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USING THE MC68000 AND THE MC6845 FOR A COLOR GRAPHICS SYSTEM

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Probably the slowest link in most computerized control systems is the display of information for human interpretation. The commonly used black and white monitor can display an adequate amount of information in most cases.

In applications where a large amount of information must be displayed in the same screen area, a color graphics system can easily provide this information by using a wide range of contrasting colors. Until recently the high cost of sophisticated components and color monitors required to generate and display color information has probably been the main prohibitive factor in development of these systems.

Recently the cost of components and color monitors has moderated to the point that using a color graphics system offers a viable solution to information display, ranging from the video games market to complex control systems.

A state-of-the-art color graphics system using the MC68000 16-bit microprocessor (MPU) with an economical MC6845 CRT controller (CRTC) is described in this application note. Hardware improvement is evident in data movement occurring in 16-bit words and multiply and divide commands while software compatibilities are greatly enhanced through the use of a processor that executes instructions which can operate on 8-, 16-, or 32-bit operands.

The general approach to a color graphics system is straightforward and almost identical to a black and white graphics system. A typical black and white graphics system is shown in Figure 1. The MPU has two responsibilities to the graphics system: first, to initially program the CRTC, and second, to transfer data to the display RAM.

Once the clock circuitry is running, the CRTC is initialized and the address lines to the dislay RAM begin incrementing sequentially. As this occurs, the appropriate data from the display RAM is loaded into the shift register and then gated out serially by the dot clock input to the shift register. The display monitor then interprets the data as either turning a particular pixel on or off.

A color graphics system (Figure 2) uses the same principle as the black and white system except that it has to control three color guns (red, green, and blue) instead of just one. Therefore, there is an increase in the amount of hardware involved, but not in complexity. The software becomes more involved due to the fact that more information is being handled and displayed. The basic display system works on the principle that three bits (one for each color) controls each pixel instead of just one as in a black and white system. If two guns are on, the resulting color is a combination of the two. If all guns are on, white is the result. With this configuration a total of eight colors, including black and white, are available. Since the three bits needed to control a pixel do not fit into an eight-bit byte evenly, the unused bits could be used to obtain more colors or some other function. In addition, color systems usually require a separate sync input.

The versatility of the internal architecture of the MC68000 (Figure 3) enhances the effectiveness of the color graphics system. Besides containing a 32-bit program counter yielding 16 megabytes of direct addressing range, the MC68000 also contains eight 32-bit data registers (D0-D7) and seven 32-bit address registers (A0-A6). The eight data registers are used for byte (8-bit), word (16-bit), and long word (32-bit) data operations. The seven address registers and the stack pointer may be used for word and long word address operations. In addition, all address and data registers may be used as index registers.

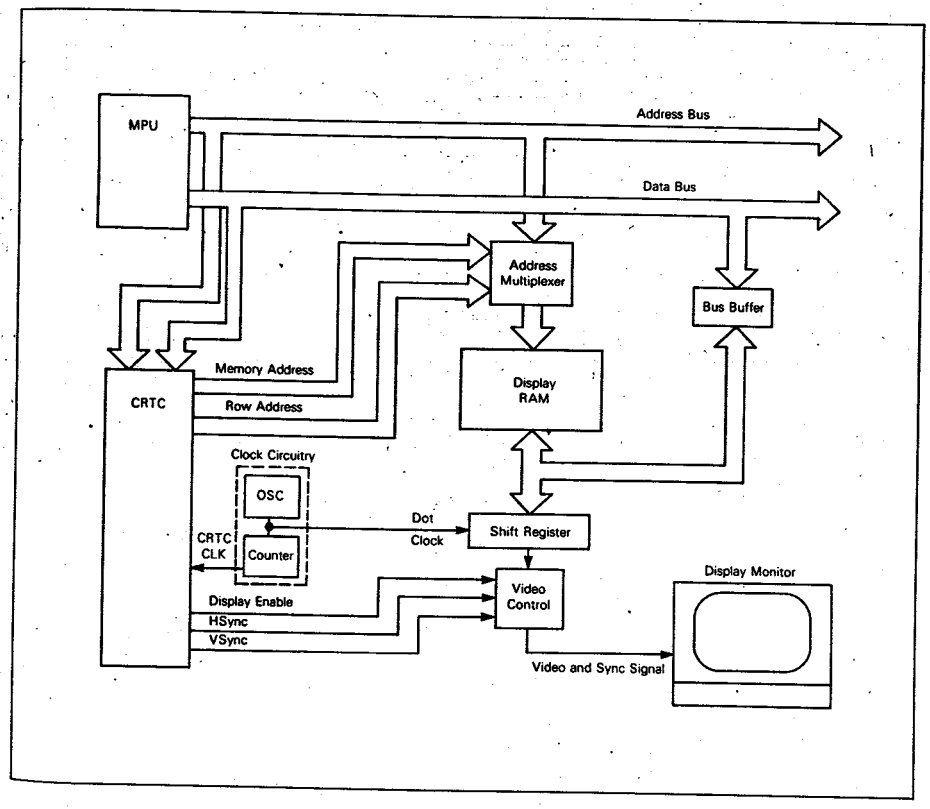

Figure 1. Black and White Graphics System — Block Diagram

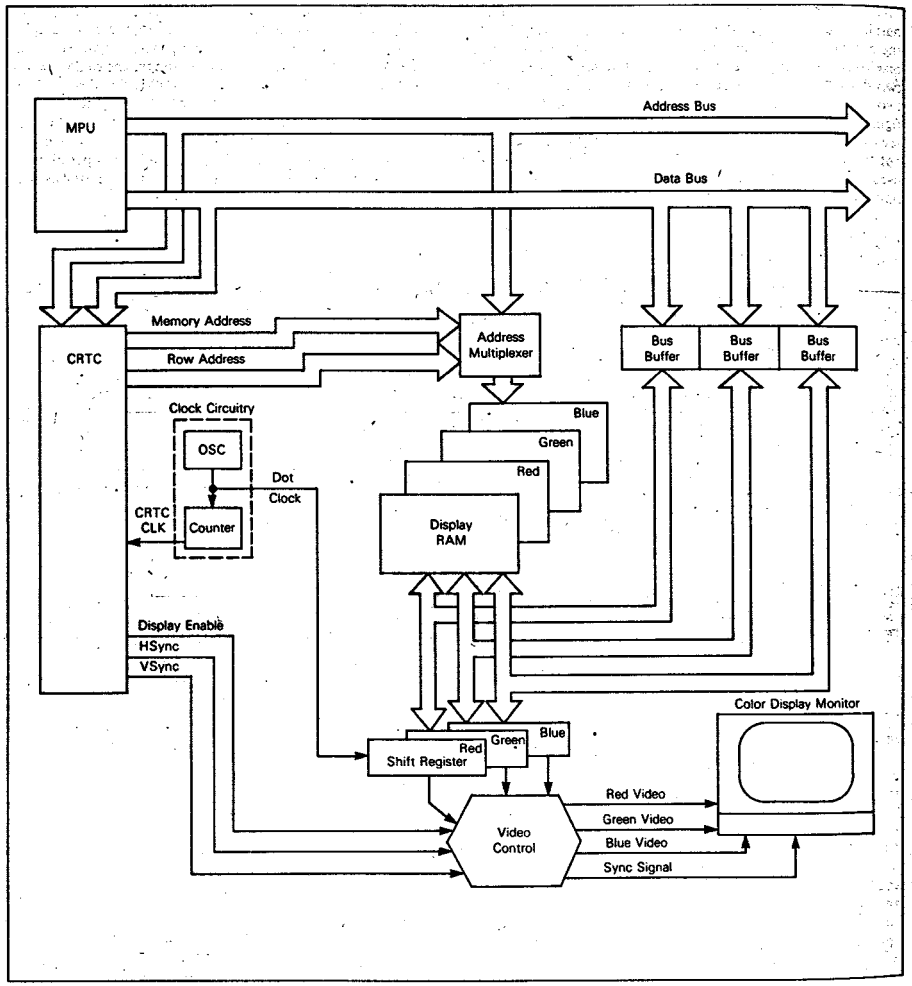

Figure 2. Color Graphics System — Block Diagram

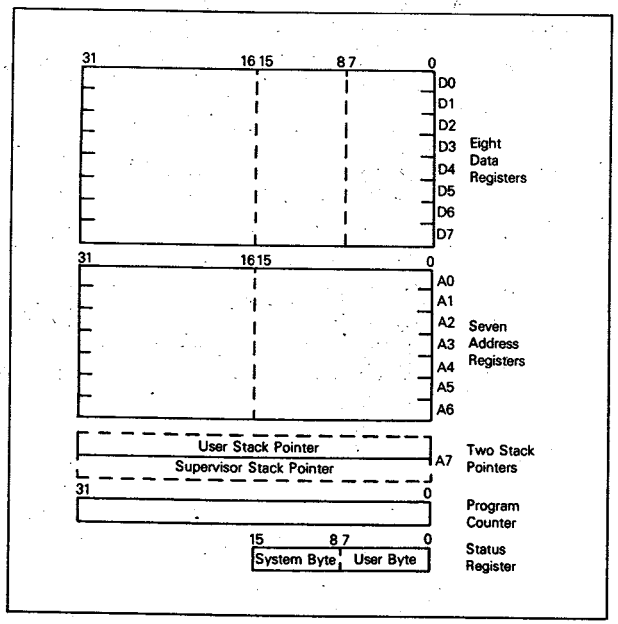

Figure 3. MC68000 Programming Model

SYSTEM HARDWARE DESCRIPTION AND FEATURES

This graphics system consists of two boards: a CPU board and a video board. The CPU board contains the processor, scratch-pad RAM, stack RAM, the program EPROM, and a terminal interface. The video board contains the CRTC, display RAM, multiplexers and buffers, parallel-to-serial shift registers, and the D/A drivers for the color display monitor.

An MC68000 Design Module (MEX68000KDM) is used as the CPU board. The resources available on the MC68000 Design Module allow more design time to be spent on the unique features of the system. The major portions of the system provided by the Design Module are the MPU (MC68000), the address decoding for the EPROM, a terminal interface, and all the software functions provided by the resident monitor (MACSbug). Included in the MACSbug is a transparent down-load feature which allows the system to communicate through the terminal to another system. The other system can provide the access to the floppy disks needed by this color graphics system for saving a full screen of data at a time.

The video board (Figure 4) contains more of the unique hardware features of the color graphics system. The video board can be separated into seven areas: the clock circuit, CRT controller, the DTACK circuit, the bus multiplexers and buffers, the display RAM, the shift registers, and the D/A converter drivers.

The clock circuit generates the five timing signals used throughout the video board; they are: a dot clock, a CRTC clock, a 2X dot clock, a shift register load, and a $\phi 2$ signal. The dot clock is used to drive the serial shift registers. The CRTC clock is used to drive the CRTC. The 2X dot clock and the shift register load are gated together to generate the parallel load (PLOAD) and chip select (PCS) signals for the shift registers and display RAM, respectively. The $\phi 2$ signal is also used to control accesses to the display RAM. A timing diagram of these signals is shown in Figure 5.

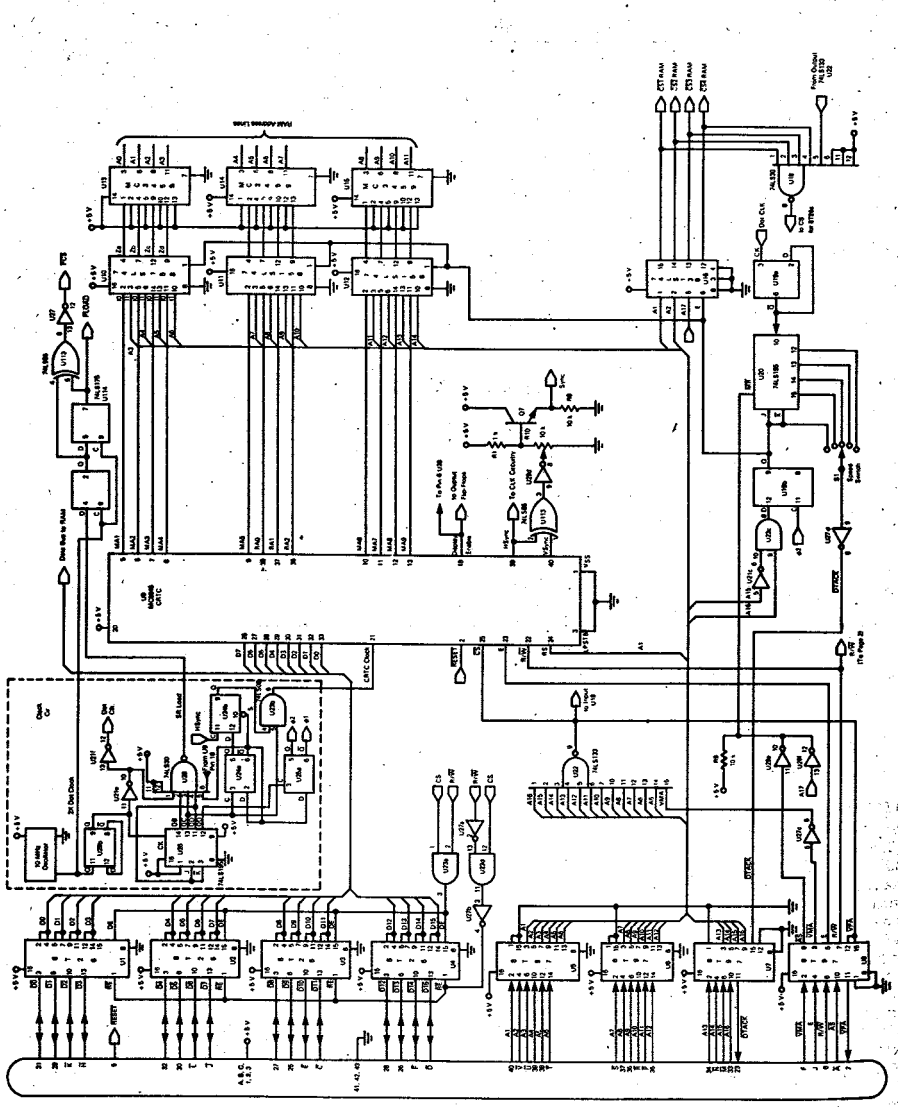

Figure 4. Color Graphics System Schematic (Sheet 1 of 3)

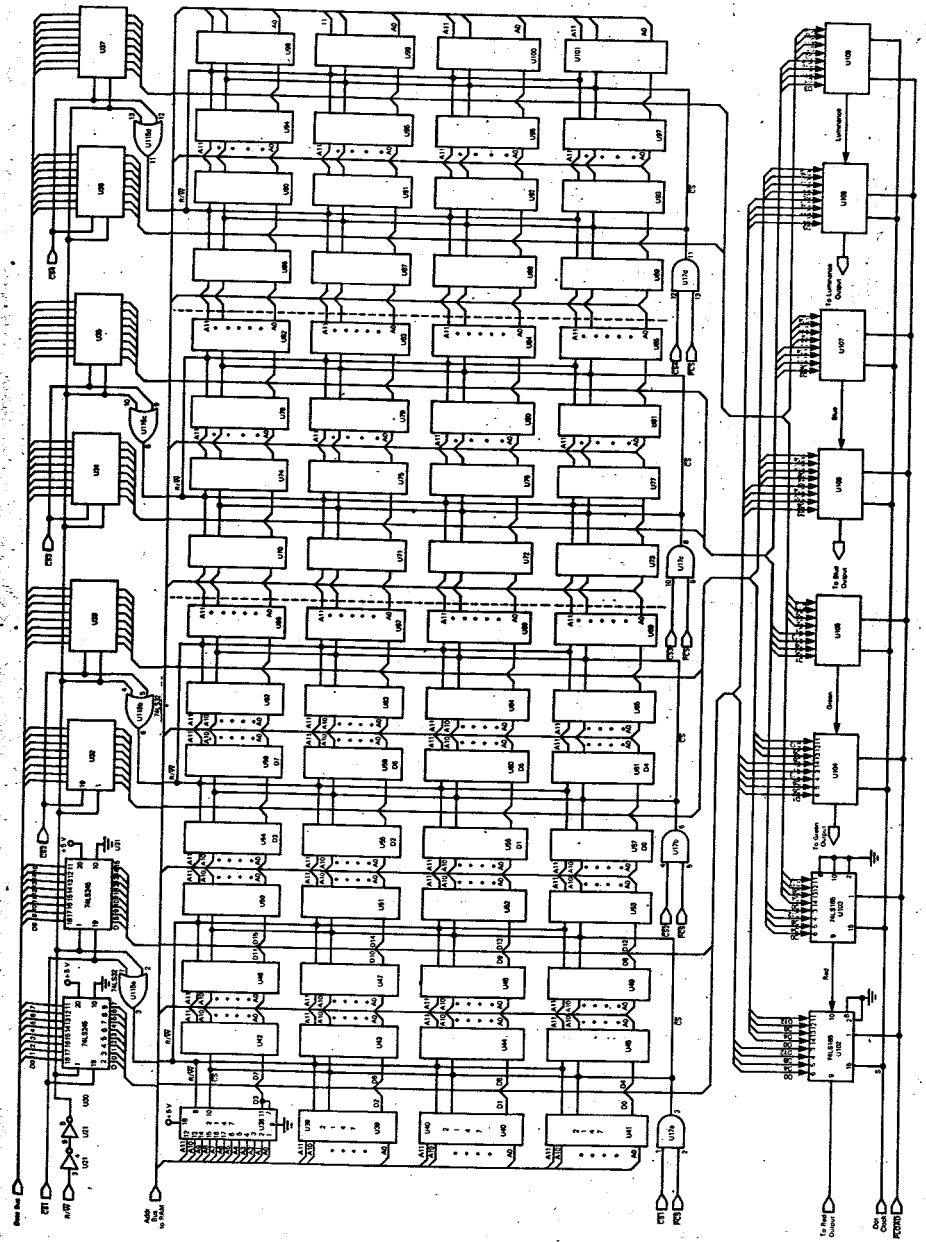

Figure 4. Color Graphics System Schematic (Sheet 2 of 3)

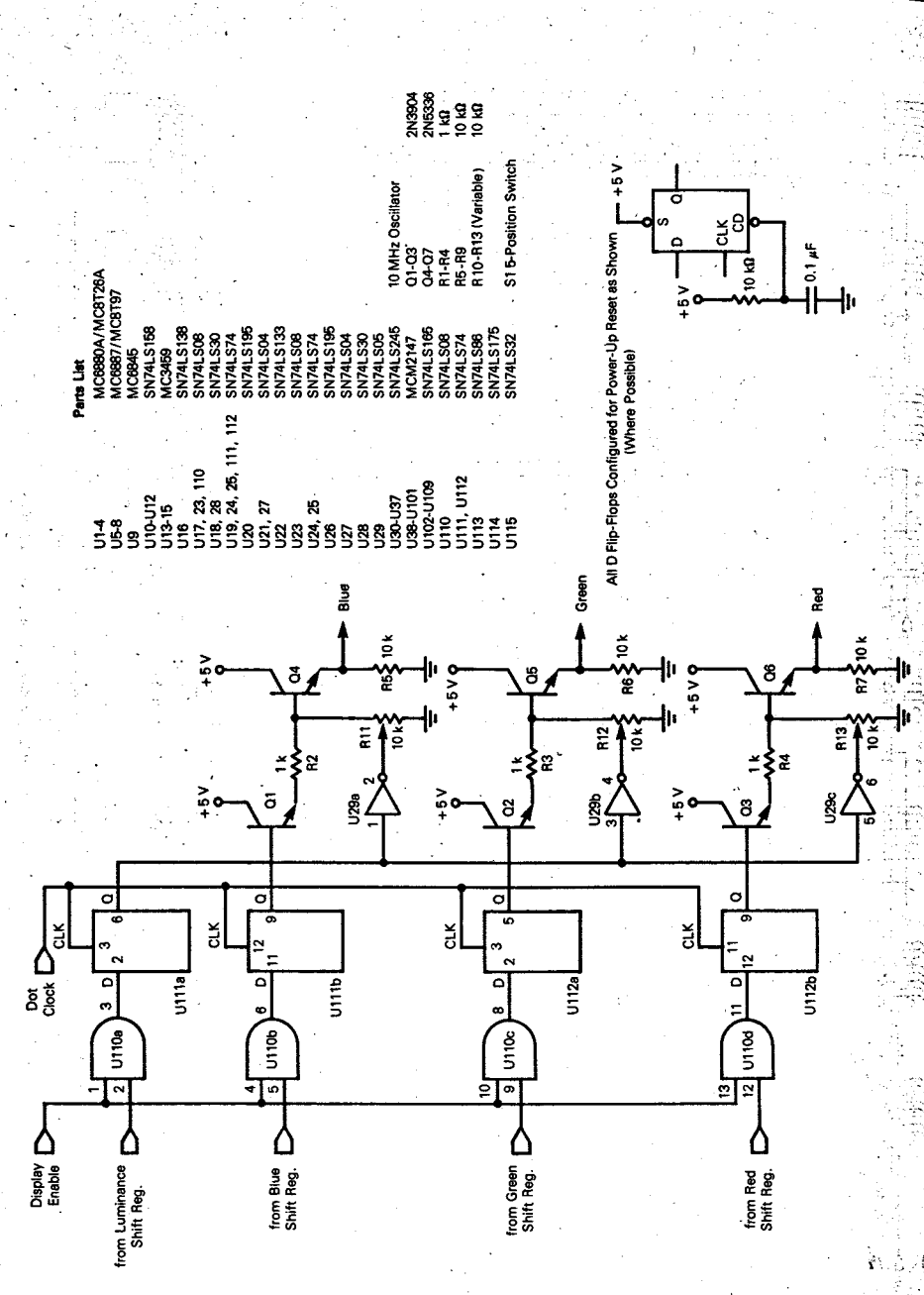

Figure 4. Color Graphics System Schematic (Sheet 3 of 3)

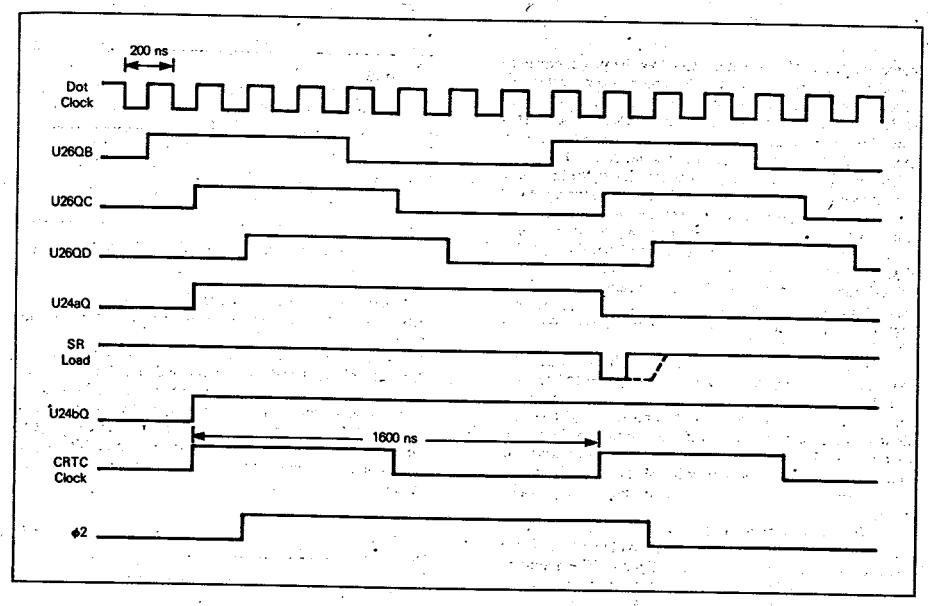

Figure 5. Clock Circuitry Timing Signals

The MC6845 CRT controller (CRTC) is a programmable controller used to prepare the information in the display RAM for use by a video display monitor. The CRTC generates the signals required to provide data at the appropriate times. Since the length and period between these signals varies from system to system, the CRTC is designed to be programmed by an MPU. In this system the internal registers are accessible synchronously through hex ($) address locations $1FFFD and $1FFFF. After programming, the CRTC provides the addresses, horizontal and vertical sync signals, and the display enable signal to the display system. The addresses, output by the CRTC in conjunction with the parallel chip select ($\overline{PCS}$) signal, are responsible for the correct data getting to the serial shift registers at the correct time. The horizontal and vertical sync signals, after being "exclusively ORed," generate the sync signal required by the color display monitor. The display enable (DE) signal is gated (U28) into either the clock circuitry to inhibit the parallel load and $\overline{PCS}$ signals or is gated (ANDed at U110, if a low represents black on the screen) with the data stream to keep the guns in the CRT off during vertical and horizontal retrace. In some cases, DE must be delayed due to specific requirements of the CRT being used. A one-shot on the output of the DE pin is usually more than adequate for providing the delay.

The $\overline{DTACK}$ circuitry is used to return an asynchronous data transfer acknowledge ($\overline{DTACK}$) signal to the MC68000 from a synchronous device (the display RAM). The $\phi 2$ signal from the clock circuitry in conjunction with address lines A15 and A16 develop the $\overline{DTACK}$ response required by the MC68000. When the display RAM address is between $10000-$17FFF, the $\overline{DTACK}$ signal is returned in 400 nanosecond increments from zero up to 1600 nanoseconds after the enabling signal goes out to the multiplexers. This time is selected by the RAM speed switch, S1. Returning $\overline{DTACK}$ to the processor is the asynchronous access method by which the MC68000 can access external devices (RAM, ROM, and peripherals). This access method was chosen over the synchronous access method used to address the CRTC because it is faster and, since this is a highly repetitive operation, any time saved here will be significant in the overall speed of the system. The synchronous access method is used to access the CRTC since the CRTC is only initialized once and this method uses fewer components.

The multiplexers and buffers are used to feed the various control signals to the rest of the system. Multiplexers U10, U11, and U12 determine which address bus will access the display RAM. When the control signal is high, the MC68000 has access to the RAM and when low, the CRTC has access. Buffers U13, U14, and U15 are used to drive the large number of devices on the address bus. Data buffers U30-U37 are used to isolate the four banks of RAM from each other. Buffers are also used for almost all the signals coming onto the video board. These board buffers interface with the modified EXORciser bus which the Design Module uses. This bus has only sixteen address lines coming from the Design Module, so address line A17 must be run separately to keep the display RAM from being accessed at the same time MACSbug or the controller program is accessed (addresses $20000 and $22000).

The display RAM is organized into four banks (red, green, blue, and luminance). However, the address lines are configured so that consecutive words are located in consecutive

banks of RAM. This was done to allow the programmer to visualize accessing one 16-bit wide bank at a time instead of accessing red, green, blue, and luminance banks all at the same time. The memories used are 4K×1 static RAMs (MCM2147) which simplify some of the chip select circuitry. Dynamic RAMs could be used and should definitely be considered in a production system since they lower the hardware cost as well as power consumption. They were omitted in this application to simplify the system configuration. It should be noted that the CRTC keeps incrementing its address lines during horizontal and vertical retrace to keep the dynamic RAM refreshed. The speed of the static memories is not critical due to the presence of the speed selection switch explained earlier. As far as the CRTC and the serial shift registers are concerned, the memory looks like one 4K×64-bit bank of RAM.

Shift registers U102-U109 consist of eight 8-bit, parallel-load, serial shift registers. They are configured to look like four 16-bit shift registers, one for each of the color guns and one for luminance. With the RAM and shift registers configured in this fashion, the RAM is accessed only 25 percent of the time. This means that the RAM has four times the amount of setup time and slower RAM can be used. The dot clock then clocks the data out to be gated with display enable.

Conversion from digital to analog voltages in this system is needed because a luminance bit is used to obtain more colors than are possible with the three guns digitally. The luminance bit is used to indicate half luminance when set and full luminance when clear. When all guns are off, the screen is black and the state of the luminance bit has no effect. Since the color display monitor uses an analog input on each gun, any number of colors may be obtained if the supporting hardware is provided. The D/A conversion used in this system was done to save space. A cleaner method would be to use special D/A converters and special line drivers for this function.

SOFTWARE DESCRIPTION AND CONSIDERATIONS

The software included to exercise this system consists of five basic commands:

CM — Clear Memory
BX — Box Draw
Q8 — Random Line
ED — Edit
BA, SH — Provides the capability of saving (BA) a screen on floppy disk and calling (SH) it back.

The clear memory (CM) command clears the screen. The box drawing (BX) command draws continuously concentric boxes which close in on each other. This gives the effect of running up a hallway. The random line (Q8) drawing command picks random points and connects them together until they form a multisided polygon and then it continues to repeat that shape, all the while collapsing in on itself and changing colors. A scaling function has been implemented to keep the figure occupying a major portion of the screen. The edit (ED) command allows the user to draw figures on the screen using the cursor controls on the terminal and allows a choice of colors. The BA command is used to store a screen full of data on floppy disk while the SH command is used to call it from the floppy disk and display it on the screen.

Each of the routines which write to the display RAM use the basic data layout for every pixel on the screen. Each pixel is controlled by four bits. Each bit corresponds to either luminance, blue, green, or red, as shown in Figure 6.

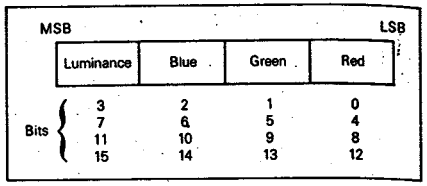

Figure 6. Pixel Control Bit — Layout

A memory map for this application is given in Figure 7. A listing of the software is given at the end of this application note.

The resolution of the display in this application is 256×256 pixels. The density could be doubled in both directions to 512×512 by quadrupling the memory. This can be easily done if dynamic RAM is used since 4K×1 and 16K×1 dynamic RAM can be arranged in the same basic configurations. As space was one of the design criteria in this application, some of the more straightforward approaches were not taken.

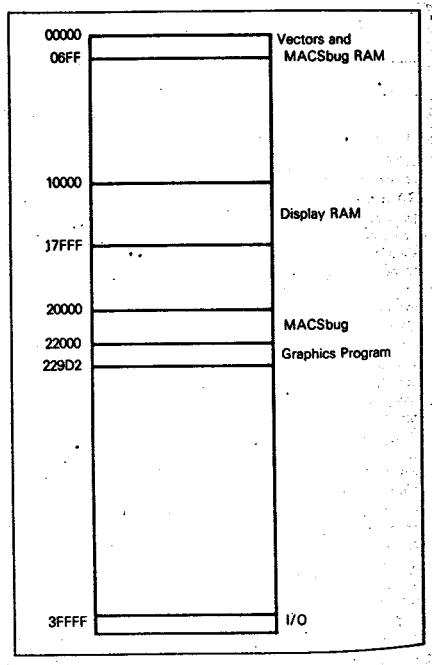

Figure 7. Memory Map

Thanks to Don Voss of Motorola Microsystems for his suggestions on the hardware and his splendid job on the software.


```
  10          00000000        ORG $0000
  20                          *
  30                          *
  40                          *
  50          000200F6        MACSBUG EQU $200F6
  60          00021BC2        OUTPUT2 EQU $21BC2
  70          00021F18        FIXBUF EQU $21F18
  80          000200EE        MSG EQU $200EE
  90          00001000        X1 EQU $1000
 100          00001001        Y1 EQU $1001
 110          00001002        X2 EQU $1002
 120          00001003        Y2 EQU $1003
 130          00001010        COLOR EQU $1010
 140          00001011        NCOLOR EQU $1011
 150          00001012        OCOLOR EQU $1012
 160          00001014        NUMPT EQU $1014
 170          00001016        SCALE EQU $1016
 180          00001018        RANADD EQU $1018
 190          00001080        ARRAY EQU $1080
 200          00001100        TABLECH EQU $1100
 210          00001800        CMDTAB EQU $1800
 220                          *
 230                          *
 240 000000 20780578          SETUP MOVE.L $578,A0
 250 000004 227C00001800       MOVE.L #CMDTAB,A1
 260 00000A 21C90578           MOVE.L A1,$578
 270 00000E 3018              SETUP1 MOVE (A0)+,D0
 280 000010 0C40FFFF           CMP #$FFFF,D0
 290 000014 6706               BEQ.S SETUP2
 300 000016 32C0               MOVE D0,(A1)+
 310 000018 22D8               MOVE.L (A0)+,(A1)+
 320 00001A 60F2               BRA SETUP1
 330 00001C B1FC00022000      SETUP2 CMP.L #$22000,A0
 340 000022 6A08               BPL.S INIT
 350 000024 207C00022082       MOVE.L #$22082,A0
 360 00002A 60E2               BRA SETUP1
 370 00002C 3280              INIT MOVE D0,(A1)
 380 00002E 207C000220D2       MOVE.L #$220D2,A0
 390 000034 303C0000           MOVE #$0000,D0
 400 000038 13C00001FFFD      INIT1 MOVE.B D0,$1FFFD
 410 00003E 1218               MOVE.B (A0)+,D1
 420 000040 4E71               NOP
 430 000042 13C10001FFFF       MOVE.B D1,$1FFFF
 440 000048 5240               ADD #1,D0
 450 00004A 0C400010           CMP #$0010,D0
 460 00004E 66E8               BNE INIT1
 470 000050 227C000229F6       MOVE.L #$229F6,A1
 480 000056 247C00001100       MOVE.L #TABLECH,A2
 490 00005C 303C0302           MOVE #770,D0
 500 000060 14D9              SETUP21 MOVE.B (A1)+,(A2)+
   0 000062 5340               SUB #1,D0
   0 000064 66FA               BNE  SETUP21
 520 000066 6014               BRA.S RETURN
 530 000068 207C00010000      CM MOVE.L #$10000,A0
 540 00006E 323C2000           MOVE #$2000,D1
```

```
 550 000072 4280            CLR.L D0
 560 000074 20C0           CLRM MOVE.L D0,(A0)+
   0 000076 5341             SUB #1,D1
   0 000078 66FA             BNE  CLRM
   0 00007A 4E71             NOP
 580 00007C 4EF9000200F6 RETURN JMP MACSBUG
 590 000082 43             NTABLE DC.W 'CM'
 600 000084 00022068        DC.L $22068
 610 000088 53              DC.W 'SH'
 620 00008A 000220E2        DC.L $220E2
 630 00008E 42              DC.W 'BX'
 640 000090 0002218A        DC.L $2218A
 650 000094 45              DC.W 'ED'
 660 000096 000221E8        DC.L $221E8
 670 00009A 42              DC.W 'BA'
 680 00009C 00022454        DC.L $22454
 690 0000A0 51              DC.W 'Q1'
 700 0000A2 00022498        DC.L $22498
 710 0000A6 51              DC.W 'Q2'
 720 0000A8 000224A4        DC.L $224A4
 730 0000AC 51              DC.W 'Q3'
 740 0000AE 000224B0        DC.L $224B0
 750 0000B2 51              DC.W 'Q4'
 760 0000B4 000224BC        DC.L $224BC
 770 0000B8 51              DC.W 'Q5'
 780 0000BA 000224C8        DC.L $224C8
 790 0000BE 51              DC.W 'Q9'
 800 0000C0 00022606        DC.L $22606
 810 0000C4 48              DC.W 'HP'
 820 0000C6 000226AC        DC.L $226AC
 830 0000CA 51              DC.W 'Q8'
 840 0000CC 00022818        DC.L $22818
 850 0000D0 FFFF            DC.W $FFFF
 860                       *
 870                       *
 880                       *
 890                       *
 900 0000D2 27             CRTC DC.B $27
 910 0000D3 20              DC.B $20
 920 0000D4 22              DC.B $22
 930 0000D5 A3              DC.B $A3
 940 0000D6 20              DC.B $20
 950 0000D7 06              DC.B $06
 960 0000D8 1F              DC.B $1F
 970 0000D9 1F              DC.B $1F
 980 0000DA 10              DC.B $10
 990 0000DB 07              DC.B 7
1000 0000DC 00000000        DC.L 0
1010 0000E0 0000            DC.W 0
1020                       *
1030                       *
1040 0000E2 61000004      SH BSR SHQ
1050 0000E6 6094           BRA RETURN
1060 0000E8 4EB900021BC2 SHQ JSR OUTPUT2
1070 0000EE 227C0003FF21   MOVE.L #$3FF21,A1
```



```
1080 0000F4 61000078      SH1 BSR INPUT
1090 0000F8 0C00000D       CMP.B #$0D,D0
1100 0000FC 6708           BEQ.S SH2
1110 0000FE 0C0000FF       CMP.B #$FF,D0
1120 000102 66F0           BNE SH1
1130 000104 6040           BRA.S SH3
1140 000106 61000066      SH2 BSR INPUT
1150 00010A 0C00000A       CMP.B #$0A,D0
1160 00010E 67F6           BEQ SH2
1170 000110 0C000000       CMP.B #0,D0
1180 000114 67F0           BEQ SH2
1190 000116 0C0000FF       CMP.B #$FF,D0
1200 00011A 672A           BEQ.S SH3
1210 00011C 4EB900021F18   JSR FIXBUF
1220 000122 2CFC4552524F   MOVE.L #'ERRO',(A6)+
1230 000128 2CFC52203B43   MOVE.L #'R ;C',(A6)+
1240 00012E 2CFC4845434B   MOVE.L #'HECK',(A6)+
1250 000134 2CFC2046494C   MOVE.L #' FIL',(A6)+
1260 00013A 2CFC45202020   MOVE.L #'E   ',(A6)+
1270 000140 4EF9000200EE   JMP MSG
1280 000146 207C00010000 SH3 MOVE.L #$10000,A0
1290 00014C 103C0055       MOVE.B #$55,D0
1300 000150 6100002A       BSR OUTPUT
1310 000154 61000018      SH4 BSR INPUT
1320 000158 1200           MOVE.B D0,D1
1330 00015A 61000012       BSR INPUT
1340 00015E E140           ASL 8,D0
1350 000160 1001           MOVE.B D1,D0
1360 000162 30C0           MOVE.W D0,(A0)+
1370 000164 B1FC00017F80   CMP.L #$17F80,A0
1380 00016A 66E8           BNE SH4
1390 00016C 4E75           RTS
1400 00016E 1011          INPUT MOVE.B (A1),D0
1410 000170 02000001       AND.B #1,D0
1420 000174 67F8           BEQ INPUT
1430 000176 10290002       MOVE.B 2(A1),D0
1440 00017A 4E75           RTS
1450 00017C 1E11          OUTPUT MOVE.B (A1),D7
1460 00017E 02070002       AND.B #2,D7
1470 000182 67F8           BEQ OUTPUT
1480 000184 13400002       MOVE.B D0,2(A1)
1490 000188 4E75           RTS
1500 00018A 4240          BX CLR D0
1510 00018C 3200           MOVE D0,D1
1520 00018E 3400           MOVE D0,D2
1530 000190 363C003F      BX3 MOVE #$3F,D3
1540 000194 207C00010000   MOVE.L #$10000,A0
1550 00019A 61000016      BX1 BSR SHOW
1560 00019E 5543           SUB #2,D3
1570 0001A0 6A02           BPL.S BX2
1580 0001A2 60EC           BRA BX3
1590 0001A4 5240          BX2 ADD #1,D0
1600 0001A6 5241           ADD #1,D1
1610 0001A8 5242           ADD #1,D2
1620 0001AA D1FC00000202   ADD.L #514,A0
```

```
1630 0001B0 60E8            BRA BX1
1640 0001B2 3803           SHOW MOVE D3,D4
1650 0001B4 30C0           BX11 MOVE D0,(A0)+
   0 0001B6 5344             SUB #1,D4
   0 0001B8 66FA             BNE  BX11
1670 0001BA 3080             MOVE D0,(A0)
1680 0001BC 3803             MOVE D3,D4
1690 0001BE E544             ASL 2,D4
1700 0001C0 D1FC00000080 BX22 ADD.L #128,A0
1710 0001C6 3081             MOVE D1,(A0)
   0 0001C8 5344             SUB #1,D4
   0 0001CA 66F4             BNE  BX22
1730 0001CC 3803             MOVE D3,D4
1740 0001CE 3080             MOVE D0,(A0)
1750 0001D0 3100           BX33 MOVE D0,-(A0)
   0 0001D2 5344             SUB  #1,D4
   0 0001D4 66FA             BNE  BX33
1770 0001D6 3803             MOVE D3,D4
1780 0001D8 E544             ASL 2,D4
1790 0001DA 91FC00000080 BX44 SUB.L #128,A0
1800 0001E0 3082             MOVE D2,(A0)
   0 0001E2 5344             SUB  #1,D4
   0 0001E4 66F4             BNE  BX44
1820 0001E6 4E75             RTS
1830                        *
1840                        *
1850                        *
1860 0001E8 11FC00801000 ED MOVE.B #$80,X1
1870 0001EE 11FC00801001    MOVE.B #$80,Y1
1880 0001F4 11FC00001011    MOVE.B #0,NCOLOR
1890 0001FA 6100014E      ED1 BSR BLINK
1900 0001FE 61000004        BSR CMD
1910 000202 60F6            BRA ED1
1920 000204 61000230      CMD BSR READK
1930 000208 0C010020        CMP.B #$20,D1
1940 00020C 6A48            BPL.S RTS
1950 00020E 0C01000B        CMP.B #$B,D1
1960 000212 673C            BEQ.S UPARROW
1970 000214 0C01000A        CMP.B #$A,D1
1980 000218 673E            BEQ.S DWARROW
1990 00021A 0C01000C        CMP.B #$C,D1
2000 00021E 673E            BEQ.S RTARROW
2010 000220 0C010008        CMP.B #$8,D1
2020 000224 673E            BEQ.S LTARROW
2030 000226 0C010001        CMP.B #$1,D1
2040 00022A 673E            BEQ.S CMD1   CHARMODE
2050 00022C 0C010003        CMP.B #$3,D1
2060 000230 6756            BEQ.S CMD2   NCOLOR
2070 000232 0C010004        CMP.B #$4,D1
2080 000236 6738            BEQ.S CMD3
2090 000238 0C01000D        CMP.B #$0D,D1
2100 00023C 673E            BEQ.S CR
2110 00023E 0C010005        CMP.B #$5,D1
2120 000242 6732            BEQ.S CMD4
2130 000244 0C010011        CMP.B #$11,D1
```



```
2140 000248 660A            BNE.S RTS1
2150 00024A 588F            ADD.L #4,A7
2160 00024C 6000FE2E        BRA RETURN
2170 000250 53381001      UPARROW SUB.B #1,Y1
2180 000254 4241          RTS1 CLR D1
2190 000256 4E75          RTS RTS
2200 000258 52381001      DWARROW ADD.B #1,Y1
2210 00025C 60F6            BRA RTS1
2220 00025E 52381000      RTARROW ADD.B #1,X1
2230 000262 60F0            BRA RTS1
2240 000264 53381000      LTARROW SUB.B #1,X1
2250 000268 60EA            BRA RTS1
2260 00026A 588F          CMD1 ADD.L #4,A7
2270 00026C 60000132        BRA CHARED
2280 000270 588F          CMD3 ADD.L #4,A7
2290 000272 600001A8        BRA DOT
2300 000276 588F          CMD4 ADD.L #4,A7
2310 000278 6000FF80        BRA ED1
2320 00027C 5E381001      CR ADD.B #7,Y1
2330 000280 11FC00001000    MOVE.B #0,X1
2340 000286 60CC            BRA RTS1
2350 000288 610001AC      CMD2 BSR READK
2360 00028C 267C00001011    MOVE.L #NCOLOR,A3
2370 000292 0C010052        CMP.B #'R',D1
2380 000296 6758            BEQ.S RED
2390 000298 0C010047        CMP.B #'G',D1
2400 00029C 6758            BEQ.S GREEN
2410 00029E 0C010042        CMP.B #'B',D1
2420 0002A2 6758            BEQ.S BLUE
2430 0002A4 0C010057        CMP.B #'W',D1
2440 0002A8 6758            BEQ.S WHITE
2450 0002AA 0C01005A        CMP.B #'Z',D1
2460 0002AE 6758            BEQ.S BLACK
2470 0002B0 0C010059        CMP.B #'Y',D1
2480 0002B4 6758            BEQ.S YELLOW
2490 0002B6 0C01004D        CMP.B #'M',D1
2500 0002BA 6758            BEQ.S MAG
2510 0002BC 0C010043        CMP.B #'C',D1
2520 0002C0 6758            BEQ.S CYAN
2530 0002C2 0C010054        CMP.B #'T',D1
2540 0002C6 6758            BEQ.S DRED
2550 0002C8 0C010048        CMP.B #'H',D1
2560 0002CC 6758            BEQ.S DGR
2570 0002CE 0C01004E        CMP.B #'N',D1
2580 0002D2 6758            BEQ.S DBLUE
2590 0002D4 0C010045        CMP.B #'E',D1
2600 0002D8 6758            BEQ.S DWH
2610 0002DA 0C010055        CMP.B #'U',D1
2620 0002DE 6758            BEQ.S DYEL
2630 0002E0 0C01002C        CMP.B #',',D1
2640 0002E4 6758            BEQ.S DMAG
2650 0002E6 0C010056        CMP.B #'V',D1
2660 0002EA 6758            BEQ.S DCYAN
2670 0002EC 4241          RTS2 CLR D1
2680 0002EE 4E75            RTS
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2690 0002F0 16BC0009      RED MOVE.B #$9,(A3)
2700 0002F4 60F6           BRA RTS2
2710 0002F6 16BC000A      GREEN MOVE.B #$A,(A3)
2720 0002FA 60F0           BRA RTS2
2730 0002FC 16BC000C      BLUE MOVE.B #$C,(A3)
2740 000300 60EA           BRA RTS2
2750 000302 16BC000F      WHITE MOVE.B #$F,(A3)
2760 000306 60E4           BRA RTS2
2770 000308 16BC0000      BLACK MOVE.B #0,(A3)
2780 00030C 60DE           BRA RTS2
2790 00030E 16BC000B      YELLOW MOVE.B #$B,(A3)
2800 000312 60D8           BRA RTS2
2810 000314 16BC000D      MAG MOVE.B #$D,(A3)
2820 000318 60D2           BRA RTS2
2830 00031A 16BC000E      CYAN MOVE.B #$E,(A3)
2840 00031E 60CC           BRA RTS2
2850 000320 16BC0001      DRED MOVE.B #1,(A3)
2860 000324 60C6           BRA RTS2
2870 000326 16BC0002      DGR MOVE.B #2,(A3)
2880 00032A 60C0           BRA RTS2
2890 00032C 16BC0004      DBLUE MOVE.B #4,(A3)
2900 000330 60BA           BRA RTS2
2910 000332 16BC0007      DWH MOVE.B #7,(A3)
2920 000336 60B4           BRA RTS2
2930 000338 16BC0003      DYEL MOVE.B #3,(A3)
2940 00033C 60AE           BRA RTS2
2950 00033E 16BC0005      DMAG MOVE.B #5,(A3)
2960 000342 60A8           BRA RTS2
2970 000344 16BC0006      DCYAN MOVE.B #6,(A3)
2980 000348 60A2           BRA RTS2
2990                       *
3000 00034A 12381000      BLINK MOVE.B X1,D1
3010 00034E 14381001       MOVE.B Y1,D2
3020 000352 61000226       BSR GETADD
3030 000356 4643           NOT D3
3040 000358 0C03000F      BL2 CMP.B #$F,D3
3050 00035C 6706           BEQ.S BL1
3060 00035E E84B           LSR 4,D3
3070 000360 E849           LSR 4,D1
3080 000362 60F4           BRA BL2
3090 000364 11C11012      BL1 MOVE.B D1,OCOLOR
3100 000368 103C000F      BL3 MOVE.B #$F,D0
3110 00036C 12381000       MOVE.B X1,D1
3120 000370 14381001       MOVE.B Y1,D2
3130 000374 610001DE       BSR DSP
3140 000378 610000D0       BSR DLY
3150 00037C 4200           CLR.B D0
3160 00037E 610001D4       BSR DSP
3170 000382 610000C6       BSR DLY
3180 000386 10381012       MOVE.B OCOLOR,D0
3190 00038A 610001C8       BSR DSP
3200 00038E 610000BA       BSR DLY
3210 000392 10390003FF01  MOVE.B $3FF01,D0
3220 000398 02000001       AND.B #1,D0
3230 00039C 67CA           BEQ BL3
```



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3240 00039E 4E75           RTS
3250                       *
3260 0003A0 31F810001002 CHARED MOVE X1,X2
3270 0003A6 61A2           BSR BLINK
3280 0003A8 6100FE5A       BSR CMD
3290 0003AC 4A01           TST.B D1
3300 0003AE 67F0           BEQ CHARED
3310 0003B0 61000004       BSR CHAR
3320 0003B4 60EA           BRA CHARED
3330 0003B6 04010020      CHAR SUB.B #$20,D1
3340 0003BA E741           ASL 3,D1
3350 0003BC 267C00001100   MOVE.L #TABLECH,A3
3360 0003C2 0281000003FF   AND.L #$3FF,D1
3370 0003C8 D7C1           ADD.L D1,A3
3380 0003CA 3C3C0004       MOVE #4,D6
3390 0003CE 4245          CHARED1 CLR D5
3400 0003D0 0B13          CHARED2 BTST D5,(A3)
3410 0003D2 6636           BNE.S SET
3420 0003D4 52381002      CHARED3 ADD.B #1,X2
3430 0003D8 5245           ADD #1,D5
3440 0003DA 0C450010       CMP #16,D5
3450 0003DE 6618           BNE.S CHARED4
3460 0003E0 52381003       ADD.B #1,Y2
3470 0003E4 11F810001002   MOVE.B X1,X2
3480 0003EA D7F80002       ADD.L $2,A3
   0 0003EE 5346           SUB  #1,D6
   0 0003F0 66DC           BNE  CHARED1
3500 0003F2 50381000       ADD.B #8,X1
3510 0003F6 4E75           RTS
3520 0003F8 0C450008      CHARED4 CMP #8,D5
3530 0003FC 66D2           BNE CHARED2
3540 0003FE 52381003       ADD.B #1,Y2
3550 000402 11F810001002   MOVE.B X1,X2
3560 000408 60C6           BRA CHARED2
3570 00040A 10381011      SET MOVE.B NCOLOR,D0
3580 00040E 12381002       MOVE.B X2,D1
3590 000412 14381003       MOVE.B Y2,D2
3600 000416 6100013C       BSR DSP
3610 00041A 60B8           BRA CHARED3
3620                       *
3630 00041C 10381011      DOT MOVE.B NCOLOR,D0
3640 000420 12381000       MOVE.B X1,D1
3650 000424 14381001       MOVE.B Y1,D2
3660 000428 6100012A       BSR DSP
3670 00042C 6100FF1C       BSR BLINK
3680 000430 6100FDD2       BSR CMD
3690 000434 60E6           BRA DOT
3700                       *
3710 000436 12390003FF01 READK MOVE.B $3FF01,D1
3720 00043C 02010001       AND.B #1,D1
3730 000440 67F4           BEQ READK
3740 000442 12390003FF03   MOVE.B $3FF03,D1
3750 000448 4E75           RTS
3760 00044A 3C3C00FF      DLY MOVE #$00FF,D6
3770 00044E 5346          DLY1 SUB #1,D6
```

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3780 000450 66FC          BNE DLY1
3790 000452 4E75          RTS
3800                      *
3810                      *
3820                      *
3830 000454 207C00010000 BA MOVE.L #$10000,A0
3840 00045A 227C0003FF23  MOVE.L #$3FF23,A1
3850 000460 247C0003FF21  MOVE.L #$3FF21,A2
3860 000466 1212         L1 MOVE.B (A2),D1
3870 000468 02010002      AND.B #$2,D1
3880 00046C 67F8          BEQ L1
3890 00046E 103C0065      MOVE.B #$65,D0
3900 000472 1280          MOVE.B D0,(A1)
3910 000474 1212         LOOP MOVE.B (A2),D1
3920 000476 02010002      AND.B #$2,D1
3930 00047A 67F8          BEQ LOOP
3940 00047C 3018          MOVE (A0)+,D0
3950 00047E 1280          MOVE.B D0,(A1)
3960 000480 E048          LSR 8,D0
3970 000482 1212         L2 MOVE.B (A2),D1
3980 000484 02010002      AND.B #$2,D1
3990 000488 67F8          BEQ L2
4000 00048A 1280          MOVE.B D0,(A1)
4010 00048C B1FC00018000  CMP.L #$18000,A0
4020 000492 66E0          BNE LOOP
4030 000494 6000FBE6      BRA RETURN
4040                      *
4050                      *
4060                      *
4070 000498 2C7C000225AC Q1 MOVE.L #$225AC,A6
4080 00049E 3E3C0010      MOVE #$10,D7
4090 0004A2 602E          BRA.S RUN
4100 0004A4 2C7C000225BE Q2 MOVE.L #$225BE,A6
4110 0004AA 3E3C0010      MOVE #$10,D7
4120 0004AE 6022          BRA.S RUN
4130 0004B0 2C7C000225D0 Q3 MOVE.L #$225D0,A6
4140 0004B6 3E3C0010      MOVE #$10,D7
4150 0004BA 6016          BRA.S RUN
4160 0004BC 2C7C000225E2 Q4 MOVE.L #$225E2,A6
4170 0004C2 3E3C0010      MOVE #$10,D7
4180 0004C6 600A          BRA.S RUN
4190 0004C8 2C7C000225F4 Q5 MOVE.L #$225F4,A6
4200 0004CE 3E3C0010      MOVE #$10,D7
4210 0004D2 61000006     RUN BSR RUN1
4220 0004D6 6000FBA4      BRA RETURN
4230                      *
4240                      *
4250                      *
4260 0004DA 3C3C0080     RUN1 MOVE #128,D6
4270 0004DE 61000034      BSR RAND
4280 0004E2 4E96         RUN2 JSR (A6)
4290 0004E4 48E76000      MOVEM.L D1/D2,-(A7)
4300 0004E8 0241007F      AND #$7F,D1
4310 0004EC 0242007F      AND #$7F,D2
4320 0004F0 61000068      BSR DSPLY
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4330 0004F4 4401          NEG.B D1
4340 0004F6 61000062      BSR DSPLY
4350 0004FA 4402          NEG.B D2
4360 0004FC 6100005C      BSR DSPLY
4370 000500 4401          NEG.B D1
4380 000502 61000056      BSR DSPLY
4390 000506 4CDF0006      MOVEM.L (A7)+,D1/D2
   0 00050A 5346          SUB  #1,D6
   0 00050C 66D4          BNE  RUN2
   0 00050E 5347          SUB  #1,D7
   0 000510 66C8          BNE  RUN1
4420 000512 4E75          RTS
4430                      *
4440                      *
4450                      *
4460 000514 6100001C     RAND BSR RAND1
4470 000518 3200          MOVE D0,D1
4480 00051A 61000016      BSR RAND1
4490 00051E 3400          MOVE D0,D2
4500 000520 61000010     RAND2 BSR RAND1
4510 000524 0200000F      AND.B #$F,D0
4520 000528 67F6          BEQ RAND2
4530 00052A 0C000008      CMP.B #$08,D0
4540 00052E 67F0          BEQ RAND2
4550 000530 4E75          RTS
4560 000532 10381019     RAND1 MOVE.B RANADD+1,D0
4570 000536 E500          ASL.B 2,D0
4580 000538 D0381018      ADD.B RANADD,D0
4590 00053C E140          ASL 8,D0
4600 00053E 10381019      MOVE.B RANADD+1,D0
4610 000542 E540          ASL 2,D0
4620 000544 D0781018      ADD RANADD,D0
4630 000548 06403619      ADD #$3619,D0
4640 00054C 31C01018      MOVE D0,RANADD
4650 000550 E048          LSR 8,D0
4660 000552 4E75          RTS
4670                      *
4680                      *
4690                      *
4700                     *DSPLY(C,X,Y)
4710                     *  D0=COLOR
4720                     *  D1=X 8-BITS
4730                     *  D2=Y 8-BITS
4740                      *
4750 000554 48E7F080     DSP MOVEM.L D0-D3/A0,-(A7)
4760 000558 600C          BRA.S DSP1
4770                      *
4780 00055A 48E7F080     DSPLY MOVEM.L D0-D3/A0,-(A7)
4790 00055E 06010080      ADD.B #128,D1
4800 000562 06020080      ADD.B #128,D2
4810 000566 0240000F     DSP1 AND #$F,D0
4820 00056A 6100000E      BSR GETADD
4830 00056E C243          AND D3,D1
4840 000570 8041          OR D1,D0
4850 000572 3080          MOVE D0,(A0)
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```
4860 000574 4CDF010F       MOVEM.L (A7)+,D0-D3/A0
4870 000578 4E75           RTS
4880 00057A 024100FF      GETADD AND #$FF,D1
4890 00057E 363CFFF0       MOVE #$FFF0,D3
4900 000582 E142           ASL 8,D2
4910 000584 D242           ADD D2,D1
4920 000586 02810000FFFF   AND.L #$FFFF,D1
4930 00058C 3401           MOVE D1,D2
4940 00058E E449           LSR 2,D1
4950 000590 E341           ASL 1,D1
4960 000592 207C00010000   MOVE.L #$10000,A0
4970 000598 D1C1           ADD.L D1,A0
4980 00059A 02420003       AND #3,D2
4990 00059E 6708           BEQ.S DSPLY1
5000 0005A0 E940          DSPLY2 ASL 4,D0
5010 0005A2 E95B           ROL 4,D3
   0 0005A4 5342           SUB  #1,D2
   0 0005A6 66F8           BNE  DSPLY2
5030 0005A8 3210          DSPLY1 MOVE (A0),D1
5040 0005AA 4E75           RTS
5050                       *
5060                       *
5070 0005AC 3601          EQU1 MOVE D1,D3
5080 0005AE 3802           MOVE D2,D4
5090 0005B0 4883           EXT D3
5100 0005B2 4884           EXT D4
5110 0005B4 E64B           LSR 3,D3
5120 0005B6 E64C           LSR 3,D4
5130 0005B8 9403           SUB.B D3,D2
5140 0005BA 9204           SUB.B D4,D1
5150 0005BC 4E75           RTS
5160                       *
5170 0005BE 3602          EQU2 MOVE D2,D3
5180 0005C0 4883           EXT D3
5190 0005C2 E64B           LSR 3,D3
5200 0005C4 9203           SUB.B D3,D1
5210 0005C6 3801           MOVE D1,D4
5220 0005C8 4884           EXT D4
5230 0005CA E64C           LSR 3,D4
5240 0005CC D404           ADD.B D4,D2
5250 0005CE 4E75           RTS
5260                       *
5270                       *
5280 0005D0 3602          EQU3 MOVE D2,D3
5290 0005D2 4883           EXT D3
5300 0005D4 E24B           LSR 1,D3
5310 0005D6 D203           ADD.B D3,D1
5320 0005D8 3801           MOVE D1,D4
5330 0005DA 4884           EXT D4
5340 0005DC E24C           LSR 1,D4
5350 0005DE 9404           SUB.B D4,D2
5360 0005E0 4E75           RTS
5370                       *
5380 0005E2 3602          EQU4 MOVE D2,D3
5390 0005E4 4883           EXT D3
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5400 0005E6 E64B           LSR 3,D3
5410 0005E8 9203           SUB.B D3,D1
5420 0005EA 3801           MOVE D1,D4
5430 0005EC 4884           EXT D4
5440 0005EE E64C           LSR 3,D4
5450 0005F0 9404           SUB.B D4,D2
5460 0005F2 4E75           RTS
5470                       *
5480 0005F4 3602          EQU5 MOVE D2,D3
5490 0005F6 4883           EXT D3
5500 0005F8 E24B           LSR 1,D3
5510 0005FA 9203           SUB.B D3,D1
5520 0005FC 3801           MOVE D1,D4
5530 0005FE 4884           EXT D4
5540 000600 E44C           LSR 2,D4
5550 000602 D404           ADD.B D4,D2
5560 000604 4E75           RTS
5570 000606 2C7C000225AC  Q9 MOVE.L #$225AC,A6
5580 00060C 3A3C0002      Q91 MOVE #2,D5
5590 000610 61000044      Q92 BSR CMQ
5600 000614 3E3C0020        MOVE #$20,D7
5610 000618 6100FEC0        BSR RUN1
5620 00061C 6100002C        BSR DLYQ
5630 000620 48E70402        MOVEM.L D5/A6,-(A7)
5640 000624 6100008E        BSR HP1
5650 000628 4CDF4020        MOVEM.L (A7)+,D5/A6
5660 00062C 6100001C        BSR DLYQ
   0 000630 5345            SUB  #1,D5
   0 000632 66DC            BNE  Q92
5680 000634 61000034        BSR LOGO
5690 000638 DDFC00000012    ADD.L #$12,A6
5700 00063E BDFC00022606    CMP.L #$22606,A6
5710 000644 670001D2        BEQ Q8
5720 000648 60C2            BRA Q91
5730 00064A 283C000AFFFF  DLYQ MOVE.L #$000AFFFF,D4
5740 000650 5384          DLYQ1 SUB.L #1,D4
5750 000652 66FC            BNE DLYQ1
5760 000654 4E75            RTS
5770 000656 4280          CMQ CLR.L D0
5780 000658 323C2000        MOVE #$2000,D1
5790 00065C 207C00010000    MOVE.L #$10000,A0
5800 000662 20C0          CMQ1 MOVE.L D0,(A0)+
   0 000664 5341            SUB  #1,D1
   0 000666 66FA            BNE  CMQ1
5820 000668 4E75            RTS
5830 00066A 48E7FFFE      LOGO MOVEM.L D0-D7/A0-A6,-(A7)
5840 00066E 4EB900021F18    JSR FIXBUF
5850 000674 2CFC53482053    MOVE.L #'SH S',(A6)+
5860 00067A 2CFC4C494445    MOVE.L #'LIDE',(A6)+
5870 000680 1CBC0020        MOVE.B #' ',(A6)
5880 000684 6100FA62        BSR SHQ
5890 000688 61C0            BSR DLYQ
5900 00068A 4EB900021F18    JSR FIXBUF
5910 000690 2CFC5348204D    MOVE.L #'SH M',(A6)+
5920 000696 2CFC41534B20    MOVE.L #'ASK ',(A6)+
```

```
5930 00069C 6100FA4A       BSR SHQ
5940 0006A0 4CDF7FFF       MOVEM.L (A7)+,D0-D7/A0-A6
5950 0006A4 283C0010FFFF   MOVE.L #$0010FFFF,D4
5960 0006AA 60A4           BRA DLYQ1
5970                       *
5980 0006AC 61000006       HP BSR HP1
5990 0006B0 6000F9CA        BRA RETURN
6000 0006B4 267C00001080 HP1 MOVE.L #ARRAY,A3
6010 0006BA 619A           BSR CMQ
6020 0006BC 4241           CLR D1
6030 0006BE 4242           CLR D2
6040 0006C0 363C00FF       MOVE #$FF,D3
6050 0006C4 3803           MOVE D3,D4
6060 0006C6 6100FE6A       BSR RAND1
6070 0006CA 02000007       AND.B #7,D0
6080 0006CE 5A00           ADD.B #5,D0
6090 0006D0 E340           ASL 1,D0
6100 0006D2 11C01014       MOVE.B D0,NUMPT
6110 0006D6 6100FE5A       BSR RAND1
6120 0006DA 0200001F       AND.B #$1F,D0
6130 0006DE 00000005       OR.B #$5,D0
6140 0006E2 11C01016       MOVE.B D0,SCALE
6150 0006E6 4245           CLR D5
6160 0006E8 6100FE48      H6 BSR RAND1
6170 0006EC 024000FF        AND #$FF,D0
6180 0006F0 17805000        MOVE.B D0,0(A3,D5)
6190 0006F4 B240            CMP D0,D1
6200 0006F6 6A02            BPL.S H1
6210 0006F8 1200            MOVE.B D0,D1
6220 0006FA B640          H1 CMP D0,D3
6230 0006FC 6B02            BMI.S H2
6240 0006FE 1600            MOVE.B D0,D3
6250 000700 6100FE30      H2 BSR RAND1
6260 000704 024000FF        AND #$FF,D0
6270 000708 17805001        MOVE.B D0,1(A3,D5)
6280 00070C B440            CMP D0,D2
6290 00070E 6A02            BPL.S H3
6300 000710 1400            MOVE.B D0,D2
6310 000712 B840          H3 CMP D0,D4
6320 000714 6B02            BMI.S H4
6330 000716 1800            MOVE.B D0,D4
6340 000718 BA381014      H4 CMP.B NUMPT,D5
6350 00071C 6704            BEQ.S H5
6360 00071E 5405            ADD.B #2,D5
6370 000720 60C6            BRA H6
6380        00000722      H5 EQU *
6390 000722 9203          H8 SUB.B D3,D1
6400 000724 9404            SUB.B D4,D2
6410 000726 4245            CLR D5
6420 000728 97335000      H61 SUB.B D3,0(A3,D5)
6430 00072C 99335001        SUB.B D4,1(A3,D5)
6440 000730 BA381014        CMP.B NUMPT,D5
6450 000734 6704            BEQ.S H9
6460 000736 5405            ADD.B #2,D5
6470 000738 60EE            BRA H61
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6480 00073A 4243          H9 CLR D3
6490 00073C 203C0000FF00   MOVE.L #$FF00,D0
6500 000742 024100FF       AND #$FF,D1
6510 000746 80C1           DIVU D1,D0
6520 000748 4245           CLR D5
6530 00074A 16335000      H12 MOVE.B 0(A3,D5),D3
6540 00074E C6C0           MULU D0,D3
6550 000750 E04B           LSR 8,D3
6560 000752 17835000       MOVE.B D3,0(A3,D5)
6570 000756 BA381014       CMP.B NUMPT,D5
6580 00075A 6704           BEQ.S H11
6590 00075C 5405           ADD.B #2,D5
6600 00075E 60EA           BRA H12
6610 000760 203C0000FF00 H11 MOVE.L #$FF00,D0
6620 000766 024200FF       AND #$FF,D2
6630 00076A 80C2           DIVU D2,D0
6640 00076C 4245           CLR D5
6650 00076E 16335001      H14 MOVE.B 1(A3,D5),D3
6660 000772 C6C0           MULU D0,D3
6670 000774 E04B           LSR 8,D3
6680 000776 17835001       MOVE.B D3,1(A3,D5)
6690 00077A BA381014       CMP.B NUMPT,D5
6700 00077E 6704           BEQ.S H13
6710 000780 5405           ADD.B #2,D5
6720 000782 60EA           BRA H14
6730 000784 31D31000      H13 MOVE (A3),X1
6740 000788 3E3C001C      H131 MOVE #$1C,D7
6750 00078C 54381014      H132 ADD.B #2,NUMPT
6760 000790 1A381014        MOVE.B NUMPT,D5
6770 000794 37935000        MOVE (A3),0(A3,D5)
6780 000798 3C3C0004      H15 MOVE #4,D6
6790 00079C 6100FD94        BSR RAND1
6800 0007A0 0240000F        AND #$F,D0
6810 0007A4 67F2            BEQ H15
6820 0007A6 0C000008        CMP.B #$8,D0
6830 0007AA 67EC            BEQ H15
6840 0007AC 0C00000F        CMP.B #$F,D0
6850 0007B0 67E6            BEQ H15
6860 0007B2 4245         HP6 CLR D5
6870 0007B4 12335000      H17 MOVE.B 0(A3,D5),D1
6880 0007B8 14335001        MOVE.B 1(A3,D5),D2
6890 0007BC 6100008A      HP17 BSR LINE
6900 0007C0 BA381014        CMP.B NUMPT,D5
6910 0007C4 6748            BEQ.S H16
6920 0007C6 12335002        MOVE.B 2(A3,D5),D1
6930 0007CA 14335000        MOVE.B 0(A3,D5),D2
6940 0007CE 024100FF        AND #$FF,D1
6950 0007D2 024200FF        AND #$FF,D2
6960 0007D6 9242            SUB D2,D1
6970 0007D8 16381016        MOVE.B SCALE,D3
6980 0007DC 024300FF        AND #$FF,D3
6990 0007E0 C3C3            MULS D3,D1
7000 0007E2 E049            LSR 8,D1
7010 0007E4 D3335000        ADD.B D1,0(A3,D5)
7020 0007E8 12335003        MOVE.B 3(A3,D5),D1
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7030 0007EC 024100FF      AND #$FF,D1
7040 0007F0 14335001      MOVE.B 1(A3,D5),D2
7050 0007F4 024200FF      AND #$FF,D2
7060 0007F8 9242          SUB D2,D1
7070 0007FA 16381016      MOVE.B SCALE,D3
7080 0007FE 024300FF      AND #$FF,D3
7090 000802 C3C3          MULS D3,D1
7100 000804 E049          LSR 8,D1
7110 000806 D3335001      ADD.B D1,1(A3,D5)
7120 00080A 5445          ADD #2,D5
7130 00080C 60A6          BRA H17
7140 00080E 5346          H16 SUB #1,D6
7150 000810 66A0          BNE HP6
7160 000812 5347          SUB #1,D7
7170 000814 6682          BNE H15
7180 000816 4E75          RTS
7190 000818 6100FE9A      Q8 BSR HP1
7200 00081C 283C000AFFFF  MOVE.L #$AFFFF,D4
7210 000822 6100FE2C      BSR DLYQ1
7220 000826 60F0          BRA Q8
7230                      *
7240                      *
7250                      *
7260 000828 12290002      DXDY MOVE.B 2(A1),D1
7270 00082C 9211          SUB.B (A1),D1
7280 00082E 650A          BCS.S XNEG
7290 000830 13410004      MOVE.B D1,4(A1)
7300 000834 42290006      CLR.B 6(A1)
7310 000838 4E75          RTS
7320 00083A 137C00010006  XNEG MOVE.B #1,6(A1)
7330 000840 4401          NEG.B D1
7340 000842 13410004      MOVE.B D1,4(A1)
7350 000846 4E75          RTS
7360                      *
7370                      *
7380         00000848     LINE EQU *
7390 000848 48E7FFFE      DRAW MOVEM.L D0-D7/A0-A6,-(A7)
7400 00084C 227C00001000  MOVE.L #X1,A1
7410 000852 13410002      MOVE.B D1,2(A1)
7420 000856 13420003      MOVE.B D2,3(A1)
7430 00085A 1211          MOVE.B (A1),D1
7440 00085C 14290001      MOVE.B 1(A1),D2
7450 000860 6100FCF2      BSR DSP
7460 000864 61C2          DRAW1 BSR DXDY
7470 000866 5289          ADD.L #1,A1
7480 000868 61BE          BSR DXDY
7490 00086A 5389          SUB.L #1,A1
7500 00086C 1211          MOVE.B (A1),D1
7510 00086E 14290001      MOVE.B 1(A1),D2
7520 000872 4A290004      TST.B 4(A1)
7530 000876 6766          BEQ.S DXZ
7540 000878 4A290005      TST.B 5(A1)
7550 00087C 67000088      BEQ DYZ
7560 000880 16290004      MOVE.B 4(A1),D3
7570 000884 B6290005      CMP.B 5(A1),D3
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7580 000888 660000B0      BNE FULMOV
7590 00088C 4A290006      TST.B 6(A1)
7600 000890 6626          BNE.S SXN
7610 000892 4A290007      TST.B 7(A1)
7620 000896 6636          BNE.S SYN
7630 000898 6100FCBA      XPYP1 BSR DSP
7640 00089C 5201          ADD.B #1,D1
7650 00089E 5202          ADD.B #1,D2
7660 0008A0 B2290002      CMP.B 2(A1),D1
7670 0008A4 66F2          BNE XPYP1
7680 0008A6 607E          BRA.S XYDONE
7690 0008A8 6100FCAA      SXNSYN BSR DSP
7700 0008AC 5301          SUB.B #1,D1
7710 0008AE 5302          SUB.B #1,D2
7720 0008B0 B2290002      CMP.B 2(A1),D1
7730 0008B4 66F2          BNE SXNSYN
7740 0008B6 606E          BRA.S XYDONE
7750 0008B8 4A290007      SXN TST.B 7(A1)
7760 0008BC 66EA          BNE.S SXNSYN
7770 0008BE 6100FC94      SNP BSR DSP
7780 0008C2 5301          SUB.B #1,D1
7790 0008C4 5202          ADD.B #1,D2
7800 0008C6 B2290002      CMP.B 2(A1),D1
7810 0008CA 66F2          BNE SNP
7820 0008CC 6058          BRA.S XYDONE
7830 0008CE 6100FC84      SYN BSR DSP
7840 0008D2 5201          ADD.B #1,D1
7850 0008D4 5302          SUB.B #1,D2
7860 0008D6 B2290002      CMP.B 2(A1),D1
7870 0008DA 66F2          BNE SYN
7880 0008DC 6048          BRA.S XYDONE
7890 0008DE 4A290005      DXZ TST.B 5(A1)
7900 0008E2 6742          BEQ.S XYDONE
7910 0008E4 4A290007      TST.B 7(A1)
7920 0008E8 660E          BNE.S DXZYN
7930 0008EA 6100FC68      DXZ1 BSR DSP
7940 0008EE 5202          ADD.B #1,D2
7950 0008F0 B4290003      CMP.B 3(A1),D2
7960 0008F4 66F4          BNE DXZ1
7970 0008F6 602E          BRA.S XYDONE
7980 0008F8 6100FC5A      DXZYN BSR DSP
7990 0008FC 5302          SUB.B #1,D2
8000 0008FE B4290003      CMP.B 3(A1),D2
8010 000902 66F4          BNE DXZYN
8020 000904 6020          BRA.S XYDONE
8030 000906 4A290006      DYZ TST.B 6(A1)
8040 00090A 660E          BNE.S DYZN
8050 00090C 6100FC46      DYZ1 BSR DSP
8060 000910 5201          ADD.B #1,D1
8070 000912 B2290002      CMP.B 2(A1),D1
8080 000916 66F4          BNE DYZ1
8090 000918 600C          BRA.S XYDONE
8100 00091A 6100FC38      DYZN BSR DSP
8110 00091E 5301          SUB.B #1,D1
8120 000920 B2290002      CMP.B 2(A1),D1
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8130 000924 66F4           BNE DYZN
8140 000926 32A90002      XYDONE MOVE 2(A1),(A1)
8150 00092A 1211           MOVE.B (A1),D1
8160 00092C 14290001       MOVE.B 1(A1),D2
8170 000930 6100FC22       BSR DSP
8180 000934 4CDF7FFF       MOVEM.L (A7)+,D0-D7/A0-A6
8190 000938 4E75           RTS
8200 00093A 33510008      FULMOV MOVE (A1),8(A1)
8210 00093E 16290004       MOVE.B 4(A1),D3
8220 000942 96290005       SUB.B 5(A1),D3
8230 000946 6208           BHI.S FUL1
8240 000948 337C0001000A   MOVE #$1,10(A1)
8250 00094E 6046           BRA.S FUL4
8260 000950 337C0100000A  FUL1 MOVE #$100,10(A1)
8270 000956 603E           BRA.S FUL4
8280 000958 16290008      FUL2 MOVE.B 8(A1),D3
8290 00095C 9611           SUB.B (A1),D3
8300 00095E 6402           BCC.S FUL21
8310 000960 4403           NEG.B D3
8320 000962 024300FF      FUL21 AND #$FF,D3
8330 000966 18290005       MOVE.B 5(A1),D4
8340 00096A 024400FF       AND #$FF,D4
8350 00096E C6C4           MULU D4,D3
8360 000970 18290009       MOVE.B 9(A1),D4
8370 000974 98290001       SUB.B 1(A1),D4
8380 000978 6402           BCC.S FUL22
8390 00097A 4404           NEG.B D4
8400 00097C 1A290004      FUL22 MOVE.B 4(A1),D5
8410 000980 024400FF       AND #$FF,D4
8420 000984 024500FF       AND #$FF,D5
8430 000988 C8C5           MULU D5,D4
8440 00098A 4A29000A       TST.B 10(A1)
8450 00098E 660E           BNE.S FULY
8460 000990 B883           CMP.L D3,D4
8470 000992 6710           BEQ.S GREAT
8480 000994 620E           BHI.S GREAT
8490 000996 3369000A000E  FUL4 MOVE 10(A1),14(A1)
8500 00099C 600C           BRA.S SAME
8510 00099E B883          FULY CMP.L D3,D4
8520 0009A0 6702           BEQ.S GREAT
8530 0009A2 62F2           BHI.S FUL4
8540 0009A4 337C0101000E GREAT MOVE #$0101,14(A1)
8550 0009AA 12290008      SAME MOVE.B 8(A1),D1
8560 0009AE 14290009       MOVE.B 9(A1),D2
8570 0009B2 4A290007       TST.B 7(A1)
8580 0009B6 6606           BNE.S NEGY
8590 0009B8 D429000F       ADD.B 15(A1),D2
8600 0009BC 6004           BRA.S S2
8610 0009BE 9429000F      NEGY SUB.B 15(A1),D2
8620 0009C2 13420009      S2 MOVE.B D2,9(A1)
8630 0009C6 4A290006       TST.B 6(A1)
8640 0009CA 6606           BNE.S NEGX
8650 0009CC D229000E       ADD.B 14(A1),D1
8660 0009D0 6004           BRA.S S3
8670 0009D2 9229000E      NEGX SUB.B 14(A1),D1
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8680 0009D6 13410008      S3 MOVE.B D1,8(A1)
8690 0009DA 6100FB78      FUL3 BSR DSP
8700 0009DE B2290002       CMP.B 2(A1),D1
8710 0009E2 670A           BEQ.S DRAW2
8720 0009E4 B4290003       CMP.B 3(A1),D2
8730 0009E8 6704           BEQ.S DRAW2
8740 0009EA 6000FF6C       BRA FUL2
8750 0009EE 32A90008      DRAW2 MOVE 8(A1),(A1)
8760 0009F2 6000FE70       BRA DRAW1
8770 0009F6 0000           END
```

****** TOTAL ERRORS 0-- 0

SYMBOL TABLE

ARRAY	001080	BA	000454	BL1	000364	BL2	000358
BL3	000368	BLACK	000308	BLINK	00034A	BLUE	0002FC
BX	00018A	BX1	00019A	BX11	0001B4	BX2	0001A4
BX22	0001C0	BX3	000190	BX33	0001D0	BX44	0001DA
CHAR	0003B6	CHARED	0003A0	CHARED1	0003CE	CHARED2	0003D0
CHARED3	0003D4	CHARED4	0003F8	CHTAB	0009F6	CLRM	000074
CM	000068	CMD	000204	CMD1	00026A	CMD2	000288
CMD3	000270	CMD4	000276	CMDTAB	001800	CMQ	000656
CMQ1	000662	COLOR	001010	CR	00027C	CRTC	0000D2
CYAN	00031A	DBLUE	00032C	DCYAN	000344	DGR	000326
DLY	00044A	DLY1	00044E	DLYQ	00064A	DLYQ1	000650
DMAG	00033E	DOT	00041C	DRAW	000848	DRAW1	000864
DRAW2	0009EE	DRED	000320	DSP	000554	DSP1	000566
DSPLY	00055A	DSPLY1	0005A8	DSPLY2	0005A0	DWARROW	000258
DWH	000332	DXDY	000828	DXZ	0008DE	DXZ1	0008EA
DXZYN	0008F8	DYEL	000338	DYZ	000906	DYZ1	00090C
DYZN	00091A	ED	0001E8	ED1	0001FA	EQU1	0005AC
EQU2	0005BE	EQU3	0005D0	EQU4	0005E2	EQU5	0005F4
FIXBUF	021F18	FUL1	000950	FUL2	000958	FUL21	000962
FUL22	00097C	FUL3	0009DA	FUL4	000996	FULMOV	00093A
FULY	00099E	GETADD	00057A	GREAT	0009A4	GREEN	0002F6
H1	0006FA	H11	000760	H12	00074A	H13	000784
H131	000788	H132	00078C	H14	00076E	H15	000798
H16	00080E	H17	0007B4	H2	000700	H3	000712
H4	000718	H5	000722	H6	0006E8	H61	000728
H8	000722	H9	00073A	HP	0006AC	HP1	0006B4
HP17	0007BC	HP6	0007B2	INIT	00002C	INIT1	000038
INPUT	00016E	L1	000466	L2	000482	LINE	000848
LOGO	00066A	LOOP	000474	LTARROW	000264	MACSBUG	0200F6
MAG	000314	MSG	0200EE	NCOLOR	001011	NEGX	0009D2
NEGY	0009BE	NTABLE	000082	NUMPT	001014	OCOLOR	001012
OUTPUT	00017C	OUTPUT2	021BC2	Q1	000498	Q2	0004A4
Q3	0004B0	Q4	0004BC	Q5	0004C8	Q8	000818
Q9	000606	Q91	00060C	Q92	000610	RANADD	001018
RAND	000514	RAND1	000532	RAND2	000520	READK	000436
RED	0002F0	RETURN	00007C	RTARROW	00025E	RTS	000256
RTS1	000254	RTS2	0002EC	RUN	0004D2	RUN1	0004DA
RUN2	0004E2	S2	0009C2	S3	0009D6	SAME	0009AA
SCALE	001016	SET	00040A	SETUP	000000	SETUP1	00000E

SETUP2	00001C	SETUP21	000060	SH	0000E2	SH1	0000F4
SH2	000106	SH3	000146	SH4	000154	SHOW	0001B2
SHQ	0000E8	SNP	0008BE	SXN	0008B8	SXNSYN	0008A8
SYN	0008CE	TABLECH	001100	UPARROW	000250	WHITE	000302
X1	001000	X2	001002	XNEG	00083A	XPYP1	000898
XYDONE	000926	Y1	001001	Y2	001003	YELLOW	00030E