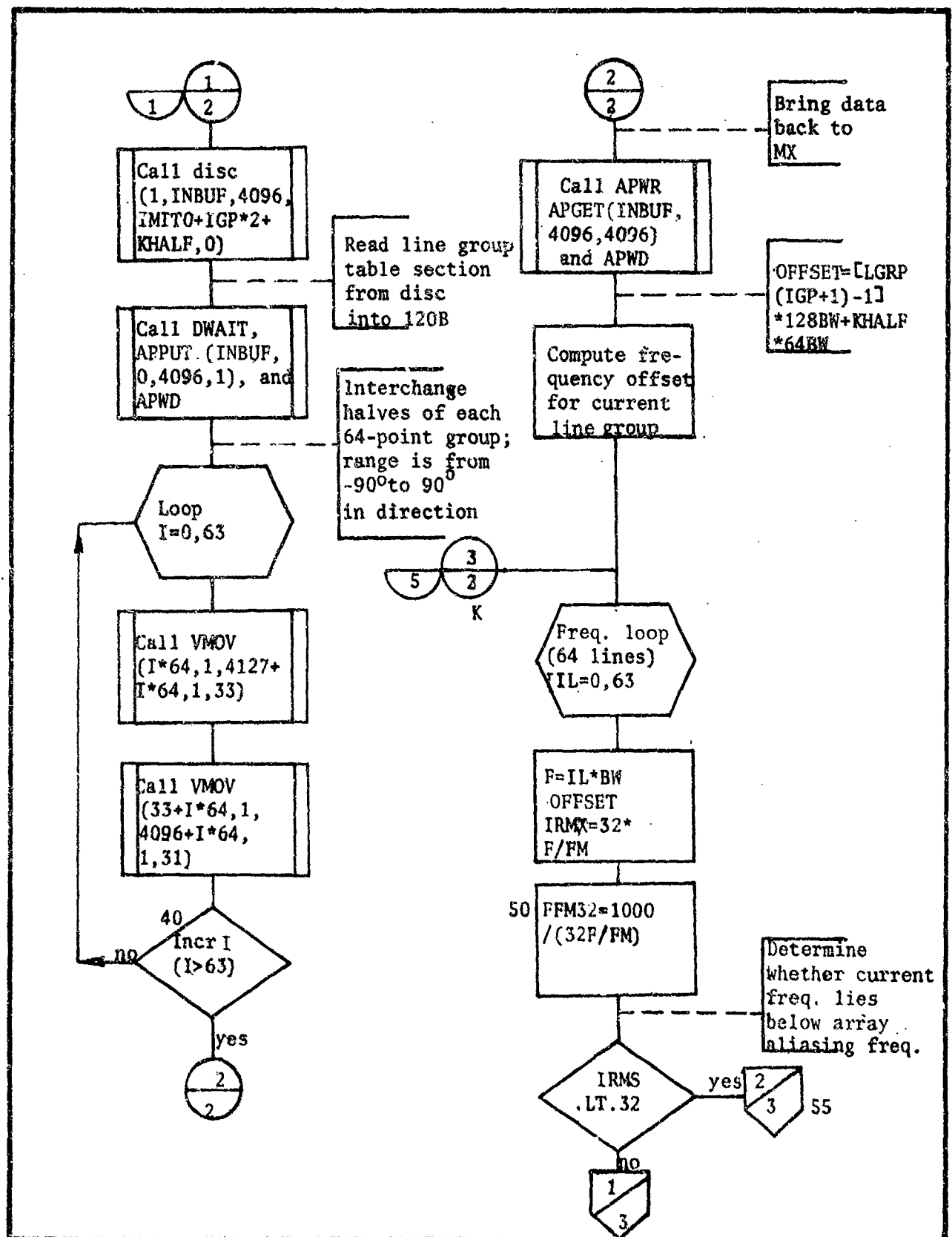


Figure 4.5.7-1 (U)

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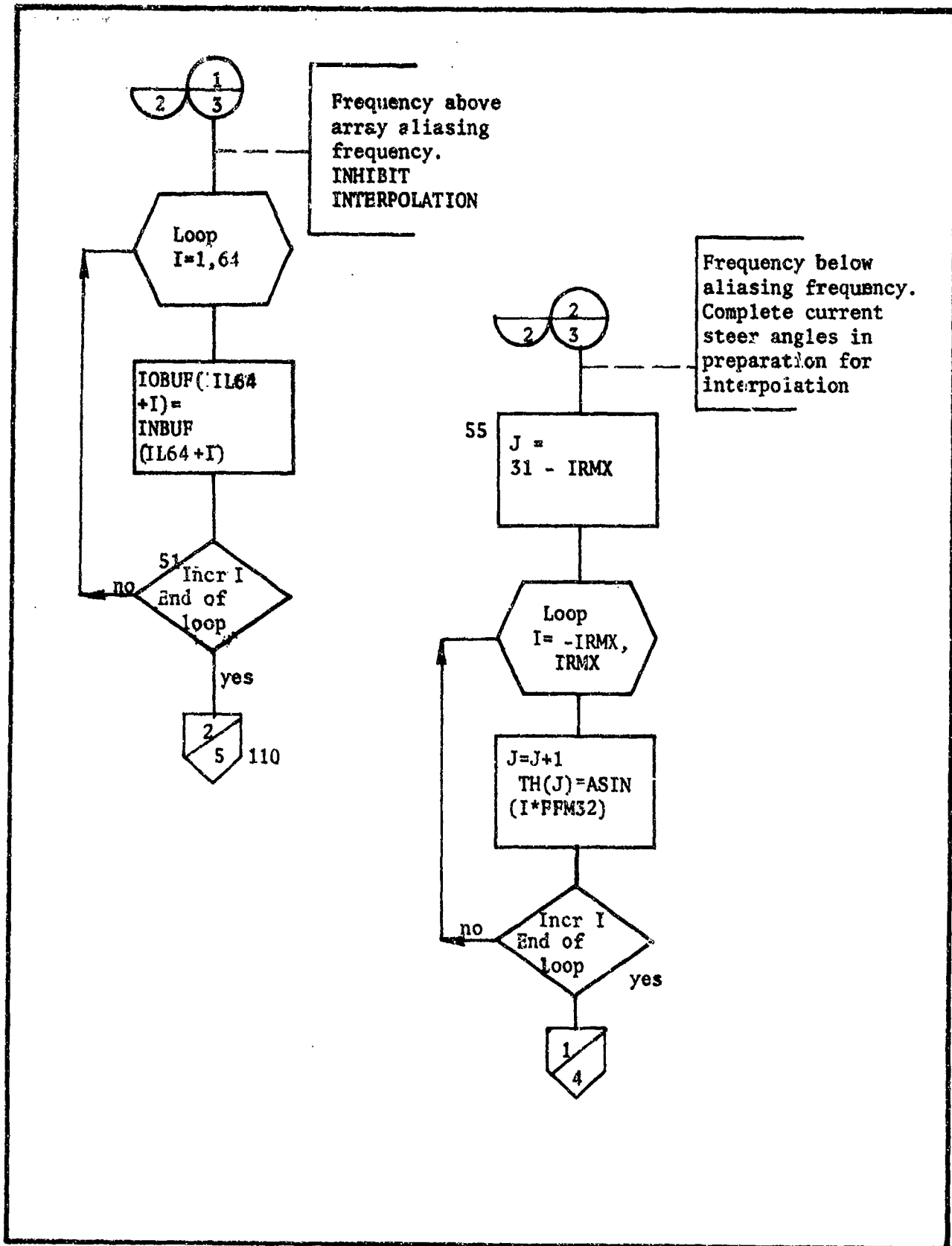


Figure 4.6.7-1 (U)

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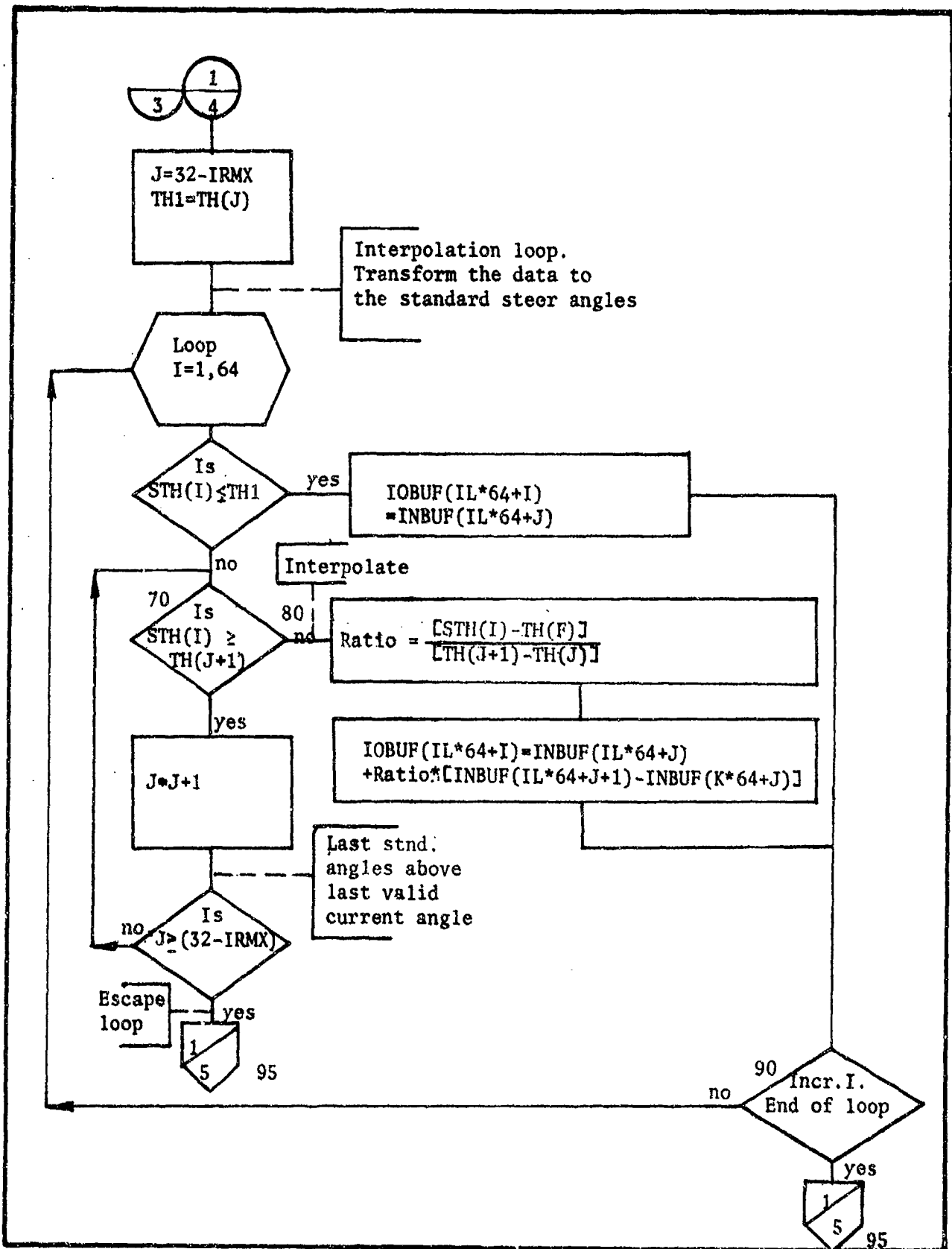


Figure 4.5.7-1 (U)

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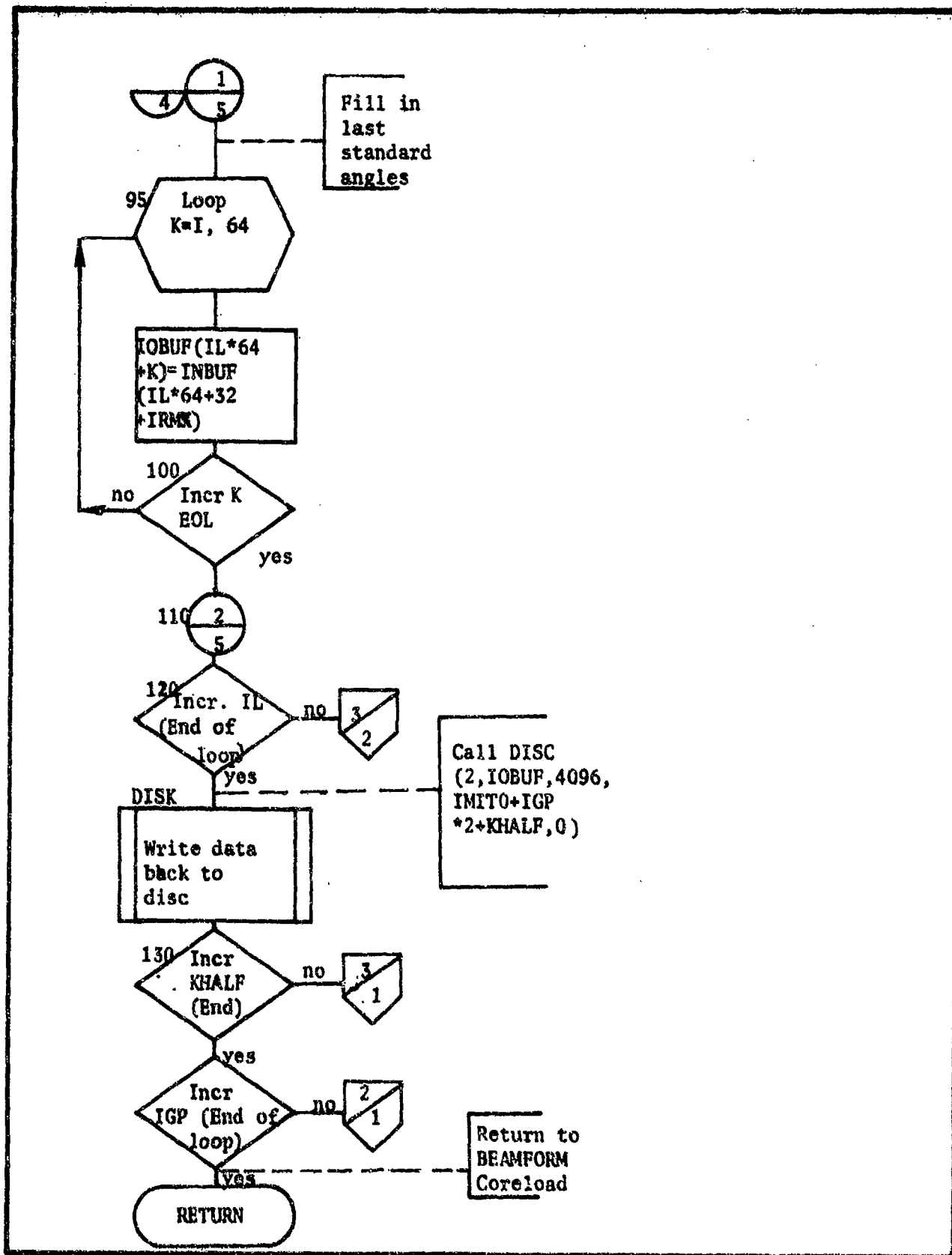


Figure 4.5.7-1 (U)

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SUBROUTINE: (U) DISC READ/WRITE, DISC

4.5.8

1. (U) FUNCTION. DISC provides general disc read/write capabilities with an immediate return to the operator. This allows interleaving with other operations.

2. (U) CONSTRAINTS. IDISC must be called before first time DISC is called. DWAIT must be called whenever completion of last transfer must be verified. Number of words must be a multiple of 128 and must not cross the track boundary.

3. (U) CALLING SEQUENCE.

CALL IDISC

Initialize disc. Must precede first DISC call.

CALL DISC (IFUNCT,IBUFR,I LENG,ITRAK,ISECT,[IGO])

where IFUNCT is 1 for read, 2 for write
IBUFR is buffer address
I LENG is number of words (multiple of 128)
ITRAK is track number, offset by FTUD (see TAT)
ISECT is sector number (0-47)
IGO (optional) track to move to when transfer complete

CALL DWAIT

Wait for transfer to complete. Does not wait for subsequent head movement (see IGO, above).

4. (U) DESCRIPTION OF INPUT. N/A

5. (U) DESCRIPTION OF OUTPUT. N/A

6. (U) FILES USED. None

7. (U) ERRORS. None

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. DISC first checks that the head busy flag (BUSYH) is clear. If BUSYH is set, BUSYH will also be set. If BUSYH is set, the program will wait until it becomes zero. This will happen when the last operation is completed. For this reason, interrupts must not be disabled before entry to DISC. Once clear, all calling parameters, including return address, are saved. The actual parameters, as opposed to the addresses of parameters, must be saved because the caller may change what is stored in those locations before DISC gets around to picking them up. The buffer address is a special

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case; it may be referenced indirectly. If the indirect bit is set, that bit must be stripped off and the true address loaded from the result. The result is different from loading directly from the parameter in the calling sequence. Subsequent processing steps are keyed to the flowchart, Figure 4.5.8-1.

(1) The number of arguments is checked. If five, IGO is set to -1 to indicate that no final head movement is desired. If six, IGO is set to the actual parameter, which is the final head destination. All of the parameter saving processing is abnormal because DISC may be re-entered before execution is finished.

(2) Both busy flags (BUSYH and BUSYT) are set to 1. CONT is called to save the address to go to when an interrupt occurs. An interrupt is then simulated. This seemingly useless step is done so that things will be set up right to return to the caller when DISC starts to wait for the next interrupt. The RETURN at (3) will not be executed until that time.

(4) Instead, control passes to label STRTD as a result of the simulated interrupt. Here all of the normal disc get-ready is done: un-bias the track by adding FTUD (see program TAT), convert sector to the head and sector control word, seek to that location, and set up DMA 6 for input or output (as appropriate). DMA 6 was chosen so that disc transfers would have higher priority than AP-120B transfers, which otherwise might interfere with the critical disc timing.

(5) The order of the next few operations is dependent upon whether the operation is read or write, but the result is the initiation of the operation. All of the disc processing is exactly as specified in the moving head disc interface manual.

(6) The address to go to when an interrupt occurs (7) is saved. Registers are restored, interrupts are enabled, and control is returned to the point of interruption. This will not be (3), the place where DISC was called, because an interrupt was processed in the seek sequence.

When the transfer is complete, an interrupt will occur, which will cause control to go to (8), as with all interrupts. Here, interrupts will be disabled, registers will be saved, and control will go to (7).

(7) The transfer has been completed, so BUSYT is cleared. IGO is checked. If negative, a final head move was not called for and control goes to (8). Otherwise, the track is unbiased and a seek to the new track is done. This involves another return to the interrupted program while waiting for the interrupt. When the interrupt occurs, after saving registers, etc., control goes to (8).

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(8) The BUSYH is reset, registers are restored, interrupts are enabled, and control is returned to the point of interruption. This is the end of the processing. It should be noted that control was passed back to the place where DISC was called several milliseconds ago.

Subroutine IDISC sets up the interrupt link in the DMA 6 trap cell and resets the two busy flags. A separate subroutine is provided so that the program may be restarted even if stopped during a disc transfer.

Subroutine DWAIT waits until BUSYT becomes zero before returning to the caller. As it is used merely to see if the data is fully transferred, there is no need to wait for BUSYH to go to zero.

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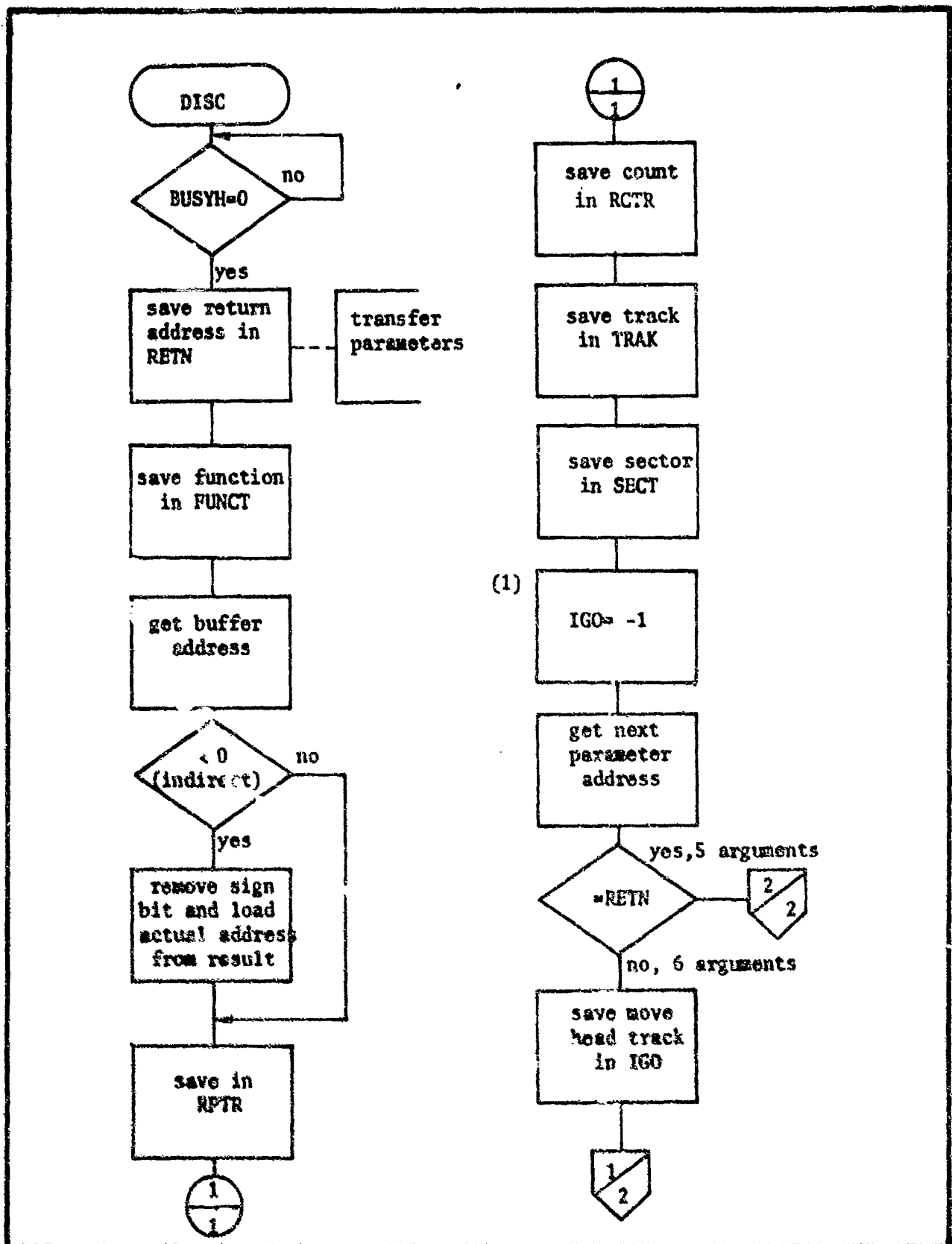


Figure 4.5.8-1 (U)

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DISC Sheet 1 of 5

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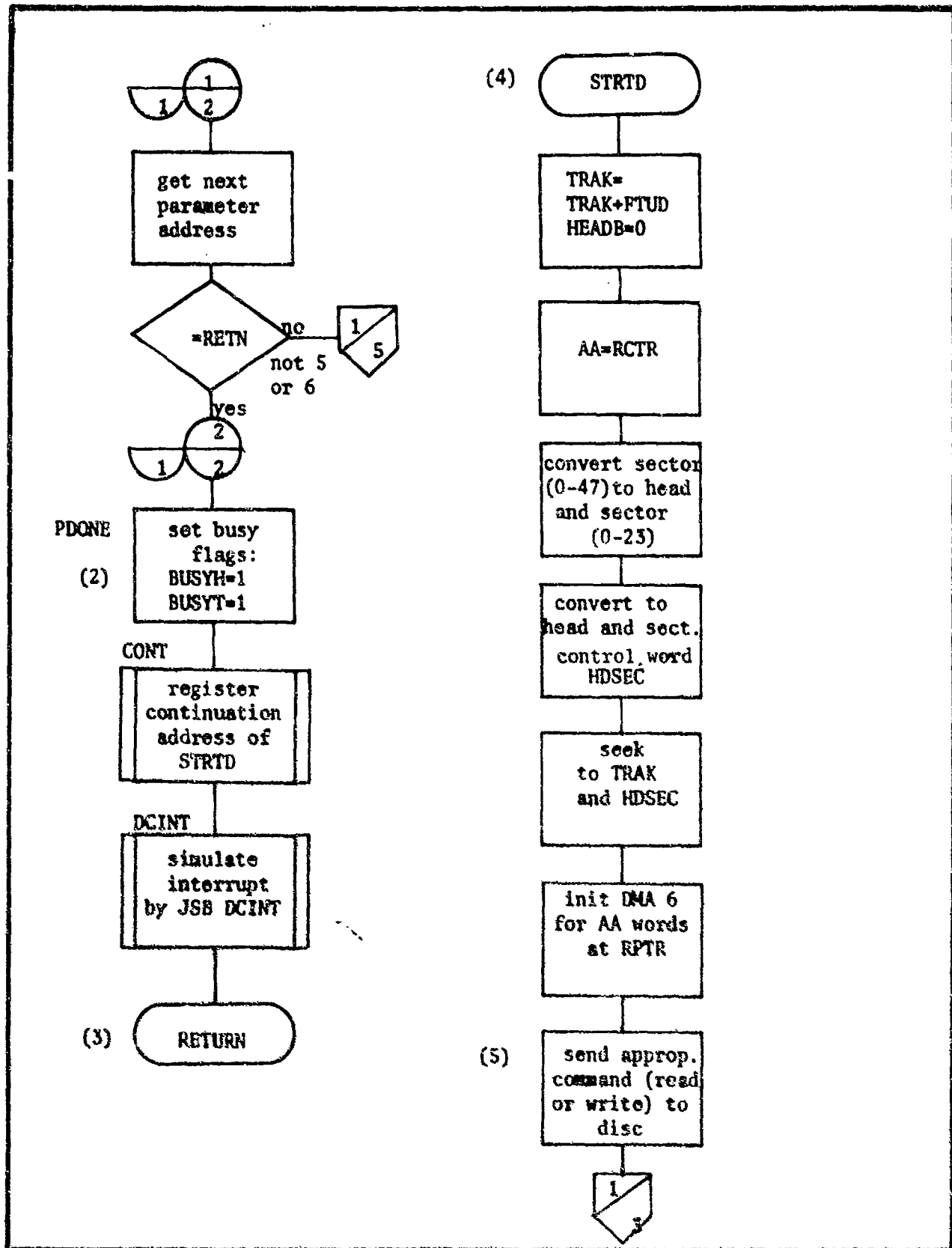


Figure 4.5.8-1 (U)

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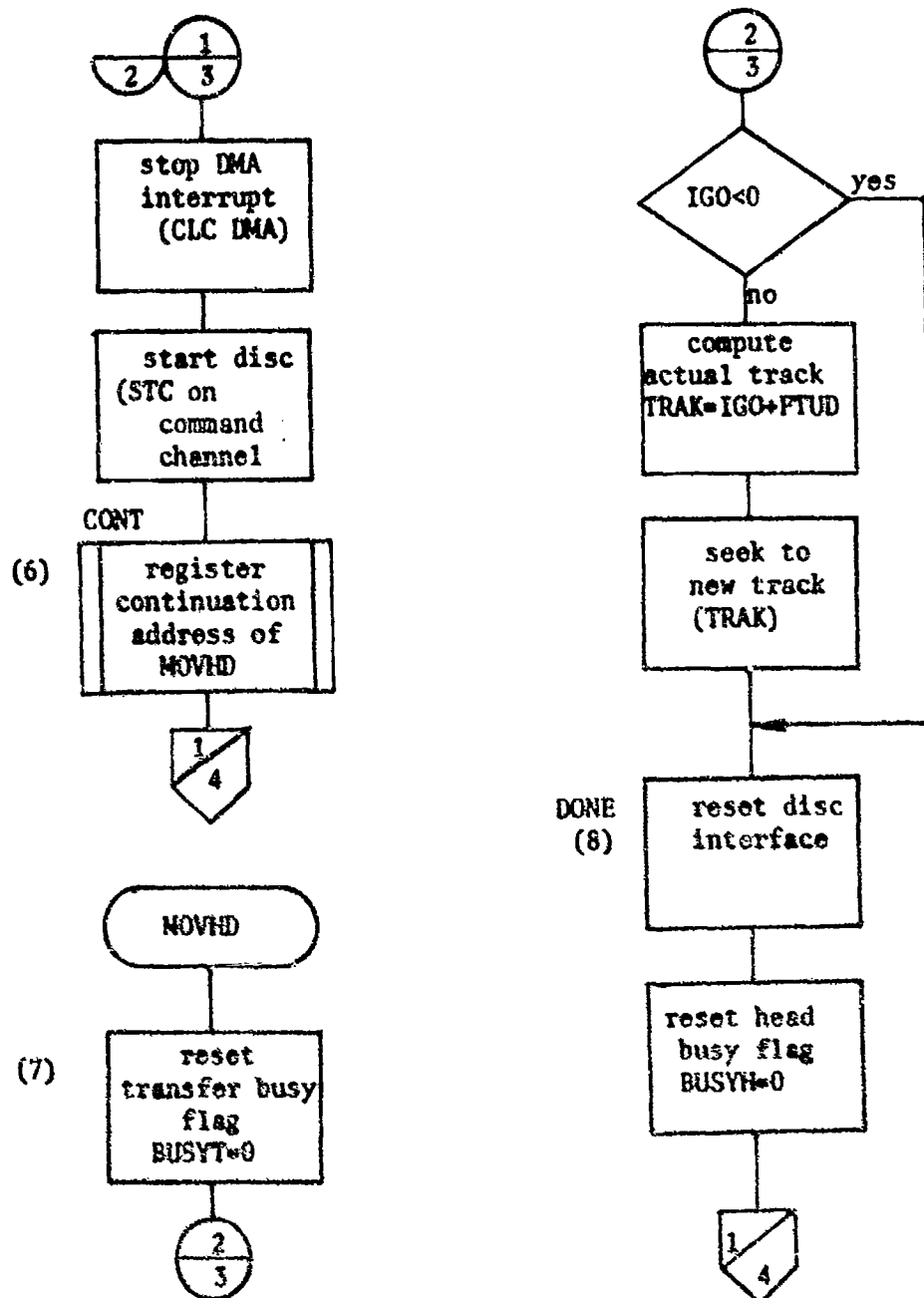


Figure 4.5.8-1 (U)

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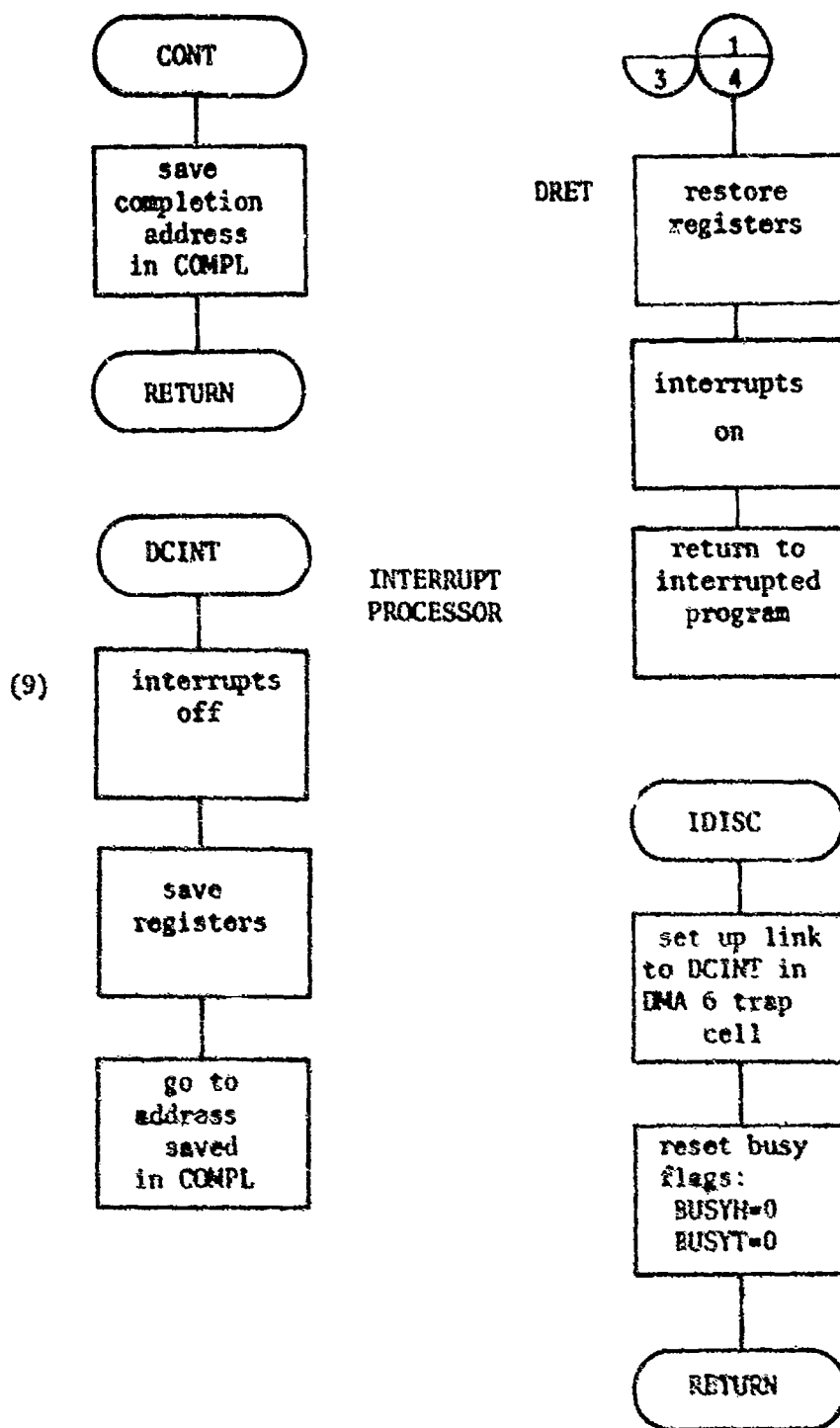


Figure 4.5.8-1 (U)

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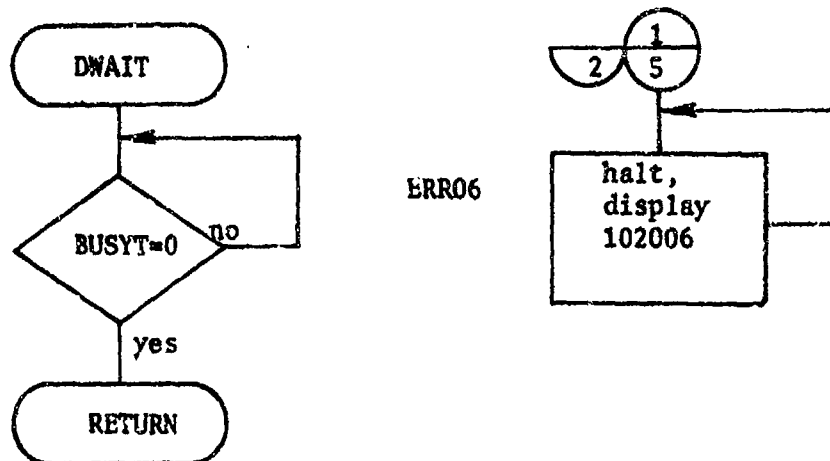


Figure 4.5.8-1(U)

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DISC Sheet 5 of 5

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SUBROUTINE: (U) TAP II TIME INPUT, TIME

4.5.9

1. (U) FUNCTION. TIME inputs the time code generator time through the digital controller and converts time to binary hours, minutes, and seconds.

2. (U) CONSTRAINTS. The data rate must not exceed 60 kHz or data will be lost due to loss of synchronization.

3. (U) CALLING SEQUENCE.

CALL TIME (ITIM)

where ITIM is dimensioned (3) and contains three words which are hours, minutes, and seconds, respectively.

4. (U) DESCRIPTION OF INPUT. See Figure 4.5.4-1 (Y9002) for description of digital controller data format.

5. (U) DESCRIPTION OF OUTPUT. Output is binary hours, minutes, and seconds in three words.

6. (U) FILES USED. None

7. (U) ERRORS. None

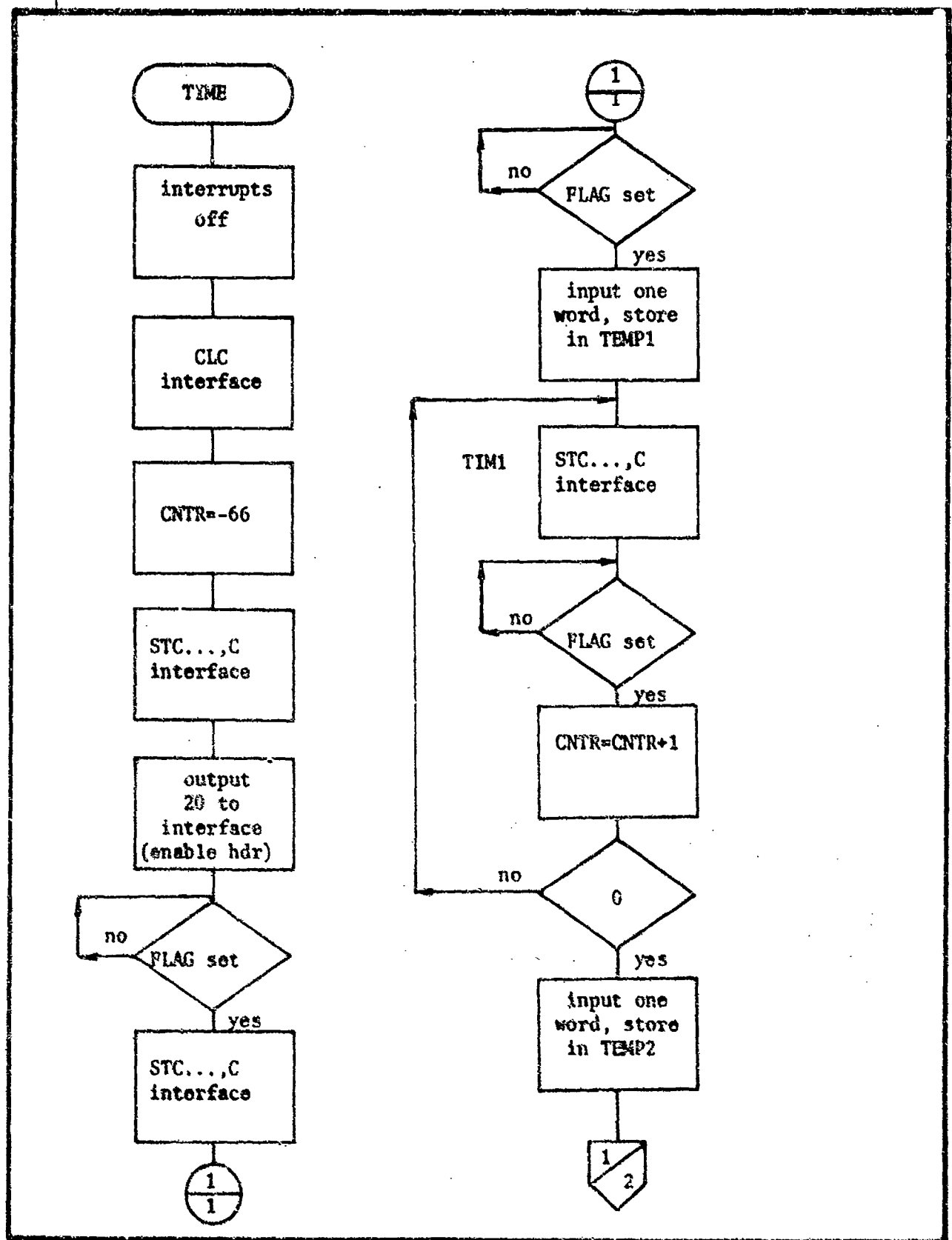
8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. Figure 4.5.9-1. TIME sets up the interface as though it was going to input channel data, but without DMA. It then counts flags until the time words come along and stores them in temporary storage. When the second time word has been input, the interface is reset and the BCD time fields are isolated, converted to binary, and stored in the caller's buffer.

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TIME Sheet 1 of 2

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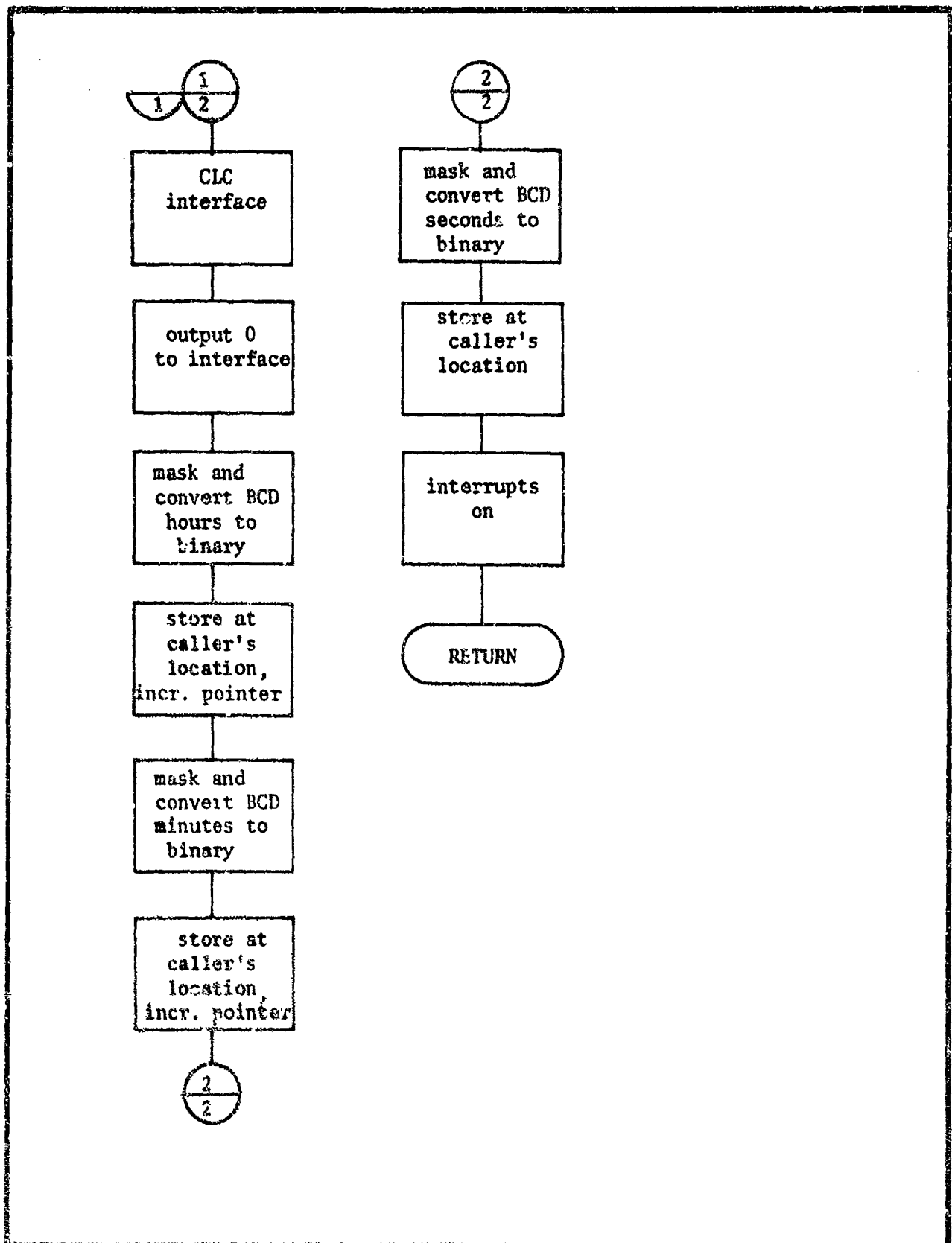


Figure 4.5 9-1 (U)

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SUBROUTINES: (U) TYPEWRITER INPUT AND LIMIT CHECKING,
INPT, INPTF

4.5.10

1. (U) FUNCTION. These subroutines input a single number from the operator and check it against limits. If a carriage return only is entered, the original value is unchanged.

2. (U) CONSTRAINTS. The value 12345 has a reserved meaning; if entered, coreload 0 is immediately read in.

3. (U) CALLING SEQUENCE.

CALL INPT (IVALUE,MIN,MAX)
CALL INPTF (VALUE,AMIN,AMAX)

4. (U) DESCRIPTION OF INPUT. 0-19 keyboard characters: 0-9, +, -, . (INPTF only), are input to specify a number representable by an integer or real number, as applicable.

5. (U) DESCRIPTION OF OUTPUT. IVALUE or VALUE is unchanged if carriage return only or an error value is entered, or is replaced by the operator value if a legal value is entered.

6. (U) FILES USED. None

7. (U) ERRORS. None

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. INPT, Figure 4.5.10-1, and INPTF, Figure 4.5.10-2, are identical except that INPT operates on integers and calls TYPI, and INPTF operates on real numbers and calls TYPF. If 12345 is entered, coreload 0 is read in without returning to the calling program, the user is referred to the flowchart for details of program flow.

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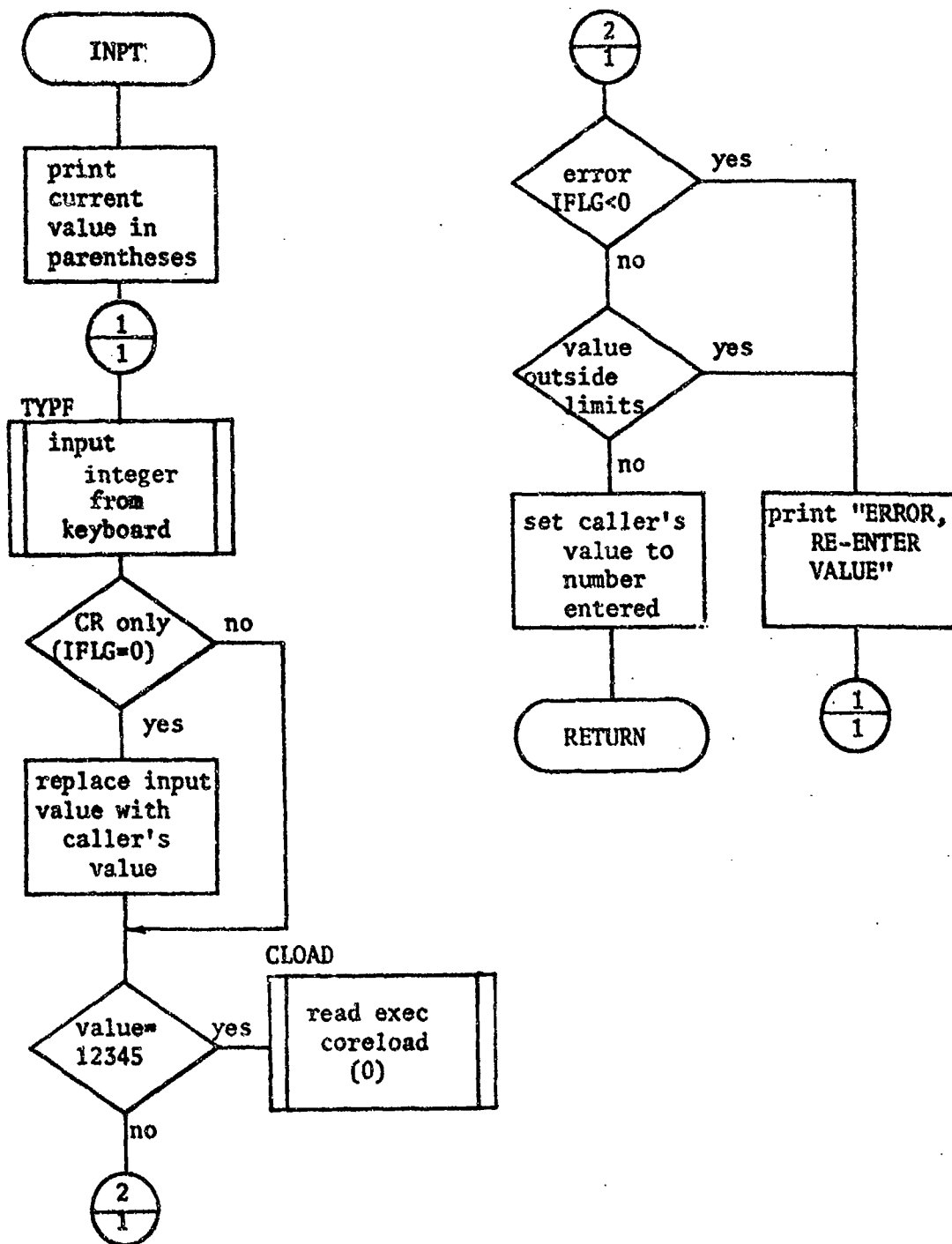


Figure 4.5.10-1 (U)

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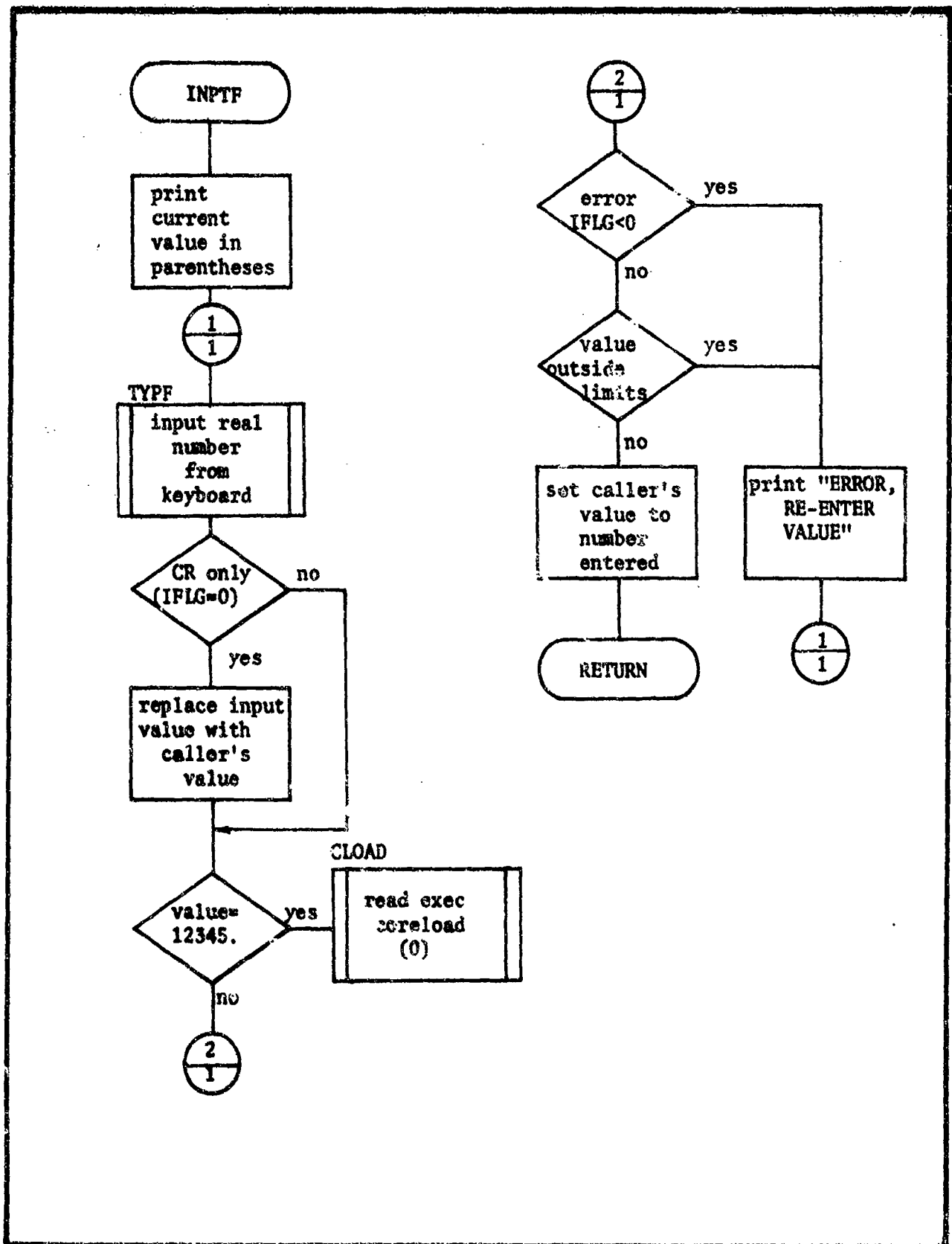


Figure 4.5.10-2 (U)

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INPTF Sheet 1 of 1

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SUBROUTINES: (U) DIRECT TYPEWRITER INPUT, TYPI, TYPF, TYP A 4.5.11

1. (U) FUNCTION. TYPI, TYPF, and TYP A Subroutines perform keyboard input of integer and real strings and single ASCII characters, respectively. These subroutines bypass IOC and its requirement for linefeed to be pressed and its lack of error checking. They also permit null entries.

2. (U) CONSTRAINTS. A maximum of 20 characters may be entered. No check is made for multiple + or - or . signs or values greater than can be held in 16 bits, all of which are error conditions.

3. (U) CALLING SEQUENCE.

CALL TYPI (IVAL,IFLG)

IVAL is the location where the entered value is stored

IFLG is the location where the error flag is stored

CALL TYPF (VAL,IFLG)

VAL is the location where the entered real value is stored

IFLG is the location where the error flag is stored

CALL TYP A (IVAL,IFLG)

IVAL is the location where the ASCII character is stored

IFLG is the location where the error flag is stored

IFLG is set negative for error, zero for no input, and positive for good input.

4. (U) DESCRIPTION OF INPUT. Input is an ASCII string entered through the keyboard, followed by a carriage return. A DEL character deletes the entire line. A carriage return alone causes a return with IFLG set to zero.

5. (U) DESCRIPTION OF OUTPUT. Output is the value entered in integer format (for TYPI), in real format (for TYPF), or the single ASCII character (for TYP A).

6. (U) FILES USED. None

7. (U) ERRORS. None

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

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9. (U) DESCRIPTION OF PROCESSING. TYPI, TYPF, and TYPA use their own I/O routines. To keep from interrupting BCS output, ENDIO is called at the beginning of each. The Formatter is called to convert the integer character string to binary in its internal conversion mode. However, in this mode there is no capability for supplying a character count. To overcome this shortcoming, a space is stored following the last character, as a delimiter. All other program details are shown in the flow chart, Figure 4.5.11-1, and the user is directed there for further information.

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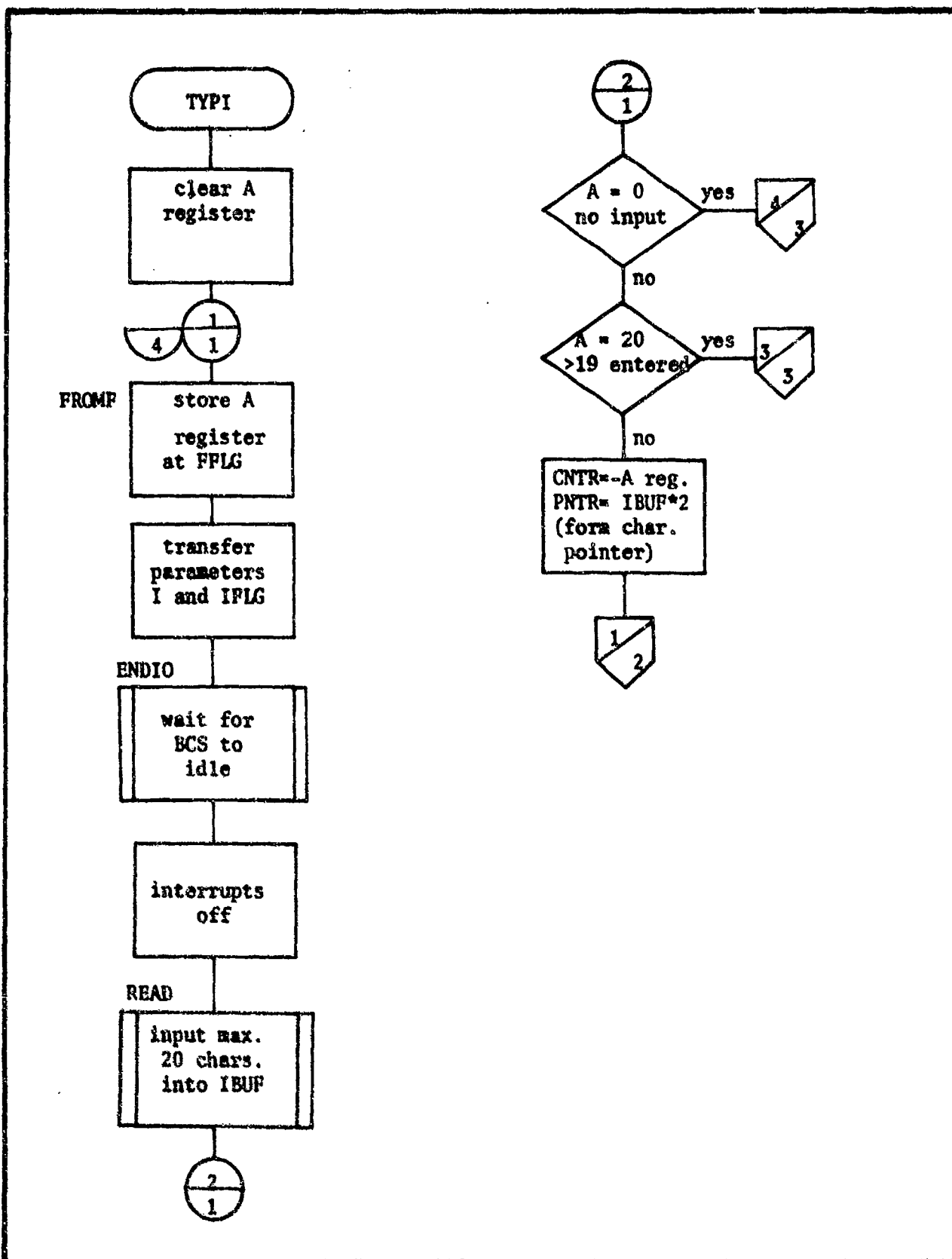


Figure 4.5.11-1 (U)

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TYPI Sheet 1 of 11

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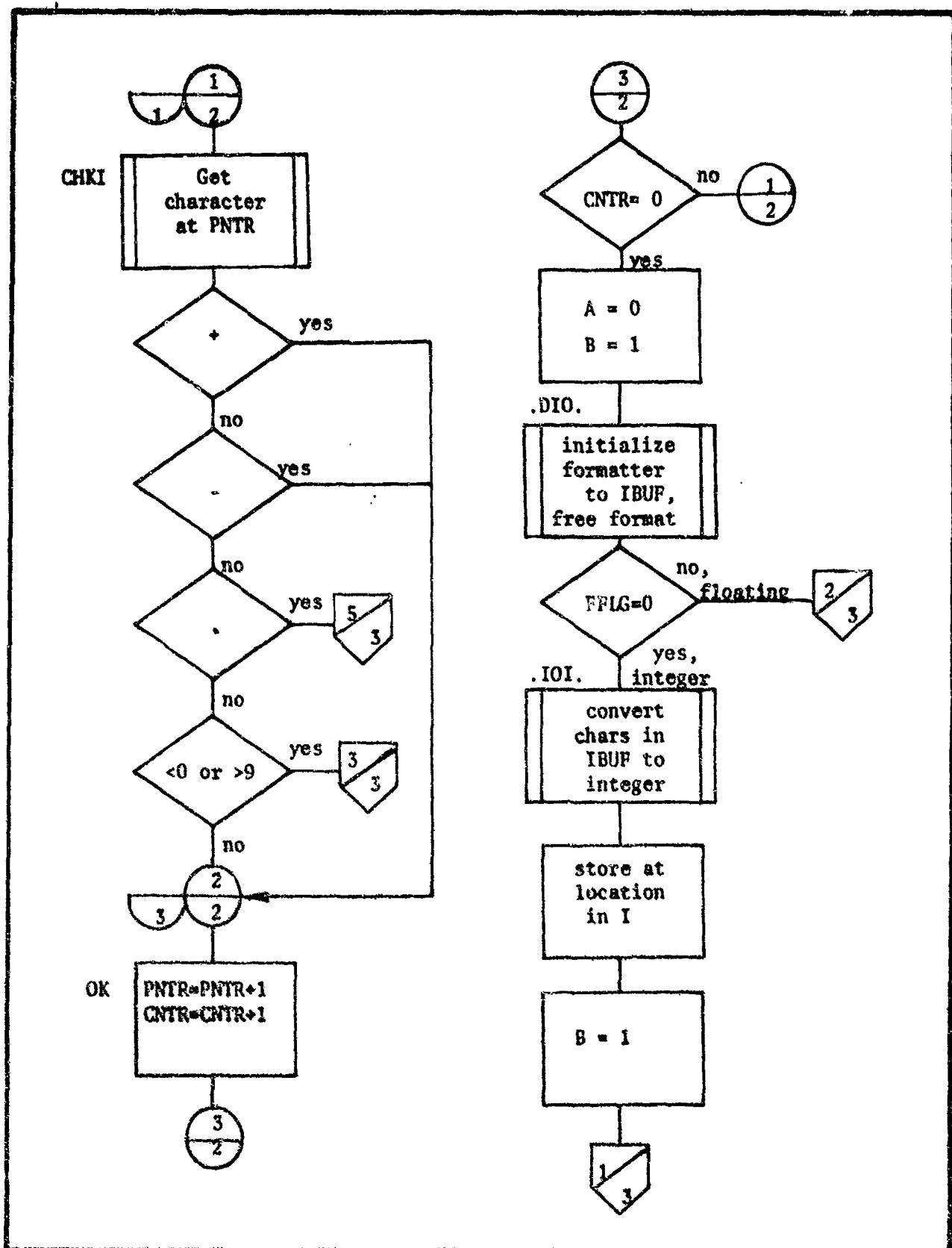


Figure 4.5.11-1 (U)

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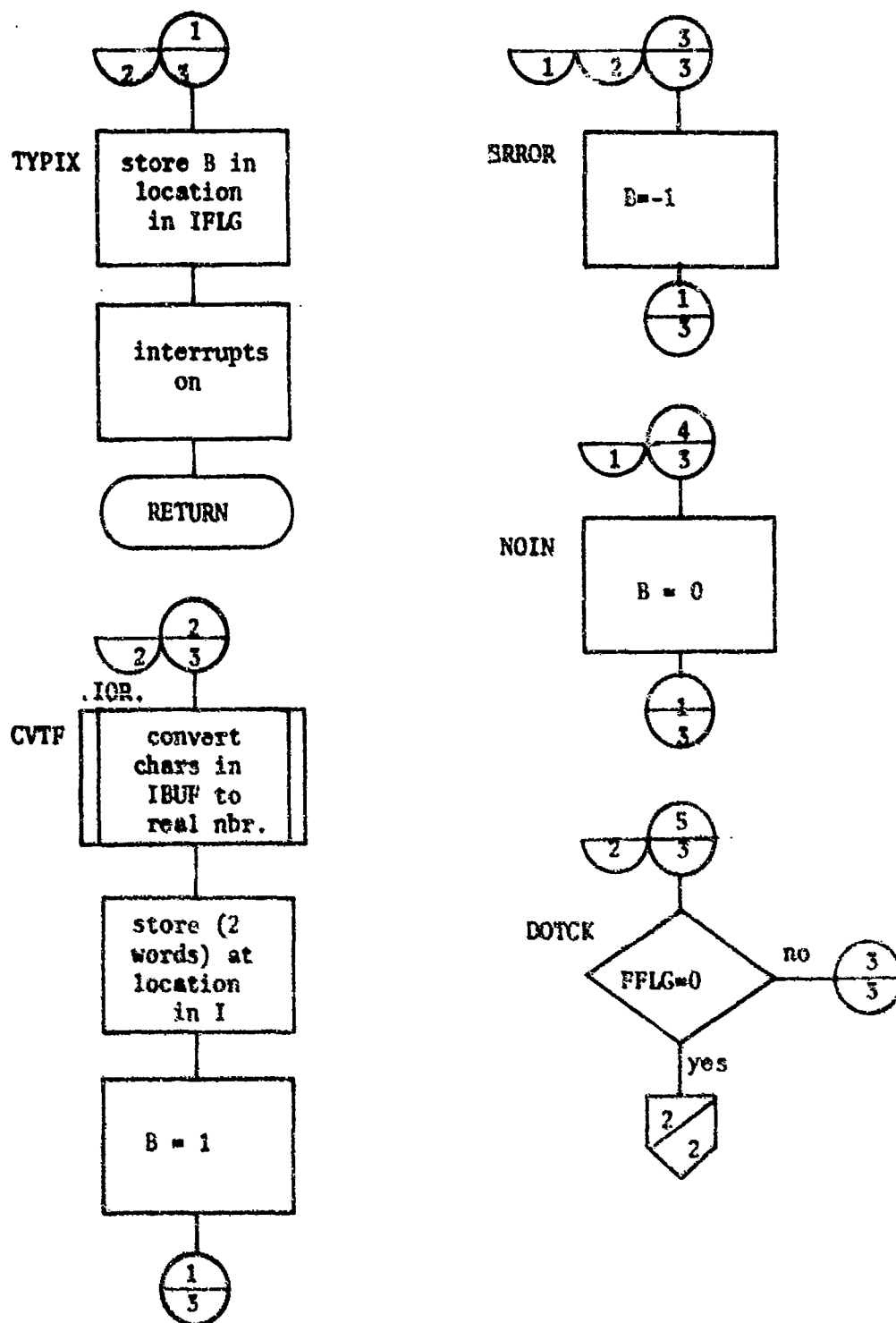


Figure 4.5.11-1 (U)

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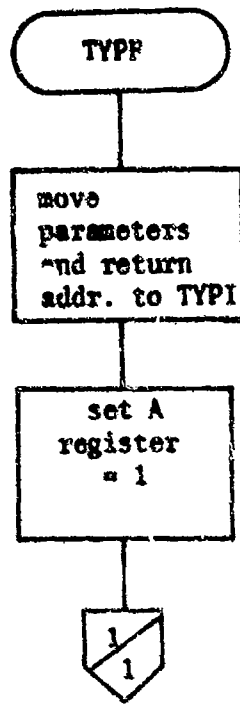


Figure 4.5.11-1 (U)

TYPI Sheet 4 of 11

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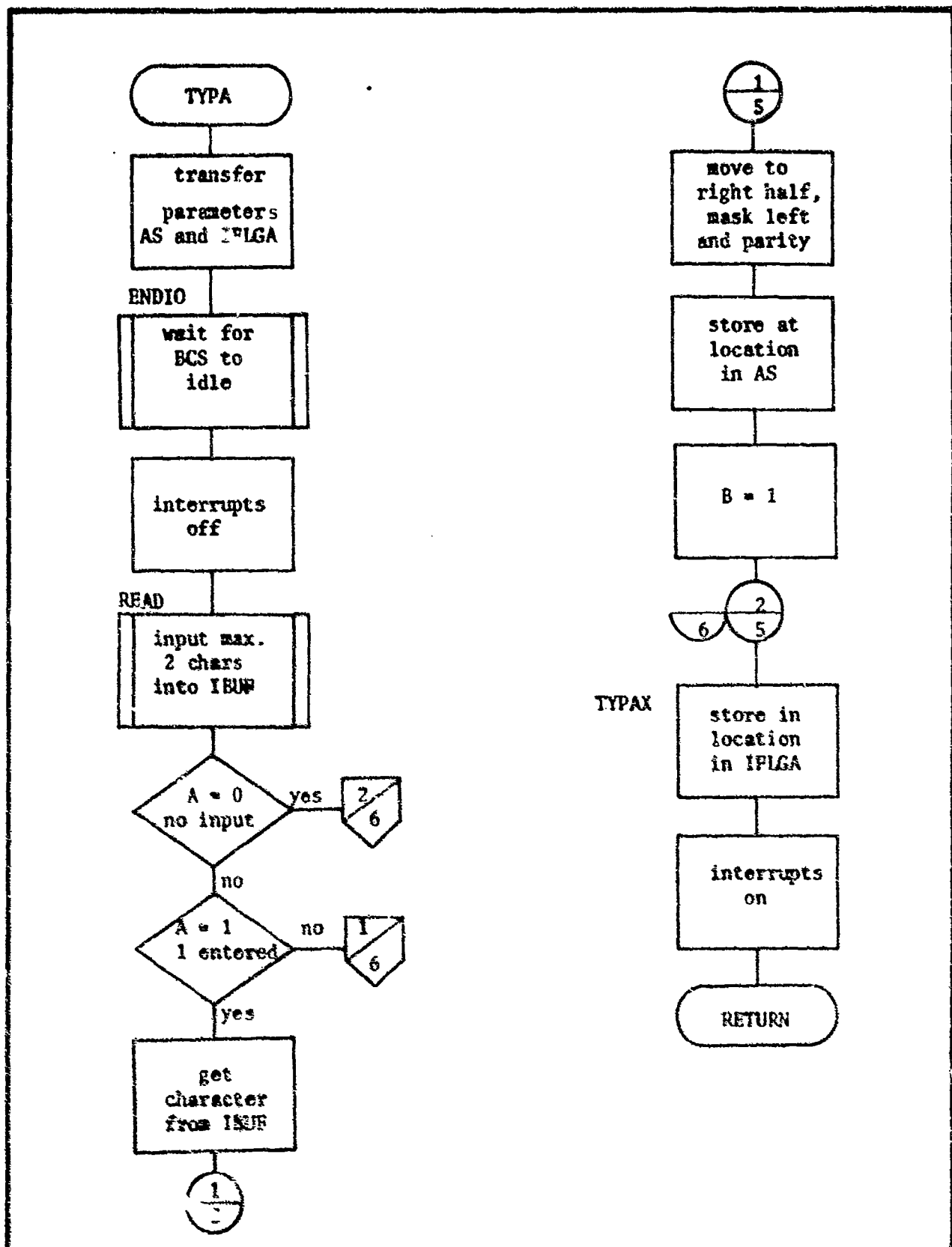


Figure 4.5.11-1 (U)

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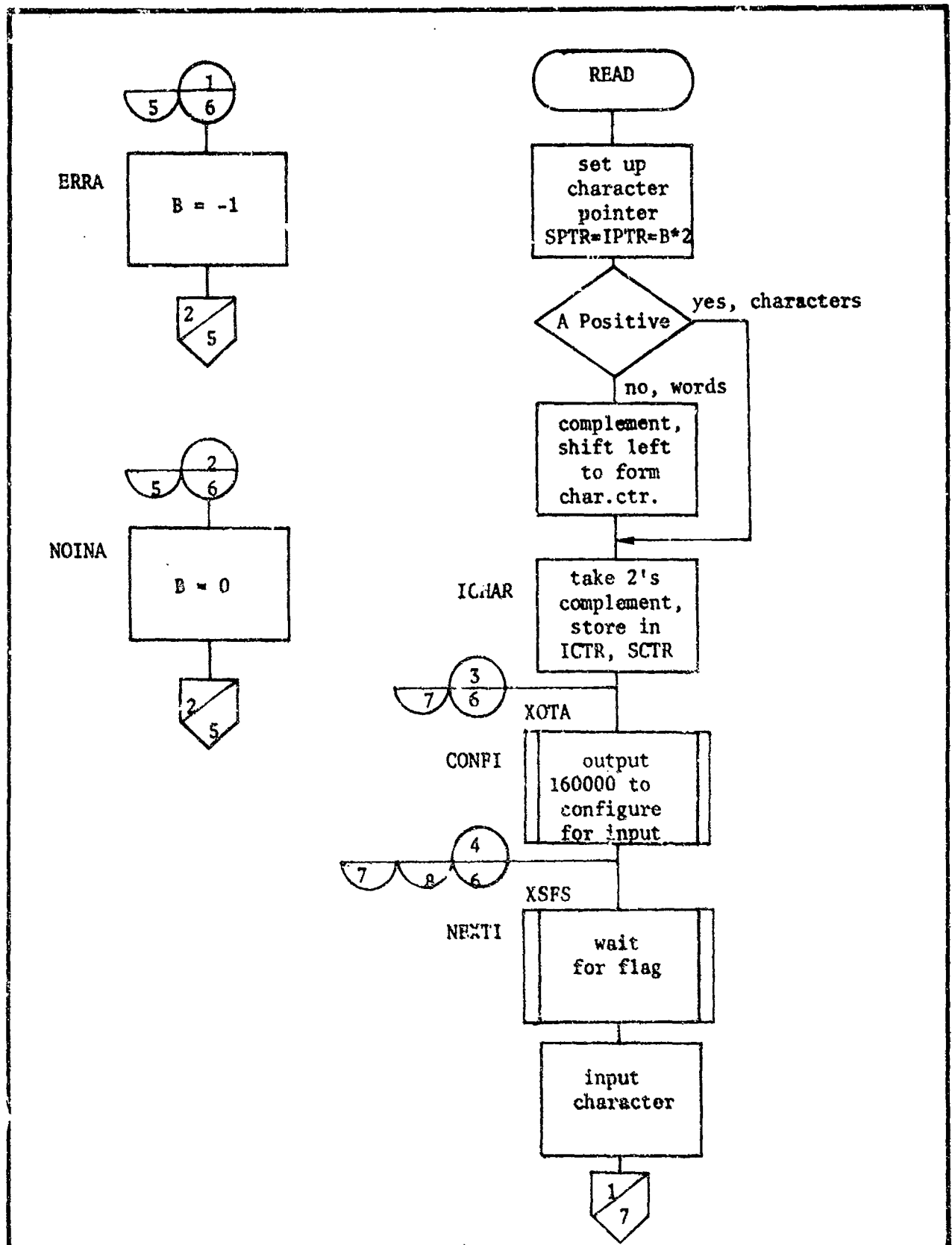


Figure 4.5.11-1 (U)

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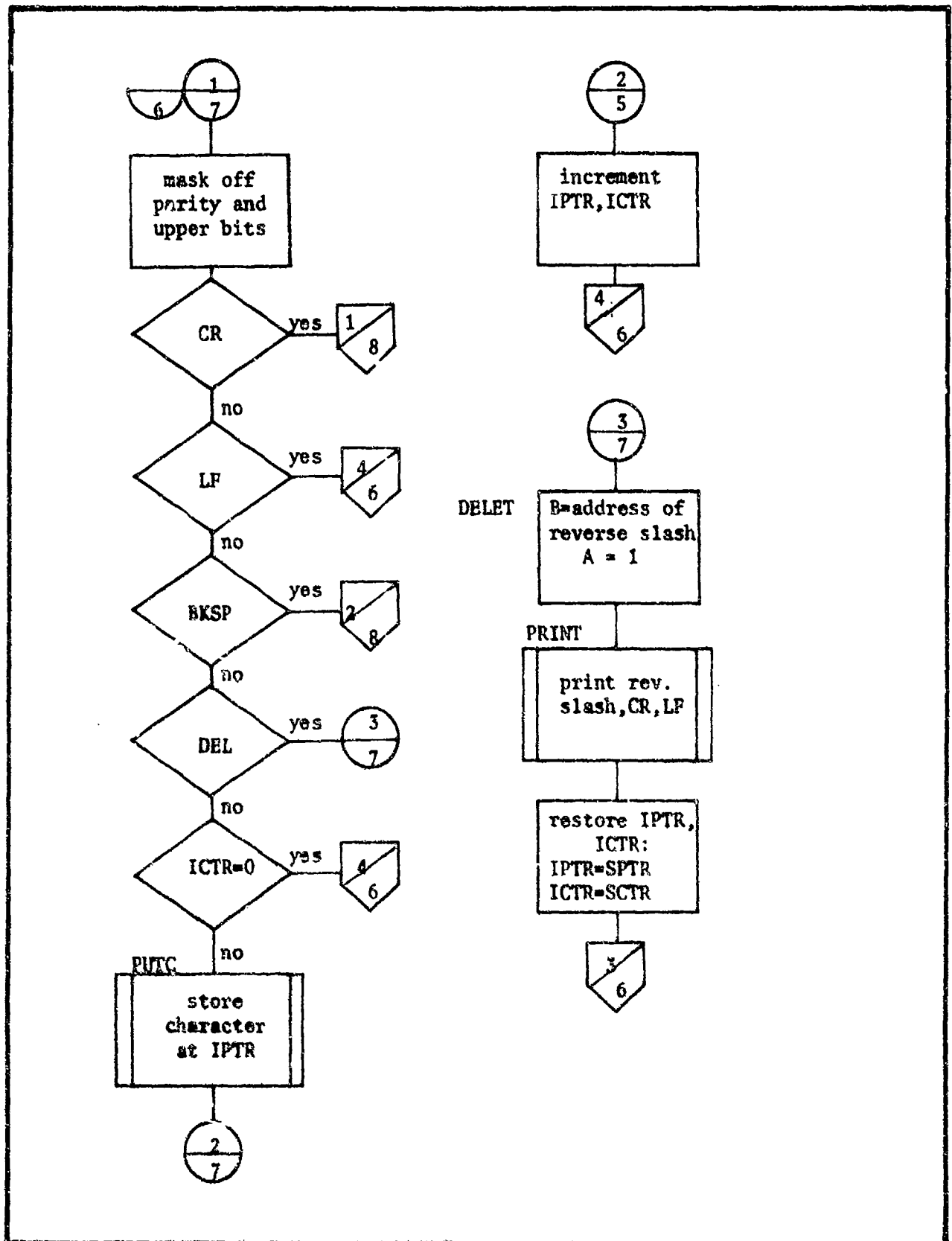


Figure 4.5.11-1 (U)

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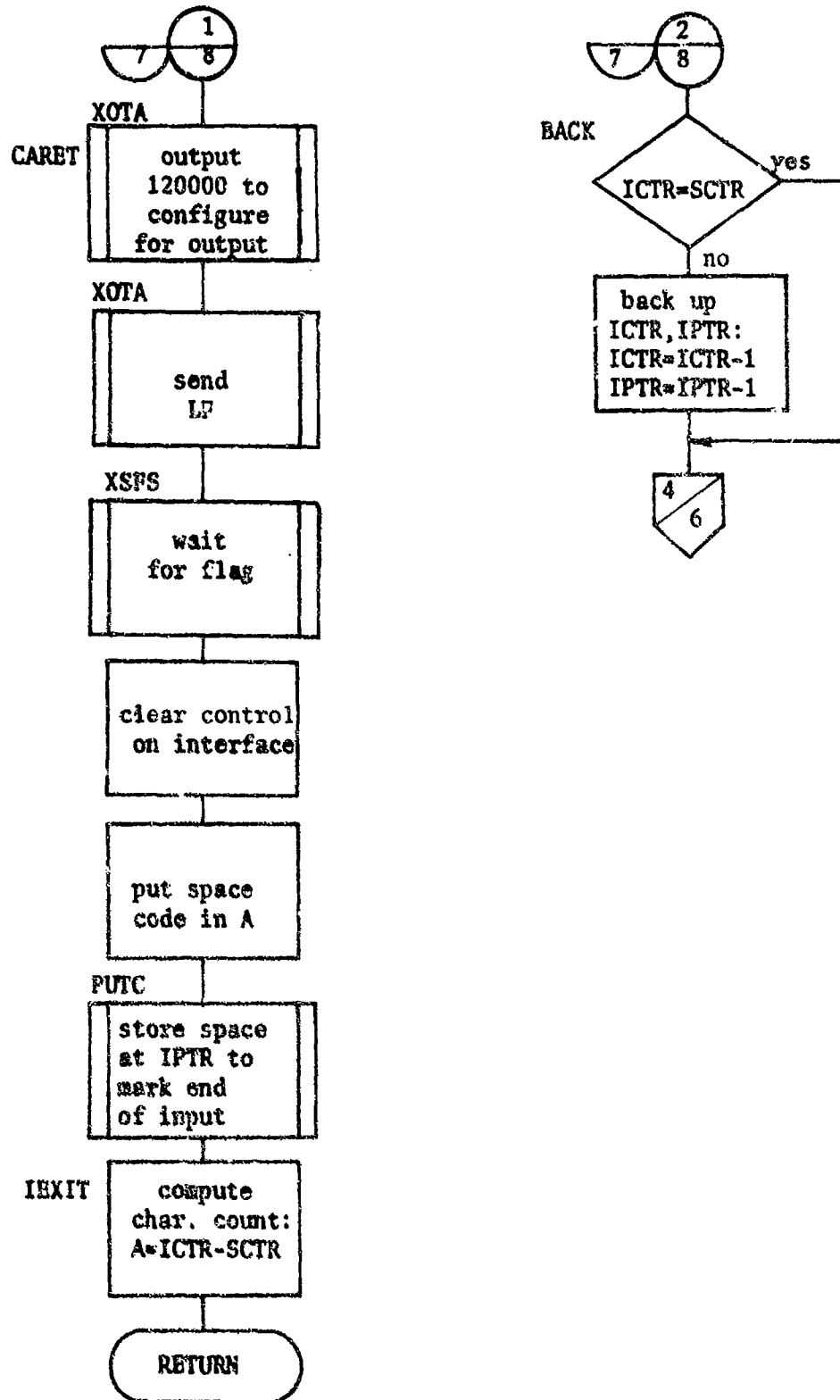


Figure 4.5.11-1 (U)

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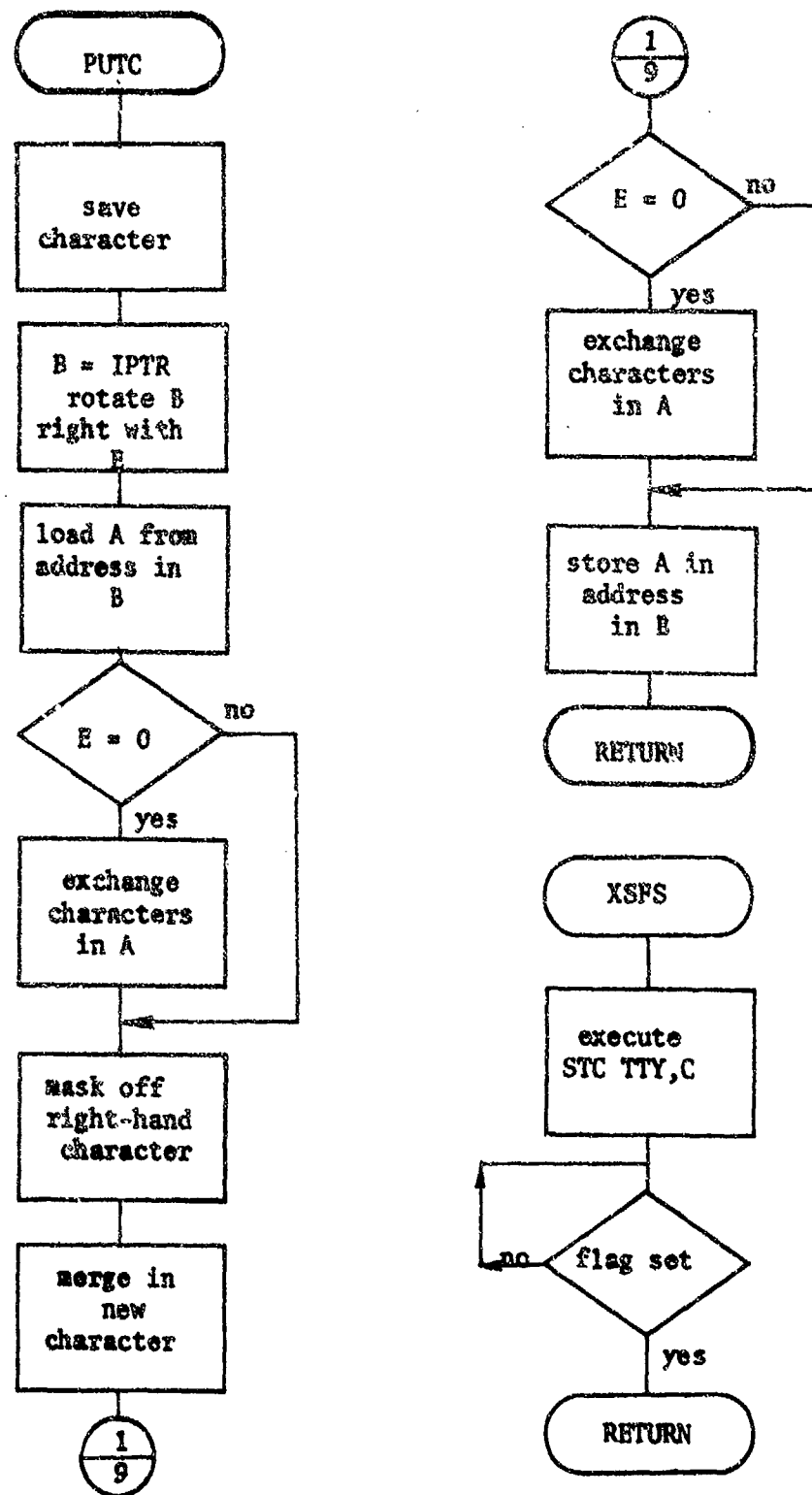


Figure 4.5.11-1 (U)

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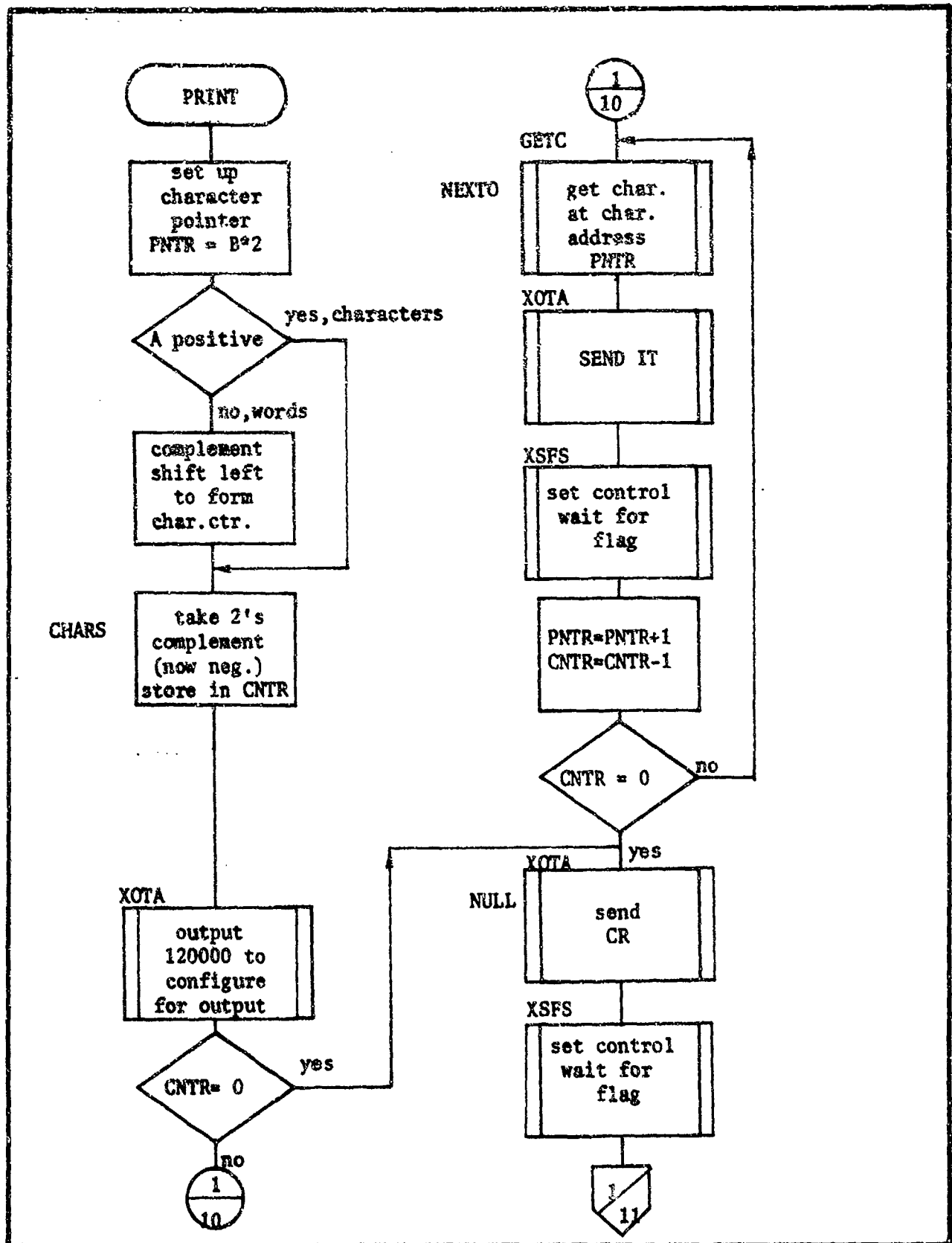


Figure 4.5.11-1 (U)

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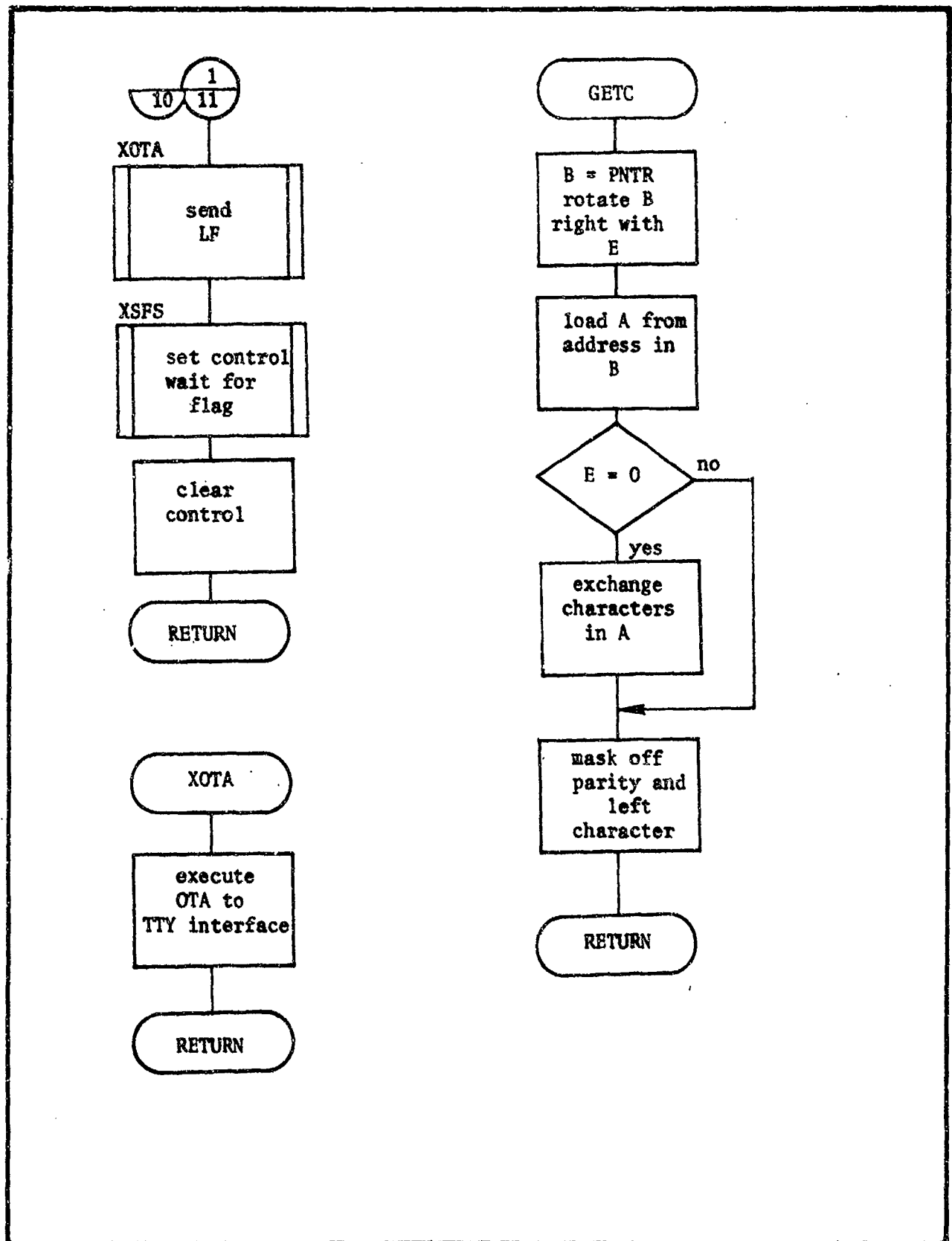


Figure 4.5.11-1 (U)

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SUBROUTINE: (U) PARAMETER EDIT, PEDIT

4.5.12

1. (U) FUNCTION. PEDIT modifies certain infrequently changed variables on the disc common track.
2. (U) CONSTRAINTS. None
3. (U) CALLING SEQUENCE. Called by Y0000.

CALL PEDIT

4. (U) DESCRIPTION OF INPUT. See general system operating instructions.
5. (U) DESCRIPTION OF OUTPUT. See Table 4.1-1, Disk Common Assignments.
6. (U) FILES USED. The common data track (ICOM0) is read and modified.
7. (U) ERRORS. None
8. (U) COMPUTER OPERATOR INSTRUCTIONS. See general system operating instructions.
9. (U) DESCRIPTION OF PROCESSING. Figure 4.5.12-1. PEDIT first reads sector 0 of the disc common track. For information on the modifications made to this data, the user is referred to the flowchart. The modified data is only written back on the disc at the request of the operator, immediately before returning control to the TAP II Executive.

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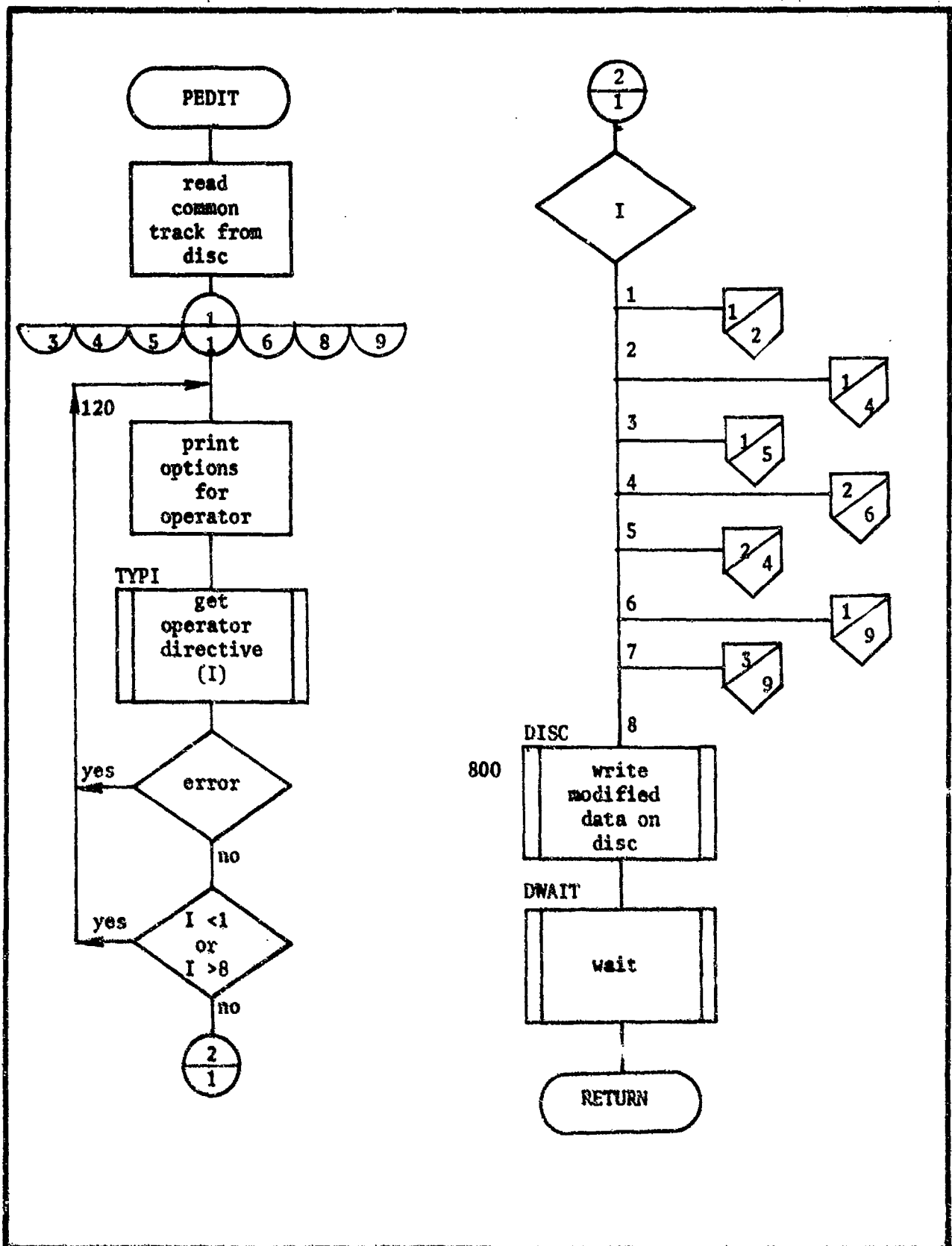


Figure 4.5.12-1 (U)

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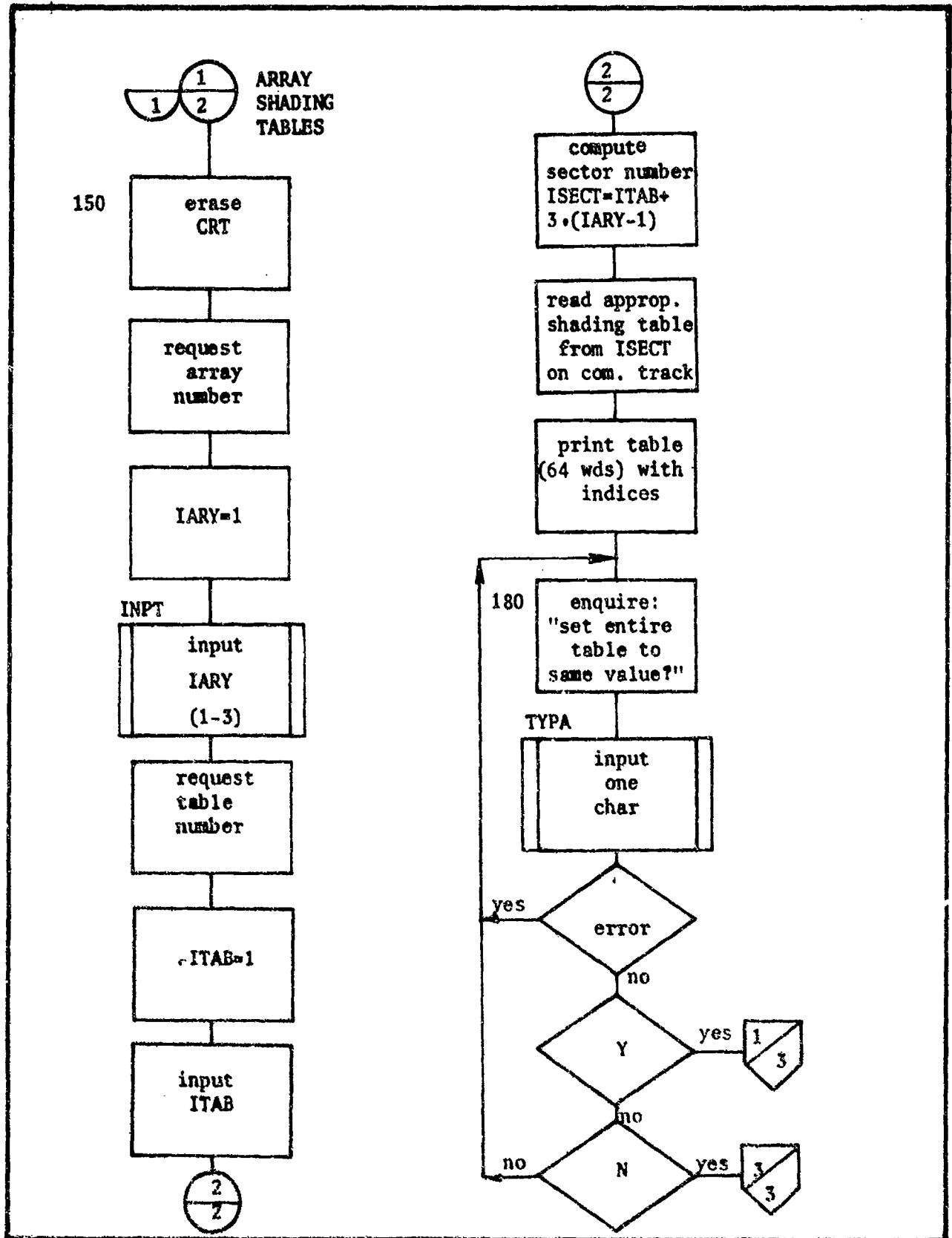


Figure 4.5.12-1 (U)

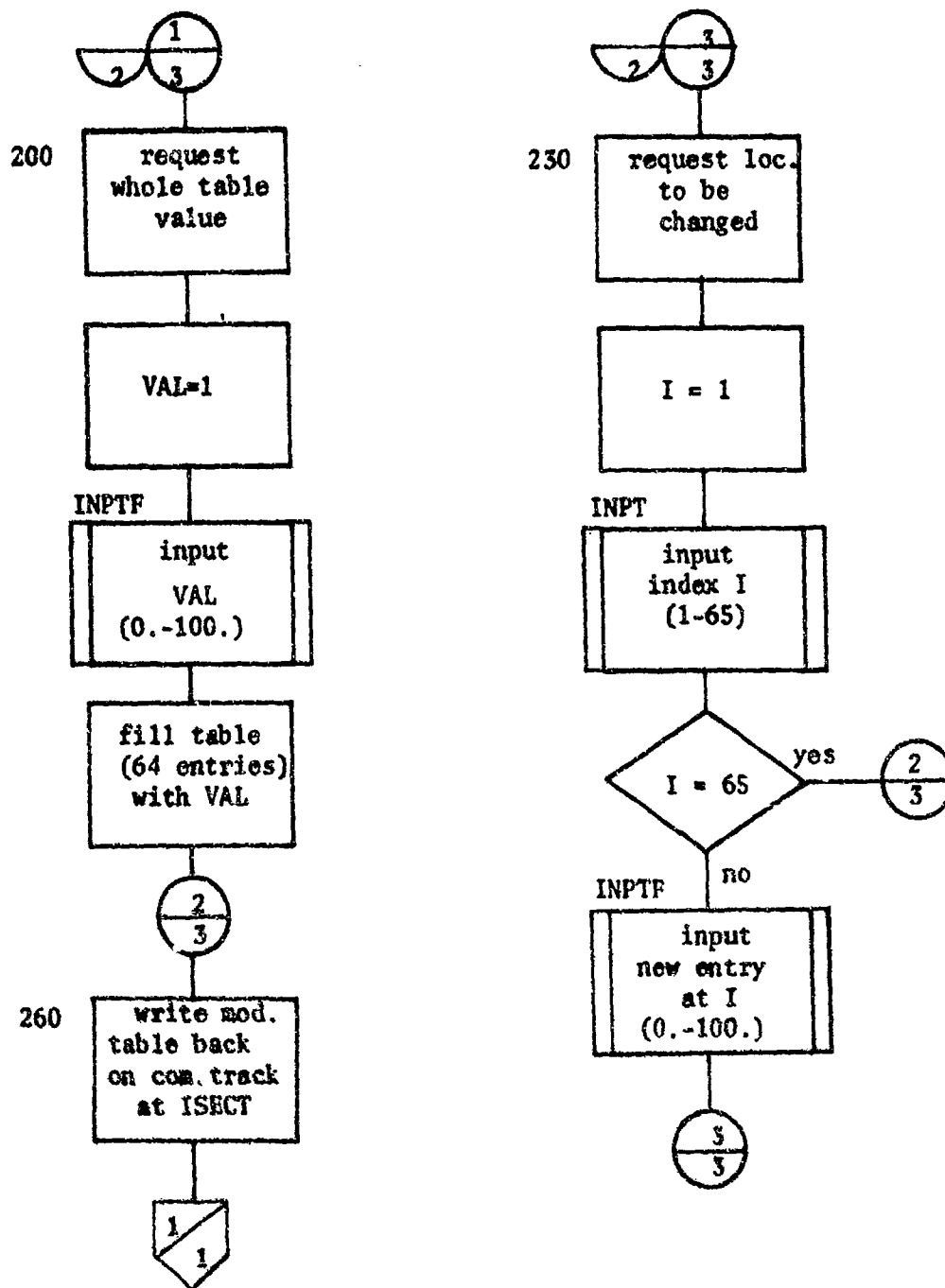


Figure 4.5.12-1 (U)

PEDIT Sheet 3 of 9

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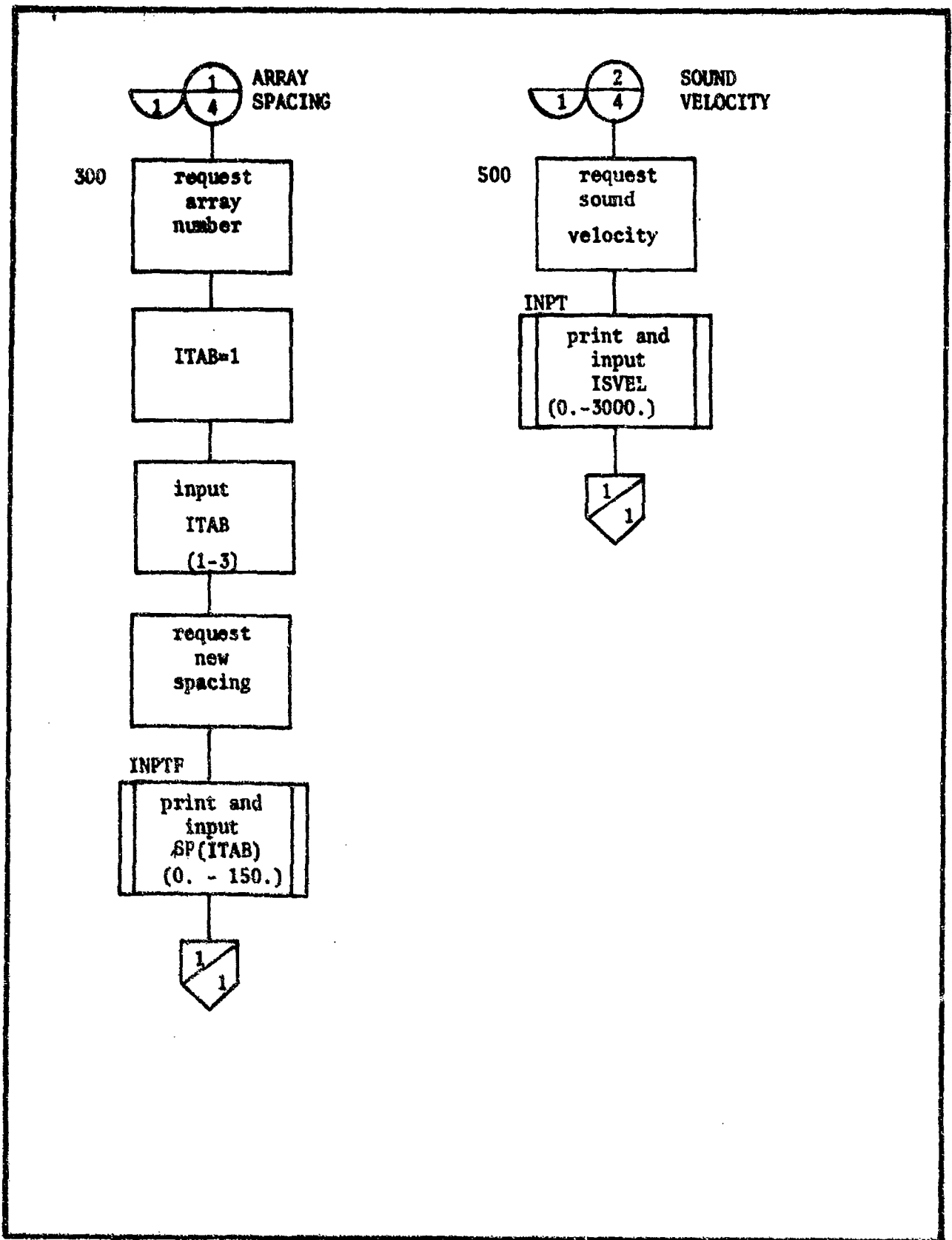


Figure 4.5.12-1 (U)

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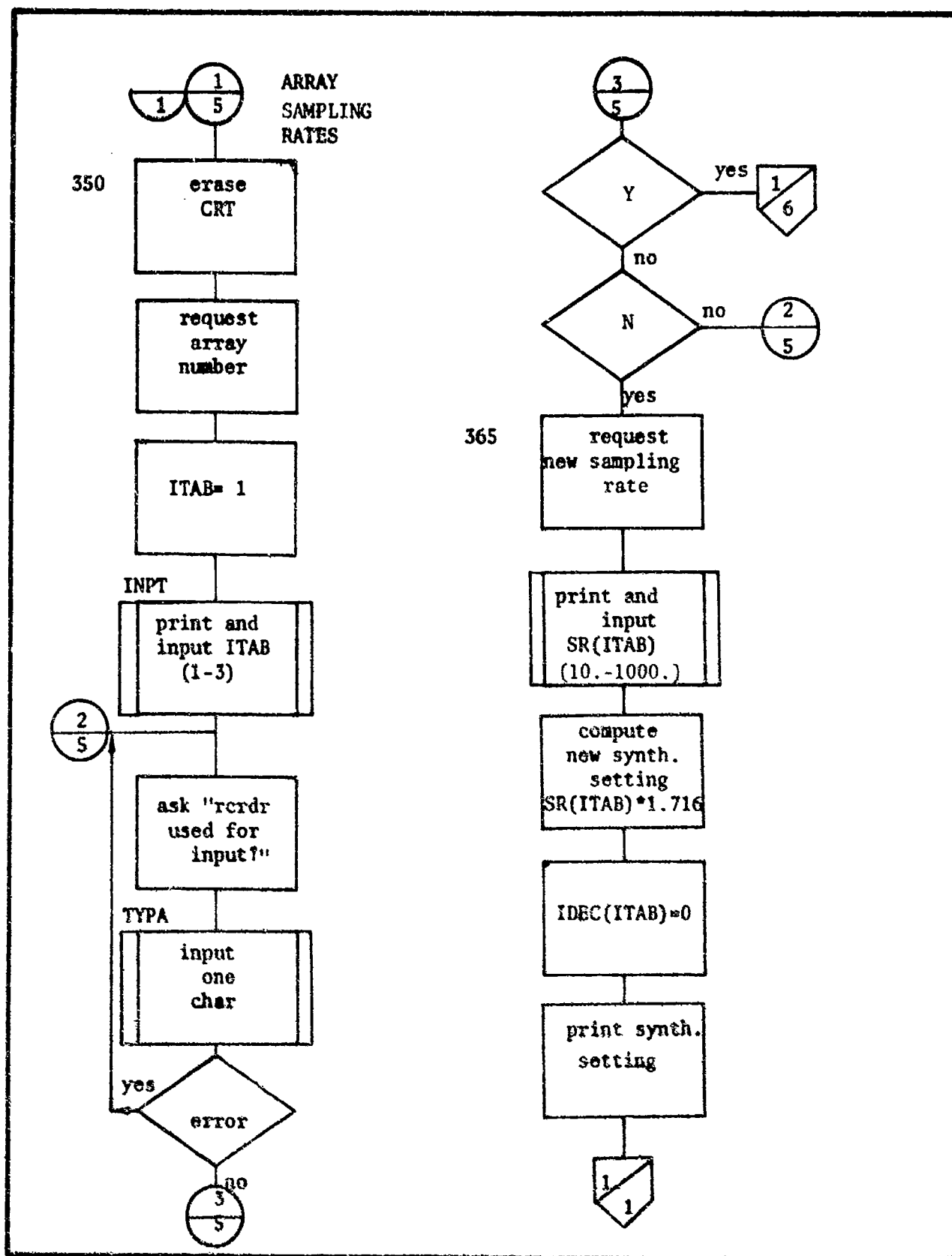


Figure 4.5.12-1 (U)

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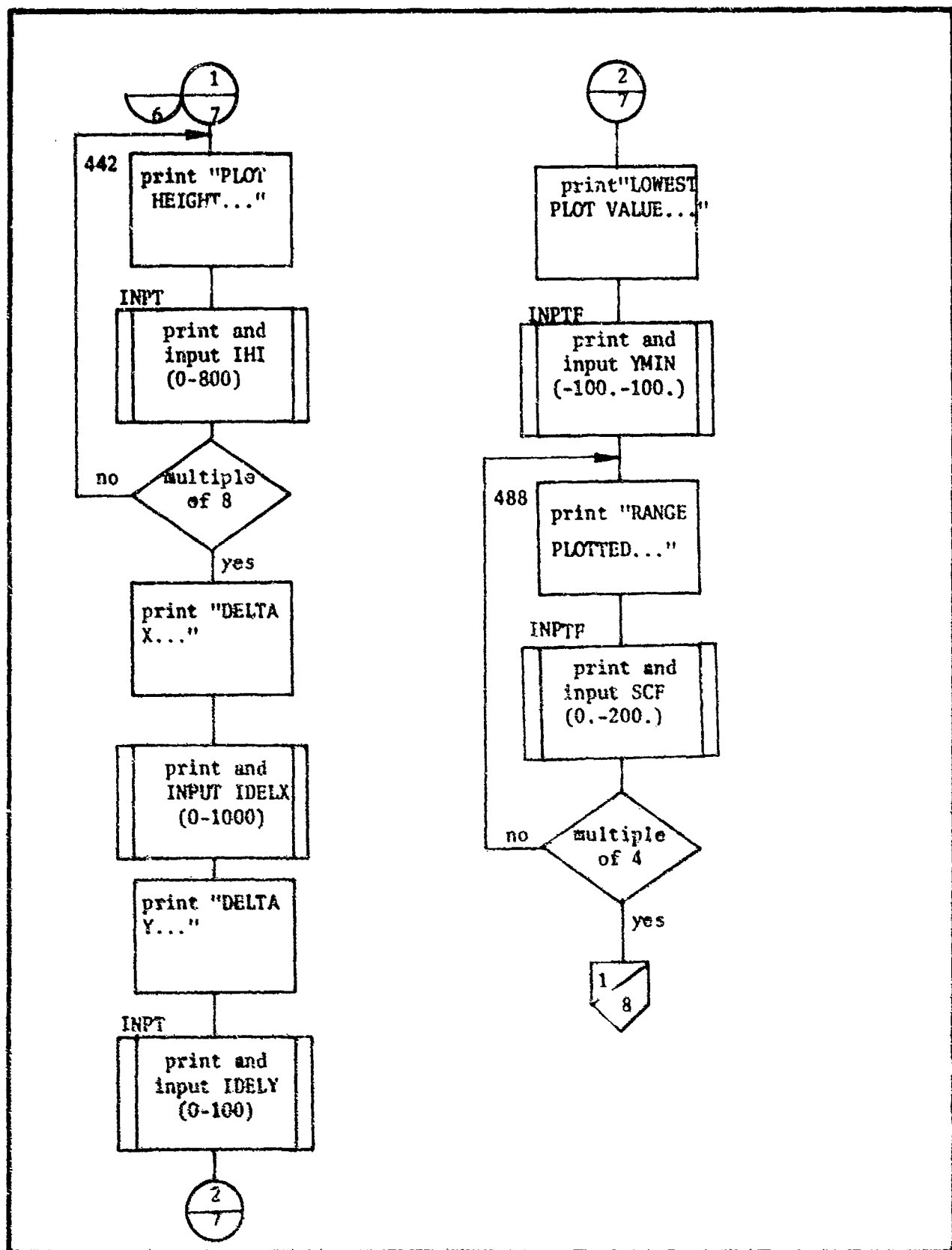


Figure 4.5.12-1 (U)

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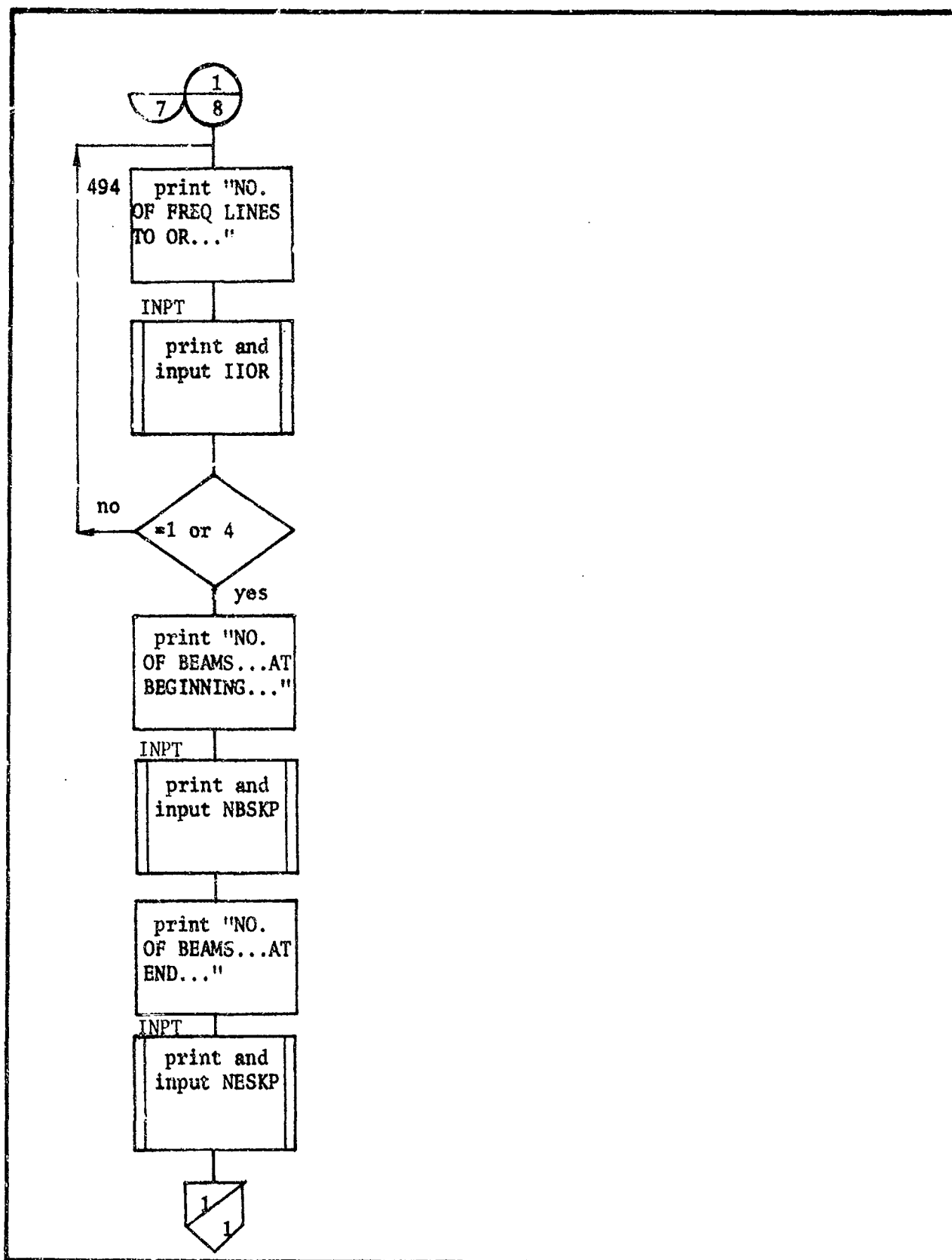


Figure 4.5.12-1 (U)

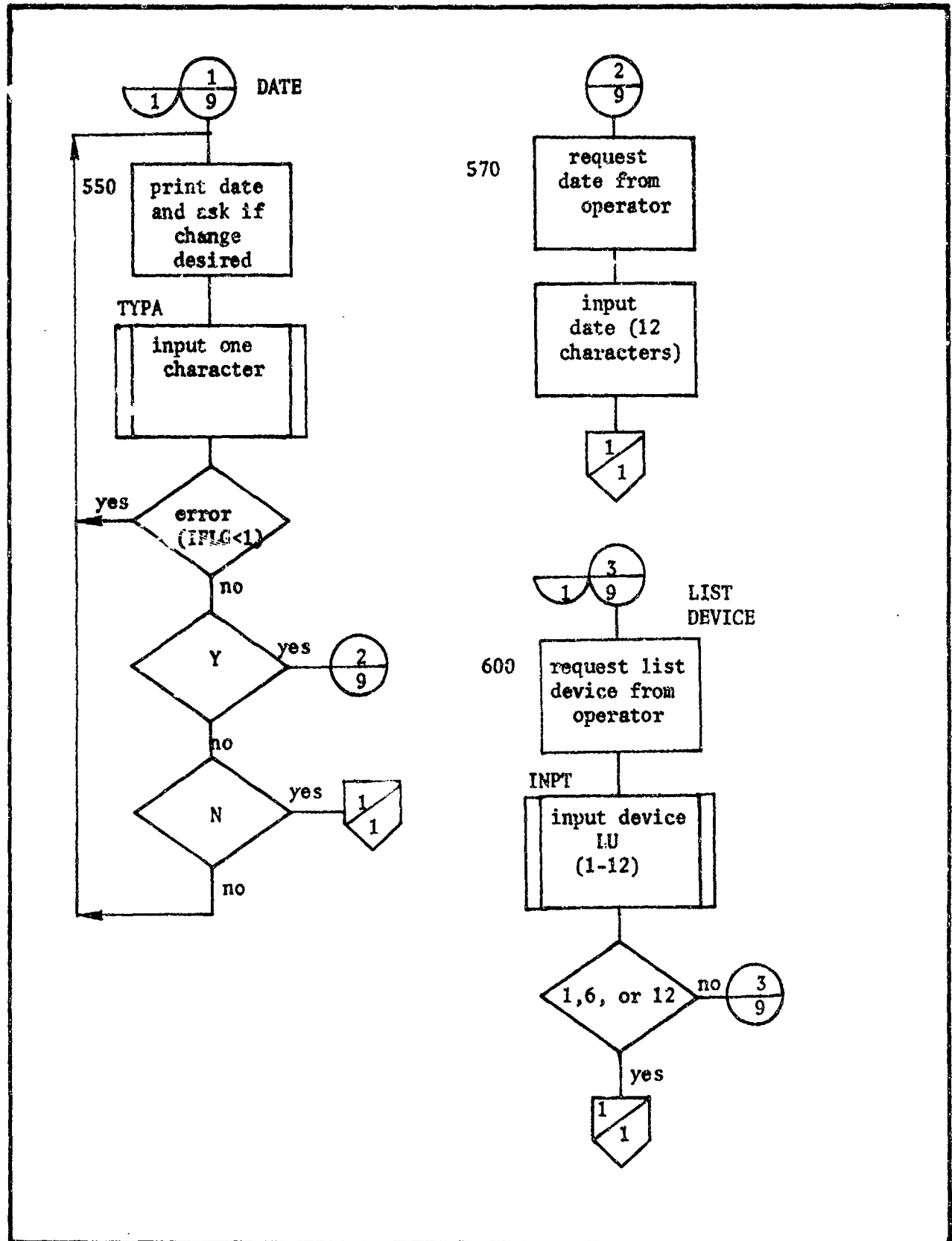


Figure 4.5.12-1 (U)

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SUBROUTINE: (U) CORE LOAD, CLOAD

4.5.13

1. (U) FUNCTION. CLOAD loads all of core (locations 2-77577) from six consecutive disc tracks specified in the calling sequence, and transfers control to a location in the new core load specified in the calling sequence.

2. (U) CONSTRAINTS. NIBBL must be in core in locations 77600-77677. NIBBL must be the unmodified HP version, since it is modified by CLOAD. The transfer address must be in base page.

3. (U) CALLING SEQUENCE.

CALL CLOAD (ICYL, IXFER)

where ICYL is the starting cylinder number of the desired coreload
IXFER is the transfer address in the new coreload.

4. (U) DESCRIPTION OF INPUT. Unknown

5. (U) DESCRIPTION OF OUTPUT. None

6. (U) FILES USED. N/A

7. (U) ERRORS. A non-recoverable error will occur if a disc transfer error or a disc status error occurs.

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. CLOAD uses NIBBL, the Disc Basic Binary Loader which reads or writes an entire coreload. However, NIBBL is a manually operated program and normally halts upon completion rather than returning to a calling program. Also, since all of core up to NIBBL will be overlaid by the new coreload, it would be impossible to return control to CLOAD. Therefore, CLOAD modifies NIBBL to return to an address specified in the CLOAD calling sequence. Processing, Figure 4.5.13-1, is as follows: CLOAD turns off interrupts, combines the transfer address in the calling sequence with a JMP instruction, and stores this in NIBBL where the completion halt usually is. The cylinder number is obtained from the calling sequence and placed in the B register, and NIBBL is entered, with A=0. NIBBL will read the desired coreload and transfer control to the specified address.

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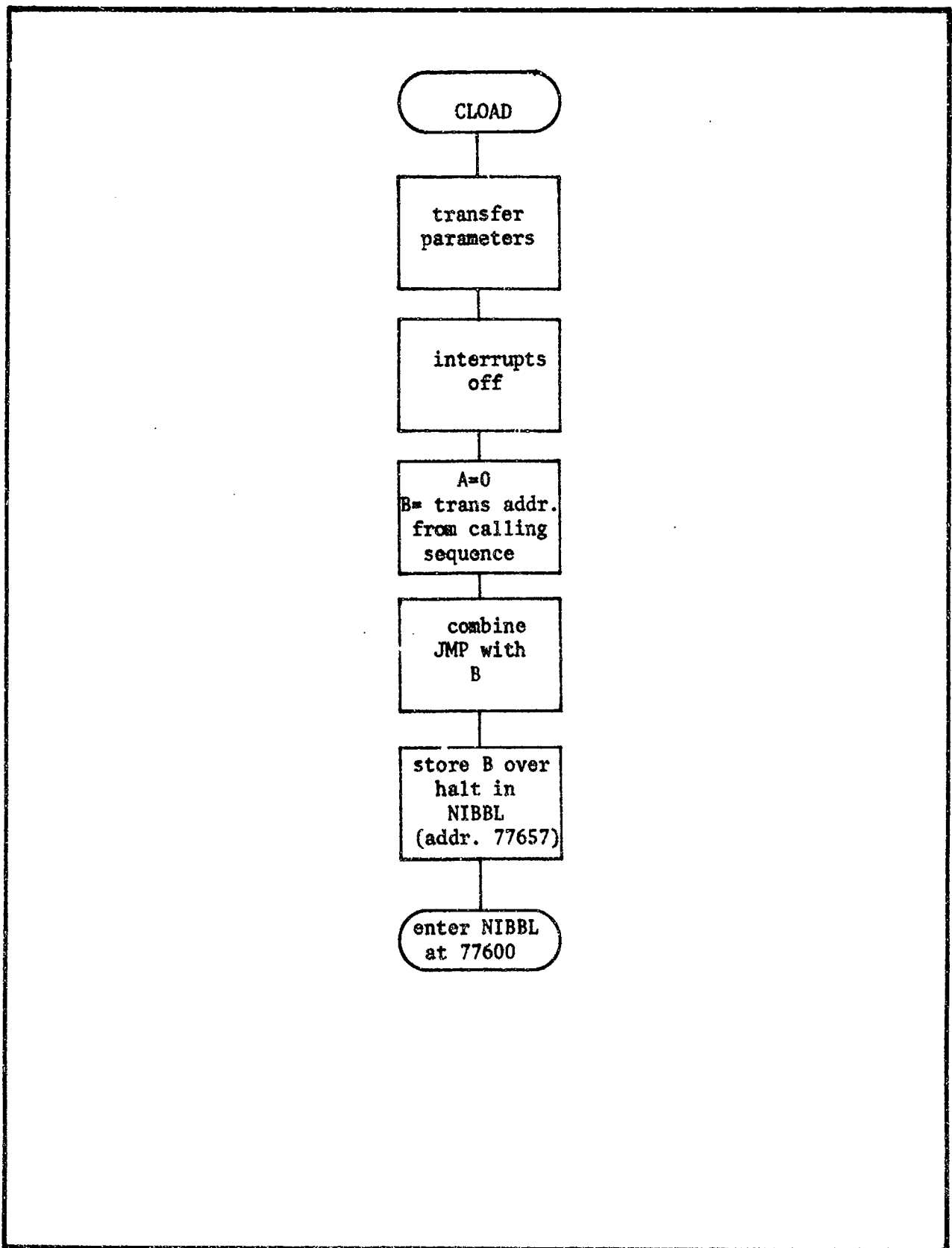


Figure 4.5.13-1 (U)

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TABLE: (U) TRACK ALLOCATION TABLE, TAT

4.5.14

1. (U) FUNCTION. TAT is a non-executable program unit which provides disc track assignment information to various programs.
2. (U) CONSTRAINTS. None
3. (U) CALLING SEQUENCE. Used by Y0002, Y0003, Y0004, DISC.
4. (U) DESCRIPTION OF INPUT. N/A
5. (U) DESCRIPTION OF OUTPUT. N/A
6. (U) FILES USED. N/A
7. (U) ERRORS. N/A
8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A
9. DESCRIPTION OF PROCESSING. TAT has the following entry points. Referencing them as externals provides the required information to the other program.
 - 1) FTUD - first track upper disc
 - 2) ITMPO - first track high speed data (relative to FTUD)
 - 3) IDATO - first tract low speed data (relative to FTUD)
 - 4) ICOMO - first track common data (relative to FTUD)

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SUBROUTINE: (U) CONVERT LINE GROUP DATA (PUT)

4.5.15

1. (U) FUNCTION. PUT subroutine gets data from line group IGP, converts it to Log Magnitude in the 120B and returns a pointer to the position in the table in which IGP was found.

2. (U) CONSTRAINTS. The AP-120B must be on and initialized. Data must be accessible on disc.

3. (U) CALLING SEQUENCE. Called by LGPLT:

CALL PUT (IGP, II, ITR0, ILOC)

(Group number list, index for list of group numbers, disc track number, Location Tag: 1 = Lower, 2 = Upper 120B Memory).

4. (U) DESCRIPTION OF INPUT. A 4224-word record is input from disc.

5. (U) DESCRIPTION OF OUTPUT. Log Magnitude scaled data is stored in 4224 locations in 120B core memory.

6. (U) FILES USED. The IGP File is on disc.

7. (U) ERRORS. An error is returned if no match for IGP is found.

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. Flowchart, Figure 4.5.15-1. The PUT subroutine searches the list of eight group numbers until a match is found for IGP, with an error return if there is no match. The disc track offset from ITR0 is calculated and the desired group is moved from disc to 120B core, lower memory if ILOC=1, upper memory if ILOC=2. Data is converted to log magnitude. (The last number in the group must be computed separately.) The index II is returned as a calling parameter.

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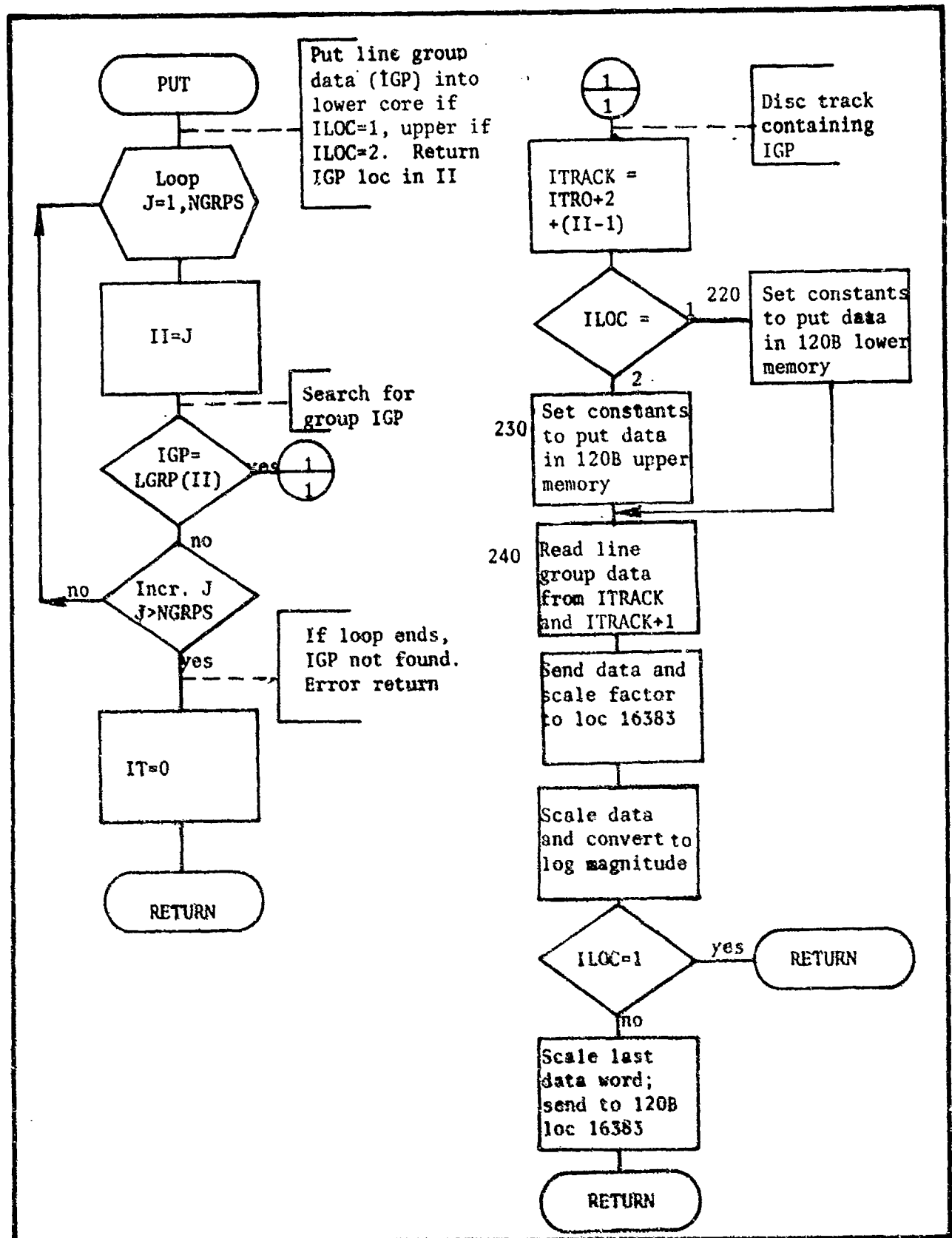


Figure 4.5.15-1 (U)

PUT Sheet 1 of 1

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SUBROUTINE: (U) DRAW AXIS, AXIS

4.5.16

1. (U) FUNCTION. Subroutine AXIS draws X, Y and Z axes with tick marks and prints labels consistent with parameters which will control the plotted data.

2. (U) CONSTRAINTS. Options and parameters must have been previously stored in the common area.

3. (U) CALLING SEQUENCE. Called by LGPLT:

CALL AXIS (MAXPLT, NPTS, IG1, IG2, NP)

The parameters are: maximum number of plots, number of points per plot, Group 1 identification, Group 2 identification, No. of groups (1 or 2).

4. (U) DESCRIPTION OF INPUT. Pre-stored values and control parameters are in the common area.

5. (U) DESCRIPTION OF OUTPUT. The X, Y and Z axes, with tick marks and label values, are displayed on the Tektronix 4010 Graphics CRT.

6. (U) FILES USED. ICOM (128) in main memory and disc common area.

7. (U) ERRORS. Some selections of control parameters may cause overflow of CRT screen display area and consequent wrap-around. (Z-axis is limited to prevent this effect.) IHI should not exceed 800 plot points and the product of NPTS and INCRX should not exceed 1020 plot points.

8. (U) COMPUTER OPERATOR INSTRUCTIONS. See 7. above.

9. (U) DESCRIPTION OF PROCESSING. Figure 4.5.16-1. Parameters are initialized for either normal plot or for ORed 4-point fast plot if IIOR FLAS is set. The cursor is set to plot origin and the screen is erased. For the X-axis, the interval between tick marks is calculated. For each mark, the axis segment to the mark is drawn, then the mark is drawn. The group identification is written below the X-axis (both are written if NP = 2). For the Y-axis, the first tick mark is made and labeled, then each 1/8 segment is drawn and a tick mark is drawn. The even tick marks are labeled with the appropriate amplitude value in db. The Z-axis is drawn from the right end of the X-axis, the angle is determined by common parameters or changed if the IIOR flag is set. A tick mark is made for each plot line expected (MAXPLT), and every 10th one labeled with 1, 2, 3, etc. The sixth label is suppressed for a normal plot to prevent wraparound to the left side of the display. The Z-axis is limited in X and Y to prevent overflow which could be caused by some parameters.

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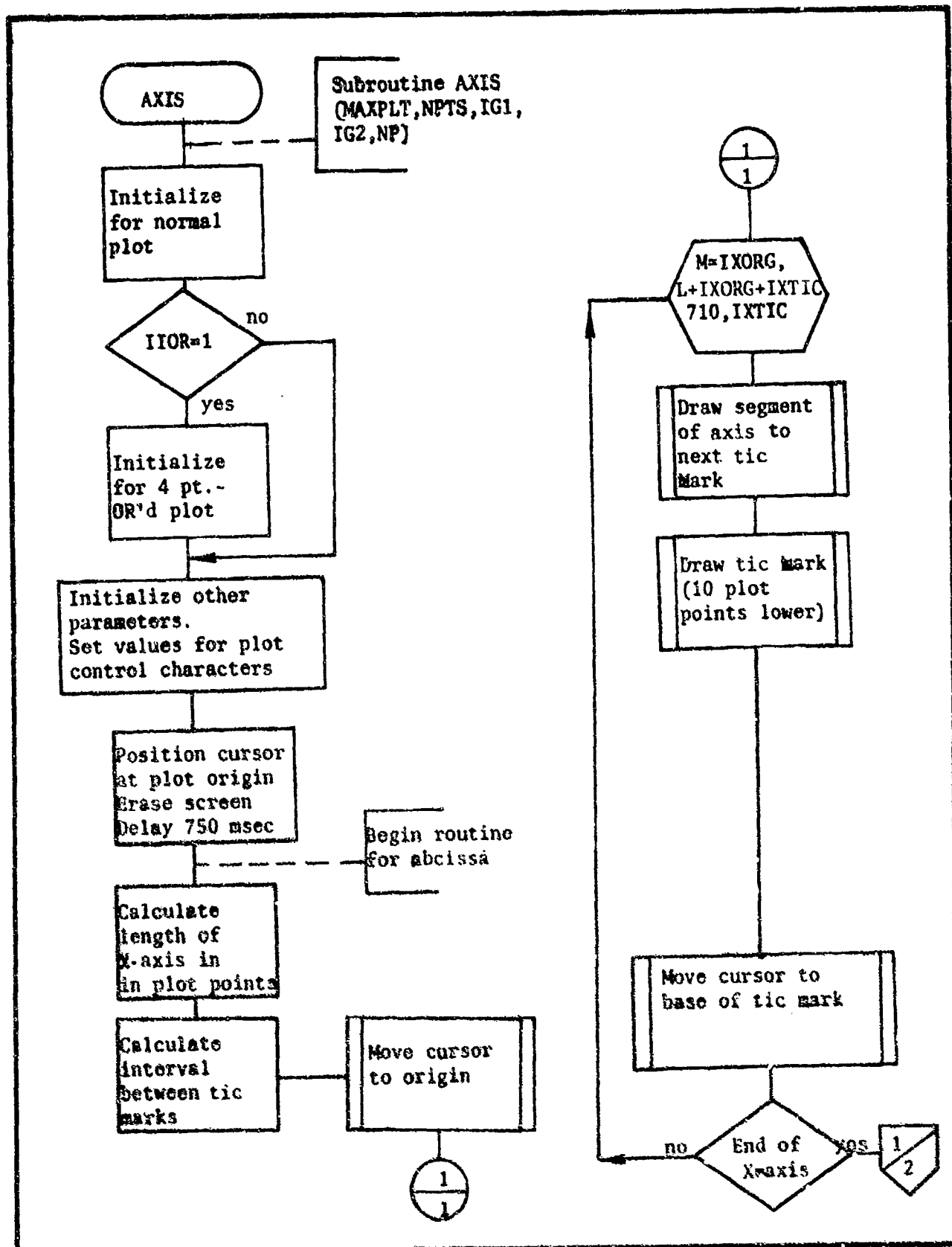


Figure 4.5.16-1 (U)

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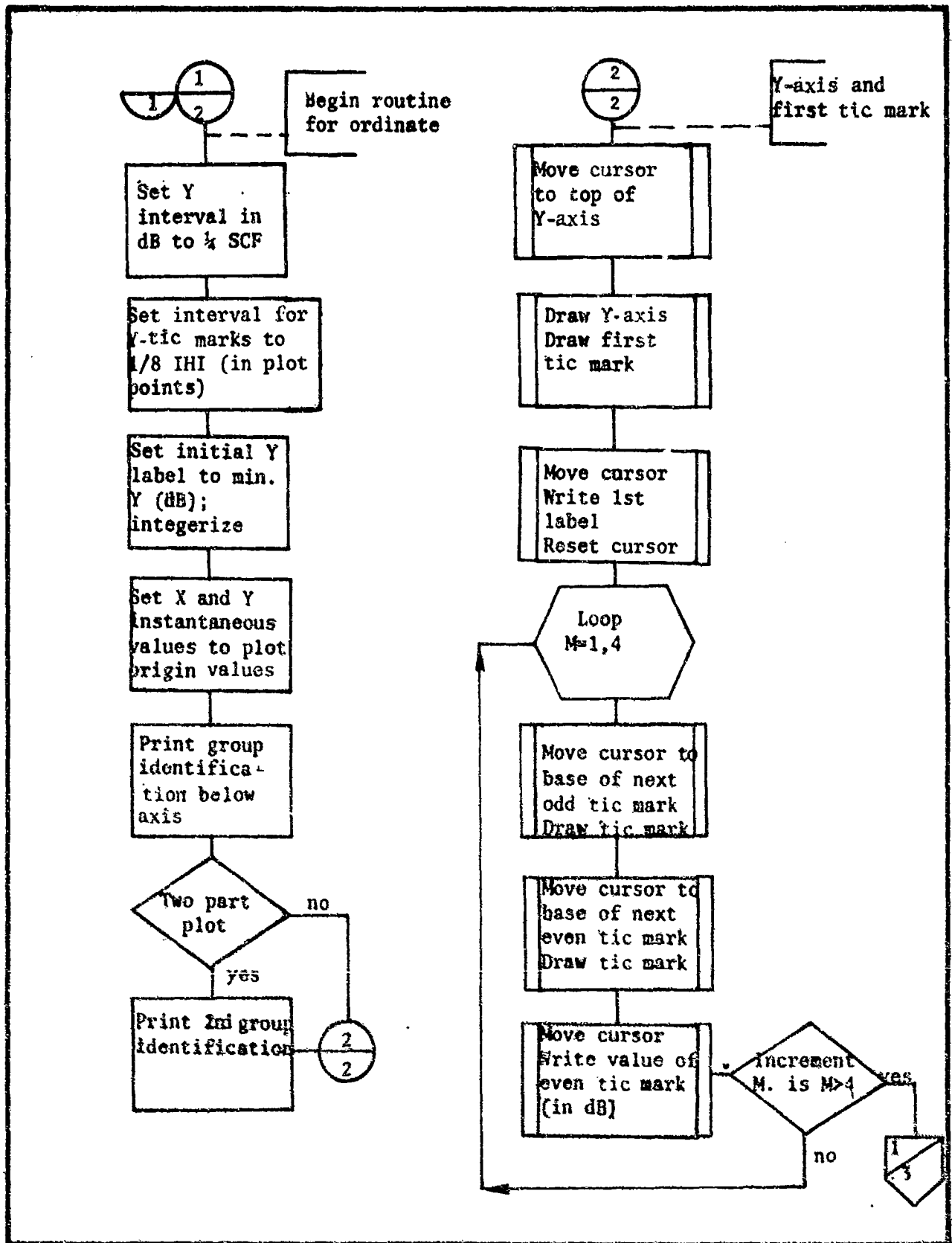


Figure 4.5.16-1 (U)

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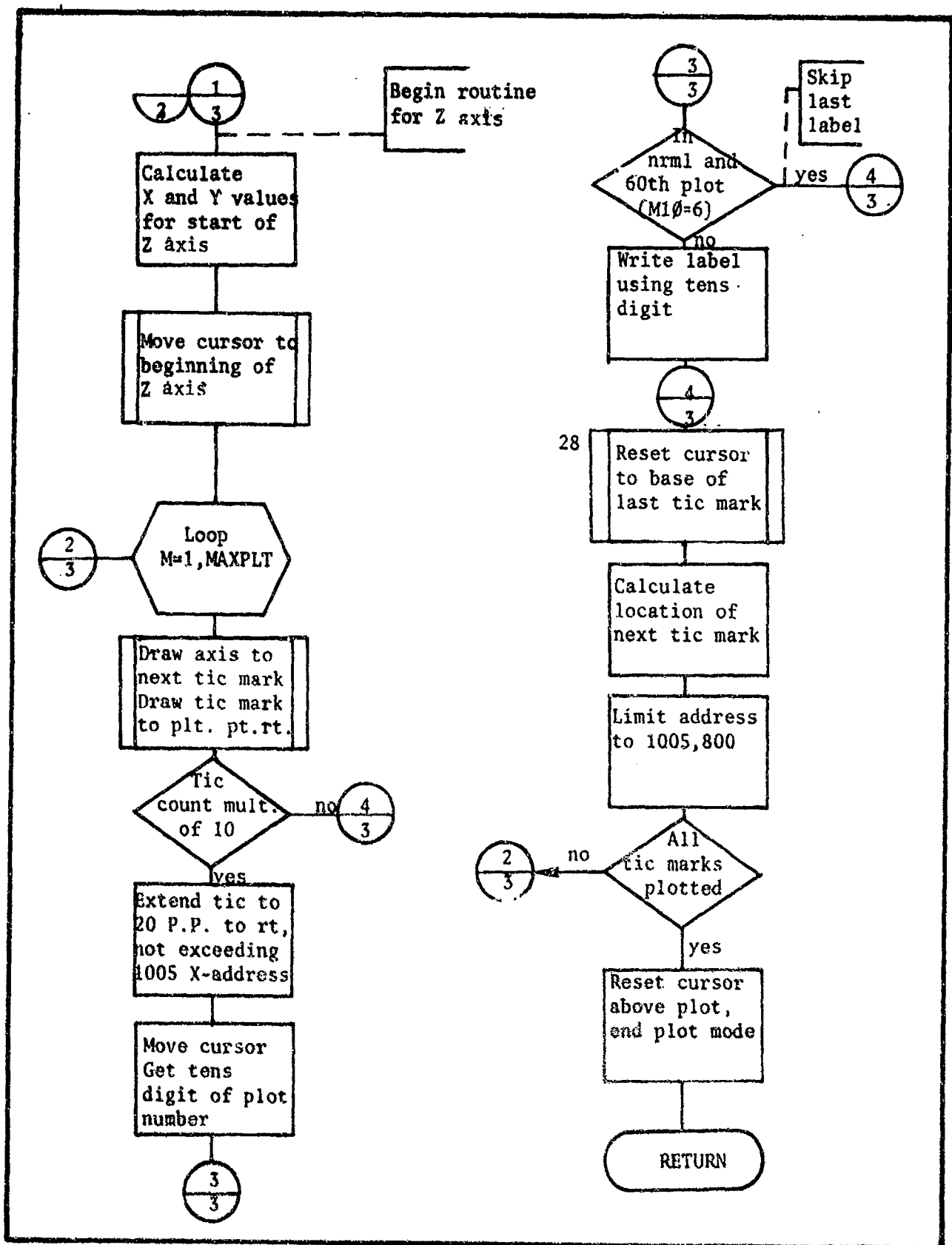


Figure 4.5.16-1 (U)

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SUBROUTINE: (U) DRAW A PLOT, PLOT

4.5.17

1. (U) FUNCTION. Subroutine PLOT draws a plot from a specified number of points. Plot origin is initialized in accordance with the plot number, to produce an isometric family, taking into account hidden points behind previous plots. Input parameters and data stored in a common area are used. An optional fast version plots only the highest value in each group of four points.

2. (U) CONSTRAINTS. Options, parameters and data vectors must be previously stored in common area.

3. (U) CALLING SEQUENCE. Called by LGPLT:

CALL PLOT (NPTS, NRPLT)

where NPTS = (number of points in vector Y to be plotted; NRPLT = plot number.)

4. (U) DESCRIPTION OF INPUT. Amplitude data are stored in common vector Y. Parameters and options are stored in a common area of main memory.

5. (U) DESCRIPTION OF OUTPUT. A plot of up to 256 points is displayed on the Tektronix 4010 CRT Graphic display.

6. (U) FILES USED.

ICOM (128) Disc and Main Memory

Y (256) Main Memory

IHIDEN (1024) Main Memory

7. (U) ERRORS. Program stops if plot number is less than 1. Program returns without plotting if plot number is outside desired range.

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. Figure 4.5.17-1. A flag (IIOR) in common is checked to see if data points are to be ORed in groups of four, and parameters are changed accordingly, if set. The location of the current origin is calculated for isometric display. If IIOR is set, the maximum of each group of four points is stored in successive locations of Y. If this is the first plot (NRPLT=1), the hidden line values are set to the Y-value of the origin. In a loop, the specified number of points are plotted. Any point of lower amplitude than a previous point with identical X-address is replaced by that "hidden-line" value. If two or more successive points have identical Y-values, a no-plot flag is set, and plotting is not done until the last point with that value has been reached, thus reducing the time to complete the plot.

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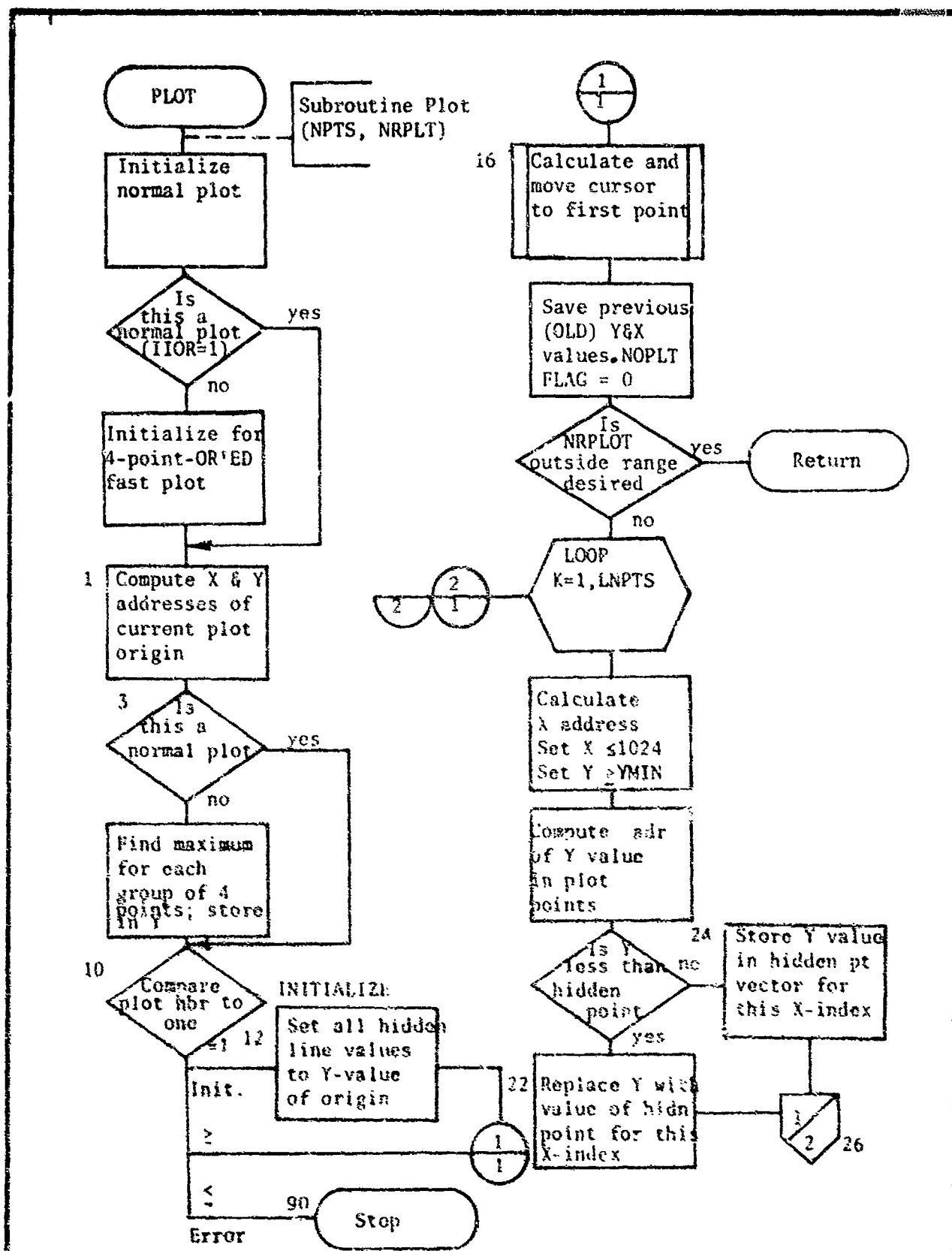


Figure 4.5.17-1 (U)

PLOT

1 of 2

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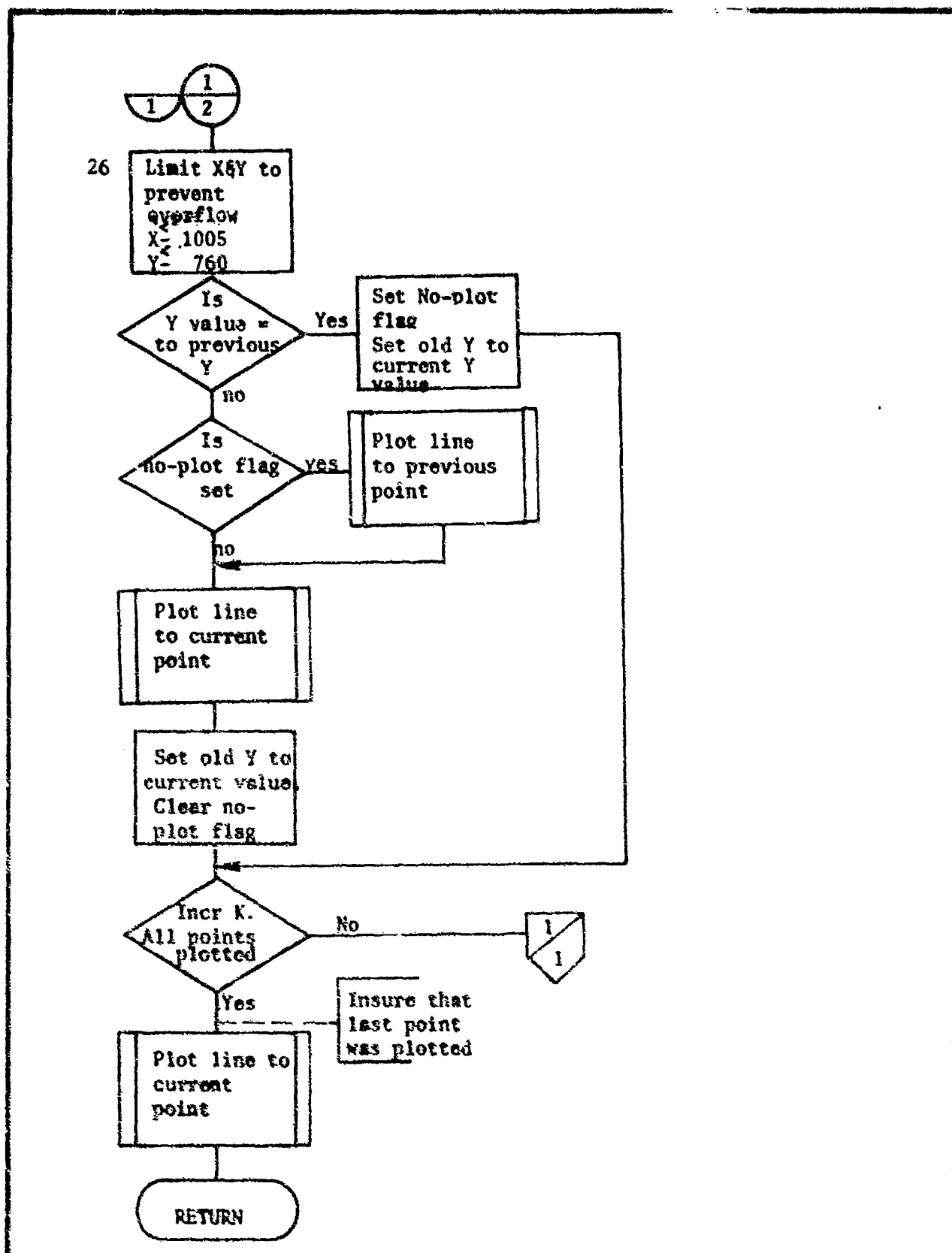


Figure 4.5.17-1 (U)

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SUBROUTINE: (U) PRINT TABLE, LGPRI

4.5.18

1. (U) FUNCTION. Subroutine LGPRI is used to print the full Frequency-Azimuth Table, in 12 pages, or a partial printout of four pages, when specified.

2. (U) CONSTRAINTS. N/A

3. (U) CALLING SEQUENCE. Called by BFORM.

CALL LGPRI (IGP, ISEC)

(Group number, section of table containing data)

4. (U) DESCRIPTION OF INPUT. 64 x 128 number array from core.

5. (U) DESCRIPTION OF OUTPUT. 12-page printout, containing 64 azimuth by 128 frequency line magnitude value. Each page has header data, including page number, date and time of collection.

6. (U) FILES USED. ABUF (4096) from main memory.

7. (U) ERRORS. N/A

8. (U) COMPUTER OPERATOR INSTRUCTIONS. Assure that line printer is on-line and ready.

9. (U) DESCRIPTION OF PROCESSING. Subroutine LGPRI, Figure 4.5.18-2, produces a full line group printout on 12 pages when ISEC is zero. A non-zero for the table section tag indicates a partial printout, as a result of sense switch 9 being down in the BFORM main program, which allowed input of frequency for printout. ISEC, a value derived from the selected frequency, is used to locate the data containing the desired frequency and to cause a single group (four pages) to be printed out. The layout of the 12 pages is shown in Figure 4.5.18-1. The header on each page is generated by Subroutine LPHDR (IGP, NPAGE, NDIR1). The first, second and third 4-page sets contain columns for 64 directions (steer angles), 16 to a page. The line groups, 0 through 127, are listed on horizontal lines, 44 to each first and second set of four pages, and 40 on the third 4-page set. The data array is put into the 120B memory. The value -99.9 replaces all numbers lower than that value. Three blocks of up to 44 lines by 64 directions are read into an array, and each block is printed on four pages with 16 directions on each page. Header data are printed by subroutine LPHDR.

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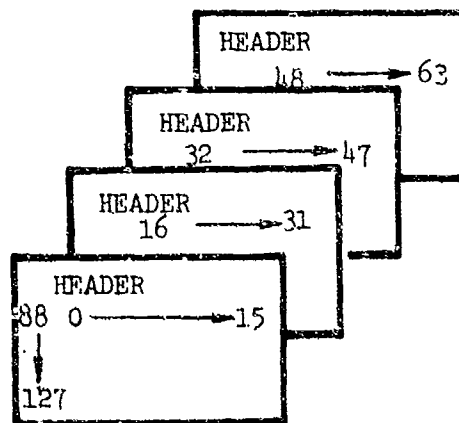
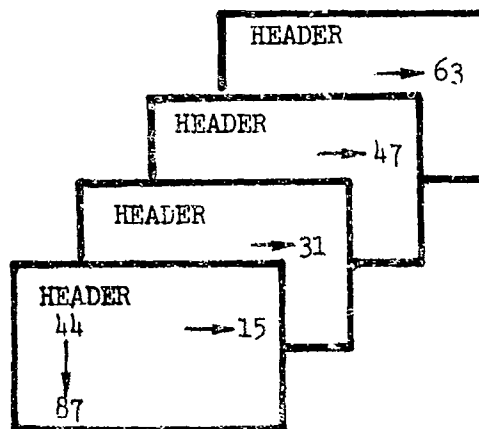
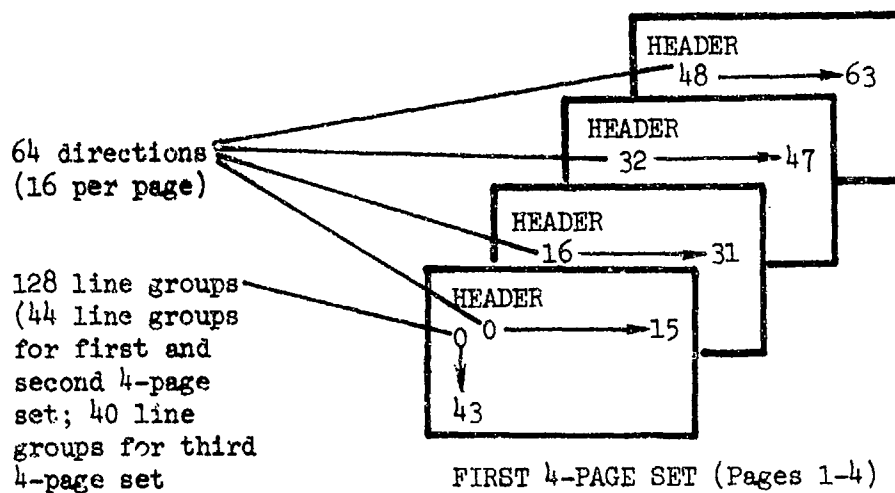


Figure 4.5.18-1 (U) Line Group Report Page Layout

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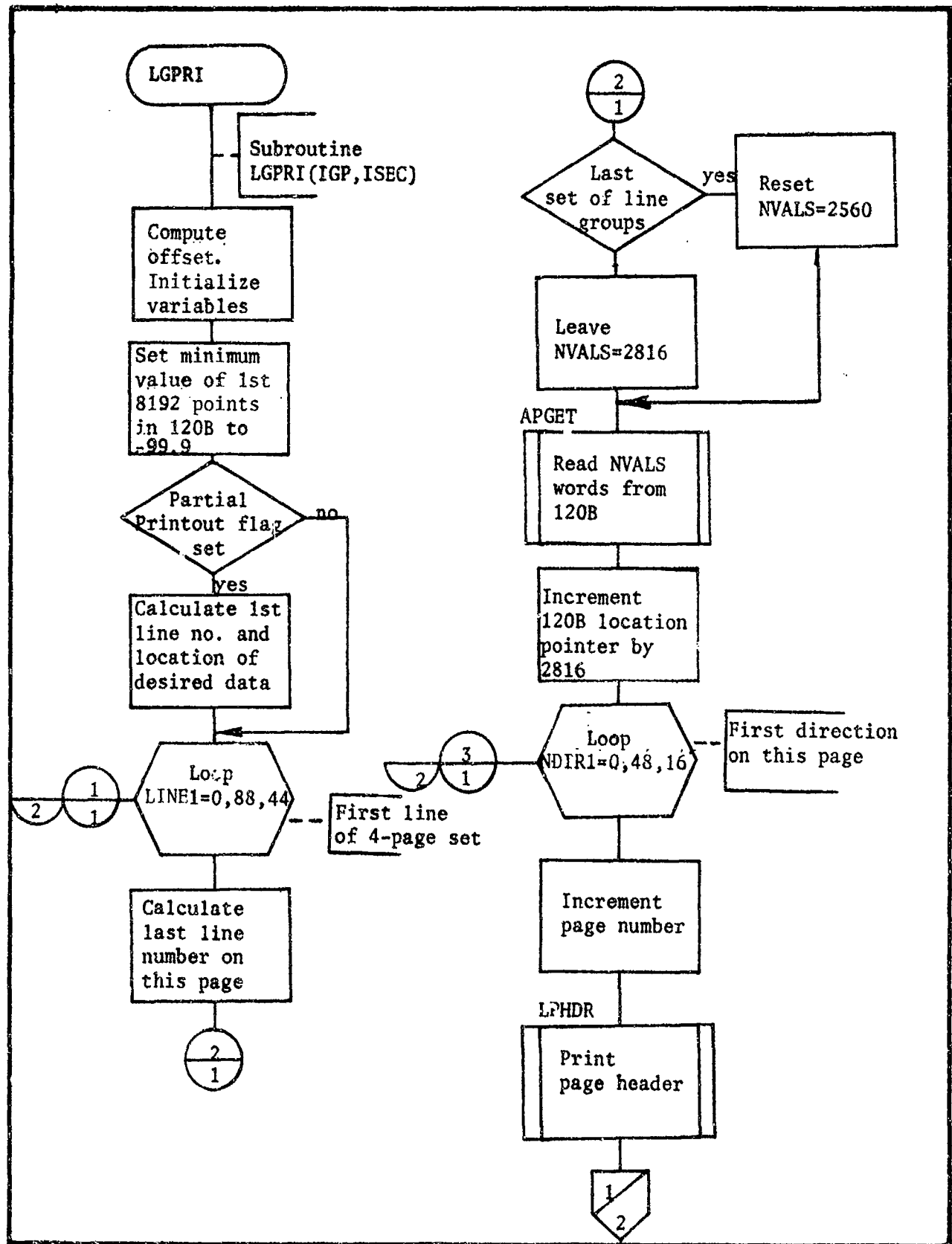


Figure 4.5.18-2 (U)

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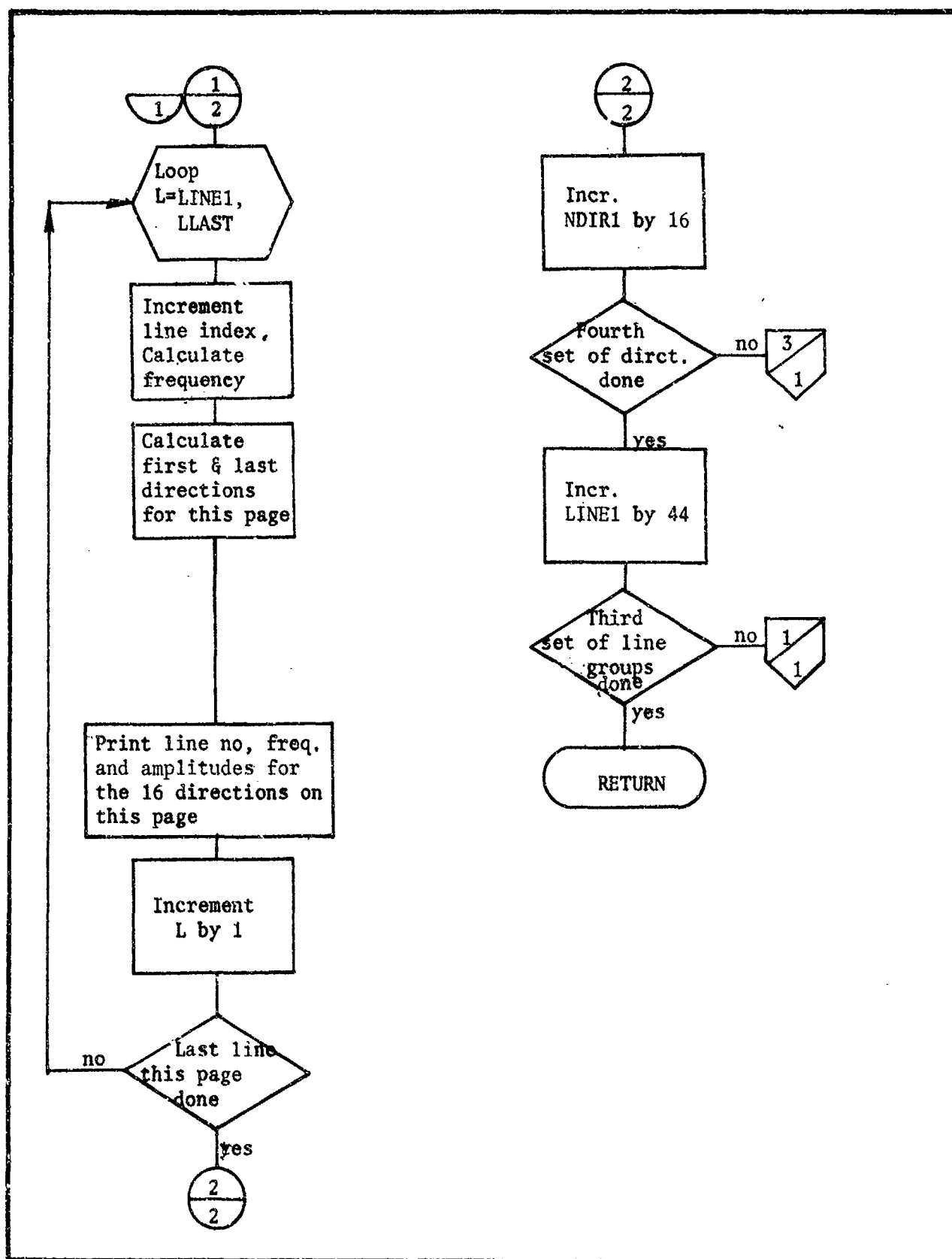


Figure 4.5.18-2 (U)

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SUBROUTINE: (U) GENERATE PLOT DISPLAY, LGPLT

4.5.19

1. (U) FUNCTION. Subroutine LGPLT is used to generate isometric plots of one or two specified line groups on the Tektronix graphic display CRT. Three axes are drawn and labeled, isometric plots are drawn, and hidden-line points are marked.

2. (U) CONSTRAINTS. Data and control parameters must be previously stored in common areas.

3. (U) CALLING SEQUENCE. Called by BFORM.

CALL LGPLT (IG1, IG1, NP)

(First Line Group Number, Second Line Group Number, Number of Groups (1 or 2)).

4. (U) DESCRIPTION OF INPUT. The data to be plotted, control parameters, and header data are input from the common area buffers.

5. (U) DESCRIPTION OF OUTPUT. The line group isometric plot is output on the graphic CRT.

6. (U) FILES USED. ICOM (128) disc and main memory common areas.

7. (U) ERRORS. N/A

8. (U) COMPUTER OPERATOR INSTRUCTIONS. N/A

9. (U) DESCRIPTION OF PROCESSING. Subroutine AXIS, Figure 4.5.19-1, is called to draw, tick-mark and label three axes. Subroutine PUT is called to retrieve the data from disc and convert it to Log Magnitude in the AP-120B. A header block is printed on the display. Data in the AP-120B is sorted into the first frequency line of constant angle and PLOT is called to draw a line. This process is repeated until 64 azimuth plots of amplitude vs. frequency have been drawn. The cursor is moved just below the header area and the program waits for carriage return (or any other keystroke) to return to the calling program.

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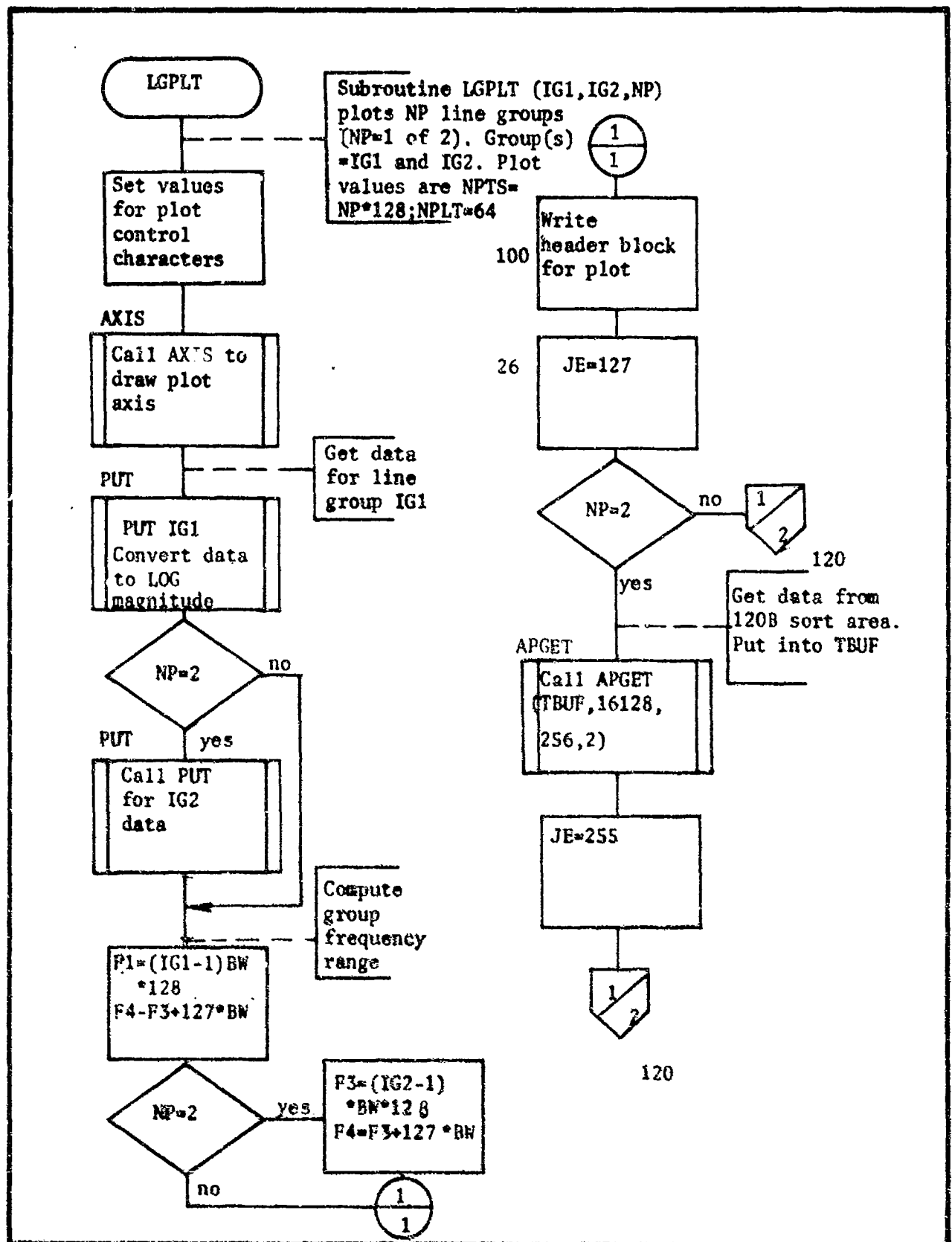


Figure 4.5.19-1 (U)

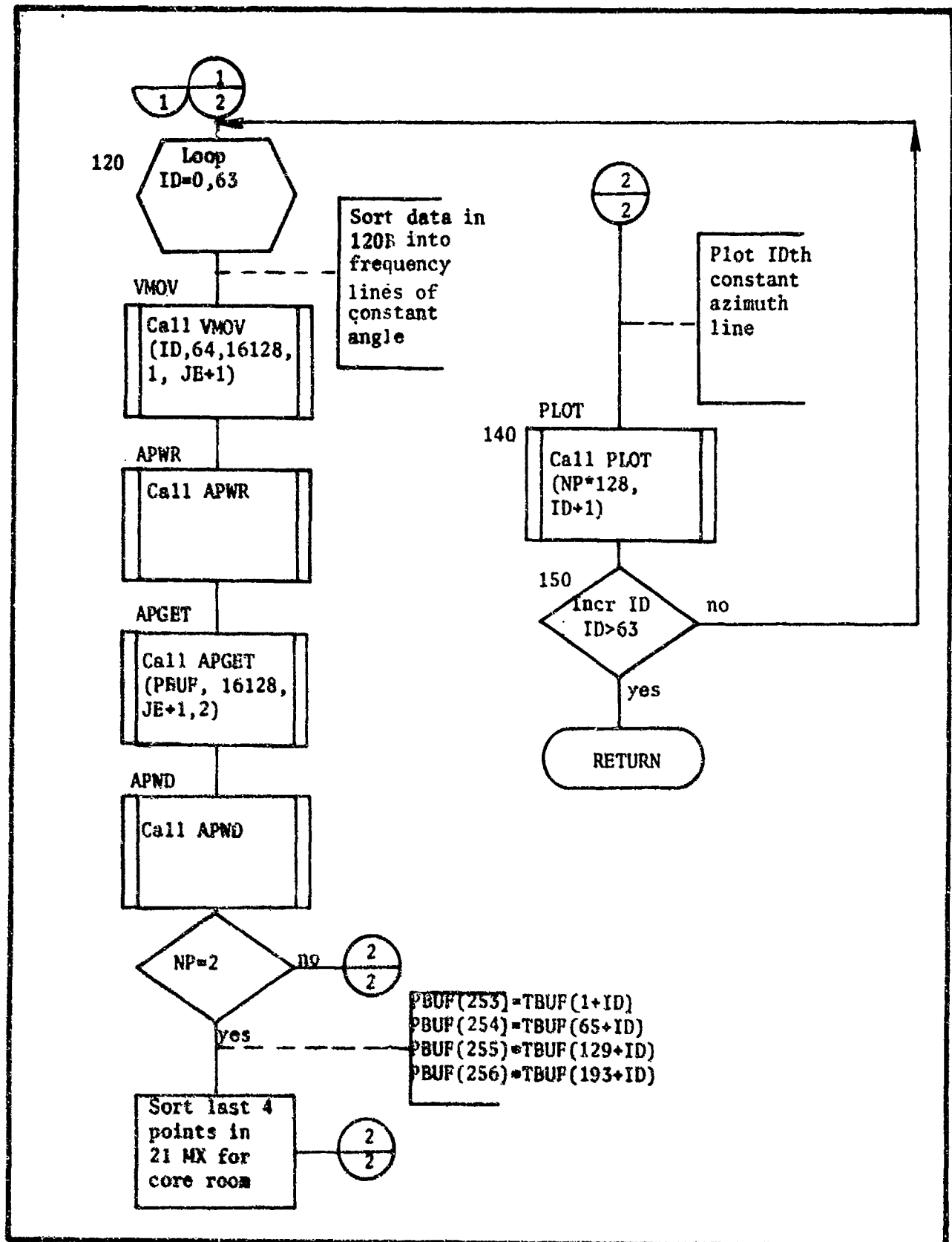


Figure 4.5.19-1 (U)

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5.0 REFERENCES

5.1 (U) APPLICABLE DOCUMENTS

Following is a list of manufacturer's documents that describe the software and operator interface to the special purpose TAP II system peripheral equipment. These documents contain supplementary information which is not duplicated in this manual.

Floating Point Systems, Inc.

7259-02	Processor Handbook
7288-02	AP-120B Math Library
FPS-7292	Software Development Package Manuals
FPS-7284-01	AP-120B Diagnostic Software Manual

Tektronix, Inc.

062-1428-01	PLOT-10/Mini Computer - 4010 Series Users Manual
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UNCLASSIFIED



DEPARTMENT OF THE NAVY

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IN REPLY REFER TO:

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Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.
2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.

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Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
DASC 012-C-77	Unavailable	LRAPP PACIFIC DYNAMIC ARCHIVE (U) SEPTEMBER 1976	Daniel Analytical Services Corporation	770201	NS; ND	U
SAI-78-527-WA	Spofford, C. W.	NELANT DATA ASSESSMENT APPENDIX III-MODELING REPORT	Science Applications, Inc.	770225	ADA 017680	U
PSI TR 036049	Barnes, A. E., et al.	OCEAN ROUTE ENVELOPES	Planning Systems Inc.	770419	ND	U
Unavailable	Unavailable	TAP II BEAMFORMING SYSTEM SOFTWARE FINAL REPORT	Bunker-Ramo Corp. Electronic Systems Division	770501	ADC011789	U
S01037C8	Unavailable	TAP 2 PROCESSING SYSTEM FINAL REPORT	Bunker-Ramo Corp. Electronic Systems Division	770501	ADC011790; NS; ND	U
Unavailable	Weinberg, H.	HARDWARE DOCUMENTATION (U)	Naval Underwater Systems Center	770601	ADB019907	U
Unavailable	Unavailable	GENERIC FACT				
Unavailable	Unavailable	TASSRAP II OB SYSTEM TEST	Analysis and Technology, Inc.	770614	ADA955352	U
Unavailable	Unavailable	LRAPP TECHNICAL SUPPORT	Texas Instruments, Inc.	770624	ND	U
Unavailable	Besette, R. J., et al.	TASSRAP INPUT MODULE	Analysis and Technology, Inc.	770729	ADA955340	U
Unavailable	Unavailable	TAP-II PHASE II FINAL REPORT	Bunker-Ramo Corp. Electronic Systems Division	770901	ADC011791	U
Unavailable	Unavailable	LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP)	Xonics, Inc.	770930	ADA076269	U
SAI78696WA	Unavailable	REVIEW OF MODELS OF BEAM-NOISE STATISTICS (U)	Science Applications Inc.	771101	NS; ND	U
TRACORT77RV109 C	Unavailable	FINAL REPORT FOR CONTRACT N00014-76-C-0066 (U)	Tracor Sciences and Systems	771130	ADC012607; NS; ND	U
Unavailable	Unavailable	LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP)	Xonics, Inc.	771231	ADB041703	U
Unavailable	Homer, C. I.	SUS SOURCE LEVEL ERROR ANALYSIS	Underwater Systems, Inc.	780120	ND	U
Unavailable	Fitzgerald, R. M.	LOW-FREQUENCY LIMITATION OF FACT	Naval Research Laboratory	780131	ADA054371	U
Unavailable	Unavailable	MIDWATER ACOUSTIC MEASUREMENT SYSTEM - PAR AND ACODAC	Texas Instruments, Inc.	780228	ADB039924	U
ORI TR 1245	Moses, E. J.	OPTIONS, REQUIREMENTS, AND RECOMMENDATIONS FOR AN LRAPP ACOUSTIC ARRAY PERFORMANCE MODEL	ORI, Inc.	780331	ND	U
Unavailable	Hosmer, R. F., et al.	COMBINED ACOUSTIC PROPAGATION IN EASTPAC REGION (EXERCISE CAPER): INITIAL ACOUSTIC ANALYSIS	Naval Ocean Systems Center	780601	ADB032496	U
LRAPPRC78023	Watrous, B. A.	LRAPP EXERCISE ENVIRONMENTAL DATA INVENTORY, JUNE 1978 (U)	Naval Ocean R&D Activity	780601	NS; ND	U
TR052085	Solomon, L. P., et al.	HISTORICAL TEMPORAL SHIPPING (U)	Planning Systems Inc.	780628	NS; ND	U