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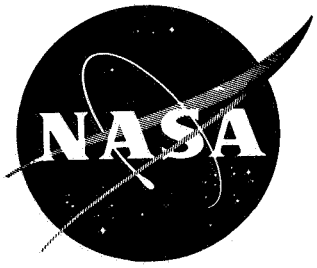

COMPUTER PROGRAM FOR EVALUATION OF OPTICAL THIN-FILM FILTERS WITH A DIGITAL COMPUTER AND DISPLAY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

COMPUTER PROGRAM FOR EVALUATION OF OPTICAL THIN-FILM FILTERS WITH A DIGITAL COMPUTER AND DISPLAY

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INTRODUCTION

The description of the computer program is designed to display and evaluate the comparison of multilayer, dielectric, thin-film optical filter transmittance values with corresponding wavelength data for normal incidence only.

The program is written for the PDP-5 and PDP-8 combined computer system which has an intercommunication buffer, a 30-G cathode ray tube (CRT) display, a deck tape system, and teletype and punched-tape input and output equipment.

This technical memorandum is a supplement to NASA Technical Memorandum X-58013, November 1967.

COMPUTER PROGRAM

The "Thin-Film Filter Computer Program System" has been written to operate with the PDP-5/8 computers linked with an interface connection. The system uses the following peripheral equipment: a teletype input-output system and a 30-G display unit with 14-inch CRT.

The program system is in three parts. The main program is a FORTRAN program that reads the input data tape, performs the necessary calculations, sends a signal to the CRT link routine, and prints complete results on the teletype unit. The CRT display program is an assembler language program that displays the FORTRAN program results on the CRT; the link program is an assembler language program that transmits the FORTRAN program output to the PDP-5.

The input data for a run are arranged on paper tape according to the format in table I. Definitions of the variables listed in table I are found in table II.

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*Programing by William J. Fehrenkamp and Marian VanZant; program analysis by James W. Martin.

The data for adjusting the thicknesses may be prepared on paper tape or typed manually on the teletype as the program proceeds. A sample data tape is shown in table III. The data on the paper tape are transmitted to the computer by the teletype unit.

Output on the teletype unit is shown in tables IV to VII. An output sample for CRT can be found on pages 6 and 8 of NASA TM X-58013 entitled "Evaluation of Optical Thin-Film Filters." Following table VII are the listings and flow charts (figs. 1 and 2) for the three computer programs.

The loading sequence is in two main parts. The first part is for the PDP-5, and the second part is for the PDP-8.

1. PDP-5 — Load CRT display routine and floating point package A in either order with the binary loader; branch to 0400 to start the display routine.

2. PDP-8 — Load according to the following order:

   a. FORTRAN operating system no. 1 with binary loader

   b. Assembler language link routine with binary loader

   c. FORTRAN program object tape with low-speed reader option

Branch to 0200 and begin.

TABLE I. - INPUT SEQUENCE AND FORMAT

Input sequence	Format
N	I
M	I
XNO	E
XNS	E
XN_1	E
⋮	⋮
XN_n	E
$XLAM_1$	E
⋮	⋮
$XLAM_m$	E
TH_1	E
⋮	⋮
TH_n	E
[a] NINP, I, TH_i	I, I, E
⋮	I, I, E
Repeat until NINP = 0	

[a]Repeat for each altered set of thicknesses.

TABLE II. - INPUT DEFINITIONS

Initial	Definition
N	Number of layers
M	Number of lambdas
XNO	Incident medium refractive index (N_o)
XNS	Substrate refractive index (N_s)
XNi	Index of refraction of layer
XLAMi	Wavelength of light (lambda)
THi	Thickness of a layer
Thickness Alterations[a]	
NINP	If NINP = 0, last thickness change If NINP = 1, more changes coming
I	That layer where thickness is to be changed
Th(i)	The changed thickness

[a]This section is repeated every time a new altered thickness table is desired.

TABLE III. - INPUT TAPE FOR INITIAL SET OF THICKNESSES[a]

Input parameters	Wavelength λ	Thickness t
18	.4ØE-Ø4	.643E-Ø5
15	.41E-Ø4	.751E-Ø5
1.Ø	.42E-Ø4	.89ØE-Ø5
1.52	.43E-Ø4	.751E-Ø5
1.38	.44E-Ø4	.89ØE-Ø5
2.3Ø	.45E-Ø4	.751E-Ø5
1.38	.46E-Ø4	.89ØE-Ø5
2.3Ø	.47E-Ø4	.751E-Ø5
1.38	.48E-Ø4	.89ØE-Ø5
2.3Ø	.49E-Ø4	.751E-Ø5
1.38	.5ØE-Ø4	.89ØE-Ø5
2.3Ø	.51E-Ø4	.751E-Ø5
1.38	.52E-Ø4	.89ØE-Ø5
2.3Ø	.53E-Ø4	.751E-Ø5
1.38	.54E-Ø4	.89ØE-Ø5
2.3Ø		.751E-Ø5
1.38		.89ØE-Ø5
2.3Ø		.751E-Ø5
1.38		
2.3Ø		
1.38		
2.3Ø		

[a]Input order: column 1 followed by column 2 followed by column 3.

TABLE IV. - OUTPUT OF INITIAL SET PARAMETERS

NUMBER OF LAYERS = 18
NUMBER OF LAMBDAS = 15

XNO = 1.Ø

XNS = 1.52

LAYER	INDEX OF REFRACTION
+1	1.38
+2	2.3Ø
+3	1.38
+4	2.3Ø
+5	1.38
+6	2.3Ø
+7	1.38
+8	2.3Ø
+9	1.38
+1Ø	2.3Ø
+11	1.38
+12	2.3Ø
+13	1.38
+14	2.3Ø
+15	1.38
+16	2.3Ø
+17	1.38
+18	2.3Ø

LAMBDA
.4ØE-Ø4
.41E-Ø4
.42E-Ø4
.43E-Ø4
.44E-Ø4
.45E-Ø4
.46E-Ø4
.47E-Ø4
.48E-Ø4
.49E-Ø4
.5ØE-Ø4
.51E-Ø4
.52E-Ø4
.53E-Ø4
.54E-Ø4

TABLE V.- OUTPUT OF INITIAL SET, λ VERSUS T

LAYER	THICKNESS OF LAYER
+1	.643E-Ø5
+2	.751E-Ø5
+3	.89ØE-Ø5
+4	.751E-Ø5
+5	.89ØE-Ø5
+6	.751E-Ø5
+7	.89ØE-Ø5
+8	.751E-Ø5
+9	.89ØE-Ø5
+1Ø	.751E-Ø5
+11	.89ØE-Ø5
+12	.751E-Ø5
+13	.89ØE-Ø5
+14	.751E-Ø5
+15	.89ØE-Ø5
+16	.751E-Ø5
+17	.89ØE-Ø5
+18	.751E-Ø5

LAMBDA	TRANSMITTANCE
+Ø.399999E-4	+Ø.987624E+Ø
+Ø.4Ø9999E-4	+Ø.942ØØ6E+Ø
+Ø.419999E-4	+Ø.9722Ø6E+Ø
+Ø.429999E-4	+Ø.992719E+Ø
+Ø.439999E-4	+Ø.91Ø667E+Ø
+Ø.449999E-4	+Ø.892187E+Ø
+Ø.459999E-4	+Ø.984376E+Ø
+Ø.469999E-4	+Ø.898954E+Ø
+Ø.48ØØØØE-4	+Ø.693483E+Ø
+Ø.489999E-4	+Ø.785219E+Ø
+Ø.499999E-4	+Ø.779257E+Ø
+Ø.5Ø9999E-4	+Ø.117121E+Ø
+Ø.519999E-4	+Ø.248735E-1
+Ø.529999E-4	+Ø.829176E-2
+Ø.539999E-4	+Ø.369789E-2

TABLE VI. - OUTPUT OF ADJUSTED SET

1 12 659E-Ø5

Thickness adjustments 1

Ø 13 767E-Ø5

LAYER	THICKNESS
+1	+Ø.642998E-5
+2	+Ø.75Ø999E-5
+3	+Ø.889999E-5
+4	+Ø.75Ø999E-5
+5	+Ø.889999E-5
+6	+Ø.75Ø999E-5
+7	+Ø.889999E-5
+8	+Ø.75Ø999E-5
+9	+Ø.889999E-5
+1Ø	+Ø.75Ø999E-5
+11	+Ø.889999E-5
+12	+Ø.658999E-2
+13	+Ø.767ØØØE-2
+14	+Ø.75Ø999E-5
+15	+Ø.889999E-5
+16	+Ø.75Ø999E-5
+17	+Ø.889999E-5
+18	+Ø.75Ø999E-5

LAMBDA	TRANSMITTANCE
+Ø.399999E-4	+Ø.832921E+Ø
+Ø.4Ø9999E-4	+Ø.789471E+Ø
+Ø.419999E-4	+Ø.984829E+Ø
+Ø.429999E-4	+Ø.935955E+Ø
+Ø.439999E-4	+Ø.937Ø62E+Ø
+Ø.449999E-4	+Ø.887739E+Ø
+Ø.459999E-4	+Ø.87Ø45ØE+Ø
+Ø.469999E-4	+Ø.682983E+Ø
+Ø.48ØØØØE-4	+Ø.389687E+Ø
+Ø.489999E-4	+Ø.2Ø6427E+Ø
+Ø.499999E-4	+Ø.374616E-1
+Ø.5Ø9999E-4	+Ø.278ØØ2E-1
+Ø.519999E-4	+Ø.591Ø1ØE-1
+Ø.529999E-4	+Ø.127748E+Ø
+Ø.539999E-4	+Ø.3884Ø2E-1

TABLE VII. - OUTPUT OF ADJUSTED SET

```
Ø1   8   .699E-Ø5
Ø1   9   .777E-Ø5   Thickness adjustments  2
ØØ  1Ø   .688E-Ø5
```

LAYER	THICKNESS
+1	+Ø.642998E-5
+2	+Ø.75Ø999E-5
+3	+Ø.889999E-5
+4	+Ø.75Ø999E-5
+5	+Ø.889999E-5
+6	+Ø.75Ø999E-5
+7	+Ø.889999E-5
+8	+Ø.698999E-5
+9	+Ø 776999E-5
+1Ø	+Ø.687999E-5
+11	+Ø.889999E-5
+12	+Ø.658999E-2
+13	+Ø.767ØØØE-2
+14	+Ø.75Ø999E-5
+15	+Ø.889999E-5
+16	+Ø.75Ø999E-5
+17	+Ø.889999E-5
+18	+Ø.75Ø999E-5

LAMBDA	TRANSMITTANCE
+Ø.399999E-4	+Ø.944412E+Ø
+Ø.4Ø9999E-4	+Ø.62Ø119E+Ø
+Ø.419999E-4	+Ø.869817E+Ø
+Ø.429999E-4	+Ø.796673E+Ø
+Ø.439999E-4	+Ø.8663Ø7E+Ø
+Ø.449999E-4	+Ø.848ØØE+Ø
+Ø.459999E-4	+Ø.717866E+Ø
+Ø.469999E-4	+Ø.38633ØE+Ø
+Ø.48ØØØØE-4	+Ø.1Ø3591E+Ø
+Ø.489999E-4	+Ø.481866E-1
+Ø.499999E-4	+Ø.153897E-1
+Ø.5Ø9999E-4	+Ø.173737E-1
+Ø.519999E-4	+Ø.177824E-1
+Ø.529999E-4	+Ø.583763E+Ø
+Ø.539999E-4	+Ø.664485E-1

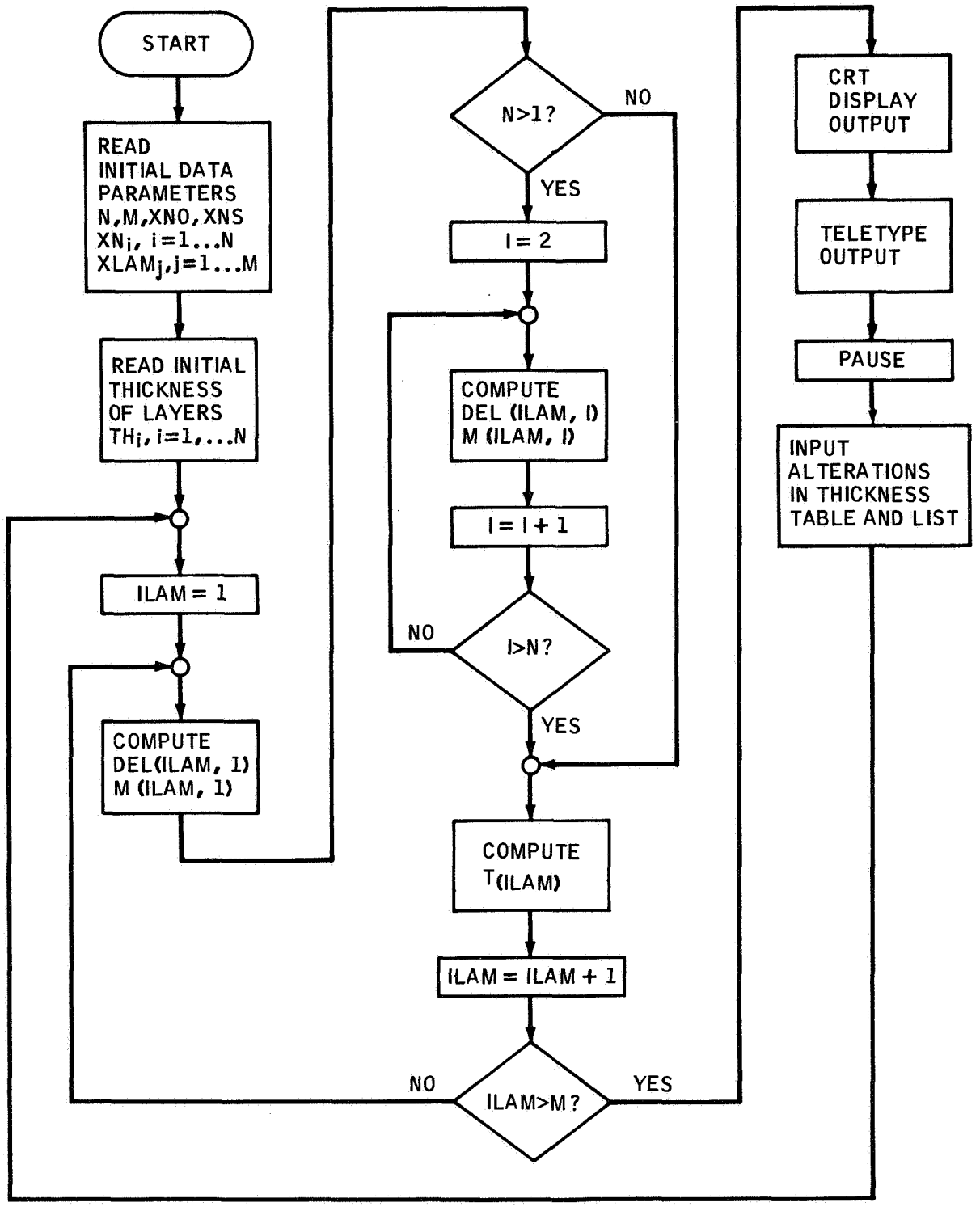

Figure 1. - Main program flow chart (FORTRAN).

MAIN PROGRAM (FORTRAN)

```
C;  OPTICAL THIN-FILM FILTER EVALUATION
C;  MANNED SPACECRAFT CENTER
C;  HOUSTON TEXAS
C;
C;  READ INITIAL PARAMETERS ON TELETYPE
C;  (MANUAL OR PAPER TAPE)
C;
    DIMENSION XN(25),TH(25),XLAM(25),T(25)
    1ØØ; FORMAT(I)
    2ØØ; FORMAT(E)
    TYPE 1Ø1
    1Ø1; FORMAT(/,"NUMBER OF LAYERS = ")
    ACCEPT 1ØØ,N
    TYPE 1Ø2
    1Ø2; FORMAT(/,"NUMBER OF LAMBDAS = ")
    ACCEPT 1ØØ,M
    TYPE 1Ø3
    1Ø3; FORMAT(/,"XNO = ")
    ACCEPT 2ØØ, XNO
    TYPE 1Ø4
    1Ø4; FORMAT(/,"XNS = ")
    ACCEPT 2ØØ,XNS
    TYPE 1Ø5
    1Ø5; FORMAT(/,"LAYER  ","INDEX OF REFRACTION",/)
    DO 2Ø I=1,N
    TYPE 1Ø6,I
    1Ø6; FORMAT (I)
    ACCEPT 2ØØ,XN(I)
    2Ø; CONTINUE
    TYPE 1Ø7
    1Ø7; FORMAT(/,"LAMBDA",/)
    DO 3Ø I=1,M
    ACCEPT 2ØØ,XLAM(I)
    3Ø; CONTINUE
C;
C;  INPUT FIRST SET OF THICKNESSES
C;
    TYPE 1Ø8
    1Ø8; FORMAT(/,"LAYER  ","THICKNESS OF LAYER",/)
    DO 4Ø I=1,N
    TYPE 1Ø9,I
    1Ø9; FORMAT(I)
    ACCEPT 2ØØ,TH(I)
       4Ø; CONTINUE
```

```
C;
C;  T_λ's COMPUTED IN THIS SECTION
C;
C;
    COMPUTE DEL AND M MATRIX
    998; DO 999 ILAM=1,M
    DEL=((6.2831853)*XN(1)*TH(1))/XLAM(ILAM)
    A=COSF(DEL)
    B=SINF(DEL)/XN(1)
    C=XN(1)*SINF(DEL)
    D=A
    IF(N-1)2,4,2
C;
C;  HERE FOR N>1 COMPUTE M_n=M
C;
    2; DO 3 I=2,N
    DEL=((6.2831853)*XN(I)*TH(I))/XLAM(ILAM)
    A1=COSF(DEL)
    B1=SINF(DEL)/XN(I)
    C1=XN(I)*SINF(DEL)
    D1=A1
    A2=A*A1-B*C1
    B2=A*B1+B*D1
    C2=C*A1+D*C1
    D2=D*D1-C*B1
    A=A2
    B=B2
    C=C2
    D=D2
    3; CONTINUE
C;
C;  T_λ EQUATION
C;
    4;T(ILAM)=4.Ø/(2.Ø+A*A*XNO/XNS+D*D*XNS/XNO+C*C/(XNO*XNS)+B*B*XNO*XNS)
    999; CONTINUE
```

MAIN PROGRAM (FORTRAN) - Concluded

```
C;
C;  GO TO DISPLAY ROUTINE AND RETURN
C;
    TYPE 11Ø
    11Ø; FORMAT(/,"LAMBDA            ","TRANSMITTANCE",/)
    PAUSE 3456
C;
C;  PRINT X_λ, T_λ TABLE
C;
    DO 6Ø I=1,M
    TYPE 3ØØ,XLAM(I),T(I)
    3ØØ; FORMAT(/,E,E)
    6Ø; CONTINUE
C;
C;  INPUT ALTERATIONS IN THICKNESS TABLE
C;
    7Ø; ACCEPT 4ØØ,NINP,I,TH(I)
    4ØØ; FORMAT(I,I,E)
    C; IF NOS OF INPUTS = Ø, START COMPUTING
    C; IF NOS OF INPUTS IS NON-ZERO, CONTINUE TO INPUT
    IF (NINP)7Ø,8Ø,7Ø
    8Ø; TYPE 111
    111; FORMAT(/,"LAYER  ","THICKNESS",/)
    DO 9Ø I=1,N
    TYPE 5ØØ,I,TH(I)
    5ØØ; FORMAT(/,I,E)
    9Ø; CONTINUE
    GO TO 998
    END
```

LINK PROGRAM (ASSEMBLER LANGUAGE)

```
/THIS SUBROUTINE TRANSFERS BILBAC PROGRAM DATA
/FROM THE PDP-8 TO THE PDP-5
*66ØØ
SUBR,     Ø
          CLA
          TAD BADR    /SET UP ADDRESS POINTER
          DCA CADR    /.....
          TAD I NLAM /GET NUMBER OF LAMBDAS AND
          DCA TEMP1  /TRANSMITTANCES
          TAD TEMP1  /MULT BY -3
          TAD TEMP1  /.....
          TAD TEMP1  /.....
          CIA        /.....
          DCA TEMP2  /PUT IN TEMP2 TO USE AS A COUNTER
          TAD TEMP1  /GET NUM. OF L&T
          6716       /TRANSFER NUM. TO 5
NXWORD,   CLA
          TAD I CADR /GET TRANSMITTANCE DATA WORD
          6711       /WAIT UNTIL 5 IS READY
          SKP        /.....
          JMP .-2    /.....
          6716       /TRANSFER TO 5
          ISZ CADR   /INCREMENT POINTER
          ISZ TEMP2  /INCREMENT COUNTER AND SKIP IF FINISHED
          JMP NXWORD /NOT FINISHED, GET ANOTHER DATA WORD
          JMP I SUBR /FINISHED, EXIT
TEMP1,    Ø
TEMP2,    Ø
NLAM,     7Ø47
BADR,     7Ø51
CADR,     7Ø51
          $
```

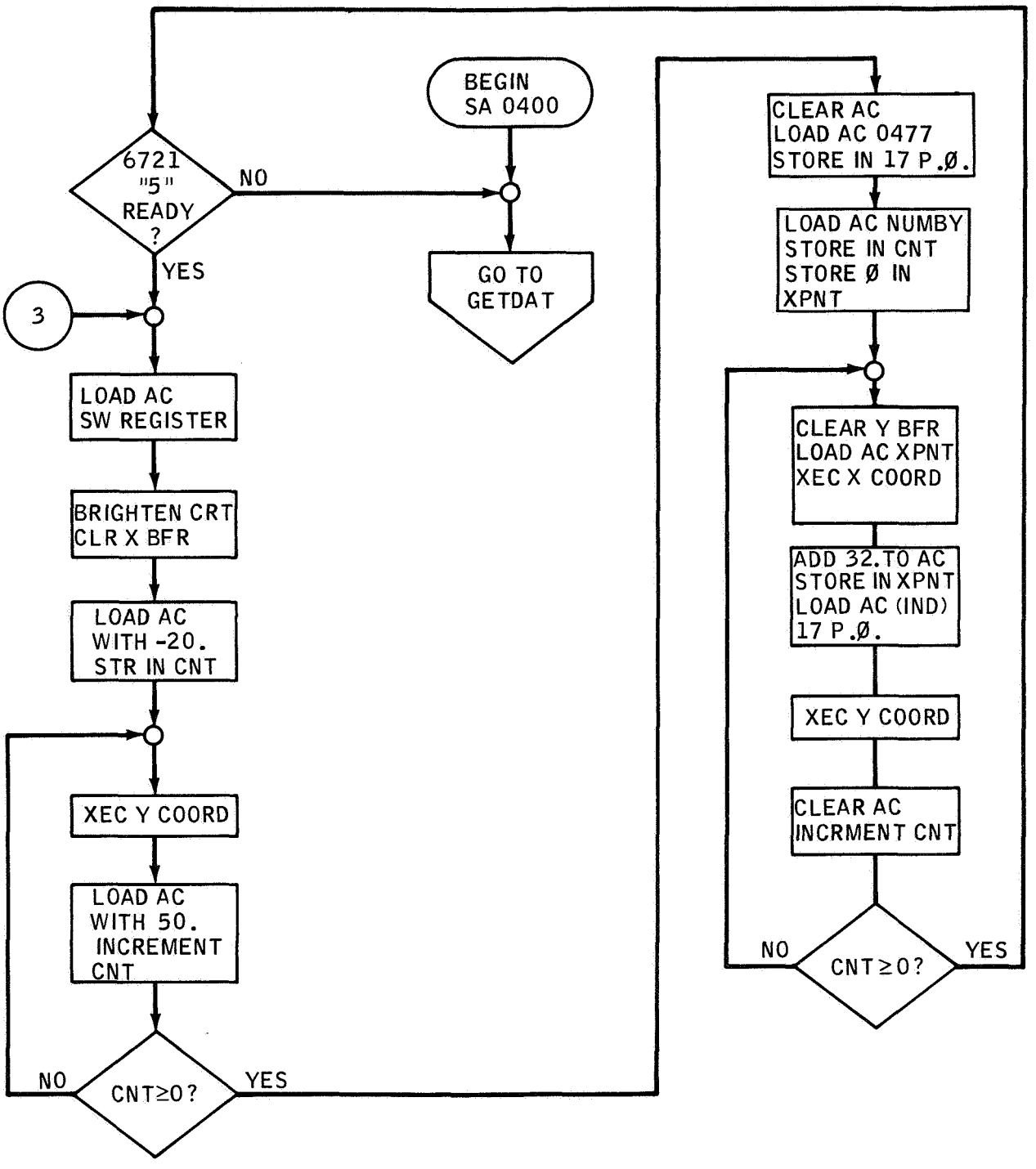

Figure 2. - Cathode ray tube flow diagram.

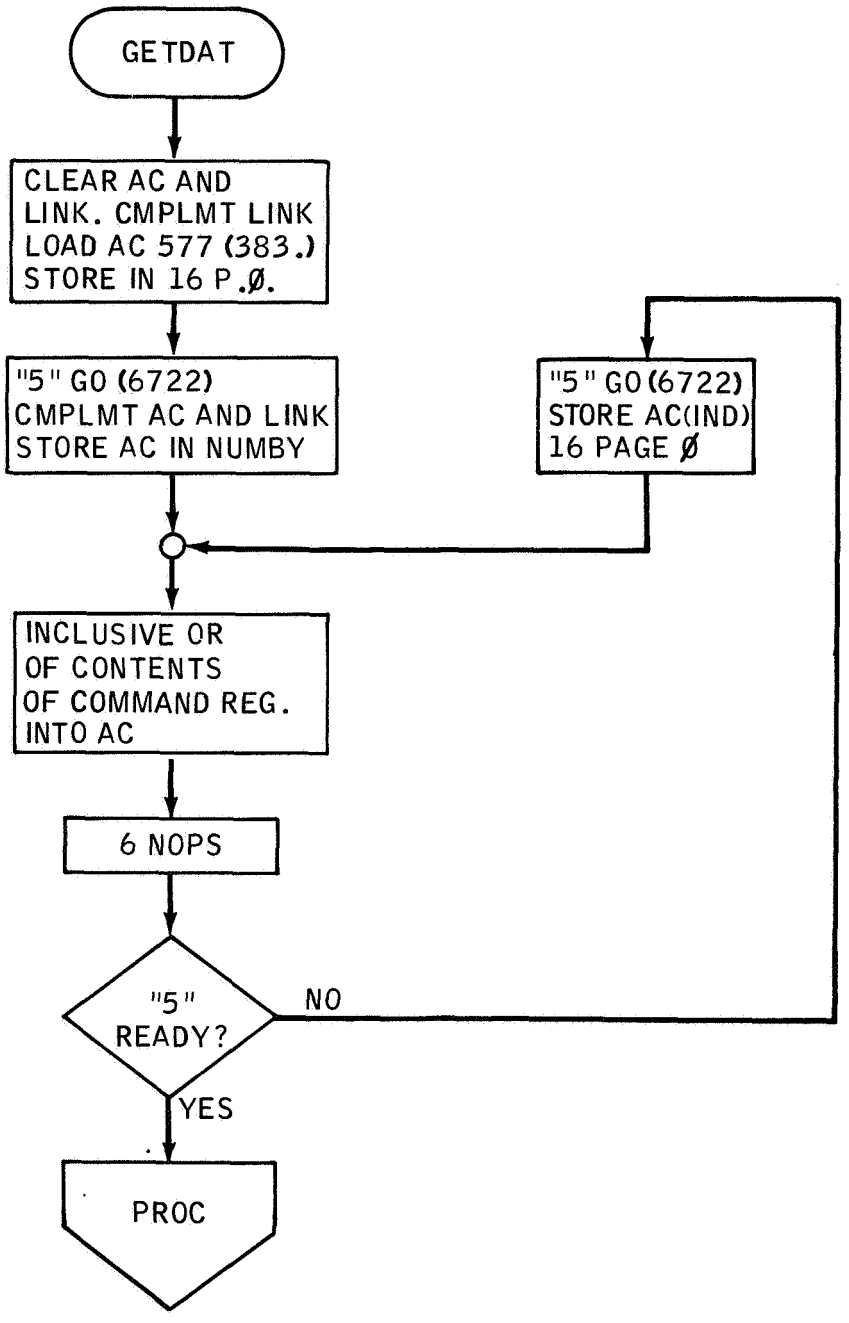

Figure 2. - Continued.

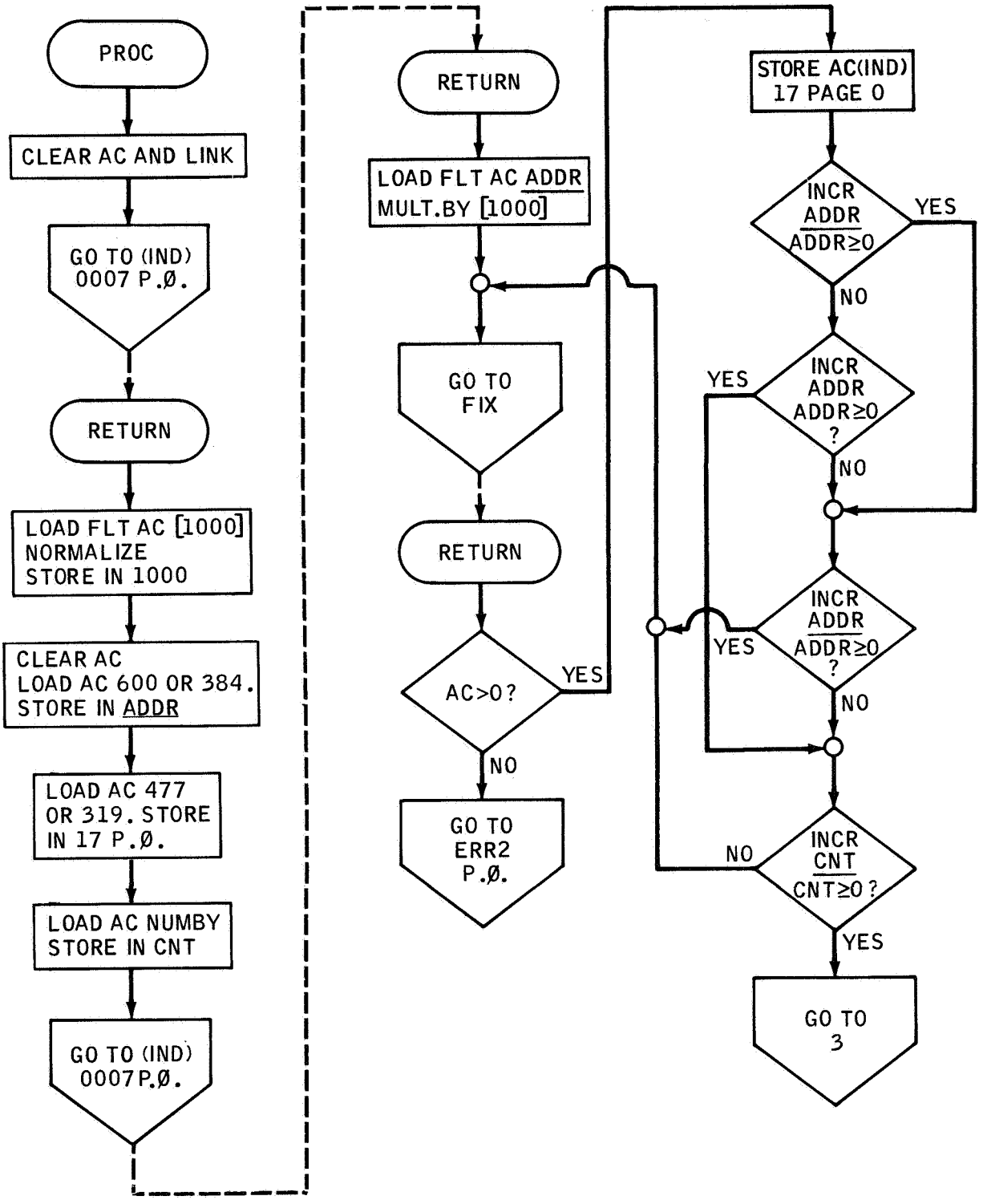

Figure 2. - Continued.

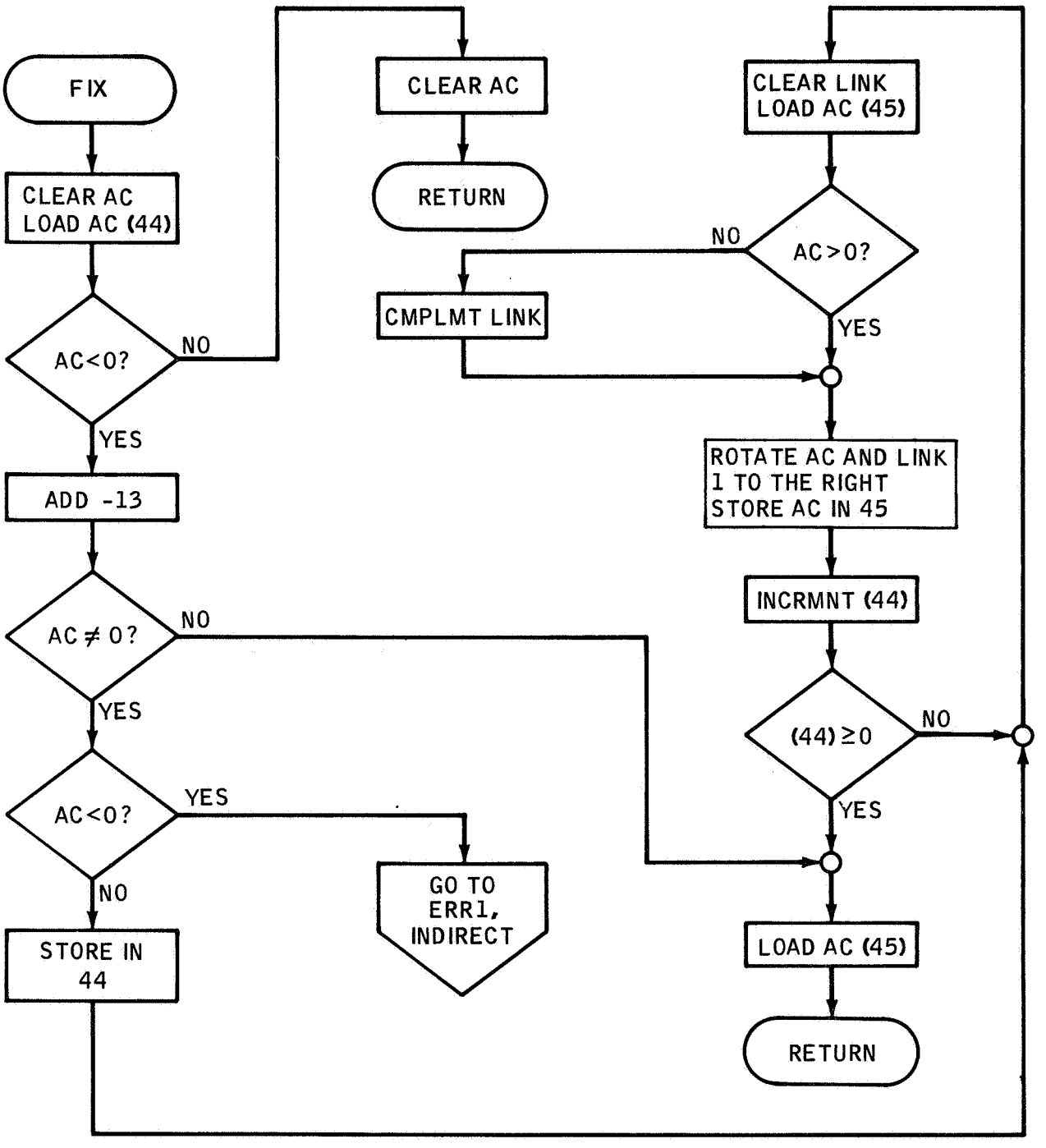

Figure 2. - Concluded.

CRT DISPLAY ROUTINE FOR PDP-5 (ASSEMBLER LANGUAGE)

```
                *7
ØØØ7  56ØØ              56ØØ
                *63
ØØ63  ØØØØ     FIX,     Ø
ØØ64  72ØØ              CLA
ØØ65  1Ø44              TAD 44
ØØ66  754Ø              SZA SMA
ØØ67  5Ø72              JMP .+3
ØØ7Ø  72ØØ              CLA
ØØ71  5111              JMP FIN +1
ØØ72  1112              TAD M13
ØØ73  745Ø              SNA
ØØ74  511Ø              JMP FIN
ØØ75  75ØØ              SMA
ØØ76  5513              JMP I ERR1
ØØ77  3Ø44              DCA 44
Ø1ØØ  71ØØ     AGN,     CLL
Ø1Ø1  1Ø45              TAD 45
Ø1Ø2  751Ø              SPA
Ø1Ø3  7Ø2Ø              CML
Ø1Ø4  7Ø1Ø              RAR
Ø1Ø5  3Ø45              DCA 45
Ø1Ø6  2Ø44              ISZ 44
Ø1Ø7  51ØØ              JMP AGN
Ø11Ø  1Ø45     FIN,     TAD 45
Ø111  5463              JMP I FIX
Ø112  7765     M13,     Ø-13
Ø113  1ØØØ     ERR1,    1ØØØ
Ø114  1ØØ1     ERR2,    1ØØ1
```

```
                *4ØØ
ØØØØ  52Ø1  BEGIN,      JMP .+1
ØØØ1  6721               6721
ØØØ2  5246               JMP GETDAT
ØØØ3  76Ø4               LAS
ØØØ4  6Ø74               6Ø74
ØØØ5  6Ø51               6Ø51
ØØØ6  72ØØ               CLA
ØØØ7  1237               TAD C2Ø
ØØ1Ø  3236               DCA CNT
ØØ11  6Ø67               6Ø67
ØØ12  124Ø               TAD C5Ø
ØØ13  2236               ISZ CNT
ØØ14  5211               JMP .-3
ØØ15  72ØØ               CLA
ØØ16  1241               TAD C477
ØØ17  3Ø17               DCA Z 17
ØØ2Ø  1245               TAD NUMBY
ØØ21  3236               DCA CNT
ØØ22  3244               DCA XPNT
ØØ23  6Ø61  NXTX,        6Ø61
ØØ24  1244               TAD XPNT
ØØ25  6Ø57               6Ø57
ØØ26  1242               TAD C4Ø
ØØ27  3244               DCA XPNT
ØØ3Ø  1417               TAD I Z 17
ØØ31  6Ø67               6Ø67
ØØ32  72ØØ               CLA
ØØ33  2236               ISZ CNT
ØØ34  5223               JMP .-11
ØØ35  52Ø1               JMP BEGIN +1
ØØ36  ØØØØ  CNT,         Ø
ØØ37  7754   C2Ø,        7754
ØØ4Ø  ØØ62   C2Ø,        ØØ62
ØØ41  Ø477   C477,       Ø477
ØØ42  ØØ4Ø   C4Ø,        4Ø
ØØ43  Ø577   C577,       577
ØØ44  ØØØØ  XPNT,        Ø
ØØ45  774Ø  NUMBY,       774Ø
ØØ46  73ØØ  GETDAT,      CLA CLL
ØØ47  7Ø2Ø               CML
ØØ5Ø  1243               TAD C577
ØØ51  3Ø16               DCA Z 16
ØØ52  6722               6722
ØØ53  7Ø41               CIA
ØØ54  3245               DCA NUMBY
```

```
ø455  6724  NXWORD,     6724
ø456  7ØØØ              NOP
ø457  7ØØØ              NOP
ø46ø  7ØØØ              NOP
ø461  7ØØØ              NOP
ø462  7ØØØ              NOP
ø463  7ØØØ              NOP
ø464  6721              6721
ø465  741ø              SKP
ø466  5342              JMP PROC
ø467  6722              6722
ø47ø  3416              DCA I Z 16
ø471  5255              JMP NXWORD
ø472  ØØ12  C1ØØØ,      ØØ12
ø473  372ø              372ø
ø474  ØØØØ              ØØØØ
ø475  ø6ØØ  ADDR,       6ØØ
ø476  ø6ØØ  C6ØØ,       6ØØ
            *5ØØ
ø5ØØ  ØØØØ              ø
ø5ø1  ØØØØ              ø
ø5ø2  ØØØØ              ø
ø5ø3  ØØØØ              ø
ø5ø4  ØØØØ              ø
ø5ø5  ØØØØ              ø
ø5ø6  ØØØØ              ø
ø5ø7  ØØØØ              ø
ø51ø  ØØØØ              ø
ø511  ØØØØ              ø
ø512  ØØØØ              ø
ø513  ØØØØ              ø
ø514  ØØØØ              ø
ø515  ØØØØ              ø
ø516  ØØØØ              ø
ø517  ØØØØ              ø
ø52ø  ØØØØ              ø
ø521  ØØØØ              ø
ø522  ØØØØ              ø
ø523  ØØØØ              ø
ø524  ØØØØ              ø
ø525  ØØØØ              ø
ø526  ØØØØ              ø
ø527  ØØØØ              ø
ø53ø  ØØØØ              ø
ø531  ØØØØ              ø
ø532  ØØØØ              ø
ø533  ØØØØ              ø
ø534  ØØØØ              ø
ø535  ØØØØ              ø
ø536  ØØØØ              ø
ø537  ØØØØ              ø
ø54ø  ØØØØ              ø
ø541  ØØØØ              ø
```

```
                *542
Ø542  73ØØ  PROC,       CLA CLL
Ø543  44Ø7              JMS I Z 7
Ø544  5272              FGET C1ØØØ
Ø545  7ØØØ              FNOR
Ø546  6272              FPUT C1ØØØ
Ø547  ØØØØ              FEXT
Ø55Ø  72ØØ              CLA
Ø551  1276              TAD C6ØØ
Ø552  3275              DCA ADDR
Ø553  1241              TAD C477
Ø554  3Ø17              DCA Z 17
Ø555  1245              TAD NUMBY
Ø556  3236              DCA CNT
Ø557  44Ø7              JMS I Z 7
Ø56Ø  5675              FGET I ADDR
Ø561  3272              FMPY C1ØØØ
Ø562  ØØØØ              FEXT
Ø563  4Ø63              JMS Z FIX
Ø564  751Ø              SPA
Ø565  5514              JMP I Z ERR2
Ø566  3417              DCA I Z 17
Ø567  2275              ISZ ADDR
Ø57Ø  2275              ISZ ADDR
Ø571  2275              ISZ ADDR
Ø572  2236              ISZ CNT
Ø573  5357              JMP .-14
Ø574  52Ø3              JMP BEGIN +3
                *1ØØØ
1ØØØ  74Ø2              HLT
1ØØ1  74Ø2              HLT
1ØØ2  52Ø1              JMP .-1

ADDR    Ø475
AGN     Ø1ØØ
BEGIN   Ø4ØØ
CNT     Ø436
C1ØØØ   Ø472
C2Ø     Ø437
C4Ø     Ø442
C477    Ø441
C5Ø     Ø44Ø
C577    Ø443
C6ØØ    Ø476
ERR1    Ø113
ERR2    Ø114
FIN     Ø11Ø
FIX     ØØ63
GETDAT  Ø446
M13     Ø112
NUMBY   Ø445
NXTX    Ø423
NXWORD  Ø455
PROC    Ø542
XPNT    Ø444
```