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OPTICAL CONTRAST VARIABLE GATE CENTROID TRACKER FOR THE INTEL 3--ETC(U)
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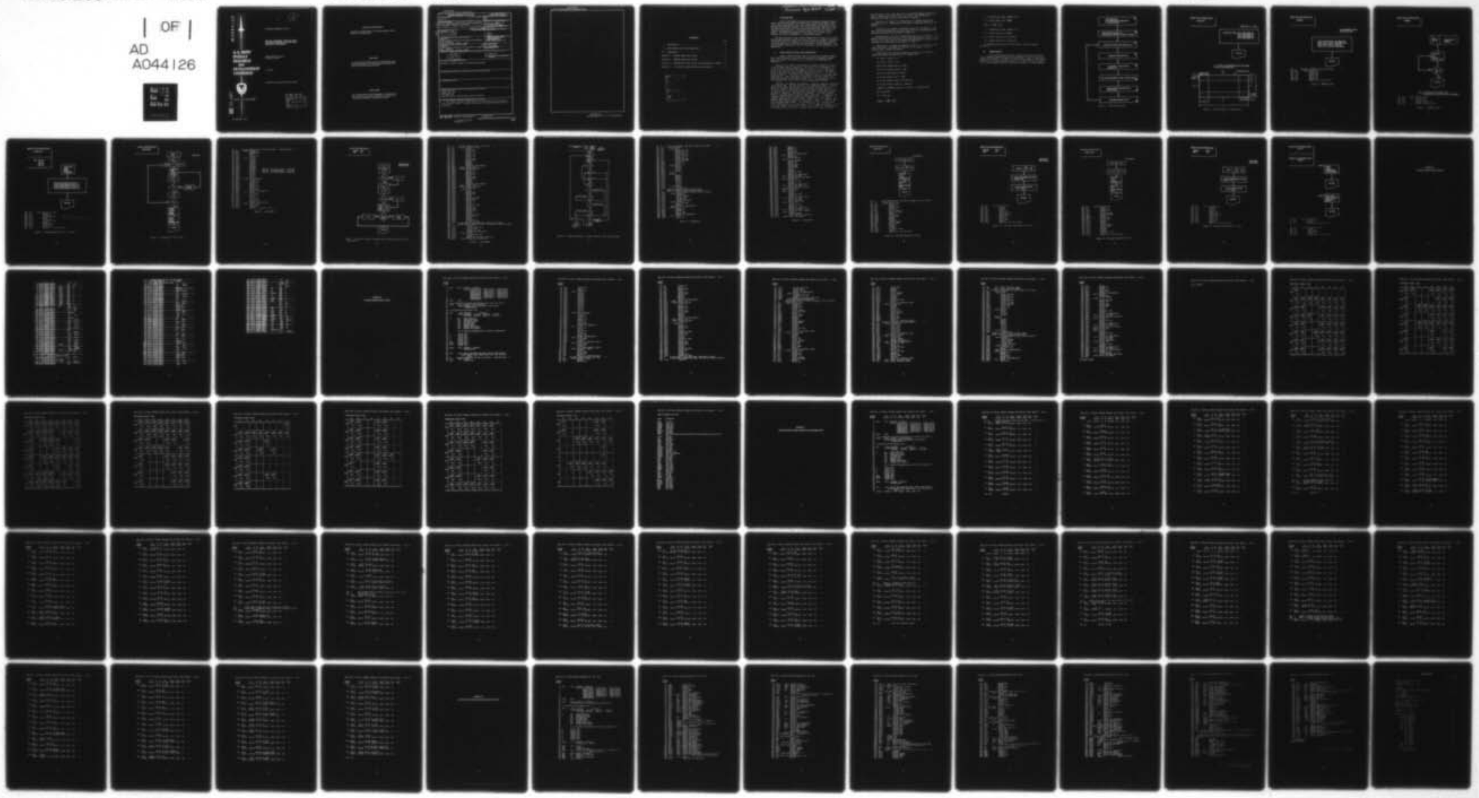

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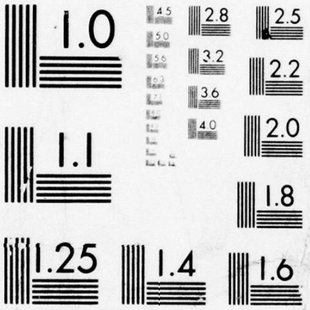

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TECHNICAL REPORT TE-77-13

OPTICAL CONTRAST VARIABLE GATE CENTROID TRACKER FOR THE INTEL 3000 MICRO PROCESSOR

Advanced Sensors Directorate
Technology Laboratory

June 1977

Approved for public release; distribution unlimited.

U.S. ARMY
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Redstone Arsenal, Alabama 35809

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MACRO code list
EAI PACER 100
Optical contrast variable gate centroid tracker

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This report presents a description of the optical contrast variable gate centroid tracker. Tracking flow charts and computer listings are also presented.

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I. INTRODUCTION

The US Army Missile Research and Development Command's Imaging Seeker Algorithm Development Microprocessor System, which employs the Intel 3000 microprocessor, was used in developing this optical contrast variable gate centroid tracker. The tracker processes data taken from a 10K memory which has been "filled" with digitized data from a 100 × 100 element image produced by a Fairchild Charge Couple Device (CCD) 201 camera. A hardware description of this system is currently being prepared and will be published in a forthcoming report.

The major portion of the tracker program is micro coded and is called through macro-mnemonics which are used like subroutine calls. This macro instruction set is an emulation of the EAI-PACER 100 assembly language with some additions to allow for the specialized tracker mnemonics. The actual program listings for the micro and macro code are presented in the appendices.

II. MAIN TRACKER LOGIC FLOW DESCRIPTION

Figure 1 shows the main flow of the optical contrast variable gate centroid tracker. The macro code presented in Appendix A implements the tracker through the micro coded subroutines presented in Appendix B.

Block No. 1 in Figure 1 corresponds to sequence numbers 19 through 23 in the macro code of Appendix A. The START routine initializes I, J, K, and L for the minimum gate as shown in Figure 2. The octal ten in latch 6 will put out the cross hairs on the gate display. The WINDOW routine will load the window latches with the current I, J, K, and L as shown in Figure 3. The tracker will display its minimum gate with cross hairs when it stops on the pause instruction. This is a "cage" mode where the contrast of the target within the 2 by 2 gate will be tracked upon resumption of execution by single stepping past the pause.

Block No. 2 in Figure 1 corresponds to sequence numbers 24 through 48 in the macro code. The six in latch 6 will enable the status on the 10K memory to be loaded from the 100 × 100 CCD array and will also enable the frame request. The FRAMEW routine will issue a frame request strobe to fill the 10K memory and loop until the status of the memory is ready as shown in Figure 4. Instructions 27 through 37 calculate the mean value of the data within the minimum gate. When this is compared to the "nominal" value of seven in this case (instructions 38 through 48), various flags are set to track either a "black" or "white" target. This nominal value does not need to be fixed as it is here, but could be set by an automatic gain control in an optimum situation. Instruction 49 reinitializes the I, J, K, and L micro registers destroyed during the mean value and compare calculations (START routine, Figure 5). Instructions 50 through 53 set up the bias and gain latches which decide the amplitude and bias point in the video that is to be digitized coming from the CCD array. Instructions 55 and 59 set the color of the tracking gate depending upon what contrast target will be tracked.

Block No. 3 in Figure 1 is represented by a FRAMEW instruction (sequence No. 57). Instructions 54 through 61 represent block No. 4 in Figure 1.

Instructions 62 through 73 represent block No. 5 in Figure 1. The MEAN instruction takes the digitized data within the tracking gate and calculates the mean value as shown in Figure 6.

Instructions 74, 75, and 76 represent block No. 6 in Figure 1. The EGATES instruction sets the size of the edge gates shown in Figure 2. It also sets the target flag if the macro code mean value calculation found the mean to be less than seven as shown in Figure 7.

Instructions 77 through 99 represent block No. 7 in Figure 1. The CNTRD instruction calculates the centroid of the target within the tracking gate as shown in Figure 8.

Instructions 100 through 122 represent block No. 8 in Figure 1. NGATEA and NGATEC calculate NX and NY, respectively.

$$NX = TAXG - AXG/2 + 4\ YS$$

$$NY = TAYG - AYG/2 + 4\ XS$$

TAXG is the target area in X gate

TAYG is the target area in Y gate

AXG is the total area of X gate

AYG is the total area of Y gate

XS is the length of gate in X direction

YS is the length of gate in Y direction

NGATEB and NGATEL calculate I, K and J, L, respectively.

$$DX = NX/(4\ YS)$$

$$DY = NY/(4\ XS)$$

$$DELXX = -\left(\frac{XS}{2} + DX\right)$$

I = X beginning of gate = DELXX + CX

K = X end of gate = CX - DELXX

$$\text{DELYY} = -\left(\frac{\text{YS}}{2} + \text{DY}\right)$$

J = Y beginning of gate = DELYY + CY

L = Y end of gate = CY - DELYY

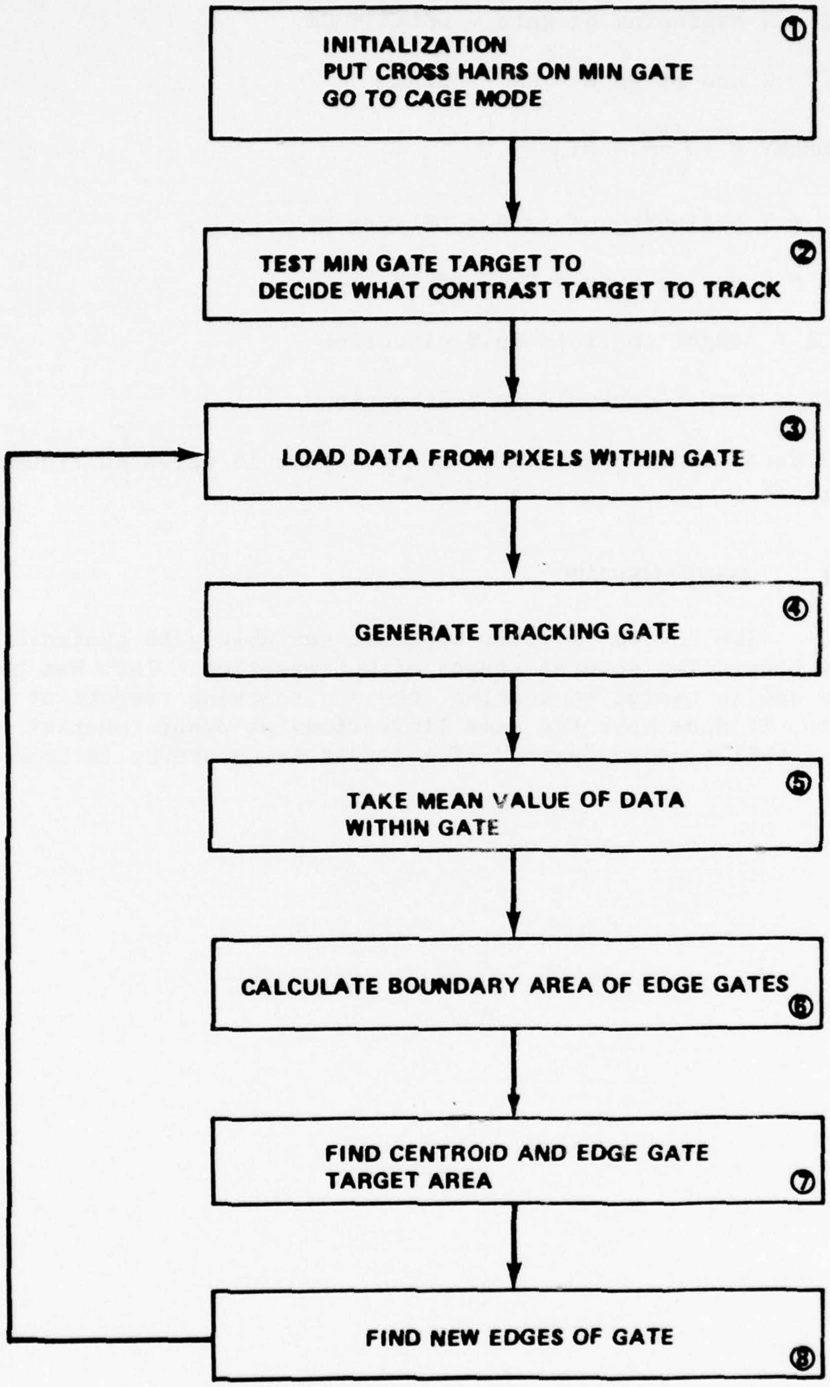
CX = target centroid in X direction

CY = target centroid in Y direction

A detailed calculation of the new gate is shown in Figures 9 through 12.

III. CONCLUSIONS

The current optical contrast variable gate centroid tracker is now undergoing several stages of optimization. This has been implemented and is useful in locking onto and tracking targets at long ranges; however, it does have the same limitations as other contrast trackers, i.e., a well bounded "patch" of contrast is necessary to track properly.



① INITIALIZATION
PUT CROSS HAIRS ON MIN GATE
GO TO CAGE MODE
② TEST MIN GATE TARGET TO
DECIDE WHAT CONTRAST TARGET TO TRACK
③ LOAD DATA FROM PIXELS WITHIN GATE
④ GENERATE TRACKING GATE
⑤ TAKE MEAN VALUE OF DATA
WITHIN GATE
CALCULATE BOUNDARY AREA OF EDGE GATES ⑥
FIND CENTROID AND EDGE GATE
TARGET AREA ⑦
FIND NEW EDGES OF GATE ⑧

Figure 1. Main tracking loop.

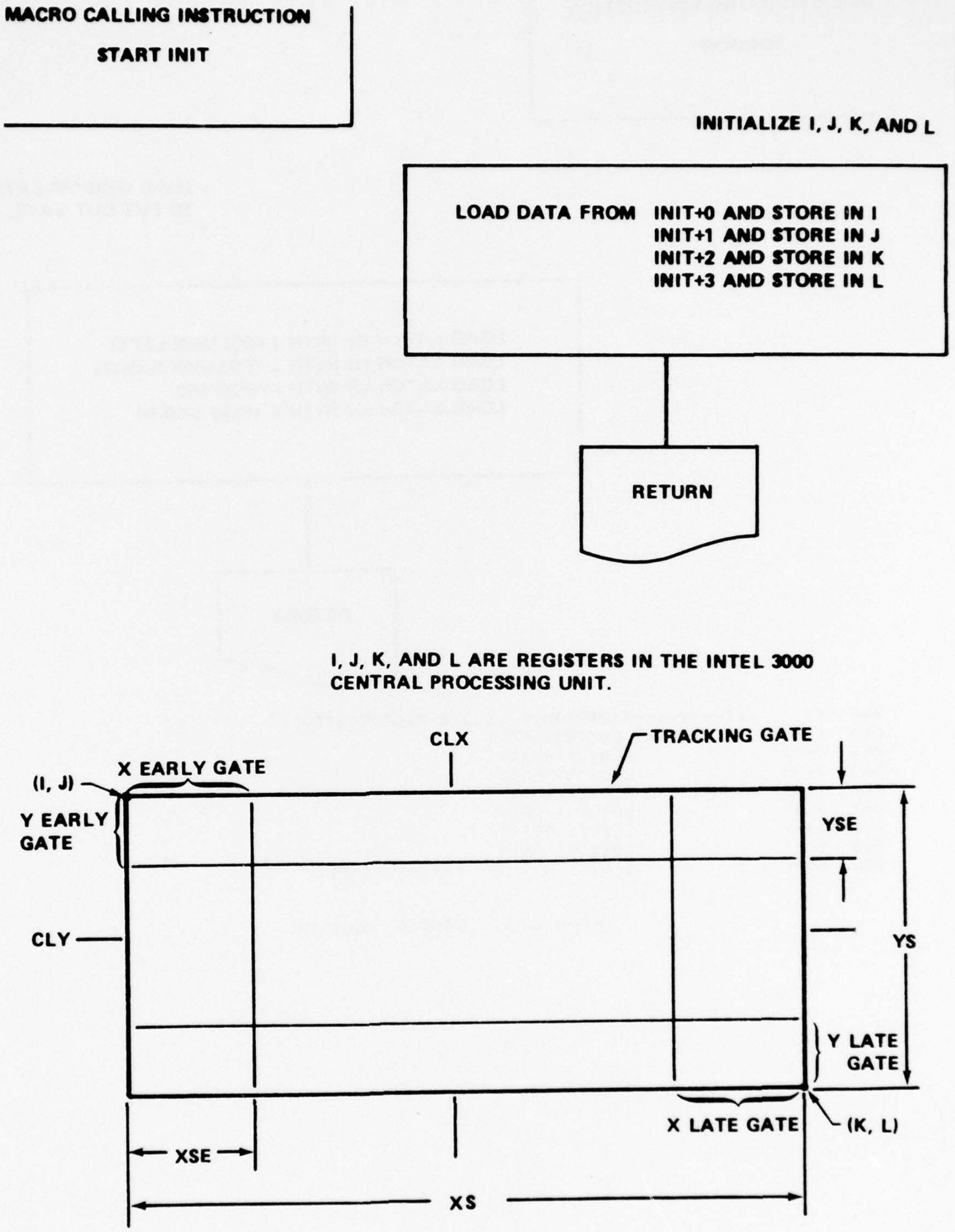
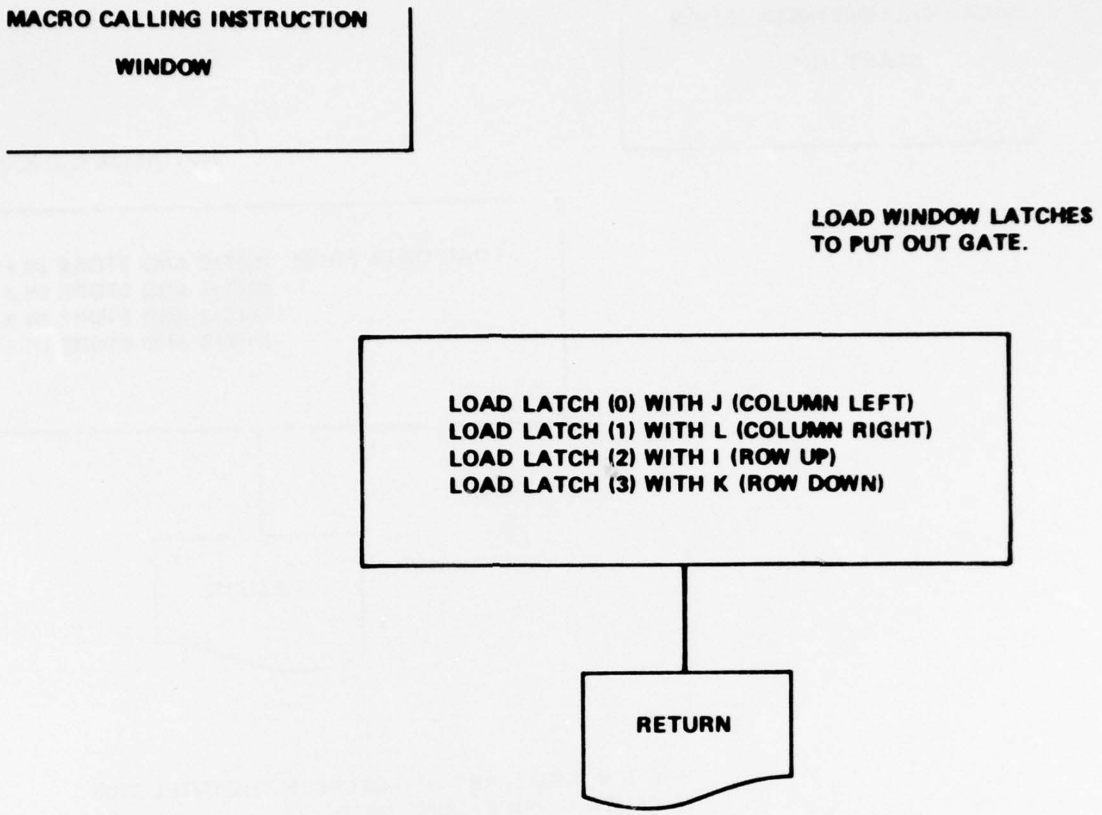


Figure 2. START routine for minimum gate.

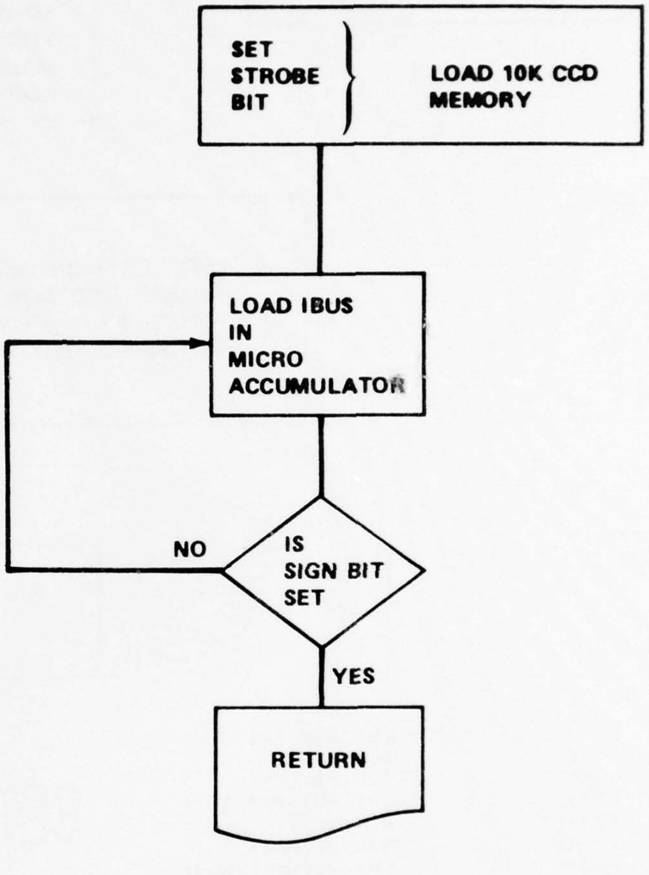

MACRO CALLING INSTRUCTION
WINDOW
LOAD WINDOW LATCHES TO PUT OUT GATE.
LOAD LATCH (0) WITH J (COLUMN LEFT)
LOAD LATCH (1) WITH L (COLUMN RIGHT)
LOAD LATCH (2) WITH I (ROW UP)
LOAD LATCH (3) WITH K (ROW DOWN)
RETURN

```
/*      WINDOW-----(VARIABLE WINDOW MICROROUTINE)           */
19H!       WINDOW! LMI(R9) FF1:
29H!               ILR(J) ROT:
39H!               LMI(R9) FF1:
49H!               ILR(L) ROT:
59H!               LMI(R9) FF1:
69H!               ILR(I) ROT:
6CH!               LMI(R9) FF1:
6DH!               ILR(K) ROT IZR(FETCH) PAGE1:
```

Figure 3. WINDOW routine.

MACRO CALLING INSTRUCTION

FRAMEW



NOTE: THE SIGN BIT OF THE IBUS IS THE STATUS READY FLAG FOR THE CCD 10K MEMORY

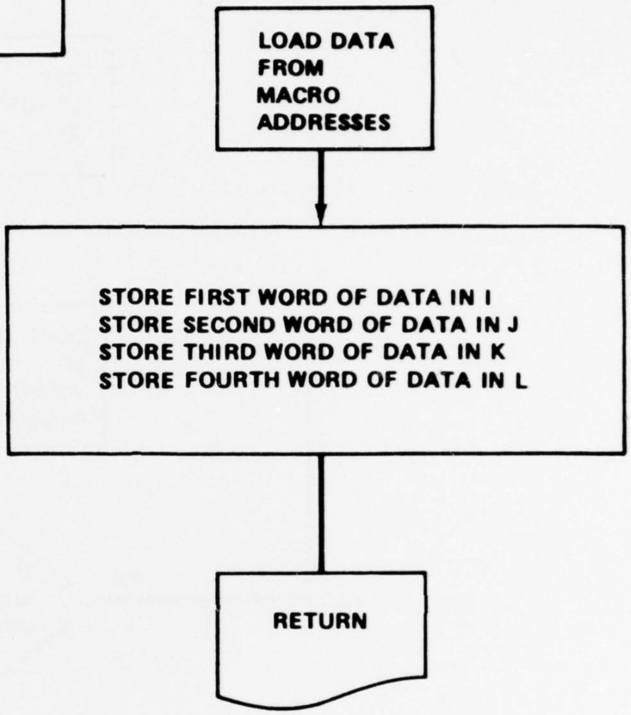
```
1AH!       FRAME! NOP(R8) STROBE2:
1AAH!      WAT!   NOP(R8) RIN:
1ACH!             LDI(AC) FF1:
1ADH!             TZR(AC) K80000:
1AEH!             NOP(R8) JFL(WAT,RDY):
1ABH!      RDY!   NOP(R8) JZR(FETCH) PAGE1:
```

Figure 4. FRAMEW routine.

```
MACRO CALLING INSTRUCTION

      START INIT

      INIT  OCT 61
            OCT 61
            OCT 63
            OCT 63
```


LOAD DATA FROM MACRO ADDRESSES
STORE FIRST WORD OF DATA IN I
STORE SECOND WORD OF DATA IN J
STORE THIRD WORD OF DATA IN K
STORE FOURTH WORD OF DATA IN L
RETURN

```
1BH!        START! LMI(R9) FF1 RRM:
3BH!               ACM(AC):
3DH!               SDR(I) FF1:
10DH!              LMI(R9) FF1 RRM:
12DH!              ACM(AC):
13DH!              SDR(J) FF1:
14DH!              LMI(R9) FF1 RRM:
15DH!              ACM(AC):
16DH!              SDR(K) FF1:
17DH!              LMI(R9) RRM:
18DH!              ACM(AC):
19DH!              SDR(L) FF1 JZR(FETCH) PAGE1:
```

Figure 5. Reinitialization of I, J, K, and L.

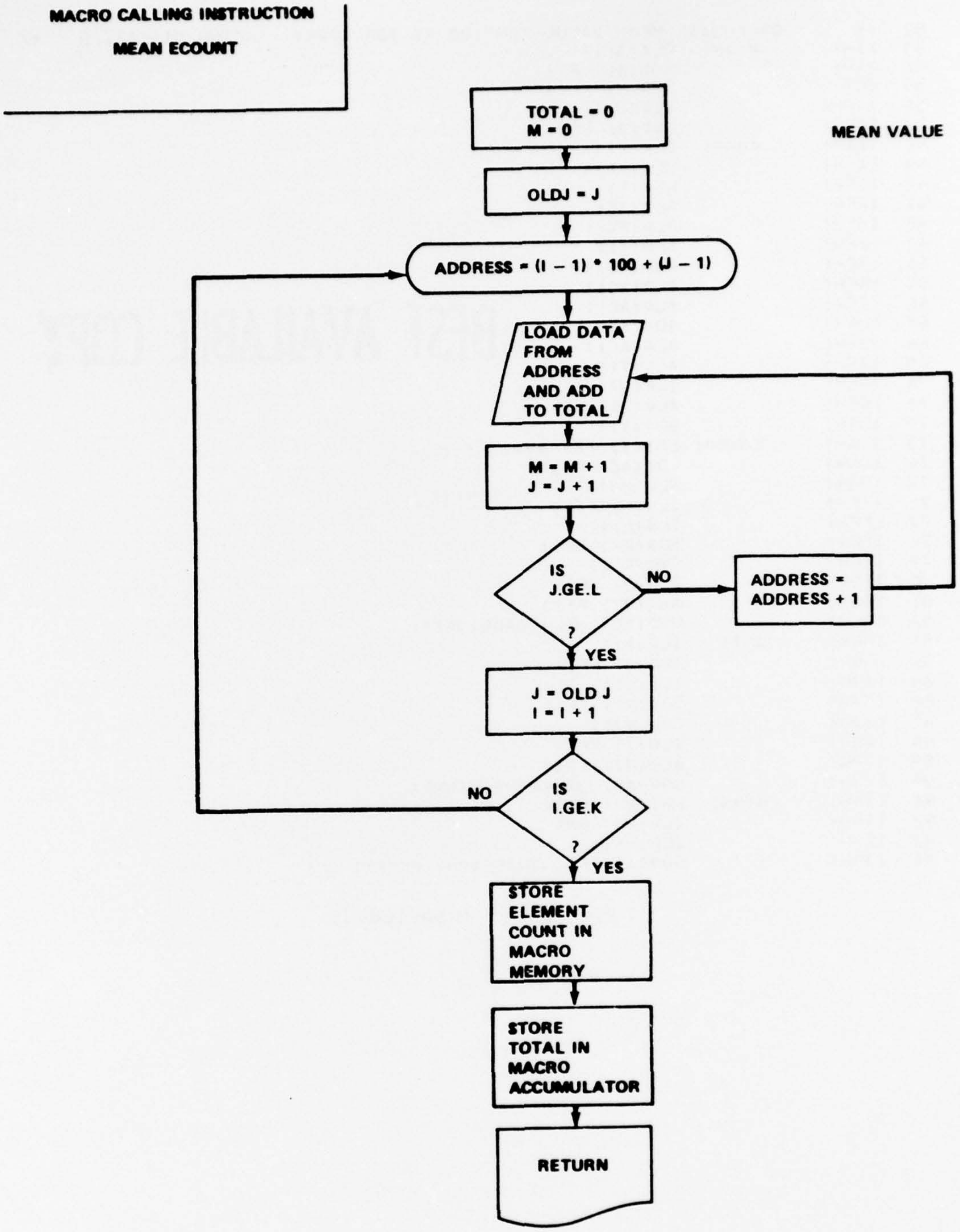

MACRO CALLING INSTRUCTION
MEAN ECOUNT
MEAN VALUE
TOTAL = 0
M = 0
OLDJ = J
ADDRESS = (I − 1) * 100 + (J − 1)
LOAD DATA FROM ADDRESS AND ADD TO TOTAL
M = M + 1
J = J + 1
IS J.GE.L ?
NO
ADDRESS = ADDRESS + 1
YES
J = OLD J
I = I + 1
IS I.GE.K ?
NO
YES
STORE ELEMENT COUNT IN MACRO MEMORY
STORE TOTAL IN MACRO ACCUMULATOR
RETURN

Figure 6. Calculation of mean value.

```
/*        CALCULATE MEAN VALUE FOR 100 BY 100 ARRAY   BEING DIGITIZED   */
11H!     MEAN!   CLA(AC);
21H!             SDR(R6) FF1:
2CH!             SDR(M) FF1:
10CH!            ILR(J);
11CH!            SDR(A) FF1:
11AH!    ADDR!   ILR(I);
11DH!            DCA(AC);
11EH!            CLA(T);
12EH!            ALR(AC);
13EH!            ALR(AC);
14EH!            ALR(T);
15EH!            ALR(AC);
16EH!            ALR(AC);
17EH!            ALR(AC);
18EH!            ADR(T);
19EH!            ALR(AC);
1AEH!            ALR(T);
1BEH!            ILR(J);
1CEH!            ALR(T);
1DEH!            SDR(T);
1DAH!    LOADD!  LMI(T) FF1 RRM;
1DDH!            LDI(AC) FF1:
1FDH!            ALR(R6);
1FEH!            ILR(M) FF1;
1FFH!            ILR(L);
1EFH!            SDR(R7) FF1:
1FEH!            CMR(R7);
1EDH!            ILR(J) FF1;
1ECH!            ALR(R7) FF1:
1DCH!            NOP(AC) JFL(LOADD.JGT);
1DBH!    JGT!    ILR(A);
1D9H!            SDR(J) FF1:
179H!            ILR(K);
169H!            SDR(R7) FF1:
159H!            CMR(R7);
149H!            ILR(I) FF1:
139H!            ALR(R7) FF1:
129H!            NOP(AC) JFL(ADDR.RTNN);
11BH!    RTNN!   LMI(R9) FF1:
11BH!            ILR(M) RWM:
12BH!            ILR(R6);
13BH!            SDR(A) FF1 JZR(FETCH) PAGE1:
```

Figure 6. (Concluded).

MACRO CALLING INSTRUCTION

EGATES	DELX
ADR	XG

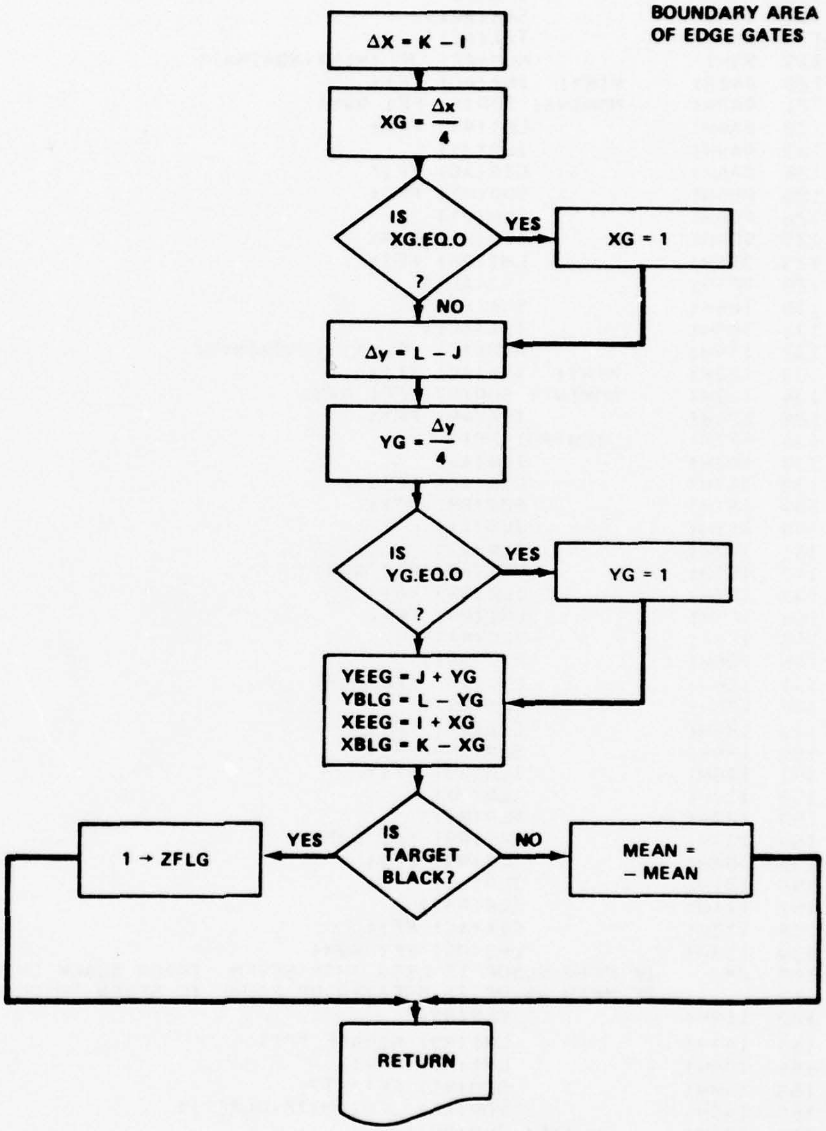


Figure 7. Setting of target flag when macro code mean value is less than seven.

```
/*          CALCULATE BOUNDARY AREA OF EDGE GATES      */
14H!          EGATES! LMI(P) FF1 RRM;
24H!                  ACM(AC);
34H!                  SDR(R6) FF1:
44H!                  LMI(R9) FF1:
54H!                  ILR(I);
64H!                  CIA(AC) FF1:
74H!                  SDR(R7) FF1:
84H!                  ILR(K);
85H!                  ALR(R7) RWM:
86H!                  LMI(R6) FF1:
87H!                  SRA(AC);
97H!                  SRA(AC);
96H!                  TZA(AC);
95H!                  NOP(AC) JFL(MINX,NOMINX);
0A2H!         MINX!   INA(AC) FF1:
0A3H!         NOMINX! SDR(A) FF1 RWM;
0A4H!                 LMI(R9) FF1:
0A5H!                 ILR(J);
0A6H!                 CIA(AC) FF1:
0B6H!                 SDR(R7) FF1:
0C6H!                 ILR(L);
0D6H!                 ALR(R7) RWM:
0E6H!                 LMI(R6) FF1:
0F6H!                 SRA(AC);
106H!                 SRA(AC);
105H!                 TZA(AC);
115H!                 NOP(AC) JFL(MINY,NOMINY);
122H!         MINY!   INA(AC) FF1:
123H!         NOMINY! SDR(R7) FF1 RWM;
124H!                 ILR(R9) FF1:
127H!           ILR(R9) FF1;
167H!                 ILR(A);
1A7H!                 CIA(AC) FF1:
1B7H!                 SDR(R8) FF1:
1C7H!                 ILR(I);
1D7H!                 ALR(A);
1E7H!                 LMI(R9) FF1 RWM:
1F7H!                 ILR(R9) FF1:
1F6H!                 LMI(R9) FF1:
1E6H!                 ILR(K);
1D6H!                 ALR(R8);
1C6H!                 CIA(AC) FF1 RWM:
1B6H!                 ILR(R7);
186H!                 CIA(AC) FF1:
156H!                 SDR(R8) FF1:
116H!                 ILR(R9) FF1:
117H!                 ILR(J);
107H!                 ALR(R7);
103H!                 LMI(R9) FF1 RWM;
102H!                 ILR(R9) FF1:
101H!                 ILR(L);
111H!                 ALR(R8);
112H!                 CIA(AC) FF1:
113H!                 LMI(R9) FF1 RWM:
/*          IF MEAN VLAUE IS LESS THAN SEVEN  TRACK BLACK ON WHITE
            IF MEAN VALUE IS GREATER OR EQUAL TO SEVEN TRACK WHITE ON BLACK*/
119H!                  CLR(R9);
109H!                  LMI(R9) K0000F FF1:
108H!                  LMI(R9) RRM;
148H!                  ACM(AC) FF1 STZ:
14CH!                  NOP(AC) JFL(WHITE,BLACK):
12AH!           WHITE! CLR(R9):
10AH!                  LMI(R9) K00005 RRM:
10BH!                  LCM(AC);
10EH!                 INA(AC) FF1 RWM PAGE1 JZR(FETCH):
12BH!           BLACK! NOP(AC) PAGE1 JZR(FETCH):
```

Figure 7. (Concluded).

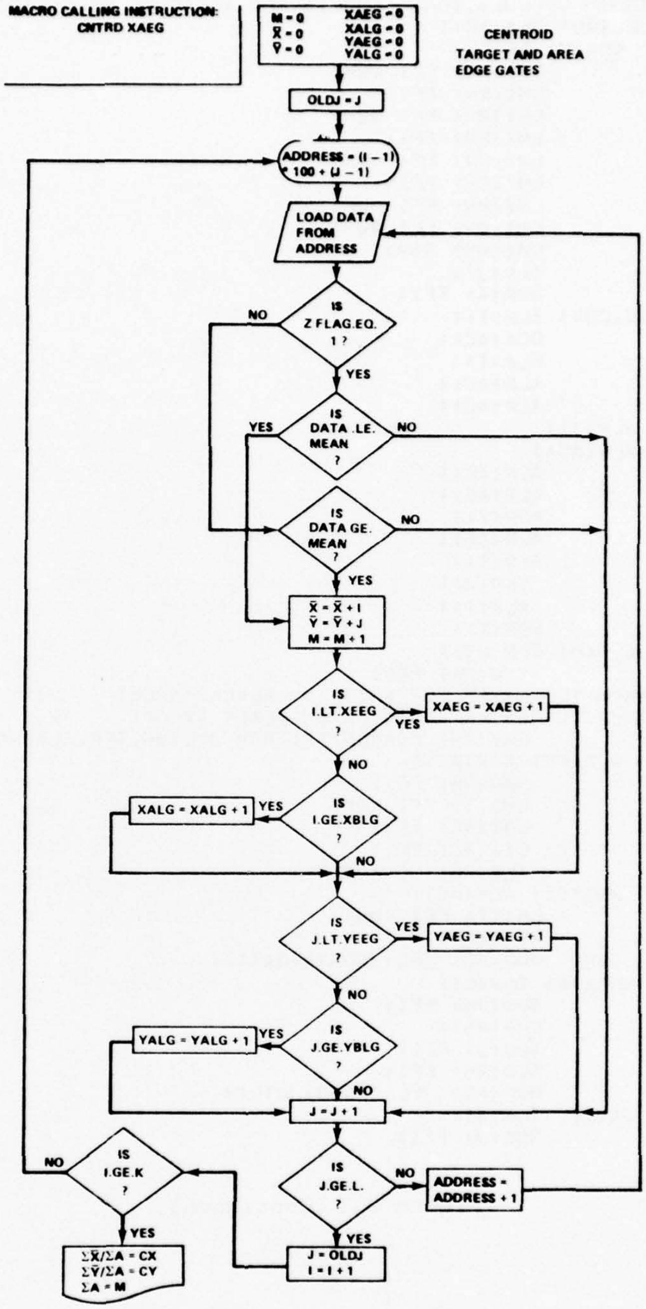
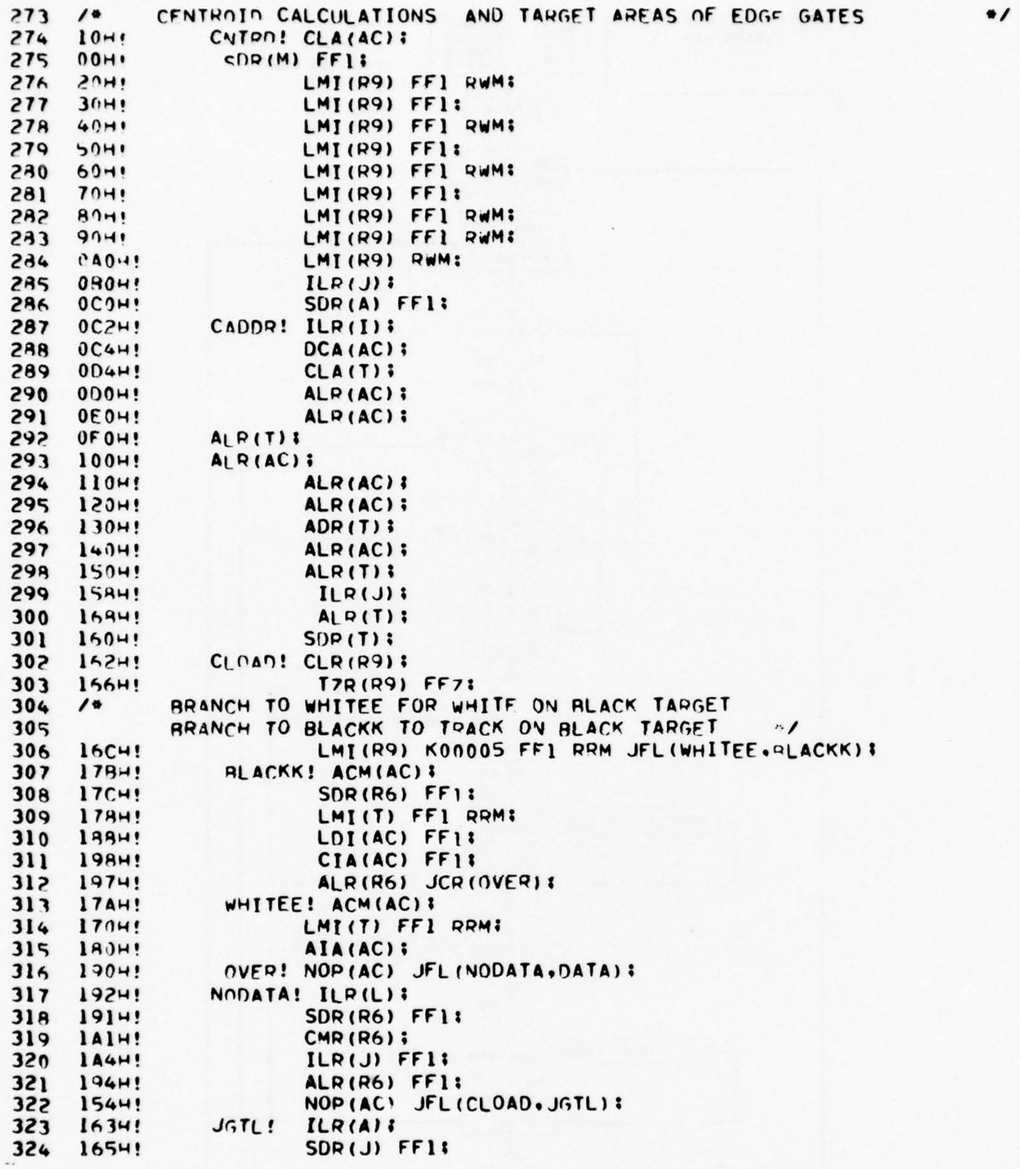


Figure 8. CNTRD calculation of target centroid within tracking gate.

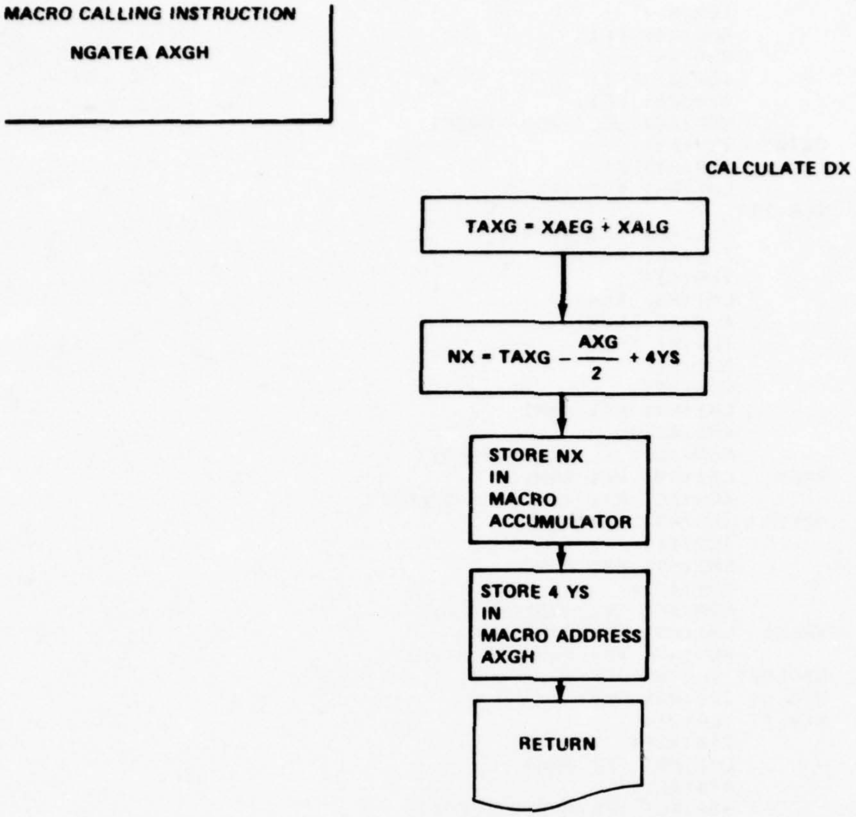


```
/*     CENTROID CALCULATIONS  AND TARGET AREAS OF EDGE GATES          */
10H!       CNTRD! CLA(AC);
00H!        SDR(M) FF1;
20H!              LMI(R9) FF1 RWM;
30H!              LMI(R9) FF1:
40H!              LMI(R9) FF1 RWM;
50H!              LMI(R9) FF1:
60H!              LMI(R9) FF1 RWM:
70H!              LMI(R9) FF1:
80H!              LMI(R9) FF1 RWM;
90H!              LMI(R9) FF1 RWM;
0A0H!             LMI(R9) RWM:
0B0H!             ILR(J);
0C0H!             SDR(A) FF1;
0C2H!      CADDR! ILR(I);
0C4H!             DCA(AC);
0D4H!             CLA(T);
0D0H!             ALR(AC);
0E0H!             ALR(AC);
0F0H!      ALR(T);
100H!      ALR(AC);
110H!             ALR(AC);
120H!             ALR(AC);
130H!             ADR(T);
140H!             ALR(AC);
150H!             ALR(T);
158H!               ILR(J);
168H!               ALR(T);
160H!             SDR(T);
162H!      CLOAD! CLR(R9);
166H!               TZR(R9) FF7:
/*     BRANCH TO WHITEE FOR WHITE ON BLACK TARGET
       BRANCH TO BLACKK TO TRACK ON BLACK TARGET     */
16CH!               LMI(R9) K00005 FF1 RRM JFL(WHITEE.BLACKK);
17BH!        BLACKK! ACM(AC);
17CH!               SDR(R6) FF1:
178H!               LMI(T) FF1 RRM;
188H!               LDI(AC) FF1;
198H!               CIA(AC) FF1;
197H!               ALR(R6) JCR(OVER);
17AH!        WHITEE! ACM(AC);
170H!             LMI(T) FF1 RRM;
180H!             AIA(AC);
190H!        OVER! NOP(AC) JFL(NODATA,DATA);
192H!      NODATA! ILR(L);
191H!             SDR(R6) FF1;
1A1H!             CMR(R6);
1A4H!             ILR(J) FF1;
194H!             ALR(R6) FF1:
154H!             NOP(AC) JFL(CLOAD.JGTL):
163H!      JGTL!  ILR(A);
165H!             SDR(J) FF1;
```

Figure 8. (Continued).

```
145H!             ILR(K);
144H!             SDR(R6) FF1;
104H!             CMR(R6);
0F4H!             ILR(I) FF1;
0E4H!             ALR(R6) FF1;
0B4H!             NOP(AC) JFL(CADDR.ENDC):
193H!     DATA!   ILR(R9);
195H!             SDR(R6)FF1;
1A5H!             LMI(R6) K00008;
1A0H!     ILR(I);
180H!             LMI(R6) FF1 RRM;
1C0H!             AMA(AC) RWM:
1D0H!             ILR(J);
1E0H!             LMI(R6) RRM:
1F0H!             AMA(AC) RWM;
1F5H!             ILR(M) FF1;
1E5H!             ILR(I);
1D5H!             CIA(AC);
1D4H!             LMI(R9) FF1 RRM;
1C4H!             AMA(AC);
1C5H!             NOP(AC) JFL(NXEEG.XEEG);
183H!     XEEG!   LMI(R9) FF1 RRM;
184H!             ACM(AC) FF1 RWM JCC(NXBLG2);
182H!     NXEEG!  ILR(R9) FF1;
181H!             ILR(I);
181H!             LMI(R9) FF1 RRM;
171H!             AMA(AC);
161H!             NOP(AC) JFL(NXBLG.XBLG):
173H!     XBLG!   LMI(R9) FF1 RRM;
175H!             ACM(AC) FF1 RWM JCR(NXBL);
174H!     NXBLG2! ILR(R9) FF1;
172H!     NXBLG!  ILR(R9) FF1:
177H!     NXBL!   ILR(J);
137H!             CIA(AC);
136H!             LMI(R9) FF1 RRM;
135H!             AMA(AC);
134H!             NOP(AC) JFL(NYEEG.YEEG):
143H!     YEEG!   LMI(R9) FF1 RRM;
146H!             ACM(AC) FF1 RWM:
196H!             NOP(A) JCR(NODATA);
142H!     NYEEG!  ILR(R9) FF1:
147H!             ILR(J);
157H!             LMI(R9) FF1 RRM;
187H!             AMA(AC);
184H!             NOP(AC) JFL(NODAT.YBLG):
183H!     YBLG!   LMI(R9) FF1 RRM;
185H!             ACM(AC) FF1 RWM JCR(NODAT);
0C3H!     ENDC!   CLR(R9);
0C5H!             LMI(R9) K00004;
0E5H!             ILR(M) RWM PAGE1 JZR(FETCH);
182H!     NODAT!  NOP(A) JCC(NODATA):
```

Figure 8. (Concluded).

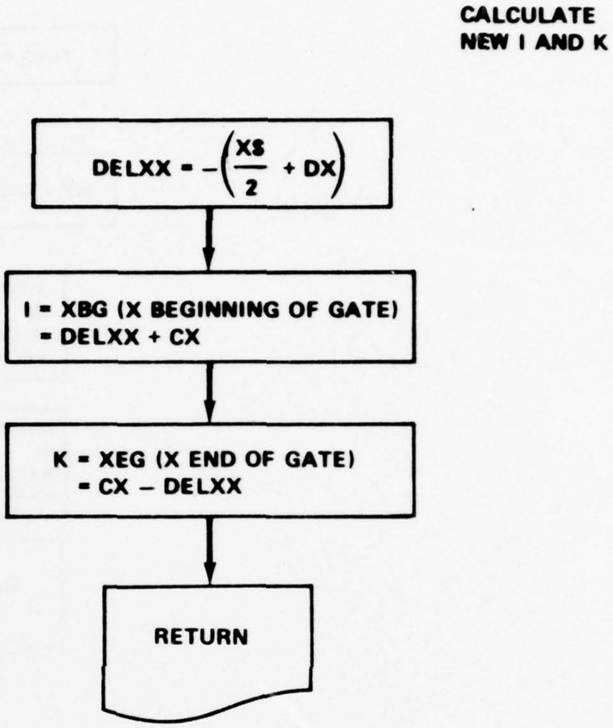

MACRO CALLING INSTRUCTION
NGATEA AXGH
CALCULATE DX
TAXG = XAEG + XALG
NX = TAXG – AXG/2 + 4YS
STORE NX IN MACRO ACCUMULATOR
STORE 4 YS IN MACRO ADDRESS AXGH
RETURN

```
/*          NGATEA NGATEB NGATEC AND NGATEL CALCULATE EDGES OF THE GATE
            AND THE NEW I J K L                                */
15H!         NGATEA! LMI(R9) RRM:
25H!                 ACM(AC):
35H!                 CIA(AC) FF1:
45H!                 SDR(R6) FF1:
55H!                 CLR(R7):
65H!                 LMI(R7) K00007:
75H!                 LMI(R7) FF1 RRM:
0B5H!                ACM(AC):
0BCH!                LMI(R7) FF1:
0DCH!                LMI(R7) RRM:
0DDH!                AMA(AC):
0CDH!                ADR(R6):
0BDH!                CLR(R7):
0ADH!                LMI(R7) K00003:
9DH!                 LMI(R7) RRM:
8DH!                 ACM(AC):
8CH!                 ALR(AC):
9CH!                 ALR(AC):
0ACH!                LMI(R9) FF1 RWM:
0CCH!                ALR(R6):
0CEH!                SDR(A) FF1 IZR(FETCH) PAGE1:
```

Figure 9. New gate calculation of DX.

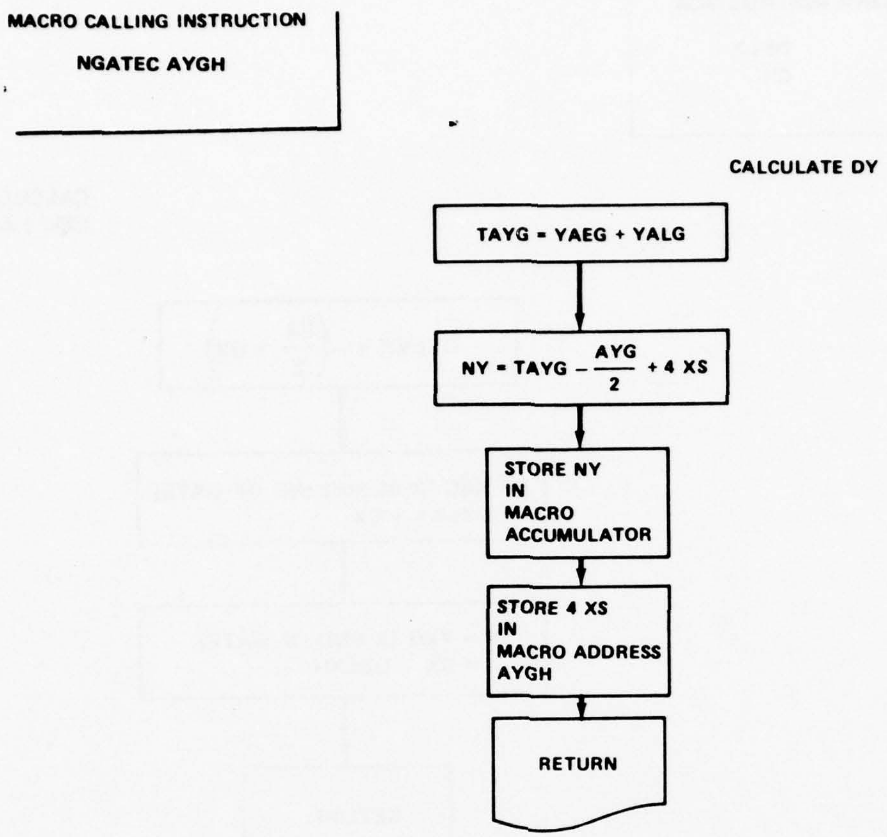
MACRO CALLING INSTRUCTION

NGATEB	DELX
ADR	CX



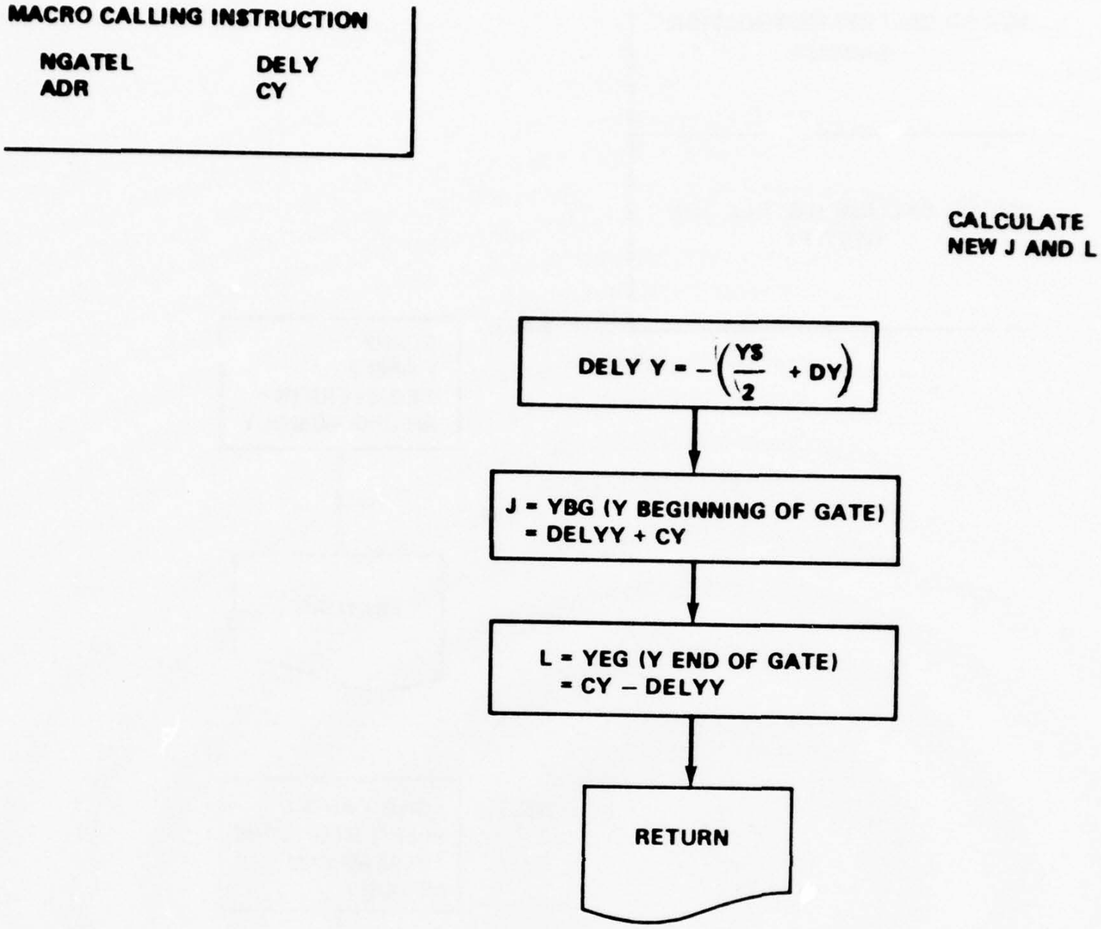
```
16H!        NGATEB! LMI(R9) RRM:
26H!                ACM(AC):
36H!                SRA(AC):
46H!                ALR(A):
56H!                SDR(A) FF1:
66H!                CIA(AC) FF1:
76H!                LMI(P) FF1 RRM:
79H!                LMM(T) RRM:
89H!                AMA(AC):
99H!                SDR(I) FF1:
0A9H!               ILR(A) RRM:
0B9H!               AMA(AC):
0C9H!               SDR(K) FF1 JZR(FETCH) PAGE1:
```

Figure 10. New gate calculation of I and K.


MACRO CALLING INSTRUCTION
NGATEC AYGH
CALCULATE DY
TAYG = YAEG + YALG
NY = TAYG – AYG/2 + 4 XS
STORE NY IN MACRO ACCUMULATOR
STORE 4 XS IN MACRO ADDRESS AYGH
RETURN

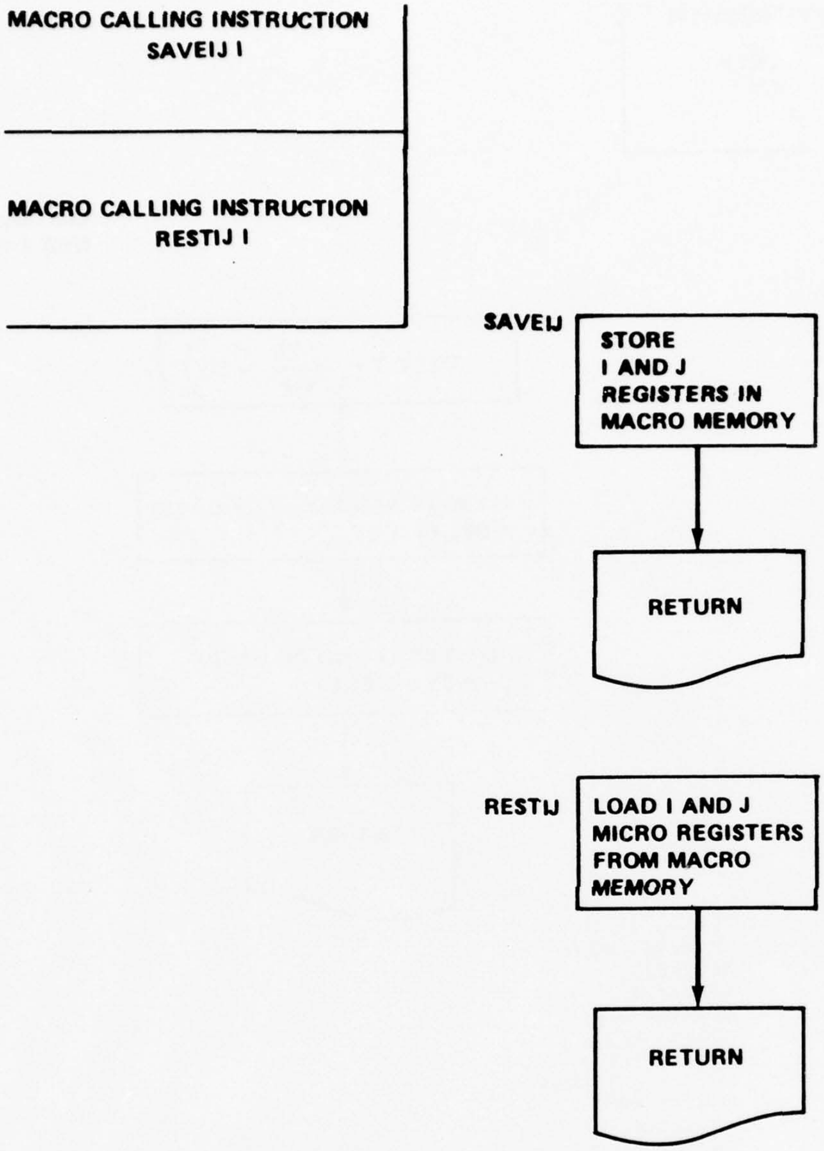
```
17H!       NGATEC! LMI(R9) RRM:
27H!               ACM(AC):
37H!               CIA(AC) FF1:
47H!               SDR(R6) FF1:
57H!               CLR(R7):
67H!               LMI(R7) K00008:
77H!               LMI(R7) FF1 RRM:
0A7H!              ACM(AC):
0B7H!              LMI(R7) FF1:
0C7H!              LMI(R7) RRM:
0D7H!              AMA(AC):
0E7H!              ADR(R6):
0F7H!              CLR(R7):
0F8H!              LMI(R7) K00002:
0F9H!              LMI(R7) RRM:
0FCH!              ACM(AC):
0FDH!              ALR(AC):
0EDH!              ALR(AC):
0ECH!              LMI(R9) FF1 RWM:
0E9H!              ALR(R6):
0E8H!              SDR(A) FF1 JZR(FETCH) PAGE1:
```

Figure 11. New gate calculation of DY.



```
1BH!         NGATEL! LMI(R9) RRM:
2BH!                 ACM(AC):
3BH!                 SRA(AC):
4BH!                 ALR(A):
5BH!                 SDR(A) FF1:
6BH!                 CIA(AC) FF1:
7BH!                 LMI(P) FF1 RRM:
8BH!                 LMM(T) RRM:
9BH!                 AMA(AC):
0ABH!                SDR(J) FF1:
0BBH!                ILR(A) RRM:
0CBH!                AMA(AC):
0DBH!                SDR(L) FF1 JZR(FETCH) PAGE1:
```

Figure 12. New gate calculation of J and L.



```
12H!       SAVEIJ! LMI(R9) FF1:
                   ILR(I) RWM:
32H!
31H!               LMI(R9):
41H!               ILR(J) RWM JZR(FETCH) PAGE1:


13H!       RESTIJ! LMI(R9) FF1 RRM:
53H!               ACM(AC):
51H!               SDR(I) FF1:
61H!               LMI(R9) RRM:
71H!               ACM(AC):
81H!               SDR(J) FF1 JZR(FETCH) PAGE1:
```

Appendix A.

TRACKER MACRO CODE LISTING

```
 1: 00000 000001 010000                  OCT    21
~~ 2: 00001 000004 000000                  OCT    100~~
 3: 00002 000001 000002        DELX      BSS    1
~~ 4: 00003 000001 000003        DELY      BSS    1~~
 5: 00004 000001 000004        ASUM      BSS    1
~~ 6: 00005 000001 000005        MEAN2     BSS    1~~
 7: 00006 000001 000006        XEEG      BSS    1
~~ 8: 00007 000001 000007        XAEG      BSS    1~~
 9: 00010 000001 000010        XBLG2     BSS    1
~~10: 00011 000001 000011        XALG      BSS    1~~
11: 00012 000001 000012        YEEG      BSS    1
~~12: 00013 000001 000013        YAEG      BSS    1~~
13: 00014 000001 000014        YBLG2     BSS    1
~~14: 00015 000001 000015        YALG      BSS    1~~
15: 00016 000001 000016        XBAR      BSS    1
~~16: 00017 000001 000017        YBAR      BSS    1~~
17: 00020 000001 000020        BWF        BSS    1
~~                                         ABS    100~~
19: 00100 125400 000262                  START  INIT
~~20: 00101 000000 000275                  LA      TEN~~
21: 00102 176400 060000                   DO     6
~~22: 00103 124400 000000                   WINDOW~~
23: 00104 037400 000000                   P
~~24: 00105 000000 000270                   LA     SIX~~
25: 00106 176400 060000                   DO     6
~~26: 00107 125000 000000                   FRAMEW~~
27: 00110 000000 000273                   LA     THREE
~~28: 00111 176400 060000                   DO     6~~
29: 00112 120400 000254                   MEAN   ECOUNT
~~30: 00113 174400 000000                  EQ~~
31: 00114 000000 000254                   LA     ECOUNT
~~32: 00115 032400 070000                   ALS    7~~
33: 00116 000400 000254                   STA    ECOUNT
~~34: 00117 030000 000000                   CLR~~
35: 00120 174400 000000                  EQ
~~36: 00121 003400 000254                   D      ECOUNT~~
37: 00122 033000 140000                   LRS    14
~~38: 00123 006000 000274                   C      SEVEN~~
39: 00124 072000 000000                   SGE
~~40: 00125 010000 000132                  J       BLACK~~
41: 00126 030000 000000                   CLR
~~42: 00127 000400 000374                   STA    TARGET~~
43: 00130 000400 000020                   STA    BWF
~~44: 00131 010000 000136                   J      WHITE~~
45: 00132 000000 000277        BLACK     LA      OONE
~~46: 00133 000400 000020                   STA    BWF~~
47: 00134 000000 000276                   LA     TWENTY
~~48: 00135 000400 000374                   STA    TARGET~~
49: 00136 125400 000262        WHITE      START INIT
~~50: 00137 000000 000272                  LA      T31~~
*      SET GAIN TO MAX
~~51: 00140 176400 050000                  DO      5~~
*      SET    OFFSET TO BLANKING LEVEL
~~52: 00141 000000 000271                  LA      BIAS~~
53: 00142 176400 040000                  DO      4
~~*      STORE MODE LATCH FOR VIDEO~~
54: 00143 000000 000270        START     LA      SIX
~~55: 00144 004400 000374                   OR     TARGET~~
56: 00145 176400 060000                  DO      6
```

```
        ~~REQUEST FRAME AND WAIT TILL DATA READY~~
 57: 00146 125000 000000                 FRAMEW
        ~~SET MODE LATCH FOR READ MODE~~
 58: 00147 000000 000266                  LA      ONE
 59: 00150 004400 000374                  OR      TARGET
 60: 00151 176400 060000                 DO      6
~~ 61: 00152 124400 000000                 WINDOW~~
 62: 00153 121000 000255                 SAVEIJ I
~~ 63: 00154 120400 000254                 MEAN    ECOUNT~~
 64: 00155 174400 000000                  EQ
~~ 65: 00156 000000 000254                 LA       ECOUNT~~
 66: 00157 032400 070000                  ALS     7
~~ 67: 00160 000400 000254                 STA      ECOUNT~~
 68: 00161 030000 000000                 CLR
~~ 69: 00162 174400 000000                  EQ~~
 70: 00163 003400 000254                 D       ECOUNT
~~ 71: 00164 033000 140000                 LRS      14~~
 72: 00165 000400 000005                 STA     MEAN2
~~ 73: 00166 121400 000255                 RESTIJ I~~
 74: 00167 122000 000002                 EGATES DELX
~~ 75: 00170 000000 000256                 ADR     XG~~
 76: 00171 121000 000255                 SAVEIJ I
~~ 77: 00172 120000 000017                 CNTRD  XAEG~~
 78: 00173 000000 000004                  LA      ASUM
~~ 79: 00174 032400 070000                  ALS     7~~
 80: 00175 000400 000004                  STA    ASUM
~~ 81: 00176 030000 000000                  CLR~~
 82: 00177 174400 000000                  EQ
~~ 83: 00200 000000 000016                 LA      XPAR~~
 84: 00201 003400 000004                 D       ASUM
~~ 85: 00202 033000 140000                  LRS     14~~
 86: 00203 000400 000252                 STA     CX
~~ 87: 00204 000000 000017                 LA      YPAR~~
 88: 00205 003400 000004                 D       ASUM
~~ 89: 00206 033000 140000                  LRS     14~~
 90: 00207 000400 000253                 STA     CY
~~ 91: 00210 000000 000003                 LA      DELY~~
 92: 00211 003000 000250                 M       XG
~~ 93: 00212 174400 000000                  EQ~~
 94: 00213 000400 000257                 STA     AXGH
~~ 95: 00214 000000 000002                 LA      DELX~~
 96: 00215 003000 000251                 M       YG
~~ 97: 00216 174400 000000                  EQ~~
 98: 00217 000400 000260                 STA     AYGH
~~ 99: 00220 121400 000255                 RESTIJ I~~
100: 00221 122400 000257                 NGATEA AXGH
~~101: 00222 174400 000000                  EQ~~
102: 00223 000000 000257                  LA      AXGH
~~103: 00224 032400 040000                 ALS      4~~
104: 00225 000400 000257                  STA     AXGH
~~105: 00226 030000 000000                  CLR~~
106: 00227 174400 000000                  EQ
~~107: 00230 003400 000257                 D        AXGH~~
108: 00231 032000 100000                  ARS     18
~~109: 00232 123000 000002                 NGATEB DELX~~
110: 00233 000000 000252                 ADR     CX
~~111: 00234 123400 000260                 NGATEC AYGH~~
112: 00235 174400 000000                  EQ
~~113: 00236 000000 000260                  LA       AYGH~~
114: 00237 032400 040000                  ALS     4
~~115: 00240 000400 000260                  STA      AYGH~~
116: 00241 030000 000000                  CLR
```

```
~~117: 00242 174400 000000                 EQ~~
118: 00243 003400 000260                 D        AYGH
~~119: 00244 032000 130000                 ARS      18~~
120: 00245 124000 000003                 NGATEL   DELY
~~121: 00246 000000 000253                 ADR      CY~~
122: 00247 010000 000143                 J        START
~~123: 00250 000001 000250     XG          BSS      1~~
124: 00251 000001 000251     YG          BSS      1
~~125: 00252 000001 000252     CX          BSS      1~~
126: 00253 000001 000253     CY          BSS      1
~~127: 00254 000001 000254     ECOUNT      BSS      1~~
128: 00255 000001 000255     I           BSS      1
~~129: 00256 000001 000256     J           BSS      1~~
130: 00257 000001 000257     AXGH        BSS      1
~~131: 00260 000001 000260     AYGH        BSS      1~~
132: 00261 000001 000261     AG2         BSS      1
~~133: 00262 000003 010000     INIT        OCT      61~~
134: 00263 000003 010000                 OCT      61
~~135: 00264 000003 030000                 OCT      63~~
136: 00265 000003 030000                 OCT      63
~~137: 00266 000000 010000     ONE         OCT      1~~
138: 00267 000000 020000     TWO         OCT      2
~~139: 00270 000000 060000     SIX          OCT      6~~
140: 00271 000000 060000     BIAS        OCT      6
~~141: 00272 000001 110000     T31         OCT      31~~
142: 00273 000000 030000     THREE       OCT      3
~~143: 00274 000000 070000     SEVEN        OCT      7~~
144: 00275 000000 100000     TEN          OCT      10
~~145: 00276 000001 000000     TWENTY       OCT      20~~
146: 00277 177777 17[illegible]00     OONE         OCT      3 77 77 77
~~147: 00300 000000 000300     XXA          BSS      12~~
148: 00312 000000 000312     XXB          BSS      12
~~149: 00324 000000 000324     YYA          BSS      12~~
150: 00336 000000 000336     YYB          BSS      12
~~151: 00350 000000 000350     YYC          BSS      12~~
152: 00362 000000 000362     DMP          BSS      12
~~153: 00374 000001 000374     TARGET BSS 1~~
154: 00375 060000 000000     G            OCT      1400000
```

Appendix B.

TRACKER MICRO CODE LISTING

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 2

RECORD
NUMBER


KBUSS       FIELD  LENGTH=5   DEFAULT=0
                   MICROPS(KFFFFF=10101B   KFFFFA=10100B   K7FFFF=10011B
                           K80000=10010B   K00FFF=10001B   K00060=10000B
                           K0000F=01111B   K0000E=01110B   K0000D=01101B
                           K0000C=01100B   K0000B=01011B   K0000A=01010B
                           K00009=01001B   K00008=01000B   K00007=00111B
                           K00006=00110B   K00005=00101B   K00004=00100B
                           K00003=00011B   K00002=00010B   K00001=00001B
                           K00000=00000B);
KBUSS       KBUS;

/* ALL MICROCODE IS ON PAGE2 WITH DEFAULT SET TO 0001 FOR OTHER */
OTHER       FIELD  LENGTH=5   DEFAULT=00001B
            MICROPS(STROBE=10000B  PAGE1=00000B  PAGE2=00001B
                    STROBE2=10001B);

/* DEFINITION OF BUS CONTROL FIELD           */

CBUS         FIELD  LENGTH=3            DEFAULT=0
            MICROPS(NBO=000B   INH=001B   RMW=010B   CNB=011B
                    RIN=100B   ROT=101B   RRM=110B   RWM=111B);

/*          NBO    NOBUS OPERATION
            INH    INHIBIT CPE ARRAY
            RMW    READ-MODIFY-WRITE
            CNB    CPU NEEDS BUS
            RIN    REQUEST INPUT
            ROT    REQUEST OUTPUT
            RRM    REQUEST READ MEMORY
            RWM    REQUEST WRITE MEMORY

            SET UP SYMBOLIC REPRESENTATION OF REGISTER DESIGNATIONS */

A           STRING 'R0';
I           STRING 'R1';
J           STRING 'R2';
P           STRING 'R3';
K           STRING 'R4';
L           STRING 'R5';
TEMP        STRING 'R6';
TEMP2       STRING 'R7';
M           STRING 'R8';

PAUSE     . FIELD  LENGTH=1   DEFAULT=1
                   MICROPS(PP=0);


0FH!        FETCH! NOP(A) JPR(CNTRD MEAN SAVEIJ RESTIJ EGATES NGATEA
                NGATEB NGATEC NGATEL WINDOW FRAME START NOTC NOTD NOTE
                        NOTF);
/*        CALCULATE MEAN VALUE FOR 100 BY 100 ARRAY   BEING DIGITIZED   */
11H!        MEAN!  CLA(AC);
21H!               SDR(R6) FF1;
```

```
RECORD
NUMBER

  55   2CH!                SDR(M) FF1;
  56   10CH!               ILR(J);
  57   11CH!               SDR(A) FF1;
  58   11AH!      ADDR!    ILR(I);
  59   11DH!               DCA(AC);
  60   11EH!               CLA(T);
  61   12EH!               ALR(AC);
  62   13EH!               ALR(AC);
  63   14EH!               ALR(T);
  64   15EH!               ALR(AC);
  65   16EH!               ALR(AC);
  66   17EH!               ALR(AC);
  67   18EH!               ADR(T);
  68   19EH!               ALR(AC);
  69   1AEH!               ALR(T);
  70   1BEH!               ILR(J);
  71   1CEH!               ALR(T);
  72   1DEH!               SDR(T);
  73   1DAH!      LOADD!   LMI(T) FF1 RRM;
  74   1DDH!               LDI(AC) FF1:
  75   1FDH!               ALR(R6);
  76   1FEH!               ILR(M) FF1;
  77   1FFH!               ILR(L);
  78   1EFH!               SDR(R7) FF1;
  79   1EEH!               CMR(R7);
  80   1EDH!               ILR(J) FF1;
  81   1ECH!               ALR(R7) FF1;
  82   1DCH!               NOP(AC) JFL(LOADD,JGT);
  83   1DBH!      JGT!     ILR(A);
  84   1D9H!               SDR(J) FF1;
  85   179H!               ILR(K);
  86   169H!               SDR(R7) FF1;
  87   159H!               CMR(R7);
  88   149H!               ILR(I) FF1;
  89   139H!               ALR(R7) FF1;
  90   129H!               NOP(AC) JFL(ADDR,RTNN);
  91   11BH!      RTNN!    LMI(R9) FF1;
  92   118H!               ILR(M) RWM;
  93   128H!               ILR(R6);
  94   138H!               SDR(A) FF1 JZR(FETCH) PAGE1;
  95   12H!       SAVEIJ!  LMI(R9) FF1;
  96   32H!                ILR(I) RWM;
  97   31H!                LMI(R9);
  98   41H!                ILR(J) RWM JZR(FETCH) PAGE1;
  99   13H!     . RESTIJ!  LMI(R9) FF1 RRM;
 100   53H!                ACM(AC);
 101   51H!                SDR(I) FF1;
 102   61H!                LMI(R9) RRM;
 103   71H!                ACM(AC);
 104   81H!                SDR(J) FF1 JZR(FETCH) PAGE1;
 105   /*      CALCULATE BOUNDARY AREA OF EDGE GATES      */
 106   14H!       EGATES!  LMI(P) FF1 RRM;
 107   24H!                ACM(AC);
 108   34H!                SDR(R6) FF1;
```

```
RECORD
NUMBER

 109  44H!              LMI(R9) FF1:
 110  54H!              ILR(I);
 111  64H!              CIA(AC) FF1:
 112  74H!              SDR(R7) FF1:
 113  84H!              ILR(K);
 114  85H!              ALR(R7) RWM:
 115  86H!              LMI(R6) FF1:
 116  87H!              SRA(AC);
 117  97H!              SRA(AC);
 118  96H!              TZA(AC);
 119  95H!              NOP(AC) JFL(MINX,NOMINX);
 120  0A2H!      MINX!  INA(AC) FF1:
 121  0A3H!      NOMINX! SDR(A) FF1 RWM;
 122  0A4H!             LMI(R9) FF1:
 123  0A5H!             ILR(J);
 124  0A6H!             CIA(AC) FF1:
 125  0B6H!             SDR(R7) FF1:
 126  0C6H!             ILR(L);
 127  0D6H!             ALR(R7) RWM:
 128  0E6H!             LMI(R6) FF1:
 129  0F6H!             SRA(AC);
 130  106H!             SRA(AC);
 131  105H!             TZA(AC);
 132  115H!             NOP(AC) JFL(MINY,NOMINY);
 133  122H!      MINY!  INA(AC) FF1:
 134  123H!      NOMINY! SDR(R7) FF1 RWM;
 135  124H!             ILR(R9) FF1:
 136  127H!        ILR(R9) FF1;
 137  167H!             ILR(A);
 138  1A7H!             CIA(AC) FF1:
 139  1B7H!             SDR(R8) FF1:
 140  1C7H!             ILR(I);
 141  1D7H!             ALR(A);
 142  1E7H!             LMI(R9) FF1 RWM;
 143  1F7H!             ILR(R9) FF1:
 144  1F6H!             LMI(R9) FF1:
 145  1E6H!             ILR(K);
 146  1D6H!             ALR(R8);
 147  1C6H!             CIA(AC) FF1 RWM:
 148  1B6H!             ILR(R7);
 149  1B6H!             CIA(AC) FF1:
 150  156H!             SDR(R8) FF1:
 151  116H!             ILR(R9) FF1:
 152  117H!             ILR(J);
 153  107H!             ALR(R7);
 154  103H!             LMI(R9) FF1 RWM;
 155  102H!             ILR(R9) FF1:
 156  101H!             ILR(L);
 157  111H!             ALR(R8);
 158  112H!             CIA(AC) FF1:
 159  113H!             LMI(R9) FF1 RWM;
 160  /*       IF MEAN VLAUE IS LESS THAN SEVEN  TRACK BLACK ON WHITE
 161           IF MEAN VALUE IS GREATER OR EQUAL TO SEVEN TRACK WHITE ON BLACK*/
 162  119H!              CLR(R9);
```

```
RECORD
NUMBER

 163  109H!              LMI(R9) K0000F FF1;
 164  108H!              LMI(R9) RRM;
 165  148H!              ACM(AC) FF1 STZ;
 166  14CH!              NOP(AC) JFL(WHITE,BLACK);
 167  12AH!       WHITE! CLR(R9);
 168  10AH!              LMI(R9) K00005 RRM;
 169  10BH!              LCM(AC);
 170  10EH!             INA(AC) FF1 RWM PAGE1 JZR(FETCH);
 171  12BH!       BLACK! NOP(AC) PAGE1 JZR(FETCH);
 172  /*        NGATEA NGATEB NGATEC AND NGATEL CALCULATE EDGES OF THE GATE
 173            AND THE NEW I J K L                             */
 174  15H!       NGATEA! LMI(R9) RRM;
 175  25H!              ACM(AC);
 176  35H!              CIA(AC) FF1;
 177  45H!              SDR(R6) FF1;
 178  55H!              CLR(R7);
 179  65H!              LMI(R7) K00007;
 180  75H!              LMI(R7) FF1 RRM;
 181  085H!             ACM(AC);
 182  0BCH!             LMI(R7) FF1;
 183  0DCH!             LMI(R7) RRM;
 184  0DDH!             AMA(AC);
 185  0CDH!             ADR(R6);
 186  0BDH!             CLR(R7);
 187  0ADH!             LMI(R7) K00003;
 188  9DH!              LMI(R7) RRM;
 189  8DH!              ACM(AC);
 190  8CH!              ALR(AC);
 191  9CH!              ALR(AC);
 192  0ACH!             LMI(R9) FF1 RWM;
 193  0CCH!             ALR(R6);
 194  0CEH!             SDR(A) FF1 JZR(FETCH) PAGE1;
 195  16H!       NGATEB! LMI(R9) RRM;
 196  26H!              ACM(AC);
 197  36H!              SRA(AC);
 198  46H!              ALR(A);
 199  56H!              SDR(A) FF1;
 200  66H!              CIA(AC) FF1;
 201  76H!              LMI(P) FF1 RRM;
 202  79H!              LMM(T) RRM;
 203  89H!              AMA(AC);
 204  99H!              SDR(I) FF1;
 205  0A9H!             ILR(A) RRM;
 206  0B9H!             AMA(AC);
 207  0C9H!             SDR(K) FF1 JZR(FETCH) PAGE1;
 208  17H!       NGATEC! LMI(R9) RRM;
 209  27H!              ACM(AC);
 210  37H!              CIA(AC) FF1;
 211  47H!              SDR(R6) FF1;
 212  57H!              CLR(R7);
 213  67H!              LMI(R7) K0000B;
 214  77H!              LMI(R7) FF1 RRM;
 215  0A7H!             ACM(AC);
 216  087H!             LMI(R7) FF1;
```

```
RECORD
NUMBER

 217  0C7H!              LMI(R7) RRM:
 218  0D7H!              AMA(AC);
 219  0E7H!              ADR(R6);
 220  0F7H!              CLR(R7);
 221  0F8H!              LMI(R7) K00002;
 222  0F9H!              LMI(R7) RRM:
 223  0FCH!              ACM(AC);
 224  0FDH!              ALR(AC);
 225  0EDH!              ALR(AC);
 226  0ECH!              LMI(R9) FF1 RWM;
 227  0E9H!              ALR(R6);
 228  0E8H!              SDR(A) FF1 JZR(FETCH) PAGE1;
 229  18H!       NGATEL! LMI(R9) RRM;
 230  28H!               ACM(AC);
 231  38H!               SRA(AC);
 232  48H!               ALR(A);
 233  58H!               SDR(A) FF1;
 234  68H!               CIA(AC) FF1:
 235  78H!               LMI(P) FF1 RRM;
 236  88H!               LMM(T) RRM;
 237  98H!               AMA(AC);
 238  0A8H!              SDR(J) FF1;
 239  0B8H!              ILR(A) RRM;
 240  0C8H!              AMA(AC);
 241  0D8H!              SDR(L) FF1 JZR(FETCH) PAGE1:
 242  /*       WINDOW-----(VARIABLE WINDOW MICROROUTINE)          */
 243  19H!       WINDOW! LMI(R9) FF1;
 244  29H!               ILR(J) ROT;
 245  39H!               LMI(R9) FF1:
 246  49H!               ILR(L) ROT;
 247  59H!               LMI(R9) FF1:
 248  69H!               ILR(I) ROT;
 249  6CH!               LMI(R9) FF1;
 250  6DH!               ILR(K) ROT JZR(FETCH) PAGE1:
 251  1AH!       FRAME!  NOP(R8) STROBE2;
 252  1AAH!      WAT!    NOP(R8) RIN;
 253  1ACH!              LDI(AC) FF1:
 254  1ADH!              TZR(AC) K80000;
 255  1AFH!              NOP(R8) JFL(WAT,RDY);
 256  1ABH!      RDY!    NOP(R8) JZR(FETCH) PAGE1;
 257  1BH!       START!  LMI(R9) FF1 RRM;
 258  3BH!               ACM(AC);
 259  3DH!               SDR(I) FF1;
 260  10DH!              LMI(R9) FF1 RRM;
 261  12DH!              ACM(AC);
 262  13DH!              SDR(J) FF1;
 263  14DH!              LMI(R9) FF1 RRM;
 264  15DH!              ACM(AC);
 265  16DH!              SDR(K) FF1;
 266  17DH!              LMI(R9) RRM;
 267  18DH!              ACM(AC);
 268  19DH!              SDR(L) FF1 JZR(FETCH) PAGE1;
 269  1CH!       NOTC!   NOP(A) JZR(FETCH) PAGE1;
 270  1DH!       NOTD!   NOP(A) JZR(FETCH) PAGE1;
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RECORD
NUMBER

 271  1EH!       NOTF!  NOP(A) JZR(FETCH) PAGE1;
 272  1FH!       NOTF!  NOP(A) JZR(FETCH) PAGE1;
 273  /*     CENTROID CALCULATIONS  AND TARGET AREAS OF EDGE GATES          */
 274  10H!       CNTRD! CLA(AC);
 275  00H!         SDR(M) FF1;
 276  20H!              LMI(R9) FF1 RWM;
 277  30H!              LMI(R9) FF1;
 278  40H!              LMI(R9) FF1 RWM;
 279  50H!              LMI(R9) FF1;
 280  60H!              LMI(R9) FF1 RWM;
 281  70H!              LMI(R9) FF1;
 282  80H!              LMI(R9) FF1 RWM;
 283  90H!              LMI(R9) FF1 RWM;
 284  0A0H!             LMI(R9) RWM;
 285  080H!             ILR(J);
 286  0C0H!             SDR(A) FF1;
 287  0C2H!      CADDR! ILR(I);
 288  0C4H!             DCA(AC);
 289  0D4H!             CLA(T);
 290  0D0H!             ALR(AC);
 291  0E0H!             ALR(AC);
 292  0F0H!      ALR(T);
 293  100H!      ALR(AC);
 294  110H!             ALR(AC);
 295  120H!             ALR(AC);
 296  130H!             ADR(T);
 297  140H!             ALR(AC);
 298  150H!             ALR(T);
 299  158H!              ILR(J);
 300  168H!              ALR(T);
 301  160H!             SDR(T);
 302  162H!      CLOAD! CLR(R9);
 303  166H!              TZR(R9) FF7;
 304  /*      BRANCH TO WHITEE FOR WHITE ON BLACK TARGET
 305          BRANCH TO BLACKK TO TRACK ON BLACK TARGET     */
 306  16CH!              LMI(R9) K00005 FF1 RRM JFL(WHITEE,BLACKK);
 307  17BH!        BLACKK! ACM(AC);
 308  17CH!              SDR(R6) FF1;
 309  178H!              LMI(T) FF1_RRM;
 310  188H!              LDI(AC) FF1;
 311  198H!              CIA(AC) FF1;
 312  197H!              ALR(R6) JCR(OVER);
 313  17AH!        WHITEE! ACM(AC);
 314  170H!             LMI(T) FF1 RRM;
 315  180H!             AIA(AC);
 316  190H!        OVER! NOP(AC) JFL(NODATA,DATA);
 317  192H!      NODATA! ILR(L);
 318  191H!             SDR(R6) FF1;
 319  1A1H!             CMR(R6);
 320  1A4H!             ILR(J) FF1;
 321  194H!             ALR(R6) FF1;
 322  154H!             NOP(AC) JFL(CLOAD,JGTL);
 323  163H!      JGTL!  ILR(A);
 324  165H!             SDR(J) FF1;
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RECORD
NUMBER

  325  145H!              ILR(K);
  326  144H!              SDR(R6) FF1;
  327  104H!              CMR(R6);
  328  0F4H!              ILR(I) FF1;
  329  0E4H!              ALR(R6) FF1;
  330  0B4H!              NOP(AC) JFL(CADDR.ENDC);
  331  193H!      DATA!   ILR(R9);
  332  195H!              SDR(R6)FF1;
  333  1A5H!              LMI(R6) K00008;
  334  1A0H!      ILR(I);
  335  180H!              LMI(R6) FF1 RRM;
  336  1C0H!              AMA(AC) RWM;
  337  100H!              ILR(J);
  338  1E0H!              LMI(R6) RRM;
  339  1F0H!              AMA(AC) RWM;
  340  1F5H!              ILR(M) FF1;
  341  1E5H!              ILR(I);
  342  1D5H!              CIA(AC);
  343  1D4H!              LMI(R9) FF1 RRM;
  344  1C4H!              AMA(AC);
  345  1C5H!              NOP(AC) JFL(NXEEG.XEEG);
  346  183H!      XEEG!   LMI(R9) FF1 RRM;
  347  184H!              ACM(AC) FF1 RWM JCC(NXBLG2);
  348  182H!      NXEEG!  ILR(R9) FF1;
  349  181H!              ILR(I);
  350  181H!              LMI(R9) FF1 RRM;
  351  171H!              AMA(AC);
  352  161H!              NOP(AC) JFL(NXBLG.XBLG);
  353  173H!      XBLG!   LMI(R9) FF1 RRM;
  354  175H!              ACM(AC) FF1 RWM JCR(NXBL);
  355  174H!      NXBLG2! ILR(R9) FF1;
  356  172H!      NXBLG!  ILR(R9) FF1:
  357  177H!      NXBL!   ILR(J);
  358  137H!              CIA(AC);
  359  136H!              LMI(R9) FF1 RRM;
  360  135H!              AMA(AC);
  361  134H!              NOP(AC) JFL(NYEEG.YEEG);
  362  143H!      YEEG!   LMI(R9) FF1 RRM;
  363  146H!              ACM(AC) FF1 RWM;
  364  196H!              NOP(A) JCR(NODATA);
  365  142H!      NYEEG!  ILR(R9) FF1;
  366  147H!              ILR(J);
  367  157H!              LMI(R9) FF1 RRM;
  368  187H!              AMA(AC);
  369  184H!              NOP(AC) JFL(NODAT.YBLG);
  370  183H!      YBLG!   LMI(R9) FF1 RRM;
  371  185H!              ACM(AC) FF1 RWM JCR(NODAT);
  372  0C3H!      ENDC!   CLR(R9);
  373  0C5H!              LMI(R9) K00004;
  374  0E5H!              ILR(M) RWM PAGE1 JZR(FETCH);
  375  182H!      NODAT!  NOP(A) JCC(NODATA);
  376  EOF

NO PROGRAM ERRORS
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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 9

END OF PROGRAM
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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 10

MICROPROGRAM MEMORY IMAGE

         0H      1H      2H      3H      4H      5H      6H      7H
====================*=======*=======*================================
    .   JCC .       *       *       *       .       .       .       =
    . 0020H .       *       *       *       .       .       .       =
000H        .       *       *       *       .       .       .       =
    .   275 .       *       *       *       .       .       .       =
    .     1 .       *       *       *       .       .       .       =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCC *   JCC *   JCC *   JCC .   JCC .   JCC .   JCC =
    . 0000H . 0021H * 0032H * 0053H * 0024H . 0025H . 0026H . 0027H =
001H        .       *       *       *       .       .       .       =
    .   274 .    53 *    95 *    99 *   106 .   174 .   195 .   208 =
    .     1 .     1 *     1 *     1 *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCR *       *       *   JCC .   JCC .   JCC .   JCC =
    . 0030H . 002CH *       *       * 0034H . 0035H . 0036H . 0037H =
002H        .       *       *       *       .       .       .       =
    .   276 .    54 *       *       *   107 .   175 .   196 .   209 =
    .     1 .     1 *       *       *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCC *   JCR *       *   JCC .   JCC .   JCC .   JCC =
    . 0040H . 0041H * 0031H *       * 0044H . 0045H . 0046H . 0047H =
003H        .       *       *       *       .       .       .       =
    .   277 .    97 *    96 *       *   108 .   176 .   197 .   210 =
    .     1 .     1 *     1 *       *     1 .     1 .     1 .     1 =
--------------------*-------*-------*-------------------------------=
    .   JCC .   JZR *       *       *   JCC .   JCC .   JCC .   JCC =
    . 0050H . 000FH *       *       * 0054H . 0055H . 0056H . 0057H =
004H        .       *       *       *       .       .       .       =
    .   278 .    98 *       *       *   109 .   177 .   198 .   211 =
    .     1 .     1 *       *       *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCC *       *   JCR *   JCC .   JCC .   JCC .   JCC =
    . 0060H . 0061H *       * 0051H * 0064H . 0065H . 0066H . 0067H =
005H        .       *       *       *       .       .       .       =
    .   279 .   101 *       *   100 *   110 .   178 .   199 .   212 =
    .     1 .     1 *       *     1 *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCC *       *       *   JCC .   JCC .   JCC .   JCC =
    . 0070H . 0071H *       *       * 0074H . 0075H . 0076H . 0077H =
006H        .       *       *       *       .       .       .       =
    .   280 .   102 *       *       *   111 .   179 .   200 .   213 =
    .     1 .     1 *       *       *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCC *       *       *   JCC .   JCC .   JCR .   JCC =
    . 0080H . 0081H *       *       * 0084H . 0085H . 0079H . 00A7H =
007H        .       *       *       *       .       .       .       =
    .   281 .   103 *       *       *   112 .   180 .   201 .   214 =
    .     1 .     1 *       *       *     1 .     1 .     1 .     1 =
====================*=======*=======*================================
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 11

MICROPROGRAM MEMORY IMAGE

         0H      1H      2H      3H      4H      5H      6H      7H
=====================*=======*=======*================================
     .   JCC .   JZR *       *       *   JCR .   JCR .   JCR .   JCC =
     . 0090H . 000FH *       *       * 0085H . 0086H . 0087H . 0097H =
008H        .       *       *       *       .       .       .       =
     .   282 .   104 *       *       *   113 .   114 .   115 .   116 =
     .     1 .     1 *       *       *     1 .     1 .     1 .     1 =
     - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
     .   JCC .       *       *       *       .   JFL .   JCR .   JCR =
     . 00A0H .       *       *       *       . 00A2H . 0095H . 0096H =
009H        .       *       *       *       .       .       .       =
     .   283 .       *       *       *       .   119 .   118 .   117 =
     .     1 .       *       *       *       .     1 .     1 .     1 =
     - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
     .   JCC .       *   JCR *   JCR *   JCR .   JCR .   JCC .   JCC =
     . 00B0H .       * 00A3H * 00A4H * 00A5H . 00A6H . 00B6H . 00B7H =
00AH        .       *       *       *       .       .       .       =
     .   284 .       *   120 *   121 *   122 .   123 .   124 .   215 =
     .     1 .       *     1 *     2 *     1 .     1 .     1 .     1 =
     - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
     .   JCC .       *       *       *   JFL .   JCR .   JCC .   JCC =
     . 00C0H .       *       *       * 00C2H . 008CH . 00C6H . 00C7H =
00BH        .       *       *       *       .       .       .       =
     .   285 .       *       *       *   330 .   181 .   125 .   216 =
     .     1 .       *       *       *     1 .     1 .     1 .     1 =
---------------------*-------*-------*--------------------------------=
     .   JCR .       *   JCR *   JCR *   JCC .   JCC .   JCC .   JCC =
     . 00C2H .       * 00C4H * 00C5H * 00D4H . 00E5H . 00D6H . 00D7H =
00CH        .       *       *       *       .       .       .       =
     .   286 .       *   287 *   372 *   288 .   373 .   126 .   217 =
     .     1 .       *     2 *     1 *     1 .     1 .     1 .     1 =
     - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
     .   JCC .       *       *       *   JCR .       .   JCC .   JCC =
     . 00E0H .       *       *       * 00D0H .       . 00E6H . 00E7H =
00DH        .       *       *       *       .       .       .       =
     .   290 .       *       *       *   289 .       .   127 .   218 =
     .     1 .       *       *       *     1 .       .     1 .     1 =
     - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
     .   JCC .       *       *       *   JCC .   JZR .   JCC .   JCC =
     . 00F0H .       *       *       * 00B4H . 000FH . 00F6H . 00F7H =
00EH        .       *       *       *       .       .       .       =
     .   291 .       *       *       *   329 .   374 .   128 .   219 =
     .     1 .       *       *       *     1 .     1 .     1 .     1 =
     - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
     .   JCC .       *       *       *   JCC .       .   JCC .   JCR =
     . 0100H .       *       *       * 00E4H .       . 0106H . 00F8H =
00FH        .       *       *       *       .       .       .       =
     .   292 .       *       *       *   328 .       .   129 .   220 =
     .     1 .       *       *       *     1 .       .     1 .     1 =
=====================*=======*=======*================================
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 12

MICROPROGRAM MEMORY IMAGE

          0H       1H       2H       3H       4H       5H       6H       7H
=======================*========*========*====================================
     .    JCC .    JCC *    JCR *    JCR *    JCC .    JCC .    JCR .    JCR =
     .  0110H .  0111H *  0101H *  0102H *  00F4H .  0115H .  0105H .  0103H =
010H          .        *        *        *        .        .        .        =
     .    293 .    156 *    155 *    154 *    327 .    131 .    130 .    153 =
     .      1 .      1 *      1 *      1 *      1 .      1 .      1 .      1 =
     - - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - =
     .    JCC .    JCR *    JCR *    JCR *        .    JFL .    JCR .    JCC =
     .  0120H .  0112H *  0113H *  0119H *        .  0122H .  0117H .  0107H =
011H          .        *        *        *        .        .        .        =
     .    294 .    157 *    158 *    159 *        .    132 .    151 .    152 =
     .      1 .      1 *      1 *      1 *        .      1 .      1 .      1 =
     - - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - =
     .    JCC .        *    JCR *    JCR *    JCR .        .        .    JCC =
     .  0130H .        *  0123H *  0124H *  0127H .        .        .  0167H =
012H          .        *        *        *        .        .        .        =
     .    295 .        *    133 *    134 *    135 .        .        .    136 =
     .      1 .        *      1 *      2 *      1 .        .        .      1 =
     - - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - =
     .    JCC .        *        *        *    JFL .    JCR .    JCR .    JCR =
     .  0140H .        *        *        *  0142H .  0134H .  0135H .  0136H =
013H          .        *        *        *        .        .        .        =
     .    296 .        *        *        *    361 .    360 .    359 .    358 =
     .      1 .        *        *        *      1 .      1 .      1 .      1 =
-----------------------*--------*--------*-----------------------------------=
     .    JCC .        *    JCR *    JCR *    JCC .    JCR .    JCC .    JCC =
     .  0150H .        *  0147H *  0146H *  0104H .  0144H .  0196H .  0157H =
014H          .        *        *        *        .        .        .        =
     .    297 .        *    365 *    362 *    326 .    325 .    363 .    366 =
     .      1 .        *      1 *      1 *      1 .      1 .      1 .      1 =
     - - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - =
     .    JCR .        *        *        *    JFL .        .    JCC .    JCC =
     .  0158H .        *        *        *  0162H .        .  0116H .  0187H =
015H          .        *        *        *        .        .        .        =
     .    298 .        *        *        *    322 .        .    150 .    367 =
     .      1 .        *        *        *      1 .        .      1 .      1 =
     - - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - =
     .    JCR .    JFL *    JCR *    JCR *        .    JCC .    JCR .    JCC =
     .  0162H .  0172H *  0166H *  0165H *        .  0145H .  016CH .  01A7H =
016H          .        *        *        *        .        .        .        =
     .    301 .    352 *    302 *    323 *        .    324 .    303 .    137 =
     .      1 .      1 *      2 *      1 *        .      1 .      1 .      1 =
     - - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - =
     .    JCC .    JCC *    JCR *    JCR *    JCR .    JCR .        .    JCC =
     .  0180H .  0161H *  0177H *  0175H *  0172H .  0177H .        .  0137H =
017H          .        *        *        *        .        .        .        =
     .    314 .    351 *    356 *    353 *    355 .    354 .        .    357 =
     .      1 .      1 *      2 *      1 *      1 .      1 .        .      2 =
=======================*========*========*====================================
MICROPROGRAM MEMORY IMAGE

       0H       1H       2H       3H       4H       5H       6H       7H
=====================*========*========*===================================
    .   JCC .   JCC *   JCC *   JCR *   JFL .   JCR .   JCC .   JCR =
    . 0190H . 0171H * 0192H * 0185H * 0182H . 0182H . 0156H . 0184H =
018H        .       *       *       *       .       .       .       =
    .   315 .   350 *   375 *   370 *   369 .   371 .   149 .   368 =
    .     1 .     1 *     2 *     1 *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JFL .   JCC *   JCR *   JCR *   JCC .   JCC .   JCR .   JCR =
    . 0192H . 01A1H * 0191H * 0195H * 0154H . 01A5H . 0192H . 0190H =
019H        .       *       *       *       .       .       .       =
    .   316 .   318 *   317 *   331 *   321 .   332 .   364 .   312 =
    .     2 .     1 *     3 *     1 *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCR *       *       *   JCC .   JCR .       .   JCC =
    . 01B0H . 01A4H *       *       * 0194H . 01A0H .       . 01B7H =
01AH        .       *       *       *       .       .       .       =
    .   334 .   319 *       *       *   320 .   333 .       .   138 =
    .     1 .     1 *       *       *     1 .     1 .       .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .   JCC *   JCR *   JCR *   JCC .       .   JCC .   JCC =
    . 01C0H . 0181H * 01B1H * 01B4H * 0174H .       . 0186H . 01C7H =
01BH        .       *       *       *       .       .       .       =
    .   335 .   349 *   348 *   346 *   347 .       .   148 .   139 =
    .     1 .     1 *     1 *     1 *     1 .       .     1 .     1 =
--------------------*-------*-------*-----------------------------------=
    .   JCC .       *       *       *   JCR .   JFL .   JCC .   JCC =
    . 01D0H .       *       *       * 01C5H . 01B2H . 01B6H . 01D7H =
01CH        .       *       *       *       .       .       .       =
    .   336 .       *       *       *   344 .   345 .   147 .   140 =
    .     1 .       *       *       *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .       *       *       *   JCC .   JCR .   JCC .   JCC =
    . 01E0H .       *       *       * 01C4H . 01D4H . 01C6H . 01E7H =
01DH        .       *       *       *       .       .       .       =
    .   337 .       *       *       *   343 .   342 .   146 .   141 =
    .     1 .       *       *       *     1 .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCC .       *       *       *       .   JCC .   JCC .   JCC =
    . 01F0H .       *       *       *       . 01D5H . 01D6H . 01F7H =
01EH        .       *       *       *       .       .       .       =
    .   338 .       *       *       *       .   341 .   145 .   142 =
    .     1 .       *       *       *       .     1 .     1 .     1 =
    - - - - - - - - *-------*-------* - - - - - - - - - - - - - - - =
    .   JCR .       *       *       *       .   JCC .   JCC .   JCR =
    . 01F5H .       *       *       *       . 01E5H . 01E6H . 01F6H =
01FH        .       *       *       *       .       .       .       =
    .   339 .       *       *       *       .   340 .   144 .   143 =
    .     1 .       *       *       *       .     1 .     1 .     1 =
=====================*========*========*===================================
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 14

MICROPROGRAM MEMORY IMAGE
          8H       9H       AH       BH       CH       DH       EH       FH
============================================================================
   =        .        *        *        *        .        .        .    JPR .
   =        .        *        *        *        .        .        .  0010H .
000H        .        *        *        *        .        .        .        .
   =        .        *        *        *        .        .        .     49 .
   =        .        *        *        *        .        .        .     17 .
   = - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - -
   =    JCC .    JCC *    JCC *    JCC *    JZR .    JZR .    JZR .    JZR .
   =  0028H .  0029H *  01AAH *  003BH *  000FH .  000FH .  000FH .  000FH .
001H        .        *        *        *        .        .        .        .
   =    229 .    243 *    251 *    257 *    269 .    270 .    271 .    272 .
   =      1 .      1 *      1 *      1 *      1 .      1 .      1 .      1 .
   = - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - -
   =    JCC .    JCC *        *        *    JCC .        .        .        .
   =  0038H .  0039H *        *        *  010CH .        .        .        .
002H        .        *        *        *        .        .        .        .
   =    230 .    244 *        *        *     55 .        .        .        .
   =      1 .      1 *        *        *      1 .        .        .        .
   = - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - -
   =    JCC .    JCC *        *    JCR *        .    JCC .        .        .
   =  0048H .  0049H *        *  003DH *        .  010DH .        .        .
003H        .        *        *        *        .        .        .        .
   =    231 .    245 *        *    258 *        .    259 .        .        .
   =      1 .      1 *        *      1 *        .      1 .        .        .
----=-----------------*--------*--------*-----------------------------------
   =    JCC .    JCC *        *        *        .        .        .        .
   =  0058H .  0059H *        *        *        .        .        .        .
004H        .        *        *        *        .        .        .        .
   =    232 .    246 *        *        *        .        .        .        .
   =      1 .      1 *        *        *        .        .        .        .
   = - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - -
   =    JCC .    JCC *        *        *        .        .        .        .
   =  0068H .  0069H *        *        *        .        .        .        .
005H        .        *        *        *        .        .        .        .
   =    233 .    247 *        *        *        .        .        .        .
   =      1 .      1 *        *        *        .        .        .        .
   = - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - -
   =    JCC .    JCR *        *        *    JCR .    JZR .        .        .
   =  0078H .  006CH *        *        *  006DH .  000FH .        .        .
006H        .        *        *        *        .        .        .        .
   =    234 .    248 *        *        *    249 .    250 .        .        .
   =      1 .      1 *        *        *      1 .      1 .        .        .
   = - - - - - - - - *--------*--------* - - - - - - - - - - - - - - - - - -
   =    JCC .    JCC *        *        *        .        .        .        .
   =  0088H .  0089H *        *        *        .        .        .        .
007H        .        *        *        *        .        .        .        .
   =    235 .    202 *        *        *        .        .        .        .
   =      1 .      1 *        *        *        .        .        .        .
============================================================================
MICROPROGRAM MEMORY IMAGE

          8H        9H        AH       BH       CH        DH        EH        FH
===========================*========*========*==================================
    =    JCC .     JCC *        *        *    JCC .     JCR .         .        .
    =  0098H .   0099H *        *        *  009CH .   008CH .         .        .
008H         .         *        *        *        .         .         .        .
    =    236 .     203 *        *        *    190 .     189 .         .        .
    =      1 .       1 *        *        *      1 .       1 .         .        .
    = - - - - - - - - -*--------*--------* - - - - - - - - - - - - - - - - - - -
    =    JCC .     JCC *        *        *    JCC .     JCC .         .        .
    =  00A8H .   00A9H *        *        *  00ACH .   008DH .         .        .
009H         .         *        *        *        .         .         .        .
    =    237 .     204 *        *        *    191 .     188 .         .        .
    =      1 .       1 *        *        *      1 .       1 .         .        .
    = - - - - - - - - -*--------*--------* - - - - - - - - - - - - - - - - - - -
    =    JCC .     JCC *        *        *    JCC .     JCC .         .        .
    =  00B8H .   00B9H *        *        *  00CCH .   009DH .         .        .
00AH         .         *        *        *        .         .         .        .
    =    238 .     205 *        *        *    192 .     187 .         .        .
    =      1 .       1 *        *        *      1 .       1 .         .        .
    = - - - - - - - - -*--------*--------* - - - - - - - - - - - - - - - - - - -
    =    JCC .     JCC *        *        *    JCC .     JCC .         .        .
    =  00C8H .   00C9H *        *        *  00DCH .   00ADH .         .        .
00BH         .         *        *        *        .         .         .        .
    =    239 .     206 *        *        *    182 .     186 .         .        .
    =      1 .       1 *        *        *      1 .       1 .         .        .
----=----------------------*--------*--------*----------------------------------
    =    JCC .     JZR *        *        *    JCR .     JCC .     JZR .        .
    =  00D8H .   000FH *        *        *  00CEH .   008DH .   000FH .        .
00CH         .         *        *        *        .         .         .        .
    =    240 .     207 *        *        *    193 .     185 .     194 .        .
    =      1 .       1 *        *        *      1 .       1 .       1 .        .
    = - - - - - - - - -*--------*--------* - - - - - - - - - - - - - - - - - - -
    =    JZR .         *        *        *    JCR .     JCC .         .        .
    =  000FH .         *        *        *  00DDH .   00CDH .         .        .
00DH         .         *        *        *        .         .         .        .
    =    241 .         *        *        *    183 .     184 .         .        .
    =      1 .         *        *        *      1 .       1 .         .        .
    = - - - - - - - - -*--------*--------* - - - - - - - - - - - - - - - - - - -
    =    JZR .     JCR *        *        *    JCR .     JCR .         .        .
    =  000FH .   00E8H *        *        *  00E9H .   00ECH .         .        .
00EH         .         *        *        *        .         .         .        .
    =    228 .     227 *        *        *    226 .     225 .         .        .
    =      1 .       1 *        *        *      1 .       1 .         .        .
    = - - - - - - - - -*--------*--------* - - - - - - - - - - - - - - - - - - -
    =    JCR .     JCR *        *        *    JCR .     JCC .         .        .
    =  00F9H .   00FCH *        *        *  00FDH .   00FDH .         .        .
00FH         .         *        *        *        .         .         .        .
    =    221 .     222 *        *        *    223 .     224 .         .        .
    =      1 .       1 *        *        *      1 .       1 .         .        .
===========================*========*========*==================================
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 16

MICROPROGRAM MEMORY IMAGE

          8H      9H      AH      BH      CH      DH      EH        FH
=====================*=======*=======*==================================
     =   JCC .   JCR *   JCR *   JCR *   JCC .   JCC .   JZR .         .
     = 0148H . 0108H * 010BH * 010EH * 011CH . 012DH . 000FH .         .
010H         .       *       *       *       .       .       .         .
     =   164 .   163 *   168 *   169 *    56 .   260 .   170 .         .
     =     1 .     1 *     1 *     1 *     1 .     1 .     1 .         .
     = - - - - - - - *-------*-------* - - - - - - - - - - - - - - - - -
     =   JCC .   JCC *   JCR *   JCR *   JCR .   JCR .   JCC .         .
     = 0128H . 0109H * 011DH * 0118H * 011AH . 011EH . 012EH .         .
011H         .       *       *       *       .       .       .         .
     =    92 .   162 *    58 *    91 *    57 .    59 .    60 .         .
     =     1 .     1 *     2 *     1 *     1 .     1 .     1 .         .
     = - - - - - - - *-------*-------* - - - - - - - - - - - - - - - - -
     =   JCC .   JFL *   JCC *   JZR *       .   JCC .   JCC .         .
     = 0138H . 011AH * 010AH * 000FH *       . 013DH . 013EH .         .
012H         .       *       *       *       .       .       .         .
     =    93 .    90 *   167 *   171 *       .   261 .    61 .         .
     =     1 .     1 *     1 *     1 *       .     1 .     1 .         .
     = - - - - - - - *-------*-------* - - - - - - - - - - - - - - - - -
     =   JZR .   JCC *       *       *       .   JCC .   JCC .         .
     = 000FH . 0129H *       *       *       . 014DH . 014EH .         .
013H         .       *       *       *       .       .       .         .
     =    94 .    89 *       *       *       .   262 .    62 .         .
     =     1 .     1 *       *       *       .     1 .     1 .         .
-----=---------------*-------*-------*----------------------------------
     =   JCR .   JCC *       *       *   JFL .   JCC .   JCC .         .
     = 014CH . 0139H *       *       * 012AH . 015DH . 015EH .         .
014H         .       *       *       *       .       .       .         .
     =   165 .    88 *       *       *   166 .   263 .    63 .         .
     =     1 .     1 *       *       *     1 .     1 .     1 .         .
     = - - - - - - - *-------*-------* - - - - - - - - - - - - - - - - -
     =   JCC .   JCC *       *       *       .   JCC .   JCC .         .
     = 0168H . 0149H *       *       *       . 016DH . 016EH .         .
015H         .       *       *       *       .       .       .         .
     =   299 .    87 *       *       *       .   264 .    64 .         .
     =     1 .     1 *       *       *       .     1 .     1 .         .
     = - - - - - - - *-------*-------* - - - - - - - - - - - - - - - - -
     =   JCR .   JCC *       *       *   JFL .   JCC .   JCC .         .
     = 0160H . 0159H *       *       * 017AH . 017DH . 017EH .         .
016H         .       *       *       *       .       .       .         .
     =   300 .    86 *       *       *   306 .   265 .    65 .         .
     =     1 .     1 *       *       *     1 .     1 .     1 .         .
     = - - - - - - - *-------*-------* - - - - - - - - - - - - - - - - -
     =   JCC .   JCC *   JCR *   JCR *   JCR .   JCC .   JCC .         .
     = 0188H . 0169H * 0170H * 017CH * 0178H . 018DH . 018EH .         .
017H         .     . *       *       *       .       .       .         .
     =   309 .    85 *   313 *   307 *   308 .   266 .    66 .         .
     =     1 .     1 *     1 *     1 *     1 .     1 .     1 .         .
=====================*=======*=======*==================================
MICROPROGRAM MEMORY IMAGE

          8H        9H        AH        BH        CH        DH        EH        FH
=============================*=========*=========*========================================
   =     JCC .         *         *         *         .     JCC .     JCC .         .
   =   0198H .         *         *         *         .   019DH .   019EH .         .
018H         .         *         *         *         .         .         .         .
   =     310 .         *         *         *         .     267 .      67 .         .
   =       1 .         *         *         *         .       1 .       1 .         .
   = - - - - - - - - - *---------*---------* - - - - - - - - - - - - - - - - - - - -
   =     JCR .         *         *         *         .     JZR .     JCC .         .
   =   0197H .         *         *         *         .   000FH .   01AEH .         .
019H         .         *         *         *         .         .         .         .
   =     311 .         *         *         *         .     268 .      68 .         .
   =       1 .         *         *         *         .       1 .       1 .         .
   = - - - - - - - - - *---------*---------* - - - - - - - - - - - - - - - - - - - -
   =         .         *     JCR *     JZR *     JCR .     JCR .     JCC .     JFL .
   =         .         *   01ACH *   000FH *   01ADH .   01AFH .   01BEH .   01AAH .
01AH         .         *         *         *         .         .         .         .
   =         .         *     252 *     256 *     253 .     254 .      69 .     255 .
   =         .         *       2 *       1 *       1 .       1 .       1 .       1 .
   = - - - - - - - - - *---------*---------* - - - - - - - - - - - - - - - - - - - -
   =         .         *         *         *         .         .     JCC .         .
   =         .         *         *         *         .         .   01CEH .         .
01BH         .         *         *         *         .         .         .         .
   =         .         *         *         *         .         .      70 .         .
   =         .         *         *         *         .         .       1 .         .
---=-----------------------------*---------*----------------------------------------------
   =         .         *         *         *         .         .     JCC .         .
   =         .         *         *         *         .         .   01DEH .         .
01CH         .         *         *         *         .         .         .         .
   =         .         *         *         *         .         .      71 .         .
   =         .         *         *         *         .         .       1 .         .
   = - - - - - - - - - *---------*---------* - - - - - - - - - - - - - - - - - - - -
   =         .     JCC *     JCR *     JCR *     JFL .     JCC .     JCR .         .
   =         .   0179H *   01DDH *   01D9H *   01DAH .   01FDH .   01DAH .         .
01DH         .         *         *         *         .         .         .         .
   =         .      84 *      73 *      83 *      82 .      74 .      72 .         .
   =         .       1 *       2 *       1 *       1 .       1 .       1 .         .
   = - - - - - - - - - *---------*---------* - - - - - - - - - - - - - - - - - - - -
   =         .         *         *         *     JCC .     JCR .     JCR .     JCR .
   =         .         *         *         *   01DCH .   01ECH .   01EDH .   01EEH .
01EH         .         *         *         *         .         .         .         .
   =         .         *         *         *      81 .      80 .      79 .      78 .
   =         .         *         *         *       1 .       1 .       1 .       1 .
   = - - - - - - - - - *---------*---------* - - - - - - - - - - - - - - - - - - - -
   =         .         *         *         *         .     JCR .     JCR .     JCC .
   =         .         *         *         *         .   01FEH .   01FFH .   01EFH .
01FH         .         *         *         *         .         .         .         .
   =         .         *         *         *         .      75 .      76 .      77 .
   =         .         *         *         *         .       1 .       1 .       1 .
=============================*=========*=========*========================================
CROSS REFERENCE DIRECTORY

LABEL      REFERENCES

ADDR       (58),90
BLACK      166,(171)
BLACKK     306,(307)
CADDR      (287),330
CLOAD      (302),322
CNTRD      49,(274)
DATA       316,(331)
EGATES     49,(106)
ENDC       330,(372)
FETCH      (49),94,98,104,170,171,194,207,228,241,250,256,268,269,270,271,272,
           374
FRAME      50,(251)
JGT        82,(83)
JGTL       322,(323)
LOADD      (73),82
MEAN       49,(53)
MINX       119,(120)
MINY       132,(133)
NGATEA     49,(174)
NGATEB     50,(195)
NGATEC     50,(208)
NGATEL     50,(229)
NODAT      369,371,(375)
NODATA     316,(317),364,375
NOMINX     119,(121)
NOMINY     132,(134)
NOTC       50,(269)
NOTD       50,(270)
NOTE       50,(271)
NOTF       51,(272)
NXBL       354,(357)
NXBLG      352,(356)
NXBLG2     347,(355)
NXEEG      345,(348)
NYEEG      361,(365)
OVER       312,(316)
RDY        255,(256)
RESTIJ     49,(99)
RTNN       90,(91)
SAVEIJ     49,(95)
START      50,(257)
WAT        (252),255
WHITE      166,(167
WHITEE     306,(313)
WINDOW     50,(243)
XBLG       352,(353)
XEEG       345,(346)
YBLG       369,(370)
YEEG       361,(362)
```

Appendix C.

TRACKER MICRO CODE LISTING WITH EXPANDED BITS

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 2

RECORD                CPE     FI  FO   JUMP     KBUSS  OTHER  CBUS  PAUSE
NUMBER             6543210  10  10  6543210  43210  43210  210     0

     1
     2  KBUSS      FIELD  LENGTH=5   DEFAULT=0
     3                    MICROPS(KFFFFF=10101B   KFFFFA=10100B   K7FFFF=10011B
     4                            K80000=10010B   K00FFF=10001B   K00060=10000B
     5                            K0000F=01111B   K0000E=01110B   K0000D=01101B
     6                            K0000C=01100B   K0000B=01011B   K0000A=01010B
     7                            K00009=01001B   K00008=01000B   K00007=00111B
     8                            K00006=00110B   K00005=00101B   K00004=00100B
     9                            K00003=00011B   K00002=00010B   K00001=00001B
    10                            K00000=00000B);
    11  KBUSS      KBUS;
    12
    13  /* ALL MICROCODE IS ON PAGE2 WITH DEFAULT SET TO 00001 FOR OTHER */
    14  OTHER      FIELD  LENGTH=5   DEFAULT=00001B
    15             MICROPS(STROBE=10000B  PAGE1=00000B  PAGE2=00001B
    16                     STROBE2=10001B);
    17
    18  /* DEFINITION OF BUS CONTROL FIELD           */
    19
    20  CBUS        FIELD  LENGTH=3          DEFAULT=0
    21             MICROPS(NBO=000B   INH=001B   RMW=010B   CNB=011B
    22                     RIN=100B   ROT=101B   RRM=110B   RWM=111B);
    23
    24  /*         NBO     NOBUS OPERATION
    25             INH     INHIBIT CPE ARRAY
    26             RMW     READ-MODIFY-WRITE
    27             CNB     CPU NEEDS BUS
    28             RIN     REQUEST INPUT
    29             ROT     REQUEST OUTPUT
    30             RRM     REQUEST READ MEMORY
    31             RWM     REQUEST WRITE MEMORY
    32
    33             SET UP SYMBOLIC REPRESENTATION OF REGISTER DESIGNATIONS */
    34
    35  A          STRING 'R0';
    36  I          STRING 'R1';
    37  J          STRING 'R2';
    38  P          STRING 'R3';
    39  K          STRING 'R4';
    40  L          STRING 'R5';
    41  TEMP       STRING 'R6';
    42  TEMP2      STRING 'R7';
    43  M          STRING 'R8';
    44
    45  PAUSE      FIELD  LENGTH=1   DEFAULT=1
    46                    MICROPS(PP=0);
    47
    48
    49  0FH!       FETCH! NOP(A) JPR(CNTRD MEAN SAVEIJ RESTIJ EGATES NGATEA
    50                 NGATEB NGATEC NGATEL WINDOW FRAME START NOTC NOTD NOTE
    51                        NOTF);
        (000FH)  1100000  11  00  1100001  00000  00001  000     1
```

```
RECORD              CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER            6543210   10  10  6543210  43210  43210  210     0

   52  /*      CALCULATE MEAN VALUE FOR 100 BY 100 ARRAY   BEING DIGITIZED    */
   53  11H!        MEAN!  CLA(AC);
       (0011H)  1001011  11  00  0000010  00000  00001  000      1

   54  21H!               SDR(R6) FF1:
       (0021H)  0100110  11  11  0111100  11111  00001  000      1

   55  2CH!               SDR(M) FF1;
       (002CH)  0101000  11  11  0010000  11111  00001  000      1

   56  10CH!              ILR(J);
       (010CH)  0000010  11  00  0010001  00000  00001  000      1

   57  11CH!              SDR(A) FF1;
       (011CH)  0100000  11  11  0111010  11111  00001  000      1

   58  11AH!       ADDR!  ILR(I);
       (011AH)  0000001  11  00  0111101  00000  00001  000      1

   59  11DH!              DCA(AC);
       (011DH)  0011111  11  00  0111110  11111  00001  000      1

   60  11EH!              CLA(T);
       (011EH)  1001010  11  00  0010010  00000  00001  000      1

   61  12EH!              ALR(AC);
       (012EH)  0001101  11  00  0010011  11111  00001  000      1

   62  13EH!              ALR(AC);
       (013EH)  0001101  11  00  0010100  11111  00001  000      1

   63  14EH!              ALR(T);
       (014EH)  0001100  11  00  0010101  11111  00001  000      1

   64  15EH!              ALR(AC);
       (015EH)  0001101  11  00  0010110  11111  00001  000      1

   65  16EH!              ALR(AC);
       (016EH)  0001101  11  00  0010111  11111  00001  000      1

   66  17EH!              ALR(AC);
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 4

RECORD               CPE     FI  FO   JUMP    KBUSS  OTHER  CRUS  PAUSE
NUMBER             6543210   10  10  6543210  43210  43210  210     0

        (017EH)    0001101   11  00  0011000  11111  00001  000     1


    67  18EH!               ADR(T);
        (01BEH)    0111100   11  00  0011001  11111  00001  000     1


    68  19EH!               ALR(AC);
        (019FH)    0001101   11  00  0011010  11111  00001  000     1


    69  1AEH!               ALR(T);
        (01AEH)    0001100   11  00  0011011  11111  00001  000     1


    70  1BEH!               ILR(J);
        (01BEH)    0000010   11  00  0011100  00000  00001  000     1


    71  1CEH!               ALR(T);
        (01CEH)    0001100   11  00  0011101  11111  00001  000     1


    72  1DEH!               SDR(T);
        (01DEH)    0101100   11  00  0111010  11111  00001  000     1


    73  1DAH!        LOADD! LMI(T) FF1 RRM;
        (01DAH)    0011100   11  11  0111101  00000  00001  110     1


    74  1DDH!               LDI(AC) FF1;
        (01DDH)    0101111   11  11  0011111  11111  00001  000     1


    75  1FDH!               ALR(R6);
        (01FDH)    0000110   11  00  0111110  11111  00001  000     1


    76  1FEH!               ILR(M) FF1;
        (01FEH)    0001000   11  11  0111111  00000  00001  000     1


    77  1FFH!               ILR(L);
        (01FFH)    0000101   11  00  0011110  00000  00001  000     1


    78  1EFH!               SDR(R7) FF1;
        (01FFH)    0100111   11  11  0111110  11111  00001  000     1


    79  1EEH!               CMR(R7);
        (01EEH)    1110111   11  00  0111101  00000  00001  000     1
```

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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 5

RECORD                 CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER               6543210   10  10  6543210  43210  43210  210     0

  80  1EDH!                 ILR(J) FF1;
      (01EDH)        0000010   11  11  0111100  00000  00001  000     1

  81  1ECH!                 ALR(R7) FF1:
      (01ECH)        0000111   11  11  0011101  11111  00001  000     1

  82  1DCH!                 NOP(AC) JFL(LOADD,JGT);
      (01DCH)        1101101   11  00  1001101  00000  00001  000     1

  83  1DBH!          JGT!   ILR(A);
      (01DBH)        0000000   11  00  0111001  00000  00001  000     1

  84  1D9H!                 SDR(J) FF1;
      (01D9H)        0100010   11  11  0010111  11111  00001  000     1

  85  179H!                 ILR(K);
      (0179H)        0000100   11  00  0010110  00000  00001  000     1

  86  169H!                 SDR(R7) FF1;
      (0169H)        0100111   11  11  0010101  11111  00001  000     1

  87  159H!                 CMR(R7);
      (0159H)        1110111   11  00  0010100  00000  00001  000     1

  88  149H!                 ILR(I) FF1:
      (0149H)        0000001   11  11  0010011  00000  00001  000     1

  89  139H!                 ALR(R7) FF1;
      (0139H)        0000111   11  11  0010010  11111  00001  000     1

  90  129H!                 NOP(AC) JFL(ADDR,RTNN);
      (0129H)        1101101   11  00  1000001  00000  00001  000     1

  91  11BH!          RTNN!  LMI(R9) FF1;
      (011BH)        00 1001   11  11  0111000  00000  00001  000     1

  92  119H!                 ILR(M) RWM;
      (0119H)        0001000   11  00  0010010  00000  00001  111     1

  93  128H!                 ILR(R6);
      (0128H)        0000110   11  00  0010011  00000  00001  000     1
```

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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 6

RECORD                  CPE     FI  FO    JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER                6543210   10  10  6543210   43210  43210  210     0

    94  138H!              SDR(A) FF1 JZR(FETCH) PAGE1:
        (0138H)  0100000   11  11  0101111   11111  00000  000     1

    95  12H!        SAVEIJ! LMI(R9) FF1:
        (0012H)  0011001   11  11  0000011   00000  00001  000     1

    96  32H!               ILR(I) RWM:
        (0032H)  0000001   11  00  0110001   00000  00001  111     1

    97  31H!               LMI(R9):
        (0031H)  0011001   11  00  0000100   00000  00001  000     1

    98  41H!               ILR(J) RWM JZR(FETCH) PAGE1:
        (0041H)  0000010   11  00  0101111   00000  00000  111     1

    99  13H!        RESTIJ! LMI(R9) FF1 RRM:
        (0013H)  0011001   11  11  0000101   00000  00001  110     1

   100  53H!               ACM(AC):
        (0053H)  0001011   11  00  0110001   00000  00001  000     1

   101  51H!               SDR(I) FF1:
        (0051H)  0100001   11  11  0000110   11111  00001  000     1

   102  61H!               LMI(R9) RRM:
        (0061H)  0011001   11  00  0000111   00000  00001  110     1

   103  71H!               ACM(AC):
        (0071H)  0001011   11  00  0001000   00000  00001  000     1

   104  81H!               SDR(J) FF1 JZR(FETCH) PAGE1:
        (0081H)  0100010   11  11  0101111   11111  00000  000     1

   105  /*          CALCULATE BOUNDARY AREA OF EDGE GATES     */
   106  14H!        EGATES! LMI(P) FF1 RRM:
        (0014H)  0010011   11  11  0000010   00000  00001  110     1

   107  24H!               ACM(AC):
        (0024H)  0001011   11  00  0000011   00000  00001  000     1

   108  34H!               SDR(R6) FF1:
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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 7

RECORD                CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER              6543210  10  10  6543210  43210  43210  210     0

          (0034H)  0100110  11  11  0000100  11111  00001  000     1

  109  44H!                 LMI(R9) FF1:
          (0044H)  0011001  11  11  0000101  00000  00001  000     1

  110  54H!                 ILR(I);
          (0054H)  0000001  11  00  0000110  00000  00001  000     1

  111  64H!                 CIA(AC) FF1;
          (0064H)  0011111  11  11  0000111  00000  00001  000     1

  112  74H!                 SDR(R7) FF1:
          (0074H)  0100111  11  11  0001000  11111  00001  000     1

  113  84H!                 ILR(K);
          (0084H)  0000100  11  00  0110101  00000  00001  000     1

  114  85H!                 ALR(R7) RWM;
          (0085H)  0000111  11  00  0110110  11111  00001  111     1

  115  86H!                 LMI(R6) FF1:
          (0086H)  0010110  11  11  0110111  00000  00001  000     1

  116  87H!                 SRA(AC);
          (0087H)  0001111  11  00  0001001  00000  00001  000     1

  117  97H!                 SRA(AC);
          (0097H)  0001111  11  00  0110110  00000  00001  000     1

  118  96H!                 TZA(AC);
          (0096H)  1011111  11  00  0110101  11111  00001  000     1

  119  95H!                 NOP(AC) JFL(MINX,NOMINX);
          (0095H)  1101101  11  00  1001010  00000  00001  000     1

  120  0A2H!       MINX!    INA(AC) FF1;
          (00A2H)  0111111  11  11  0110011  00000  00001  000     1

  121  0A3H!       NOMINX! SDR(A) FF1_RWM;
          (00A3H)  0100000  11  11  0110100  11111  00001  111     1
```

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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 8

RECORD                   CPF     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER                 6543210   10  10  6543210  43210  43210  210     0

  122  0A4H!                 LMI(R9) FF1:
       (00A4H)  0011001  11  11  0110101  00000  00001  000     1


  123  0A5H!                 ILR(J);
       (00A5H)  0000010  11  00  0110110  00000  00001  000     1


  124  0A6H!                 CIA(AC) FF1:
       (00A6H)  0011111  11  11  0001011  00000  00001  000     1


  125  0B6H!                 SDR(R7) FF1:
       (00B6H)  0100111  11  11  0001100  11111  00001  000     1


  126  0C6H!                 ILR(L);
       (00C6H)  0000101  11  00  0001101  00000  00001  000     1


  127  0D6H!                 ALR(R7) RWM:
       (00D6H)  0000111  11  00  0001110  11111  00001  111     1


  128  0E6H!                 LMI(R6) FF1:
       (00E6H)  0010110  11  11  0001111  00000  00001  000     1


  129  0F6H!                 SRA(AC);
       (00F6H)  0001111  11  00  0010000  00000  00001  000     1


  130  106H!                 SRA(AC);
       (0106H)  0001111  11  00  0110101  00000  00001  000     1


  131  105H!                 TZA(AC);
       (0105H)  1011111  11  00  0010001  11111  00001  000     1


  132  115H!                 NOP(AC) JFL(MINY,NOMINY);
       (0115H)  1101101  11  00  1000010  00000  00001  000     1


  133  122H!        MINY!  INA(AC) FF1;
       (0122H)  0111111  11  11  0110011  00000  00001  000     1


  134  123H!       NOMINY! SDR(R7) FF1 RWM;
       (0123H)  0100111  11  11  0110100  11111  00001  111     1


  135  124H!                 ILR(R9) FF1;
       (0124H)  0001001  11  11  0110111  00000  00001  000     1
```

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RECORD                  CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER                6543210   10  10  6543210  43210  43210  210     0

  136  127H!        ILR(R9) FF1;
       (0127H)    0001001   11  11  0010110  00000  00001  000      1

  137  167H!                ILR(A);
       (0167H)    0000000   11  00  0011010  00000  00001  000      1

  138  1A7H!                CIA(AC) FF1;
       (01A7H)    0011111   11  11  0011011  00000  00001  000      1

  139  1B7H!                SDR(R8) FF1;
       (01B7H)    0101000   11  11  0011100  11111  00001  000      1

  140  1C7H!                ILR(I);
       (01C7H)    0000001   11  00  0011101  00000  00001  000      1

  141  1D7H!                ALR(A);
       (01D7H)    0000000   11  00  0011110  11111  00001  000      1

  142  1E7H!                LMI(R9) FF1 RWM;
       (01E7H)    0011001   11  11  0011111  00000  00001  111      1

  143  1F7H!                ILR(R9) FF1:
       (01F7H)    0001001   11  11  0110110  00000  00001  000      1

  144  1F6H!                LMI(R9) FF1;
       (01F6H)    0011001   11  11  0011110  00000  00001  000      1

  145  1E6H!                ILR(K);
       (01E6H)    0000100   11  00  0011101  00000  00001  000      1

  146  1D6H!                ALR(R8);
       (01D6H)    0001000   11  00  0011100  11111  00001  000      1

  147  1C6H!                CIA(AC) FF1 RWM;
       (01C6H)    0011111   11  11  0011011  00000  00001  111      1

  148  1B6H!                ILR(R7);
       (01B6H)    0000111   11  00  0011000  00000  00001  000      1

  149  1B6H!                CIA(AC) FF1;
       (01B6H)    0011111   11  11  0010101  00000  00001  000      1
```

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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 10

RECORD                CPE     FI  FO   JUMP     KRUSS  OTHER  CBUS  PAUSE
NUMBER              6543210   10  10  6543210   43210  43210  210     0

  150  156H!                SDR(R8) FF1:
       (0156H)     0101000   11  11  0010001   11111  00001  000     1

  151  116H!                ILR(R9) FF1;
       (0116H)     0001001   11  11  0110111   00000  00001  000     1

  152  117H!                ILR(J);
       (0117H)     0000010   11  00  0010000   00000  00001  000     1

  153  107H!                ALR(R7);
       (0107H)     0000111   11  00  0110011   11111  00001  000     1

  154  103H!                LMI(R9) FF1 RWM;
       (0103H)     0011001   11  11  0110010   00000  00001  111     1

  155  102H!                ILR(R9) FF1;
       (0102H)     0001001   11  11  0110001   00000  00001  000     1

  156  101H!                ILR(L);
       (0101H)     0000101   11  00  0010001   00000  00001  000     1

  157  111H!                ALR(R8);
       (0111H)     0001000   11  00  0110010   11111  00001  000     1

  158  112H!                CIA(AC) FF1:
       (0112H)     0011111   11  11  0110011   00000  00001  000     1

  159  113H!                LMI(R9) FF1 RWM;
       (0113H)     0011001   11  11  0111001   00000  00001  111     1

  160  /*       IF MEAN VLAUE IS LESS THAN SEVEN  TRACK BLACK ON WHITE
  161           IF MEAN VALUE IS GREATER OR EQUAL TO SEVEN TRACK WHITE ON BLACK*/
  162  119H!                 CLR(R9);
       (0119H)     1001001   11  00  0010000   00000  00001  000     1

  163  109H!                 LMI(R9) K0Q00F FF1;
       (0109H)     0011001   11  11  0111000   01111  00001  000     1

  164  108H!                 LMI(R9) RRM;
       (0108H)     0011001   11  00  0010100   00000  00001  110     1
```

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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 11

RECORD              CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER            6543210   10  10  6543210  43210  43210  210     0

  165  148H!                ACM(AC) FF1 STZ;
       (0148H)    0001011   01  11  0111100  00000  00001  000     1

  166  14CH!                NOP(AC) JFL(WHITE,BLACK);
       (014CH)    1101101   11  00  1000010  00000  00001  000     1

  167  12AH!         WHITE! CLR(R9);
       (012AH)    1001001   11  00  0010000  00000  00001  000     1

  168  10AH!                LMI(R9) K00005 RRM;
       (010AH)    0011001   11  00  0111011  00101  00001  110     1

  169  10BH!                LCM(AC);
       (010BH)    1111011   11  00  0111110  00000  00001  000     1

  170  10EH!               INA(AC) FF1 RWM PAGE1 JZR(FETCH);
       (010EH)    0111111   11  11  0101111  00000  00000  111     1

  171  12BH!         BLACK! NOP(AC) PAGE1 JZR(FETCH);
       (012BH)    1101101   11  00  0101111  00000  00000  000     1

  172  /*         NGATEA NGATEB NGATEC AND NGATEL CALCULATE EDGES OF THE GATE
  173             AND THE NEW I J K L                          */
  174  15H!        NGATEA! LMI(R9) RRM;
       (0015H)    0011001   11  00  0000010  00000  00001  110     1

  175  25H!               ACM(AC);
       (0025H)    0001011   11  00  0000011  00000  00001  000     1

  176  35H!               CIA(AC) FF1;
       (0035H)    0011111   11  11  0000100  00000  00001  000     1

  177  45H!               SDR(R6) FF1;
       (0045H)    0100110   11  11  0000101  11111  00001  000     1

  178  55H!               CLR(R7);
       (0055H)    1000111   11  00  0000110  00000  00001  000     1

  179  65H!               LMI(R7) K00007;
       (0065H)    0010111   11  00  0000111  00111  00001  000     1
```

```
RECORD                  CPF     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER                6543210   10  10  6543210  43210  43210  210     0

  180  75H!                     LMI(R7) FF1 RRM:
       (0075H)        0010111   11  11  0001011  00000  00001  110     1

  181  0B5H!                    ACM(AC):
       (00B5H)        0001011   11  00  0111100  00000  00001  000     1

  182  0BCH!                    LMI(R7) FF1:
       (00BCH)        0010111   11  11  0001101  00000  00001  000     1

  183  0DCH!                    LMI(R7) RRM:
       (00DCH)        0010111   11  00  0111101  00000  00001  110     1

  184  0DDH!                    AMA(AC):
       (00DDH)        0001011   11  00  0001100  11111  00001  000     1

  185  0CDH!                    ADR(R6):
       (00CDH)        0110110   11  00  0001011  11111  00001  000     1

  186  0BDH!                    CLR(R7):
       (00BDH)        1000111   11  00  0001010  00000  00001  000     1

  187  0ADH!                    LMI(R7) K00003:
       (00ADH)        0010111   11  00  0001001  00011  00001  000     1

  188  9DH!                     LMI(R7) RRM:
       (009DH)        0010111   11  00  0001000  00000  00001  110     1

  189  8DH!                     ACM(AC):
       (008DH)        0001011   11  00  0111100  00000  00001  000     1

  190  8CH!                     ALR(AC):
       (008CH)        0001101   11  00  0001001  11111  00001  000     1

  191  9CH!                     ALR(AC):
       (009CH)        0001101   11  00  0001010  11111  00001  000     1

  192  0ACH!                    LMI(R9) FF1 RWM:
       (00ACH)        0011001   11  11  0001100  00000  00001  111     1

  193  0CCH!                    ALR(R6):
       (00CCH)        0000110   11  00  0111110  11111  00001  000     1
```

```
RECORD                  CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER                6543210   10  10  6543210  43210  43210  210     0

  194  0CEH!                SDR(A) FF1 JZR(FETCH) PAGE1:
       (00CEH)   0100000   11  11  0101111  11111  00000  000     1

  195  16H!         NGATFB! LMI(R9) RRM;
       (0016H)   0011001   11  00  0000010  00000  00001  110     1

  196  26H!                 ACM(AC);
       (0026H)   0001011   11  00  0000011  00000  00001  000     1

  197  36H!                 SRA(AC);
       (0036H)   0001111   11  00  0000100  00000  00001  000     1

  198  46H!                 ALR(A);
       (0046H)   0000000   11  00  0000101  11111  00001  000     1

  199  56H!                 SDR(A) FF1;
       (0056H)   0100000   11  11  0000110  11111  00001  000     1

  200  66H!                 CIA(AC) FF1;
       (0066H)   0011111   11  11  0000111  00000  00001  000     1

  201  76H!                 LMI(P) FF1 RRM;
       (0076H)   0010011   11  11  0111001  00000  00001  110     1

  202  79H!                 LMM(T) RRM;
       (0079H)   0011010   11  00  0001000  00000  00001  110     1

  203  89H!                 AMA(AC);
       (0089H)   0001011   11  00  0001001  11111  00001  000     1

  204  99H!                 SDR(I) FF1;
       (0099H)   0100001   11  11  0001010  11111  00001  000     1

  205  0A9H!                ILR(A) RRM;
       (00A9H)   0000000   11  00  0001011  00000  00001  110     1

  206  0B9H!                AMA(AC);
       (00B9H)   0001011   11  00  0001100  11111  00001  000     1

  207  0C9H!                SDR(K) FF1 JZR(FETCH) PAGE1;
       (00C9H)   0100100   11  11  0101111  11111  00000  000     1
```

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XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 14

RECORD                CPE     FI  FO    JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER              6543210  10  10  6543210   43210  43210  210     0

  208  17H!         NGATEC! LMI(R9) RRM;
       (0017H)  0011001  11  00  0000010   00000  00001  110     1

  209  27H!                 ACM(AC);
       (0027H)  0001011  11  00  0000011   00000  00001  000     1

  210  37H!                 CIA(AC) FF1:
       (0037H)  0011111  11  11  0000100   00000  00001  000     1

  211  47H!                 SDR(R6) FF1:
       (0047H)  0100110  11  11  0000101   11111  00001  000     1

  212  57H!                 CLR(R7);
       (0057H)  1000111  11  00  0000110   00000  00001  000     1

  213  67H!                 LMI(R7) K0000B;
       (0067H)  0010111  11  00  0000111   01011  00001  000     1

  214  77H!                 LMI(R7) FF1 RRM;
       (0077H)  0010111  11  11  0001010   00000  00001  110     1

  215  0A7H!                ACM(AC);
       (00A7H)  0001011  11  00  0001011   00000  00001  000     1

  216  0B7H!                LMI(R7) FF1:
       (00B7H)  0010111  11  11  0001100   00000  00001  000     1

  217  0C7H!                LMI(R7) RRM;
       (00C7H)  0010111  11  00  0001101   00000  00001  110     1

  218  0D7H!                AMA(AC);
       (00D7H)  0001011  11  00  0001110   11111  00001  000     1

  219  0E7H!                ADR(R6);
       (00E7H)  0110110  11  00  0001111   11111  00001  000     1

  220  0F7H!                CLR(R7);
       (00F7H)  1000111  11  00  0111000   00000  00001  000     1

  221  0F8H!                LMI(R7) K00002;
       (00F8H)  0010111  11  00  0111001   00010  00001  000     1
```

```
RECORD               CPE     FI  FO    JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER             6543210   10  10  6543210   43210  43210  210     0

  222  0F9H!                LMI(R7) RRM;
       (00F9H)   0010111   11  00  0111100   00000  00001  110     1


  223  0FCH!                ACM(AC);
       (00FCH)   0001011   11  00  0111101   00000  00001  000     1


  224  0FDH!                ALR(AC);
       (00FDH)   0001101   11  00  0001110   11111  00001  000     1


  225  0EDH!                ALR(AC);
       (00EDH)   0001101   11  00  0111100   11111  00001  000     1


  226  0ECH!                LMI(R9) FF1 RWM;
       (00ECH)   0011001   11  11  0111001   00000  00001  111     1


  227  0E9H!                ALR(R6);
       (00E9H)   0000110   11  00  0111000   11111  00001  000     1


  228  0E8H!                SDR(A) FF1 JZR(FETCH) PAGE1;
       (00E8H)   0100000   11  11  0101111   11111  00000  000     1


  229  18H!        NGATEL! LMI(R9) RRM;
       (0018H)   0011001   11  00  0000010   00000  00001  110     1


  230  28H!                 ACM(AC);
       (0028H)   0001011   11  00  0000011   00000  00001  000     1


  231  38H!                 SRA(AC);
       (0038H)   0001111   11  00  0000100   00000  00001  000     1


  232  48H!                 ALR(A);
       (0048H)   0000000   11  00  0000101   11111  00001  000     1


  233  58H!                 SDR(A) FF1;
       (0058H)   0100000   11  11  0000110   11111  00001  000     1


  234  68H!                 CIA(AC) FF1;
       (0068H)   0011111   11  11  0000111   00000  00001  000     1


  235  78H!                 LMI(P) FF1 RRM;
       (0078H)   0010011   11  11  0001000   00000  00001  110     1
```

```
RECORD                CPE     FI  FO   JUMP     KBUSS  OTHER  CBUS  PAUSE
NUMBER              6543210   10  10  6543210   43210  43210  210     0

  236  88H!                   LMM(T) RRM;
       (0088H)    0011010   11  00  0001001   00000  00001  110     1

  237  98H!                   AMA(AC);
       (0098H)    0001011   11  00  0001010   11111  00001  000     1

  238  0A8H!                  SDR(J) FF1;
       (00A8H)    0100010   11  11  0001011   11111  00001  000     1

  239  0B8H!                  ILR(A) RRM;
       (00B8H)    0000000   11  00  0001100   00000  00001  110     1

  240  0C8H!                  AMA(AC);
       (00C8H)    0001011   11  00  0001101   11111  00001  000     1

  241  0D8H!                  SDR(L) FF1  JZR(FETCH) PAGE1;
       (00D8H)    0100101   11  11  0101111   11111  00000  000     1

  242  /*      WINDOW-----(VARIABLE WINDOW MICROROUTINE)              */
  243  19H!          WINDOW! LMI(R9) FF1;
       (0019H)    0011001   11  11  0000010   00000  00001  000     1

  244  29H!                   ILR(J) ROT;
       (0029H)    0000010   11  00  0000011   00000  00001  101     1

  245  39H!                   LMI(R9) FF1;
       (0039H)    0011001   11  11  0000100   00000  00001  000     1

  246  49H!                   ILR(L) ROT;
       (0049H)    0000101   11  00  0000101   00000  00001  101     1

  247  59H!                   LMI(R9) FF1;
       (0059H)    0011001   11  11  0000110   00000  00001  000     1

  248  69H!                   ILR(I) ROT;
       (0069H)    0000001   11  00  0111100   00000  00001  101     1

  249  6CH!                   LMI(R9) FF1;
       (006CH)    0011001   11  11  0111101   00000  00001  000     1

  250  6DH!                   ILR(K) ROT JZR(FETCH) PAGE1;
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0    PAGE 17

RECORD                CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER              6543210   10  10  6543210  43210  43210  210     0

        (006DH)     0000100   11  00  0101111  00000  00000  101     1


  251   1AH!          FRAME! NOP(R8) STROBE2;
        (001AH)     11 1000   11  00  0011010  00000  10001  000     1


  252   1AAH!         WAT!   NOP(R8) RIN;
        (01AAH)     1101000   11  00  0111100  00000  00001  100     1


  253   1ACH!                LDI(AC) FF1:
        (01ACH)     0101111   11  11  0111101  11111  00001  000     1


  254   1ADH!                TZR(AC) K80000;
        (01ADH)     1011101   11  00  0111111  10010  00001  000     1


  255   1AFH!                NOP(R8) JFL(WAT,RDY);
        (01AFH)     1101000   11  00  1001010  00000  00001  000     1


  256   1ABH!         RDY!   NOP(R8) JZR(FETCH) PAGE1;
        (01ABH)     1101000   11  00  0101111  00000  00000  000     1


  257   1BH!          START! LMI(R9) FF1 RRM;
        (001BH)     0011001   11  11  0000011  00000  00001  110     1


  258   3BH!                 ACM(AC);
        (003BH)     0001011   11  00  0111101  00000  00001  000     1


  259   3DH!                 SDR(I) FF1;
        (003DH)     0100001   11  11  0010000  11111  00001  000     1


  260   10DH!                LMI(R9) FF1 RRM;
        (010DH)     0011001   11  11  0010010  00000  00001  110     1


  261   12DH!                ACM(AC);
        (012DH)     0001011   11  00  0010011  00000  00001  000     1


  262   13DH!                SDR(J) FF1;
        (013DH)     0100010   11  11  0010100  11111  00001  000     1


  263   14DH!                LMI(R9) FF1 RRM;
        (014DH)     0011001   11  11  0010101  00000  00001  110     1
```

```
RECORD                  CPE      FI  FO   JUMP      KRUSS   OTHER   CBUS   PAUSE
NUMBER                6543210    10  10  6543210    43210   43210   210      0

  264  150H!                    ACM(AC):
       (0150H)        0001011    11  00  0010110    00000   00001   000      1

  265  160H!                    SDR(K) FF1:
       (0160H)        0100100    11  11  0010111    11111   00001   000      1

  266  170H!                    LMI(R9) RRM:
       (0170H)        0011001    11  00  0011000    00000   00001   110      1

  267  180H!                    ACM(AC):
       (0180H)        0001011    11  00  0011001    00000   00001   000      1

  268  190H!                    SDR(L) FF1 JZR(FETCH) PAGE1:
       (0190H)        0100101    11  11  0101111    11111   00000   000      1

  269  1CH!          NOTC!     NOP(A) JZR(FETCH) PAGE1:
       (001CH)        1100000    11  00  0101111    00000   00000   000      1

  270  1DH!          NOTD!     NOP(A) JZR(FETCH) PAGE1:
       (001DH)        1100000    11  00  0101111    00000   00000   000      1

  271  1EH!          NOTE!     NOP(A) JZR(FETCH) PAGE1:
       (001EH)        1100000    11  00  0101111    00000   00000   000      1

  272  1FH!          NOTF!     NOP(A) JZR(FETCH) PAGE1:
       (001FH)        1100000    11  00  0101111    00000   00000   000      1

  273  /*     CENTROID CALCULATIONS  AND TARGET AREAS OF EDGE GATES              */
  274  10H!          CNTRD! CLA(AC):
       (0010H)        1001011    11  00  0000000    00000   00001   000      1

  275  00H!           SDR(M) FF1:
       (0000H)        0101000    11  11  0000010    11111   00001   000      1

  276  20H!                    LMI(R9) FF1 RWM:
       (0020H)        0011001    11  11  0000011    00000   00001   111      1

  277  30H!                    LMI(R9) FF1:
       (0030H)        0011001    11  11  0000100    00000   00001   000      1

  278  40H!                    LMI(R9) FF1 RWM:
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 19

RECORD                  CPF    FI  FO    JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER                6543210  10  10  6543210   43210  43210  210     0

          (0040H)     0011001  11  11  0000101   00000  00001  111     1


  279   50H!                   LMI(R9) FF1;
          (0050H)     0011001  11  11  0000110   00000  00001  000     1


  280   60H!                   LMI(R9) FF1 RWM;
          (0060H)     0011001  11  11  0000111   00000  00001  111     1


  281   70H!                   LMI(R9) FF1;
          (0070H)     0011001  11  11  0001000   00000  00001  000     1


  282   80H!                   LMI(R9) FF1 RWM;
          (0080H)     0011001  11  11  0001001   00000  00001  111     1


  283   90H!                   LMI(R9) FF1 RWM;
          (0090H)     0011001  11  11  0001010   00000  00001  111     1


  284   0A0H!                  LMI(R9) RWM;
          (00A0H)     0011001  11  00  0001011   00000  00001  111     1


  285   0B0H!                  ILR(J);
          (00B0H)     0000010  11  00  0001100   00000  00001  000     1


  286   0C0H!                  SDR(A) FF1;
          (00C0H)     0100000  11  11  0110010   11111  00001  000     1


  287   0C2H!          CADDR!  ILR(I);
          (00C2H)     0000001  11  00  0110100   00000  00001  000     1


  288   0C4H!                  DCA(AC);
          (00C4H)     0011111  11  00  0001101   11111  00001  000     1


  289   0D4H!                  CLA(T);
          (00D4H)     1001010  11  00  0110000   00000  00001  000     1


  290   0D0H!                  ALR(AC);
          (00D0H)     0001101  11  00  0001110   11111  00001  000     1


  291   0E0H!                  ALR(AC);
          (00E0H)     0001101  11  00  0001111   11111  00001  000     1
```

```
RECORD          CPE   FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER        6543210 10  10  6543210  43210  43210  210     0

  292 0F0H!    ALR(T);
      (00F0H) 0001100 11  00  0010000  11111  00001  000     1


  293 100H!    ALR(AC);
      (0100H) 0001101 11  00  0010001  11111  00001  000     1


  294 110H!          ALR(AC);
      (0110H) 0001101 11  00  0010010  11111  00001  000     1


  295 120H!          ALR(AC);
      (0120H) 0001101 11  00  0010011  11111  00001  000     1


  296 130H!          ADR(T);
      (0130H) 0111100 11  00  0010100  11111  00001  000     1


  297 140H!          ALR(AC);
      (0140H) 0001101 11  00  0010101  11111  00001  000     1


  298 150H!          ALR(T);
      (0150H) 0001100 11  00  0111000  11111  00001  000     1


  299 158H!           ILR(J);
      (0158H) 0000010 11  00  0010110  00000  00001  000     1


  300 168H!           ALR(T);
      (0168H) 0001100 11  00  0110000  11111  00001  000     1


  301 160H!          SDR(T);
      (0160H) 0101100 11  00  0110010  11111  00001  000     1


  302 162H!  CLOAD! CLR(R9);
      (0162H) 1001001 11  00  0110110  00000  00001  000     1


  303 166H!           TZR(R9) FFZ;
      (0166H) 1011001 11  10  0111100  11111  00001  000     1


  304 /*    BRANCH TO WHITEE FOR WHITE ON BLACK TARGET
  305       BRANCH TO BLACKK TO TRACK ON BLACK TARGET    */
  306 16CH!           LMI(R9) K00005 FF1 RRM JFL(WHITEE.BLACKK);
      (016CH) 0011001 11  11  1000111  00101  00001  110     1
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 21

RECORD                 CPE     FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER               6543210   10  10  6543210  43210  43210  210     0

  307  17BH!       BLACKK! ACM(AC);
       (017BH)   0001011   11  00  0111100  00000  00001  000     1

  308  17CH!               SDR(R6) FF1;
       (017CH)   0100110   11  11  0111000  11111  00001  000     1

  309  178H!               LMI(T) FF1 RRM;
       (0178H)   0011100   11  11  0011000  00000  00001  110     1

  310  188H!               LDI(AC) FF1;
       (0188H)   0101111   11  11  0011001  11111  00001  000     1

  311  198H!               CIA(AC) FF1;
       (0198H)   0011111   11  11  0110111  00000  00001  000     1

  312  197H!               ALR(R6) JCR(OVER);
       (0197H)   0000110   11  00  0110000  11111  00001  000     1

  313  17AH!       WHITEE! ACM(AC);
       (017AH)   0001011   11  00  0110000  00000  00001  000     1

  314  170H!              LMI(T) FF1 RRM;
       (0170H)   0011100   11  11  0011000  00000  00001  110     1

  315  180H!              AIA(AC);
       (0180H)   0111111   11  00  0011001  11111  00001  000     1

  316  190H!       OVER! NOP(AC) JFL(NODATA.DATA);
       (0190H)   1101101   11  00  1001001  00000  00001  000     1

  317  192H!     NODATA! ILR(L);
       (0192H)   0000101   11  00  0110001  00000  00001  000     1

  318  191H!              SDR(R6) FF1;
       (0191H)   0100110   11  11  0011010  11111  00001  000     1

  319  1A1H!              CMR(R6);
       (01A1H)   1110110   11  00  0110100  00000  00001  000     1

  320  1A4H!              ILR(J) FF1;
       (01A4H)   0000010   11  11  0011001  00000  00001  000     1
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 22

RECORD                CPE     FI  FO    JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER              6543210   10  10  6543210   43210  43210  210     0

  321  194H!                  ALR(R6) FF1:
       (0194H)      0000110   11  11  0010101   11111  00001  000     1


  322  154H!                  NOP(AC) JFL(CLOAD.JGTL):
       (0154H)      1101101   11  00  1000110   00000  00001  000     1


  323  163H!          JGTL!   ILR(A):
       (0163H)      0000000   11  00  0110101   00000  00001  000     1


  324  165H!                  SDR(J) FF1:
       (0165H)      0100010   11  11  0010100   11111  00001  000     1


  325  145H!                  ILR(K):
       (0145H)      0000100   11  00  0110100   00000  00001  000     1


  326  144H!                  SDR(R6) FF1:
       (0144H)      0100110   11  11  0010000   11111  00001  000     1


  327  104H!                  CMR(R6):
       (0104H)      1110110   11  00  0001111   00000  00001  000     1


  328  0F4H!                  ILR(I) FF1:
       (00F4H)      0000001   11  11  0001110   00000  00001  000     1


  329  0E4H!                  ALR(R6) FF1:
       (00F4H)      0000110   11  11  0001011   11111  00001  000     1


  330  0B4H!                  NOP(AC) JFL(CADDR.ENDC):
       (00B4H)      1101101   11  00  1001100   00000  00001  000     1


  331  193H!          DATA!   ILR(R9):
       (0193H)      0001001   11  00  0110101   00000  00001  000     1


  332  195H!                  SDR(R6)FF1:
       (0195H)     .0100110   11  11  0011010   11111  00001  000     1


  333  1A5H!                  LMI(R6) K00008:
       (01A5H)      0010110   11  00  0110000   01000  00001  000     1


  334  1A0H!          ILR(I):
       (01A0H)      0000001   11  00  0011011   00000  00001  000     1
```

```
RECORD                 CPF      FI  FO   JUMP     KBUSS  OTHER  CBUS  PAUSE
NUMBER               6543210   10  10  6543210   43210  43210  210     0

  335  1B0H!                  LMI(R6) FF1 RRM;
       (01B0H)  0010110  11  11  0011100  00000  00001  110     1

  336  1C0H!                  AMA(AC) RWM;
       (01C0H)  0001011  11  00  0011101  11111  00001  111     1

  337  1D0H!                  ILR(J);
       (01D0H)  0000010  11  00  0011110  00000  00001  000     1

  338  1E0H!                  LMI(R6) RRM;
       (01F0H)  0010110  11  00  0011111  00000  00001  110     1

  339  1F0H!                  AMA(AC) RWM;
       (01F0H)  0001011  11  00  0110101  11111  00001  111     1

  340  1F5H!                  ILR(M) FF1;
       (01F5H)  0001000  11  11  0011110  00000  00001  000     1

  341  1E5H!                  ILR(I);
       (01E5H)  0000001  11  00  0011101  00000  00001  000     1

  342  1D5H!                  CIA(AC);
       (01D5H)  0011111  11  00  0110100  00000  00001  000     1

  343  1D4H!                  LMI(R9) FF1 RRM;
       (01D4H)  0011001  11  11  0011100  00000  00001  110     1

  344  1C4H!                  AMA(AC);
       (01C4H)  0001011  11  00  0110101  11111  00001  000     1

  345  1C5H!                  NOP(AC) JFL(NXEEG.XEEG);
       (01C5H)  1101101  11  00  1001011  00000  00001  000     1

  346  1B3H!        XEEG!     LMI(R9) FF1 RRM;
       (01B3H)  0011001  11  11  0110100  00000  00001  110     1

  347  1B4H!                  ACM(AC) FF1 RWM JCC(NXBLG2);
       (01B4H)  0001011  11  11  0010111  00000  00001  111     1

  348  1B2H!       NXEEG!     ILR(R9) FF1;
       (01B2H)  0001001  11  11  0110001  00000  00001  000     1
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 24

RECORD                CPE     FI  FO    JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER              6543210   10  10  6543210   43210  43210  210     0

  349  181H!                ILR(I);
       (0181H)  0000001   11  00  0011000   00000  00001  000     1

  350  181H!                LMI(R9) FF1 RRM;
       (0181H)  0011001   11  11  0010111   00000  00001  110     1

  351  171H!                AMA(AC);
       (0171H)  0001011   11  00  0010110   11111  00001  000     1

  352  161H!                NOP(AC) JFL(NXBLG,XBLG);
       (0161H)  1101101   11  00  1000111   00000  00001  000     1

  353  173H!      XBLG!  LMI(R9) FF1 RRM;
       (0173H)  0011001   11  11  0110101   00000  00001  110     1

  354  175H!                ACM(AC) FF1 RWM JCR(NXBL);
       (0175H)  0001011   11  11  0110111   00000  00001  111     1

  355  174H!      NXBLG2! ILR(R9) FF1;
       (0174H)  0001001   11  11  0110010   00000  00001  000     1

  356  172H!      NXBLG! ILR(R9) FF1;
       (0172H)  00 1001   11  11  0110111   00000  00001  000     1

  357  177H!      NXBL!  ILR(J);
       (0177H)  0000010   11  00  0010011   00000  00001  000     1

  358  137H!                CIA(AC);
       (0137H)  0011111   11  00  0110110   00000  00001  000     1

  359  136H!                LMI(R9) FF1 RRM;
       (0136H)  0011001   11  11  0110101   00000  00001  110     1

  360  135H!                AMA(AC);
       (0135H)  0001011   11  00  0110100   11111  00001  000     1

  361  134H!                NOP(AC) JFL(NYEEG,YEEG);
       (0134H)  1101101   11  00  1000100   00000  00001  000     1

  362  143H!      YEEG!  LMI(R9) FF1 RRM;
       (0143H)  0011001   11  11  0110110   00000  00001  110     1
```

```
XMAS VERS 2.0 OPTICAL CONTRAST VARIABLE GATE CENTROID TRACK ERRORS= 0   PAGE 25

RECORD               CPE    FI  FO   JUMP    KBUSS  OTHER  CBUS  PAUSE
NUMBER             6543210  10  10  6543210  43210  43210  210     0

  363  146H!               ACM(AC) FF1 RWM;
       (0146H)  0001011  11  11  0011001  00000  00001  111      1


  364  196H!               NOP(A) JCR(NODATA);
       (0196H)  1100000  11  00  0110010  00000  00001  000      1


  365  142H!        NYEEG! ILR(R9) FF1;
       (0142H)  00 1001  11  11  0110111  00000  00001  000      1


  366  147H!               ILR(J);
       (0147H)  0000010  11  00  0010101  00000  00001  000      1


  367  157H!               LMI(R9) FF1 RRM;
       (0157H)  0011001  11  11  0011000  00000  00001  110      1


  368  187H!               AMA(AC);
       (0187H)  0001011  11  00  0110100  11111  00001  000      1


  369  184H!               NOP(AC) JFL(NODAT,YBLG):
       (0184H)  1101101  11  00  1001000  00000  00001  000      1


  370  183H!        YBLG!  LMI(R9) FF1 RRM;
       (0183H)  0011001  11  11  0110101  00000  00001  110      1


  371  185H!               ACM(AC) FF1 RWM JCR(NODAT):
       (0185H)  0001011  11  11  0110010  00000  00001  111      1


  372  0C3H!        ENDC!  CLR(R9);
       (00C3H)  1001001  11  00  0110101  00000  00001  000      1


  373  0C5H!               LMI(R9) K00004;
       (00C5H)  0011001  11  00  0001110  00100  00001  000      1


  374  0E5H!               ILR(M) RWM PAGE1 JZR(FETCH);
       (00E5H)  0001000  11  00  0101111  00000  00000  111      1


  375  182H!        NODAT! NOP(A) JCC(NODATA);
       (0182H)  1100000  11  00  0011001  00000  00001  000      1


  376  EOF
```

Appendix D.

EAI PACER 100 EMULATION MICRO CODE LISTING

XMAS VERS 2.0 PACER EMULATOR MICROCODE FOR INTEL 3000

RECORD
NUMBER

```

KBUSS     FIELD  LENGTH=5   DEFAULT=0
                 MICROPS(KFFFFF=10101B    KFFFFA=10100B    K7FFFF=10011B
                         K80000=10010B    K01FFF=10001B    K00060=10000B
                         K0000F=01111B    K0000E=01110B    K0000D=01101B
                         K0000C=01100B    K0000B=01011B    K0000A=01010B
                         K00009=01001B    K00008=01000B    K00007=00111B
                         K00006=00110B    K00005=00101B    K00004=00100B
                         K00003=00011B    K00002=00010B    K00001=00001B
                         K00000=00000B);
KBUSS     KBUS;

OTHER     FIELD  LENGTH=5   DEFAULT=0
          MICROPS(SET1=11111B  PAGE1=00000B  PAGE2=00001B);

/* DEFINITION OF BUS CONTROL FIELD            */

CBUS       FIELD  LENGTH=3          DEFAULT=0
          MICROPS(NBO=000B   INH=001B   RMW=010B   CNB=011B
                  RIN=100B   ROT=101B   RRM=110B   RWM=111B);

/*        NBO    NOBUS OPERATION
          INH    INHIBIT CPE ARRAY
          RMW    READ-MODIFY-WRITE
          CNB    CPU NEEDS BUS
          RIN    REQUEST INPUT
          ROT    REQUEST OUTPUT
          RRM    REQUEST READ MEMORY
          RWM    REQUEST WRITE MEMORY

          SET UP SYMBOLIC REPRESENTATION OF REGISTER DESIGNATIONS */

A         STRING 'R0';
X         STRING 'R1';
Q         STRING 'R2';
P         STRING 'R3';
S         STRING 'R4';
B         STRING 'R5';
E         STRING 'R6';
W         STRING 'R7';

PAUSE     FIELD  LENGTH=1   DEFAULT=1
                 MICROPS(SP1=1   SP0=0);

00H!      INIT!  CLR(A);
10H!             CLR(X);
20H!             CLR(W) JCC(INIT1);
30H!      DIR!   LMI(AC) RRM JPR(LA STA LX STX A1 S1 M D AOM OR1 XOR1
                                     ANDD C EE FF GG);
40H!      INIT1! CLR(T) JCC(INIT2);
60H!      SE!    NOP(A) JCF(NTEQL,EQL);
70H!      LA!    ACM(AC);
80H!             SDR(A) FF1 JZR(FETCH);
90H!      INIT2! LMI(T);
```

```
RECORD
NUMBER

  55  0A0H!                 ILR(W) ROT;
  56  0B0H!                 LMI(T) FF1 RRM;
  57  0C0H!                 ACM(AC);
  58  0D0H!                 SDR(S) FF1;
  59  0E0H!                 LMI(T) RRM;
  60  0F0H!                 ACM(AC);
  61  100H!                 SDR(P) FF1 JZR(FETCH);
  62  110H!         CLR1!   CLR(A) JZR(FETCH);
  63  1E0H!         N1!     NOP(A) JZR(FETCH);
  64  31H!          J!      SDR(P) FF1 JZP(FETCH);
  65  61H!          SG!     NOP(A) JCC(SGC);
  66  71H!          STA!    ILR(A) RWM JZR(FETCH);
  67  91H!          SGC!    NOP(A) JCF(NTEQL2,EQL2):
  68  111H!         AOA!    ILR(A) FF1 STC JZR(FETCH):
  69  131H!         YY!     SDR(A) FF1 JZR(FETCH);
  70  151H!         WW!     SDR(A) FF1 JZR(FETCH);
  71  1E1H!         N2!     NOP(A) JZR(FETCH);
  72  02H!          N EQ3!  NOP(A) JZF(LT,NTLT):
  73  12H!          LT!     ILR(P) FF1 JZR(FETCH);
  74  22H!          NTEQL!  NOP(A) JZR(FETCH);
  75  32H!          L!      LMI(S) FF1;
  76  42H!                  ILR(P) RWM;
  77  52H!                  ILR(R9) JCR(CL);
  78  62H!          SL!     NOP(A) JCF(NTEQ3,EQ3);
  79  72H!          LX!     ACM(AC);
  80  82H!                  SDR(X) FF1 JZR(FETCH);
  81  92H!          NTEQL2!                       NOP(A) JZF(NTGT,GT):
  82  0A2H!         NTGT!   NOP(A) JZR(FETCH);
  83  0D2H!         NTEQL4!                        ILR(P) FF1 JZR(FETCH):
  84  0E2H!         NTEQ5!  NOP(A) JZF(NTGT5,GT5);
  85  0F2H!         NTGT5!  NOP(A) JZR(FETCH);
  86  112H!         CAO!    CLR(A);
  87  122H!                 ILR(A) FF1 JZR(FETCH);
  88  132H!         OUT2!   ALR(AC) FFZ JCR(YY);
  89  142H!         OUT3!   NOP(A) JZR(FETCH);
  90  162H!         NTEQ6!  NOP(A) JZF(NTGT6,GT6);
  91  172H!         NTGT6!  ILR(P) FF1 JZP(FETCH);
  92  1E2H!         N3!     NOP(A) JZR(FETCH);
  93  03H!          E 3!    NOP(A) JZR(FETCH);
  94  13H!          NTLT!   NOP(A) JZR(FETCH);
  95  23H!          EQL!    ILR(P) FF1 JZR(FETCH);
  96  33H!          RFG!    ILR(A) JCC(REGC);
  97  63H!          SNE!    NOP(A) JCC(SNEC);
  98  73H!          S X!    ILR(X) RWM JZR(FETCH);
  99  83H!          SNEC!   NOP(A) JCF(NTEQL4,EQL4);
 100  93H!          EQL2!   NOP(A) JZR(FETCH);
 101  0A3H!         GT!     ILR(P) FF1 JZR(FETCH);
 102  0D3H!         EQL4!   NOP(A) JZR(FETCH);
 103  0E3H!         EQ5!    ILR(P) FF1 JZR(FETCH);
 104  0F3H!         GT5!    ILR(P) FF1 JZP(FETCH);
 105  103H!         REGC!   NOP(A) JPR(CLR1 AOA CAO TCA ARS ALS LRS SSP
 106                                  SSN EX EP ES ICX DCX NOPP PZ);
 107  113H!         TCA!    CMR(A);
 108  123H!                 ILR(A) FF1 STC JZR(FETCH):
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RECORD
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  109  133H!      AGN2!  DSM(R9) JCR(XX);
  110  143H!      AGN3!  DSM(R9) JCR(BACK);
  111  163H!      EQ6!   ILR(P) FF1 JZR(FETCH);
  112  173H!      GT6!   NOP(A) JZR(FETCH);
  113  1E3H!      N4!    NOP(A) JZR(FETCH);
  114  34H!       I!     LMI(AC) RRM:
  115  44H!              ACM(AC);
  116  54H!              LMI(AC) RRM JPR(LA STA LX STX A1 S1 M D AOM OR1 XOR1
  117                                       ANDD C EE FF GG);
  118  64H!       SGE!   NOP(A) JCC(SGEC);
  119  74H!       A1!    ACM(AC);
  120  84H!              ALR(A) STC JZR(FETCH);
  121  0E4H!      SGEC!  NOP(A) JCF(NTEQ5,EQ5);
  122  114H!      ARS!   TZR(A) STC K80000 INH;
  123  124H!             DSM(R9);
  124  134H!      XX!    SRA(AC) STZ FFC JFL(OUT2,AGN2);
  125  1D4H!      DWN1!  LMI(R9) FF1 JCR(PUSA4);
  126  1E4H!      N5!    NOP(A) JZR(FETCH);
  127  35H!       J-!    LMI(AC) RRM:
  128  45H!              ACM(AC);
  129  55H!       CL!    SDR(P) FF1 JZR(FETCH);
  130  65H!       SLE!   NOP(A) JCC(SLEC);
  131  75H!       S1:    ACM(AC);
  132  85H!              CIA(AC) FF1;
  133  95H!              ALR(A) STC JZR(FETCH);
  134  115H!      ALS!   DSM(R9);
  135  125H!             ILR(A);
  136  135H!             DSM(R9);
  137  145H!      BACK!  ALR(A) STC JFL(OUT3,AGN3);
  138  155H!      SLEC!  NOP(A) JCF(NTEQ6,EQ6);
  139  1D5H!      DWN2!  ILR(R8) RWM JCR(DWN1);
  140  1E5H!      TRAP!  NOP(A) JZR(FETCH);
  141  36H!       LI!    LMI(S) FF1;
  142  46H!              ILR(P) RWM;
  143  56H!              LMI(R9) RRM JCR(CLI);
  144  66H!       PUSA!  LMI(R9) FF1 JCC(PUSAC);
  145  /*   LOAD MULTIPLIER      ---MLT--%T       */
  146  76H!       M,     ACM(T);
  147  /*   SAVE SIGN BIT IN C FLAG    */
  148  86H!              ILR(T);
  149  8EH!              SDR(R9) FF1;
  150  9EH!              TZR(A) K80000 INH STC;
  151  /*     WIPE OUT SIGN BIT    */
  152  96H!              TZR(T) K7FFFF;
  153  /*    SET UP LOOP COUNTER    */
  154  0A6H!      .      CLR(AC);
  155  0A5H!             LMI(AC) K0000F;
  156  0A4H!             LMI(AC) K00004;
  157  0B4H!             CIA(AC) FF1;
  158  0B5H!             SDR(R8) FF1;
  159  /*    CLEAR PARTIAL PRODUCT    */
  160  0C5H!             CLR(AC);
  161  /*    FETCH AND TEST MULTIPLIER   LSB      */
  162  0C4H!             SRA(T);
```

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  163  0C2H!      MLP!   LMI(R8) FF1 STZ JFL(MBZ.MB1):
  164  /*    ADD SEQUENCE    */
  165  0B3H!      MB1!   SDR(R7) FF1 JCR(OV1);
  166  0BFH!      Ov1!   ILR(A) FF0;
  167  0BEH!             ALR(R7) FF0 JCR(MBZ):
  168  /*     SHIFT RIGHT FILL WITH ONES    */
  169  0B2H!      MBZ!   SRA(AC) FFC STZ;
  170  0B1H!             SRA(T) FFZ JZF(MLP.MEX):
  171  /*          APPLY CORRECTION  */
  172  0C3H!      MEX!   TZR(R9) K80000 INH JCR(XXX);
  173  0C9H!      XxX!   NOP(A) JFL(POS,NEG);
  174  0CBH!      NEG!   CMR(A) JCR(OV2);
  175  0CDH!      Ov2!   ALR(A) FF1;
  176  0CAH!      P S!   SDR(A) FF1 JCR(OV3);
  177  0CEH!      Ov3!   ILR(T);
  178  0C1H!             SRA(AC) FF0:
  179  0CFH!             SDR(Q) FF1 JZR(FETCH);
  180  0B6H!    PUSAC!    ILR(R0) RWM;
  181  0C6H!              LMI(R9) FF1;
  182  0D6H!              ILR(R1) RWM;
  183  0E6H!              LMI(R9) FF1:
  184  0F6H!              ILR(R2) RWM:
  185  106H!             LMI(R9) FF1 JCC(PUSA2);
  186  116H!      LRS!   ILR(A);
  187  126H!             DSM(R9) JCC(Z7);
  188  136H!      PUSA2! ILR(R3) RWM:
  189  146H!             LMI(R9) FF1 JCC(PUSA3);
  190  156H!      Z7!    SRA(AC) STZ JFL(OUT.AGN);
  191  152H!      OUT!   ALR(AC) FFZ JCR(WW);
  192  153H!      AGN!   DSM(R9) JCR(ZZ);
  193  166H!      PUSA3! ILR(R4) RWM:
  194  176H!             LMI(R9) FF1:
  195  186H!             ILR(R5) RWM;
  196  196H!             LMI(R9) FF1:
  197  1A6H!             ILR(R6) RWM:
  198  1B6H!             LMI(R9) FF1:
  199  1C6H!             ILR(R7) RWM:
  200  026H!      LMI(R9) FF1;
  201  27H!       ILR(R8) RWM;
  202  28H!       LMI(R9) FF1;
  203  29H!       ILR(T) RWM JZR(FETCH);
  204  1E6H!      N7!    NOP(A) JZR(FETCH);
  205  1D6H!             LMI(R9) FF1 JCR(DWN2);
  206  37H!       MSC!   NOP(A) JPR(SE SG SL SNE SGE SLE PUSA PUSX POPX
  207                                RTN SKN SKP SO SNO SAE DD);
  208  57H!       CLI!   LTM(AC) JCR(CL);
  209  67H!       PUSX!  LMI(S) FF1 JCC(PUSX1);
  210  /*      DIVIDE ...........................................       */
  211  77H!       D!     CLR(R6);
  212  0F7H!             CLR(AC);
  213  107H!             LMI(AC) K0000F;
  214  127H!             LMI(AC) K00005;
  215  137H!             CIA(AC) FF1:
  216  147H!             SDR(R8) FF1:
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RECORD
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 217  157H!              LMI(R9) RRM;
 218  167H!              ACM(AC);
 219  177H!              SDR(R9) FF1;
 220  187H!              SDP(T) FF1;
 221  185H!              ILP(A);
 222  184H!              SDR(R2) FF1:
 223  /*    START MAIN LOOP, COMPARF SIGN Y WITH SIGN RI    */
 224  182H!       DIV!   XNR(R9);
 225  181H!              TZR(R9) FFO K80000 INH;
 226  180H!              ILR(R6) JFL(SZERO,SONE):
 227  /*    DIFFERENT SIGNS    */
 228  192H!       SZERO! ALR(R6) FFO;
 229  191H!              ILR(R2);
 230  190H!              ALR(R2) FFO;
 231  1A0H!              ILR(T);
 232  180H!              SDR(R9) FF1;
 233  1C0H!              ALR(R2) JCR(OVER):
 234  /*    SAME SIGNS    */
 235  193H!       SONF!  ALR(R6) FF1:
 236  194H!              ILR(R2);
 237  195H!              ALP(R2);
 238  197H!              ILR(T);
 239  1A7H!              SDR(R9);
 240  187H!              CMR(AC);
 241  181H!              ALR(R2) FF1:
 242  /*    CHECK FOR I=0      */
 243  1C1H!       OVER!  LMI(R8) FF1;
 244  1C7H!              NOP(A) JFL(DIV,DONE);
 245  /*     APPLY CORRECTION     */
 246  183H!       DONE!  CLR(AC);
 247  188H!              LMI(AC) K80000 FF1;
 248  198H!              ALR(R6);
 249  1A8H!              SDR(A) FF1 JZR(FETCH);
 250  87H!        PUSX1! ILR(A) RWM;
 251  97H!               LMI(S) FF1;
 252  0A7H!               ILR(X) RWM;
 253  087H!               LMI(S) FF1;
 254  0C7H!               ILR(P) RWM:
 255  0D7H!               LMI(S) FF1;
 256  0E7H!               ILR(W) RWM JZR(FETCH);
 257  117H!       SSP!   TZR(A) K7FFFF JZR(FETCH);
 258  107H!       PUSA6! ILR(T) RWM JZR(FETCH);
 259  1E7H!       R I!   NOP(A) JZR(FETCH);
 260  38H!        XK!    ALR(X);
 261  48H!               LMI(AC) RRM JPR(LA STA LX STX A1 S1 M D AOM OR1 XOR1
 262                                          ANDD C EE FF GG);
 263  68H!        POPX!  DSM(S) JCC(POPX1);
 264  78H!        AOM!   ACM(AC) FF1 RWM JZR(FETCH);
 265  88H!        POPX1! LMI(S) RRM;
 266  98H!               ACM(AC);
 267  0A8H!               SDR(W) FF1;
 268  0B8H!               DSM(S);
 269  0C8H!               LMI(S) RRM;
 270  0D8H!               ACM(AC);
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RECORD
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  271  0E8H!               SDR(P)FF1;
  272  0F8H!               DSM(S);
  273  108H!              LMI(S) RRM JCC(POPX2);
  274  118H!       SSN!   CSP(AC);
  275  128H!              ORR(A) K80000 JZR(FETCH):
  276  138H!       POPX2! SDR(X) FF1;
  277  148H!              DSM(S);
  278  158H!              LMI(S) RRM;
  279  168H!              SDR(A) FF1 JZR(FETCH);
  280  1D8H!       PUSA5! LMI(R9) FF1 JCR(PUSA6);
  281  1E8H!       SMI!   NOP(A) JZR(FETCH);
  282  39H!        JJ!    NOP(A) JZR(FETCH);
  283  49H!        RTN2!  ACM(AC) JCR(RTN3);
  284  59H!        RTN1!  LMI(S) RRM JCC(RTN2);
  285  69H!        RTN!   DSM(S) JCC(RTN1);
  286  79H!        OR1!   ACM(AC);
  287  89H!               ORR(A) JZR(FETCH);
  288  119H!       EX!    SDR(T)  FF1;
  289  129H!              ILR(X);
  290  139H!              SDR(A) FF1;
  291  149H!              ILR(T);
  292  159H!              SDR(X) FF1 JZR(FETCH);
  293  189H!       DN1!   SDR(T) FF1;
  294  199H!              ILR(Q);
  295  1A9H!              SDR(A) FF1;
  296  1B9H!              ILR(T);
  297  1C9H!              SDR(Q) FF1 JZR(FETCH);
  298  1D9H!       PUSA4! ILR(R9) RWM JCR(PUSA5);
  299  1E9H!       EQ!    ILR(A) JCC(DN1);
  300  1AH!        POS1!  ILR(P) FF1 JZR(FETCH);
  301  2AH!        POSS!  NOP(A) JZR(FETCH);
  302  /* ENTRY FOR PAGE 2 CENTROID TRACKER */
  303  3AH!       CTRACK! NOP(A) JZR(FETCH) PAGE2:
  304  4AH!        RTN3!  SDR(P) FF1 JZR(FETCH);
  305  5AH!        SKN1!  NOP(A) JFL(POSS.NEGG);
  306  6AH!        SKN!   TZR(A) K80000 INH JCC(SKN1):
  307  7AH!        XOR1!   ACM(AC);
  308  8AH!               XNR(A) JCR(DWN5);
  309  /*  IF A .LT. MEM CF=0 ZF=0. IF A .GT. MEM CF=0 ZF=1
  310      IF A .EQ. MEM CF=1 ZF=0     */
  311  0AAH!         TSAME!                 NOP(A) JFL(APOS2.ANEG2);
  312  0BAH!       NOCRY! NOP(A) JZR(FETCH);
  313  0DAH!       NOCRY2!               NOP(A) FF1 STC JZR(FETCH);
  314  0FAH!       APOS2! NOP(A) FF1 STZ JZR(FETCH);
  315  10AH!       SP!    ILR(P) FF1 JZR(FETCH);
  316  11AH!       EP!    SDR(T)  FF1;
  317  12AH!       .      ILR(P);
  318  13AH!              SDR(A) FF1;
  319  14AH!       ILR(T);
  320  15AH!              SDR(P) FF1 JZR(FETCH);
  321  16AH!       NSKIP! NOP(A) JZR(FETCH);
  322  17AH!       EVEN!  ILR(P) FF1 JZR(FETCH);
  323  18AH!       NC!    NOP(A) JFL(NOVEF1.OVEF1);
  324  19AH!       NOVEF1!               NOP(A) JZR(FETCH):
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RECORD
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 325  1AAH!      OVEF2! ILR(P) FF1 JZR(FETCH):
 326  1BAH!      NC2!   NOP(A) JFL(NOVEF3.OVEF3):
 327  1CAH!      NOVEF3!                     ILR(P) FF1  JZR(FETCH):
 328  1DAH!      OVEF4! ILR(P) FF1 JZR(FETCH):
 329  1EAH!      N11!   NOP(A) JZR(FETCH):
 330  1BH!       NEG1!  NOP(A) JZR(FETCH):
 331  2BH!       NEGG!  ILR(P) FF1  JZR(FETCH):
 332  3BH!       LL!    NOP(A) JZR(FETCH):
 333  5BH!       SKP1!  NOP(A) JFL(POS1.NEG1):
 334  6BH!       SKP!   TZR(A) K80000 INH JCC(SKP1):
 335  7BH!       ANDD!  ACM(AC):
 336  8BH!              ANR(A) JZR(FETCH):
 337  0ABH!      SAME!  CMR(R8) JCR(DWN7):
 338  0BBH!      CRY!   NOP(A) JFL(NOCRY2.CRY2):
 339  0DBH!      CRY2!  NOP(A) FF1 STZ JZR(FETCH):
 340  0FBH!      ANEG2!  NOP(A) JZR(FETCH):
 341  10BH!      NSP!   NOP(A) JZR(FETCH):
 342  11BH!      ES!    SDR(T)  FF1:
 343  12BH!             ILR(W):
 344  13BH!             SDR(A) FF1:
 345  14BH!             ILR(T):
 346  15BH!             SDR(W) FF1 JZR(FETCH):
 347  16BH!      SKIP!  ILR(P) FF1 JZR(FETCH):
 348  17BH!      ODD!   NOP(A) JZR(FETCH):
 349  18BH!      CR!    NOP(A) JFL(OVEF2.NOVEF2):
 350  19BH!      OVEF1! ILR(P) FF1 JZR(FETCH):
 351  1ABH!      NOVEF2!                     NOP(A)  JZR(FETCH):
 352  1BBH!      CR22!  NOP(A) JFL(OVEF4.NOVEF4):
 353  1CBH!      OVEF3! NOP(A) JZR(FETCH):
 354  1DBH!      NOVEF4!                     NOP(A)  JZR(FETCH):
 355  1EBH!      N12!   NOP(A) JZR(FETCH):
 356  3CH!       IX!    LMI(R9) RRM:
 357  4CH!              ACM(AC):
 358  5CH!              ALR(X) JCR(CIX):
 359  6CH!       SO!    NOP(A) JCC(SO1):
 360  /*      REGISTER EIGHT IS SET TO STACK POINTER WHEN SIGNS OF MEMORY LOCAT
 361     AND ACCUMULATOR ARE DIFFERENT
 362
 363    REGISTER EIGHT IS SET TO THE DIFFERENCE OF THE MEMORY LOCATION AND THE
 364    ACCUMULATOR WHEN THE SIGNS OF MEMORY LOCATION AND ACCUMULATOR ARE DIFF
 365  ERENT    */
 366  7CH!        C!     ACM(AC):
 367  8CH!               SDR(R8) FF1:
 368  9CH!               SDR(T)  FF1 K80000:
 369  0ACH!               ILR(A) STC:
 370  0BCH!               SDR(R5) FF1 K80000:
 371  0CCH!               ILR(R5) FF0 STZ:
 372  0DCH!               XNR(T)  JCC(CX2):
 373  0ECH!     CX3!      TZR(T)  INH:
 374  0FCH!               TZR(R5) INH JFL(NTSAME.SAME):
 375  10CH!    CX2!  ILR(A) FF0 JCC(CX3):
 376  11CH!     ICX!   ILR(R9):
 377  12CH!             ALR(X):
 378  13CH!             TZA(AC) K80000 INH:
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RECORD
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  379  14CH!              NOP(A) JFL(NSKIP,SKIP);
  380  16CH!      DWN3!   LTM(AC);
  381  17CH!      SDR(A)  FF1 JZR(FETCH);
  382  18CH!      SO1!    TZR(A) K80000 INH JCF(NC,CR);
  383  1ECH!      DI!     LMI(R9) RIN JCC(DWN3);
  384  30H!       AA!     NOP(A) JZR(FETCH);
  385  50H!       CIX!    LMI(AC) RRM JPR(LA STA LX STX AI SI M D AOM ORI XORI
  386                                          ANDD C EE FF GG);
  387  60H!       SNO!    NOP(A) JCC(SNO1);
  388  70H!       EE!     NOP(A) JZR(FETCH);
  389  80H!       DWN5!   CMR(A) JZR(FETCH);
  390  0ADH!      DWN7!   ALR(R8) FF1;
  391  0BDH!      C XXX!  TZR(R8) JFL(NOCRY,CRY);
  392  11DH!      DCX!    ILR(R9);
  393  12DH!              CMA(AC);
  394  13DH!              ALR(X) FF1;
  395  14DH!              NOP(A) JFL(SP,NSP);
  396  19DH!      SNO1!   TZR(A) K80000 INH JCF(NC2 CR22);
  397  1DDH!      D N4!   LMI(R9) ROT JZR(FETCH);
  398  1EDH!      DO!     ILR(A) JCC(DWN4);
  399  3EH!       COR!    NOP(A)  PAGE2 JCC(DWN8);
  400  5EH!       DWN8!   NOP(A) JCC(SAE);
  401  6EH!       SAE!    TZR(A) K00001 INH JCC(SAE1);
  402  7EH!       FF!     NOP(A) JZR(FETCH);
  403  11EH!      NOPP!   NOP(A) JZR(FETCH);
  404  16EH!      SAE1!   NOP(A) JFL(EVEN,ODD);
  405  1EEH!      HH!     NOP(A) JZR(FETCH);
  406  0FH!       FETCH!  LMI(P) FF1 RRM;
  407  1FH!               LTM(AC) K01FFF;
  408  2FH!               SDR(R9) FF1 JPX(DIR J L REG I JI LI MSC XK JJ
  409                                          CTRACK LL IX AA COR IO);
  410  3FH!       IO!     NOP(A) JCC(IO1);
  411  6FH!       DD!     NOP(A) JZR(FETCH);
  412  7FH!       GG!     NOP(A) JZR(FETCH);
  413  11FH!      P7!     NOP(A) SPO JZR(FETCH);
  414  14FH!      IO1!    NOP(A) JCC(JK);
  415  1DFH!      JK!     NOP(A) JPR(N1,N2,N3,N4,N5,TRAP,N7,RMI,SMI,EQ,N11,N12
  416                                    DI DO HH II);
  417  1EFH!      II!     NOP(A) JZR(FETCH);
  418  EOF

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Mr. Wylie	1
-ESL, Mr. Schrenk	1
-NT, Mr. Norman	1
-TBD	3
-TI (Record Set)	1
(Reference Copy)	1

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