1. IDENTIFICATION

1.1 Digital-7-60-N

1.2 Type 34 Display Test

1.3 April 28, 1965

2. ABSTRACT

The test program causes a variety of patterns to be displayed on the Type 34 CRT to aid an operator's efforts to maintain and align the display. With one exception, the operator is able, by means of the switch register, to go from pattern to pattern specifying parameters without having to restart the program.

3. REQUIREMENTS

3.1 Storage

The program occupies 1051_8 registers; locations 1, 100-144, and 200-1232.

3.2 Subprograms and/or Subroutines (Not Applicable)

3.3 Equipment

Standard PDP-4/7. Type 34 Oscilloscope Display. Type 370 Light Pen optional.

3.4 Miscellaneous (Not Applicable)

4. USAGE

4.1 Loading

4.1.1 Set the address switches to the starting address (17770 or 7770) of the RIM Loader.

4.1.2 Place the binary program tape in the reader.

4.1.3 Press START.

4.2 Calling Sequence (Not Applicable)

4.3 Switch Settings

4.3.1 ACS bits 0-2 select the pattern to be displayed according to the octal number contained in them as follows: (individual routines are explained in Section 6.)

0	Blank screen; no operation.
1	Vertical line.
2	Horizontal line.
3	Diagonal line.
4	Horizontal segmented sweep.
5	Vertical segmented sweep.
6	Blank screen; no operation.
7	Blank screen; no operation.

The only pattern not selectable by these switches is the axial point plotter, which is separate from the others and must be entered by manually starting at address 100.

4.3.2 Axial Point Plotter

Starting at address 100 causes the program to immediately halt so that the following settings can be made before pressing CONTINUE:

ACS bit 0 = 1 to plot on X-axis from coordinate in ACS bits 8-17.
ACS bit 0 = 0 to plot on Y-axis from coordinate in ACS bits 8-17.

Changes in ACS bits 8-17 may be made while program is displaying, with immediate results.

4.3.3 Horizontal and Vertical Segmented Sweep Patterns

ACS bits 9-17 select the segments of the CRT face to be illuminated by the chosen sweep pattern.

Bit a 1	Selects Segment Number (see diagram 11.1)
17	1
16	2
15	3
14	4
13	5
12	6
11	7
10	8
9	9

4.3.4 Light Pen Pattern

The letter P appears on the screen when ACS 0 – 17 = 0.

4.4 Start Up and/or Entry

4.4.1 Preliminary Procedures

Initial settings of 34 Display controls:

1. Vertical sensitivity	1v/cm
2. Horizontal sensitivity	1v/cm
3. Sensitivity verniers	Adjust to suit*
4. Horizontal display	Horizontal amp only
5. Vertical input switch	DC
6. Horizontal input switch	Any
7. Sweep time/cm	Any
8. Trigger controls	Any

*The exact setting of sensitivity and position controls should be such that the patterns produced by the program fill the CRT reticle entirely. The horizontal, vertical, and diagonal line patterns are programmed to pass through the center of the CRT and barely touch the extremities of the reticle grid.

9.	Position controls	Approximately 12 o'clock*
10.	Focus	Adjust to suit***
11.	Intensity	Adjust to suit**

Set the switch register to the desired initial operating conditions before entering the program.

4.4.2 Entry

For axial plotting, set the address switches at 100. For all other patterns, set the address switches at 200. Press START.

4.4.3 Restart

Restarting is normally unnecessary as provisions have been made to transfer from pattern to pattern while the program is in progress by merely changing the setting of ACS0-2, the only exception being the manual transfer to or from the axial plotting mode.

4.5 Errors in Usage

Address	Comments
100	Not an error halt. Occurs to allow operator time to set initial conditions for Axial Plot Program.
730	DCF has failed to clear Display flag, or DSF always skips.
734	Display flag has failed to cause an interrupt.

4.6 Recovery from Such Errors

Address	Comments
100	Set initial conditions into ACS (4.3) and press CONTINUE.
730	No recovery. Program must be restarted.
734	Press CONTINUE to resume program.

*The exact setting of sensitivity and position controls should be such that the patterns produced by the program fill the CRT reticle entirely. The horizontal, vertical, and diagonal line patterns are programmed to pass through the center of the CRT and barely touch the extremities of the reticle grid.

**The intensity should be adjusted so that the unintensified beam just disappears from view.

***It may be desirable, when using the sweep patterns to check the continuity of the phosphor coating, to defocus the beam and increase the intensity. Be sure to return the intensity to its former level.

5. RESTRICTIONS (Not Applicable)

6. DESCRIPTION

6.1 Discussion

6.1.1 Axial Plotting Mode

This program beginning at address 100 immediately executes a HLT instruction to allow the operator time to set up the AC switches for desired initial conditions. Upon continuing, these switches are examined. Program control branches to either an X-plot routine or a Y-plot routine (PLOX or PLOY) depending upon the polarity of ACS 0. Each routine loads its "active" coordinate register with the coordinate in ACS 8-17 and clears the other coordinate register. The point so referenced is then displayed and control is returned to the beginning of the program.

6.1.2 Dispatch

The dispatch routine (BEG) is entered at address 200. SR bits 0-2 are examined and program control is transferred to the subroutine responsible for the display of the pattern named by the number in these switches. If this number is 0 and all other ACS are 0 as well, control is transferred to the Light Pen subroutine. Return from all pattern subroutines except the Light Pen subroutine is accomplished automatically at the termination of a single pattern display or when all switch conditions have been met (segmented sweep). The Light Pen subroutine relinquishes program control only when the ACS register becomes nonzero. The return from pattern subroutines is to the dispatch routine where the same pattern subroutine is entered without a noticeable break if SR bits 0-2 are unchanged. A change in these bits causes a new subroutine to be entered and a new pattern displayed.

6.1.3 Vertical Line Subroutine (VLT)

This subroutine plots all points having an X-coordinate of 1000, beginning with X = 1000, Y = 0 and ending with X = 1000, and Y = 1777. After plotting the last point, the dispatch routine is reentered. The line displayed bisects the center.

6.1.4 Horizontal Line Subroutine (HTS)

This subroutine plots all points having a Y-coordinate of 1000, beginning with X = 0, Y = 1000 and ending with X = 1777, Y = 1000. After plotting the last point, the dispatch routine is reentered. The line displayed bisects the center.

6.1.5 Diagonal Line Subroutine (DLT)

This subroutine plots all points having equal X- and Y-coordinates, beginning with X = 0, Y = 0 and ending with X = 1777, Y = 1777. After plotting the last point, the dispatch routine is reentered. The line displayed bisects the center.

6.1.6 Common Line Pattern Subroutine (COM)

This subroutine is common to VLT, HTS, and DLT and accomplishes the actual incrementation of the coordinates and decides whether or not the pattern is complete.

6.1.7 Segmented Sweep Routines

6.1.7.1 General

The Segmented Sweep Routines provide a means of checking the uniformity of the phosphor coating on the CRT. In order to facilitate checking, the CRT reticle is divided into nine overlapping segments, (see diagram 11.1). Vertical or horizontal lines are swept over a segment several times causing the phosphor to remain illuminated. The SR bits 9-17 specify which segments are to be swept. If more than one switch is "on," the segments are illuminated in order. The sweep routines can also be used to check for AC ripple and decoder network deficiencies. The line which sweeps a segment contains every fourth point only. Thus, individual points are visible and the wake of the sweep has a ribbed appearance. Uneven trace spacing indicates improper adjustment of the decoder network. If the line appears wavy, ripple is present somewhere in the display circuitry. These conditions may be present concurrently. The sweep routines use a set of subroutines to do the actual sweeping. Description of these subroutines follow the description of the sweep routines.

6.1.7.2 Horizontal Segment Sweep Routine (HST)

The Horizontal Segment Sweep Routine first initializes the segment counter to segment 1. The program then sets the line and point increments for the plot subroutines. The segment counter contains all 0's except for one bit, the position of which determines the current segment (see diagram 11.1), before each sweep, the segment counter is ANDed with the contents of the switches. If the AC then contains 0, the program skips the segment, rotates the counter left one space, and tests again. After illuminating segment 9, the program returns to the dispatch routine.

When a given segment is selected, the AC contains the contents of the segment counter after the AND operation. The program then determines whether the segment is in the left, middle, or right portion of the screen.

The segment is then illuminated by using the plot subroutine four times to sweep right, left, right, left over the segment. If the adjacent segment on the right is to be illuminated, the program uses the plot subroutines a fifth time, sweeping to the right. This last sweep ends at the leftmost boundary of the adjacent segment to provide a smooth transition from one segment to the next.

If the adjacent segment is not to be illuminated, the segment counter is rotated until another segment is illuminated, or SR 9-17 = 0 and returns to the dispatch routine.

6.1.7.3 Vertical Segmented Sweep Routine (VST)

Except for the following differences, this program is the same as the horizontal sweep routines.

The segments are swept down, up, down, up and the smooth transition is to the segment below.

Since the vertical program sweeps the sections in a different order (1, 4, 7, 2, 5, 8, 3, 6, 9), the segment counter is either rotated left three spaces or right five spaces, depending on the number of the current segment.

6.1.7.4 Plot Subroutines

These subroutines can display a vertical line which sweeps either from left to right or from right to left. Similarly, a horizontal line can be swept upward or downward. The subroutine requires four parameters: the end points of the line and the boundaries of the sweep. Furthermore, two rates must be specified, the point rate and the line rate. The point rate determines the distance between displayed points on the line. For example, a point rate of 1 plots every point on the line; 4, every fourth point.

The line rate similarly determines the distance between displayed lines--again, 1 plots every line; 4, every fourth line. Only one bit of a rate number may be 1. After the six parameters are set, a JMS is executed. The JMS address determines the direction of the sweep and the orientation of the line.

6.1.8 Light Pen Routine (PEN)

This routine displays the letter P on the CRT. The light pen is used to sense this display. If the pen is operating correctly the program will complete the display by adding the letters EN and will continue to display the word PEN until the pen no longer sees light. When the program is first entered, the Light Pen flag is cleared by DCF and the Light Pen Skip flag instruction DCF is executed. If a skip occurs, the program halts at address 730, indicating that the DCF instruction failed to clear the flag or that DSF always skips. A loop responsible for the display of P is then entered. As part of this loop, the switch register is checked to determine that this register has remained in a 0 state. This allows the operator to exit from the Light Pen routine, and display other patterns at any time.

Actual display of the letter P is delegated to a subroutine (P), which in turn calls upon a line drawing routine (LINE) to trace the elements of the figure. The loop is reentered after the P is drawn and a program flag (SKIP) is interrogated to determine if an interrupt due to the light pen sensing light has occurred. If no light pen interrupt has occurred, the Light Pen flag is sensed to see if one was attempted. A halt at location 734 indicates to the operator that the pen saw light and sets its flag, but that no interrupt resulted; otherwise, the loop recycles.

When an interrupt due to the light pen occurs, program control shifts to a subroutine (PENSE) which sets a program flag (SKIP) and returns control to the point of interruption.

6.2 Examples and/or Applications

6.2.1 Horizontal and Vertical Patterns

These patterns are useful for determining raster position and symmetry. The lines should be straight, just touch the edge of the reticle grid, and pass through the center of the screen.

6.2.2 Diagonal Line Pattern

This pattern is useful in the evaluation of decoder network operation and the detection of dropped, picked up, or interchanged bits. Proper operation yields a straight line, one point in width, proceeding from the lower left to the upper right of the reticle grid.

6.2.3 Horizontal and Vertical Segmented Sweep

SR 9-17 select any of nine segments on the screen to be checked as shown in diagram 11.1. Each segment selected is illuminated in turn by a vertical line moving horizontally or by a horizontal line moving vertically across the screen four or five times.

6.2.3.1 Uniformity of Phosphor Coating

Nonuniform or burnt-out spots on the screen will appear as burnt-out spots.

6.2.3.2 Ripple

If the lines appear wavy, ripple is present somewhere in the display circuitry.

6.2.3.3 Decoder Network

If the line traces are spaced unevenly, the decoder network is not functioning properly.

6.3 Scaling (Not Applicable)

7. METHODS

(see Section 6.1.)

8. FORMAT (Not Applicable)

9. EXECUTION TIME

Time between plots can be lengthened by the placement of a suitable LAM instruction in register 1176 (TIME + 1). The present contents, LAM-1, can be replaced by LAM-N where N > 1. Each increment will increase time between displays by 4.25 μsec.*

*24μsec for PDP-4.

10. PROGRAM

10.4 Program Listing

```
TYPE 34B DISPLAY TEST FOR PDP-4/7
RPS         700601    DCF         700702
RPS         700501    DSF         700701


BEG         200
BV          554
CHEX        1120
CLEAR       1155
COM         260
DCF         700702
DIR         1225
DISPAT      213
DLT         251
DLTCOM      227
DSF         700701
EN          1004
ENDCK       1213
EXEC        1123
GOH         522
GOV         454
HSI         270
HTS         241
HTSCOM      225
IXH         533
IXV         464
LH          541
LINE        1047
LINER       1102
LNS         1203
MH          565
MV          526
P           762
PAP         100
PDN         657
PEN         725
PEND        740
PENNY       731
PENSE       750
PH          612
PICKUP      1216
PLF         600
PLOX        111
PLOY        105
PRI         567
PTS         1204
```

```
PUP         646
PV          671
P1          1205
P2          1206
P3          1207
P4          1210
P5          1211
P6          1212
RH          411
SAC         1217
SEG         1232
SERVE       1143
SKIP        1220
TIMER       1175
TV          502
VLT         231
VLTCOM      223
VSI         422
VS1         440
VS2         450
X           1224
XADJ        1215
XEND        1223
XMN         1227
XMX         1226
Y           1222
YADJ        1214
YEND        1221
YMN         1231
YMX         1230
PAP         100
PLOY        105
PLOX        111
BEG         200
DISPAT      213
VLICOM      223
HISCOM      225
DLICOM      227
VLI         231
HIS         241
DLI         251
COM         260
HSI         270
GOH         322
IXH         333
LH          341
MH          365
RH          411
VSI         422
VS1         440
VS2         450
```

```
GOV         454
IXV         464
TV          502
MV          526
BV          554
PRI         567
PLF         600
PH          612
PUP         646
PDN         657
PV          671
PEN         725
PENNY       731
PEND        740
PENSE       750
P           762
EN          1004
LINE        1047
LINER       1102
CHEX        1120
EXEC        1123
SERVE       1143
CLEAR       1155
TIMEK       1175
LNS         1203
PTS         1204
P1          1205
P2          1206
P3          1207
P4          1210
P5          1211
P6          1212
ENDCK       1213
YADJ        1214
XADJ        1215
PICKUP      1216
SAC         1217
SKIP        1220
YEND        1221
Y           1222
XEND        1223
X           1224
DIM         1225
XMX         1226
XMN         1227
YMX         1230
YMN         1231
SEG         1232
DSF         700701
DCF         700702
```

```
TYPE 34B DISPLAY TEST FOR PDP-4/7

DCF=700702
DSF=700701

1/
                JMP SERVE

100/
/ROUTINE TO PLOT A POINT ON EITHER AXIS
PAP,            HLT
                JMS TIMEK
                LAS
                SPA CLA
                JMP PLOX.               /BIT 0 UP. VARY X COORDINATE
PLOY,           DXL                     /LOAD X REGISTER WITH ZERO
                LAS
                DYS                     /PLOT COORD. IN AS 8-17
                JMP PAP+1
PLOX,           DYL                     /LOAD Y REGISTER WITH ZERO
                LAS
                DXS                     /PLOT COORD. IN AS 8-17
                JMP PAP+1

200/

/DISPATCH ROUTINE
BEG,            IOF
                JMS CLEAR
                LAS
                SNA
                JMP PEN
                RTL
                RTL
                AND (7
                TAD (JMP DISPAT
                DAC .+1
                HLT
DISPAT,         JMP BEG+2
                JMP VLTCOM              /GO TO VERT. LINE TEST
                JMP HTSCOM              /GO TO HORIZ. LINE TEST
                JMP DLTCOM              /GO TO DIAG. LINE TEST
                JMP HST                 /GO TO HORIZ. SWEEP TEST
                JMP VST                 /GO TO VERT. SWEEP TEST
                JMP BEG+2
                JMP BEG+2
VLTCUM,         JMS VLT
                JMP BEG+2
HISCUM,         JMS HTS
                JMP BEG+2
```

```
DLTCOM,         JMS DLT
                JMP BEG+2

/VERTICAL LINE TEST
VLT,            0
                LAW 1000
                DXL
                CLA
                DYS
                JMS COM
                JMP .-2
                JMP I VLT

/HORIZONTAL LINE TEST
HTS,            0
                LAW 1000
                DYL
                CLA
                DXS
                JMS COM
                JMP .-2
                JMP I HTS

/DIAGONAL LINE TEST
DLT,            0
                CLA
                DXL
                DYS
                JMS COM
                JMP DLT+2
                JMP I DLT

/COMMON LINE TEST ROUTINE
COM,            0
                NOP
                NOP
                TAD (1
                AND (1777
                SNA                     /UNFINISHED LINE
                ISZ COM                 /FINISHED LINE
                JMP I COM

/HORIZONTAL SWEEP TEST
HST,            LAC (1
                DAC SEG                 /INITIALIZE SEGMENT INDICATOR
                LAS
                AND S+EG
                SNA
                JMP IXH                 /CURRENT SEGMENT NOT REQUESTED
                LAC P4                  /SET Y LIMITS FOR TOP THREE
                DAC Y+MN
```

```
                LAC P6
                DAC Y→MX
                LAC SEG
                AND (7
                SZA
                JMP GOH
                LAC P2          /REQUESTED SEGMENT NOT IN TOP THREE
                DAC YMN         /SET Y LIMITS FOR MIDDLE THREE
                LAC P5
                DAC YMX
                LAC SEG
                AND (70
                SZA
                JMP GOH
                LAC P1          /REQ. SEGMENT NOT IN MIDDLE THREE
                DAC YMN         /SET Y LIMITS FOR MIDDLE THREE
                LAC P3
                DAC YMX
GOH,            LAC SEG
                AND (111
                SZA
                JMP LH          /REQUESTED SEGMENT IN LEFT THREE
                LAC SEG
                AND (222
                SZA
                JMP MH          /REQUESTED SEGMENT IN MIDDLE THREE
                JMP RH          /REQUESTED SEGMENT  IN RIGHT THREE
IXH,            LAC SEG
                RALVCLL
                AND (777
                SNA
                JMP REG         /LAST SEGMENT DISPOSED OF
                JMP HST+1       /CHECK NEXT HORIZ. SEQUENTIAL SEGM

/ROUTINE TO CONTROL ILLUMINATION OF LEFT SEGMENT
LH,             LAC P1
                DAC X→MN        /SET X LIMITS
                LAC P3
                DAC X→MX
                JMS PRT         /SWEEP RIGHT
                JMS PLF         /SWEEP LEFT
                JMS PRT         /SWEEP RIGHT
                JMS PLF         /SWEEP LEFT
                LAS
                AND (777
                RARVCLL
                AND SEG
                SNA
                JMP IXH         /CHECK NEXT SEGMENT
```

```
                LAC L+NS            /NEXT SEQUENTIAL SEGMENT ILLUM.
                CMA
                ADD P2
                DAC XMX
                JMS PRT             /SWEEP RIGHT
                JMP IXH


/ROUTINE TO CONTROL ILLUMINATION OF MIDDLE SEGMENT
MH,             LAC P2
                DAC XMN             /SET X LIMITS
                LAC P5
                DAC XMX
                JMS PRT             /SWEEP RIGHT
                JMS PLF             /SWEEP LEFT
                JMS PRT             /SWEEP RIGHT
                JMS PLF             /SWEEP LEFT
                LAS
                AND (777
                RARVCLL
                AND SEG
                SNA
                JMP IXH             /CHECK NEXT SEGMENT
                LAC LNS             /NEXT SEQUENTIAL SEGMENT ILLUM.
                CMA         /RESET X LIMIT
                ADD P4
                DAC XMX
                JMS PRT             /SWEEP RIGHT
                JMP IXH


/ROUTINE TO CONTROL ILLUMINATION OF RIGHT SEGMENT
RH,             LAC P4
                DAC XMN             /SET X LIMITS
                LAC P6
                DAC XMX
                JMS PRT             /SWEEP RIGHT
                JMS PLF             /SWEEP LEFT
                JMS PRT             /SWEEP RIGHT
                JMS PLF             /SWEEP LEFT
                JMP IXH             /CHECK NEXT SEGMENT
```

```
/VERTICAL SWEEP TEST
VST,        LAC (1
            DAC SEG          /INITIALIZE SEGMENT INDICATOR
            LAS
            AND SEG
            SNA
            JMP IXV          /CURRENT SEGMENT NOT REQUESTED
            AND (333
            SZA
            JMP VS1          /REQ. SEGMENT NOT IN RIGHT THREE
            LAC P4           /SET X LIMITS FOR RIGHT THREE
            DAC XMN
            LAC P6
            DAC XMX
            JMP GOV
VS1,        AND (555
            SZA
            JMP VS2          /REQ. SEGMENT IN LEFT THREE
            LAC P2           /REQ. SEGMENT IN MIDDLE THREE
            DAC XMN          /SET X LIMITS FOR MIDDLE THREE
            LAC P5
            DAC XMX
            JMP GOV
VS2,        LAC P1           /SET X LIMITS FOR LEFT THREE
            DAC XMN
            LAC P3
            DAC XMX
GOV,        LAC SEG
            AND (770
            SNA
            JMP TV           /REQ. SEGMENT IN TOP THREE
            AND (70
            SNA
            JMP BV           /REQ. SEGMENT IN BOTTOM THREE
            JMP MV           /REQ. SEGMENT IN MIDDLE THREE
IXV,        LAC SEG
            RALVCLL
            AND (777
            SNA
            JMP REG          /LAST SEGMENT DISPOSED OF
            RTL
            AND (777
            SZA
            JMP VST+1        /CHECK NEXT VERTICALLY SEQUENTIAL
            LAC SEG          /DIFFERENT ROTATION NEEDED (SEGS 7,8,9)
            RTR
            RTR
            RAR
            JMP VST+1        /CHECK NEXT VERTICALLY SEQUENTIAL
```

```
/ROUTINE TO CONTROL ILLUMINATION OF TOP SEGMENT
TV,             LAC P6
                DAC YMX             /SET Y LIMITS FOR TOP SEGMENT
                LAC P4
                DAC YMN
                JMS PDN             /SWEEP DOWN
                JMS PUP             /SWEEP UP
                JMS PDN             /SWEEP DOWN
                JMS PUP             /SWEEP UP
                LAS
                AND (777
                CLL
                RTR
                RAR
                AND SEG
                SNA
                JMP IXV             /CHECK NEXT SEGMENT
                LAC P5              /NEXT SEQUENTIAL SEGMENT ILLUMINATED
                DAC YMN             /RESET Y LIMIT
                JMS PDN             /SWEEP DOWN
                JMP IXV

/ROUTINE TO CONTROL ILLUMINATION OF MIDDLE SEGMENT
MV,             LAC LNS
                CMA                 /SET Y LIMITS
                ADD P5
                DAC YMX
                LAC P2
                DAC YMN
                JMS PDN             /SWEEP DOWN
                JMS PUP             /SWEEP UP
                JMS PDN             /SWEEP DOWN
                JMS PUP             /SWEEP UP
                LAS
                AND (777
                CLL
                RTR
                RAR
                AND SEG
                SNA
                JMP IXV             /CHECK NEXT SEGMENT
                LAC P3              /NEXT SEQUENTIAL SEGMENT ILLUMINATED
                DAC YMN             /RESET Y LIMIT
                JMS PDN             /SWEEP DOWN
                JMP IXV
```

```
/ROUTINE TO CONTROL ILLUMINATION OF BOTTOM SEGMENT
BV,             LAC LNS
                CMA
                ADD P3
                DAC YMX
                LAC P1
                DAC YMN
                JMS PDN                 /SWEEP DOWN
                JMS PUP                 /SWEEP UP
                JMS PDN                 /SWEEP DOWN
                JMS PUP                 /SWEEP UP
                JMP IXV

/ROUTINE TO CONTROL PLOTTING TO THE RIGHT
PRT,            0
                DZM D→IR                /SET DIRECTION INDICATOR TO "RIGHT"
                LAC XMN
                DXL
                DAC →X
                LAC XMX
                DAC X→END                       /SET  RIGHT HAND LIMIT
                JMS PH                  /EXCUTE
                JMP I PRT               /RETURN

/ROUTINE TO CONTROL PLOTTING TO THE LEFT
PLF,            0
                LAC (400000
                DAC DIR                 /SET DIRECTION INDICATOR TO "LEFT"
                LAC XMX
                DXL
                DAC X
                LAC XMN
                DAC XEND                /SET LEFT HAND LIMIT
                JMS PH                  /EXECUTE
                JMP I PLF                       /RETURN


/ROUTINE TO EXECUTE HORIZONTAL SWEEPING
PH,             0
                LAC YMN
                DAC →Y
                DYS                     /DISPLAY A POINT
                NOP
                CMA
                ADD YMX
                SAD (LAM
```

```
                JMP .+4                 /END OF LINE
                LAC PTS                 /UNFINISHED LINE
                TAD Y                   /RESET Y COORDINATE
                JMP PH+2                /DISPLAY NEXT POINT
                LAC X
                CMA
                ADD XEND
                SAD CLAM
                JMP I PH                /END OF SWEEP
                LAC DIR                 /UNFINISHED SWEEP
                RALVCLL
                LAC LNS
                SZL
                CMA
                ADD X                   /RESET X COORDINATE
                SAD CLAM
                CLA
                DXL
                DAC X
                JMP PH+1                /START NEXT LINE

/ROUTINE TO CONTROL UPWARDS PLOTTING
PUP,            0
                DZM DIR                 /SET DIRECTION INDICATOR TO "UP"
                LAC YMN
                DYL
                DAC Y
                LAC YMX
                DAC Y+END                       /SET UPPER LIMIT
                JMS PV                  /EXECUTE
                JMP I PUP                       /RETURN


/ROUTINE TO CONTROL DOWNWARDS PLOTTING
PDN,            0
                LAC C400000
                DAC DIR                 /SET DIRECTION INDICATOR TO "DOWN"
                LAC YMX
                DYL
                DAC Y
                LAC YMN
                DAC YEND                /SET LOWER LIMIT
                JMS PV                  /EXECUTE
                JMP I PDN                       /RETURN


/ROUTINE TO EXECUTE VERTICAL SWEEPING
PV,             0
                LAC XMN
                DAC X
```

```
                DXS             /DISPLAY A POINT
                NOP
                CMA
                ADD XMX
                SAD CLAM
                JMP .+4         /END OF LINE
                LAC PTS         /UNFINISHED LINE
                TAD X           /RESET X COORDINATE
                JMP PV+2        /DISPLAY NEXT POINT
                LAC Y
                CMA
                ADD YEND
                SAD CLAM
                JMP I PV        /END OF SWEEP
                LAC DIR         /UNFINISHED SWEEP
                RALYCLL
                LAC LNS
                SZL
                CMA
                ADD Y           /RESET Y COORDINATE
                SAD CLAM
                CLA
                DYL
                DAC Y
                JMP PV+1        /START NEXT LINE


/LIGHT PEN ROUTINE
PEN,            DCF
                DSF
                JMP PENNY
                HLT             /DCF FAILED TO CLEAR DISPLAY FLAG
PENNY,          DSF
                JMP .+3
                NOP
                HLT             /DISPLAY FLAG FAILED TO CAUSE INTERRUPT
                LAS
                SZA
                JMP REG
PEND,           DZM S-KIP
                ION
                JMS P
                ISZ SKIP
                JMP PENNY
                JMS EN
                DCF
                JMP PEND
PENSE,          DCF
                DSF
```

```
                JMP .+2
                JMP PEN+3
                LAM
                DAC SKIP
                LAC 0
                RAL
                LAC SAC
                JMP I 0

/ROUTINE TO DRAW THE LETTER P
P,              0
                DZM X
                LAW 400
                DAC Y
                JMS LINE
                000777
                ISZ X
                JMS LINE
                100377
                LAW 776
                DAC Y
                JMS LINE
                200000
                LAW 376
                DAC X
                JMS LINE
                300001
                JMP I P


/ROUTINE TO DRAW EN
EN,             0
                LAW 777
                DAC Y
                LAW 600
                DAC X
                JMS LINE
                101177
                LAW 400
                DAC Y
                JMS LINE
                300000
                ISZ Y
                JMS LINE
                000776
                ISZ X
                LAW 600
                DAC Y
                JMS LINE
                101177
                LAW 1777
```

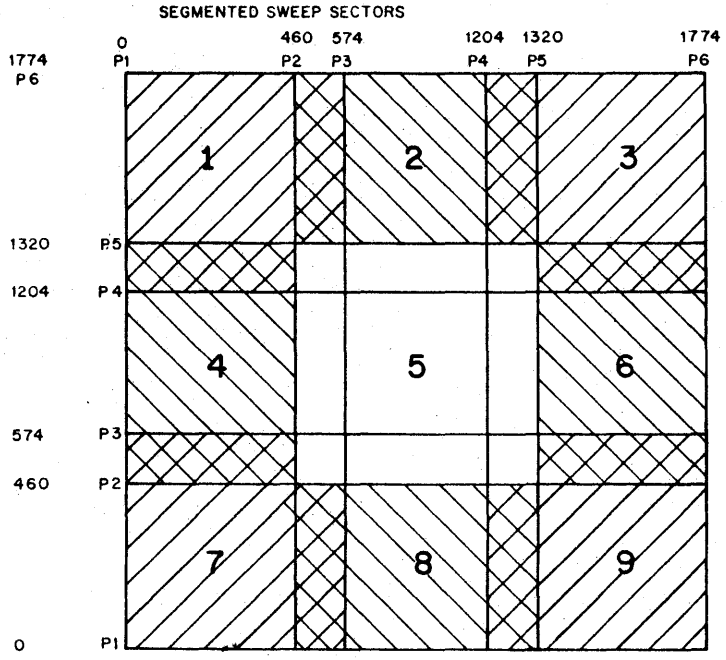
```
        DAC X
        LAW 777
        DAC Y
        JMS LINE
        200400
        ISZ Y
        LAW 1776
        DAC X
        JMS LINE
        700777
        LAW 776
        DAC Y
        JMS LINE
        200400
        JMP I EN


/ROUTINE TO DRAW A LINE
LINE,   0
        LAC I LINE
        RTL
        RTL
        AND (7
        RALYCLL
        TAD (LAC EXEC
        DAC P+ICKUP
        XCT PICKUP
        DAC X+ADJ
        ISZ PICKUP
        XCT PICKUP
        DAC Y+ADJ
        LAC I LINE
        ISZ LINE
        AND (1777
        DAC E+NDCK
        LAC YADJ
        RAR
        LAC (CHEX+1
        SNL
        TAD (1
        DAC CHEX
        LAC X
        DXL
        LAC Y
        DYS
```

```
LINER,          JMS TIMER
                LAC X
                TAD XADJ
                DAC X
                DXL
                LAC Y
                TAD YADJ
                DAC Y
                DYS
                XCT I CHEX
                AND (1777
                SAD ENDCK
                JMP I LINE
                JMP LINER

CHEX,           0
                LAC Y
                LAC X

EXEC,           0
                1
                1
                0
                0
                LAM
                LAM
                0
                1
                1
                1
                LAM
                LAM
                LAM
                LAM
                1


/INTERRUPT ROUTINE
SERVE,          DAC S+AC
                DSF
                JMP .+2
                JMP PENSE
                JMS CLEAR
                LAC 0
                RAL
                LAC SAC
                TON
                JMP I 0

/CLEAR FLAGS ROUTINE
```

```
CLEAR,          0
                IOT 3302                /PnP-7 CLEAR ALL
                CLOF
                RRB
                PCF
                KRB
                TCF
                700704                  /InCF
                CPCF
                LSCF
                LPCF
                CRRB
                NOP
                NOP
                NOP
                JMP I CLEAR

/TIME DELAY
TIMEK,          0
                LAM-1
                DAC CLEAR
                ISZ CLEAR
                JMP .-1
                JMP I TIMEK

/VARIABLES
LNS,            2
PIS,            4
P1,             0
P2,             460
P3,             574
P4,             1204
P5,             1320
P6,             1774

VARIABLES
START
```

11. DIAGRAM

Segmented Sweep Program



SEGMENT NUMBER	CORRESPONDING TW SWITCH
1	17
2	16
3	15
4	14
5	13
6	12
7	11
8	10
9	9

12. REFERENCES (Not Applicable)