SOFTWARE OPERATIONS MANUAL OF A COMPUTERIZED BEEF GRADING INSTRUMENT

by

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B.S., Kansas State University, 1977

A MASTER'S REPORT

Submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Electrical Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas
1982

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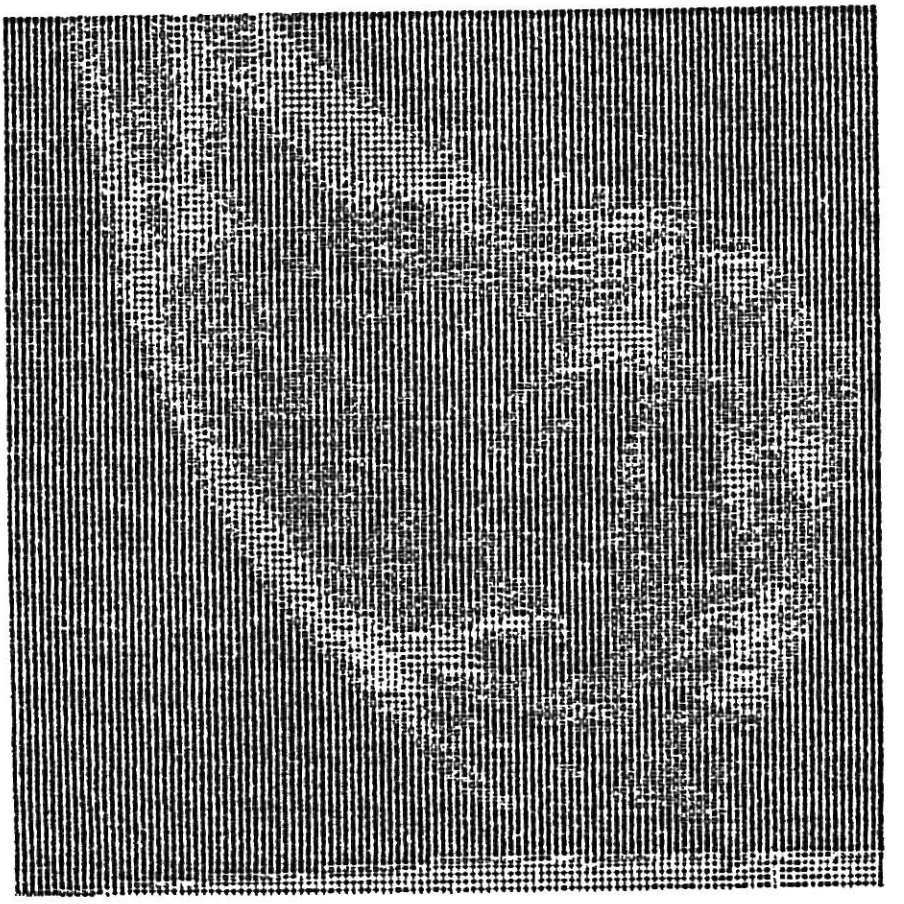

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Acknowledgement

The author wishes to express his deep appreciation to Professor Don Lenhert of the Electrical Engineering Department. The author also wishes to thank Tim Anderson and Kevin Williams for their hardware and software contributions, Dr. Dell Allen of the Animal Science Department, and Robert Young for his development of the XASM86 cross-assembler.

Introduction

1.1 The Kansas State University Meat Grader is basically an image processing system. The documentation for the system consists of three manuals titled: Operating and Hardware Service Manual Section 1-8, Software Operations Manual, and Operating and Hardware Service Manual Section 9. This manual, Software Operations, describes all software for the system as well as providing flow-charts and summary sheets for each program. Each summary sheet contains the subroutines, registers and variables used by the routine. Routine inputs and outputs are indicated. The version number is located at the bottom of the summary sheet and should match the corresponding assembly code version number located at the top of the code listing. For further details refer to the assembly listing for each program.

Section 1 describes some of the system software organization. The memory map and system program hierarchy are explained.

Section 2 contains the beef grading programs which include some display and computational modules. Although this section contains routines which are seemingly not beef grading e.g. Save results, the routines were included because they are the basis for a minimum software beef grading system.

Section 3 contains the utility programs to facilitate data analysis. The utility programs allow the system operator to 1) display picture data; 2) plot area as a function of light intensity; 3) adjust the average light intensity; 4) provide communication to a Nova 4 computer system; 5) enter date and location information for data storage; 6) successively store one line of picture data for diagnostics; 7) quickly check purged data and 8) allow classifier level changing.

Section 4 contains the floppy disk support package for off line storage of data and/or pictures.

Shown in Fig. 1.1-1 is a typical cross section of the meat surface showing the various muscle (lettered areas), bone and fat locations [4]. It may be helpful to refer to the figure when reading some sections of the manual.

A typical grading session is described below to give the operator some insight into the software procedures.

The video camera is held a fixed distance and perpendicular to the cut through the loin eye muscle and surrounding tissue and the button on the handgrip is pressed. The analog video image is digitized (analog to digital conversion) and entered into high or picture memory via command from a picture loading program called Next picture. After storing the image, the processing begins. The picture data is classed as lean meat, fat, or background based on its light reflectance. A boundary is drawn in picture memory totally or partially around the outside of the longissimus dorsi (loin eye) muscle and a determination is made as to whether the eye is left or right sloped. An attempt is made to eliminate those muscles or bounded areas that should not be included. The total lean and fat area is found and stored for later calculation. Depending on whether a right or left loin eye is indicated the fat thickness measurement is taken on the appropriate right or left side and stored. At the present time the fat thickness location depends upon operator positioning of the cross hair targets at the proper location within the loin eye.

The operator at this time may view the progress of the algorithm by calling in the Squeeze-display program. The program compresses the 240 row x 248 column data point picture memory for display on 24 row x 80 column data terminal.

A section of picture memory expected to be within the loin eye is sampled for marbling data, where the fat, lean and number of fat pieces is determined and stored.

All the intermediate calculations are stored until the next image is processed. Potentially the yield grade and quality grade could be calculated.

The system user is encouraged to become familiar with the 8086 microprocessor architecture as well as the 86/12 monitor and monitor commands. Knowledge of the registers and how they are used will be invaluable for any future modifications by the user [1].

A short listing is given below;

Destination index	DI - usually used as picture pointer
Source index	SI - general purpose
	CX - usually used as counter, general purpose
	BX - general purpose
	DX - general purpose
Accumulator	AX - general purpose
Base pointer	BP - used as memory pointer, general purpose
Code Segment register	CS - usually set to zero
Data Segment register	DS - usually zero, 1000 or 2000
Extra Segment register	ES - usually zero or 40
Stack Segment register	SS - usually zero

Addresses to picture memory are given in row-column form, e.g., 7E6FH is row 7E, column 6F. Throughout the manual, if a number is followed by an H, it is a Hexadecimal Number (base 16).

Knowledge of the 86/12 monitor will be helpful in debugging. A short description follows:

Keys	Name	Example	Action
D	Display	D7000,73FF	Memory is displayed from 7000H to 73FFH
M	Move	M1000:400,7FFF,400	Memory is moved from 1000H on high memory locations 400H to 7FFFH to low memory starting at location 400H
S	Substitute	S1E00,00 FF	Substitute FFH for 00H in location 1E00H
G	GO	G1000,1100	Execute at location 1000H until 1100H break point

NOTE: If the breakpoint is never reached a CC will be stored at the breakpoint location. This must be removed for proper program execution.

N	Next	N 1000	Execute the instruction at location 1000H. A typed comma single steps to the next instruction
O	Output	OCE, 82	Output an 82H to output port CEH
I	Input	IC2,	Input a value from port C2H.

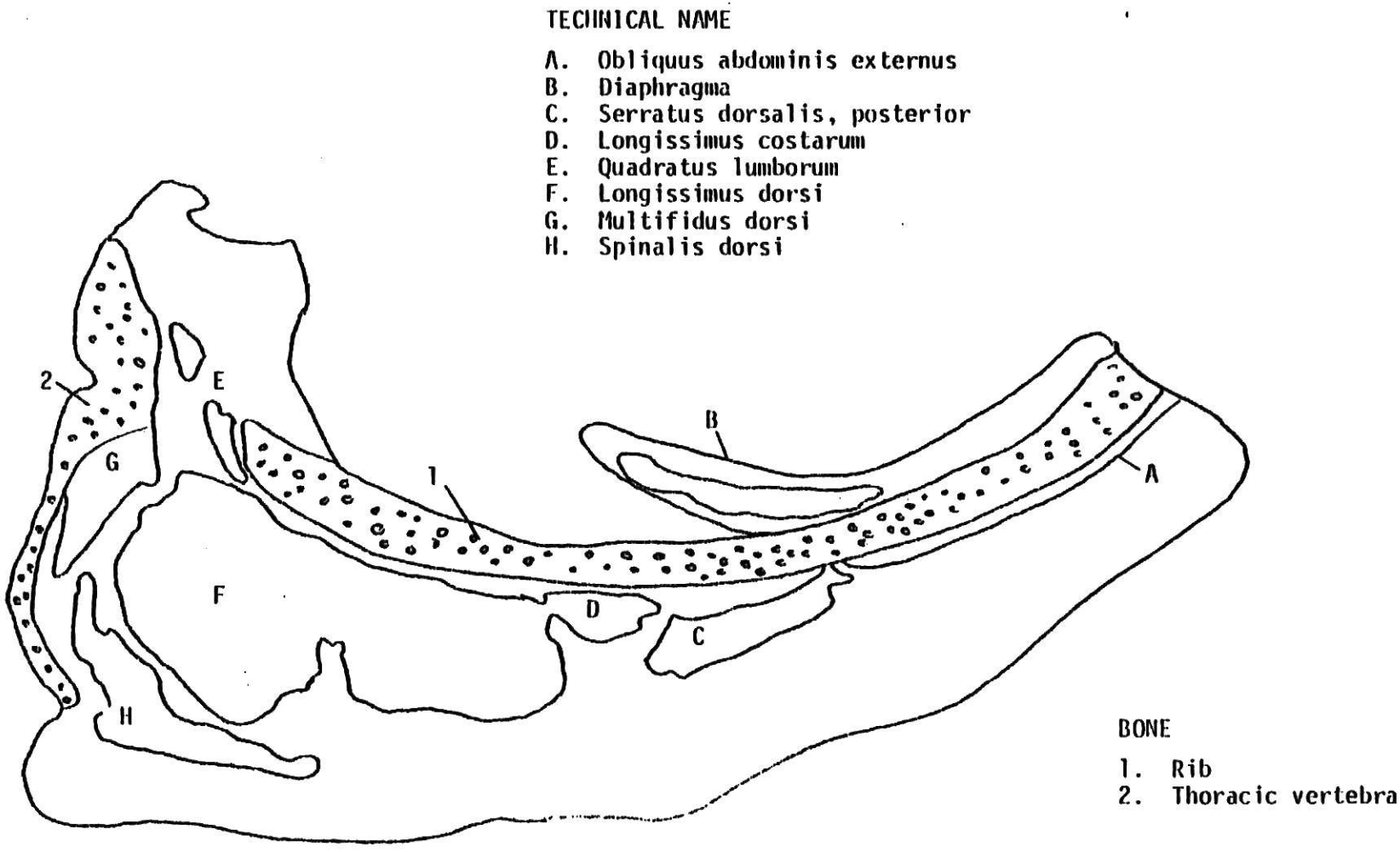


FIG. 1.1-1. Meat Surface Cross Section.

Memory Map

1.2 The Memory map gives information relating to the locations of all programs, data and variables in the computer system, Fig. 1.2-1. Remember, this is program memory, not picture memory which is located much higher in the system architecture. The addresses are listed on the left by hexadecimal numbers from top of program memory to bottom. The program name is next followed by the shortened mnemonic that corresponds to the program. This mnemonic is used for the XASM86 Assembler as a shortened program name for convenience purposes. Listed with the mnemonic is a symbol. To run a program from the Master loop program only that symbol need be typed in. Variable names are represented by the following fields; variable name:(description), program using the variable, next program using the variable. The isolated input-output (I/O) port is shown at the bottom of the memory map. The setting and clearing of these bits control the focus and flood lights as well as communication to the data terminal.

```
**************************************************
*
*           MEMORY MAP
*           MEAT GRADING RESEARCH
*           FIG.1.2-1
*
**************************************************

ADDRESS     NAME                                SYMBOL

9000-97FF   FIRMWARE-BOOTSTRAP ON EPROM
7A00-7CFF   SPLINE REDUCTION          SPLINE  X
7500-7517   TRACK SET VAR FOR R/W/PIC ON DISK
7200-79FA   SPLINE ADDR STOR(OK OVERWRT ABV)
7100-71FF   DATA BUFFER FOR INDAT
7030-7050   RECIPE FOR MASTERLOOP    RECIPE
7000-       MASTER LOOP STRING        STRING
6200-627D   SET DATE AND LOCATION     SETDAT
6100-6183   INITIALIZE DATA DISK      INTDAT
6000-60E7   FORMAT DISK               FORMAT
5700-57FF   BUFFER FOR READ BIN
5300-53CA   BINARY READ VARIABLES
5000-524B   READ BIN DISK             DSKBIN
4D00-4D36   LINE LOAD UTILITY         LINLOD  C
4800-4D00   LIGHT METER               LMETER  U
4600-4748   BOX DISTRIBUTION          BOXDIS  S
4400-45A3   FATBOUND SUBROUTINE       FATBDY
4200-42FB   FAT PIECES                FATPCS  I
4180-41F9   DRECTN SUBROUTINE
4000-415D   FAT THICKNESS             FTHICM  H
3D20-3D2F   TRANSFER CORR TABLE       TRSCOR
3D00-3D1E   CLOCKWISE TABLE           CWTBL
3C00-3C1E   COUNTERCLOCKWISE TABLE    CCWTBL
3B00-3B2A   FIND MAX SUBROUTINE       FINDM
3A00-3A9E   NEXTPOINT SUBROUTINE      NEXTPT
3900-398F   DISTANCE SUBROUTINE       DISTAN
3800-3842   MAX POINT SEARCH          MXMAIN
3600-3773   PRINT DISTRIBUTION        PTDIST  F
3580-35CD   DISTRIBUTION              DISTRB  E
3400-34E8   AREA AQUISITION           AREAAQ  D
3340-33CF   SQUEEZE DISPLAY           KRMDSP  C
3100-3302   BOUNDARY SEARCH           BOUSCH  B
3000-3050   CLASSIFIER                CLSIFR  A
2F00-2F17   MOVPOS SUBROUTINE,BOUSCH
2B00-2E8C   CALCULATE RESULTS         CLCRES  R
2A20-2A31   PAUSE                     PAUSE   L
2A00-2A10   TEMPORARY STOP            TMPSTP  Q
2700-275F   NEXT PICTURE              NEXPIC  P
2600-268C   DISPLAY RESULTS           DSPRES  O
2550-25D0   DRAW A BOX IN MEMORY      DRWBOX  G
2528-2545   MESSAGES FOR DISPIC
247B-248B   NON SEQ WRITE PICTURE     NSWRDSK T
2434-245C   WRITE DISK PICTURE        WRDSK   N
2400-2433   DISK READ PICTURE         RDDSK   M
2200-2270   MESSAGES FOR SAVE RESULTS
```

```
2100-2267   SAVE RESULTS                SAVRES  K
2060-20BC   LIGHT CALIBRATION           LGTCAL  Y
2000-2036   PREPROCESSOR 64K            PREPRO  V
1FBE-1FC8   MESSAGE FOR MASTER LOOP, PROGRAM?
1FBC        J
1FBA        /
1FB8        C
1FB6        Z
1FB4        Y
1FB2        X
1FB0        W
1FAE        V
1FAC        U
1FAA        T
1FA8        S
1FA6        R
1FA4        Q
1FA2        P
1FA0        O
1F9E        N
1F9C        M
1F9A        L
1F98        K
1F96        J
1F94        I
1F92        H
1F90        G
1F8E        F
1F8C        E
1F8A        D
1F88        C
1F86        B
1F84        A
1F82        OFFSET BACK MASTER
1F80        CNT1:,MASTER
1E22        GET STRING ENTRY PT         GETSTR
1E00-1EB1   MASTER LOOP                 MASTER
1DFF        DISK CONTROL PROGRAMS
 !
1400-1442   VBLES FOR DSK SUBS,HEX,DECTBL,NUM,TEMP
 !
126C-12D0   CLASSIFIER LEVEL CH MESSAGES
1200-1268   CLASSIFIER LEVEL CHANGE CLLVCH  Z
1000-118C   BLOCK DISPLAY PICTURE    BLKDPY  J
0F3E        M:,CLCRES
0F3C        KPHH:,CLCRES
0F3A        WGTH:,CLCRES
0F39        MAPCNT:,CLCRES
0F37        LESCNT:,CLCRES
0F35        GRTCHT:,CLCRES
0F33        EQUCNT:,CLCRES
0F31        SGBCNT:,CLCRES
0F2F        FATTH:,CLCRES
0F2D        NPCS:,CLCRES
0F2B        PFATBX:(PERCENT FAT IN BOX),CLCRES
```

```
0F29        PMEAT:(PERCENT MEAT),CLCRES
0F27        PFAT:(PCTFAT),CLCRES
0F25        AMEAT:(AREA OF MEAT),CLCRES
0F23        AFAT:(AREA OF FAT),CLCRES
0F21        AREA:(AREAHU),CLCRES
0F1F        SIGL:(SIGNIFICANT BOX LEVEL),CLCRES
0F1D        BXAREA:(BOX AREA),CLCRES
0F1B        DELL:(DELTA LOWER),CLCRES
0F19        DELU:(DELTA UPPER),CLCRES
0F17        TEMP:(TEMPORARY STORAGE),CLCRES
0F16        ASCBUF:(ASCII BUFFER),DSPRES
 :
 :
0F12        CTRL:DUMMY:,SUBS
0F11        CNT3:
0F10        SGBCT:,CLCRES
0F0F        CNT2:,SUBS
0F0D        CNT1:,SUBS
0F0C        DRV:,SUBS
0F0A        ADDR:,SUBS
0F08        BSEADDR:,SUBS
0F06        FIRST:,SUBS
0F05        LEN:,SUBS
0F04        TRK1:,SUBS
0F03        NUM:,SUBS
0F02        SEC:,SUBS
0F01        TRK:,SUBS
0F00        COMMAND:,SUBS
0D0A        PROFLG:
0D09        SAVB:,FTHICM
0D07        SAVG:,FTHICM
0D05        SUMDST:,FTHICM
0D03        BKGD POINT ROW ADDR
0D02        BKGD POINT COL ADDR
0D01        EDGE BNDY PT. ROW ADDR
0D00        EDGE BNDY PT. COL ADDR
0CC0        RESERVED FOR DISPLAY RESULTS
 :          ROUTINE
 :
0C34        DPYBUF:(DISPLAY STRING),DSPRES
 :
 :
0A56
 :          PCKDEC:(PACKED DECIMAL STRING),DSPRES
 :          ,SAVRES,INTDAT,CLCRES
0A00
09FE        SAVCNT:SAVRES,INTDAT,SETDAT
09FC        LOC1:SAVRES,INTDAT,SETDAT
09FA        DAT2:SAVRES,INTDAT,SETDAT
09F8        DAT:SAVRES,INTDAT,SETDAT
0940        HEX VALUE STRING FOR CALCUL
 :
 :
0900        FREAD:,CLCRES
08D8        MFSQU:(MEAT FAT IN SQUARE),CLCRES
```

```
08D6          MEATSQ:(MEAT IN SQUARE),CLCRES,AREAAQ
08D4          FATSQ:(FAT IN THE SQUARE),CLCRES,AREAAQ
08D2          SMLFLG:,CLCRES,DRWBOX,CLSIFR,AREAAQ
08D0          LCRS:,DRWBOX,BOUSCH,FTHICM
08CD          OLDBOU:(BOUNDARY WRITE OVER LOC),BOUSCH
08CB          LWRLV2:(LOWER LEVEL 2),CLSIFR
08CA          LWRLV1:(LOWER LEVEL 1),CLSIFR
08C9          UPRLV2:(UPPER LEVEL 2),CLSIFR
08C8          UPRLV1:(UPPER LEVEL 1),CLSIFR
08C6          STARTD:,LGTCAL,PREPRO,FTHICM
08C4          LMSKP:,LGTCAL,PREPRO,FTHICM
08C2          LMFLAG:,LGTCAL,PREPRO,FTHICM
08C0          LMRVAL:,LGTCAL,PREPRO,FTHICM
0810-08A0     COMMUNICATION TO NOVA   COMNOV  W
0718          FATCNT:(FATCOUNT),CLSIFR
0716          MEATCNT:(MEAT COUNT),CLSIFR
0714          BKGDCNT:,CLSIFR,AREAAQ,BOXDIS
0712          CFLG:
0710          MEACNTP:(MEAT COUNT POS SLOPE),FTHICM
070E          FATCNTP:(FAT COUNT NEG SLOPE),FTHICM
070C          SLENGTH:(LENGTH OF SPLINE),SPLINE
070A          STTPT:(START POINT SPLINE),SPLINE
0708          SPFLG:(SPLINE FLAG),SPLINE
0706          SPLTD:(SPLINE TAIL DIRECTION),SPLINE
0704          SPLT:(SPLINE TAIL ADDRESS),SPLINE
0702          SPLHD:(SPLINE HEAD DIRECTION),SPLINE
0700          SPLH:(SPLINE HEAD ADDRESS),SPLINE
06B1
 :
0672          BXDISV:(BOX DISTRIBUTION),CLCRES,BOXDIS
0671          BXSIZE:ROW,CLCRES,BOXDIS
0670          BXSIZE:COL,CLCRES,BOXDIS
064E          KPH:(PERCENT KIDNEY),CLCRES
064C          WEIGHT:,CLCRES
064A          STRFLG:,LMETER
0649
 :
 :
0640          ERROR COUNT:
0639          OLDVAT:(OLD VALUE),CLCRES
0637          EQNA:,CLCRES
0633          NOPCS:(NUMBER OF PIECES),FATPCS,CLCRES
062E          EQFT:,CLCRES
062A          FTTENS:,CLCRES
0628          FATMEA:,CLCRES
0626          EQKPH:,CLCRES
0622          EQWEI:,CLCRES
0620          FTHRUN:(RUN FLAG),FTHICM,CLSIFR,KRMDSP
061C          EFRAG:(ERROR LOC FOR FATBDY),FATPCS
061A          MTFT:(CHANGED MEAT TO FAT),BOUSCH
0619          FAT THICKNESS:,FTHICM
0618          FAT THICKNESS:NUMM1,FTHICM
0617          FAT THICKNESS:MSD,FTHICM
0616          BKGD POINT ROW ADDR:,FTHICM
0615          BKGD POINT COL ADDR:,FTHICM
```

```
0614          EDGE BNDY PT. ROW ADDR:,FTHICM
0613          EDGE BNDY PT. COL ADDR:,FTHICM
0612          MAX DIS STORAGE:,MXMAIN
0611          MAX DIS STORAGE;,MXMAIN
0610          MAX DIS STORAGE MSD:,MXMAIN
060F          MVBLE ROW MAX DIS PT  ] A:,MXMAIN,AREAAQ
060E          MVBLE COL MAX DIS PT  ]:,MXMAIN,AREAAQ
060D          STNRY ROW MAX DIS PT  ] B:,MXMAIN,AREAAQ
060C          STNRY COL MAX DIS PT  ]:,MXMAIN,AREAAQ
060B          MCHIGH:(MEAT COUNT HIGH),CLCRES,AREAAQ
060A          MCLOW:(MEAT COUNT LOW),CLCRES,AREAAQ
0609          FCHIGH:(FAT COUNT HIGH),CLCRES,AREAAQ
0608          FCLOW:(FAT COUNT LOW),CLCRES,AREAAQ
0607          BROW:(BOT ROW ADR),BOXDIS,FATPCS,AREAAQ
0606          BCOL:(BOT COL ADR),BOXDIS,FATPCS,AREAAQ
0605          TROW:(TOP ROW ADR),BOXDIS,FATPCS,AREAAQ
0604          TCOL:(TOP COL ADR),BOXDIS,FATPCS,AREAAQ
0603          RROW:(RGT ROW ADR),BOXDIS,FATPCS,AREAAQ
0602          RCOL:(RGT COL ADR),BOXDIS,FATPCS,AREAAQ
0601          LROW:(LFT ROW ADR),BOXDIS,FATPCS,AREAAQ
0600          LCOL:(LFT COL ADR),BOXDIS,FATPCS,AREAAQ
05FF          RESERVED BLOCK FOR LSD'S:,DISTRB
 |
 |
0500
04FF          RESERVED BLOCK FOR MSD'S:,DISTRB
 |            THIS AREA WILL BE WRITTEN OVER IF
 |            THE DISTRIBUTION PROGRAM IS RUN
0400          ALSO USED BY BOUNDARY SEARCH.
011A          ADR:,NEXPIC

PORT ASSIGNMENTS

C8            OUTPUT PORT
              BIT 0 - PICTURE
              BIT 1  FLOOD
              BIT 2 - FOCUS
CA            INPUT PORT
              BIT 0
CE            STATUS CONTROL REGISTER  USUAL SET 82
DE            COMM PORT STATUS-CONSOLE
D8            COMM PORT DATA-CONSOLE
END
```

Program Hierarchy

1.3 The Beef grading, utility and disk support programs are semi-independent. Certain programs can be run at any time (Set date & location) while others require a particular order to have meaningful results.

The program hierarchy chart is shown in Fig. 1.3-1. The chart gives an indication of the proper order for program execution. For each block the preceding block must at least be run for outputs to have meaningful data. For example, the Squeeze-display program must be preceded by the running of the Classifier program. Squeeze display can also be run after Fat thickness or any program following Classifier. Note that Squeeze-display cannot be run directly following Next picture.

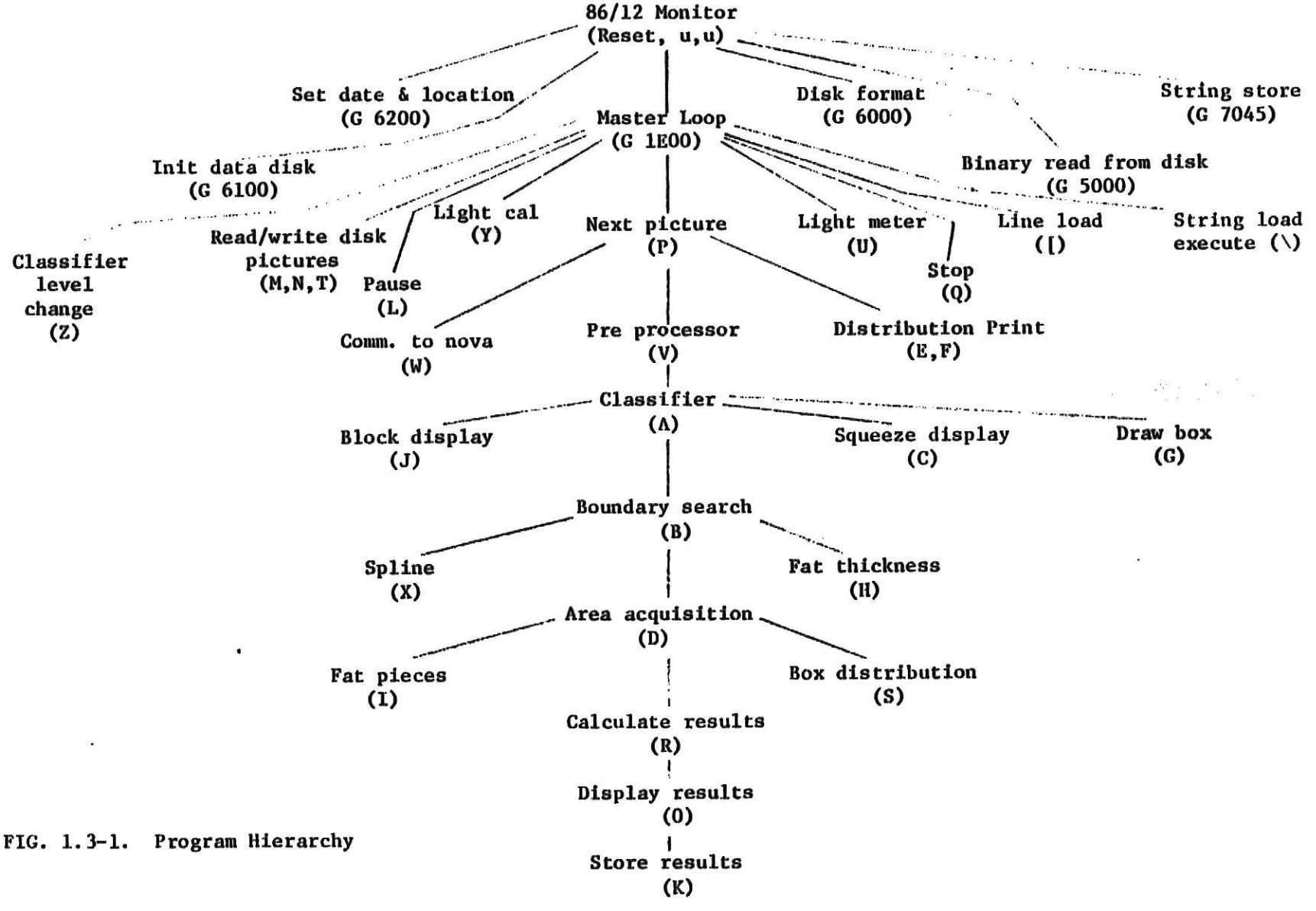


FIG. 1.3-1. Program Hierarchy

Master Loop (MASTER)

2.1 Master loop is designed to input a string of symbols or letters from the keyboard corresponding to the programs to be executed and then executes each one in order. When the string of programs has completed execution Master loop continuously repeats the string except with the Q (Temporary Stop) or L (Pause) command.

Master loop starts by calling subroutine INIT to initialize the string pointer to -1 (FFFF Hex). Next the routine GETSTR inputs the string of symbols. Each symbol is converted to a number (A=1, B=2, etc.) and stored in the string called STR. The program continues inputting symbols until a [CR] is pressed. Then a zero is stored to terminate STR, and the string pointer is zeroed. If an error is made on the keyboard, a rubout should be typed. The RUBOUT routine causes the pointer to decrement thus ignoring the error.

The first value in STR is loaded and multiplied by two. Now the number corresponds to a location in the jump table TBL. The values in TBL are the starting addresses of each program. An indirect call is perfcrmed to call that program. When control returns to Master loop the string pointer is incremented and this process is repeated. A program called BACK is executed when the string pointer points to a value of zero in STR. BACK resets the string pointer so that the next program executed is the first value in STR. An example of Master loop response is shown below.

```
G 2434- B8 1E00
Programs:  PVABXDGHCISROK [CR]
```

Master Loop (MASTER)

SUBROUTINES: GETSTR, MESSAGE, CHARIN, RUBOUT, CHAROT, INIT

REGISTERS:
- BP - input string pointer
- BX - calling program address
- SI - message pointer
- DI - string pointer
- AX - general purpose, counter, input, output

VARIABLES:

1F82H-1FB6H	TBL
1FB8H-1FBFH	MESS1
1F80H	CNTL
7000H	STR

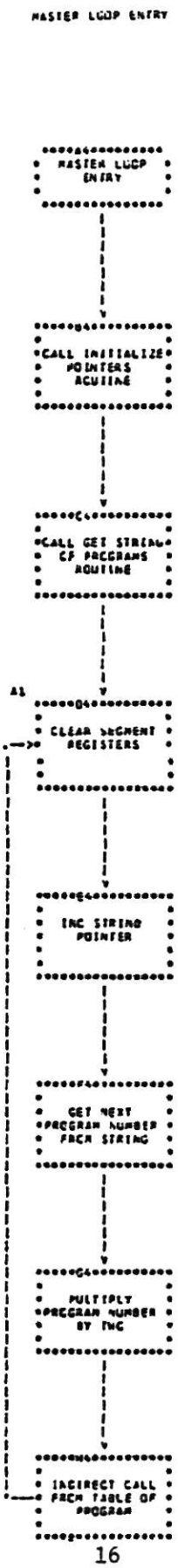
INPUTS: ASCII characters from data terminal

OUTPUT: Indirect calls to stored programming

LOCATION: 1E00H

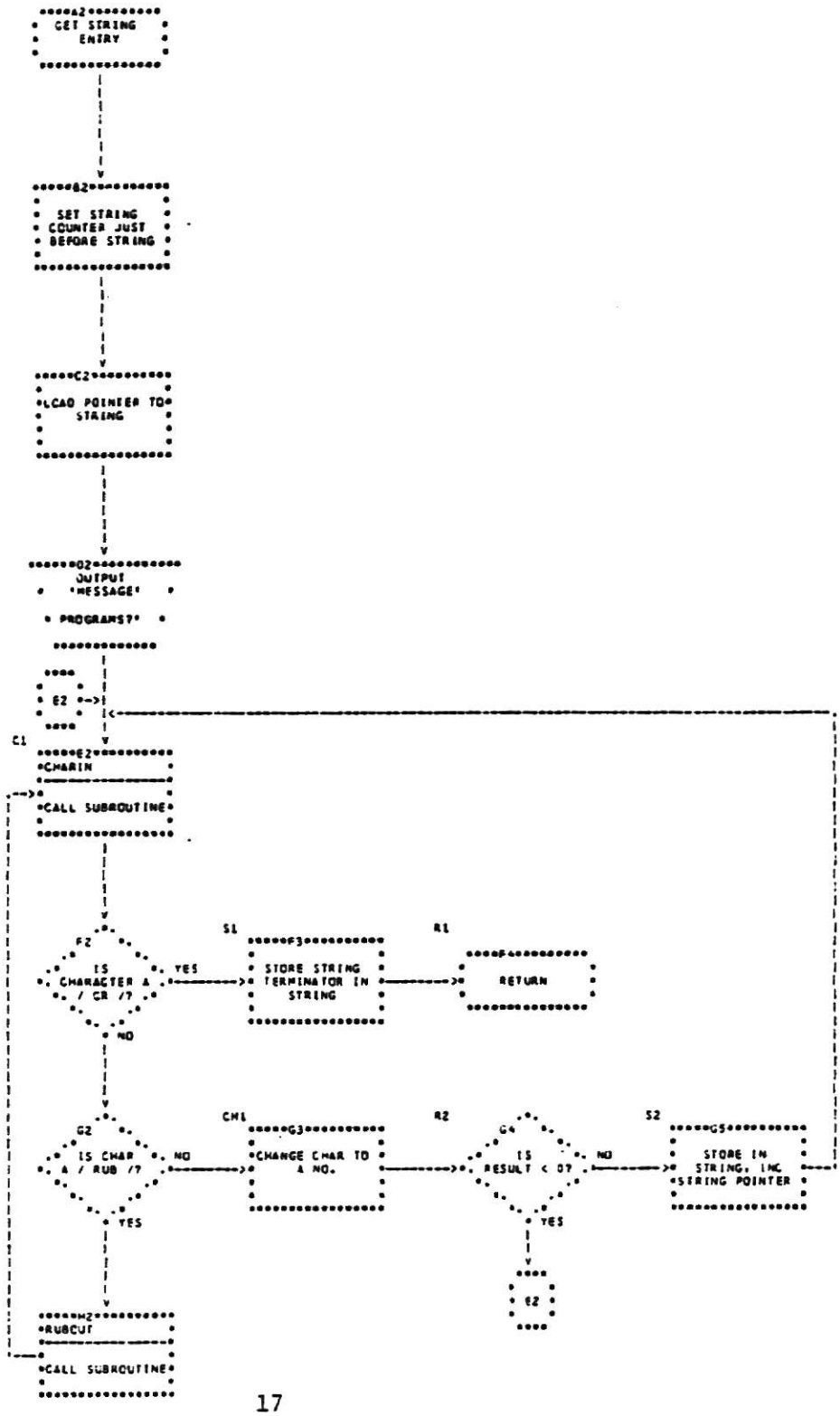
SIZE: 0B1H

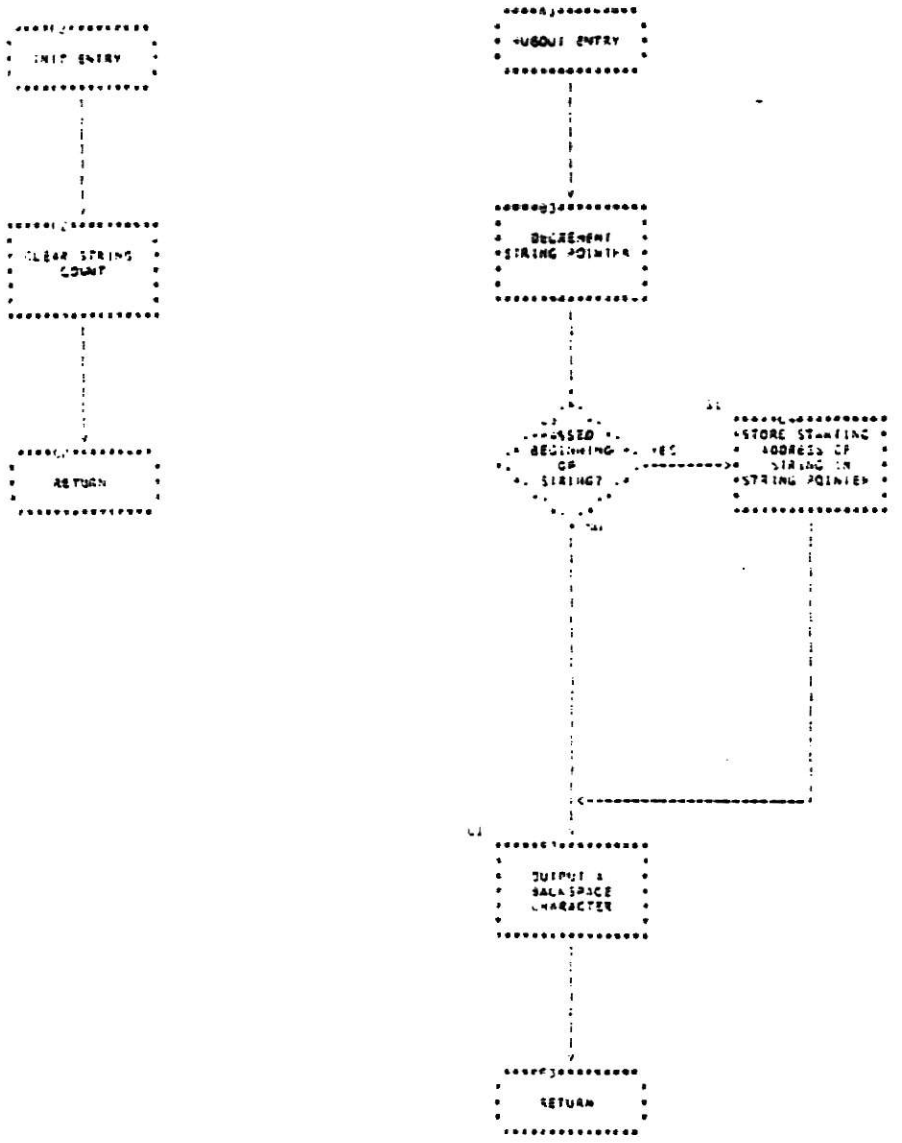
VERSION: 2/12/81


MASTER LOOP ENTRY
MASTER LOOP ENTRY
CALL INITIALIZE POINTERS ROUTINE
CALL GET STREAM OF PROGRAMS ROUTINE
A1
CLEAR SEGMENT REGISTERS
INC STRING POINTER
GET NEXT PROGRAM NUMBER FROM STRING
MULTIPLY PROGRAM NUMBER BY INC
INDIRECT CALL FROM TABLE OF PROGRAM

GET STRING ENTRY

FLOWCHART




INIT ENTRY
CLEAR STRING COUNT
RETURN
SUBOUT ENTRY
DECREMENT STRING POINTER
PASSED BEGINNING OF STRING?
YES
STORE STARTING ADDRESS OF STRING IN STRING POINTER
OUTPUT A BALA SPACE CHARACTER
RETURN

Next Picture Routine (NEXPIC)

2.2 NEXPIC turns on the focus lights then waits for the picture taking button to be pushed on either the computer enclosure or the camera handle. Once the button has been depressed NEXPIC turns off the focus lights, turns on the flash and after the light has reached full intensity NEXPIC then activates the digitizer to take a picture. Upon the completion of the picture storage by the direct memory access (DMA) board this program turns off all lights then returns.

If while NEXPIC is waiting for the picture button a [CNTL C] is pressed on the keyboard the program returns control back to the monitor routine. This gives an escape point from the string of programs presently executing.

The warmup time for the flood light was chosen to be 30 frames (about one second). This allows the lamp to reach a constant color temperature prior to storing the picture.

NOTE-

	PORT A IS OUTPUT		PORT B IS INPUT
bit 0	G1 and G2	bit 0	picture taking button
bit 1	focus lamp control	bit 1	VSYNC
bit 2	flash lamp control	bit 2	n/c
bit 3	n/c	bit 3	n/c
bit 4	n/c	bit 4	n/c
bit 5	n/c	bit 5	n/c
bit 6	n/c	bit 6	n/c
bit 7	n/c	bit 7	n/c

where n/c means no connection

Next Picture (NEXPIC)

SUBROUTINES: none

REGISTERS: AX - Input, Output

CX - delay counter, counter

VARIABLES: 011AH ADR

INPUTS: Control signals from digitizer and ports

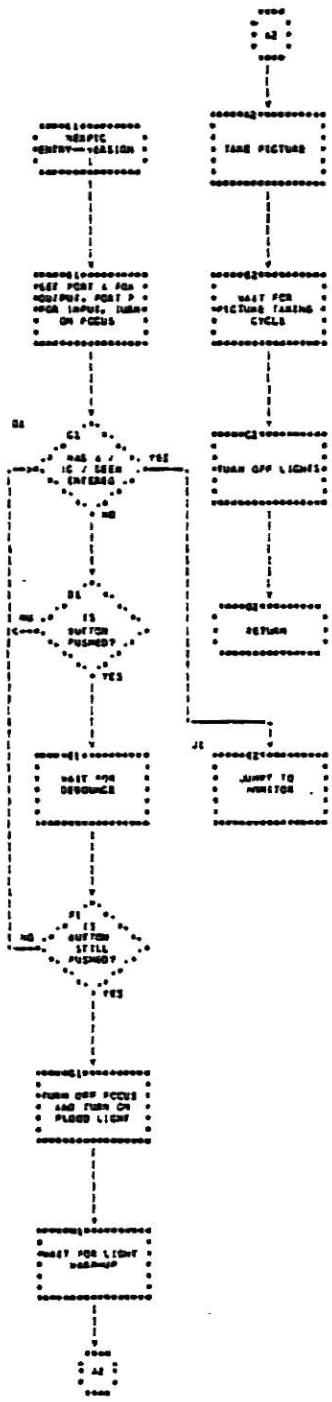
CUTPUTS: Signals to ports for flood, focus and DMA transfer to take picture.

LOCATION: 2700H

SIZE: 062H

COMMENTS: Must be run from Master Loop

VERSION: 3 8 22.36



Preprocessor (PREPRO)

2.3 The purpose of the Preprocessor is to help remove the non-uniformity of the flood light illumination.

Each location in picture memory has its own encoded 8 bit multiplier. The multipliers are stored in upper memory (20000H) henceforth called multiplier memory which is above the picture memory (10000H). In general the program takes in each multiplier, decodes it, then multiplies the corresponding location in picture memory and adjusts that location towards the average intensity found from LMETER.

The encoding of multipliers enables multiplications by any number between zero to 1.99 decimal. Bits 0-6 of the multiplier represent the value of the multiplier. Bit 7 is the code bit. A 1 represents a subtraction while a 0 represents addition. For example if value 20H was a multiplier at address 20143H and 13H was a number stored in address 10143H, then after decoding and multiplication the top byte of (13H x 20H) = 0260H or 02H would be added to the value leaving an 15H at address 10143H. The addition occurs because of the encoding of a 0 in the most significant bit and the multiplier actually represents the fractional difference to the average. Refer to Section 3.6 for a further discussion of multiplier encoding.

Fig. 2.3-1 shows a graph of picture memory value vs. address. After running the Preprocessor the values are closer to a sample average as determined by the Light calibration program and LMETER. Also marked improvement can be observed in an intensity distribution of a uniform surface. Obviously the correct multipliers must already reside in multiplier memory before attempting to execute the Preprocessor routine.

Intentionally or unintentionally the preprocessor can bias the entire picture memory. Care must be taken to load in the proper multipliers.

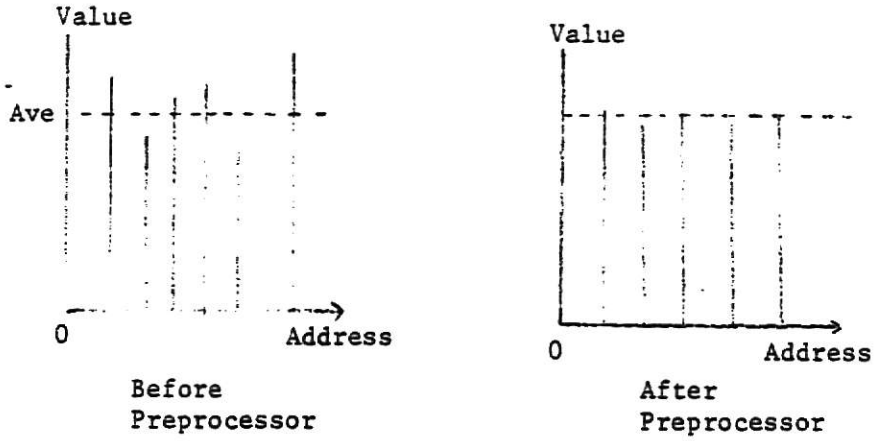


FIG. 2.3-1. Picture Memory Vs. Address For PREPRO

Preprocessor (PREPRO)

SUBROUTINES: None

RESISTERS: DI - Picture pointer

DS - segment set to 1000

ES - segment set to 2000

CX - general purpose

AX - multipliers, general purpose

BL - add or subtract flag

DL - general purpose

VARIABLES: 08C4 LMSKP

INPUTS: Values from picture memory and multiplier memory.

OUTPUTS: Values to picture memory linearized with respect to light intensity.

LOCATION: 2000H

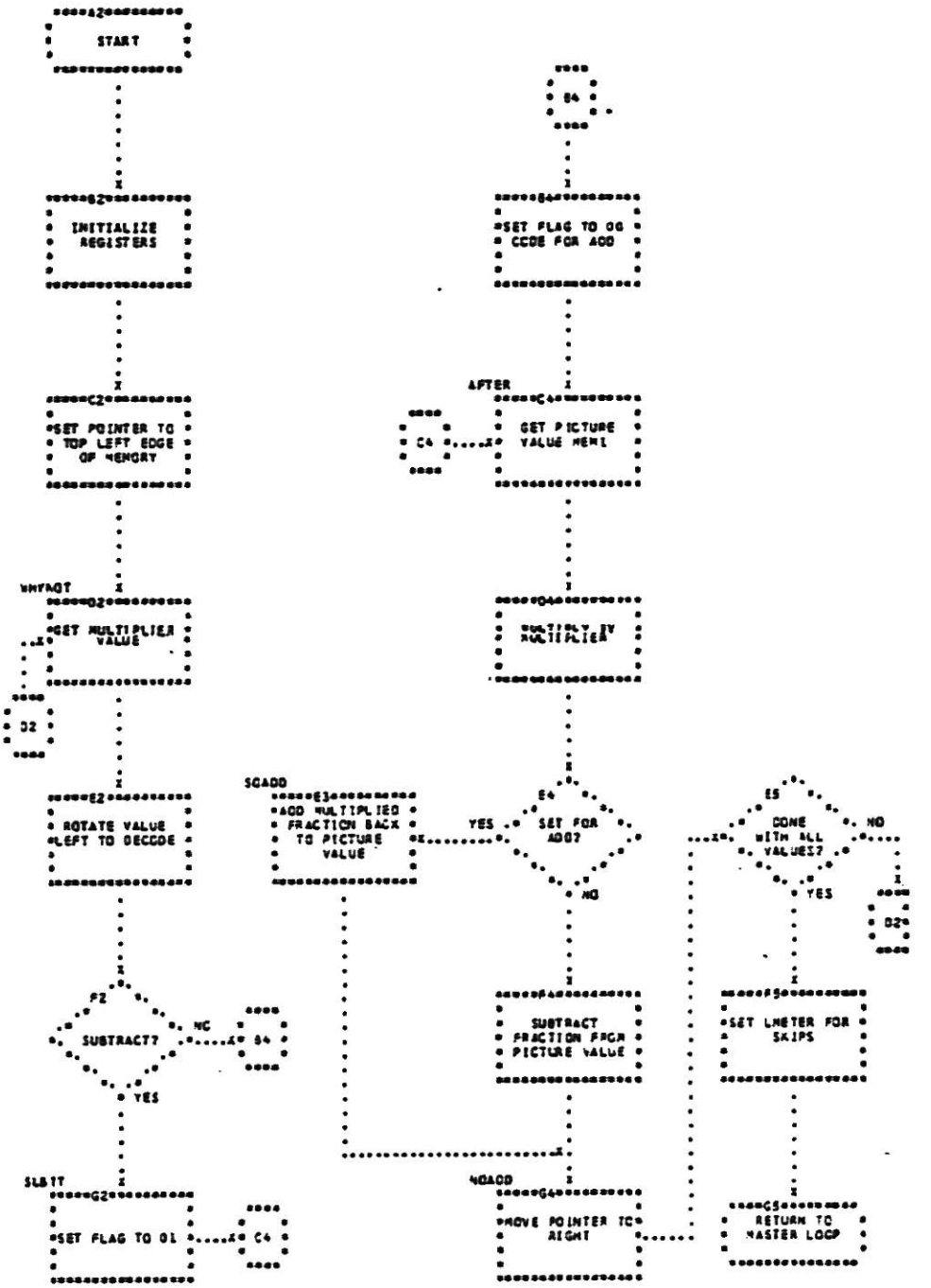
SIZE: 36H

NOTE: Preprocessor should be executed before Classifier and the proper multipliers should reside in multiplier memory. This program could be transferred to the Classifier routine but is left in the present configuration to aid analysis.

VERSION: 8 10 13.52

SUBROUTINE PREPROCESSOR

FLOWCHART



Classifier (CLSIFR)

2.4 The Classifier routine separates the picture data stored in picture memory as fat (02), meat (00) or background (03). The useful picture information resides between rows 00 and EF and columns 00 to EC as shown in Fig. 2.4-1. All surrounding areas are ignored. In addition boundary values are stored on the perimeter of the useful stored image by the calling of DRWBOX Subroutine.

USEFUL PICTURE INFORMATION

0000	0001	0002	0003	...	00EC	...	00FF
0100	0101	0102	0103	...	01EC	...	01FF
0200	0201	0202	0203	...	02EC	...	02FF
0300	0301	0302	0303	...	03EC	...	03FF
0400	0401	0402	0403	...	04EC	...	04FF
0500	0501	0502	0503	...	05EC	...	05FF
.	.	.	.		.		.
.	.	.	.		.		.
.	.	.	.		.		.
EF00	EF01	EF02	EF03	...	EFEC	...	EFFF
.	.	.	.		.		.
.	.	.	.		.		.
.	.	.	.		.		.
FF00	FF01	FF02	FF03	...	FFEC	...	FFFF

FIG. 2.4-1. Picture Memory

Fig. 2.4-2 is a distribution showing the light intensity on the x axis vs. area on the y axis for all data points in picture memory. Initially assume points 1, 2 are together and points 3, 4 are together. The classifier separates meat from background (1,2) then meat from fat (3,4). The values 03, 00, 02 are assigned to background, meat, and fat respectively.

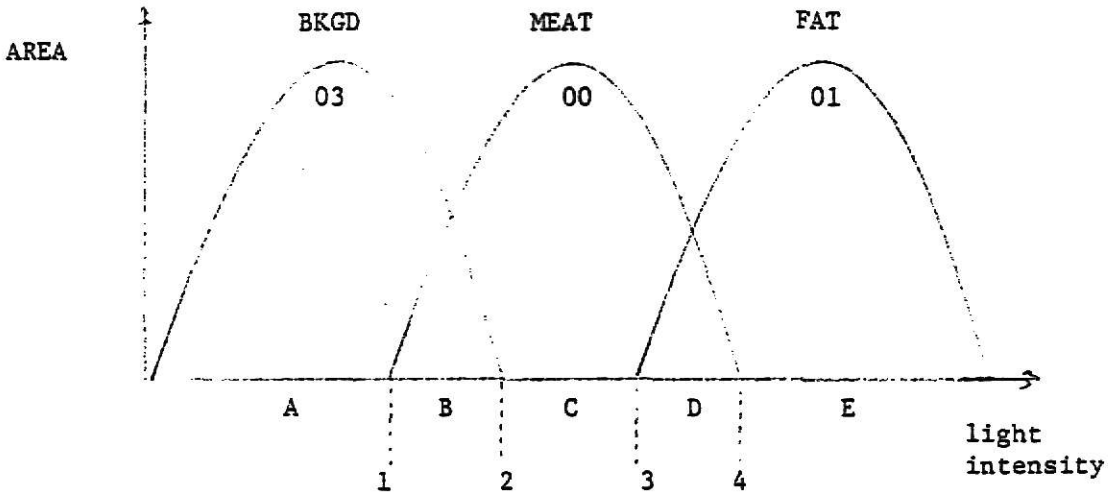


FIG. 2.4-2. Intensity Distribution

If points 1,2 and 3,4 are separated there remains regions B and D that are unknowns. For these unknown regions the hysteresis algorithm can be used to determine their classifications based on the previously classified point. For example if the pointer had been classifying background and hit a slightly higher intensity pixel (region B) it will be classed as background. Only if it exceeds point 2 will it be classed as meat or fat. This effect is commonly known as hysteresis and may be implemented merely by separating in value points 1,2 and 3, 4.

Classifier (CLSIFR)

SUBROUTINES: DRWBOX

REGISTERS USED: DI - used as pointer to upper memory picture array

CX - temp storage

- store the # of columns in a row

- last address storage

BX - # of rows in the matrix

VARIABLES:

620H	FTHRUN
8C8H	UPRLV1
8C9H	UPRLV2
8CAH	LWRLV1
08CBH	LWRLV2
8CCH	BIGFLG
8D2H	SMLFLG

INPUTS: Hex intensity values from picture.

OUTPUTS: Values 00,02,03 back to picture memory.

Previous values purged.

LOCATION: 3000H

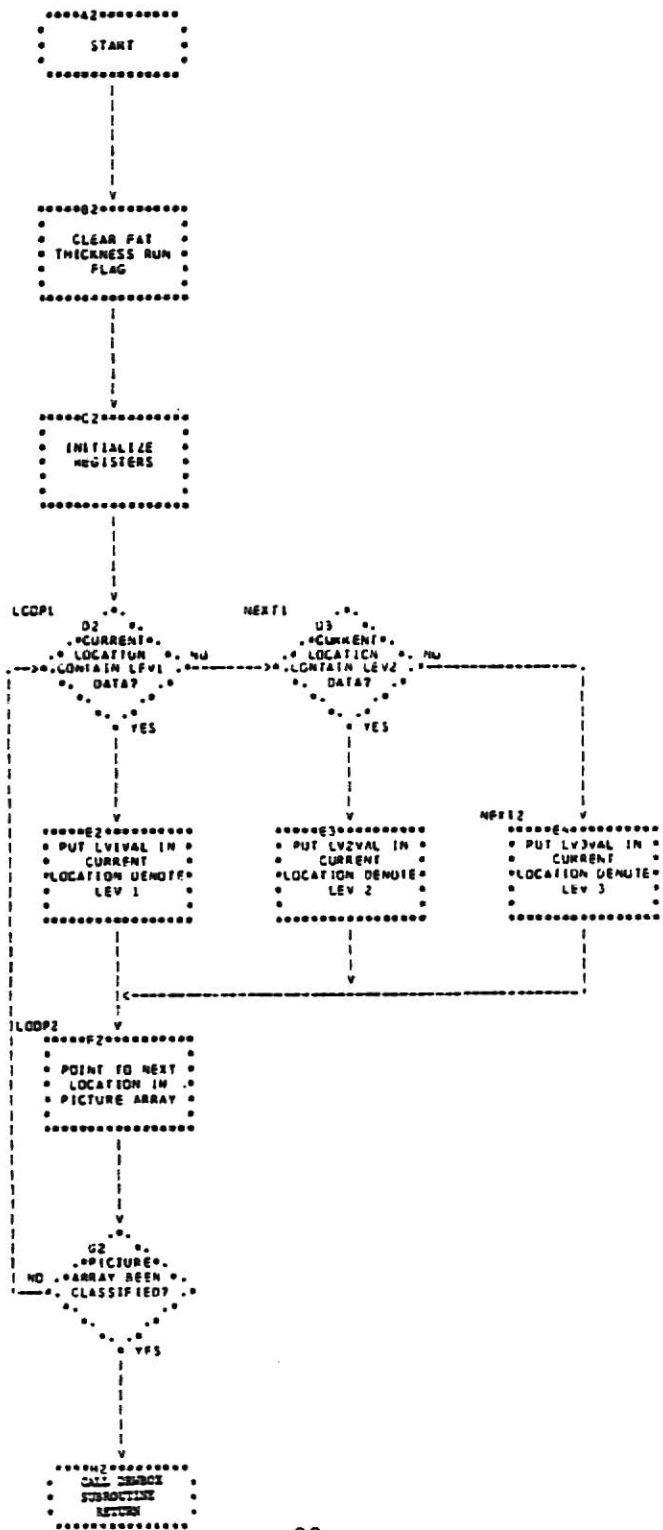
SIZE: 7CH

COMMENTS: Classifier must precede any beef grading analysis programs.

VERSION: 9 5 14.18

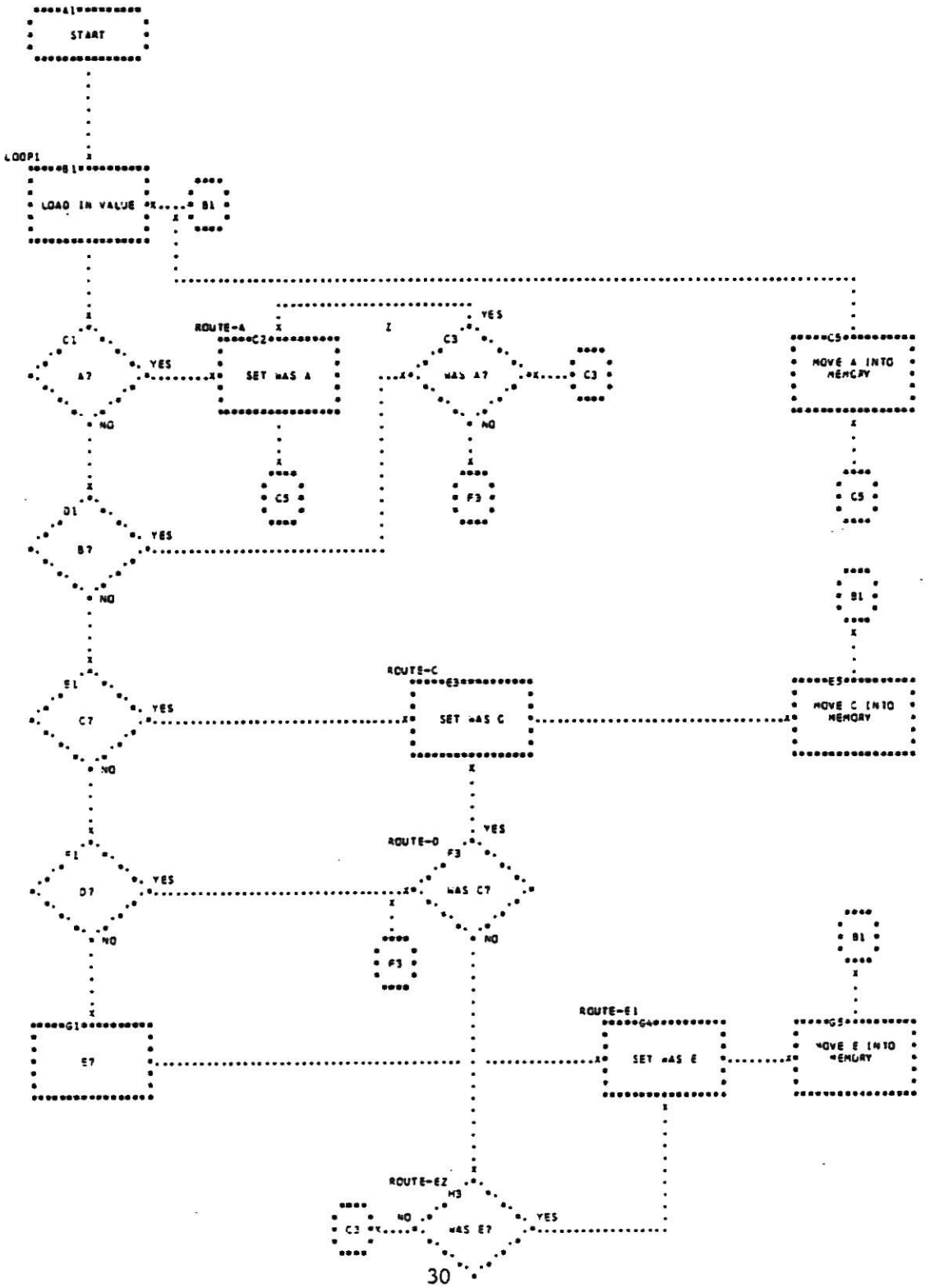
CLASSIFIER CHART

FLOWCHART



HYSTERESIS

FLOWCHART



Boundary Search (BOUSCH)

2.5 This program finds the boundary between meat and fat. In Boundary search the background is also treated as fat so a boundary can be drawn between meat and background also.

The search starts with a pointer at the center of the loin eye (location 7F76H). Unusual conditions must be accounted for in starting at the center. If the pointer lands in the middle of a large piece of fat or background the pointer must be moved until it is in the meat area. The pointer is positioned according to the cross hairs from the focus lights. (It is assumed that the pointer will land inside the loin eye.)

Some of the conditions that the program will encounter are illustrated in Fig. 2.5-1. Pointer movement is from right to left in this case with the exclamation point indicating where the boundary will be drawn.

OK	B		F	*	M		F	
No meat error	B		F		B		F	
OK	F		B	*	M		F	
No meat error	B		B		F		B	
OK	B		B		F	*	M	
OK	B		B		B	*	M	
OK	B		B	*	M		B	
OK	B	*	M		F		B	
OK	F	*	M		B		F	
OK	B		F	*	M		B	

BACKGROUND - B

FAT - F

MEAT - M

BOUNDARY - *

FIG. 2.5-1. Boundary Conditions

When the pointer finds a fat cell it checks to see if it is an isolated cell. If it is isolated Fig. 2.5-2 the pointer will start searching for another fat cell again. If another fat cell is found and non-isolated, a boundary search is attempted, Fig. 2.5-3.

M M M

M F M

M M M

FIG. 2.5-2. Isolated Fat Cell (no attempt to draw boundary).

F M M

F M M

M M M

FIG. 2.5-3. Non-isolated Fat Cell (boundary search attempted).

When a boundary search is attempted the pointer must follow a line that will lead it to the inner most edge between meat and fat. The first boundary point is saved.

The following describes the Freeman chain code algorithm [2]. The boxes in Fig. 2.5-4 represent the directions the pointer may take in searching for the next fat cell. The pointer moves in a counterclockwise direction e.g., 0-1-2-3 until it finds a fat cell.

3 2 1

4 C 0 C = Current Boundary Point

5 6 7

FIG. 2.5-4. Direction Boxes

When a fat cell is found the direction boxes are overlayed onto the fat cell with the fat cell in the center of the boxes, Fig. 2.5-5. The center fat cell is changed to a boundary point represented by an "X" Fig. 2.5-6. The boundary address is stored in lower memory.

F	F	M	M
3^F	2^F	1^M	M
4^F	C^F	0^M	M
5^F	6^F	7^F	M

FIG. 2.5-5. Box Overlayed Onto Memory Cells.

F	F	M	M
3^F	2^F	1^M	M
4^F	C^X	0^M	M
5^F	6^F	7^F	M

FIG. 2.5-6. Center Fat Cell to Boundary Point.

At this point a new direction is sought. The new direction is chosen by the relationship.

$$N^+ = \begin{cases} \text{Mod}(N-1) & N \text{ even} \\ \text{Mod}(N-2) & N \text{ odd} \end{cases}$$

where N^+ is the new direction

N is the old direction

Mod 8 arithmetic is used.

Example 1. If the fat point was found in the direction 4,

(even) the next direction starts at direction 3.

Example 2. Old direction = 5

New start direction = 3

3^F	2^F	1^M	M
4^F	C^F	0^M	M
5^F	6^X	7^M	M
F	F	F	M

FIG. 2.5-7. New Box Location.

If a fat cell is not found in the new direction the pointer moves in a counterclockwise direction until it finds a fat cell. The direction boxes are centered about the new cell, Fig. 2.5-7, and the process is repeated until the pointer reaches the original starting point.

The boundary is now checked to see if it is large enough to be called a valid area. If the bounded area found is too small (Fig. 2.5-8 and Fig. 2.5-9) then all previously found boundary points are changed back to fat. The locations of the boundary points to be changed have been stored in lower memory.

The pointer is moved vertically, about an inch, and the search for a large enough boundary continues. Fig. 2.5-10 and Fig. 2.5-11 shows the correct boundary. The initial pointer direction is determined by the LCRS flag which is set by the DRECTN Subroutine. If the LCRS flag is a 1 the pointer moves to the left in subroutine MOVPOS. If the LCRS is zero, the pointer moves to the right or is incremented in MOVPOS subroutine.

It is interesting that after classification, many boundarys exist. The Boundary search program along with Spline must choose the proper valid boundary.

FIG. 2.5-8. Too Small Boundary

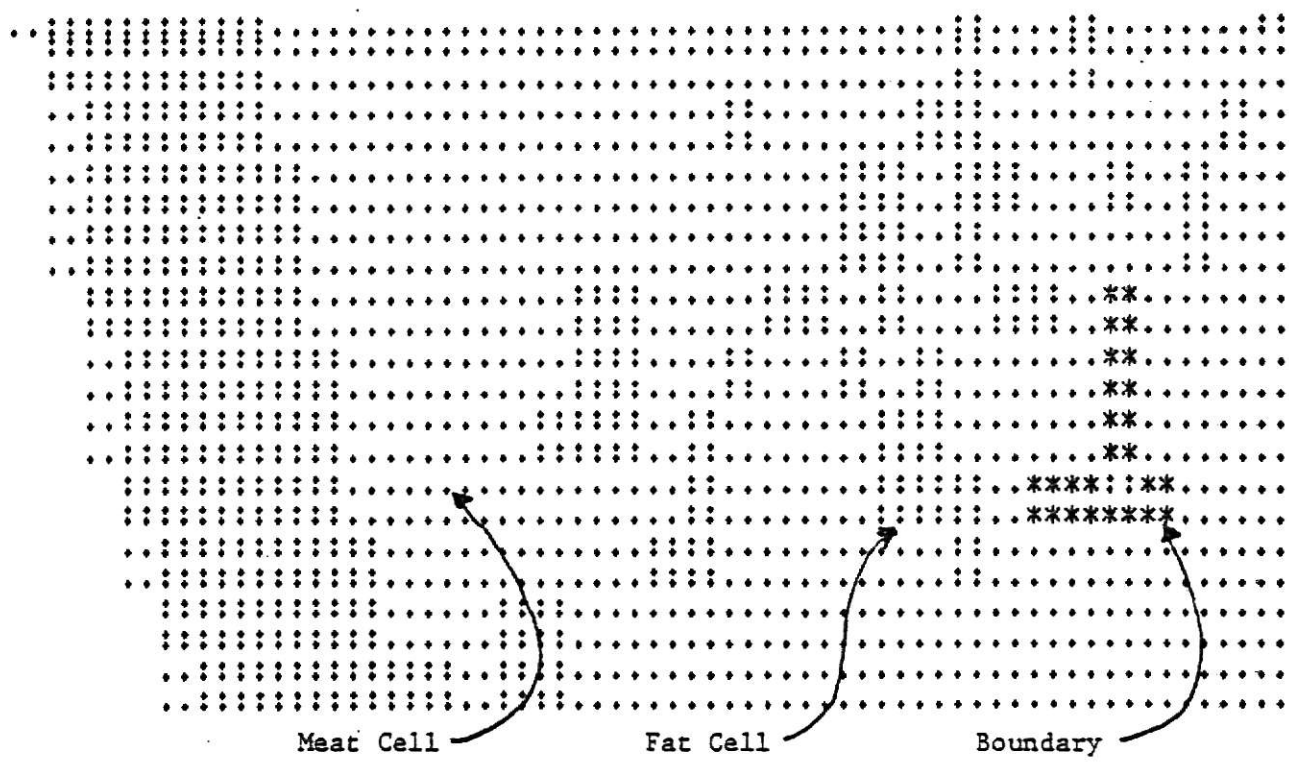


FIG. 2.5-9. Too Small Boundary (Block Display).

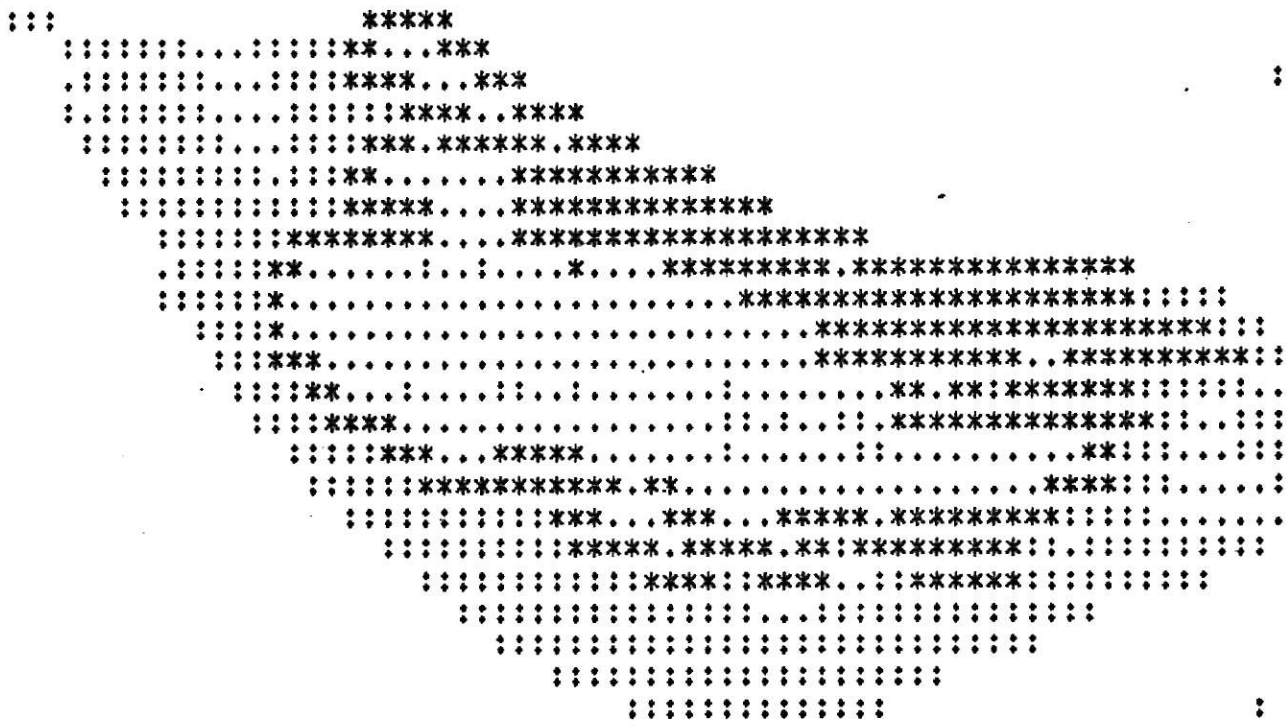


FIG. 2.5-10. Correct Boundary.

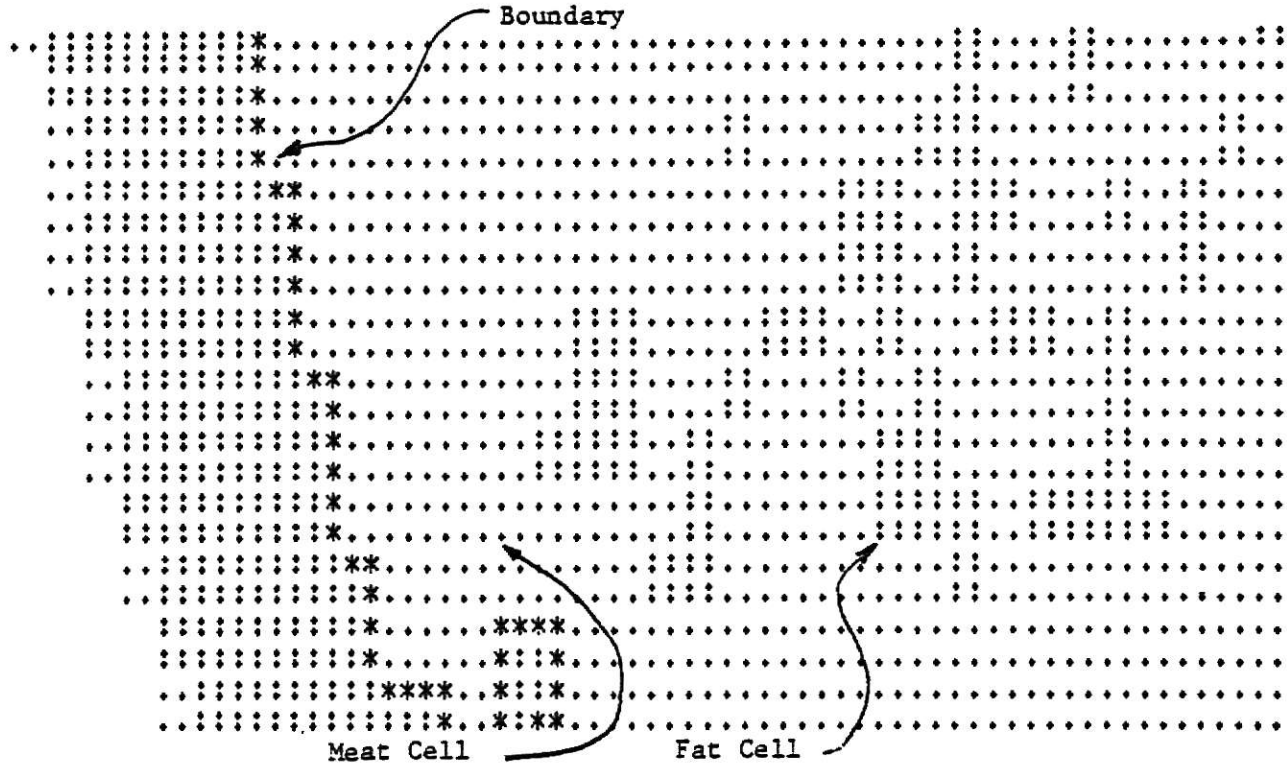


FIG. 2.5-11. Correct Boundary (Block Display).

Boundary Search (BOUSCH)

SUBROUTINE: THER, OVRWRT, DRECTN, MOVPOS

REGISTER: DI - picture pointer

BP - pointer to lower memory storage of Boundary Location

BH - fat or Bkgd indicator, # of Boundary points

DX - starting point

CX - counter

VARIABLES:

400-600H	MBLK	8CCH	BIGFLG
061AH	MTFT	8CDH	OLDROU
06D2H	FLAGOV	8DOH	LCRS

INPUTS: Bytes 00,02,03 nominal or 00,01,02,03 from picture memory.

OUTPUTS: Boundary (01) along Meat/Background or Meat/Fat edge.

LOCATION: 3100H

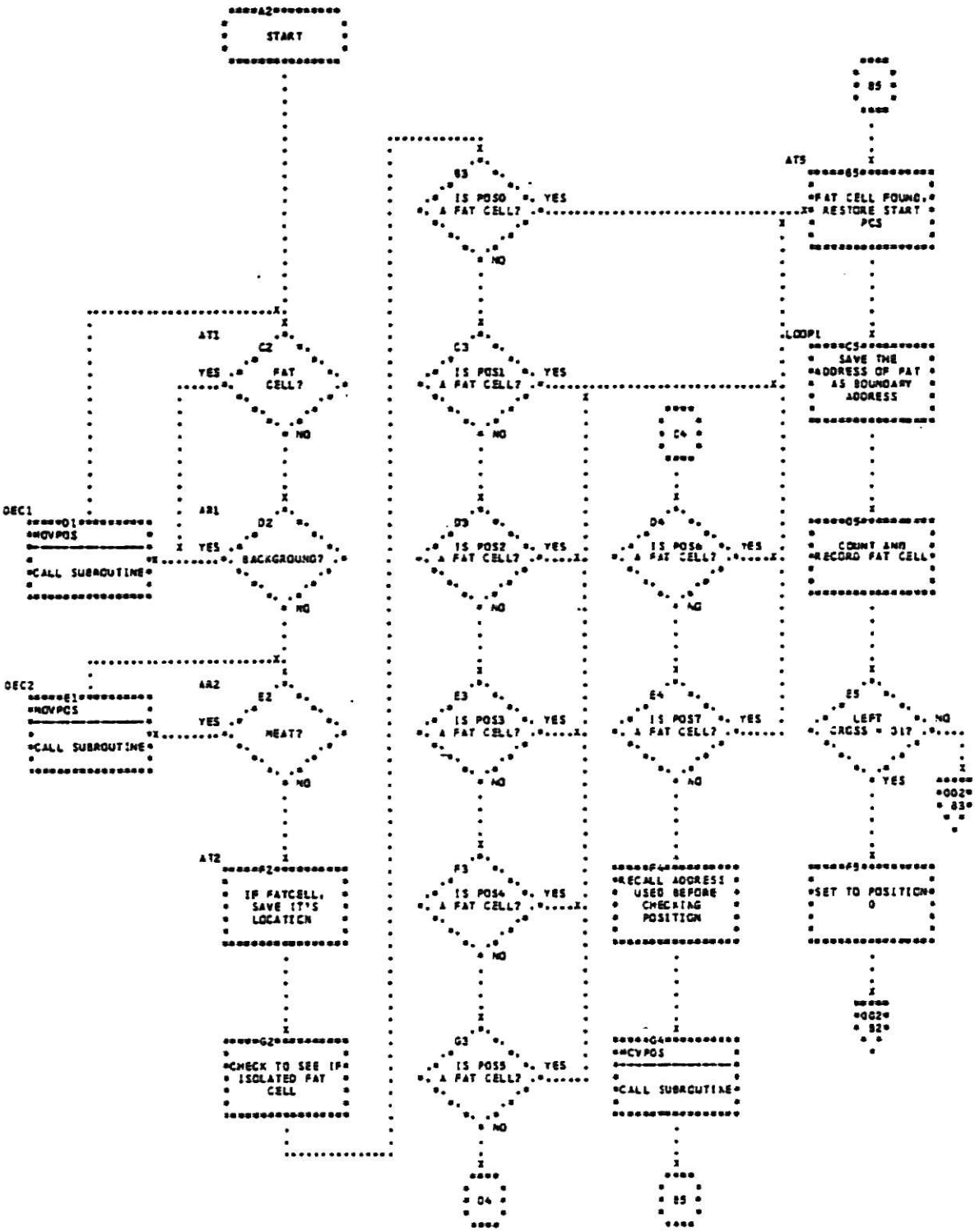
SIZE: 1DBH

COMMENT: Must be preceded by Classifier.

VERSION: 9 3 13.52

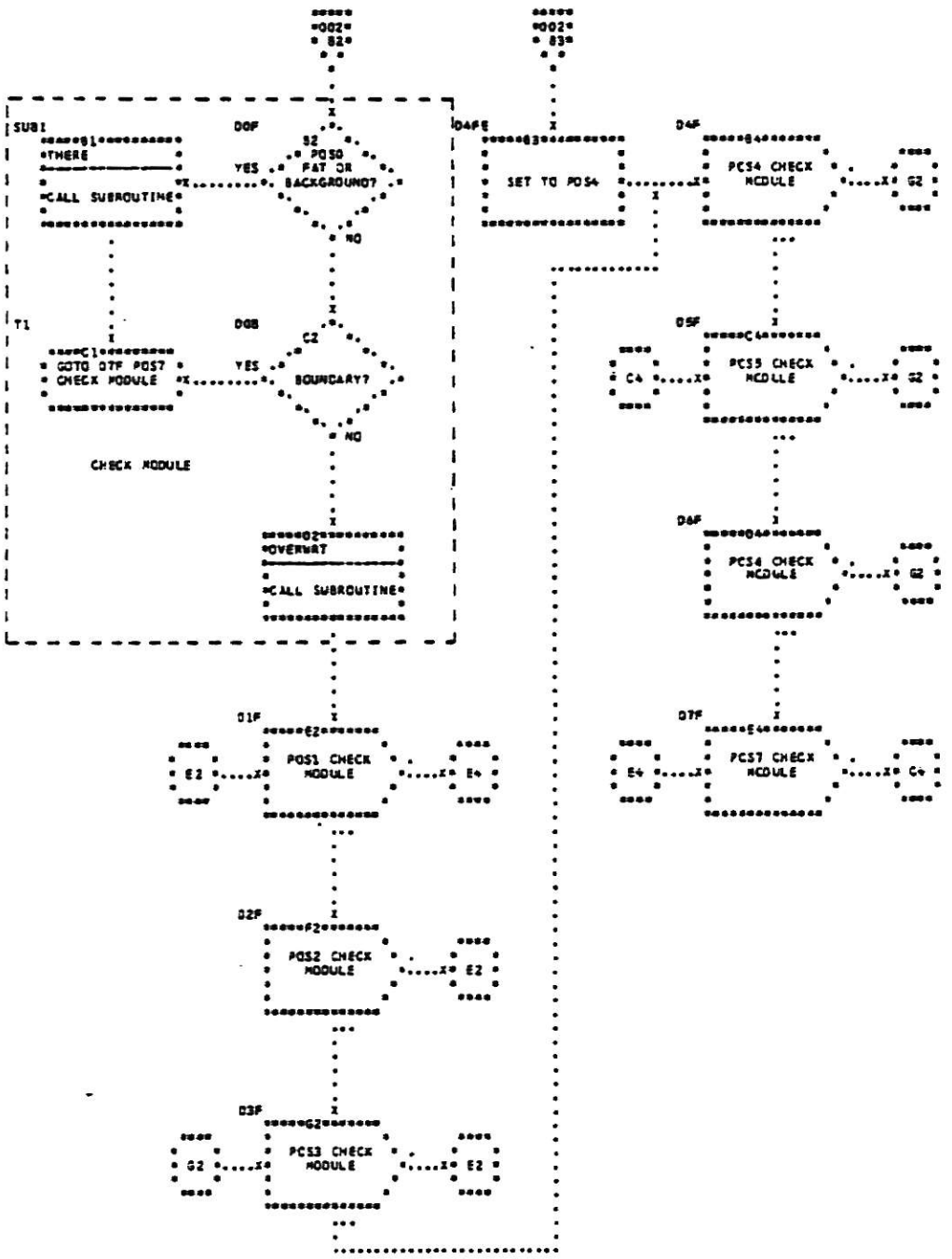
SUBROUTINE BOUNDARY SEARCH

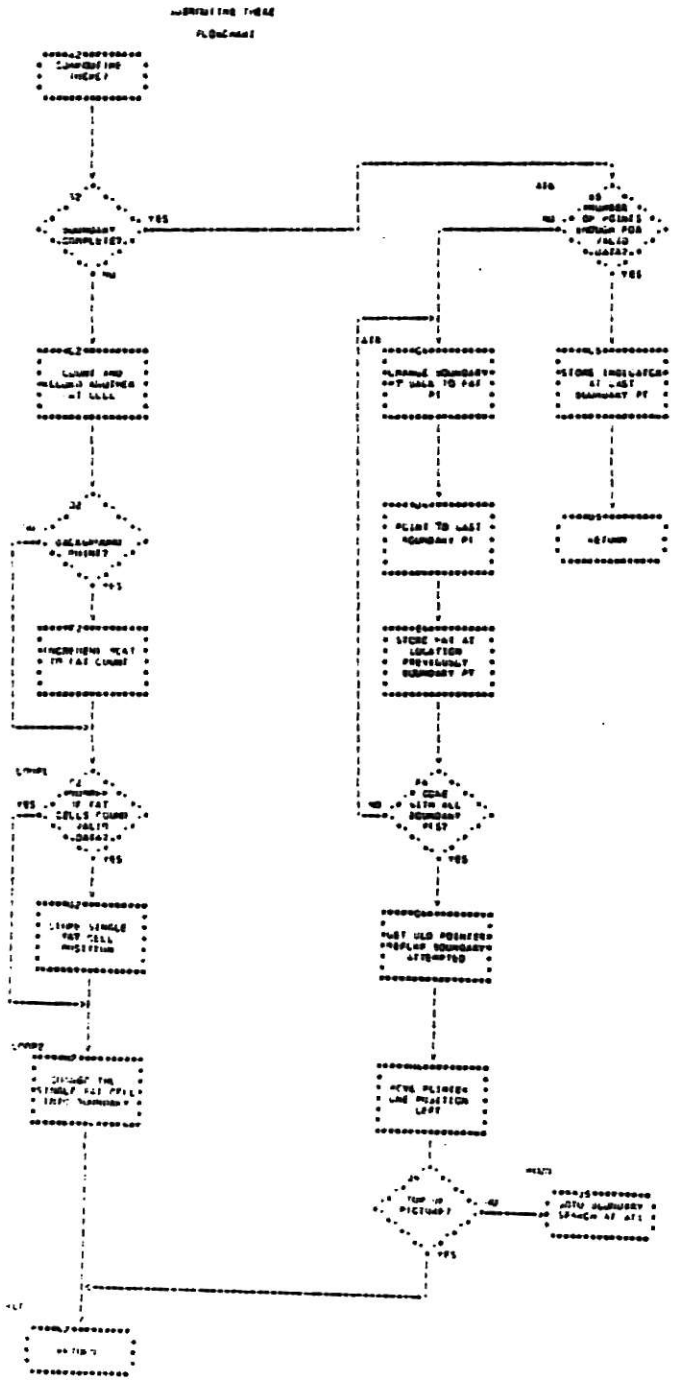
FLOWCHART

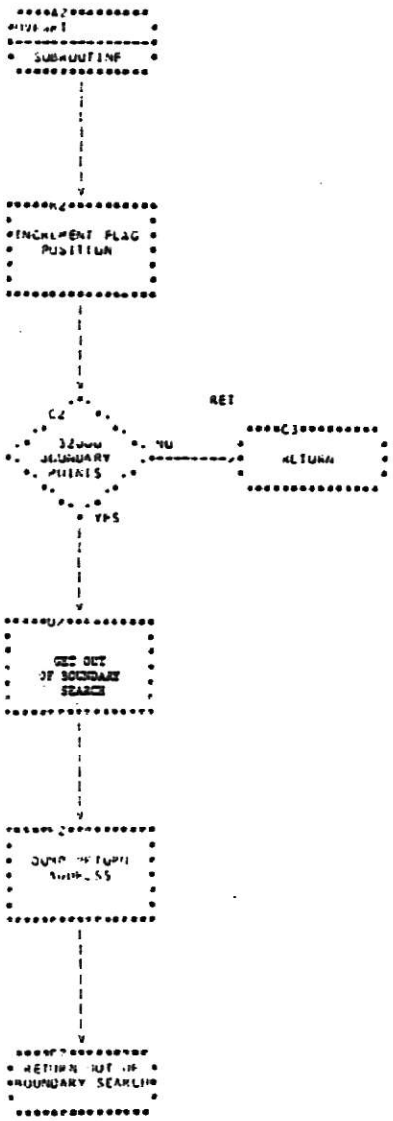


SUBROUTINE BOUNDARY SEARCH

FLOWCHART

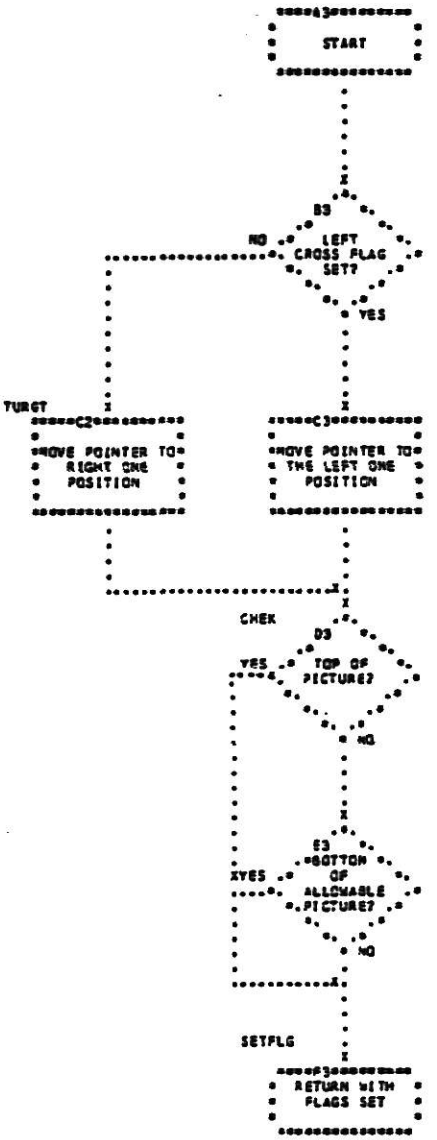





SUBROUTINE
ENCLOSURE FLAG
POSITION
RET
RETURN
YES

SUBROUTINE MOVE POSITION

FLOWCHART



Spline (SPLINE)

2.6 The Spline routine eliminates the boundary, if any, around the Spinalis dorsi, longissimus costarum and serratus dorsalis muscles. See Fig. 1.1-1. These muscles should not be included within the longissimus dorsi (Loin eye) boundary. This is an acute problem because the separation may not be large enough to determine the muscles from the running of Boundary search routine.

Spline also reduces the "breakout" effect that may occur in Boundary search. Breakout occurs when the boundary follows the edge of the carcass towards the edge of picture memory.

The routine first steps to the boundary and overlays a line of specified length on top of the existing boundary. This line is called a spline. The first spline length drawn is extremely long compared to the circumference of the longissimus costarum (LC) muscle. Its purpose is to help eliminate the breakout problems associated with incomplete fat around the loin eye proper.

The entire spline is moved one position along the boundary.

The distance between the beginning (H) and ending (T) points is computed. If the distance is within an allowable minimum distance the H and T addresses are stored in memory for later processing.

After the points are stored the spline is moved one position along the boundary and a check on the H-T distance is made again.

The process continues until all allowable minimum distance points are loaded into memory. Subroutine PRECON is called which calls CONNT Subroutine to connect point pairs whose addresses are stored in memory. The points are connected by storing an (01) boundary along the path between 2 points. Fig. 2.6-1, illustrates the original boundary. Fig. 2.6-2 shows

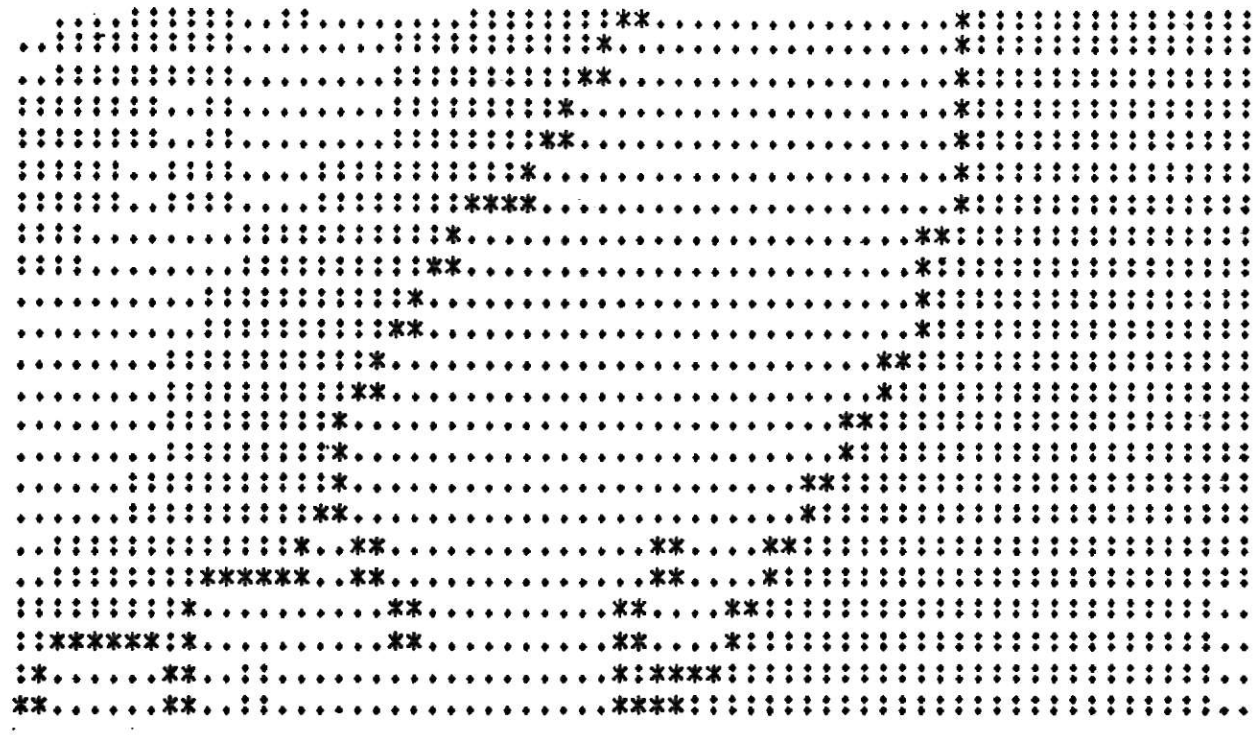


FIG. 2.6-1. Spline Before CONNT.

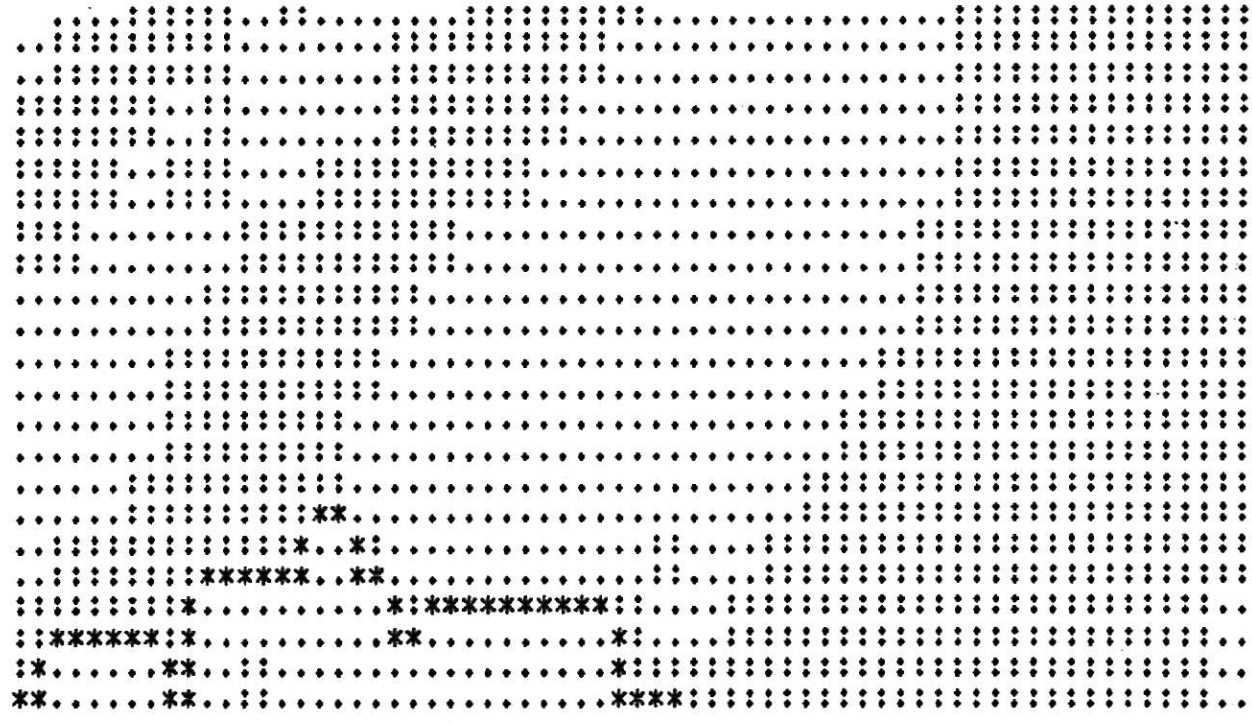


FIG. 2.6-2. Spline After CONNT,
REST and BOUSCH.

the altered boundary after CONNT, REST and BOUSCH subroutines. REST is a subroutine that converts all boundary points to fat cells. BOUSCH is the Freeman chain code algorithm described in Section 2.5.

After the CONNT subroutine has connected all the points previously stored in memory, the entire process is repeated using shorter apline lengths. Ideally the spline length should be reduced by one for each complete path around the boundary. The new spline length is chosen as new length = old length - n. As n gets larger the number of iterations about that loin eye is reduced thus improving execution speed. Also as n increases the smoothness of the boundary decreases.

In Fig. 2.6-3 the original boundary is shown. Note the inclusion of the L.C. muscle and musculature in the lower right section. The first run through Spline removes some of the excess boundary from the bottom, Fig. 2.6-4. The next run further reduces boundary in this area, Fig. 2.6-5. Next the top L.C. muscle is removed, Fig. 2.6-6. More boundary is removed to the final configuration, Fig. 2.6-7. The final Figure 2.6-8 is included to show that after the spline program is called again no further reduction of the boundary takes place.

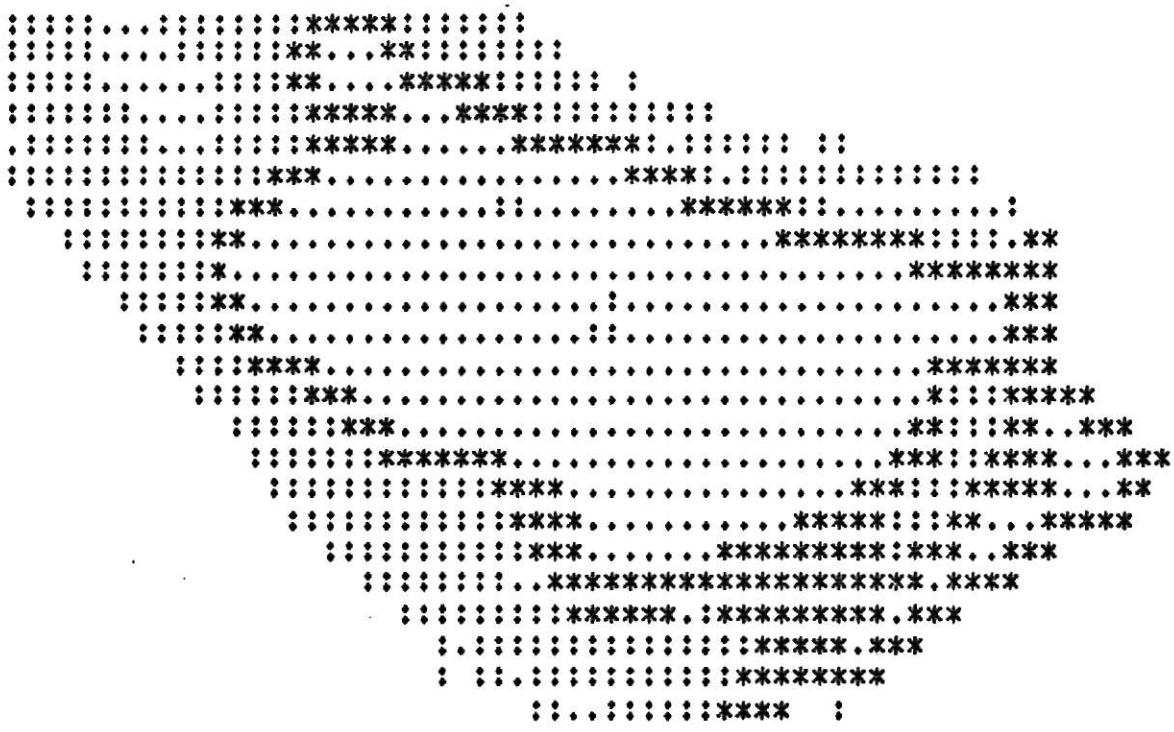


FIG. 2.6-3. Before Spline.

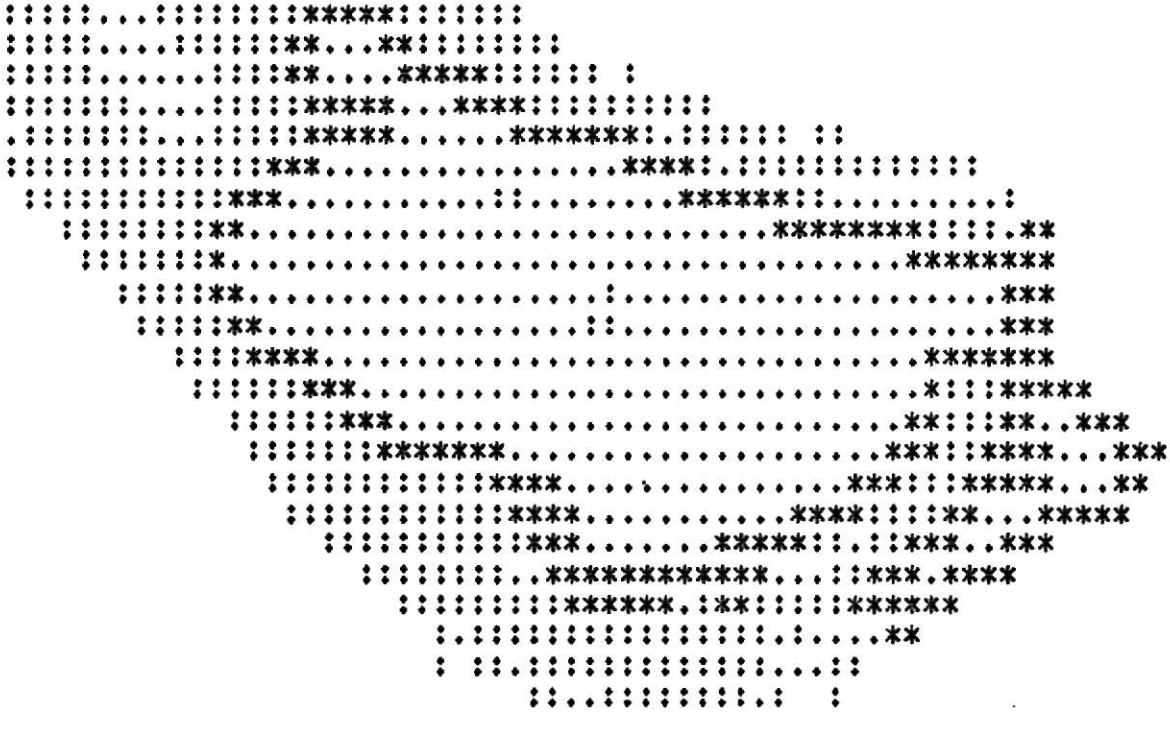


FIG. 2.6-4. Spline Iteration.

FIG. 2.6-5. Spline Iteration 2.

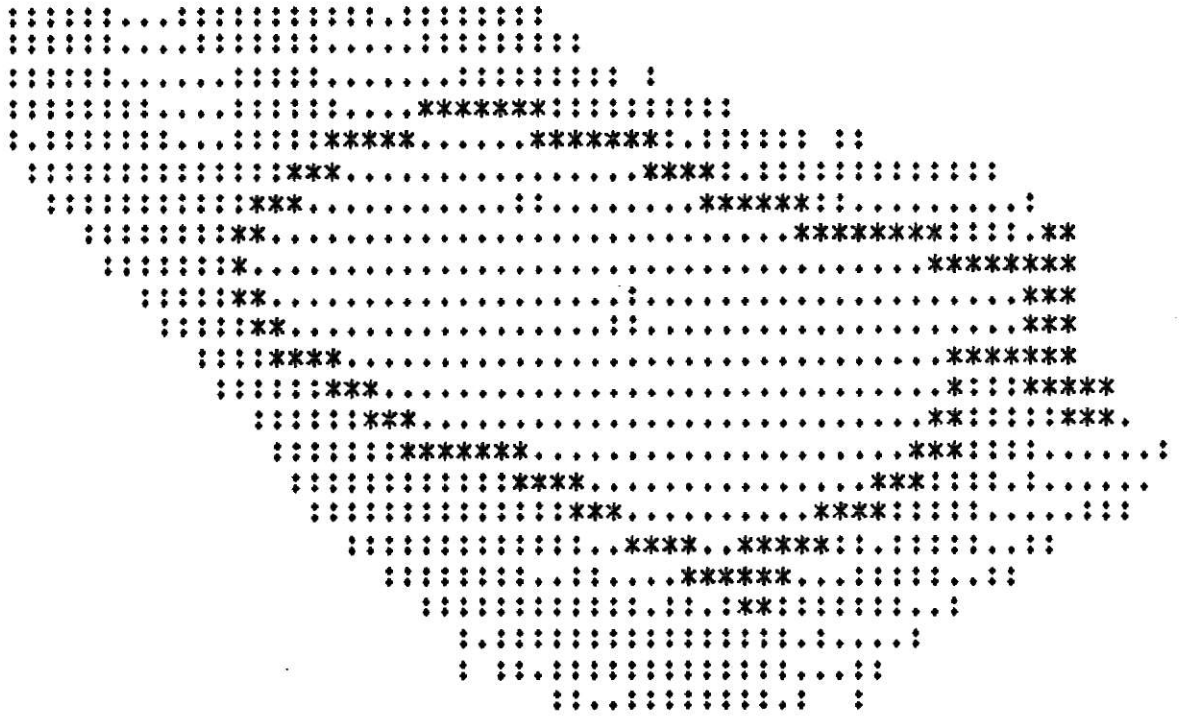


FIG. 2.6-6. Spline Iteration 3.

FIG. 2.6-7. Spline Interation 4.

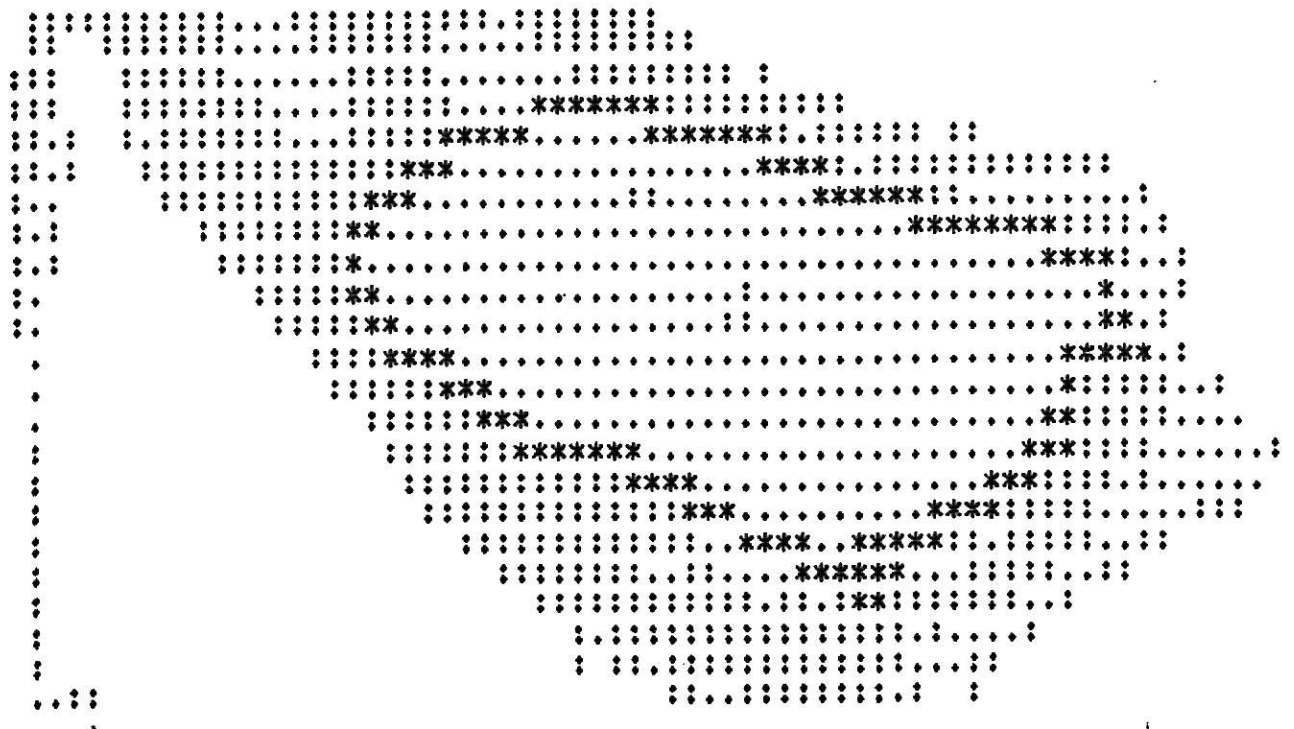


FIG. 2.6-8. Spline Iteration 5, No Change.

Spline (SPLINE)

SUBROUTINE: REST, BOUSCH, SPLN, SMOVE, PRECON
NEXTPT, SQUARE, CONNT, POCK

REGISTERS: CX - counter, spline length
DI - picture pointer
BX - direction pointer, general
DX - difference, slope flag, general
BP - memory pointer to 72ØØ

VARIABLES:

060EH	SPLHM	0709H	SPFLG
060CH	SPLTM	070AH	STTPT
060CH	SPLTB	070CH	SLENGTH
060EH	SPLHB		
0700H	SPLH		
0702H	SPLHD		
0704H	SPLT		
0706H	SPLTD		

INPUTS: 00, 01, 02, 03 from picture array

OUTPUTS: 00, 01, 02, 03 to picture array (altered shape)

LOCATION: 7A00H

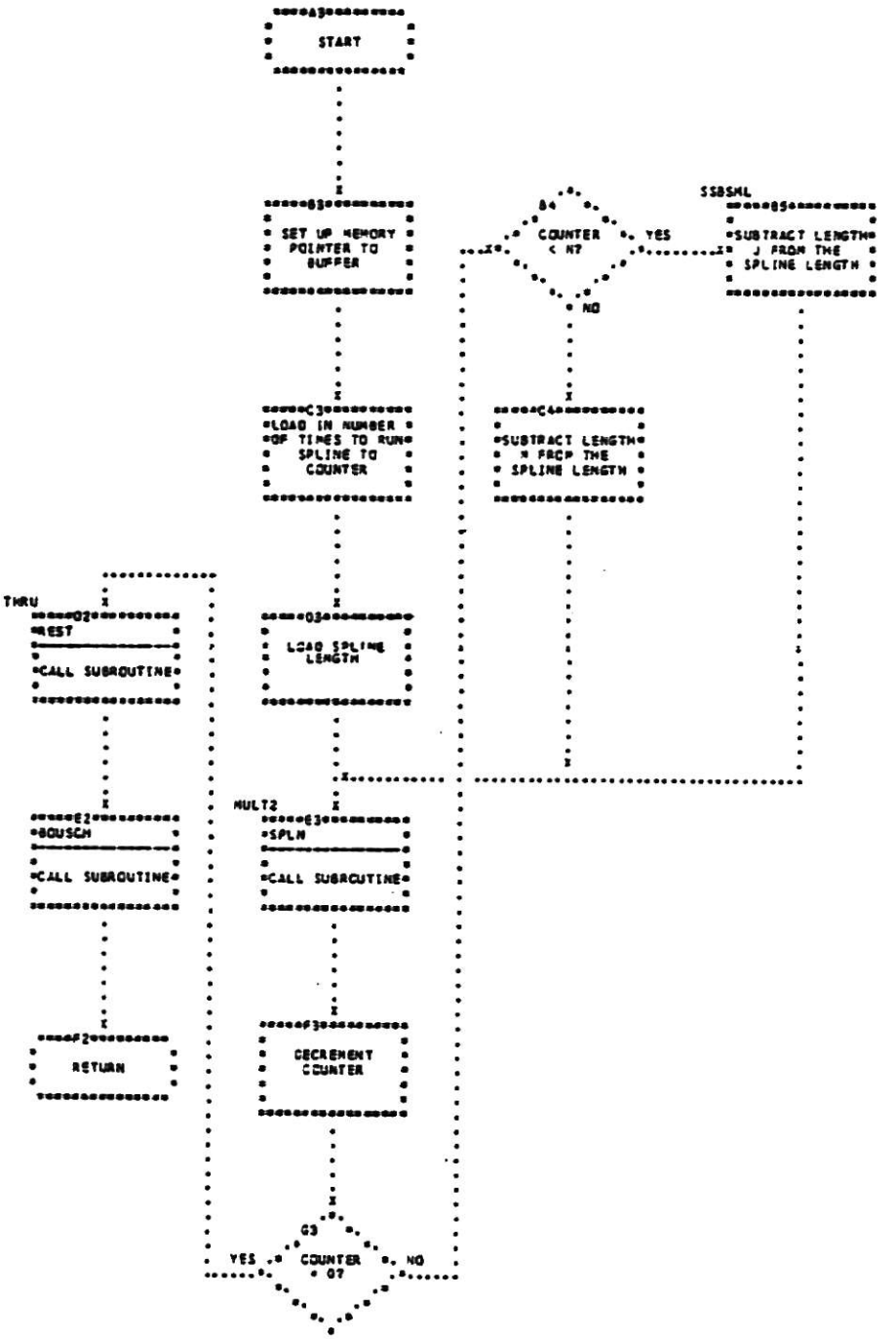
SIZE: 1EDH

COMMENTS: Boundary search must precede Spline

VERSION: 8 2 11.13

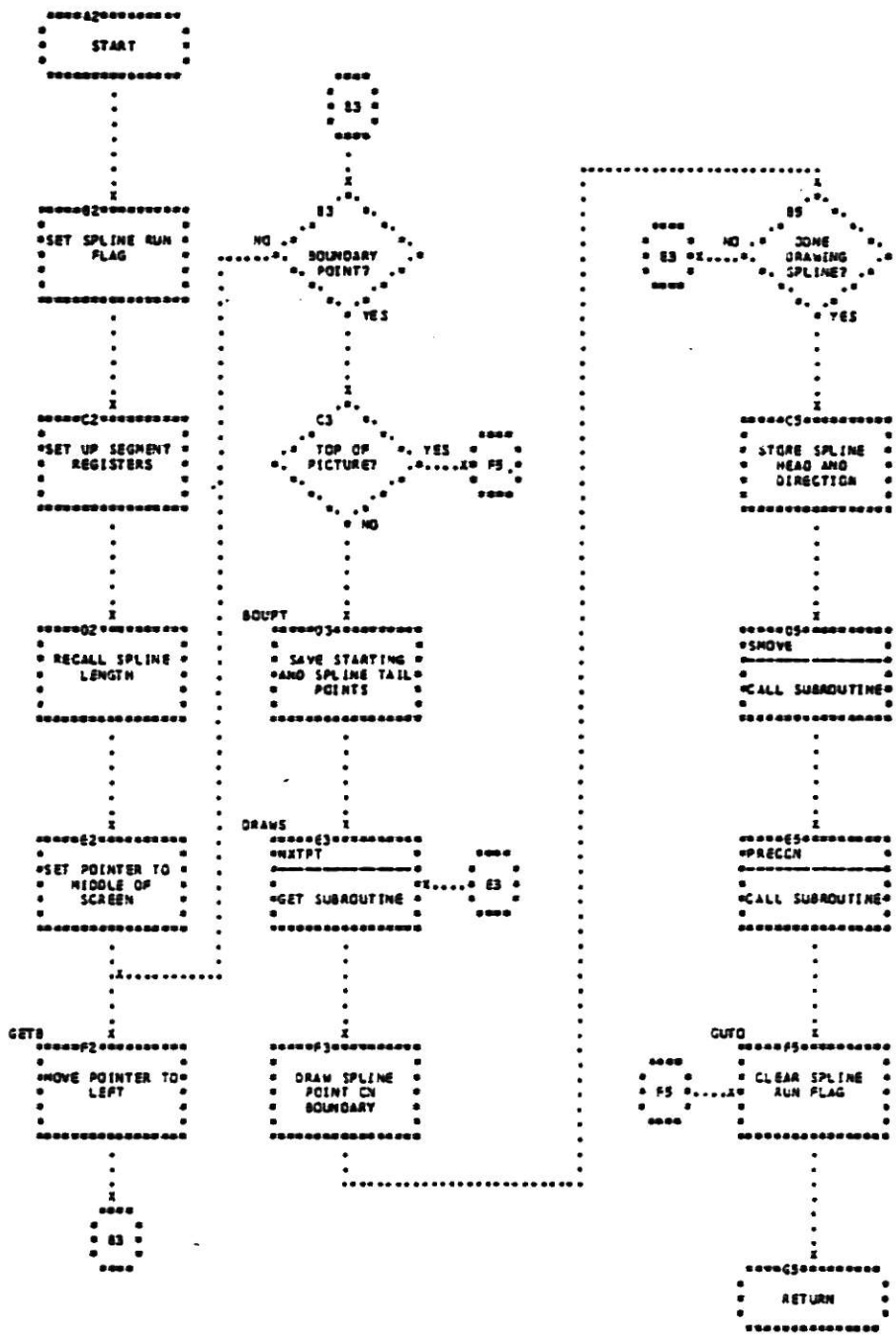
SUBROUTINE SPLINE

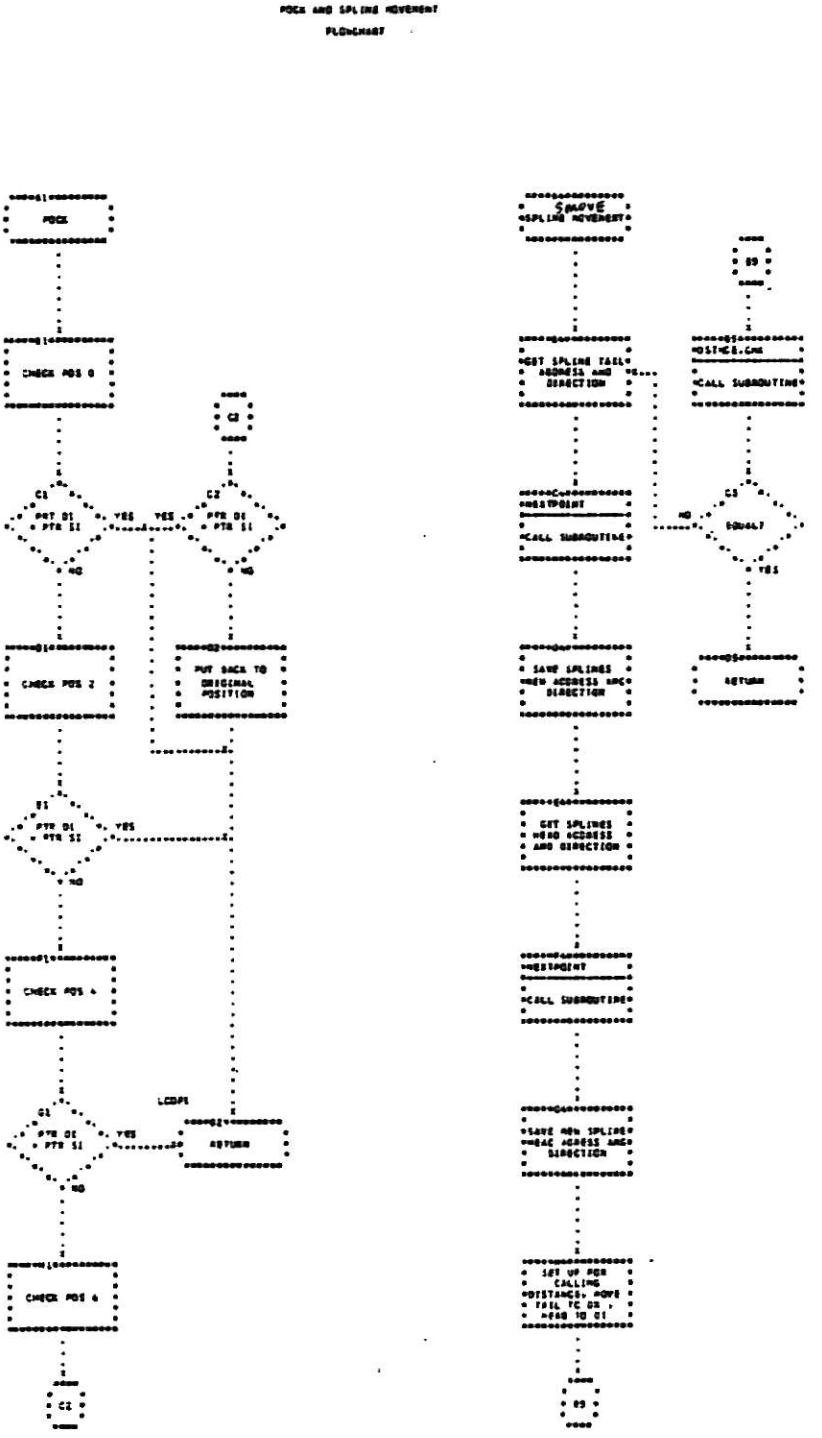
FLOWCHART



SUBROUTINE SPLN

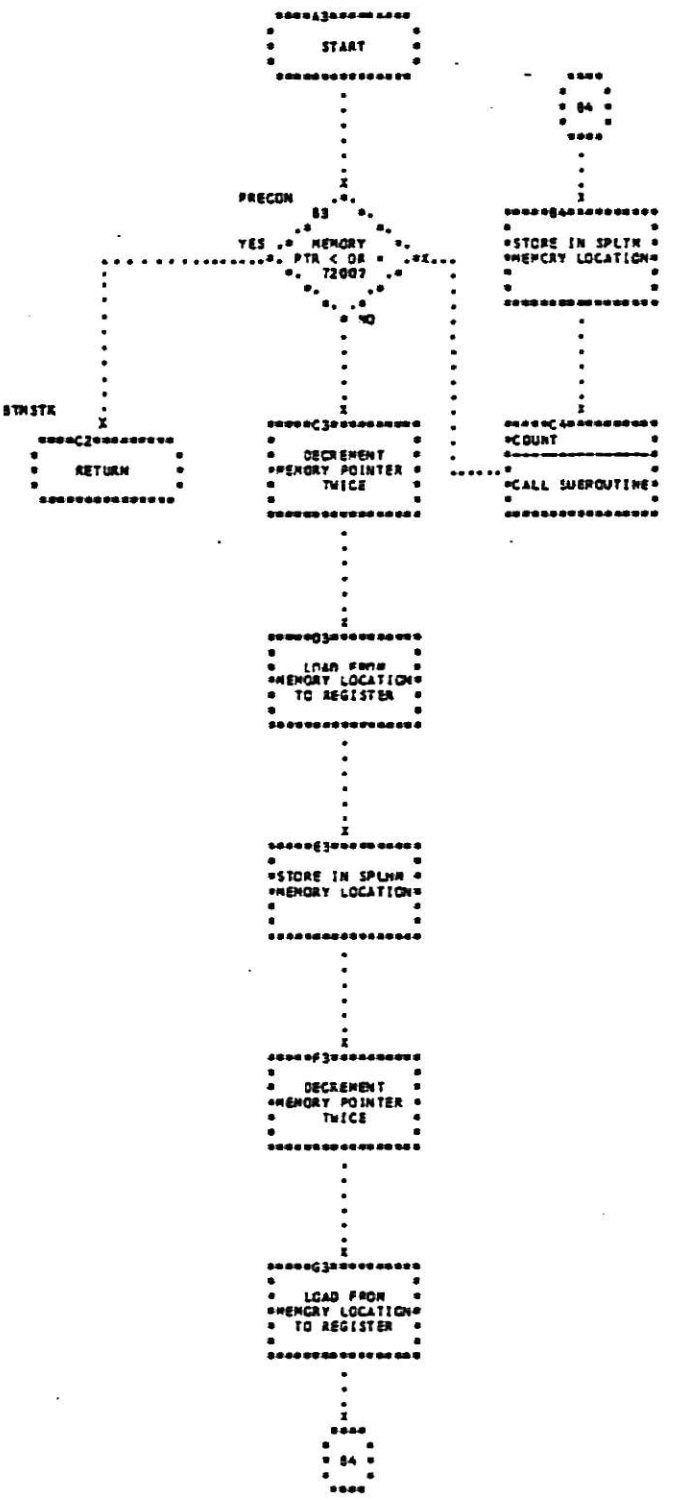
FLOWCHART





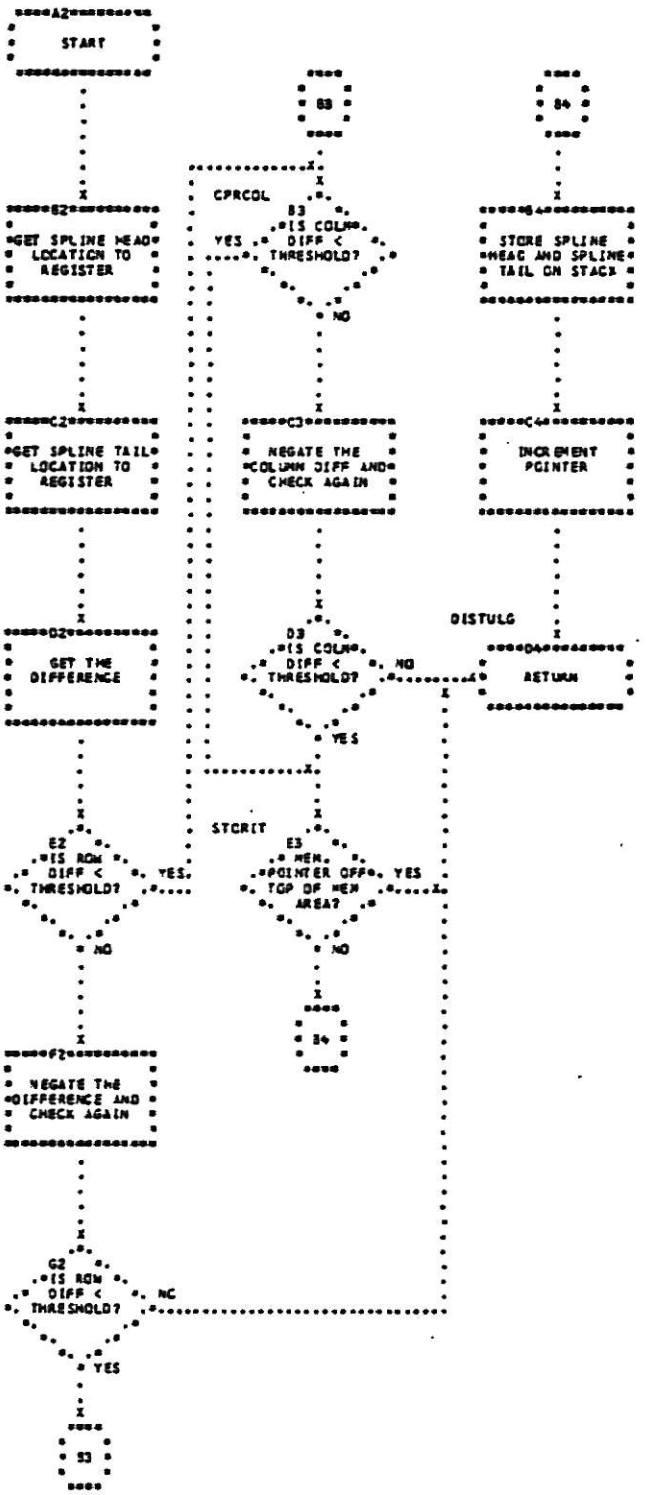
SUBROUTINE PRECONNECT

FLOWCHART



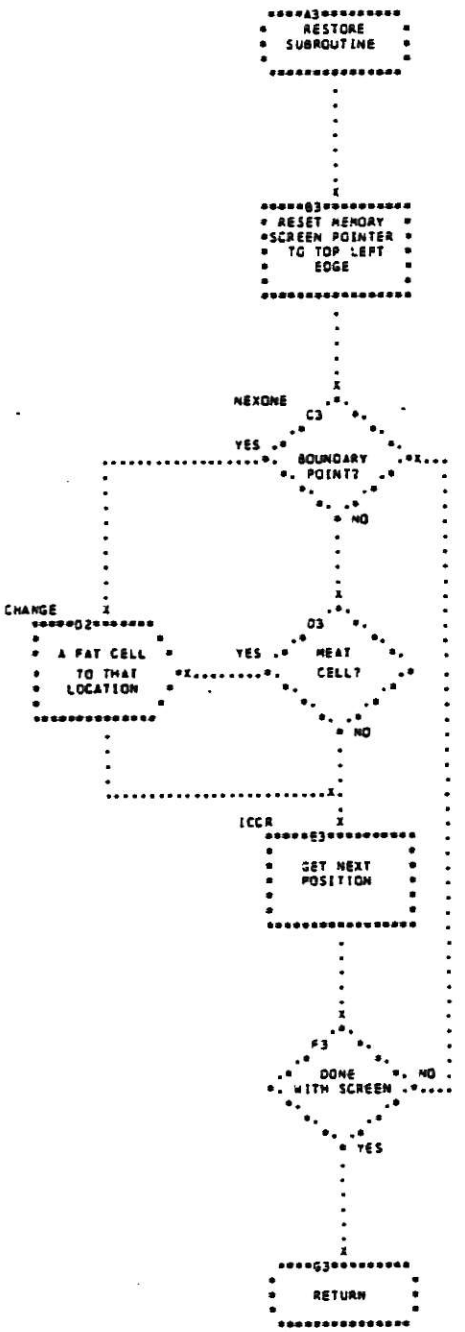
SUBROUTINE SQUARE

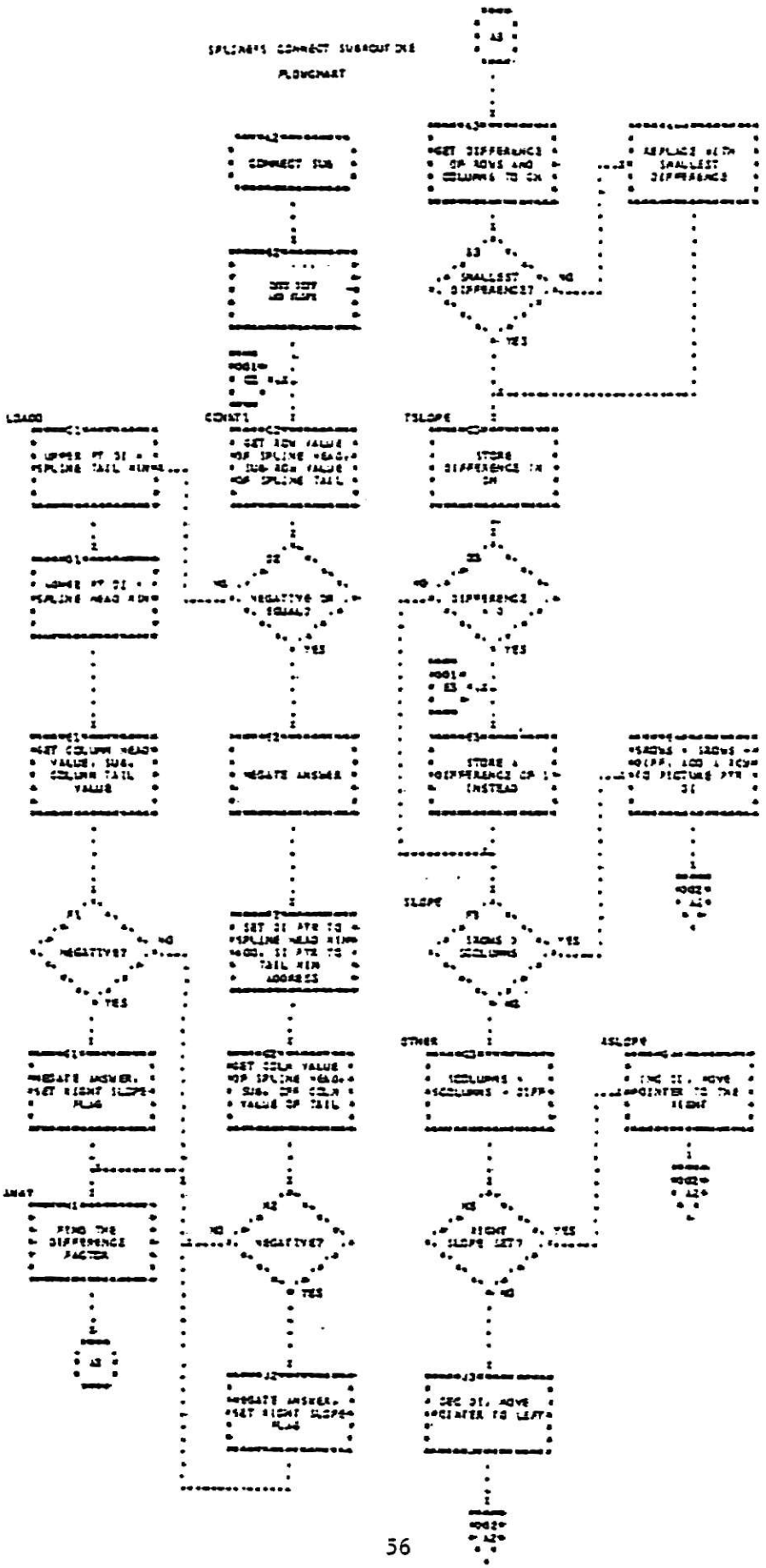
FLOWCHART

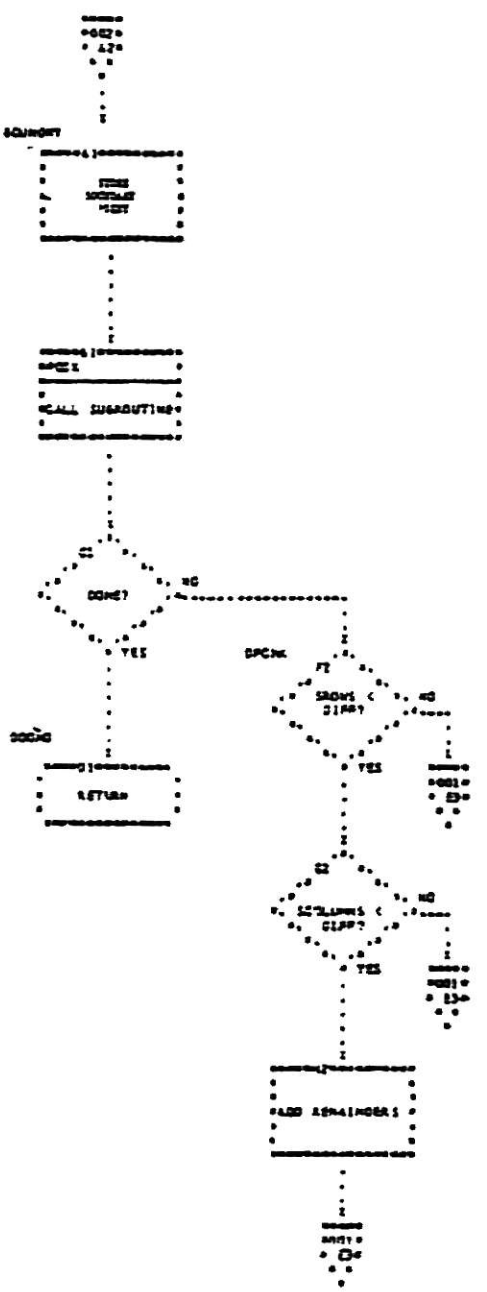


RESTORE SUBROUTINE

FLOWCHART







Area Acquisition (AREAAQ)

2.7 Area acquisition totals the meat and fat within the boundary. The picture pointer DI is initialized to the bottom left point of useful picture information in upper memory. The pointer is moved across the row searching for a boundary point. If the end of the row is reached before a boundary point is found, the pointer is moved up one row, placed to the left edge and the process continues until a boundary point is found. When the first boundary point is found its picture memory address is saved as the bottom point. The LRFIND subroutine is then called to record whether the point found is the left or right most boundary point. Assuming the pointer is not at the end of the row a check is made on BIGFLG. If BIGFLG is zero, and a meat cell is found to the right of the boundary point the fat or meat counting begins. The fat and meat are counted as the pointer moves left to right across the row. If BIGFLG is set, counting begins regardless of the type of cell following the boundary. When the pointer reaches the next boundary the counting ceases, the pointer is moved up one row and the process is repeated.

An error condition exists if the pointer finds the end of the row before finding a boundary point. This error usually occurs when only one boundary point is found in the row, i.e., top or bottom point. In this case the previously counted cells must be subtracted from their respective counters.

The picture pointer moves up a row and continues until a boundary is no longer found in the row. The top most boundary point address is saved and the fat cell, meat cell and background cell count is saved in memory.

The output of Area acquisition is the bottom, top, left and right most boundary points of the enclosed boundary along with the total meat cells, total fat cells and total background cells.

Note that the background cells are recorded separately in memory, but since they were located within the bounded area they should be considered very dark meat.

Area Acquisition (AREAAQ)

SUBROUTINE: LRFIND

REGISTERS:

BP - variable pointer	DH - first boundary point flag
DI - picture pointer	DL - row boundary point flag
AX - meat counter/adder compare	SI - current boundary point
BX - fat counter	
CX - loop counter	

VARIABLES:

0600H	LCOL	0606H	BCOL	0714	BKGDCNT
0601H	LROW	0607H	BROW	08CC	BIGFLG
0602H	RCOL	0608	FCLOW	08D2	SMLFLG
0603H	RROW	0609	FCHIGH	08D4	FATSQ
0604H	TCOL	060AH	MCLOW	08D6	MEATSQ
0605H	TROW	060BH	MCHIGH		

INPUTS: 00,01,02,03 from picture array.

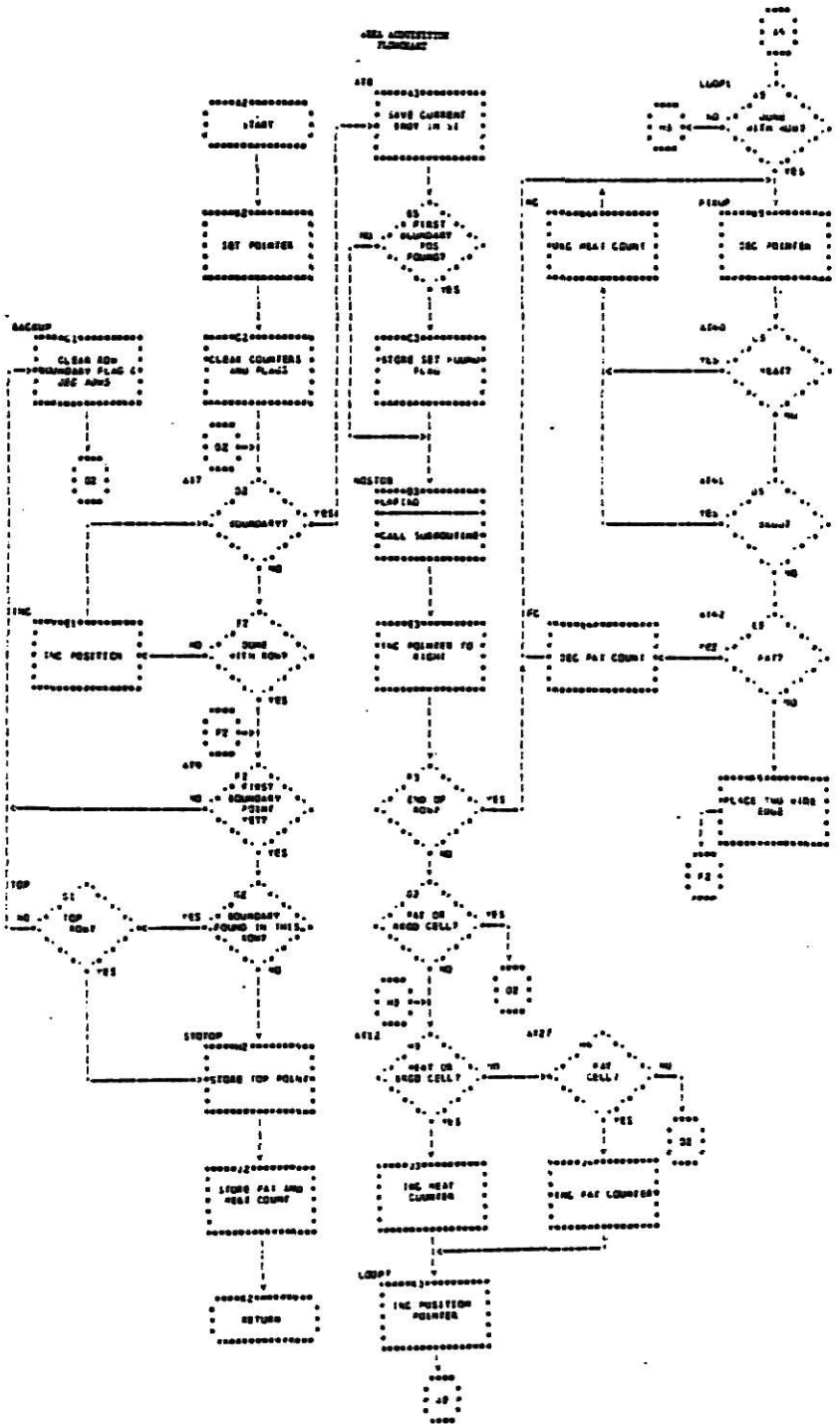
OUTPUTS: Meat and fat cell count as well as top, bottom, left and right edge points. Alternate storage locations depending on flag settings.

LOCATION: 3400H

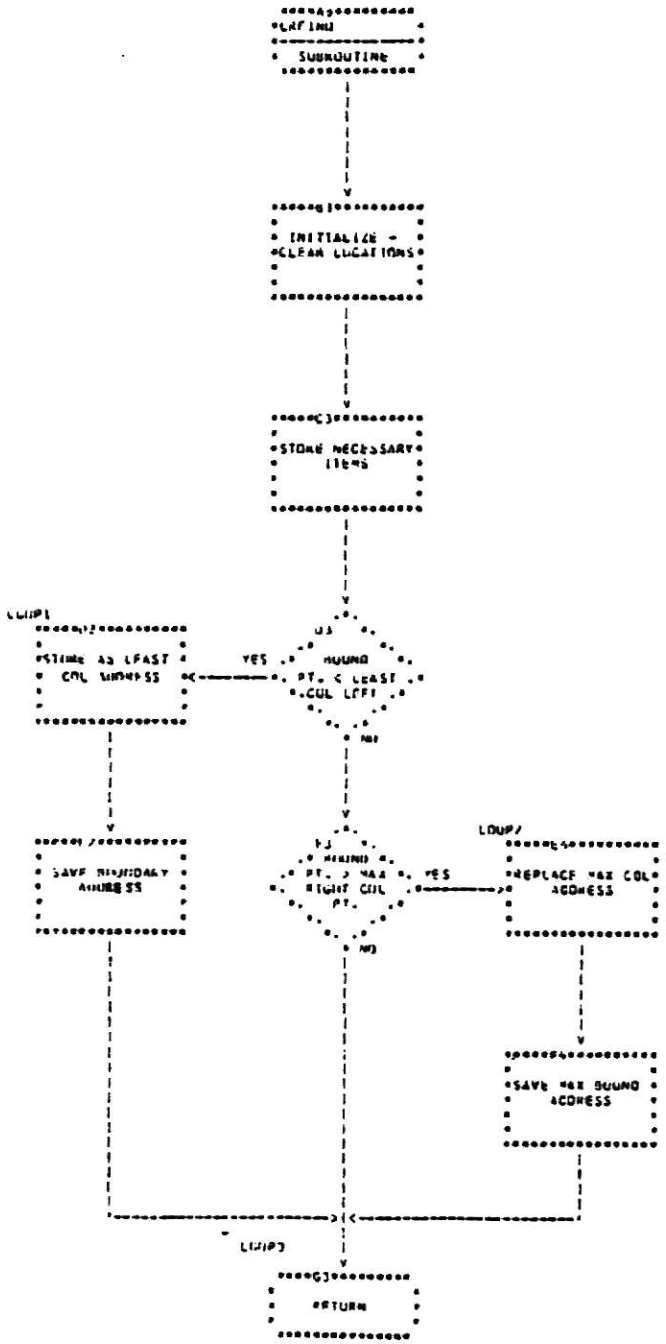
SIZE: 11BH

COMMENTS: Must be preceded by Boundary search.

VERSION: 9 5 12.34



SUBROUTINE LEFTEND
FLOWCHART



Max Point Search (MXMAIN)

2.8 Max point search program finds the longest line or axis that can be drawn within the loin eye. The top and bottom most boundary point addresses are loaded in from their storage locations as found from AREAAQ. The picture pointer is set to the address of the top most boundary point. This point is called movable. The other point is called stationary. The movable point is moved to either side of the original point searching for the maximum distance to the stationary point. When a certain number of points each side of the original point are checked then the program makes the movable point stationary and changes the stationary point to movable, then repeats the process. The two points that have the maximum distance are stored in memory to be used later in the fat thickness measurement routine.

Within the Max point search package is included the subroutines Next-point, Find max and Distance.

The Nextpoint subroutine finds an adjacent point along the boundary. The Freeman chain code algorithm is used [2]. The description is the same as Boundary search with the exception that the Nextpoint routine can change direction. A clockwise or counterclockwise table is used for this function. The table is chosen by the top byte of a two byte register BX called BH. The specific direction within the table is referenced by the register BL, the lower byte of the BX register. Every time BL is loaded within the subroutine, a new direction is chosen. When a boundary point is found, the program returns to the calling program with the picture pointer (DI) at the next boundary point.

The Findmax subroutine is essentially the counter that records the number of points each side of the original point. The changing of BH via correction table is to reverse directions of the next point.

The distance subroutine is used by Max point to find the distance between two points. The maximum or minimum distance can be found depending on flag settings. Note that the distance subroutine has various checks to recognize the calling program, i.e. SPFLAG, SI register.

The stationary row and column is loaded into the DX general purpose register. The movable point is already pointed to by the DI register.

The equation to determine distance between the two points is

$$d^2 = (\text{mrow} - \text{srow})^2 + (\text{mcol} - \text{scol})^2$$

The program computes for the distance squared not the distance. It is not necessary to take the square root at this time.

Since the aspect ratio (width to height) of the individual pixels is not 1:1, a correction must be made to linearize the squared distance.

Max Point Search (MXMAIN)

SUBROUTINES: FINDM, NEXTPT, DISTAN

REGISTERS: CX - counter, general purpose, 2 MSD, LSD

SI - offset data pointer, move data pointer,

temporary storage of movable, stationary.

DI - move data pointer

BP - data pointer

DI - picture pointer

DX - mask and test for picture pointer, temp DI storage

BL - direction indicator for table

BH - which table pointer

DL - most significant digit for distance

VARIABLES: 704H SPLT

708H SPFLG

3C00H-31FH CCW table

3D00H-3DIFH CW table

3D20H-302F TABLE transfer correction

INPUTS: Values from area acquisition, TROW, BROW, TCOL, BCOL.

Values 00,01,02,03 from picture memory.

OUTPUTS: Maximum axis points on the boundary.

LOCATION: 3800H

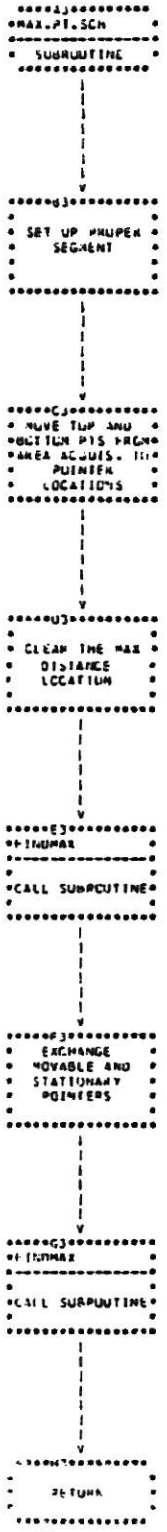
SIZE: 52EH

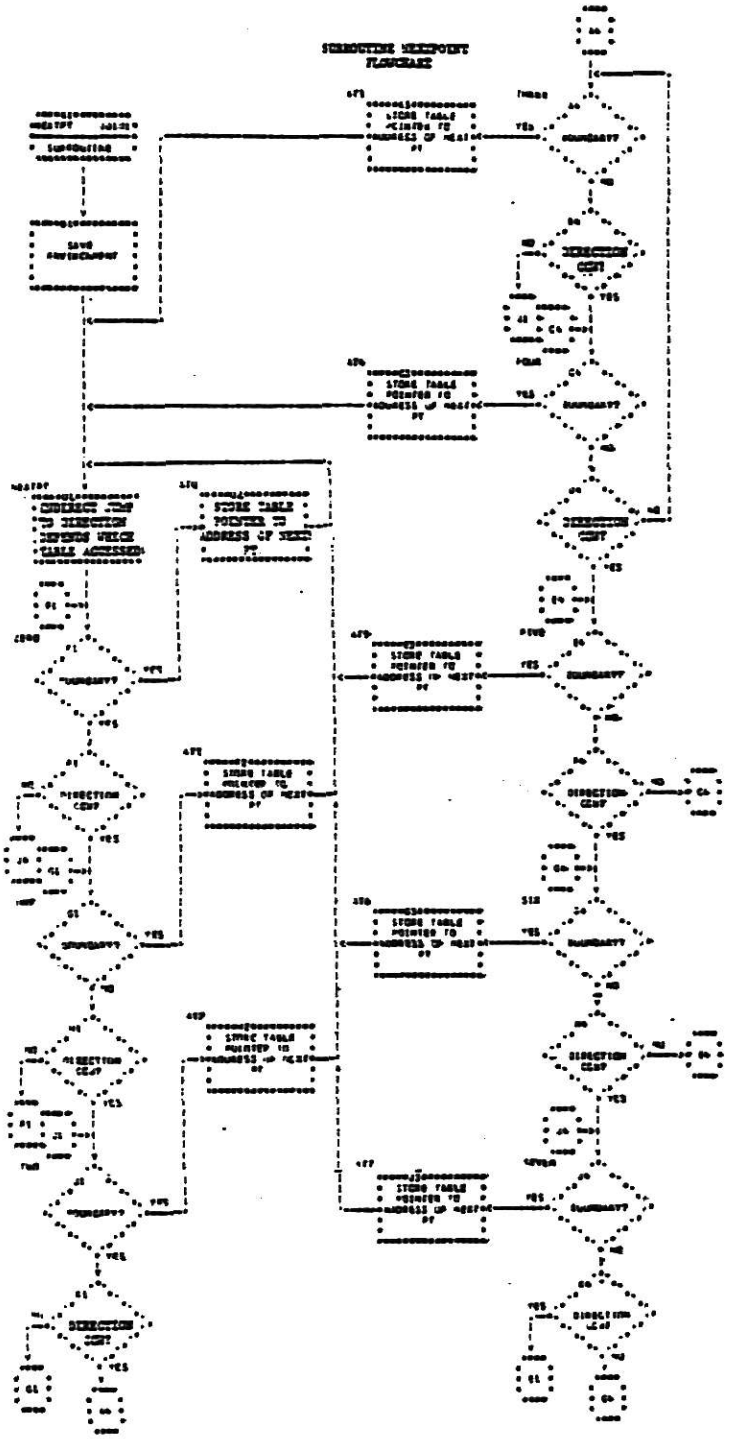
COMMENTS: Area acquisition must precede Max point.

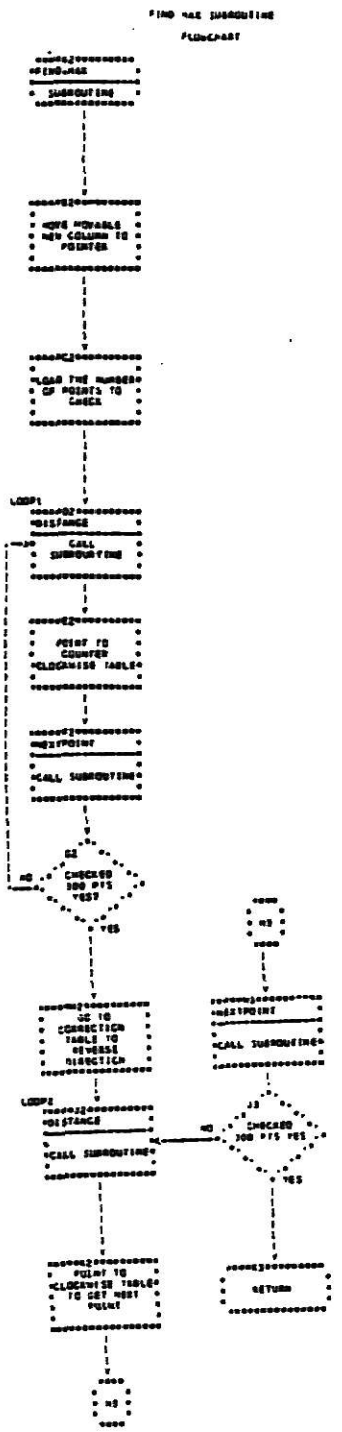
VERSION: 9 5 12.34

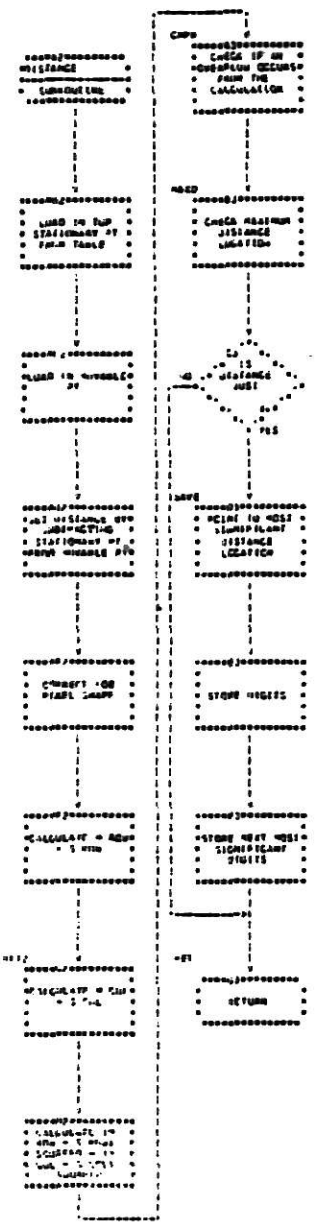
MAX PT SEARCH

FLOWCHART









Fat Thickness (FTHICM)

2.9 The Fat thickness program finds the fat thickness at a point between a boundary and the external background. The boundary point that is chosen is based on the placement of the cross hairs during picture loading. If the loin is right sloped then the fat thickness will be found off the right cross hair. If loin is a left sloped, the fat thickness will be measured from the left edge of the cross hair. The placement of the cross hair is important in locating the proper fat thickness measurement location.

Before Fat thickness is called, DRECTN should already have been run by a call from Boundary search. The DRECTN Subroutine determines whether the stored picture image is right or left slope oriented. A short description follows here because of the subroutine's location in the assembly listing.

The MEACNTP and MEACNTN are cleared initially and the picture pointer is set to 7679H (center of the screen where the cross hairs cross).

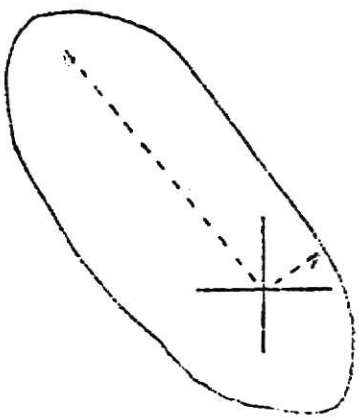


FIG. 2.9-1. Right Sloped Loin Eye.

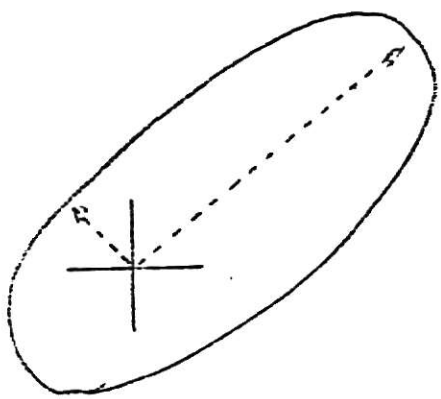


FIG. 2.9-2. Left Sloped Loin Eye.

Two slopes at 45° to the cross are followed down until a boundary is reached. The meat is counted in each line and totalled in MEACNTP and MEACNTN.

If the MEACNTN was less than MEACNTP then the LCRS flag is cleared, Fig. 2.9-1. Otherwise the LCRS flag is set, Fig. 2.9-2.

The pointer is shifted left or right depending upon the slope. The routine then returns to the calling program.

The proper center location is found after CORRECTQ has been called. A check is made to see if the LCRS flag is set or cleared. If set, the picture pointer (DI) moves to the left searching for a boundary point. When a boundary is found the program checks to see if it is the first boundary point found or not. If the pointer moves a fixed distance left or right without finding a boundary the program terminates.

After the boundary is found a search begins for the background point. When both a boundary point and background point are found each address is stored for processing. A minimum distance must be found between the background point and a boundary point to eliminate angle as an influencing factor, Fig. 2.9-3.

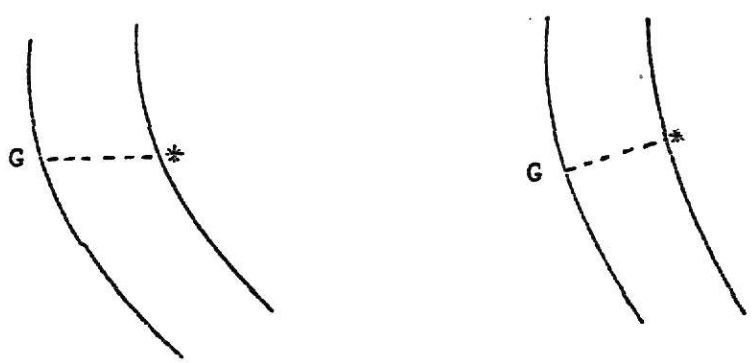


FIG. 2.9-3. Minimum Fat Thickness

FIG. 2.9-4. Fat Thickness Points.

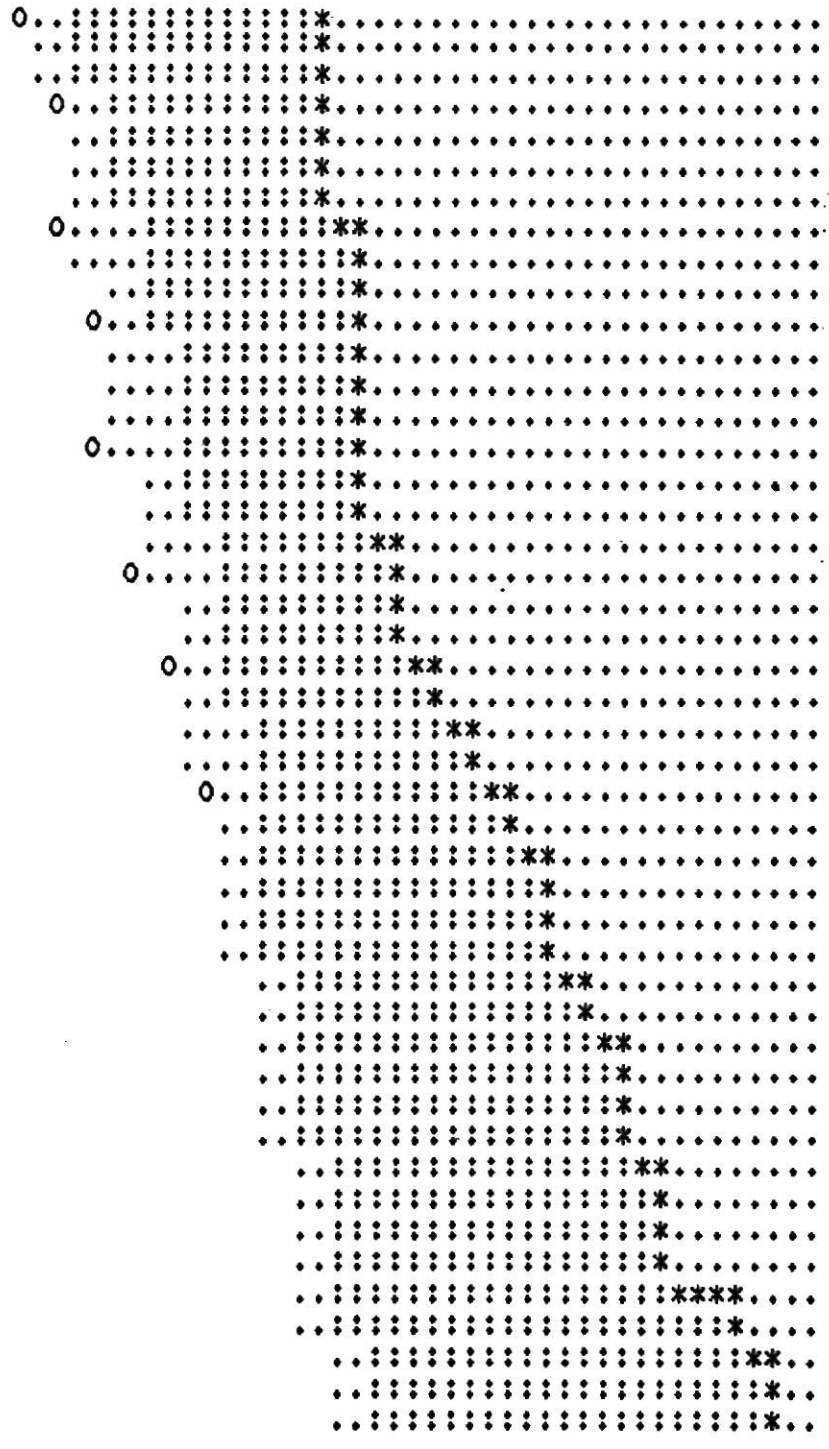


FIG. 2.9-5. Fat Thickness Points (Block Display).

Before the fat thickness measurement is summed the minimum fat thickness must be found by moving the boundary point up and down the edge and calculating the distance at each location. When the minimum is found, it is summed in a program called TABUL for tabulation. The above procedure is repeated eleven times, Fig. 2.9-4. Each time the procedure is rerun the initial start point is moved downward by CORRECTQ. Each fat thickness measurement is summed in SUMDST, Fig. 2.9-5.

When the iteration is complete the average over 11 distances are found and loaded into NUMM.

The program returns to Master loop. If an error occurs, e.g. not finding a boundary point, the average over the existing sum is taken and loaded into NUMM. The approximate fat thickness location for a left slope loin is shown in Fig. 2.9-6.

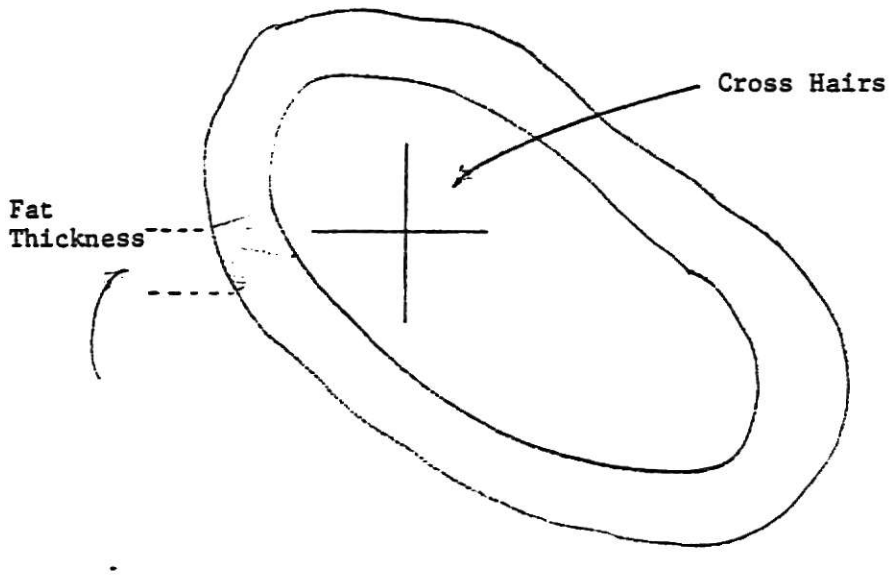


FIG. 2.9-6. Approximate Fat Thickness Location.

Fat Thickness (FTHICM)

SUBROUTINES: CORRECTQ, DISTAN, NEXTPT, TABUL, CHECK

REGISTERS: BH - table pointer

BL - element pointer

DI - picture pointer, boundary address

SI - address pointer

AL - boundary found flag

DX - background address, row-column check

AX - summations

CS - counter

VARIABLES:

620H - FTHRUN	8C6H - STARTD
708H - SPFLG	8D0H - LCRS
618H - NUMM	D05H - SUMDST
710H - MEACNTP	D07H - SAVG
7DEH - MEACNTN	D09H - SAVB

INPUTS: Values from picture array. 00,01,02,03

OUTPUTS: Squared average fat thickness value to NUMM. The output is an average squared of eleven measurements.

LOCATION: 4000H

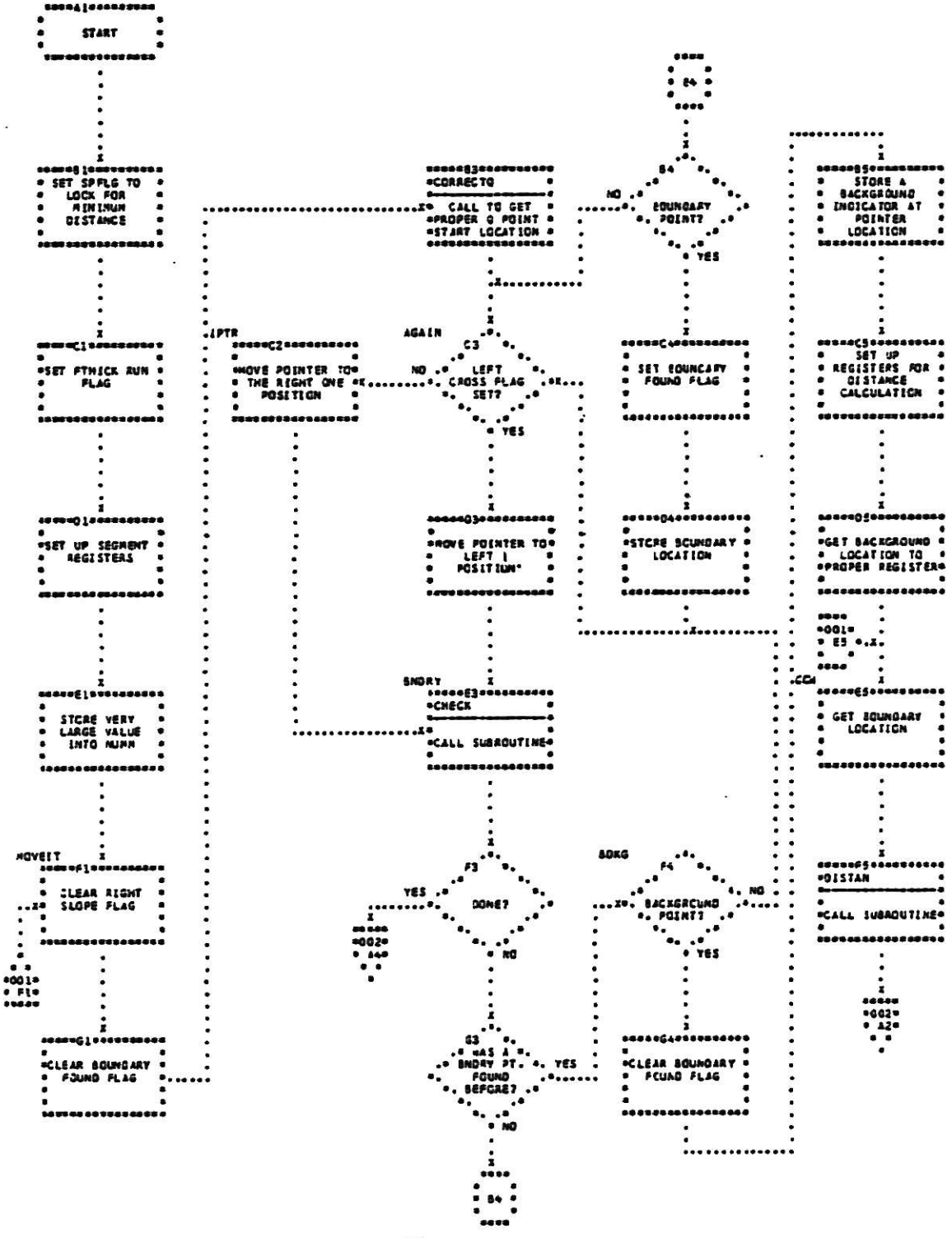
SIZE: 1F9

COMMENTS: Fat thickness must be preceded by Boundary search.

VERSION: 9 2 10.32

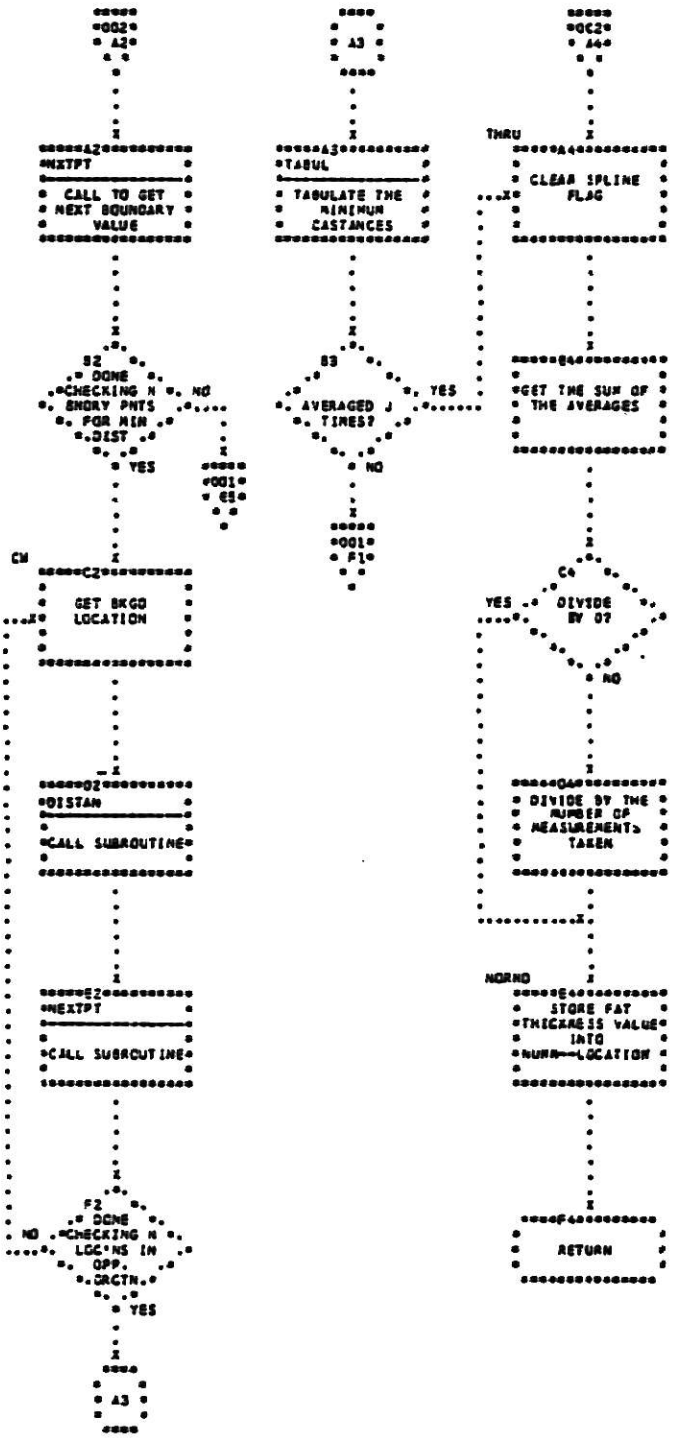
SUBROUTINE PAT THICKNESS

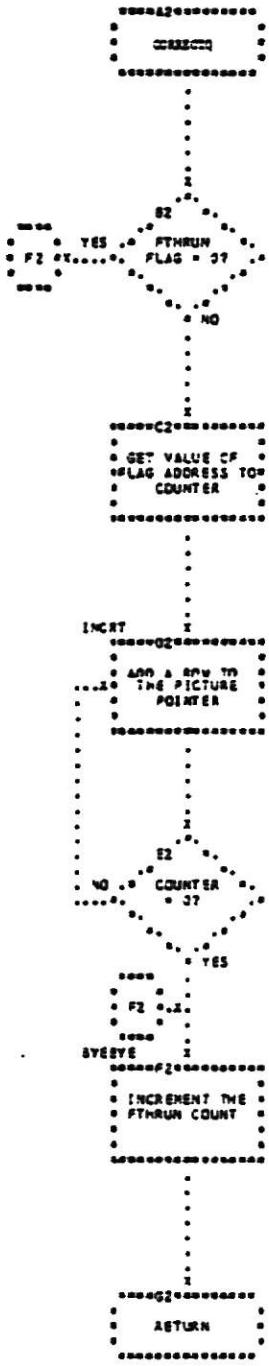
FLOWCHART

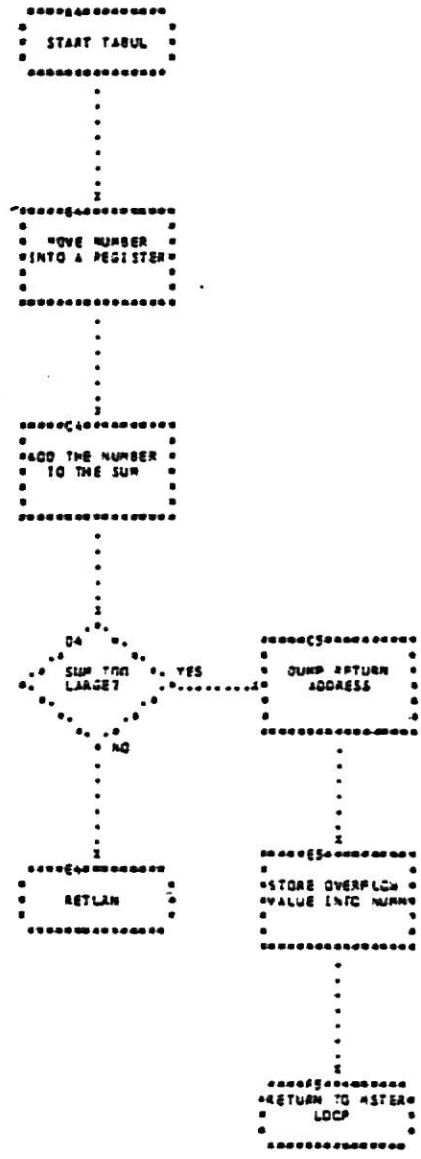


SUBROUTINE FAT THICKNESS

FLOWCHART

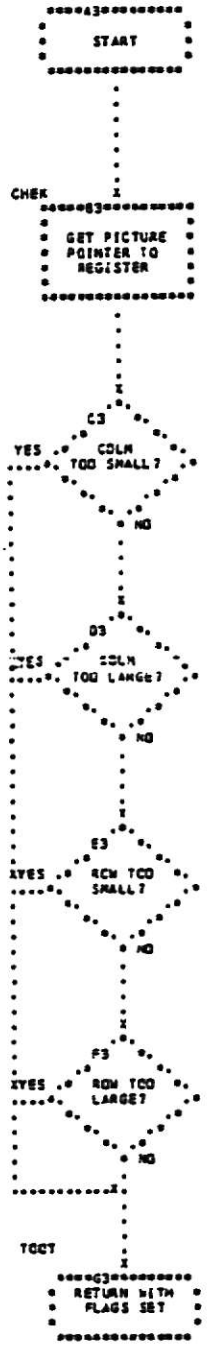



CORRECT
B2
YES
F2 ON
FTHRUN FLAG = 37
NO
C2
GET VALUE OF FLAG ADDRESS TO COUNTER
INCRT
D2
ADD A ROW TO THE PICTURE POINTER
E2
NO
COUNTER = 37
YES
F2
BYEBYE
F2
INCREMENT THE FTHRUN COUNT
RETURN


START TABUL
MOVE NUMBER INTO A REGISTER
C4
ADD THE NUMBER TO THE SUM
D4
SUM TOO LARGE?
YES
NO
RETLAN
C5
DUMP RETURN ADDRESS
E5
STORE OVERFLOW VALUE INTO NUMM
F5
RETURN TO MSTER LOOP

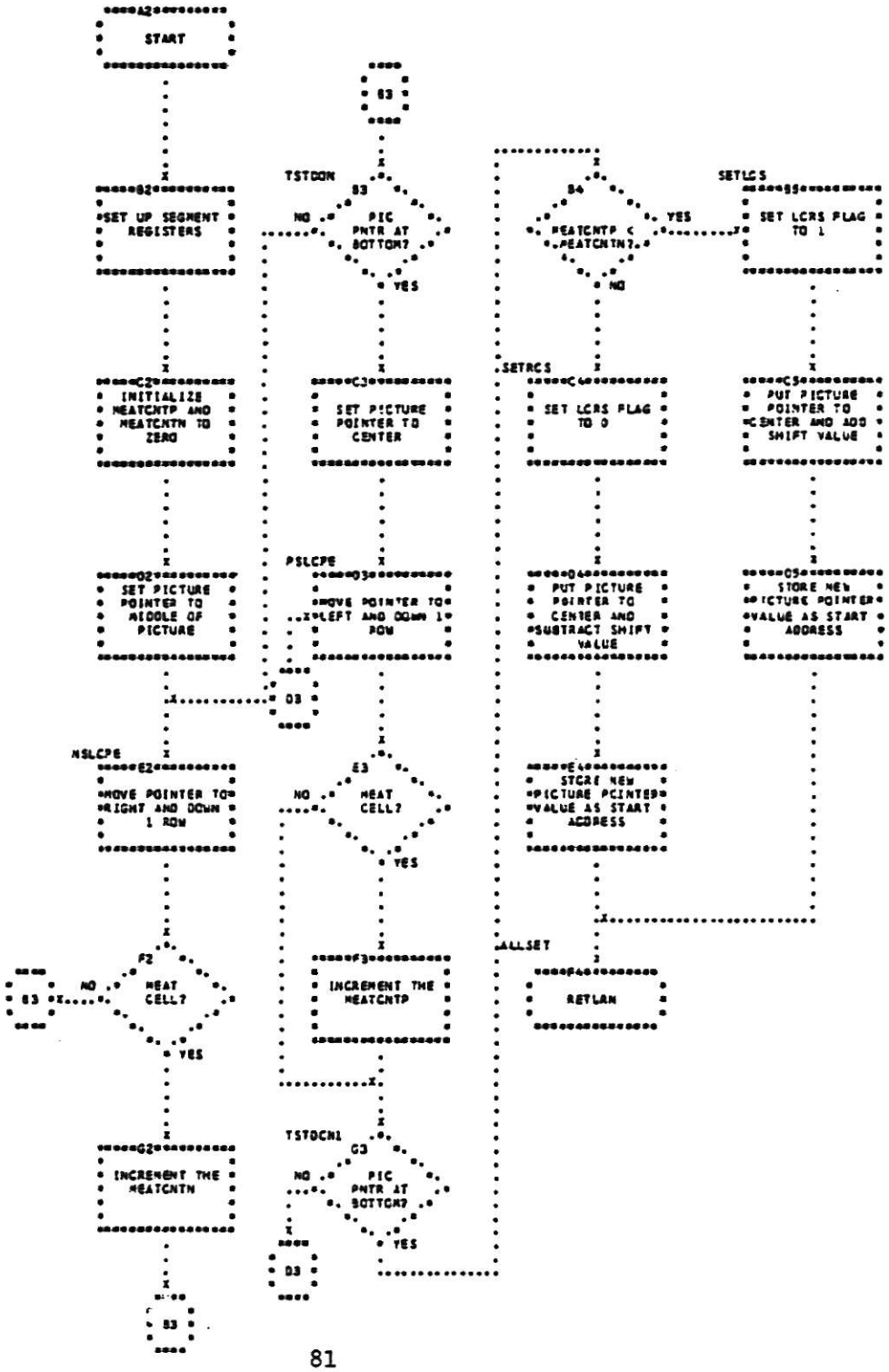
SUBROUTINE CHECK

FLOWCHART



SUBROUTINE DRECTN

FLOWCHART



Squeeze-Display (KRMDSP)

2.10 The Squeeze display program allows the operator to see a compressed view of the picture memory.

A determination can quickly be made as to whether a correct boundary has been found in addition to the fat thickness measurement location.

Note that the view as seen on a data terminal is distorted, mainly because the data terminal is usually an 80 column by 24 row display.

The cells in a 3 x 10 block of picture array are summed. The sum is compared to a constant level value and a character is loaded into the printer buffer according to this level. For example, if the 3 x 10 area is mostly fat cells (02) then the character for fat is loaded into the printer buffer. If the 3 x 10 group of cells was mostly meat then the meat character is loaded into the print buffer. If any one cell in the 3 x 10 group is an edge character (04) or boundary character (01) the ASCII character representing an edge or boundary is loaded into the print buffer directly without regard to the sum. An edge character has priority over a boundary character for printing.

After the single character for the 3 x 10 block is printed the character for the next 3 x 10 block to the right is printed and so on until all characters for all blocks in useful picture memory are printed. At this point the operator should see a complete picture on the data terminal.

Note that Squeeze-display may be run after Fat pieces or Fat thickness to get some indication of the fat piece distribution and/or fat thickness measurement location. The display is a summation-comparison process and

gives no useful data other than a rough estimate of the accuracy or inaccuracy of the boundary and fat thickness measurement locations. Examples of the output from Squeeze-display may be seen in Figs. 2.9-4 and 2.6-5.

Squeeze-Display (KRMDSP)

SUBROUTINES: CHRO

REGISTERS: DI - picture pointer

AX - character register

SI - sum register

CX - character rows

BX - character columns

DX - mask and compare rows and columns

VARIABLES: 620H FTHRUN

INPUTS Values from picture memory 00,01,02,03,04

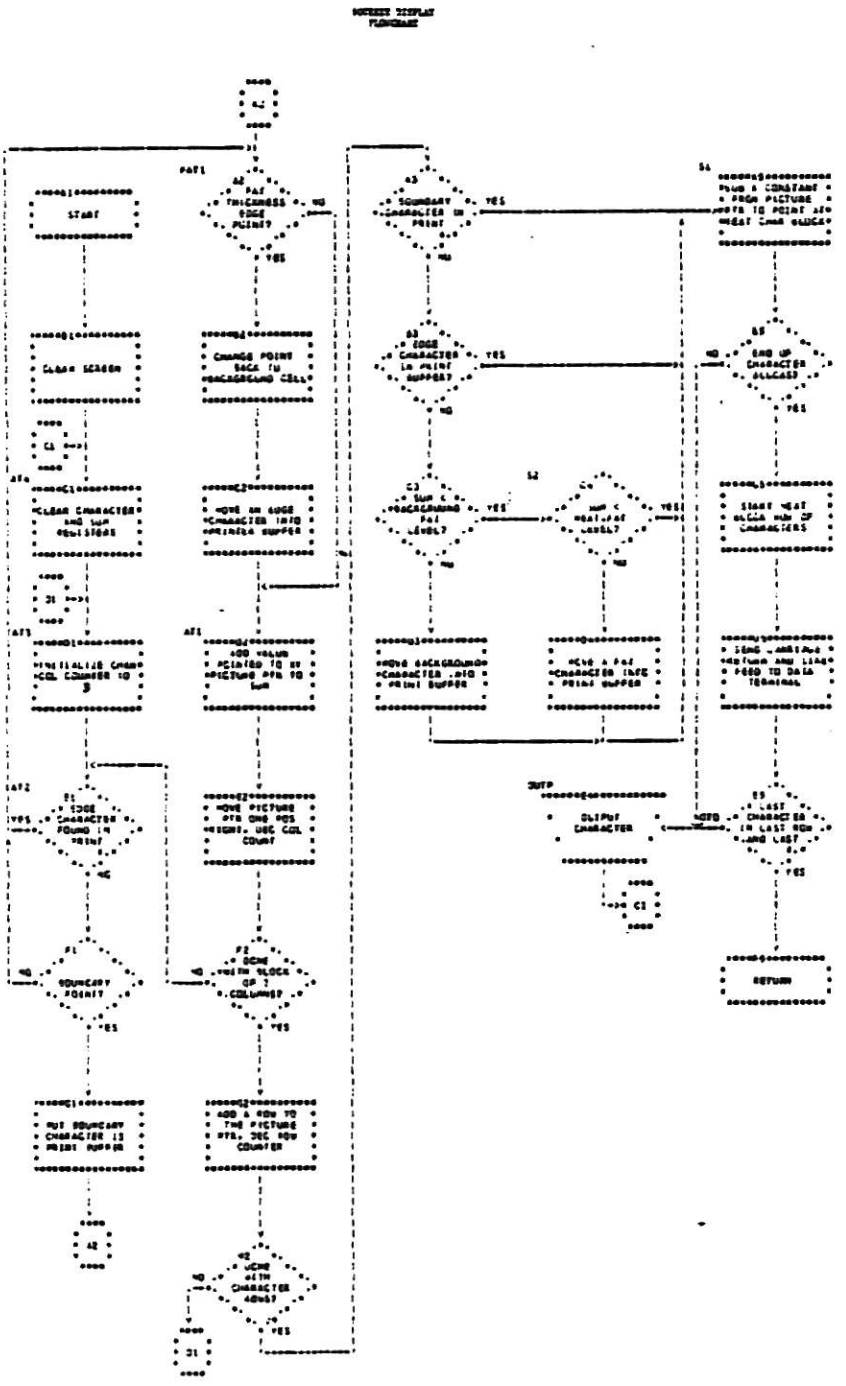
OUTPUTS: ASCII characters to data terminal representing a 3 x 10 block in picture memory.

LOCATION: 3300H

SIZE: 8FH

COMMENTS: Classifier must precede Squeeze-display.

VERSION: 9 3 16.47



Box Distribution (BOXDIS)

2.11 The Box distribution module breaks the boundary enclosed area into sixteen separate boxes and stores the cell type distribution for each box in memory.

The Area acquisition module must be run first in order to obtain the left, right, top and bottom edges of the bounded area. These four edges form a large box around the area.

In the initialization section of the module the edge points from Area acquisition are used to find the box sizes. After determination, the box sizes are stored in DCOL and DROW.

Box distribution works very much like Area acquisition in that the pointer (DI) begins at the lower most edge of the large box surrounding the bounded area. The pointer moves from left to right while looking for a boundary point. If found the program attempts to determine whether the pointer is inside or outside the area. It does this by checking to the right of the boundary point if BIGFLG is a zero. If the position is fat or background then the pointer must be outside the loin eye area. If the cell pointed to is meat then the counting or distribution data gathering begins. If BIGFLG is set to a one then no check is made to the right of the boundary point.

Subroutine Whatbox finds what box the pointer DI is in. It then gets the memory pointer (BP) to point to the proper meat or fat storage location for the box. In Fig. 2.11-1, numbers 672 and 673 are the meat count locations, 1 is the box number and 674 and 675 are the fat count locations. The figure shows the meat and fat counter locations for all 16 boxes.

Each time the pointer is incremented, a check is made to see if the pointer is at the right edge of the large box surrounding the area. If the end of the row or edge of the large box is found before finding the right boundary point an error condition exists. Upon error the Fixup routine subtracts off the cell counts that were accumulated in error. The usual running of the Fixup routine occurs when there is a single boundary point in the bottom or top row. The cells to the right of this singular point are not in the bounded region and thus are subtracted from the box distribution tally locations.

With no error condition the end of the row is found. The pointer is moved up 1 row (decremented in memory) and the process of finding the distribution is repeated.

When a boundary point is not found in the row being scanned the module is done and returns to Master loop.

672	676	67A	67E
Meat Count			
673	677	67B	67F
1 - Box #	2	3	4
674	678	67C	680
Fat Count			
675	679	67D	681
682	686	68A	68E
683	687	68B	68F
5	6	7	8
684	688	68C	690
685	689	68D	691
692	696	69A	69E
693	697	69B	69F
9	10	11	12
694	698	69C	6A0
695	699	69D	6A1
6A2	6A6	6AA	6AE
6A3	6A7	6AB	6AF
13	14	15	16
6A4	6A8	6AC	6B0
6A5	6A9	6AD	6B1

FIG. 2.11-1. Boxes For Box Distribution

Box Distribution (BOXDIS)

SUBROUTINES: WHTBOX

REGISTERS: CX - counter, general purpose

BP - memory pointer to box-meat, fat counts

DI - picture pointer

DX - masking for DI

VARIABLES: 600H LCOL

602H RCOL

605H TROW

607H BROW

670H DCOL

671H DROW

672-6B1 meat and fat counts for individual boxes

INPUTS: Top, bottom, left and right edge points of the loin eye area (computed from Area acquisition)

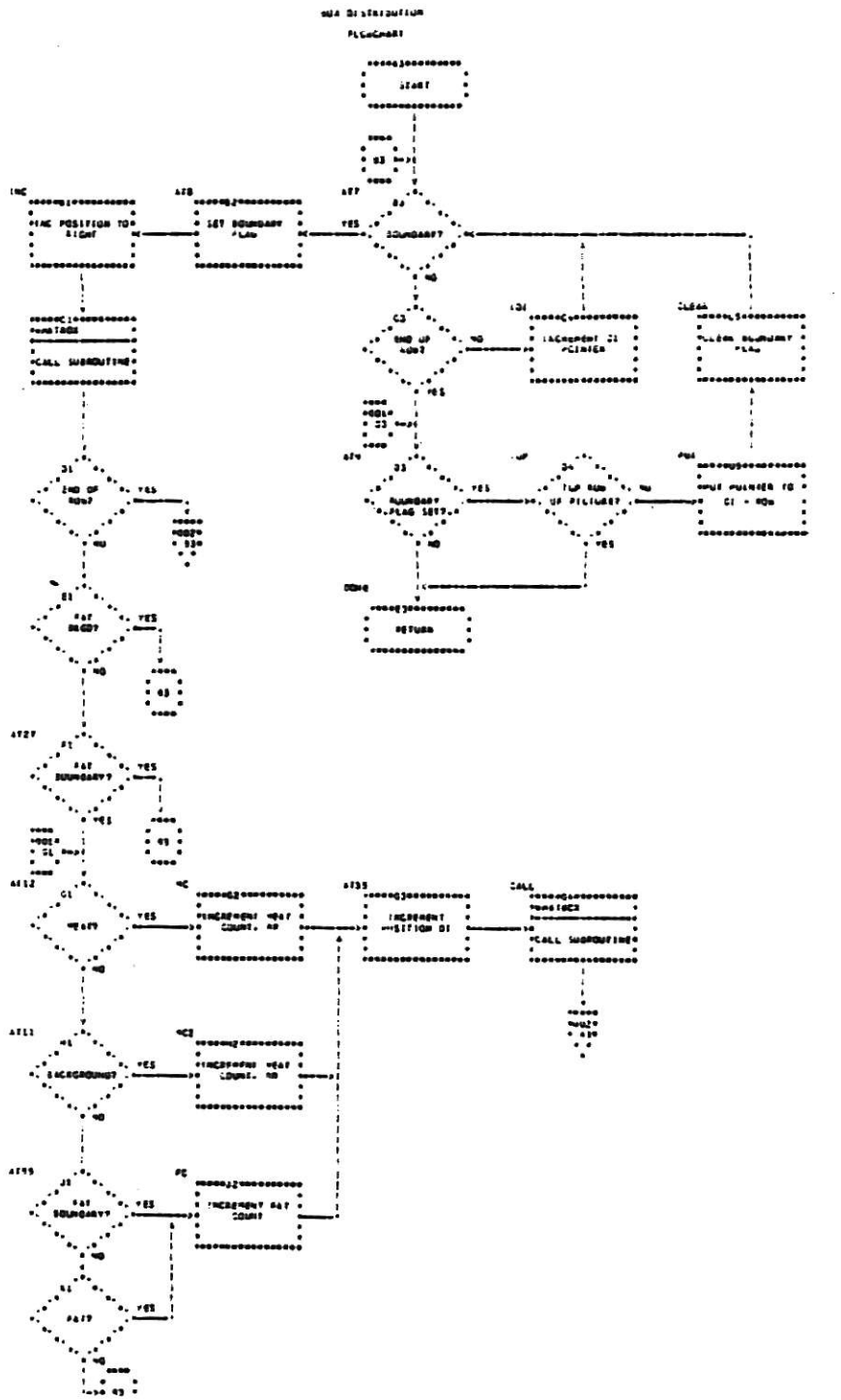
OUTPUTS: Stored meat and fat counts for each of the sixteen boxes and box size.

LOCATION: 4600H

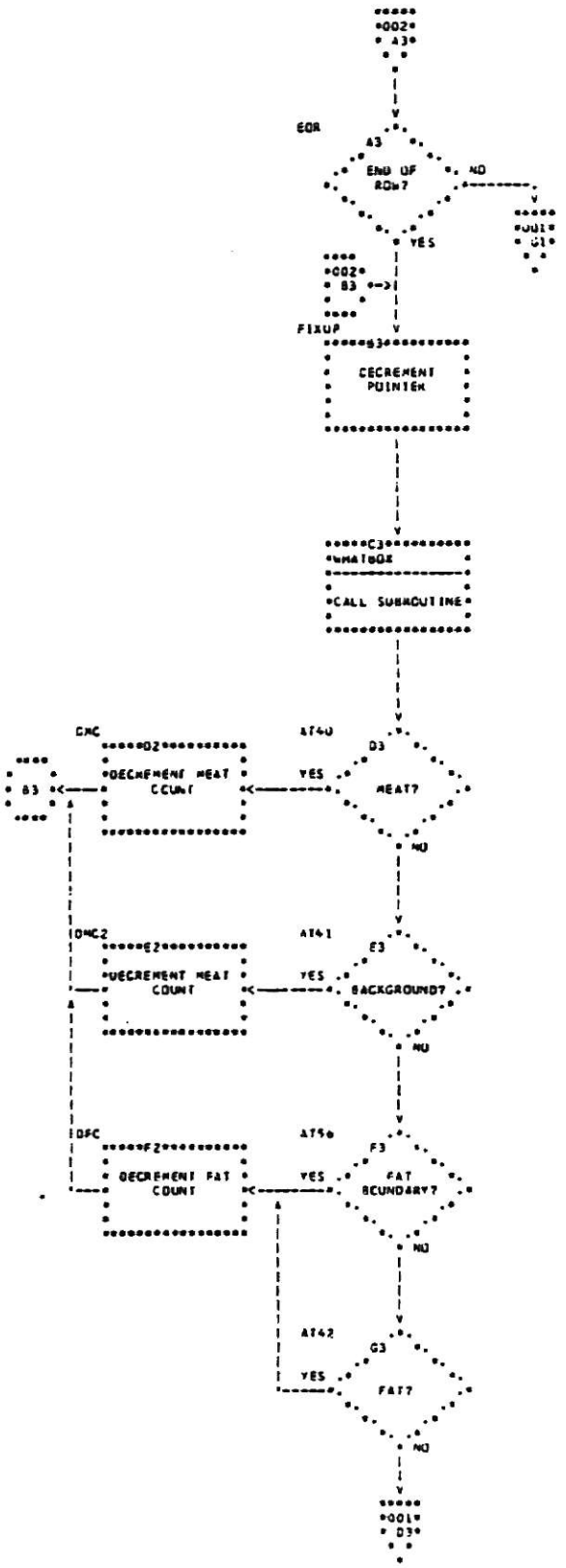
SIZE: 148H

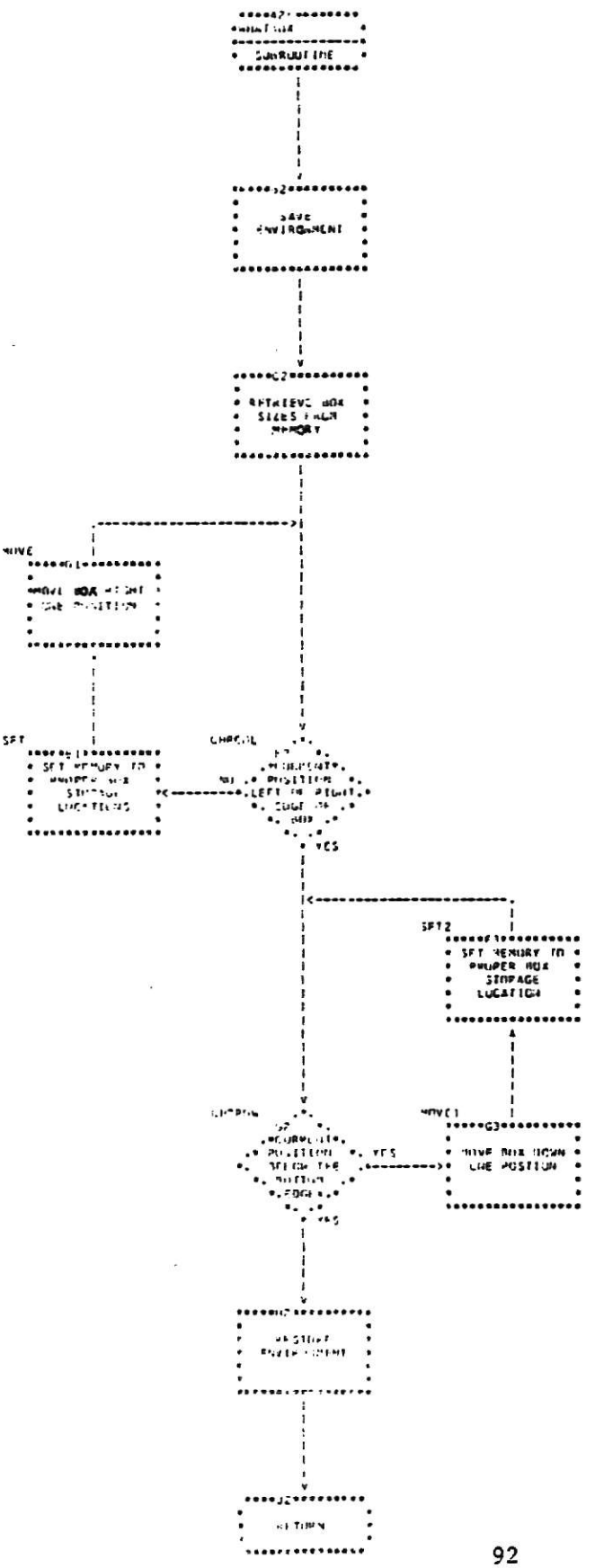
COMMENTS: Area acquisition must precede Box distribution

VERSION: 8 14 14.59



FLOWCHART


002
A3
EOR
A3
END OF ROW?
NO
YES
001
G1
002
B3
FIXUP
DECREMENT POINTER
CALL SUBROUTINE
DMC
002
DECREMENT HEAT COUNT
B3
AT40
D3
YES
HEAT?
NO
DMC2
E2
DECREMENT HEAT COUNT
AT41
E3
YES
BACKGROUND?
NO
DFC
F2
DECREMENT FAT COUNT
AT50
F3
YES
FAT BOUNDARY?
NO
AT42
G3
YES
FAT?
NO
001
D3



Fat Pieces (FATPCS) and Fat Boundary Search (FATBDY)

2.12 FATPCS finds all the fat pieces within the loin eye and stores the number in memory.

The picture pointer (DI) begins outside the loin eye area (OLEA). The bottom row, top row, left column, right column information found from area acquisition is loaded into registers. The top row left column address is loaded into the DI register. The pointer DI is moved to the right until it hits a boundary point or the right column. If a boundary point is found the pointer is incremented to the right and checked to see if it has reached the right column. If the cell is exclusively meat then 1) a flag is set indicating inside the loin eye, 2) the picture pointer (DI) is incremented. The pointer continues row by row until finding a fat cell. Subroutine Fat boundary is called and a boundary is drawn around the fat piece and the number of fat pieces is increased by 1. Compare Fig. 2.12-1 and 2.12-2. Note that the boundary is drawn by storing a (04) in the picture memory location. This is to distinguish a fat boundary from a loin eye boundary (01). After the fat boundary is drawn the pointer is back to the starting point on the fat piece. The pointer is moved one position to the right. At this point it is likely that the pointer has landed inside the fat piece. The pointer is incremented until it finds a meat cell, then the search for all fat pieces continues. If a single fat cell is encountered, the cell is changed to a fat boundary and the fat counter incremented.

Fig. 2.12-1 shows a magnified view of picture memory. The fat cells are indicated by colons, meat by a period, and loin eye boundary by an asterisk. Fig. 2.12-2 shows the same area of picture memory after the fat pieces routine has executed. The fat boundaries are indicated by a

zero. In all, eleven fat pieces are shown. Figure 2.12-3 gives a rough estimate of where the fat pieces reside in the loin eye. Fig. 2.12-3 is the output of Squeeze-display. A zero may represent one or for worst case twenty-two fat boundary cells.

When the picture pointer is at the bottom row right column the procedure is done.

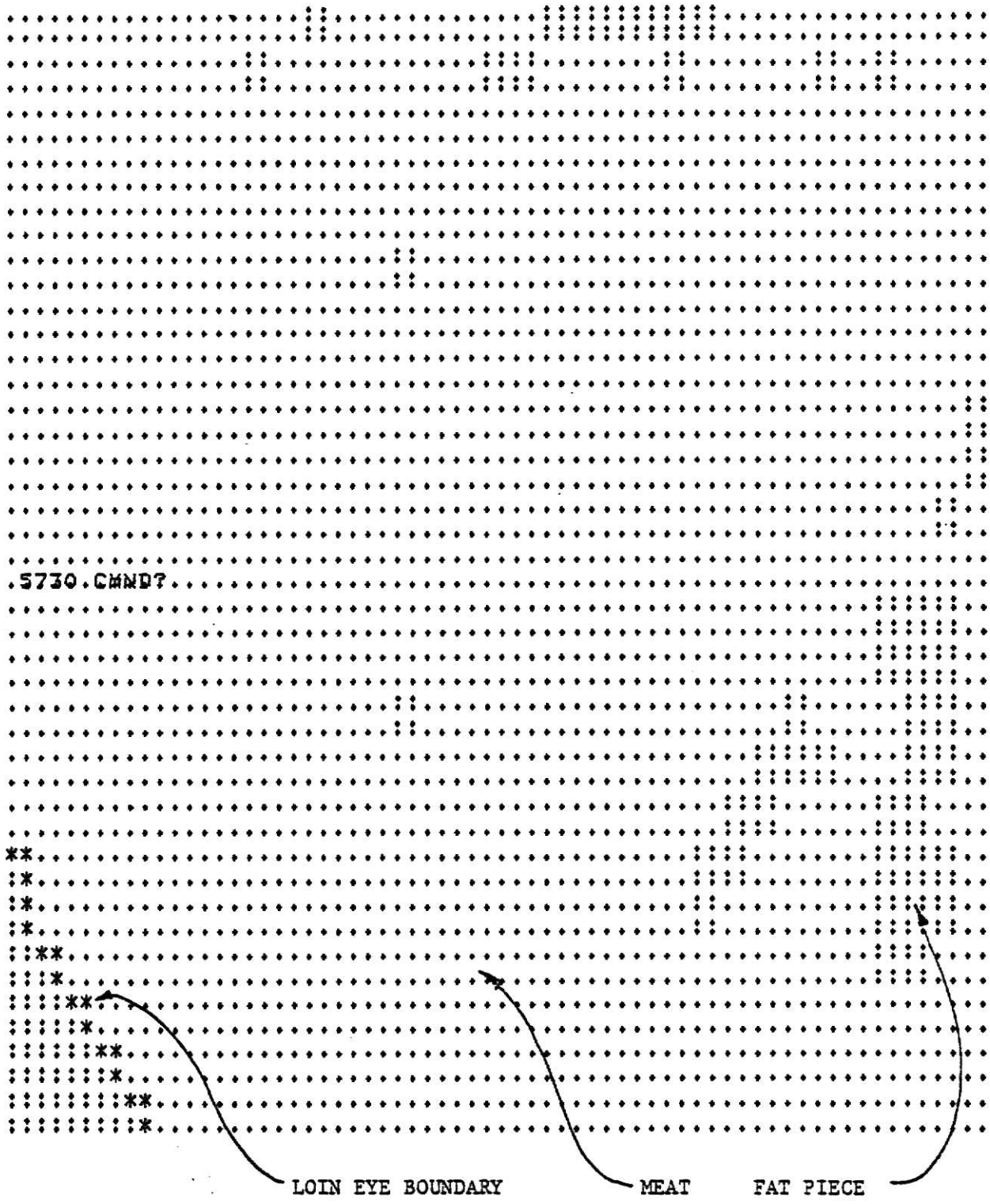


FIG. 2.12-1. Fat Pieces, No Fat Boundary Drawn.

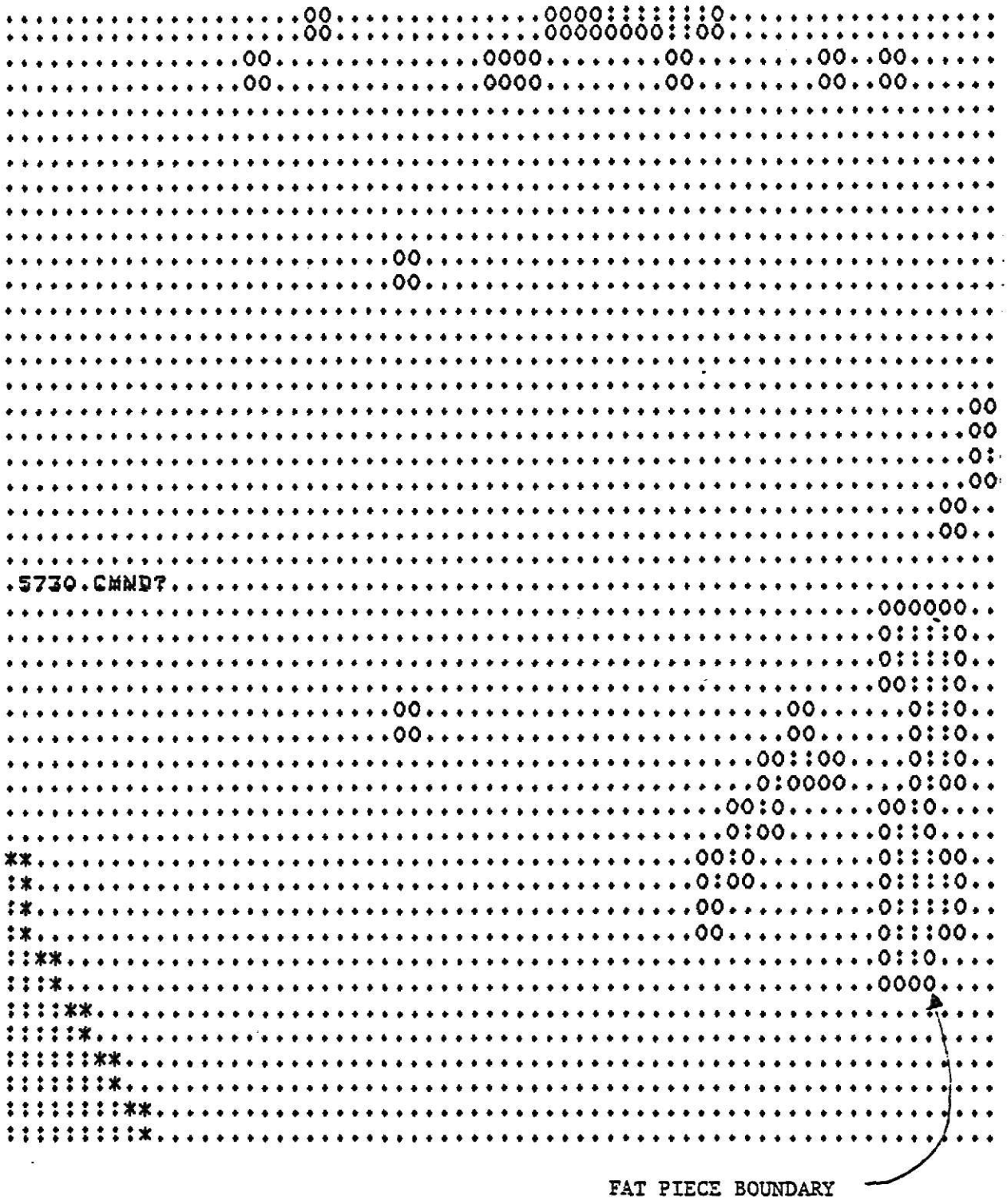


FIG. 2.12-2. Fat Pieces, Fat Boundaries Drawn.

FIG. 2.12-3. Fat Pieces (Squeeze-display).

Fat Pieces (FATPCS) and Fat Boundary Search (FATBDY)

SUBROUTINES: INCR, FATB

REGISTERS: AX - fat pieces counter

BX - last row, column

CX - end address for current row

DH - new row indicator

DL - inside/outside loin eye flag

BP - error pointer table

DF - pointer to picture memory

DS - pointer to data

SI - first fat boundary in FATB search

VARIABLES: 600H LCOL

602H RCOL

605H TROW

607H BROW

633H NOPCS

INPUTS: Values from picture array 00,01,02,03

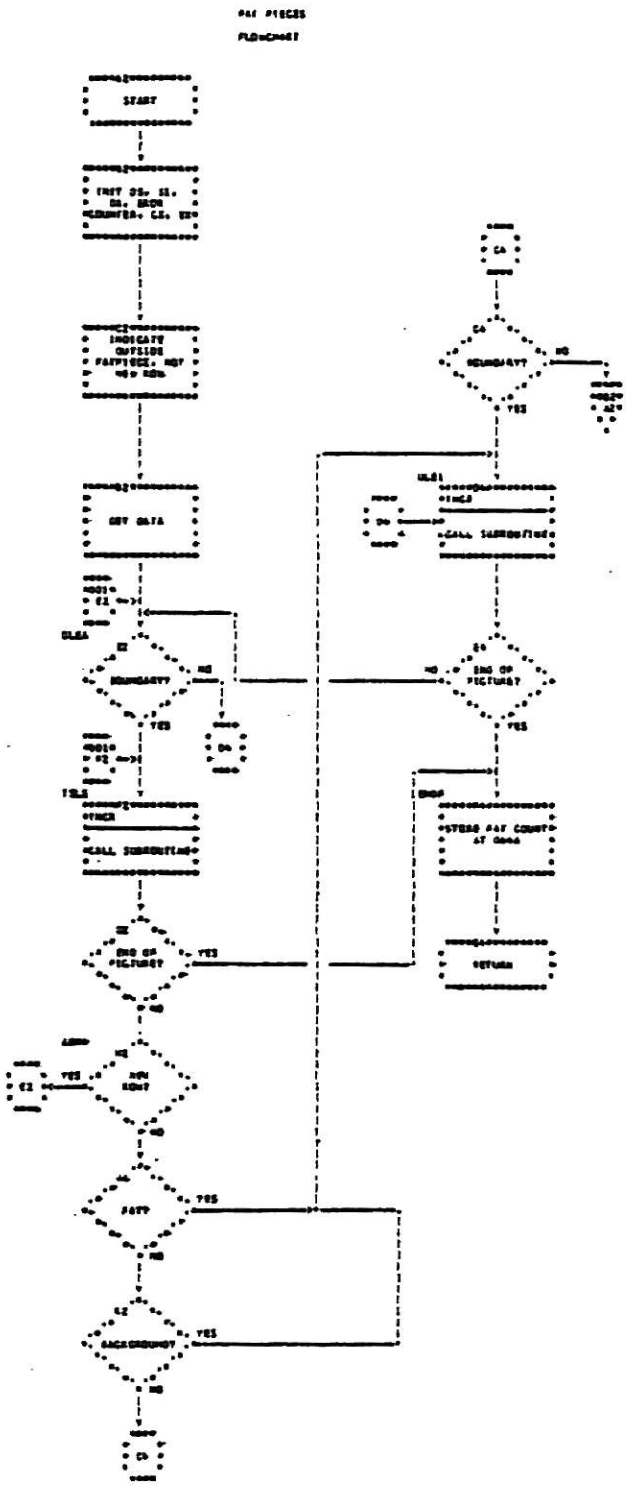
OUTPUTS: Altered picture array. Fat boundaries around fat pieces. Number of fat pieces to memory NOPCS.

LOCATION: 4200H

SIZE: 3A3H

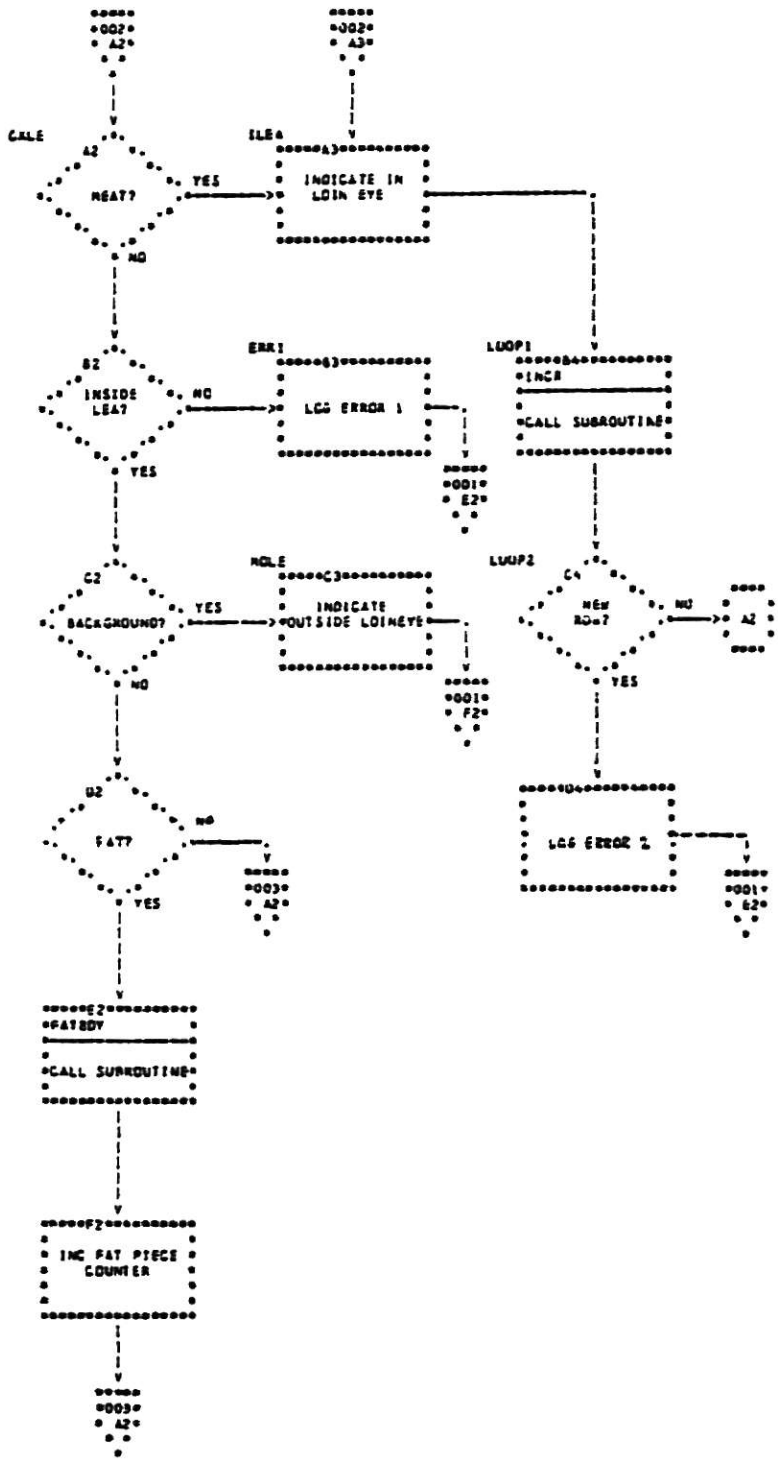
COMMENTS: Area acquisiton must precede Fat pieces.

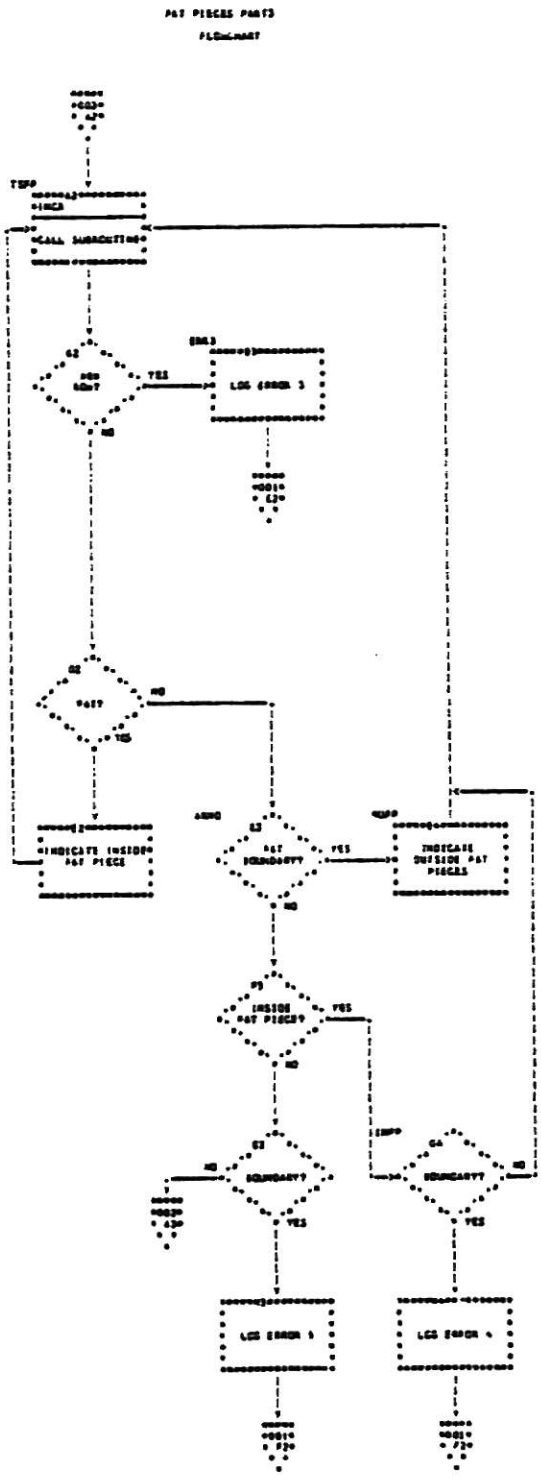
VERSION: 9 13 16.59


START
GET DATA
YES
YES
YES
YES
YES
YES
YES
YES
YES
YES
NO
NO
NO
NO
NO
NO
NO
NO
NO
NO
RETURN

FAT PIECES PART2

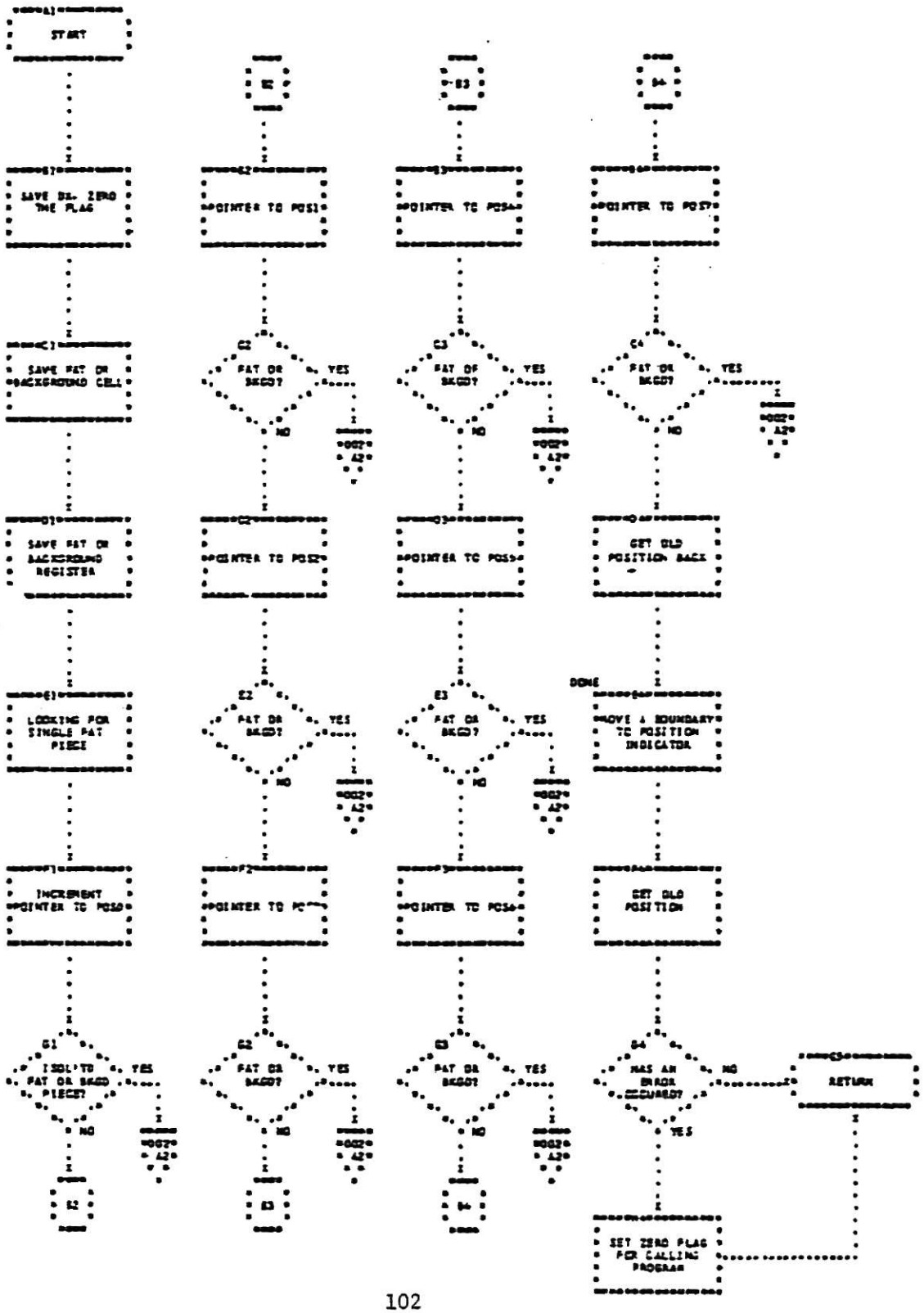
FLOW CHART





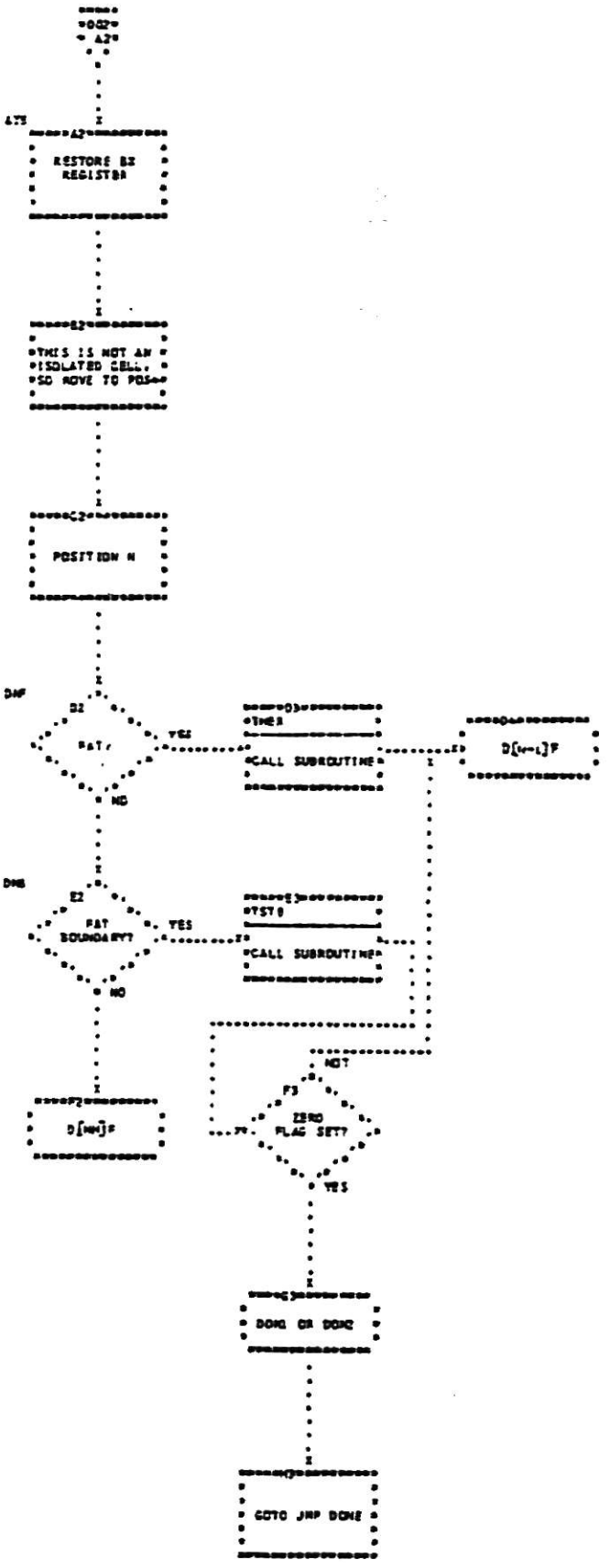
SUBROUTINE PAT BOUNDARY SEARCH

FLOWCHART



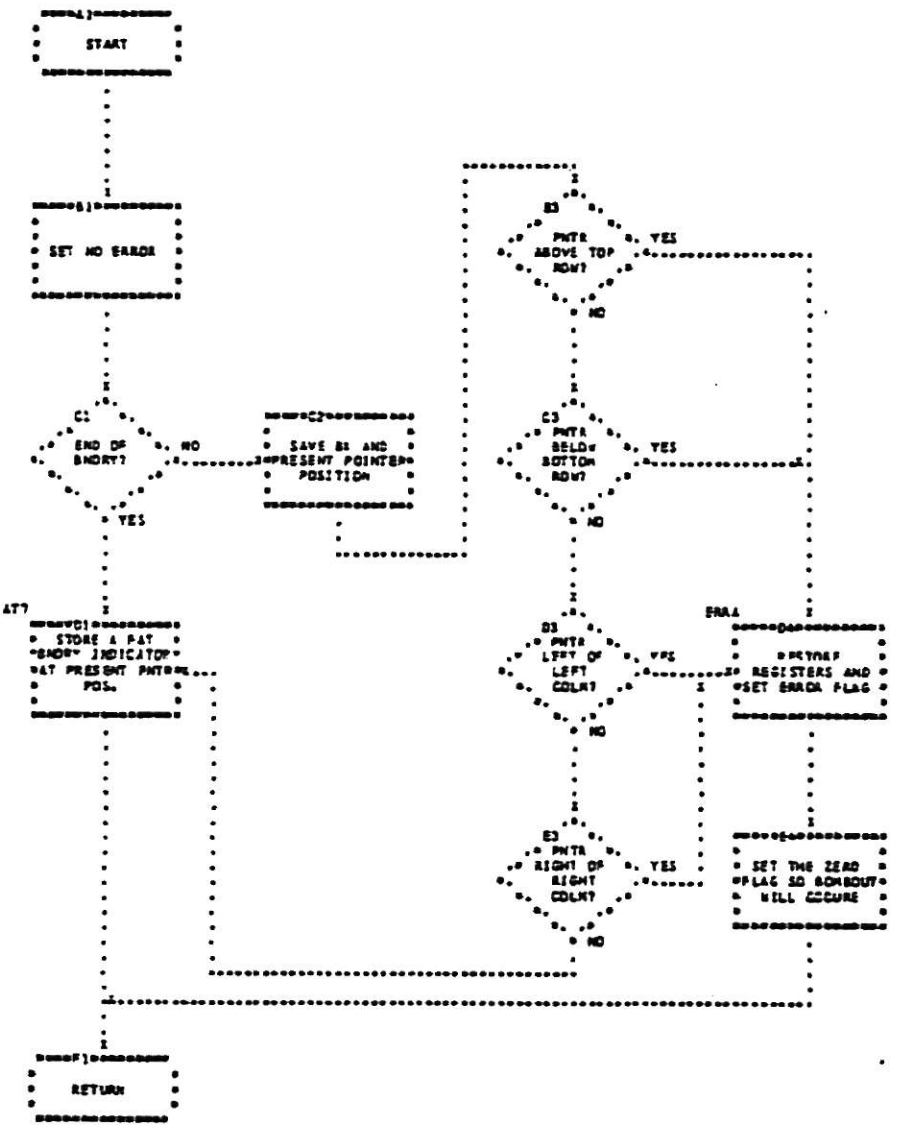
SUBROUTINE F67 BOUNDARY SEARCH

FLOWCHART



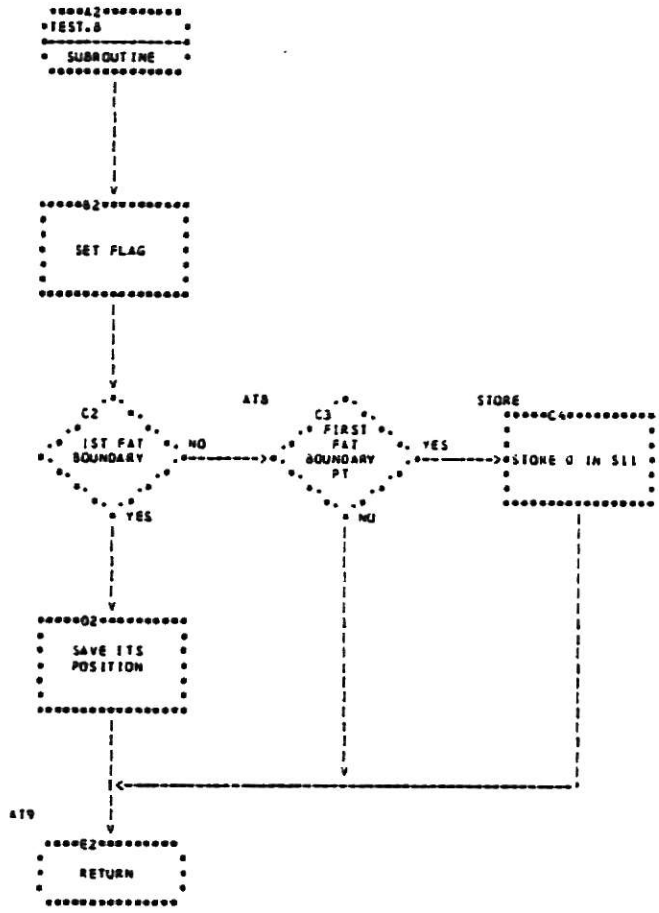
SUBROUTINE THERE

FLOWCHART



SUBROUTINE TEST 8

FLOWCHART



Calculate Results (CLCRES)

2.13 CLCRES performs all the calculations necessary for the beef grading programs. Although the program has the capability to enter values from the keyboard e.g. weight, %KPH, the present version does not query the keyboard for information.

Two programs are called to give the proper results, CALCUL and PCNTOT. The CALCUL subroutine first adds the fat count and meat count together to form a total fat meat area. In each case a subroutine, AREAML, is called to convert to hundredths of an inch from the pixel element count.

The next section in CALCUL converts the meat, fat areas into %fat and %meat of the total area. The subroutine PERCNT does the actual calculation after the proper registers are loaded. The %fat in the square is also found.

The fat thickness calculations are performed by taking the squared average fat thickness and square rooting by an interval halving technique until the proper tolerance is found. The fat thickness is converted to inches.

Next, from the results of BOXDIS, CLCRES uses the subroutine PCNTDT to calculate the percent of the total loin eye cells in each box to the total cells in each box. PCNTDT then calculates the percent of fat cells in the box to the number of loin eye cells in the box. All percents are found for each of 16 boxes that contain the loin eye. Each calculation performed is checked for a zero divide and the fractional part is rounded not truncated.

The map for DSPRES is also created in CLCRES. The symbols are as follows:

[ ] - non significant box less than 1/3 of its contents is loin eye.

[--] - significant box, percent of loin eye fat in box is less than overall percent of loin eye fat.

[==] - significant box, percent of loin eye fat in box is the same as the overall percent of loin eye fat.

[++] - significant box, percent of loin eye fat in box is greater than the overall percent of loin eye fat.

After all the percentages are calculated, the numbers are converted to their equivalent decimal numbers and stored in the PCKDEC string for later printout or display.

NOTE - BOXDIS must be executed prior to executing CLCRES for this area to have any meaning.

Calculate Results (CLCRES)

SUBROUTINES: STX, INPINT, ASCII, STR1, DECHEX, CALCUL, PCNTDT, MESSAGE, DECLOD, INSMAP, DECMIL, CHAROT

REGISTERS:
SI - header string pointer
CX - counter
AH - general purpose
DI - string transfer, map pointer
DX - general purpose
BX - general purpose

VARIABLES:
608H - FAT
60AH - MEAT
618H - NUM1
622H - EQUEI
626H - EQKPH
628H - FATMEA
62AH - FTTENS
62EA - EQFT
633H - NOPCS
637H - EQNA
639H - OLDVAT
900H - FREAD
A00H - PCKDEC, WGT
A02H - KPH
F13H-F16H-ASCBUF
F17H - TEMP
F19H - DELU

F1BH - DELL

F1DH - BXAREA

F1FH - SIGL

F21H - AREA

F23H - AFAT

F25H - AMEAT

F27H - PFAT

F29H - PMEAT

F2BH - PFATBX

F2DH - NPCS

F2FH - FATTH

F31H - SGBCT

F33H - EQUCNT

F35H - GRTCNT

F37H - LESCNT

F39H - MAPCNT

F3AH - WGTH

F3CH - KPHH

F3EH - M

2DEFH - 2DFEH HEX

2DFFH - 2E08H DECTBL

2E09H - 2E11H NUM

INPUTS: Values from Box distribution, Area acquisition and Fat thickness that were stored in memory.

OUTPUTS: Computed beef grading results stored in memory.

LOCATION: 2B00H

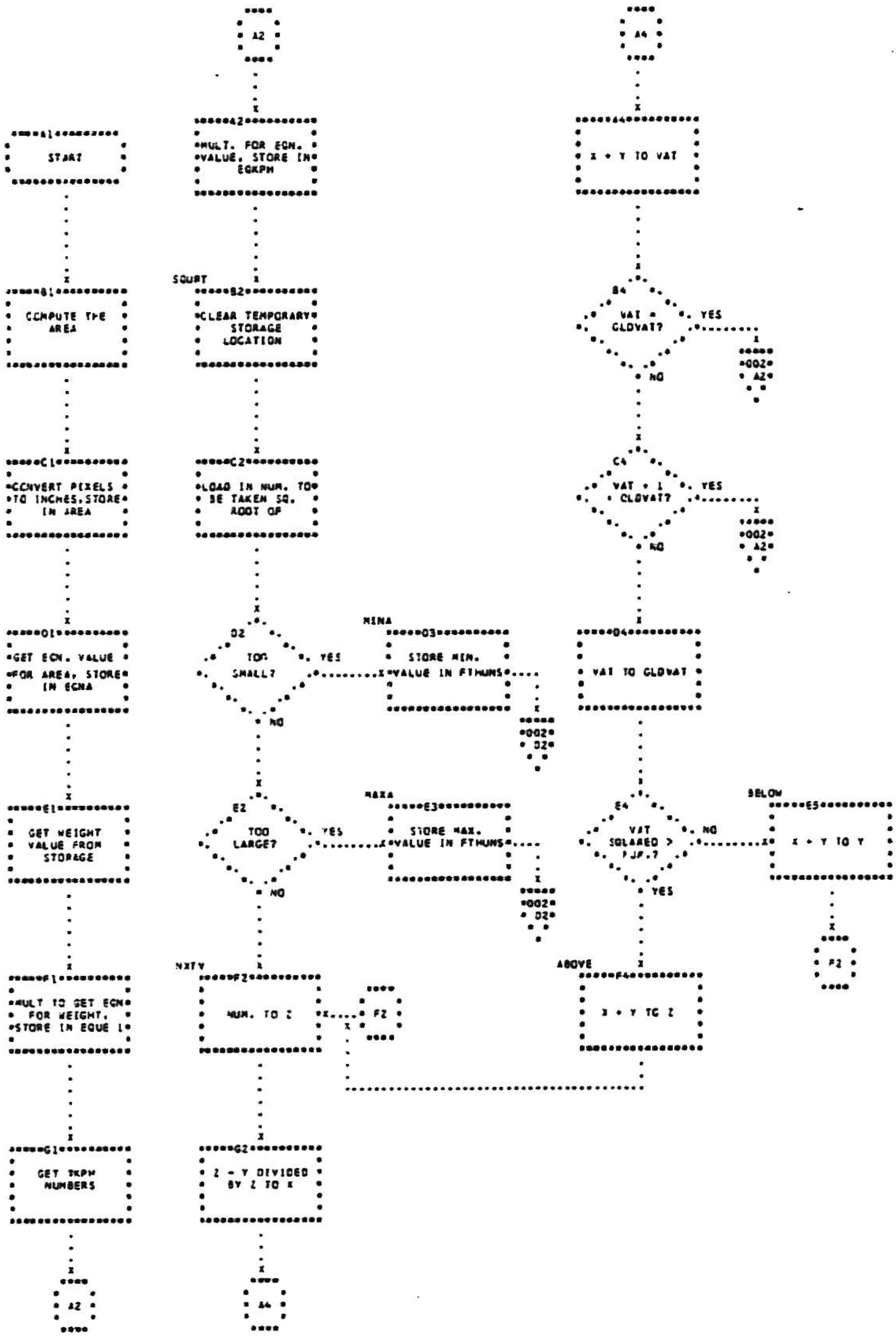
SIZE: 311H

COMMENTS: Must be preceded by inputting routines; Box distribution, Area acquisition, Fat thickness.

VERSION: 9 7 16.22

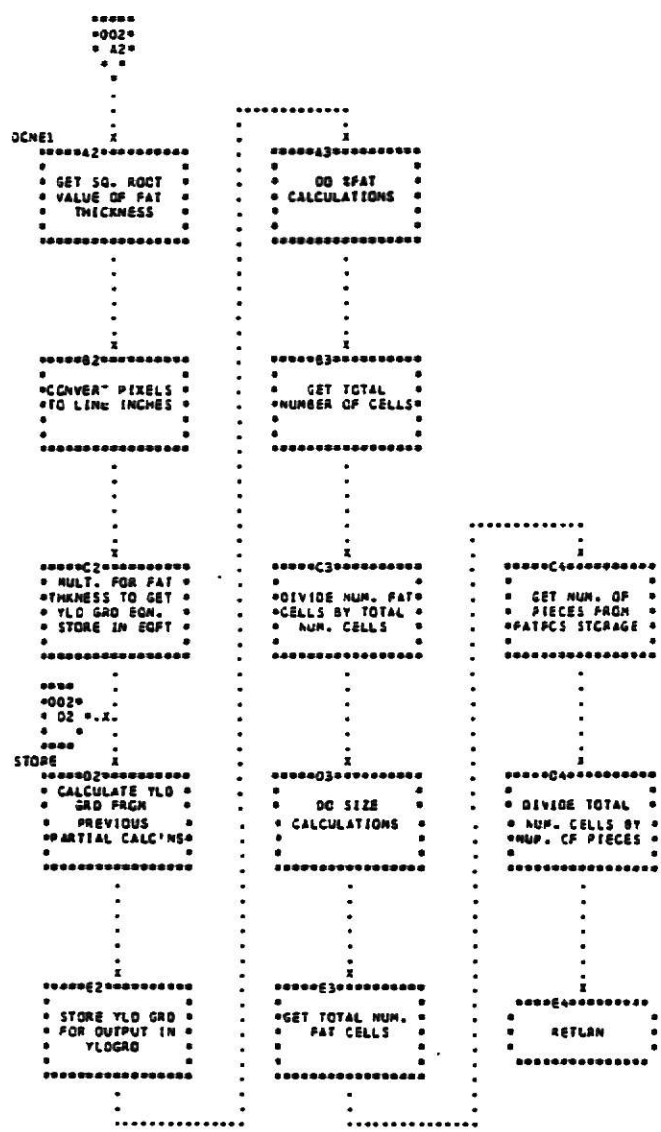
CALCULATION SUBROUTINE

FLOWCHART



CALCULATION SUBROUTINE

FLOWCHART



Display Results (DSPRES)

2.14 Display results takes the decimal values found in the PCKDEC string, converts the numbers to their ASCII equivalents, inserts the ASCII into a string called DPYBUF, then outputs the DPYBUF to the data terminal screen.

DPYBUF is a display string which contains the english identification (in ASCII equivalent code) for all the numbers in PCKDEC as well as the ASCII equivalents of PCKDEC. DPYBUF is created in the loading of the program and is updated with the new values of PCKDEC each time Display results is executed. The DPYBUF as created is seen in Fig. 2.14-1 and Fig. 2.14-2 includes a sample set of data. Notice that the X location in the first figure are updated to numbers in the second figure.

NOTE - This program assumes that the string PCKDEC has been properly created and contains the valid numbers for the selected carcass (i.e., all the measurement programs and calculation programs were run prior to DSPRES).

```
AREA=XX.XX   TOTAL FAT=XX.XX   TOTAL MEAT=XX.XX   TOT FAT=XX.X%   TOT MEAT=XX.X%

FAT IN BOX=XX.X%   NO OF PCS=XXXX   FAT TH=X.XX   SIG BOXES XX   =XX   >XX   <XX

%FAT  XX.X  XX.X  XX.X  XX.X   %AREA  XX.X  XX.X  XX.X  XX.X   MAP [         ]
DISTR XX.X  XX.X  XX.X  XX.X   DISTR  XX.X  XX.X  XX.X  XX.X       [         ]
      XX.X  XX.X  XX.X  XX.X          XX.X  XX.X  XX.X  XX.X       [         ]
      XX.X  XX.X  XX.X  XX.X          XX.X  XX.X  XX.X  XX.X       [         ]
```

FIG. 2.14-1. Empty DPYBUF Output.

```
AREA=08.48   TOTAL FAT=03.23   TOTAL MEAT=05.25   TOT FAT=38.0%   TOT MEAT=61.9%

FAT IN BOX=06.9%   NO OF PCS=0008   FAT TH=0.36   SIG BOXES 12   =03   >05   <04

%FAT  07.5  06.1  00.0  00.0   %AREA  73.9  96.7  34.9  02.0   MAP [====--   ]
DISTR 00.7  12.0  00.0  12.9   DISTR  78.5  99.9  51.0  73.1       [--++--++]
      00.0  09.8  09.9  07.9          07.9  75.9  99.9  92.8       [  ++++==]
      00.0  00.0  11.1  00.0          00.0  03.1  33.2  78.5       [    ++--]
```

FIG. 2.14-2. Sample Data in DPYBUF Output.

Display Results (DSPRES)

SUBROUTINES: ASCII, STOR, MESSAGE, CHAROT

REGISTERS: BP - increment table position

SI - message pointer

DI - display pointer

BX - length table pointer

CS - counter

AX - mask, data input, output

DX - general

VARIABLES: A00H - A55H PCKDEC

A56H - C34B DPYBUF

C3CH - CC0H INCTBL

CC1H - CCCH LENTBL

CCDH - STP

INPUTS: Tables and values stored in memory.

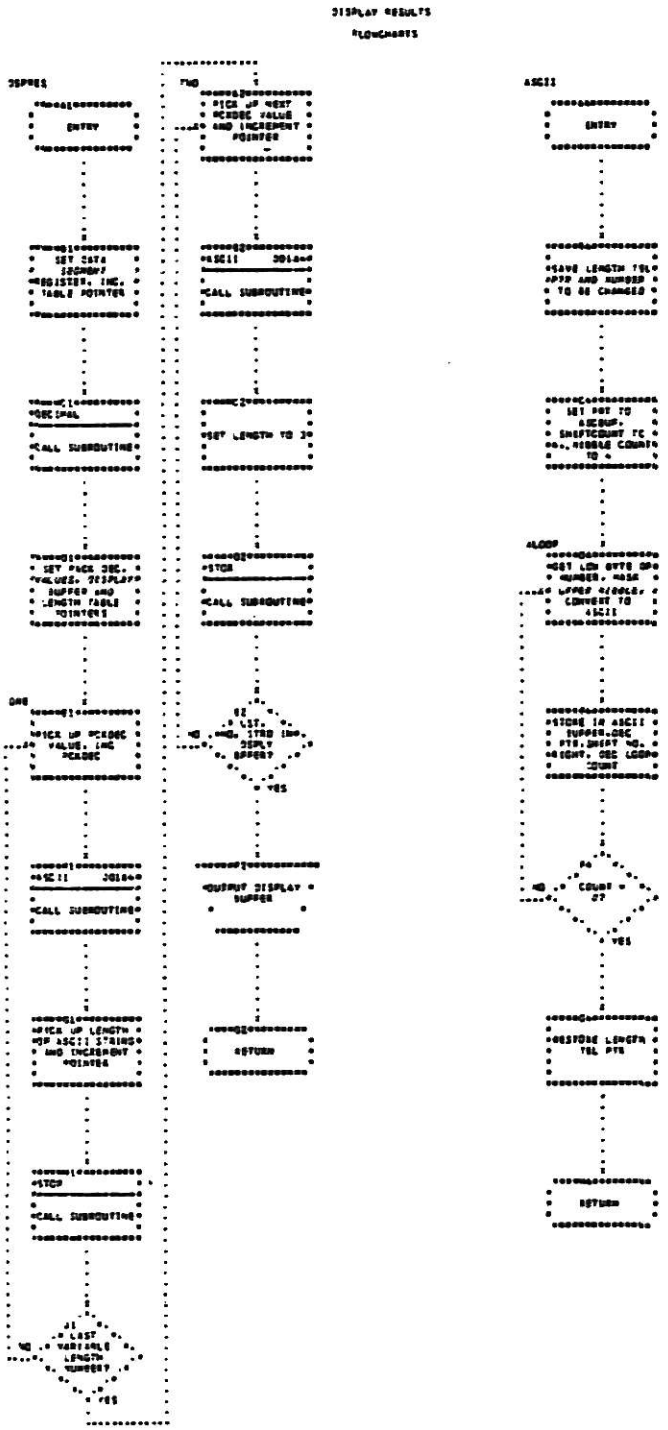
OUTPUTS: Proper ASCII characters to data terminal.

LOCATION: 2600H

SIZE: 8CH

COMMENTS: Must be preceded by Calculate results program.

VERSION: 9 5 19.44


DISPLAY RESULTS
FLOWCHARTS
DSPRES
ENTRY
SET DATA SEGMENT REGISTER, INC. TABLE POINTER
DECIMAL
CALL SUBROUTINE
SET PACK DEC. VALUES, DISPLAY BUFFER AND LENGTH TABLE POINTERS
CALL SUBROUTINE
PICK UP PCADDR VALUE, INC PCADDR
ASCII DSP&&
CALL SUBROUTINE
PICK UP LENGTH OF ASCII STRING AND INCREMENT POINTER
STOP
CALL SUBROUTINE
NO
LAST VARIABLE LENGTH NUMBER?
YES
TWO
PICK UP NEXT PCADDR VALUE AND INCREMENT POINTER
ASCII DSP&&
CALL SUBROUTINE
SET LENGTH TO 2
STOP
CALL SUBROUTINE
NO
LAST ITEM IN BUFFER?
YES
OUTPUT DISPLAY BUFFER
RETURN
ASCII
ENTRY
SAVE LENGTH TBL APTR AND NUMBER TO BE CHANGED
SET PBT TO ASCBUF, SHIFTCOUNT TO 4, NIBBLE COUNT TO 4
ALOOP
GET LOW BYTE OF NUMBER, MASK
CONVERT TO ASCII
STORE IN ASCII BUFFER.DEC PTR,SHIFT NO. & CONT. DEC LOOP COUNT
NO
COUNT = 0?
YES
RESTORE LENGTH TBL PTR
RETURN

Save Results (SAVRES)

2.15 Save results stores the date, location, area, and all the data presented in the displayed results (i.e. total fat, total meat) on a disk previously initialized as a data disk.

Save results reads track one sector one of the disk using a universal disk read/write routine DSKIO. The data is stored in a buffer called BUFF location at 7100H. This data is a directory of the date, location, carcass count, next track and sector addresses, and the number of data fields stored on the disk. Save results compares the present date and location to the one of the directory to see whether to continue with the carcass count (same date and location) or start counting at one (either different date, different location, or both). Using DSKIO, the present data in PCKDEC is stored on the disk at the track and sector specified by the directory. The sector address is incremented and compared to the maximum sectors on a track. If it exceeds the maximum then the track is set to one and a message is output to the terminal which reads; "THIS DISK IS FULL PLEASE REPLACE IT WITH A NEW FORMATTED DISK AND PRESS RETURN WHEN READY". The directory is then updated and stored on the disk using DSKIO whether a new disk was installed or not.

Save results uses the Disk support package and the routine DSKIO for support.

NOTE: This routine assumes that an initialized data disk is in drive 0 and all the data to be stored has been already calculated and the present date and location are stored in memory.

Save Results (SAVRES)

SUBROUTINES: DSKIO, MESSAGE, CHARIN, OUTHEX, DMASET, VFYDRVRDY, PARMREG, RESULT, ERROR

REGISTERS: DX - general purpose, track, sector number
DI - string pointers,
SI - string pointers, message pointer
AL - track number, sector number

VARIABLES:

2200	FLG	
2202-225F	MESS1	Full disk message
2260-2267	MESS2	Disk error message
0F00	COMMAND	
0F01	TRK	
0F02	SEC	
0F03	NUM	
0F04	TRK1	
0F05	LEN	
0F06	FIRST	
0F08	BSEADDR	
0F0A	ADDR	
0F0C	DRV	
0F0D	CNT1	
0F0F	CNT2	
0F11	CNT3	
0F12	CRTL	
0F13-0F16	ASCBUF	
09F8	DAT	

09FA	DAT2
09FC	LOC1
09FE	SAVCNT
0A00	PCKDEC
7100	BUFF

INPUTS: Values from computed beef grading results. Input also from Date & location.

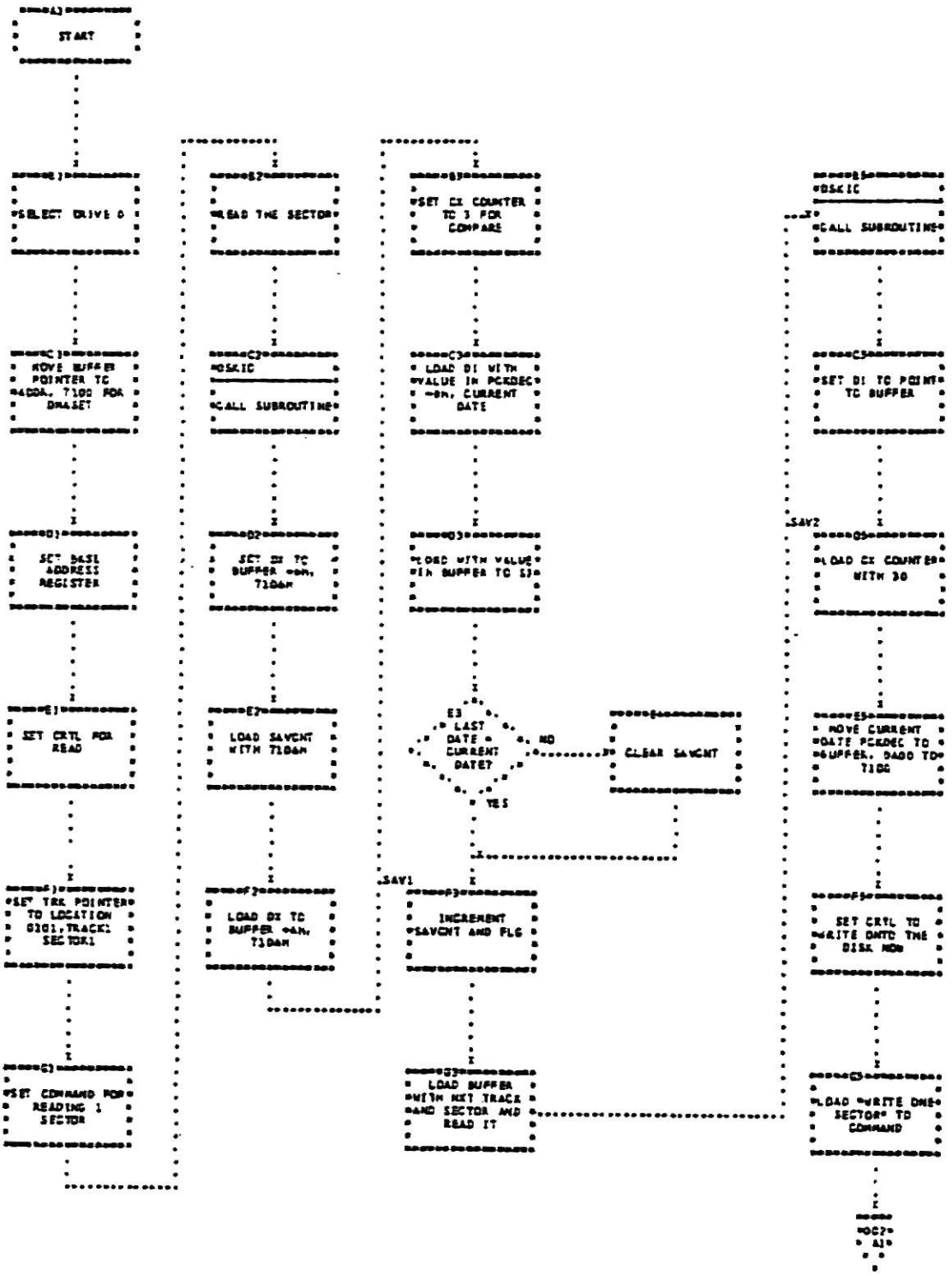
OUTPUTS: Stored beef grading results on data disk.

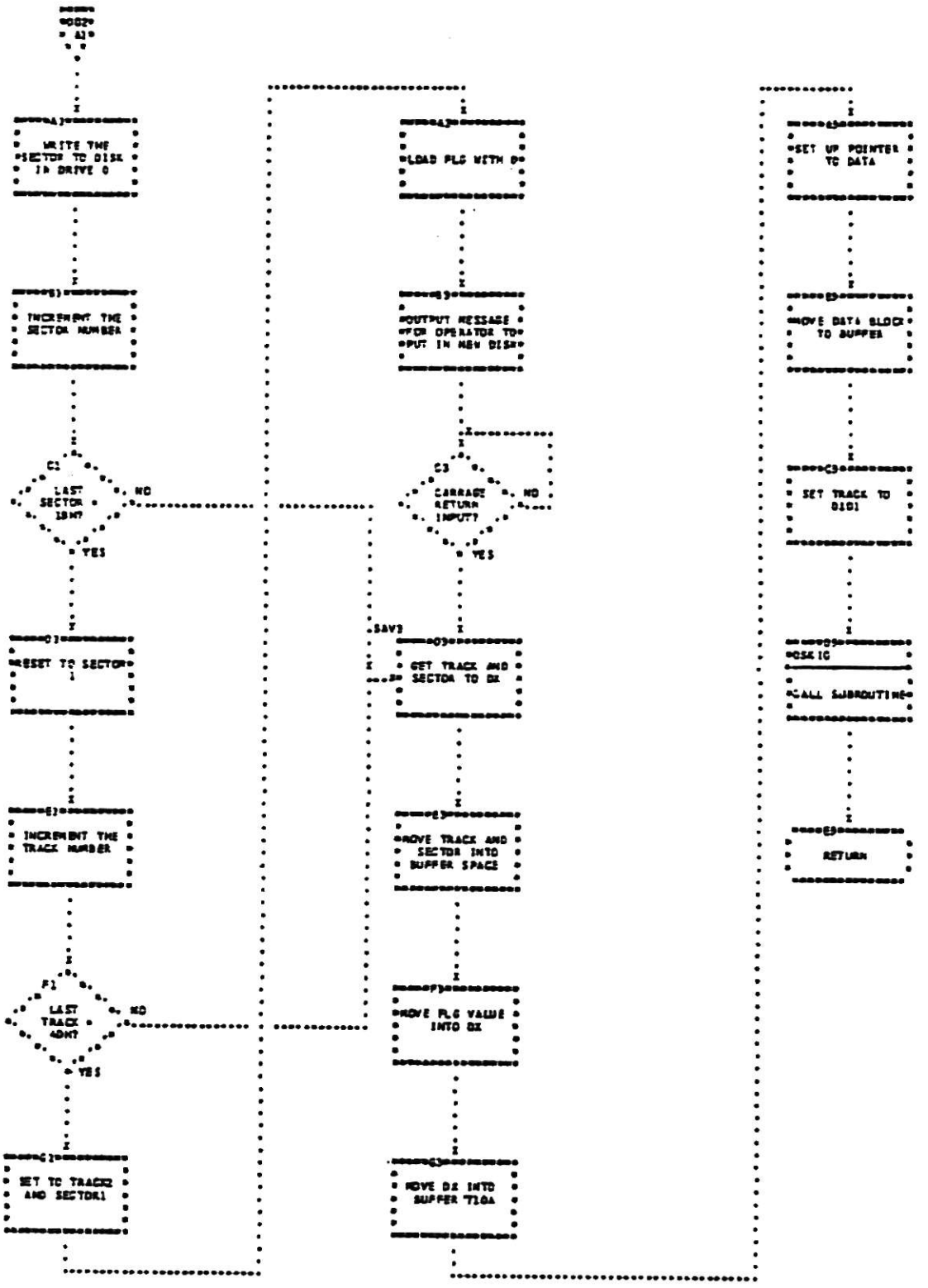
LOCATION: 2100H

SIZE: 167H

COMMENTS: Should be run after Calculate results.

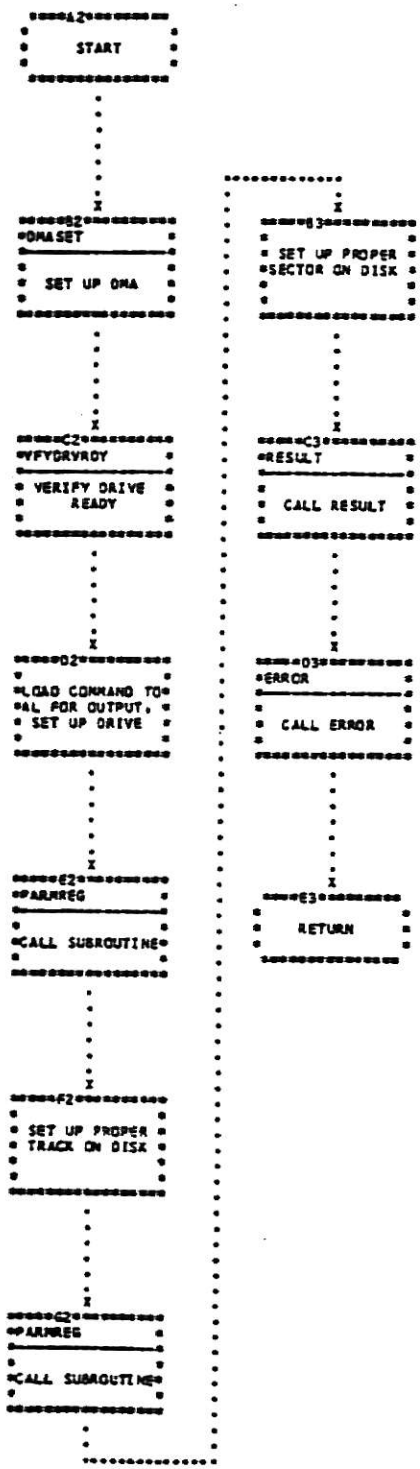
VERSION: 3 19 14.11


START
SELECT DRIVE 0
MOVE BUFFER POINTER TO ADDR. 7100 FOR DMASET
SET DMSL ADDRESS REGISTER
SET CNTL FOR READ
SET TRK POINTER TO LOCATION 0101,TRACK1 SECTOR1
SET COMMAND FOR READING 1 SECTOR
READ THE SECTOR
DSKIC
CALL SUBROUTINE
SET DX TO BUFFER ADDR. 7100H
LOAD SAVCNT WITH 7100H
LOAD DX TO BUFFER ADDR. 7100H
SET CX COUNTER TO 3 FOR COMPARE
LOAD DI WITH VALUE IN PCKDEC ADDR. CURRENT DATE
STORE WITH VALUE IN BUFFER TO DI
E3
LAST DATE = CURRENT DATE?
NO
YES
CLEAR SAVCNT
SAV1
INCREMENT SAVCNT AND FLG
LOAD BUFFER WITH NXT TRACK AND SECTOR AND READ IT
DSKIC
CALL SUBROUTINE
SET DI TO POINT TO BUFFER
SAV2
LOAD CX COUNTER WITH 30
MOVE CURRENT DATE PCKDEC TO BUFFER, DADD TO 7100
SET CNTL TO WRITE DATA TO THE DISK NOW
LOAD WRITE ONE SECTOR TO COMMAND
OC2
A1


WRITE THE SECTOR TO DISK IN DRIVE 0
INCREMENT THE SECTOR NUMBER
C1
LAST SECTOR ISN?
NO
YES
RESET TO SECTOR 1
INCREMENT THE TRACK NUMBER
F1
LAST TRACK ADR?
NO
YES
SET TO TRACK2 AND SECTOR1
LOAD PLC WITH 0
OUTPUT MESSAGE FOR OPERATOR TO PUT IN NEW DISK
C3
CARRAGE RETURN INPUT?
NO
YES
SAV3
GET TRACK AND SECTOR TO DX
MOVE TRACK AND SECTOR INTO BUFFER SPACE
MOVE PLC VALUE INTO DX
MOVE DX INTO BUFFER T10A
SET UP POINTER TO DATA
MOVE DATA BLOCK TO BUFFER
SET TRACK TO 01D1
POSKIO
CALL SUBROUTINE
RETURN

SUBROUTINE DSKIO

FLOWCHART



Draw Box (DRWBOX)

2.16 The Draw box routine essentially forms a rectangular boundary of (01) cells in memory. The location and size of the box depends upon whether a right or left slope area is detected.

A call is made to DRECTN subroutine to determine right or left slope. The LCRS flag is set if a left slope was found. Before the box is drawn a call is made to RESTORE subroutine. The subroutine removes any previously drawn boundaries (01) by changing them to (02) cells.

The appropriate starting top left edge of the box is loaded into registers.

The top edge of the box is drawn, then down to the bottom right edge, followed by the left and bottom edge. When complete, flags are set and the program returns to Master loop.

Draw Box (DRWBOX)

SUBROUTINES: DRECTN, RESTORE, DRWBOX

REGISTERS: DI - picture pointer

BX - start address for right box

DX - height, width

AL - boundary

CX - number of columns, counter

VARIABLES: 08CCH - BIGFLG

08DOH - LCRS

08D2 - SMLFLG

INPUTS: Values from picture memory.

OUTPUTS: Boundary points in a square pattern in picture memory.

LOCATION: 2550 Start

2580 DRWBOX subroutine

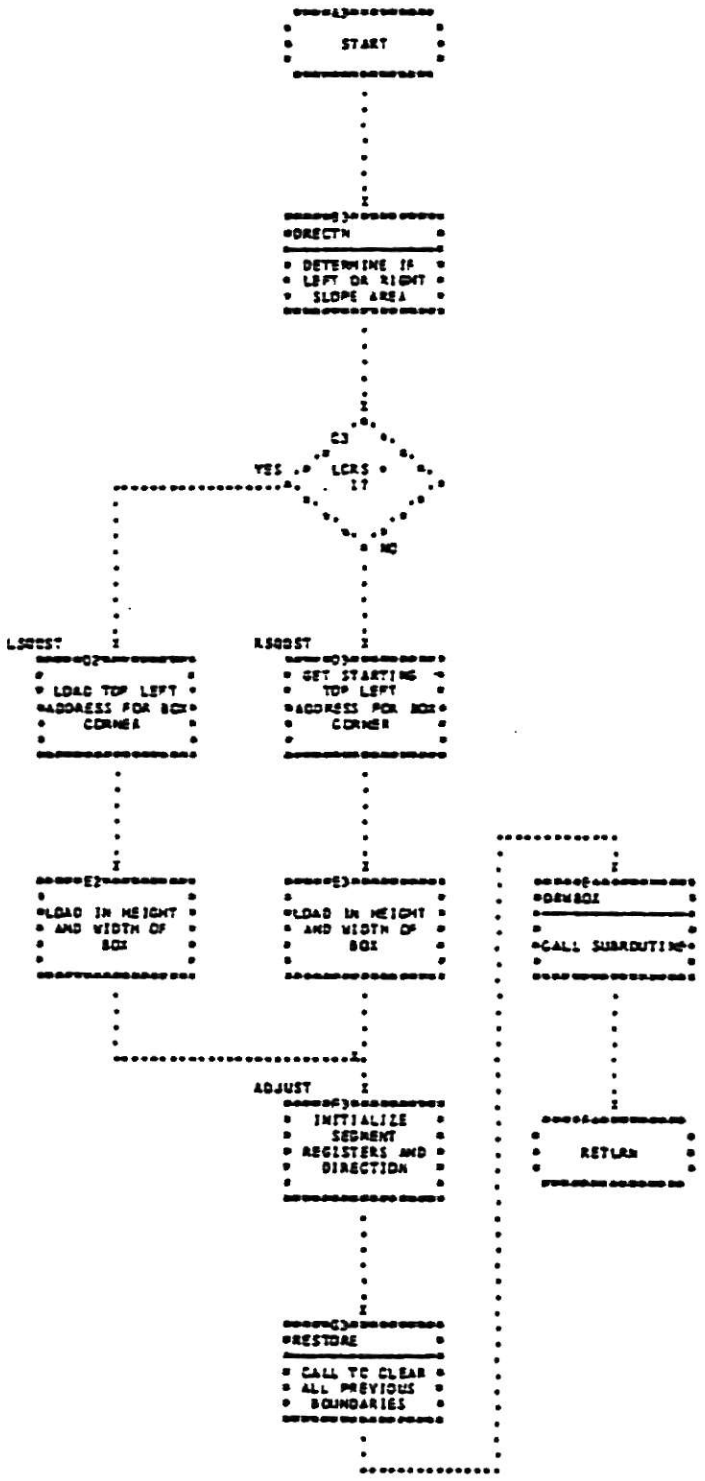
SIZE: 80H

COMMENTS: The start location refers to the normal entry point to draw a box within the loin eye proper. Any box drawn without regard to the loin eye slope should be implemented with a direct call to DRWBOX subroutine.

VERSION: 9 12 1.58.21

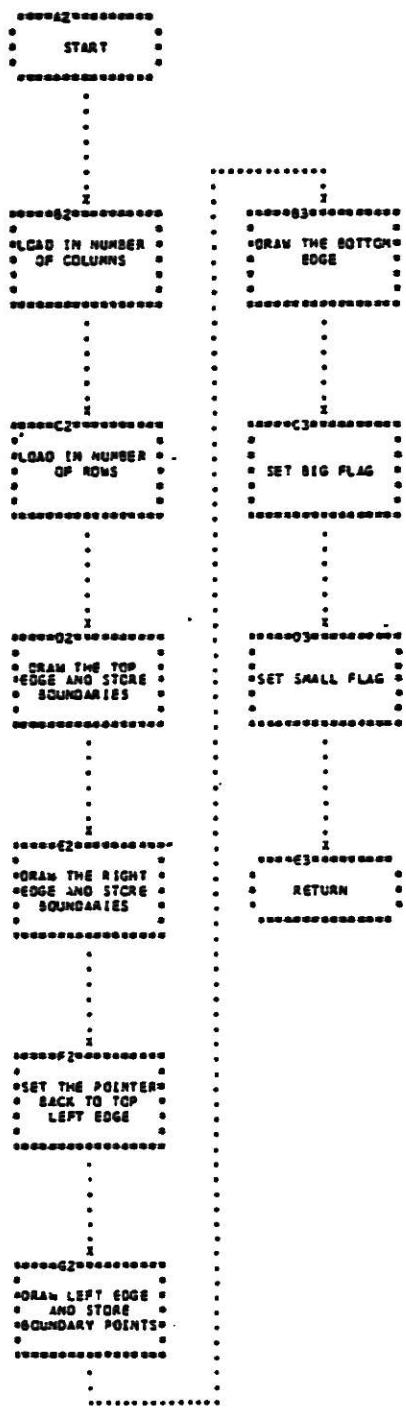
PRELIMINARY DRAW A BOX IN MEMORY

FLOWCHART



SUBROUTINE DRWBOX

FLOWCHART



Block Picture Display (BLKDPY)

3.1 BLKDPY displays a block of upper memory 80x23 bytes on the terminal screen as well as the address of the upper left hand corner (the start of the block). BLKDPY inputs a character from the keyboard and compares it to its set of commands. If the character is not one of the commands the program ignores the character. The valid commands are:

R (Relocate) - changes the starting address of the block (frame) to be displayed to that specified. Then displays that block. EXAMPLE: R<new address>[CR].

H (left arrow) - changes the starting address of the block (frame) to be 80 columns to the left of the present position (one to the left). Then displays that block.

K (up arrow) - changes the starting address of the block (frame) to be 23 rows up from the present position (one frame up). Then displays that block.

L (right arrow) - changes the starting address of the block (frame) to be 80 columns to the right of the present position (one frame to the right). Then displays that block.

J (down arrow) - changes the starting address of the block (frame) to be 23 rows down from the present position (one frame down). Then displays that block.

E (escape) - exit the program and return to the calling program.

After a command is typed the program offsets to the proper value then calls subroutine Display frame. Examples of output from block display can be seen in Figs. 2.9-5 and 2.6-1, 2. Although any location within memory can be the

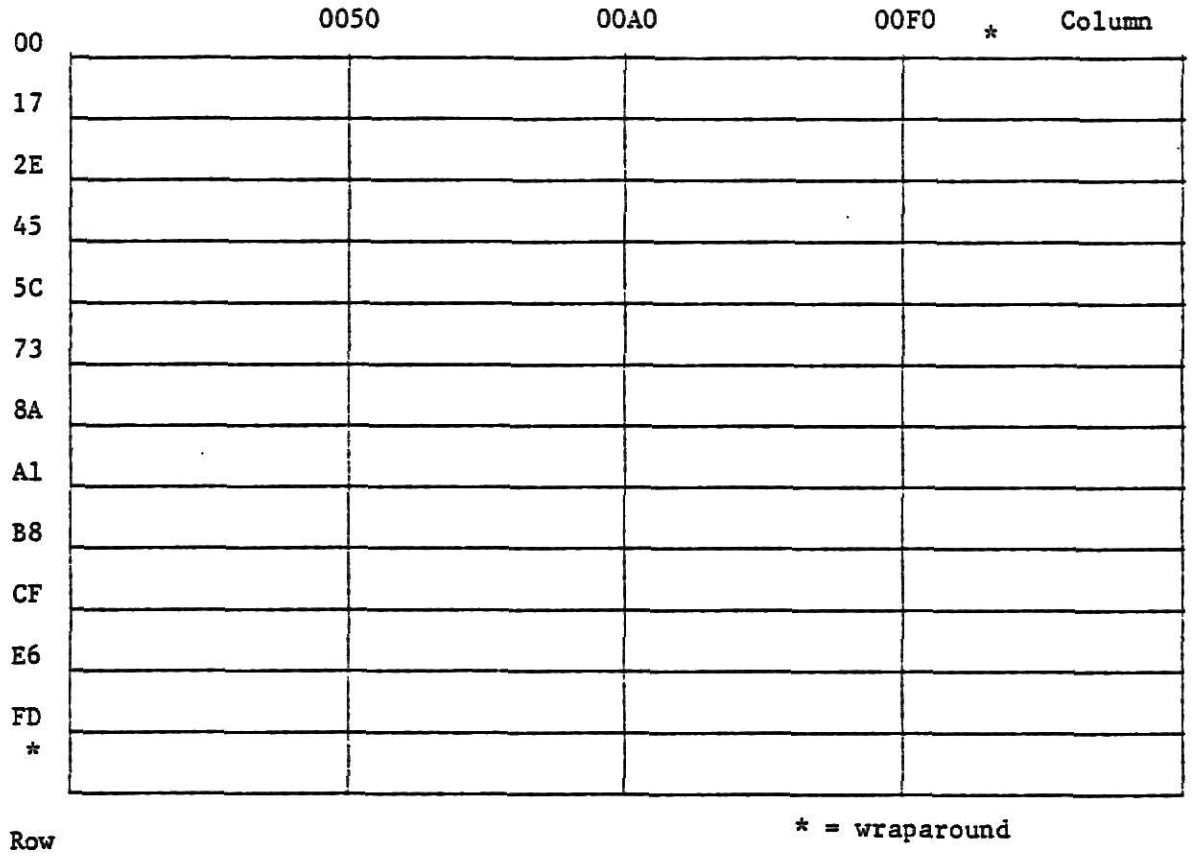


FIG. 3.1-1. Block Display Addresses

top left location in the displayed block, Fig. 3.1-1 shows the block locations if only the arrow commands are used. Remember the data terminal output is distorted because a rectangular block in memory is shown as a square like display.

Block Picture Display (BLKDPY)

SUBROUTINES: MESSAGE, CHARIN, INPINT, DISP, OUTWRD, CHAROT, OUTHEX

REGISTERS: SI - message pointer, picture location

AL - input, output data

DX - picture location

BX - row counter

CX - column counter

VARIABLES:

110D	LW
110E-1111H	TABLE
1112-1121H	HEX
1122-1177H	MESS1
1178-117FH	MESS2
1180-1187H	MESS3

INPUTS: Values from picture memory

OUTPUTS: ASCII characters to data terminal representing a block of picture memory.

LOCATION: 1000H

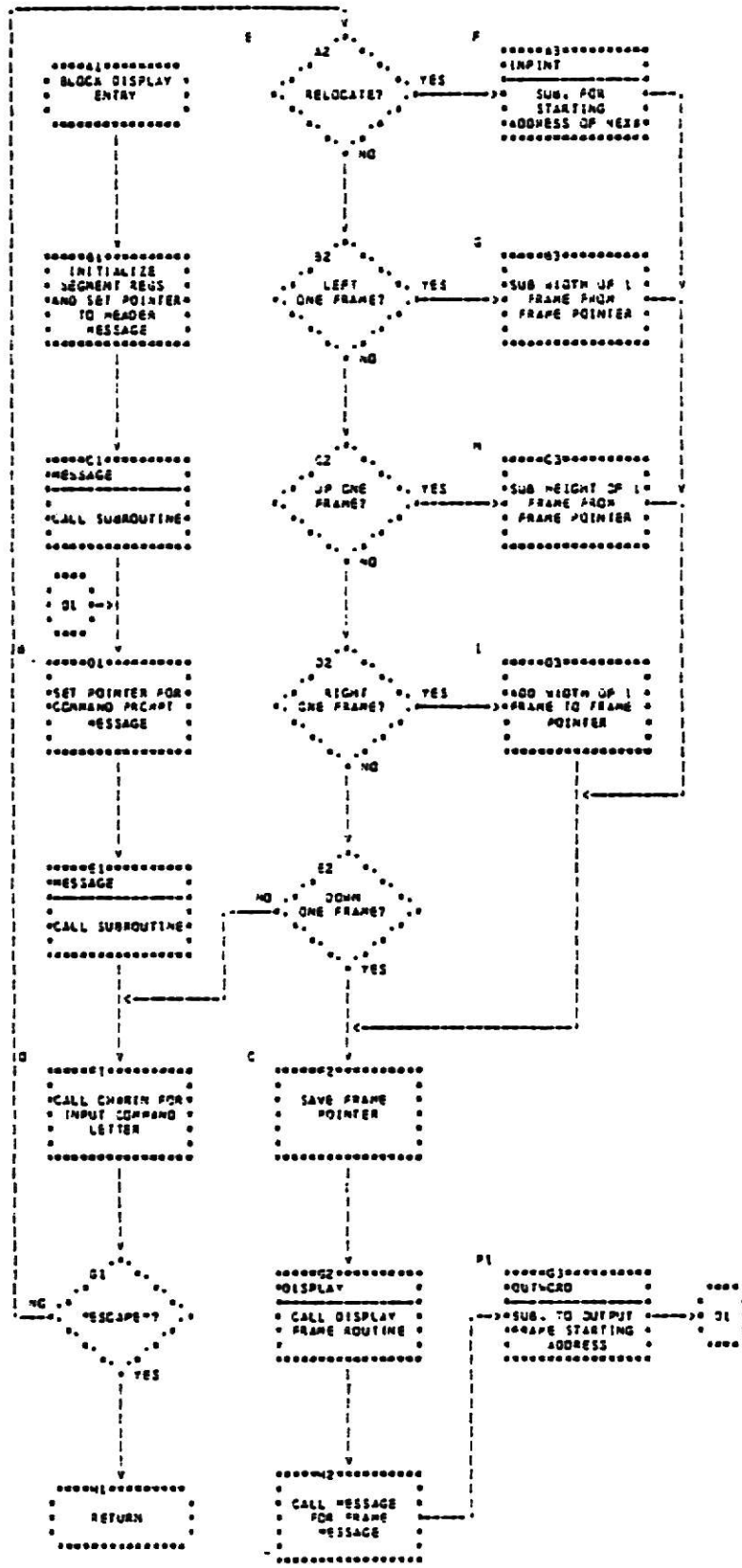
SIZE: 180H

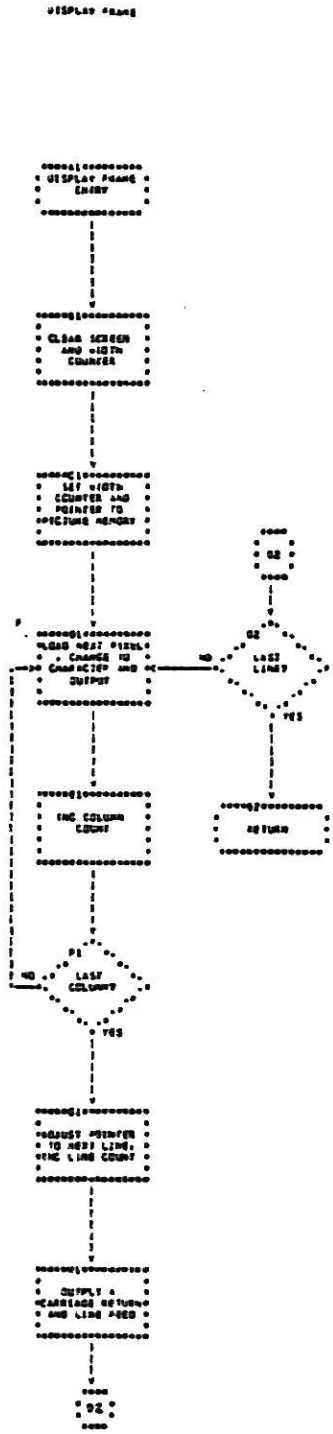
COMMENTS: Block display is run after the data is classified.

VERSION: 0

BLOCK DISPLAY ENTRY

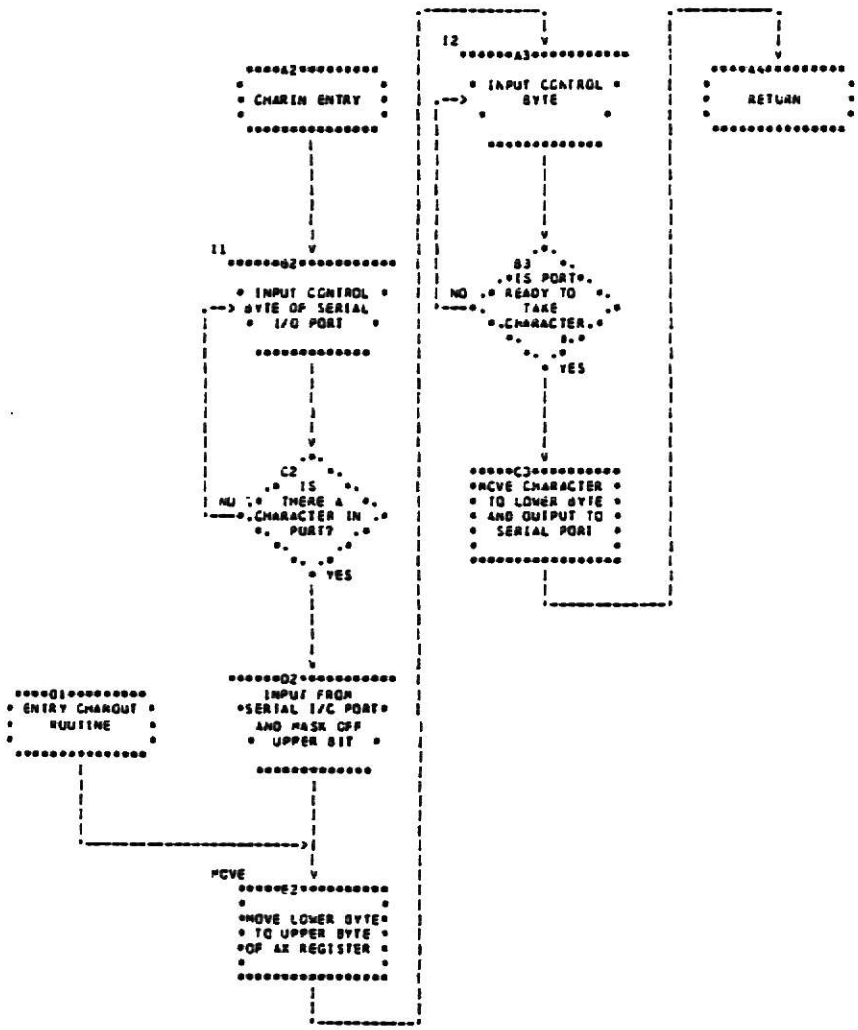
FLOWCHART

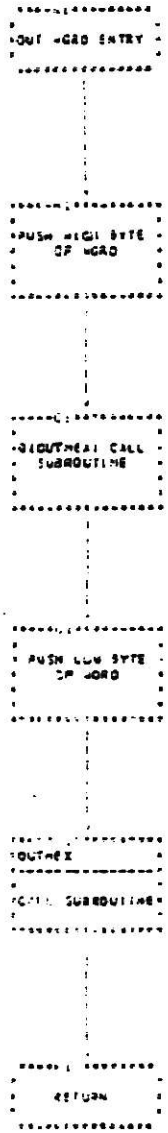




CHARACTER INPUT/OUTPUT ROUTINE

FLOWCHART





Distribution (DISTRB) and Print Distribution (PTDIST)

3.2 The purpose of Distribution and Print distribution is to display for the operator a plot of light intensity (abscissa) vs. area (ordinate).

If the operator wishes to view the plot on the data terminal the Baud rate must be slow enough to view the information. The Baud rate (rate at which the terminal allows the information to be received) is set by first removing the plate on the data terminal located to the left of the keyboard. With a ball point pen or other object set the rate of 300 or 1200 Baud by pressing in the appropriate switch. The previous setting (usually, 9600) must be disabled by resetting the 9600 switch. The operator should then reset the system. The Distribution program loads in the starting and ending picture row and column. A section of memory is cleared to make ready for fresh data. The intensity values in upper memory can range from 00H to FFH. If the value pointed to by the picture pointer (DI) was 3DH, location 3DH in lower memory would be incremented by 1. If all of upper memory was filled with the value 3DH then another counter would be needed since each address in lower memory can be increased to FFH maximum. Therefore, two addresses for each value are needed.

If the first address fills to FF and is incremented, the second address is incremented and the first cleared.

The picture pointer is set to the next position and a check is made for last row, last column. The process repeats until all memory values are tabulated.

After the distribution is stored into lower memory it must be printed or displayed on a data terminal to be of any use. Print distribution program takes these values and sends them to the data terminal along with the appropriate control characters, Fig. 3.2-1.

If the distribution is such that there is a gap of no area between two values, two stars are printed in place of intensity numbers. This procedure saves paper. After each intensity value is printed, the number or area is printed followed by a series of stars. The number of stars is equal to the area divided by a constant. The constant can be changed to scale the ordinate of the graph.

When all the intensity and area numbers are printed the program returns to Master loop.

Note that Print distribution can be run without destroying the stored values from Distribution.

FIG. 3.2-1. Output Print Distribution.

Distribution (DISTRB) and Print Distribution (PTDIST)

SUBROUTINES: CHAR

REGISTERS: AX - starting row, column

EX - ending row, column

PI - picture pointer

CS - number of locations counter

VARIABLES: 36D3H-36E3H TABL - ASCII numbers for printing

INPUTS: Values 00H-FFH from picture array

OUTPUTS: Values to 400H-600H in lower memory and ASCII values to data terminal.

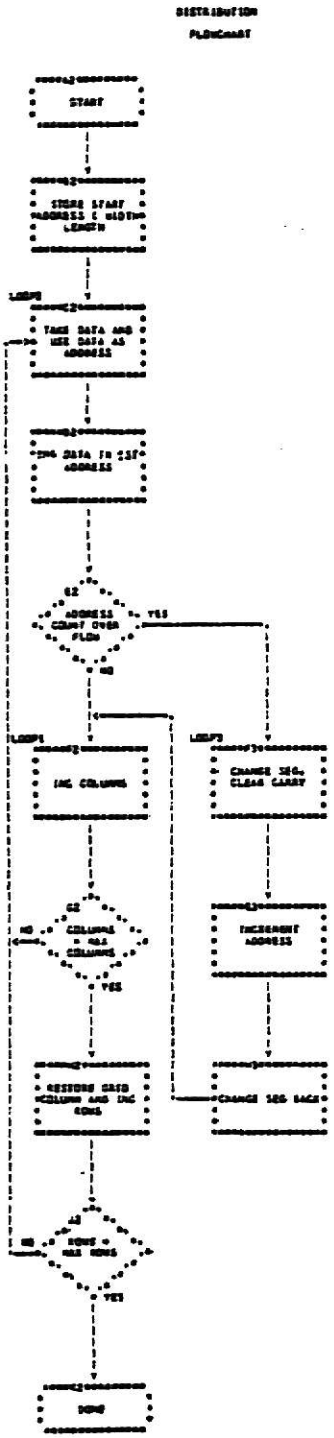
LOCATION: 3580H

PTDIST
STARTING ADDRESS: 3600H

SIZE: 173H

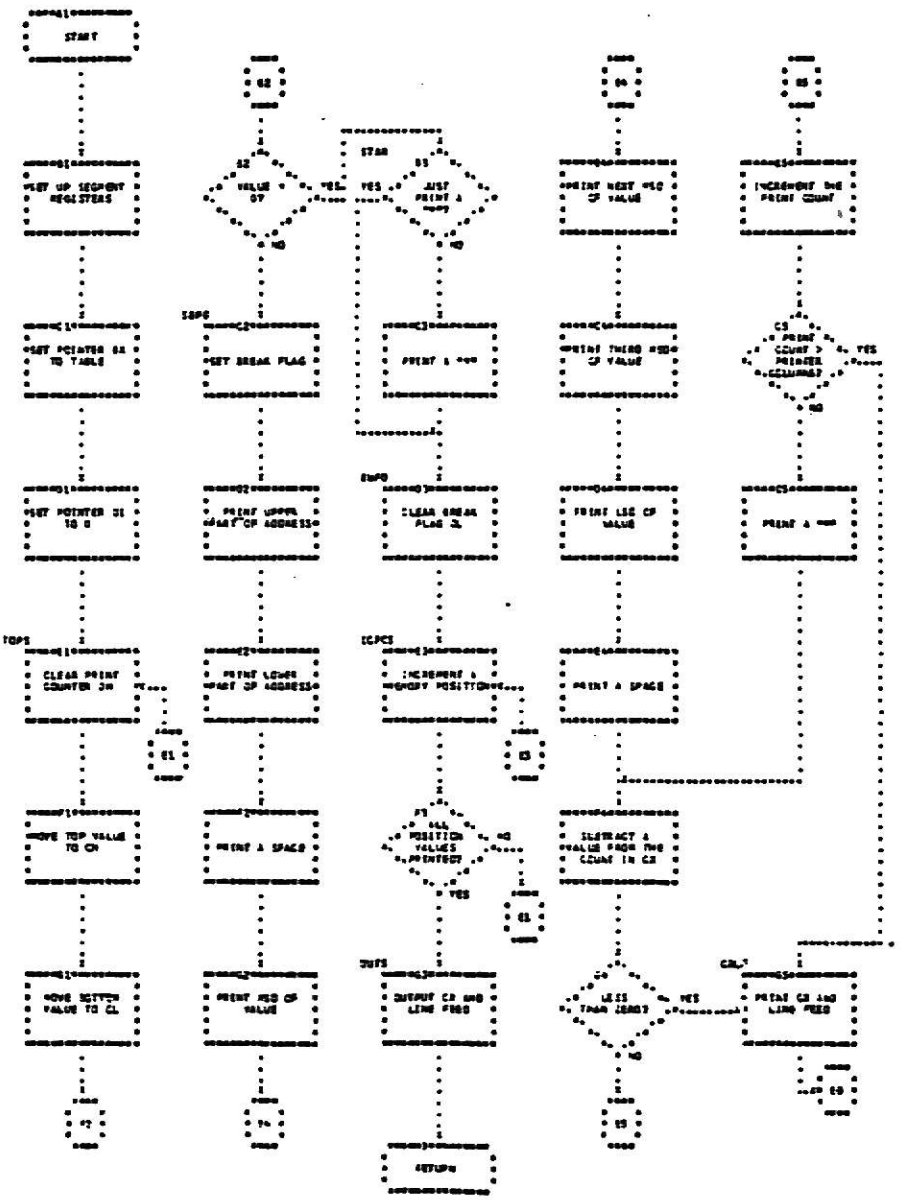
COMMENTS: Should be run after a picture is loaded to upper memory.

VERSION: 9 4 20.26



PRINT DISTRIBUTION

FLOWCHART



Light Meter (LMETER)

3.3 The Light meter routine finds the average light intensity from a block of picture memory (256 points) and displays the result on the data terminal.

This utility program is used to set the light intensity seen by the charge injection device (CID) imaging circuit in the camera. To run the program the proper symbol must be entered into the Master loop monitor command string. After typing a carriage return the program is in a loop waiting for the operator to take a picture. After taking a picture the average intensity is displayed. The operator should adjust the f-stop on the lens until the average is at the proper level.

The program immediately calls the Next picture program to operate the focusing and flood lamps and takes care of loading the image to picture memory.

The data terminal screen is cleared to make ready for output information. The row counters are cleared and a check is made to see if a key was pressed at the data terminal. This is the escape from program execution. If a key was not pressed the sum for averaging is cleared. The pointer DI is set to location 6766H in picture memory. The value pointed to by DI is added to the sum. DI is moved two positions to the right and the value pointed to is again added to the sum. The process continues across the row until 32 points are summed. The pointer is moved down three rows and the process repeats until 32 points in 8 rows are summed. The sum is divided by 256 for the average intensity.

The next section of the program displays one of the four scales shown in Fig. 3.3-1. Scale 2 shows an average level of 86.

To determine which scale is displayed the average intensity is compared to 75. If less than 75 scale one is displayed. If greater than 75 but less than 151 scale two is displayed, etc. The exclamation mark is displayed to show the level. The entire program repeats until a key on the data terminal is pressed.

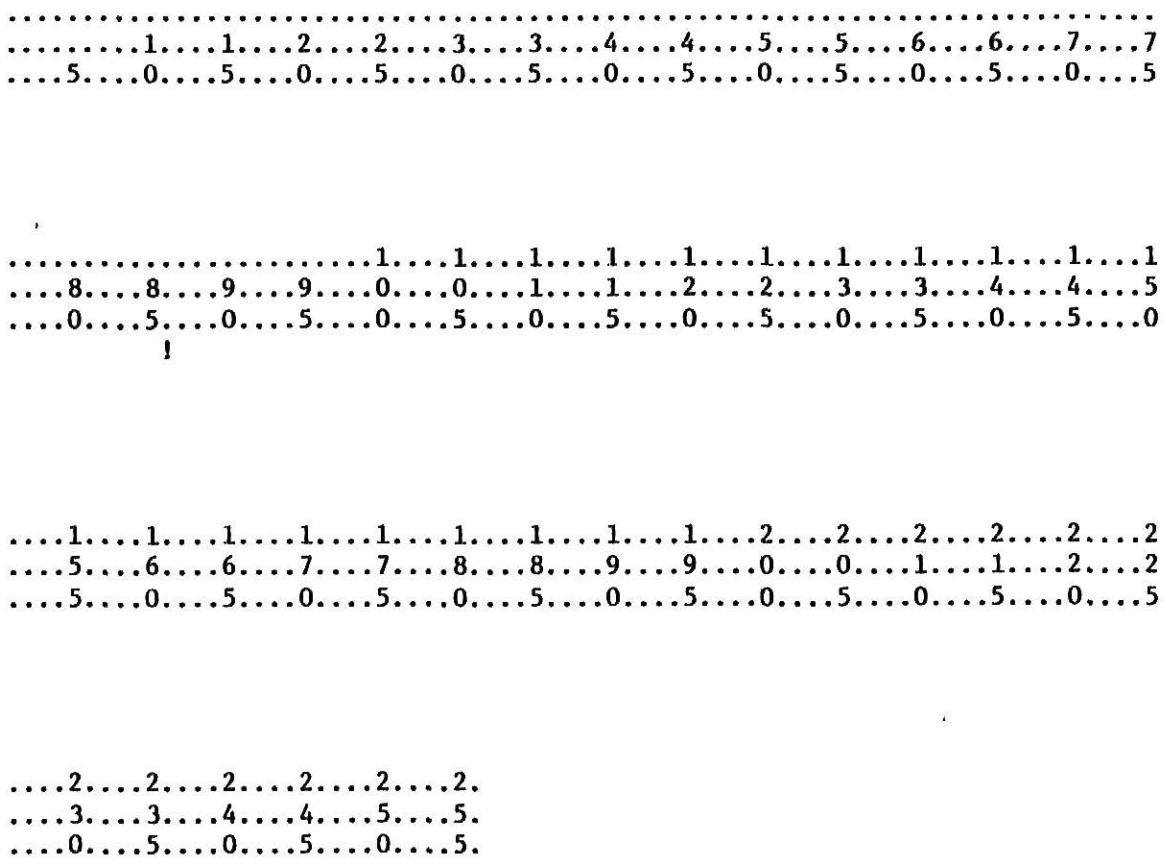


FIG. 3.3-1. Light Meter Scales.

Light Meter (LMETER)

SUBROUTINES: CHRO, NEXPIC

REGISTERS: SI - row character pointer

AX - input, output, general

BX - scale counter (pointer)

DX - sum value

DI - picture pointer

VARIABLES:

D64AH	STRFLG	
48FDH-49E6H	MSC01	Scale 1
49E7H-4AD0H	MSC02	Scale 2
4AD1H-4BBAH	MSC03	Scale 3
4BBBH-4C1FH	MSC04	Scale 4

INPUTS: Now classified values 00-FFH from picture memory

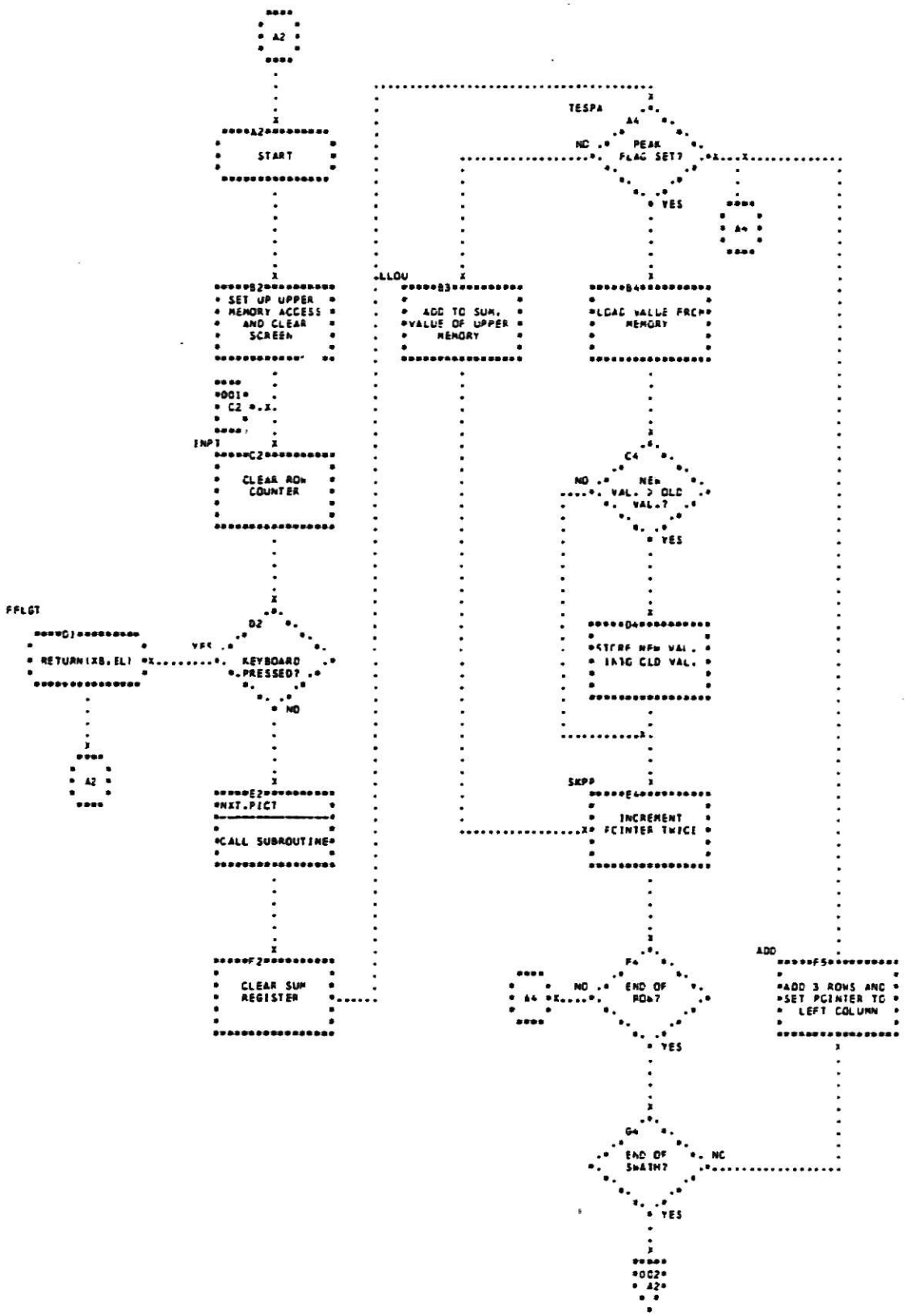
OUTPUTS: ASCII characters to data terminal representing relative light intensity.

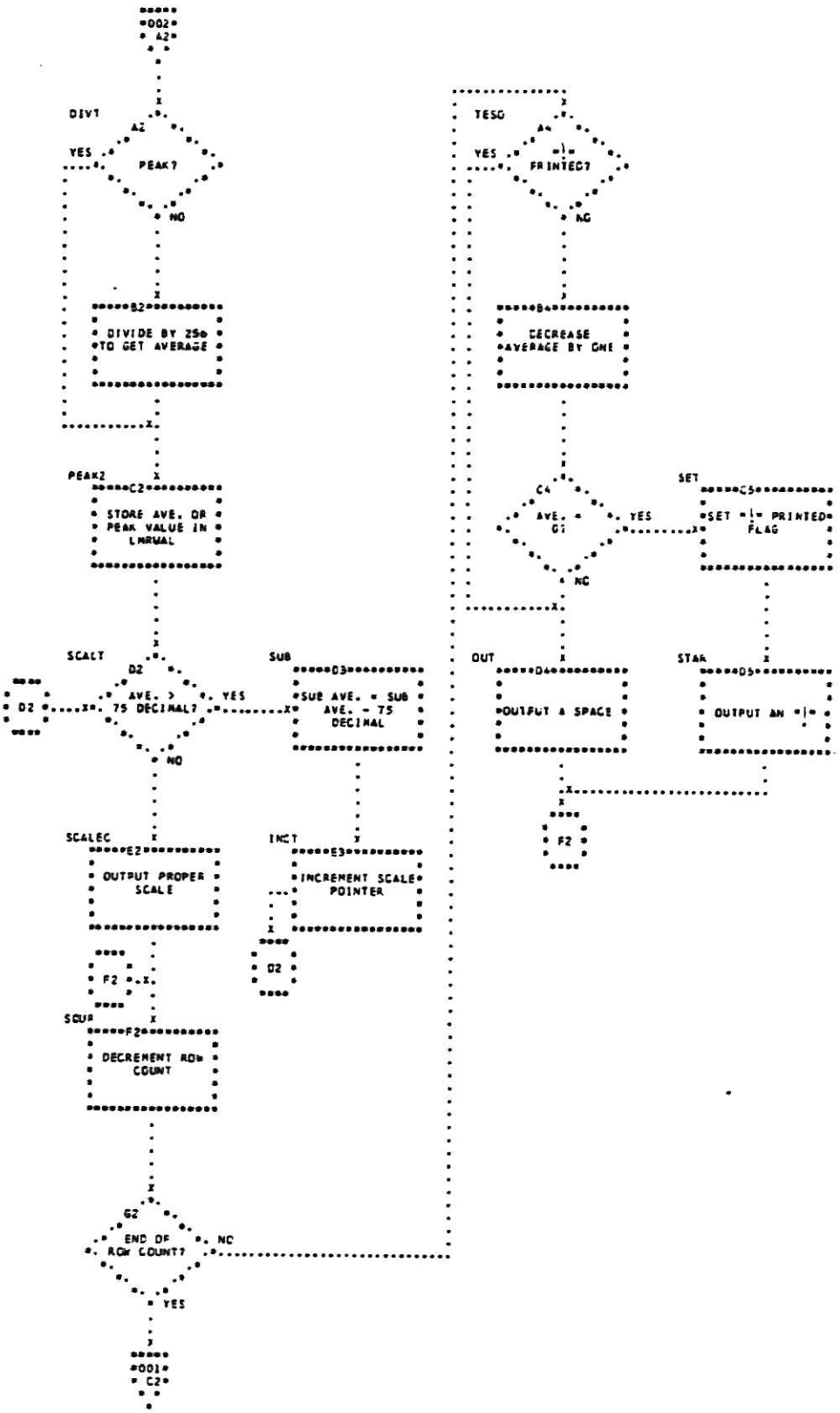
LOCATION: 4800H

SIZE: 41FH

COMMENTS: This program loads the picture automatically. Previous picture data is destroyed.

VERSION: 8 10 14.15


A2
START
B2
SET UP UPPER MEMORY ACCESS AND CLEAR SCREEN
0001
C2 X.
INPT
C2
CLEAR ROW COUNTER
D2
KEYBOARD PRESSED?
YES
NO
FFLGT
D1
RETURN(XB,EL)
A2
E2
NXT.PICT
CALL SUBROUTINE
F2
CLEAR SUM REGISTER
LLOU
B3
ADD TO SUM, VALUE OF UPPER MEMORY
TESPA
A4
PEAK FLAG SET?
NO
YES
A4
B4
LOAD VALUE FROM MEMORY
C4
NEW VAL. > OLD VAL.?
NO
YES
D4
STORE NEW VAL. AS OLD VAL.
SKPP
E4
INCREMENT POINTER TWICE
F4
END OF ROW?
NO
YES
A4
G4
END OF SWATH?
NO
YES
ADD
F5
ADD 3 ROWS AND SET POINTER TO LEFT COLUMN
0002
A2


002
A2
DIVT
A2
YES
PEAK?
NO
B2
DIVIDE BY 256
TO GET AVERAGE
PEAKZ
C2
STORE AVE. OR
PEAK VALUE IN
ACCUMULATOR
SCALT
D2
AVE. > 75 DECIMAL?
YES
NO
SUB
D3
SUB AVE. = SUB
AVE. - 75
DECIMAL
SCALEC
E2
OUTPUT PROPER
SCALE
F2
INCT
E3
INCREMENT SCALE
POINTER
D2
SCUR
F2
DECREMENT ROW
COUNT
G2
END OF
ROW COUNT?
NO
YES
001
C2
TESD
A4
YES
PRINTED?
NO
B4
DECREASE
AVERAGE BY ONE
C4
AVE. =
G1
YES
NO
SET
C5
SET =/= PRINTED
FLAG
OUT
D4
OUTPUT A SPACE
F2
STAR
D5
OUTPUT AN =/=

Communication to Nova (COMNOV)

3.4 The purpose of the module is to transfer picture memory to the Nova/ Grinnell image processing system. The image processing system has, at the present time, matrix handling as well as disk and magnetic tape storage capabilities.

The proper hardware connections should be made between the Nova and the data terminal on the beef grading instrument. The RS232 terminal cable from the Nova needs to be connected to the extension output of the ADM data terminal. After data is loaded into picture memory the program is started by typing the proper symbol into the Master loop. A carriage return is typed to start execution. The program should start before the Nova comes on line to request data. After the program receives the proper message from the Nova receiver, an on-line message is sent to the Nova. The routine sends one row of picture data then waits for receiver ready. The process is repeated until all rows are sent.

Communication to NOVA (COMNOV)

SUBROUTINES: CHARIN, CHAROT, MESSOUT

REGISTERS: AL - input, output data

SI - pointer for message routines

DH - top row

DL - left column

DI - picture pointer

VARIABLES: 874-884H MESS1 - on line code to NOVA

885-888H MESS2 - received data code

889H DUMMY

INPUTS: Data from picture array. Usually not classified.

OUTPUTS: Input data to output ports to NOVA

Ports: STATUS ODEH

DATA OD8H

LOCATION: 810H

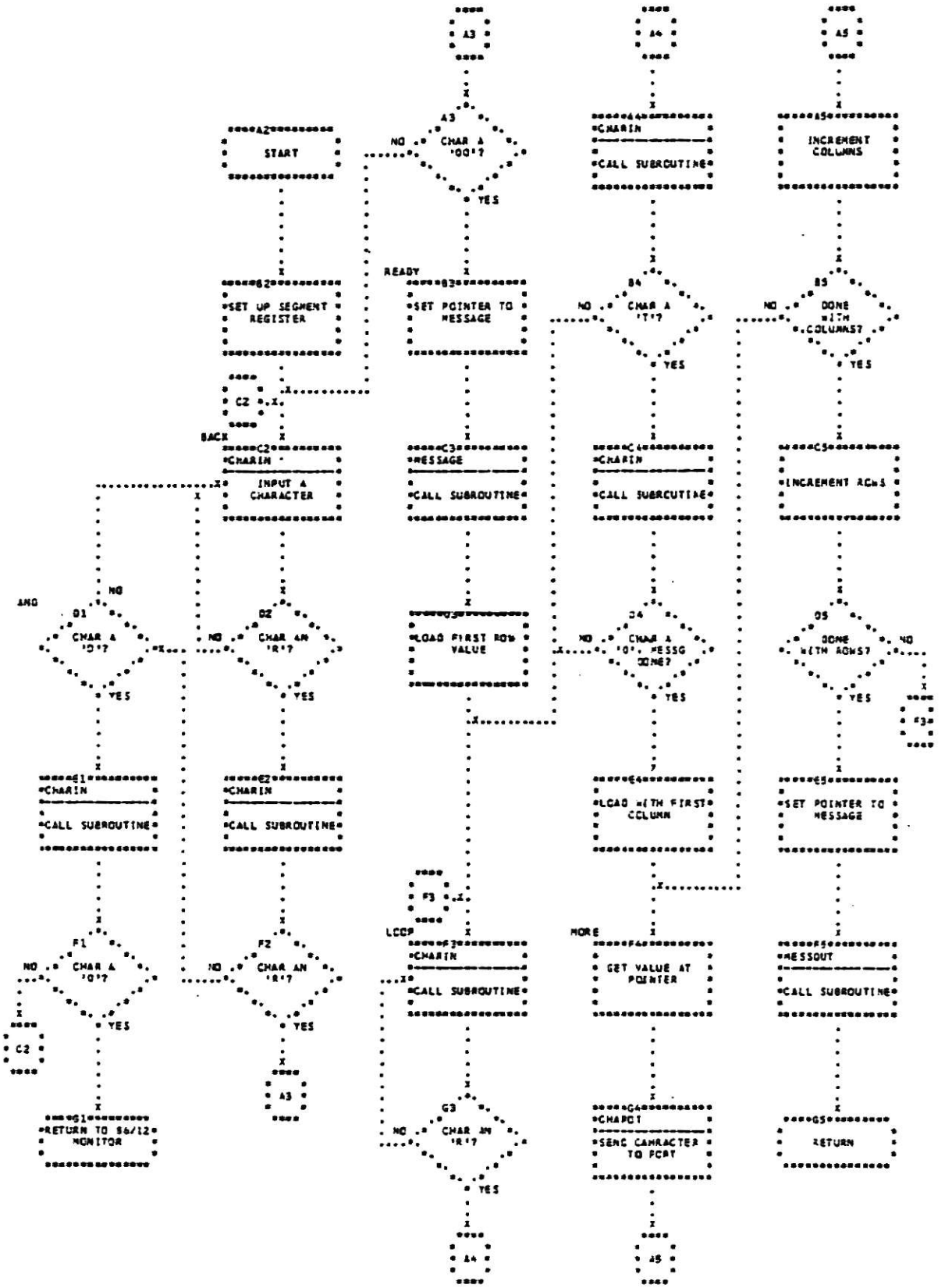
SIZE: 8FH

COMMENTS:

VERSION: 8 15 9.54

SUBROUTINE COMMUNICATION TO NOVA

FLOWCHART



Set Date and Location (SETDAT)

3.5 SETDAT is a stand alone program starting execution at 6200H. SETDAT inputs from the keyboard the month, day, year, and a three letter identifier for the location. The string is stored in memory starting at 9F8H. The data is stored as a number and the location is stored in ASCII. For a date of 5/26/81, for example, the string as seen in memory would be as follows: (note all values are in hexadecimal notation) 26H, 05H, 4DH, 81H, 4EH, 41H. The location was MAN for Manhattan. The data is stored as words; 05, 26, 81, M, A, N.

Set Date and Location (SETDAT)

SUBROUTINES: MESSAGE, INPINT, CHARIN

REGISTERS: SI - message pointer

AX - input, output

VARIABLES: 9F8H - DAT

9FAH - DAT 2

9FCH - LOC

624DH-625DH MESS1 month ? message

625EH-626CH MESS2 day ? message

626DH-6275H MESS3 year ? message

6276H-627DH MESS4 location ? message

INPUTS: Values of month, day, year and location from data terminal.

OUTPUTS: Storage into memory

LOCATION: 6200H

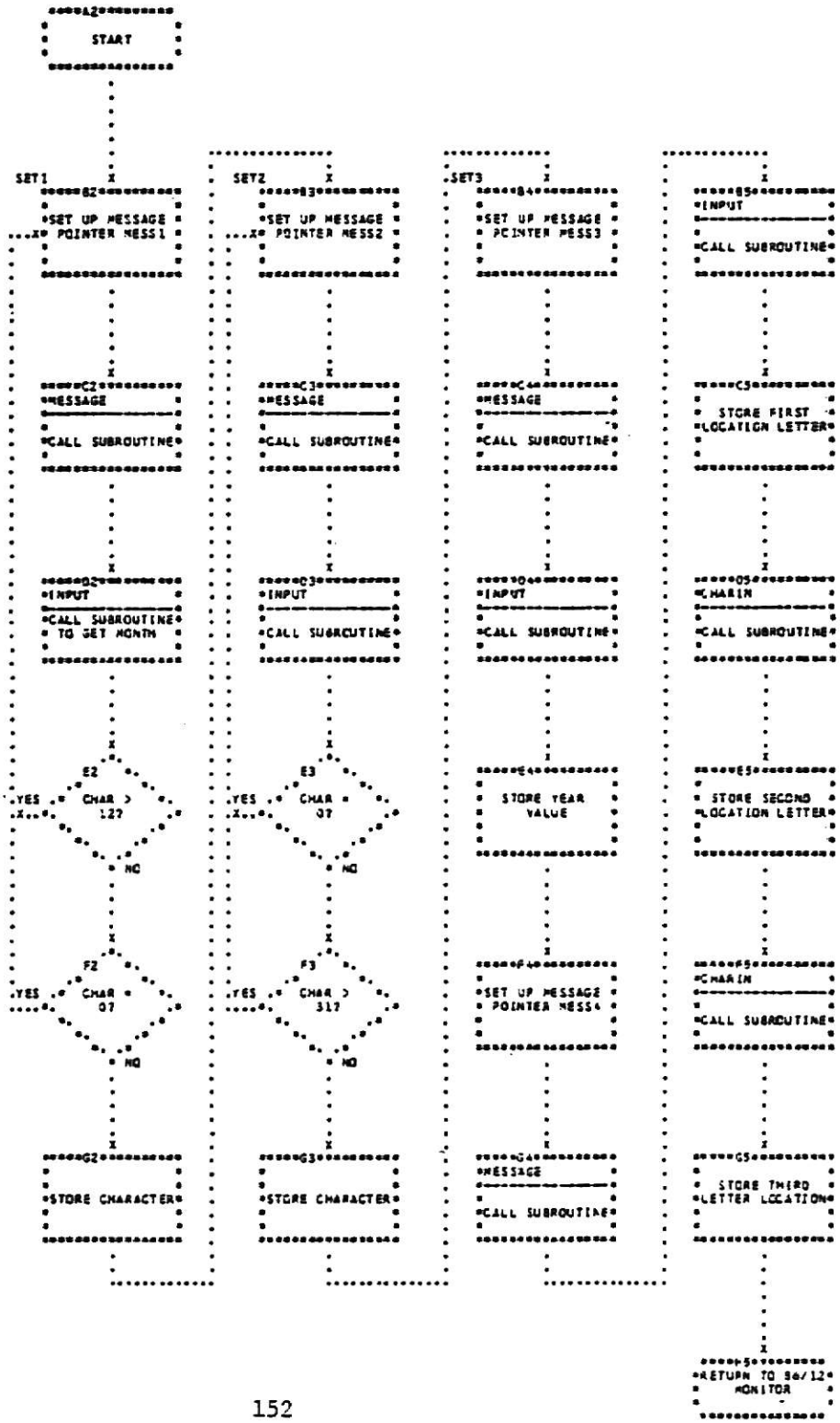
SIZE: 7DH

COMMENTS: Set date and location must proceed Initialize data disk routine.

VERSION: 3 19 14.09

SUBROUTINE SET DATE AND LOCATION

FLOWCHART



Light Calibration (LGTCAL)

3.6 The purpose of Light calibration is to ultimately load in multipliers to the multiplier memory. The routine will store values to linearize the video image with respect to light from the flood lamps.

The initial value to be determined is the peak or average value of an area of the stored image. To obtain an average value the light meter flag (LMFLAG) is set to ØØH. To get a peak value, LMFLAG is set to Ø1.

After calling LMETER (description 3.3 in this manual) the location LMRVAL contains the average or peak value.

The multiplier routine (DDDD) is called to find the multiplier for a value in picture memory pointed to be DI.

(pointer DI)(multiplier) = average value

A multiplier for each value of picture memory is found and stored in the multiplier memory.

The multipliers are encoded to indicate whether the DI value was larger or smaller than the average value.

For example if the average was 47H and the DI value was 45 the multiplier would be

$$45\overline{)47H} \quad \underline{1.0H} \text{ with a remainder of 2. The remainder needs to be}$$

fractional so is divided again by 45H to obtain Ø7H.

$$45\overline{)02.00H} \quad \underline{.07H}$$

Since 45H is smaller than 47H it is encoded as such by clearing the carry bit and shifting to the right. By shifting, one bit of resolution is lost.

00000111

00000011

The multiplier is stored as 03H.

During the Preprocessor routine the multiplier is loaded back and shifted left. The carry was cleared so the multiplicant will be added to image memory.

$$\begin{array}{r} 45H \\ \times\ 06H \\ \hline 01.9EH \end{array}$$

The value of 01H is added to 45H to obtain 46H or 47H ± 1 bit. If the value in DI was greater than 47H, then it will be encoded as negative (carry set) and a subtraction will take place in Preprocessor. When the multipliers for every position are determined and stored in multiplier memory the program returns to Master loop.

Light Calibration (LGTCAL)

SUBROUTINES: LMETER, DDDD

REGISTERS: CX - general, temp. storage LMRVAL

DI - picture pointer

ES - extra segment to 2000H

DS - data segment to 1000H

AL - average or peak value, general

BL - plus or minus flag

DL - general

VARIABLES: 88C0-LMRVAL

C8C2-LMFLAG

08C4-NUMZERO

INPUTS: Average or peak value from LMETER program.

Unclassified values from picture memory.

OUTPUTS: Multipliers to multiplier memory located at 20000H

LOCATION: 2060H

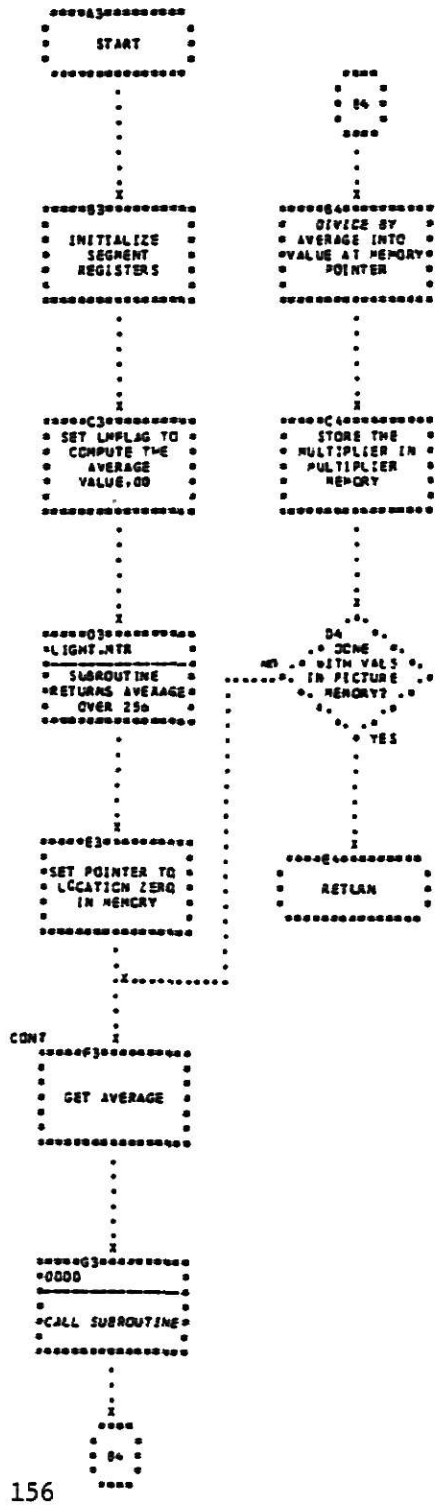
SIZE: 65H

COMMENT: Light calibration is usually run at the beginning of a beef grading session. If the multipliers are to be retained they may be stored on diskette and reloaded.

VERSION: 8 10 13.52

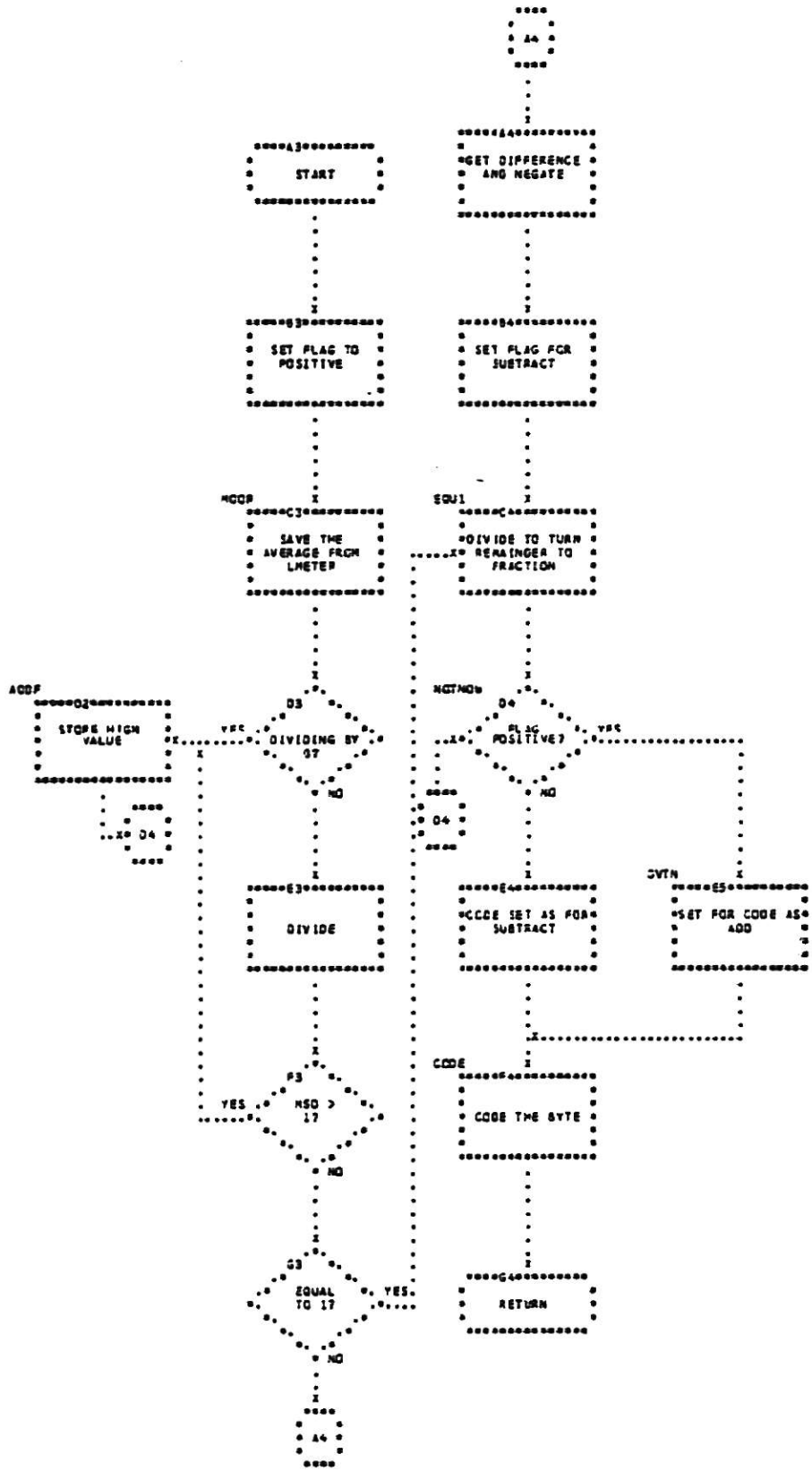
SUBROUTINE LIGHT CALIBRATION

FLOWCHART



SUBROUTINE DCOD

FLOWCHART



Line Load (LINLOD)

3.7 The Line load utility's purpose is to load the same line from successive pictures into multiplier memory to test camera repeatability.

The SI register points to the desired line out of the picture. The output and input ports are initialized. The picture is taken with no control signals to the focus or flood lights and loaded into picture memory 10000H to 1FFFFH. The selected line is pulled out and stored into the first line of multiplier memory 20000H. The multiplier memory pointer (DI) is moved to the next line and the process repeats storing the selected line into 20001H. When all multiplier memory is loaded the program returns to Master loop.

Line Load (LINLOD)

SUBROUTINES: None

RESGISTERS: CX - general purpose, counter

DI - destination index

SI - source index, line loaded

AL - port control, data

VARIABLES: None

INPUTS: Line of data from each stored picture image.

OUTPUTS: Line storage to multiplier memory.

LOCATION: 4DOOH

SIZE: 36H

COMMENT: This utility is used for camera evaluation.

VERSION: 9 8 15.55

3.8 The XOR utility is a simple data check scheme. The area checked is between the 10000H and 20000H physical address space.

The program sets the pointer to the address 10000H and loads in the first value. The pointer is incremented and the value at 10001H is exclusive Or'ed with the previous value. The process continues until location 1FFFDH is reached. The old value of the exclusive oring process is stored at 1FFFEH and 1FFFFH. If a change has occurred between the old memory block and the new memory block the new XOR value will not match the old value. In this case the new value is stored into the old location and a message is output to the terminal indicating a change of data has occurred.

The normal procedure for running XOR is to load the EPROM program down into memory, read in a picture or program disk, then run the XOR program to see if the program disk programs were unchanged. After the XOR program is run the program disk contents between 10400H and 17FFFH can be loaded into work addressable memory space if desired.

Exclusive-or (XOR)

SUBROUTINES: MESSAGE

REGISTERS: CX - general purpose

DI - picture pointer

DX - Exclusive-or register

VARIABLES: 153DH-154DH MESS4

INPUTS: Values from picture memory, classified or unclassified.

OUTPUTS: Stored Exclusive-or code into picture memory with a message to the data terminal.

LOCATION: 1500H

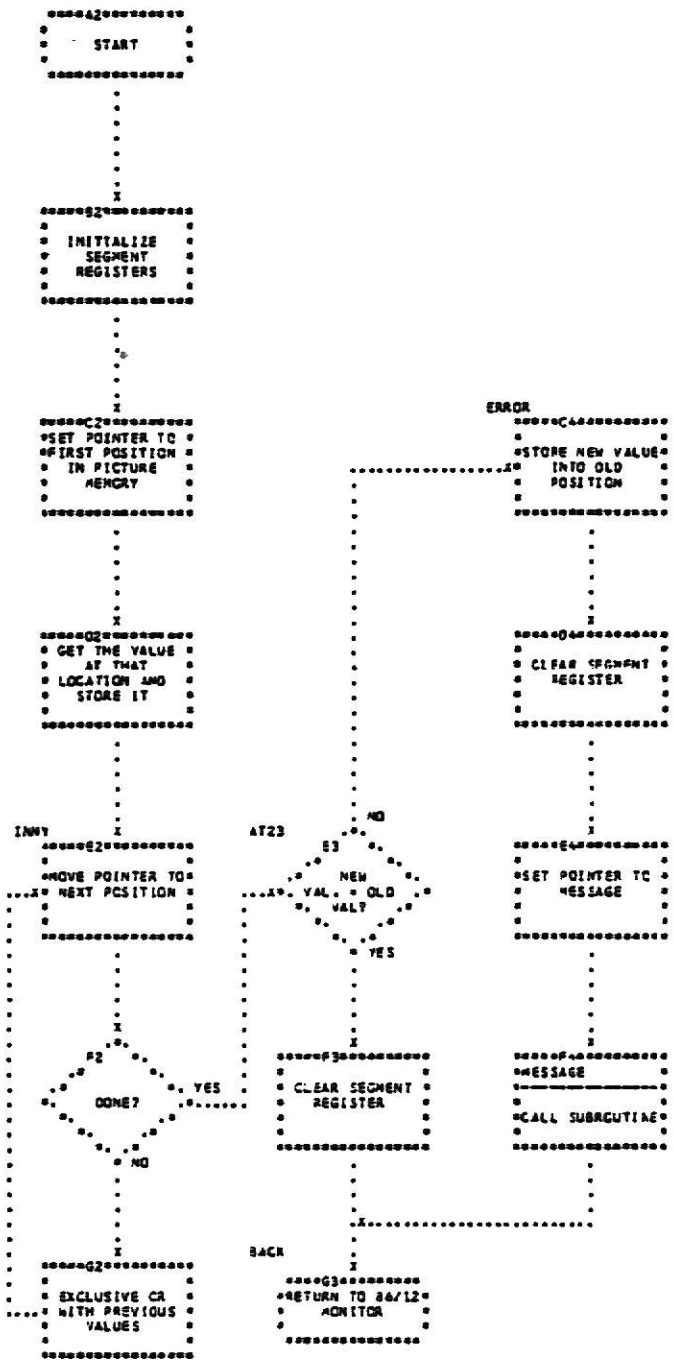
SIZE: 4DH

COMMENTS: XOR resides in the start-up EPROM. It can be used on program as well as on image.

VERSION: 9 16 18.00

SUBROUTINE XOR UTILITY

FLOWCHART



Classifier Level Change (CLLVCH)

3.9 The Classifier level change utility retrieves and stores classifier levels from the data terminal to a specific memory location.

Initially the message pointers are set and a message is displayed on the data terminal asking for the lower classifier level. The old classifier level is displayed and the program is now prompting for input. If a valid number is entered it is stored into a memory location. If an improper number is entered the program skips to the next section and nothing is stored in memory. The same procedure occurs for the upper level except that upon completion the program returns to the Master loop program.

Classifier Level Change (CLLVCH)

SUBROUTINES: CHAR, INPINT, MESSAGE

REGISTERS: BX - hex table pointer

SI - message pointer

CL - counter for shifts

AL - general purpose transfer

VARIABLES: 8C8H LWRLV1

8C9H LWRLV2

8CAH UPRLV1

8CBH UPRLV2

126C-1295 MESS1 - lower classifier message

1296-12BF MESS2 - upper classifier message

12C0-12CF hex table

INPUTS: Values from program memory and/or the keyboard.

OUTPUTS: Values stored back into memory for classifier levels.

LOCATION: 1200E

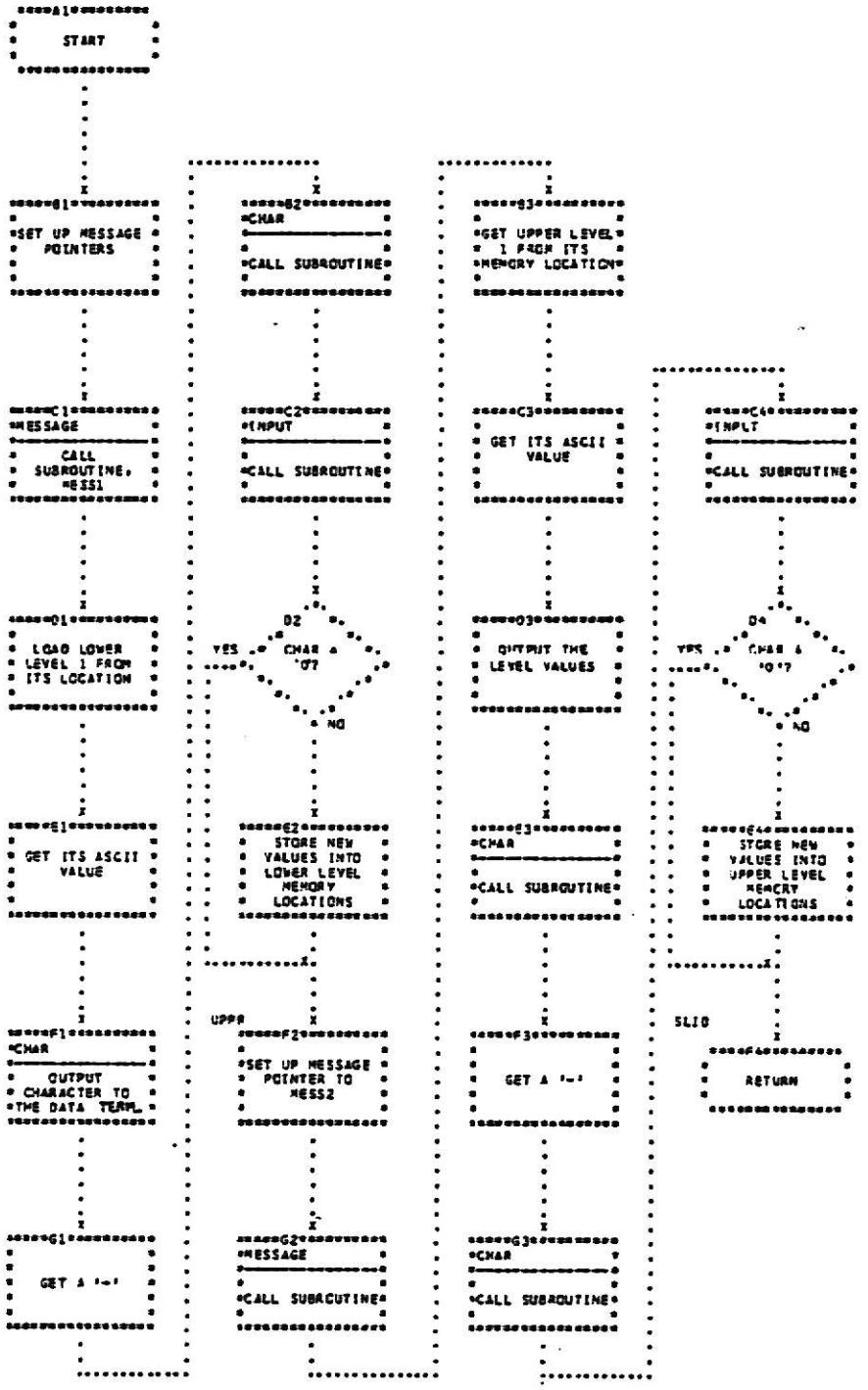
SIZE: CFH

COMMENTS: Classifier level change is the program by which quick level changes may be made.

VERSION: 9 5 14.18

SUBROUTINE CLASSIFIER LEVEL CHANGE

FLOWCHART



Recipe (RECIPE)

3.10 The Recipe routine moves a total of 32 characters to the Master loop program.

The characters or program list (e.q. PABCHCQ) must already reside in program memory.

To run the standard recipe only a (\) backslash need be typed followed by a carriage return.

PROCEDURE FOR LOADING A NEW RECIPE

1. Type G1E00 [CR]

System => 2. PROGRAMS?

3. PABCGHCQ or new string characters.

4. Do not type [CR]

5. Reset the system.

6. Type U,U

System => 7. 86/12 monitor message.

8. Type G7045 (stores the new string).

9. Type G1E00 (back to Master loop).

Recipe (RECIPE)

SUBROUTINES: None

REGISTERS: CX - counter

SI - location of recipe string, master string (SENTRY)

DI - location of master string, recipe string (SENTRY)

VARIABLES: 1F80H CNT1

INPUTS: Values from recipe string or master string.

OUTPUTS: Values to master string or recipe string.

LOCATION: 7030H RECIPE

7045H SENTRY

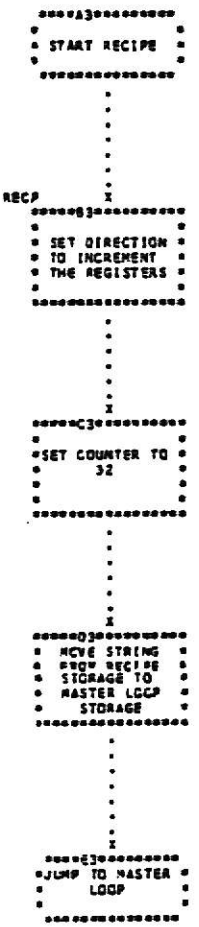
SIZE: 20H

COMMENTS: Recipe makes easy the running of strings of programs by typing in only one symbol in Master loop.

VERSION: 9 14 21.52

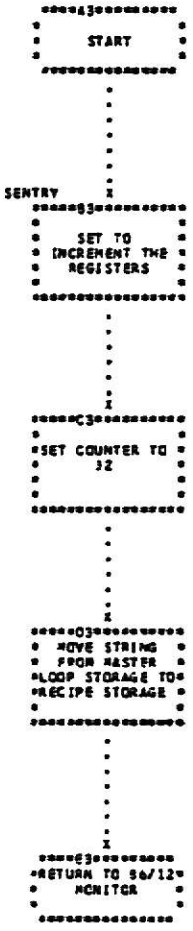
SUBROUTINE RECIPE

FLOWCHART



SUBROUTINE SENTRY

FLOWCHART



Disk Support Package (SUBS)

4.1 SUBS are the subroutines necessary for control of the floppy disk control board, and general use utilities. Twelve routines are in this package. They are: MESSAGE, CHARIN, CHAROT, DMASET, VFYDRVRDY, COMMANDBUSY PERMREG, RESULT, OUTHEX, DECHEX, INPINT, and DECMIL.

MESSAGE - This routine outputs an ASCII string of characters starting at the address passed in the SI register and ending at an ASCII null character (00). The output goes to the terminal.

CHARIN - This routine inputs an ASCII character from the terminal keyboard, masks off the most significant bit (not used in ASCII characters) and uses CHAROT to echo the character to the terminal display screen.

CHAROT - This routine outputs to the display screen an ASCII character passed to it.

DMASET - DMASET sets the floppy disk controller's;

1) base address register,
2) starting memory address register,
3) the DMA enable bit and
4) the DMA control register,

by outputting to its proper port addresses.

VFYDRVRDY - This routine is to verify the selected drive is ready by outputting a read drive status command of the drive specified in DRV. A drive goes "not ready" on power up or when the drive door is opened. To clear the "drive not ready" line the read drive status command must be output twice.

COMMANDBUSY - This is also a wait routine. It waits for the command busy line of the FDC to go inactive. (Ready for another command byte.)

PARMREG - This is also a wait routine. It waits for the parameter register full line to go inactive. (Ready for another parameter byte.)

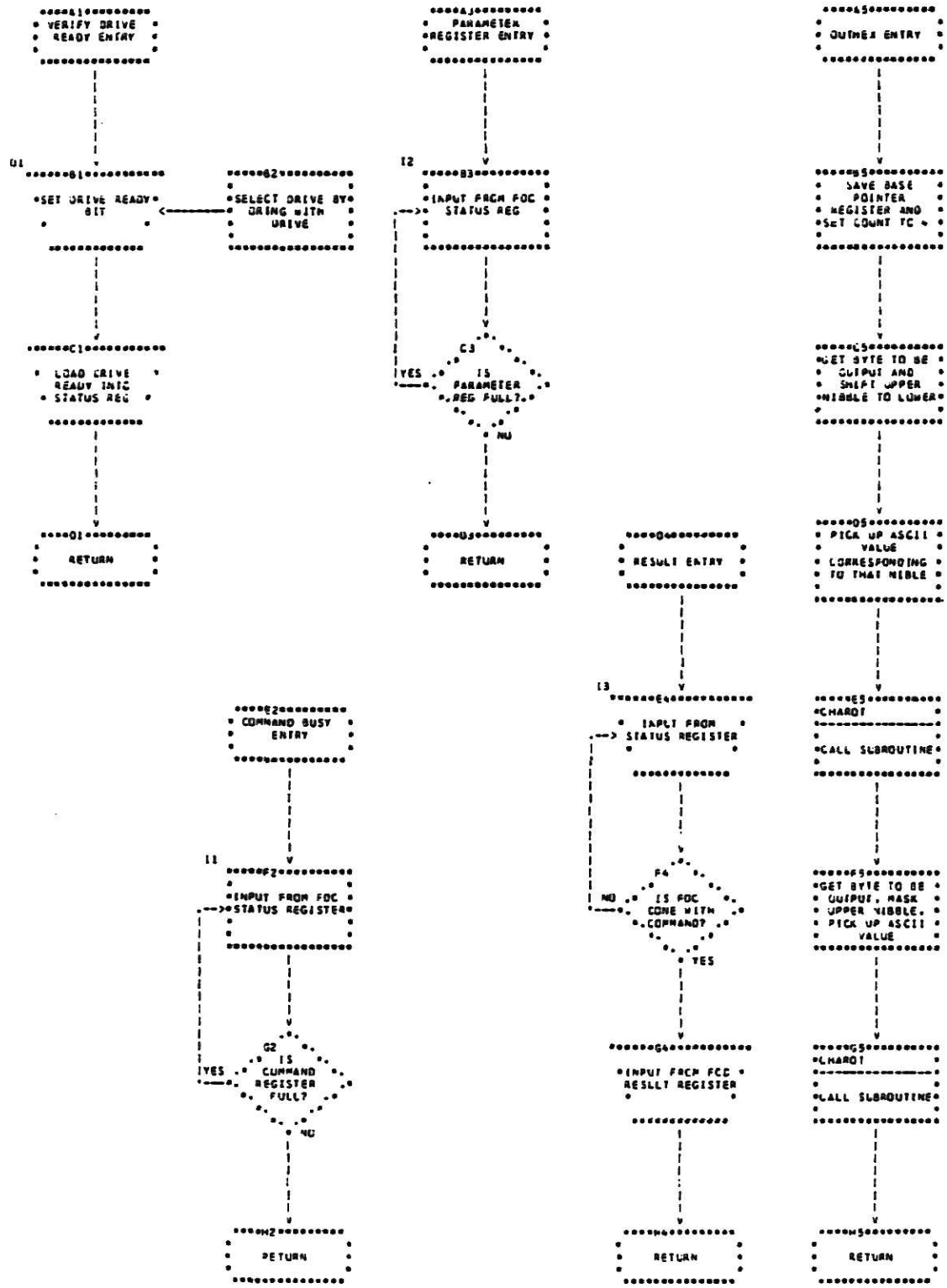
RESULT - This routine waits for the command to complete its execution and retrieves the result byte.

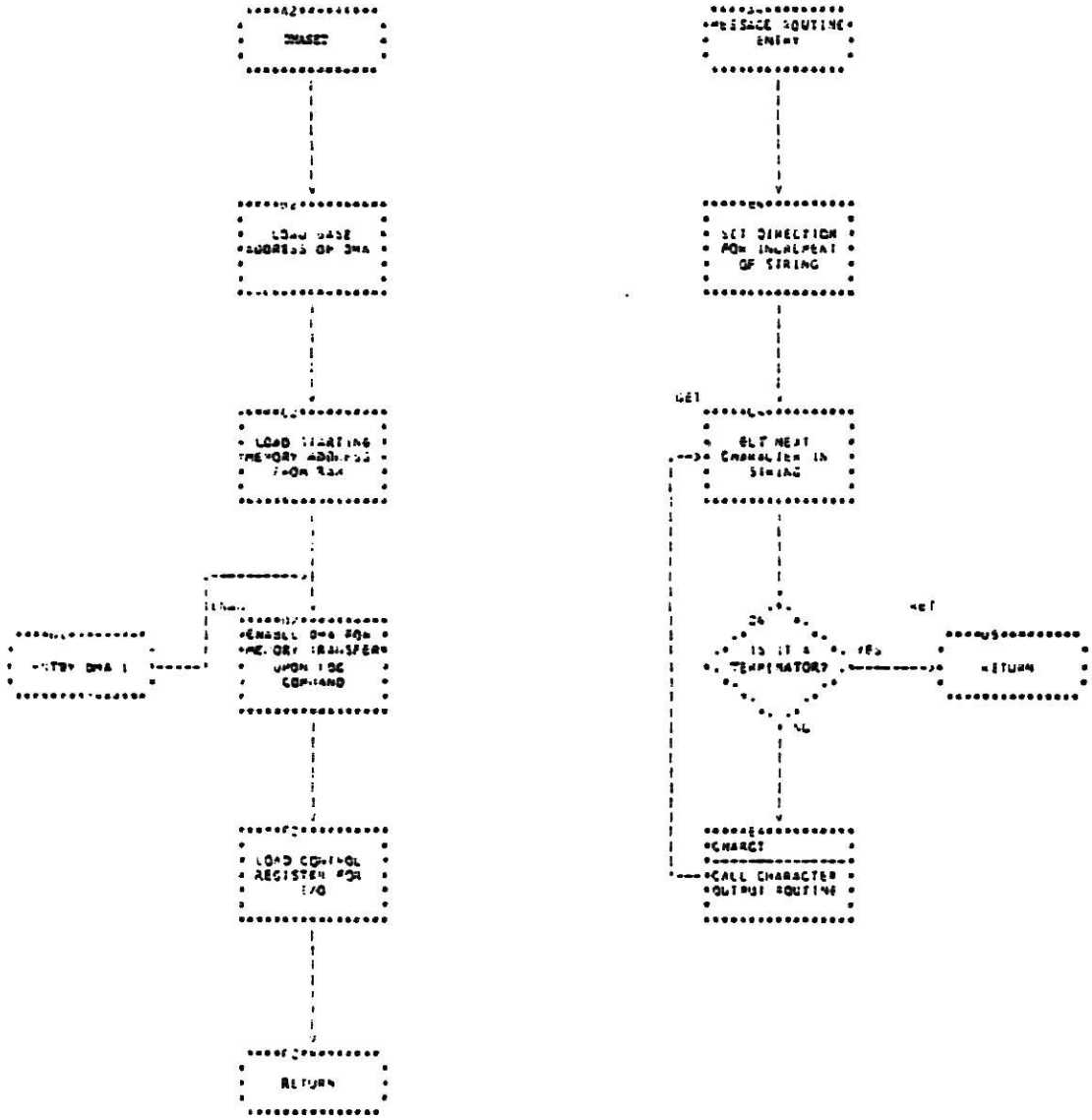
OUTHEX - This routine takes the byte passed to it and converts the byte to the ASCII representation of that byte and uses CHAROT to output the ASCII to the terminal screen.

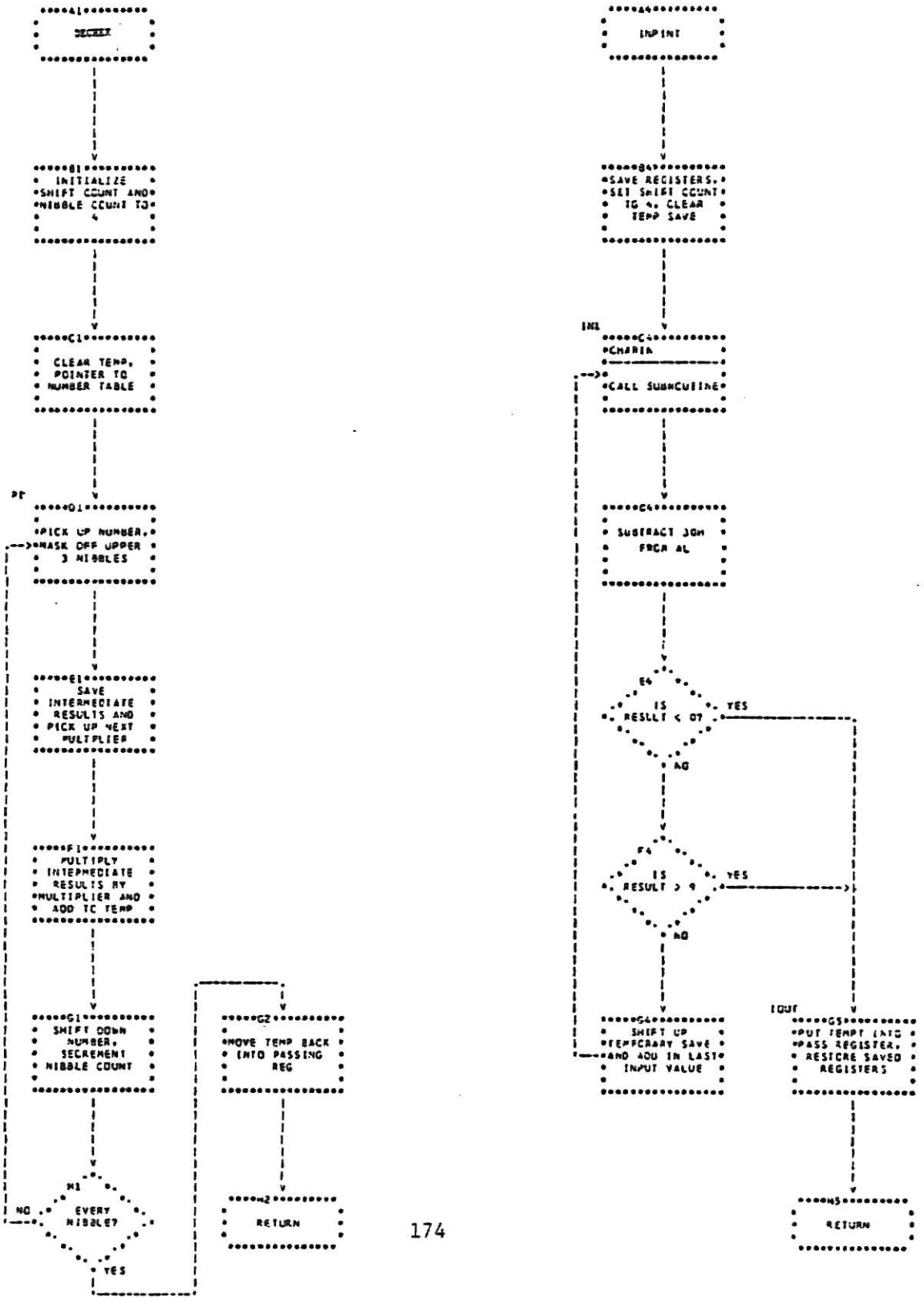
DECHEX - This routine converts the number passed to it to a hexadecimal equivalent of that number. NOTE: this routine assumes the number passed is a valid BCD number. The result is passed in the AX register.

INPINT - This routine inputs a string of numbers until a [CR] is pressed. Then takes the last four and converts it from ASCII to a hexadecimal number. The number is returned in the AX register.

DECMIL - This routine takes the hexadecimal number passed to it and converts it to its equivalent decimal value. The result is returned in AX register.

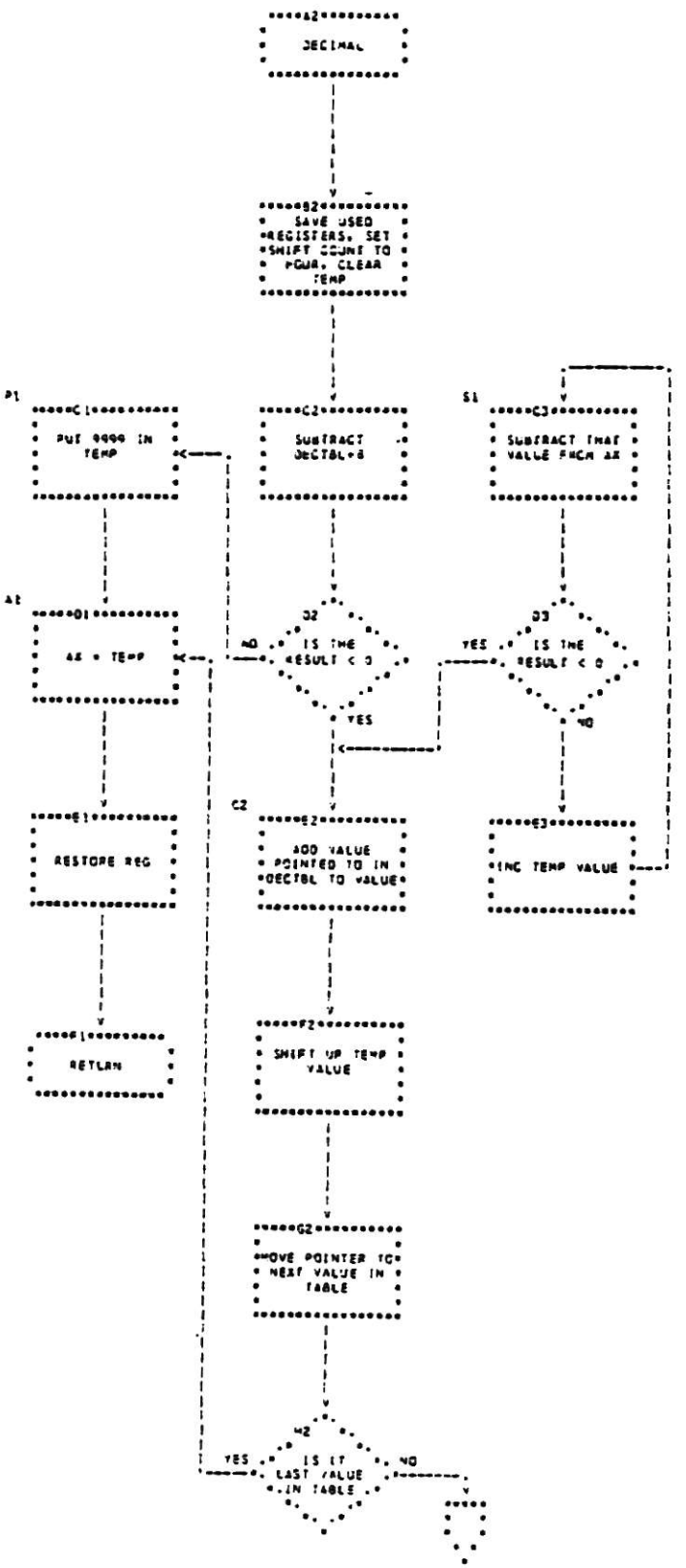

VERIFY DRIVE READY ENTRY
SET DRIVE READY BIT
SELECT DRIVE BY ORING WITH DRIVE
LOAD DRIVE READY INTO STATUS REG
RETURN
PARAMETER REGISTER ENTRY
INPUT FROM FDC STATUS REG
C3 IS PARAMETER REG FULL?
YES
NO
RETURN
OUTREX ENTRY
SAVE BASE POINTER REGISTER AND SET COUNT TO 4
GET BYTE TO BE OUTPUT AND SHIFT UPPER NIBBLE TO LOWER
PICK UP ASCII VALUE CORRESPONDING TO THAT NIBBLE
CHAROT
CALL SUBROUTINE
GET BYTE TO BE OUTPUT, MASK UPPER NIBBLE, PICK UP ASCII VALUE
CHAROT
CALL SUBROUTINE
RETURN
RESULT ENTRY
INPUT FROM STATUS REGISTER
F4 IS FDC DONE WITH COMMAND?
NO
YES
INPUT FROM FDC RESULT REGISTER
RETURN
COMMAND BUSY ENTRY
INPUT FROM FDC STATUS REGISTER
G2 IS COMMAND REGISTER FULL?
YES
NO
RETURN




DECBIN
INITIALIZE SHIFT COUNT AND NIBBLE COUNT TO 4
CLEAR TEMP, POINTER TO NUMBER TABLE
PICK UP NUMBER, MASK OFF UPPER 3 NIBBLES
SAVE INTERMEDIATE RESULTS AND PICK UP NEXT MULTIPLIER
MULTIPLY INTERMEDIATE RESULTS BY MULTIPLIER AND ADD TO TEMP
SHIFT DOWN NUMBER, DECREMENT NIBBLE COUNT
M1
EVERY NIBBLE?
NO
YES
MOVE TEMP BACK INTO PASSING REG
RETURN
INPINT
SAVE REGISTERS, SET SHIFT COUNT TO 4, CLEAR TEMP SAVE
INI
CHARIN
CALL SUBROUTINE
SUBTRACT 30H FROM AL
E4
IS RESULT < 07
YES
NO
F4
IS RESULT > 9
YES
NO
SHIFT UP TEMPORARY SAVE AND ADD IN LAST INPUT VALUE
IOUT
PUT TEMPT INTO PASS REGISTER, RESTORE SAVED REGISTERS
RETURN

HEXIDECIMAL TO DECIMAL CONVERSION

FLOWCHART



Initialized Data Disk (INTDAT)

4.2 INTDAT constructs the directory for a data storage disk, then writes that directory on the disk in drive #0. The directory consists of the month (1-12), day (1-31), year (0-99), location (any three ASCII characters), and the carcass count of zero. The directory is written on sector one of track one on drive #0.

INTDAT is a stand alone program starting execution at 6100H.

NOTE: The set date routine must have been run prior to this program.

Initialized Data Disk (INTDAT)

SUBROUTINES: DSKIO, MESSAGE, OUTHEX, DMASET, VFYDRVFDY, COMMANDBUSY, PARMREG, RESULT, ERROR

REGISTERS:
- CX - counter
- DI - buffer pointer
- SI - data pointer, message pointer
- AX - input, output
- DX - port address

VARIABLES:
- 9F8H - DAT
- 9FAH - DAT 2
- 9FCH - LOC 1
- 9FEH - SAVCNT
- A00H - PCKDEC
- F00H - COMMAND
- F01H - TRK
- F02H - BSEADDR
- F0CH - DRV
- F12H - CRTL
- 617BH - MESS1 disk error message

INPUTS: Input values from Set date and location

OUTPUTS: Constructed directory on disk in drive Ø

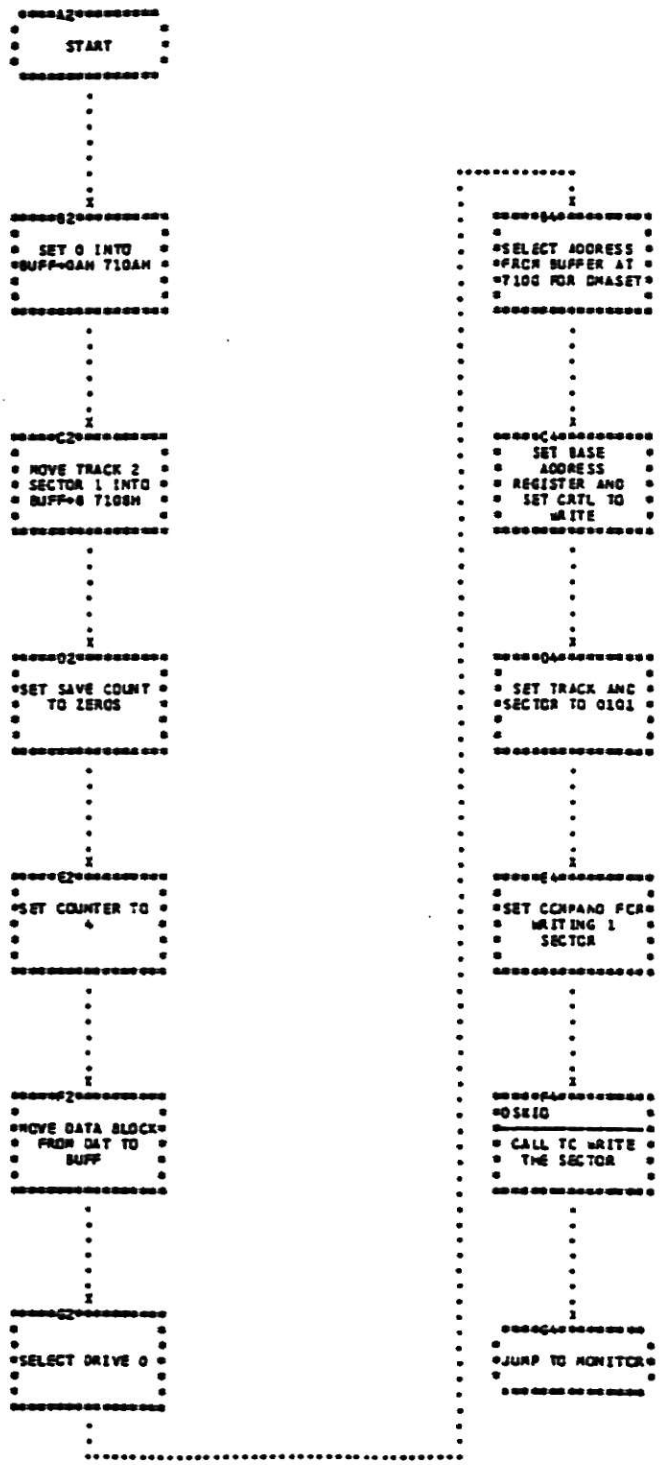
LOCATION: 6100H

SIZE: 83H

VERSION: 3 19 10.29

INITIALIZE DATA DISK

FLOWCHART



4.3 FORMAT meets the requirements of the floppy disk controller (FDC) for formatting a floppy disk to IBM standard format (128 bytes per sector, 26 sectors per track, and 76 usuable tracks per disk) for single density floppy disks. To meet the requirements of the FDC, FORMAT creates a table of numbers the FDC manual calls a format table. The table consists of (in order); track addresses, head address, sector address, and sector length for each of the 26 sectors of a track. The table is for only one track. The numerically consecutive sectors (1, 2, 3, etc.) are spaced or interleaved three apart. This means the adjacent sectors on a track are numbered; 1, 10, 19, 2, 11, 20, 3, 12, 21, 4, 13, 22, 5, 14, 23, 6, 15, 24, 7, 16, 25, 8, 17, 26, 9, 18. After this table is written for track zero just the track addresses and head addresses are updated for the remaining 76 tracks. The error bit is checked after each track is formatted and if an error is detected the routine outputs the error code to the terminal and terminates execution. The buffer for the format table is at 7100H in the system memory. Disk format is a stand alone program set to format a write enabled disk in drive 1.

Disk Format (FORMAT)

SUBROUTINES: VFYDRVRDY, TABLE, DMASET, COMMANDBUSY, PARMREG, RESULT, ERROR, MESSAGE, OUTHEX, CRLF

REGISTERS: AX - general purpose input, output
DX - port address
BX - track pointer
SI - base pointer, pointer to format table/message pointer
CX - sector count

VARIABLES: 0F00H - COMMAND
0F01H - TRK
0F08H - BSEADDR
0F0AH - ADDR
0F0CH - DRV
60DFH - MESS1 disk error number message

INPUTS: None

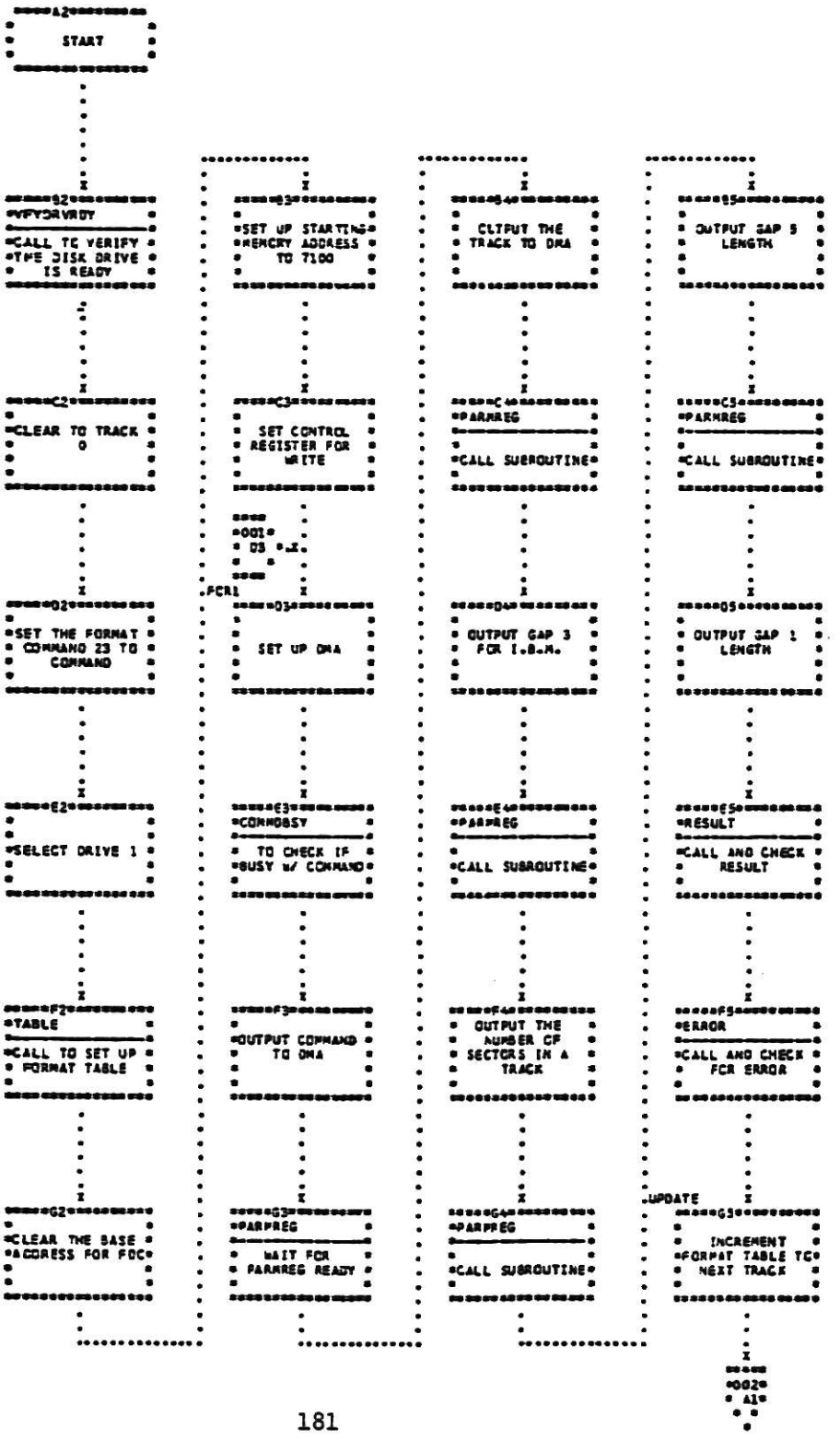
OUTPUTS: Formatted data disk

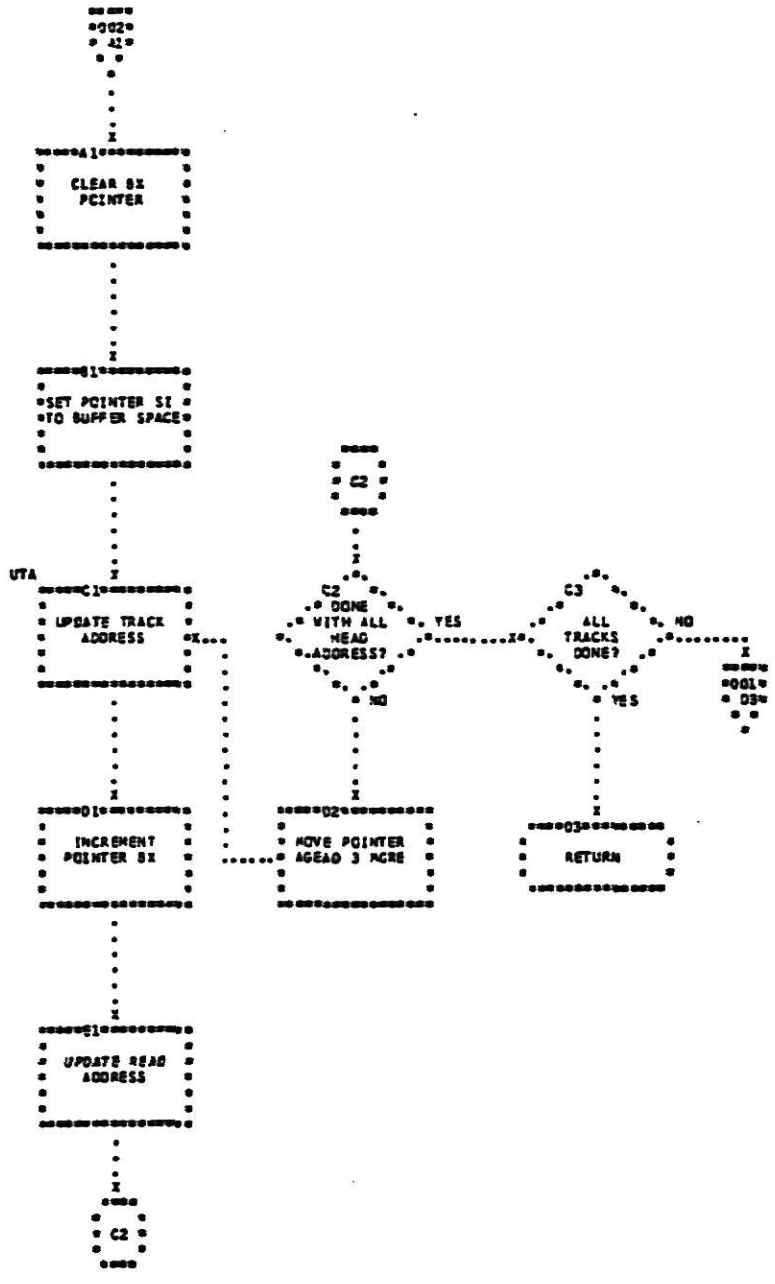
LOCATION: 6000H

SIZE: E7H

COMMENT: Format disk must be run on a blank data disk before trying to store disk data. Any previous disk data will be purged.

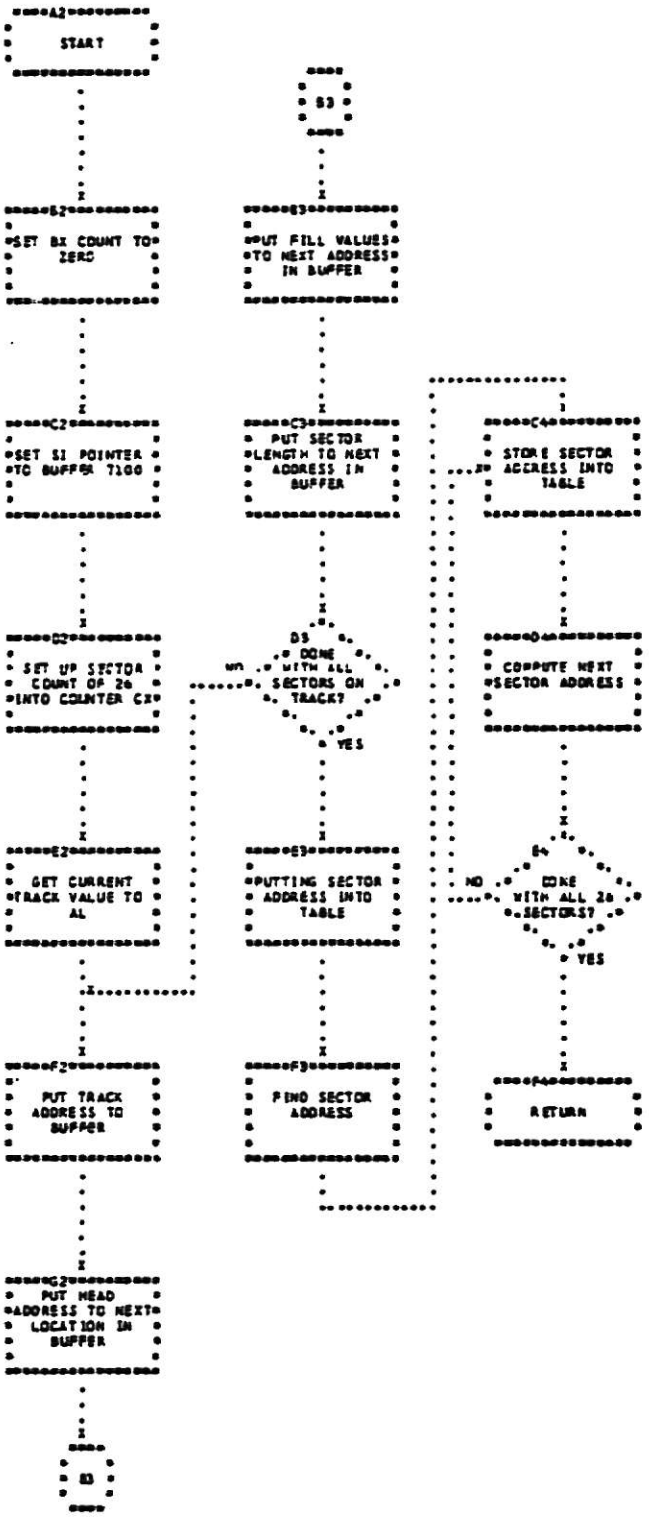
VERSION: 3 18 20.52


START
VFYDRVRDY
CALL TO VERIFY THE DISK DRIVE IS READY
CLEAR TO TRACK 0
SET THE FORMAT COMMAND 23 TO COMMAND
SELECT DRIVE 1
TABLE
CALL TO SET UP FORMAT TABLE
CLEAR THE BASE ADDRESS FOR FDC
SET UP STARTING MEMORY ADDRESS TO 7100
SET CONTROL REGISTER FOR WRITE
001
DS *.+1
FCR1
SET UP DMA
CMNDBSY
TO CHECK IF BUSY W/ COMMAND
OUTPUT COMMAND TO DMA
PARMREG
WAIT FOR PARMREG READY
OUTPUT THE TRACK TO DMA
PARMREG
CALL SUBROUTINE
OUTPUT GAP 3 FOR I.B.M.
PARMREG
CALL SUBROUTINE
OUTPUT THE NUMBER OF SECTORS IN A TRACK
PARMREG
CALL SUBROUTINE
OUTPUT GAP 5 LENGTH
PARMREG
CALL SUBROUTINE
OUTPUT GAP 1 LENGTH
RESULT
CALL AND CHECK RESULT
ERROR
CALL AND CHECK FCR ERROR
UPDATE
INCREMENT FORMAT TABLE TO NEXT TRACK
002
A1


002
A1
CLEAR SI POINTER
B1
SET POINTER SI TO BUFFER SPACE
C2
UTA
C1
UPDATE TRACK ADDRESS
C2 DONE WITH ALL HEAD ADDRESS?
YES
NO
C3 ALL TRACKS DONE?
NO
YES
001
03
D1
INCREMENT POINTER SI
D2
MOVE POINTER AHEAD 3 MORE
D3
RETURN
E1
UPDATE READ ADDRESS
C2

SUBROUTINE TABLE

FLOWCHART



4.4 DSKBIN inputs from the keyboard a block address and number of blocks then reads the blocks from the disk in drive #1. The data blocks are on the disk in a PDP/11 format.

A PDP/11 block structure is as follows:

BLOCK ADDRESS	TRACK ADDRESS	SECTORS FIRST	SECOND	THIRD	FOURTH
0	1	1	3	5	7
1	1	9	11	13	15
2	1	17	19	21	23
3	1	25	2	4	6
4	1	8	10	12	14
5	1	16	18	20	22
6	1/2	24	26	7	9
7	2	11	13	15	17
8	2	19	21	23	25
9	2	1	3	5	8
10	2	10	12	14	16
11	2	18	20	22	24
12	2	26	2	4	6
13	3	13	15	17	19
14	3	21	23	25	1
15	3	3	5	7	9
16	3	11	14	16	18
17	3	20	22	24	26
18	3	2	4	6	8
19	3/4	10	12	19	21
20	4	23	25	1	3

This continues in the same manner for all the 492 blocks.

To translate the block numbers inputted to the proper track and sector addresses the equations look like these;

TRK=INTEGER (I/26)+1

SEC=[SECI[I+1)MOD26]+6(TRK-1)]MOD26

with I being BLKx4 for the first sector of the block, I=BLKx4+1 for the second sector and so on for the thrid and fourth sectors. The string SECI in the above equation is

location	SECI	location	SECI
0	26	13	25
1	1	14	2
2	3	15	4
3	5	16	6
4	7	17	8
5	9	18	10
6	11	19	12
7	13	20	14
8	15	21	16
9	17	22	18
10	19	23	20
11	21	24	22
12	23	25	24

The INTEGER function takes the parameter and truncates the fraction and MOD26 is a modulo divide.

The data read from the disk is a string of ASCII characters in paper tape format. The string is stored in a buffer called BUFF. Once in BUFF the data is then converted and stored in memory using a paper tape read routine called READIO.

DSKBIN is a stand alone program starting execution at 5000H.

Binary Read From Disk (DSKBIN)

SUBRCUTINES: MESSAGE, INPINT, DECHEX, READONE, RESULT, ERROR, READIO, CHARIN, DMAI, VFYDRVRDY, COMMANDBUSY, PARMREG, BYTEI, WORDI, CONVHEX, OUTHEX, CHAROT

REGISTERS: SI - message pointer

AX - block number, general purpose, track number, hex converted number, input, output

CX - counter

BX - general purpose

VARIABLES:

5300H	BLK	
5302H	LEN	
5304H	I	
5305H	TS	
5306H	TRK	
5307H	SEC	
5308H	CRTL	
5309H	DRV	
530AH	DRIVE	
530BH	TEMP	
530DH-531CH	HEX	
531DH-5324H	NUM	
5325H-5332H	SECI	
5333H-533EH	SECI2	
533FH-5363H	MESS1	read object code
5364H-5376H	MESS2	starting block
5377H-538BH	MESS3	length in blocks

538CH-5394H MESS4 Done?

5395H-53BDH MESS5 disk error

53B1H-53C7H MESS6 checksum error

53C8H BUFF

INPUTS: Values from disk in PDP/11 block format

OUTPUTS: Messages to data terminal. Data to proper location in memory.

LOCATION: 5000H

SIZE: 24BH

COMMENTS: Preceded by Master loop. Data is in standard paper tape format.

VERSION: 0

DSKBIN Procedure

1. Get into the 86/12 monitor. If in the program mode, type in a Q and two carriage returns.
2. Load transfer disk into drive #1 making sure that the metallic strip is removed from the disk.
3. Type G5000[CR].
4. The system will prompt for the starting block on the transfer disk. Enter the proper block corresponding to the program to be loaded and type [CR].
5. The system will prompt for the number of blocks used to store the program. Read this number from the directory listings and type [CR].
6. The system will respond with Done? Type a 'Y' if you wish to enter more programs from the transfer disk, otherwise type 'N' and exit the program. The program will automatically load into the correct position in memory.

Read (RDDSK)/Write (WRDSK) Disk Picture

4.5 DISPIC transfers picture data (256x244 bytes) between upper memory and one of four locations on disk drive #1. The starting track and sector addresses for the four locations (pictures) on a disk are as follows:

PICTURE NUMBER	STARTING TRACK	STARTING SECTOR
1	20	19
2	39	13
3	58	07
4	01	25

These addresses are indexed in table TRKSET by the inputted picture number. The picture is then read or wirtten sequentially by sector and by track.

DISPIC has three entry points:

RDDSK - This routine inputs a picture number from the keyboard and transfers the corresponding picture frcm the disk to memory.

WRDSK - This routine writes the picture number found in variable CNT3. CNT3 is incremented for sequential writing onto the disk.

NSWRDSK - This routine inputs a picture number from the keyboard and transfers memory to the corresponding picture location on the disk.

Read (RDDSK/Write (WRDSK) Disk Picture

SUBROUTINES: MESSAGE, CRLF, CHAROT, CHARIN, SETPIC, PICT, VFYDRVRDY, DMASET, RWNSEC, DMAI, COMMANDBUSY, PARMREG, RESULT, ERROR, OUTHEX

REGISTERS: SI - message pointer
AX - input, output, general purpose, track and sector
CX - counter
DX - general purpose

VARIABLES: 0F17 HEX hex characters
7500-7517 TRKSET

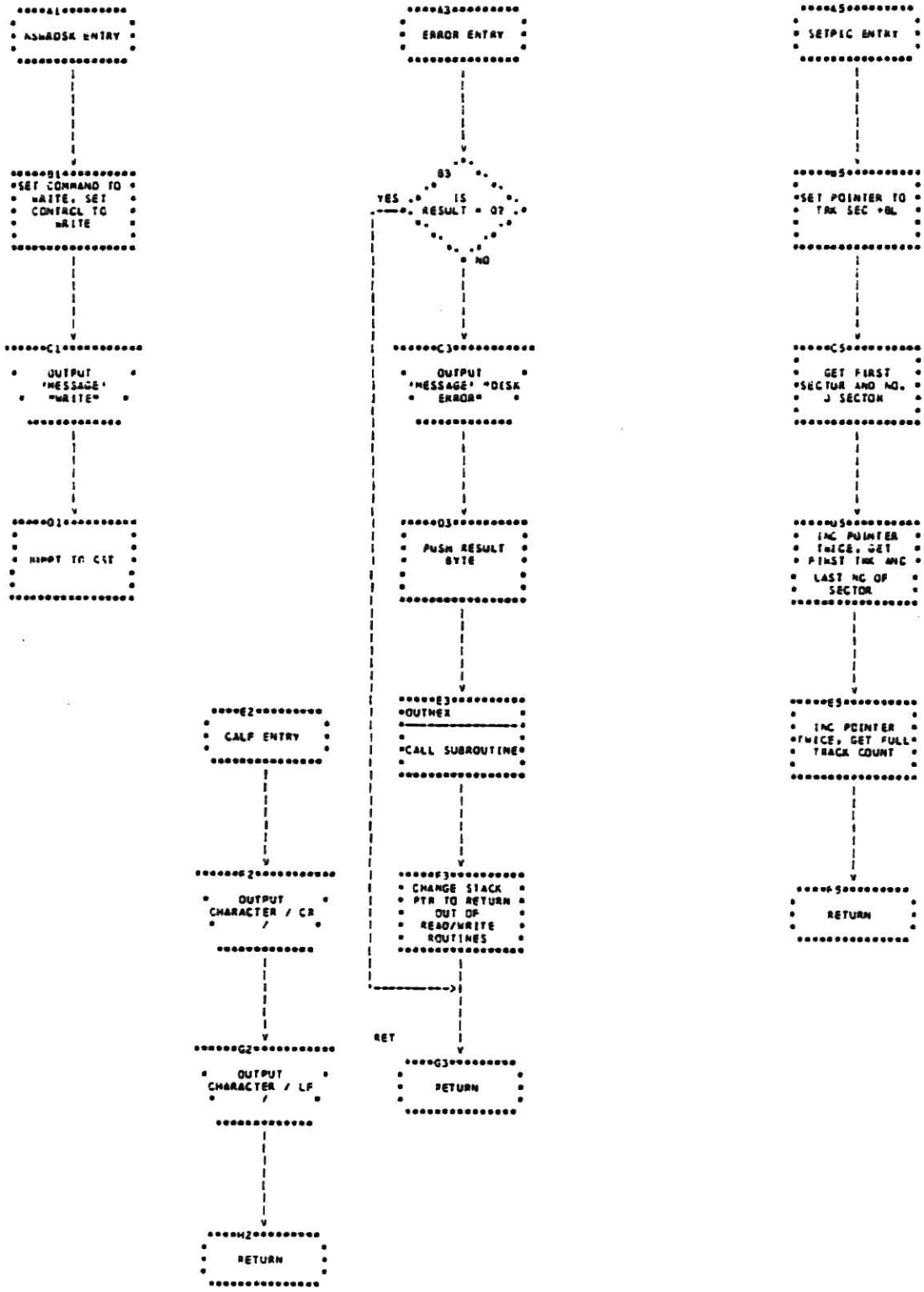
INPUTS: Values from/to disk.

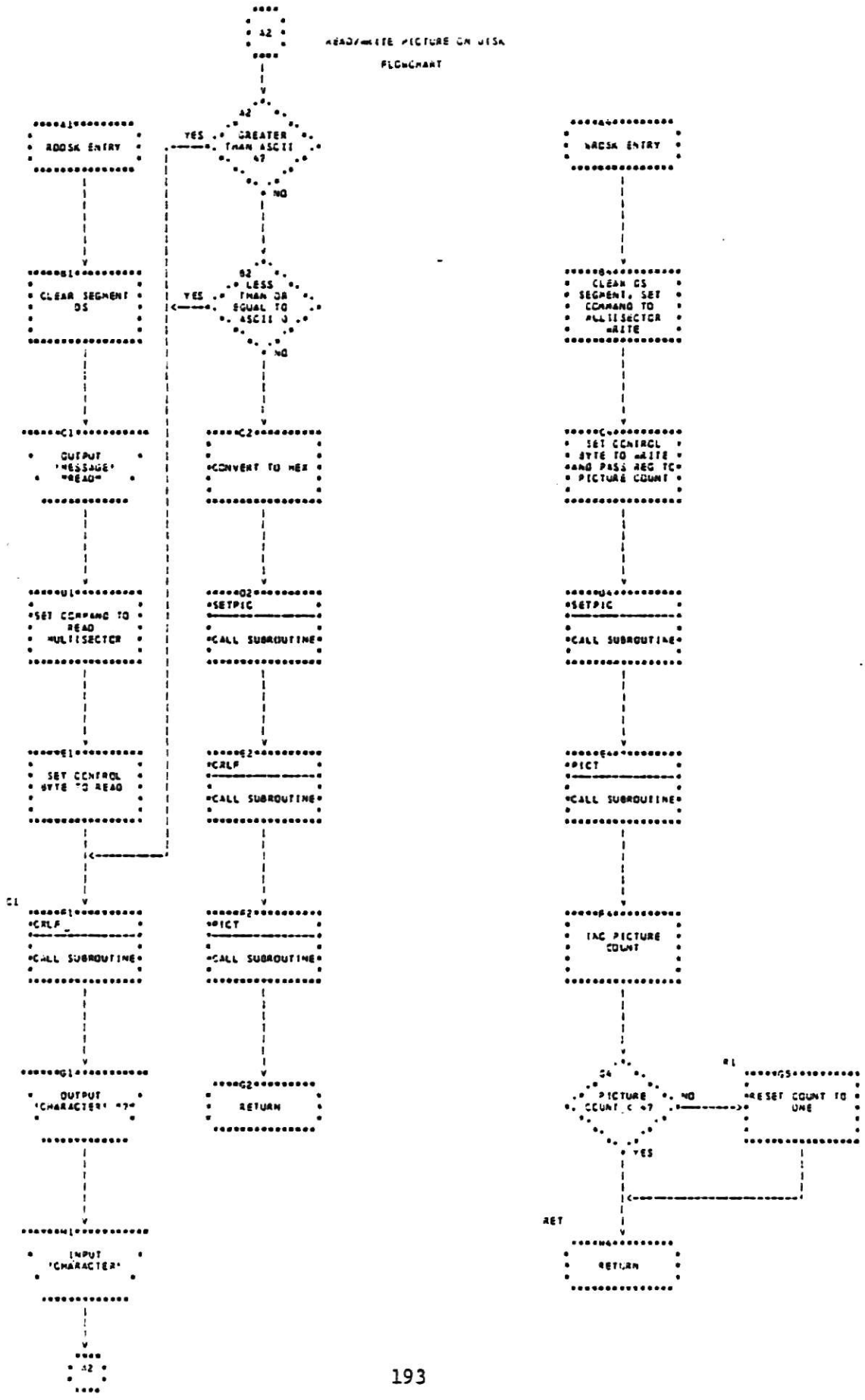
OUTPUTS: Values to/from picture memory.

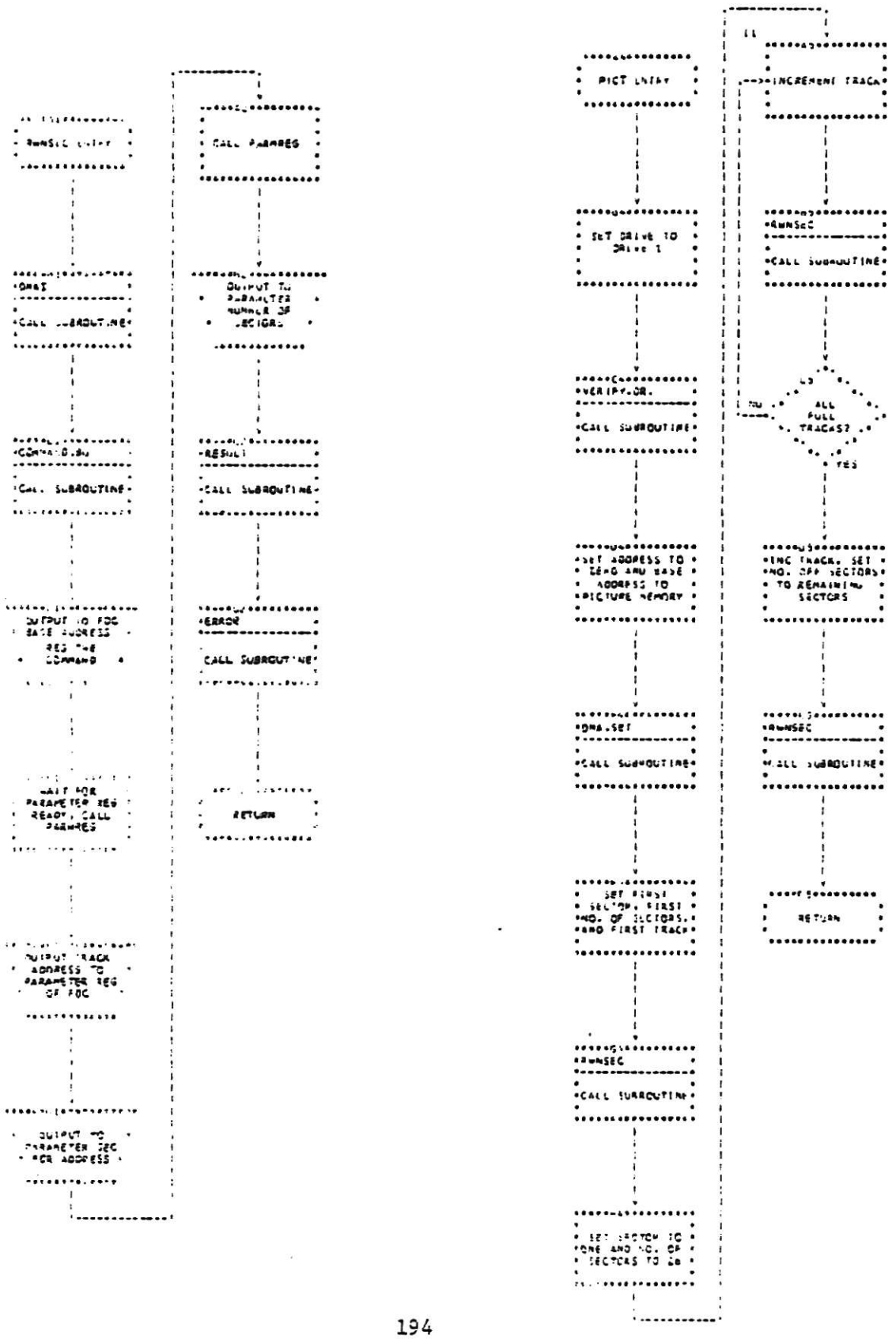
LOCATION: 2400H

SIZE: 13EH

VERSION: 3 13 10.32


A1
ASWADSK ENTRY
B1
SET COMMAND TO WRITE, SET CONTROL TO WRITE
C1
OUTPUT 'MESSAGE' "WRITE"
D1
JUMP TO CSI
A3
ERROR ENTRY
B3
IS RESULT = 0?
YES
NO
C3
OUTPUT 'MESSAGE' "DISK ERROR"
D3
PUSH RESULT BYTE
E3
OUTNEX
"CALL SUBROUTINE"
F3
CHANGE STACK PTR TO RETURN OUT OF READ/WRITE ROUTINES
RET
G3
RETURN
A5
SETPIC ENTRY
B5
SET POINTER TO TRK SEC +BL
C5
GET FIRST SECTOR AND NO. OF SECTOR
D5
INC POINTER TWICE, GET FIRST TRK AND LAST NO OF SECTOR
E5
INC POINTER TWICE, GET FULL TRACK COUNT
F5
RETURN
E2
CALF ENTRY
F2
OUTPUT CHARACTER / CR
G2
OUTPUT CHARACTER / LF
H2
RETURN


A2
READ/WRITE PICTURE ON DISK
FLOWCHART
A2
YES
GREATER THAN ASCII 47?
NO
B2
YES
LESS THAN OR EQUAL TO ASCII 0
NO
A1
ADDSK ENTRY
B1
CLEAR SEGMENT DS
C1
OUTPUT 'MESSAGE' "READ"
D1
SET COMMAND TO READ MULTISECTOR
E1
SET CONTROL BYTE TO READ
C1
F1
CRLF
CALL SUBROUTINE
G1
OUTPUT 'CHARACTER' "?"
H1
INPUT 'CHARACTER'
A2
C2
CONVERT TO HEX
D2
SETPIC
CALL SUBROUTINE
E2
CRLF
CALL SUBROUTINE
F2
PICT
CALL SUBROUTINE
G2
RETURN
A1
WADSK ENTRY
B1
CLEAR CS SEGMENT, SET COMMAND TO MULTISECTOR WRITE
C1
SET CONTROL BYTE TO WRITE AND PASS REG TO PICTURE COUNT
D1
SETPIC
CALL SUBROUTINE
E1
PICT
CALL SUBROUTINE
F1
TAC PICTURE COUNT
G1
PICTURE COUNT < 47?
NO
G2
RESET COUNT TO ONE
YES
RET
H1
RETURN



References

1. iSBC 86/12 Interface and Execution Package Users Guide, Santa Clara, California: Intel Corporation, 1979.
2. T. Pavlidis, Structural Pattern Recognition, Berlin Heidelburg, New York: Springer-Verlag., 1977.
3. S. P. Lin, Automated Pattern Recognition of Beef, Manhattan, Kansas, Masters Report, 1978.
4. D. M. Allen and D. H. Kropf, Meat Processing Laboratory Manual, Manhattan, Kansas, 1975, Rev. 1979.

Test Patterns

A.1 Two basic test pattern are stored on floppy disk to test programs such as Area acquisition, Box distribution, Max point and others. The patterns may also be used for program modification.

The test patterns are provided to help the operator load in a known shape quickly instead of entering picture data point by point.

The first pattern shown (#2 on Test Pattern disk) was used for testing Max point and Fat pieces, Fig. 4.1-1. It can be seen that there are 6 fat pieces as well as 1 section of background.

From the top left point 1F65 one can find the address of any point in the display, e.g., the top most boundary point is located at 1F84.

top most point 1F84H

left most point 2C6AH

bottom most point 356FH

right most point 2890H

There is a total of 104 decimal boundary points.

The second pattern (pattern #3 on Test pattern disk) was used mainly for Area acquisition, Max point, and Box distribution. Fig. A.1-2.

	hex	decimal
Meat in LEA	47H	74
Fat in LEA	13H	19
BKGD LEA	10H	16
Total Meat Count LEA	57H	87
Maximum top point	7971H	
Maximum bottom point	8679H	
Center point	7F76H	

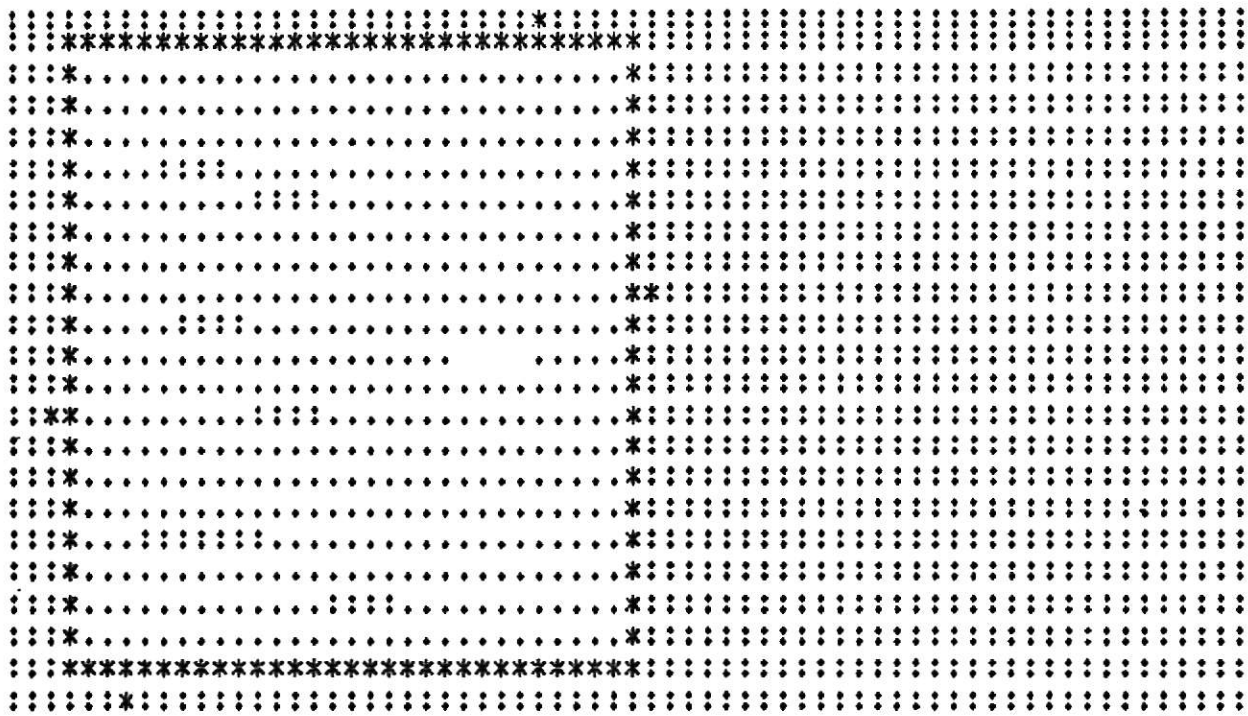


FIG. A.1-1. Test Pattern #2.

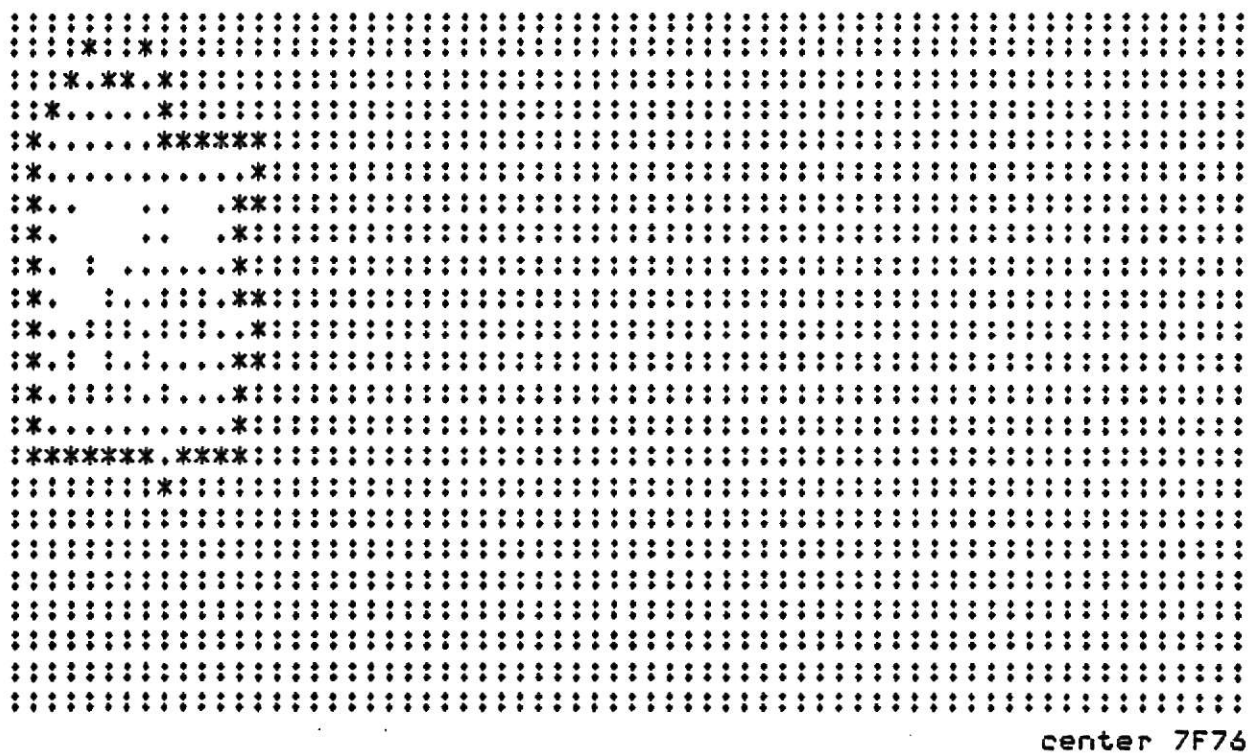


FIG. A.1-2. Test Pattern #3.

A.2 Start Up Procedure

The operator types what is indicated above the asterisks.

1. Plug in box.
2. Turn on fan and power switches.
3. Type the indicated

   a) UU
      **

   b) M9000,97FF,1000[CR]
      ********** *

4. Wait for the prompt. (.)
5. Insert a blank disk in drive #0.
6. Insert PROGRAM DISK in drive #1.
7. Type the indicated

   a) G0000- XX 1000[CR]
      * **** *

8. This prompt will return

   READ

   ?

9. Type 1
10. Wait for the prompt. (.)
11. Type the indicated

    a) M1000:400,7FFF,400[CR]
       ********** *

12. Wait for the prompt. (.)
13. Insert current data disk in drive #0.
14. Insert current picture disk in drive #1.
15. Type the indicated

    a) GXXXX- XX 6200[CR]
       **** *

    b) MONTH 91-12) ? 5[CR] (CURRENT MONTH)
       * *

c) DAY (1-31)? 25[CR] (CURRENT DAY)
               ** *

d) YEAR? 82[CR] (CURRENT YEAR)
         ** *

e) LOCATION? CCN[CR] (PROPER LOCATION)
             *** *

f) GXXXX- XX 1E00[CR]
   *   **** *

g) PROGRAMS?
             *   ************

Start Up Procedure Example

ACTUAL SAMPLE OF STARTUP:

```
{
ISBC 86/12 MONITOR, VI.2
.M9000,97FF,1000
.G 0000- 50 1000
READ .
?1
@0000:1062
.M1000:400,7FFF,400
.G 2434- B8 6200
MONTH (1-12)? 5
DAY (1-31)? 27
YEAR? 81
LOCATION: MAN
@0000:624D 0D
.G 624D- 0D 1E00
PROGRAMS
```

A.3 Procedure For Making A New Program Disk

1. Using Binary Read from Disk, load into memory all programs to be stored on the new program disk.
2. Make any variable changes necessary.
3. Type M400, 7FF,1000:400[CR]. This command moves all the programs from lower or program memory to picture memory.
4. Use Read/Write Disk Picture to write the picture image (now programs) to the disk by tpying:

```
        G1EØØ[CR]
System → PROGRAMS?
        TQ[CR]
System → WRITE?
        1              or whatever section on the disk you wish
System → ,             to write on.
        [CR]
                       you should now be back in the 86/12 monitor.
```

SOFTWARE OPERATIONS MANUAL OF A COMPUTERIZED BEEF GRADING INSTRUMENT

by

DON A. GILLILAND

B.S., Kansas State University, 1977

AN ABSTRACT OF A MASTER'S THESIS

Submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Electrical Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

ABSTRACT

The computerized beef grading instrument was developed as an aid to the beef grader in making a more accurate analysis of the exposed cut surface of a carcass. The analysis includes a determination of fat area and lean meat area over the surface as well as the fat thickness covering the longissimus dorsi muscle. The software manual herein describes the algorithms and procedures necessary to perform the data acquisition and analysis.