MICRO TECHNOLOGY UNLIMITED

# GRAPHICS SOFTWARE PACKAGE FOR THE K-1008 VISIBLE MEMORY

The graphics software package for the K-1008 Visable Memory is designed to provide the user with a library of basic graphics oriented subroutines. By incorporating calls to these routines, the user can create and manipulate text and graphic images whose complexity is limited only by the 320 by 200 display matrix size. The graphics and text display subroutines are available only as printed, assembled, and commented program listings since the user is expected to assemble them into his own application programs.

In addition, two self-contained demonstration programs are included. Both of these will run on the bare KIM with no extra hardware other than the K-1008 Visible Memory and video monitor. In many cases, the demonstration programs contain simplified versions <u>of</u> the graphics subroutine package having only enough capability to satisfy the needs of the demonstration. Printed listings of the demo programs are normally included with the graphics software package. The demo programs are also available on a standard KIM cassette for $5.00.

## INCLUSIONS

In this package you should find the following:

1. Printed, assembled, and commented program listings of
    A. SWIRL demonstration program
    B. LIFE demonstration program
    C. SDTXT Simplified text display subroutine, 22 lines 53 char.
    D. Comprehensive graphics subroutine library containing point and line plotting routines, a character drawing routine, and an ASCII text display routine.
2. Instruction manual which your are now reading
3. Copyright notice

In addition, a standard speed KIM format cassette may be supplied if it was specifically ordered (available only to purchasers of the entire software package for $5.00). The cassette contains:

1. File 01 (recorded twice) SWIRL demonstration program.
   Loads into locations 0000 - 03EC
2. File 02 (recorded twice) LIFE demonstration program.
   Loads into locations 0000 - 3FB
3. File 03 (recorded twice) Continuation of LIFE program.
   Loads into locations 1780 - 17DC

Note that the demonstration programs assume that the VM occupies addresses from 2000-3FFF. If your system is configured differently, put the first VM page number in 000B for SWIRL and 0000 for LIFE.

A separate package will be available shortly for linking MicroSoft BASIC for the KIM with the text and graphics routines. Using this patch package, the user may utilize the Visible Memory for normal textual communications with BASIC (along with an external keyboard) and for graphic output. Repetitive graphic calculations are handled by the package in machine language thus insuring maximum overall speed.

RUNNING THE DEMONSTRATION PROGRAMS

## I. SWIRL

Swirl is a demonstration program that generates a variety of interesting spirl and spiderweb like patterns on the screen. Two parameters determine the appearance of the pattern and a third either includes or suppresses lines connecting the computed points. The user may set these parameters manually and then have a single pattern computed and held or another routine may be invoked which uses a random number generator to select the parameters thus giving an endless series of different patterns.

The program is based on the differential equation for a circle which tends toward an elipse when evaluated digitally a point at a time. As the calculation proceeds, the radius of the circle decreases until it is essentially zero. Since the calculation is point by point, the visual effect on the display can be considerably different from a simple inward spiral.

One may also think of the algorithm as a digital damped sine wave generator or ultimately a digital bandpass filter. The algorithm works on two variables, SIN and COS, which relate to the sine and cosine of an angle. Basically, the program takes the current values of SIN and COS and computes new values of both under the control of two constants. Each time a new SIN,COS pair is computed, it is treated as an X,Y pair and plotted on the Visible Memory screen. Straight lines may or may not connect successive points; both give distinctive patterns.

Two constants control the program, FREQ and DAMP which, of course, relate to the damped sine wave nature of the algorithm. FREQ is a double precision, signed binary fraction. The larger its value, the fewer points per revolution of the circle and therefore the higher the frequency. The relationship between FREQ and points per cycle is roughly linear. A value of +.9999 ($7FFF_{16}$) gives 6 points per cycle, +.5 ($4000_{16}$) gives about 12, and so forth. <u>Negative</u> values of FREQ cause the spiral to rotate clockwise rather than counterclockwise. DAMP is also a double precision signed binary fraction but it must be positive for proper operation. If it is negative, the oscillation will build up instead of dying out until the fixed point arithmetic routines overflow creating a garbage display. Normal values of DAMP are very close to 1.0 and the useful range is from approximately 7000 to 7FFF. Smaller values of DAMP produce so few points before the circle collapses to zero that the resulting pattern is diffuse and uninteresting.

To run the program, first load it into KIM memory <u>exactly</u> as it appears in the listing. If the cassette was ordered, load file 01 into memory. If loading was done by hand, check it (goes twice as fast with two people, one calling out the hex and the other reading the listing) and then immediately dump it to cassette. The slightest error in hand loading could cause the program to wipe itself out!

Default values for all of the parameters have been supplied. To see the default pattern, start execution at address 002F (SWIRL). The screen, which was initially semi-random garbage, should be cleared and then a spiderweb-like pattern should be gradually built up over a time span of several seconds. It is complete when the dark area at the center of the screen is completely filled up. The user may return to the KIM monitor with the ST or the reset key at any time even if the pattern is not complete.

In order to get a feel for the visual effect of the various parameters, first try setting LINES (at address 0000) to 00 and then go to SWIRL again. This time only the vertices of the angled lines that were seen earlier are shown. Although the defalut FREQ and DAMP parameters were chosen for an appealing display with LINES equal to 1, some very impressive displays indeed are possible with LINES set to 00. For an example, set FREQ to 1102 (0001<02, 0002<11) and DAMP to 7FC0 (0003<C0, 0004<7F) and execute SWIRL again. Interrupt the program execution when the hole in the middle is completely surrounded by a couple of dot depths of solid white. The resulting display, particularly when viewed at a distance in a darkened room, could easily pass for an artist's conception of a Black Hole; an astronomical object which is thought to be matter crushed out of existence by its own gravity!

Returning to the original settings of FREQ, DAMP, and LINES, lets see the effect of changing DAMP. Regenerate the default pattern and fix it in your mind. Then change DAMP from 7E00 to 7F00. This has the effect of cutting the decay rate of the damped sine wave in half. The visual effect is a denser display that decays toward the center more slowly. DAMP may be further increased to 7F80, 7FC0, etc. (set 0006 to 70 to avoid overflow). As DAMP approaches 7FFF, the density of the image becomes so great that the pattern becomes essentially solid white and takes a long time to complete. Conversely, as DAMP is reduced to 7C00, 7800, 7000, etc., the pattern becomes sparser and eventually degrades into an angular spiral. Try some of these values of DAMP with LINES set to zero also.

All of the preceeding patterns had very nearly 6 points per revolution of the spiral. The vertices themselves created a spiral pattern as they overlapped and created moire-like effects. Slight changes in FREQ can have a profound effect on the moire aspect of the pattern without a significant effect on the number of points per revolution. Try 7E80, 7F80, and 7FFF for FREQ to see this effect. Many more points per revolution are possible by reducing FREQ. Reduction to 4000, 2000, 1000, and even lower will cause the vertices to become so closely spaced that the effect of a continuous curve (within the resolution constraint of the display) is created. Also note that decreasing FREQ apparently increases the damping causing the spiral to decay after fewer revolutions than before. This effect may be countered by increasing DAMP. For example, if FREQ was reduced in half from, say, 3000 to 1800, then the difference between DAMP and 7FFF should also be reduced in half, say from 7D00 to 7E80. The lower values of FREQ are particularly effective with LINES set to zero. If FREQ is low enough, there will be no visual difference between LINES=1 and LINES=0.

Some combinations of FREQ and DAMP can cause the arithmetic to overflow, that is, SIN or COS may try to reach or exceed 1.0 in magnitude. There is no danger of such an occurance damaging the program or wiping out memory but the resulting pattern on the screen can be very random looking. Simultaneous high values of FREQ and DAMP will cause the overflow situation. Reducing COSINT to 7000 will prevent the possibility of overflow but will also reduce the image size somewhat. If FREQ is kept less than 4000 or so, COSINT may be increased to 7E00 for a somewhat larger pattern.

Entry into RSWIRL (address 0045) will cause continuous random selection of the parameters and computation of patterns. To insure that the "pattern complete" test functions properly, COSINT should to set to 7000 to prevent the possibility of overflow. The sequence of patterns will not repeat for days!

## II. LIFE

This program is based on the Life cellular automaton algorithm written up in Scientific American magazine several years ago. The basic concept is that of a rectangular array of "cells" that "live" and "die" in discrete time "generations". On the Visible Memory screen, each picture element (pixel or bit position) is a cell location. A live cell is represented as a One bit which shows as a white dot and a dead or missing cell is represented as a Zero which leaves a black area. A generation is the state or configuration of live cells on the screen at a point in time. A set of rules are defined which determines, based on the configuration of live cells in the present generation, which cells live or die in the next generation as well as "births" of new cells where none had existed previously.

The rules of Life are simple. In fact, their very simplicity yet varied and wonderful effect is what makes Life so appealing to many people. The rules are based purely on the eight neighbors (above, below, left of, right of, and the 4 diagonal neighbors) of every cell position. To determine the next generation, the <u>live</u> neighbors of every cell position in the life field are counted. Based on this count and the current state of the central cell, the fate of the central cell is determined. The rules are as follows:

- A. Central cell is alive
  1. 0 or 1 live neighbors, the central cell dies of starvation
  2. 2 or 3 live neighbors, the central cell lives on
  3. 4 or more live neighbors, the central cell dies of overcrowding
- B. Central cell is not alive
  1. Fewer than or more than 3 live neighbors, the central cell remains dead
  2. Exactly 3 live neighbors, a birth is recorded.

When applying these rules to determine the next generation, the present configuration of live cells is always used. Any births or deaths are recorded separately and do not influence events around the birth or death site until the next generation becomes current. When programming Life, this may be accomplished by making a copy of the Life field as the next generation is formed. In a limited memory machine such as the KIM, buffering of lines of cells is needed to simulate a copy of the field.

The resulting sequence of generations is completely determined by the configuration of the initial colony of cells and is called a life history. Such a history may end in one of several ways. The colony may eventually die out completely leaving no cells on the screen at all. This often happens after several generations of spectacular buildup which suddenly shrink and disintegrate after a few more. A colony may also become stable. This happens when each succeeding generation is exactly like the previous one. Cycles of generations are also possible in which a configuration may go through a cycle of two or more differing configurations only to return to the exact same configuration for another cycle. A variation of the cyclic pattern is one which moves accross the screen as it cycles. Finally, a pattern may grow without limit. Initially this was thought to be impossible until a pattern that periodically emits cyclic, traveling patterns was discovered.

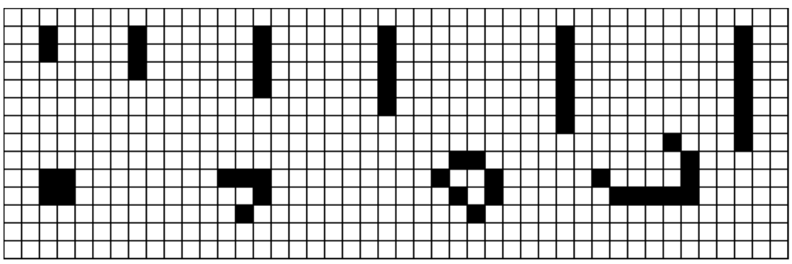
The Life demonstration program consists of four entry points. INIT (009A) when entered will merely clear the screen and return to the KIM monitor. This is generally necessary before entering a pattern by hand. KYPT (03C7) allows entry of an initial pattern of cells using a graphic cursor and the KIM keypad. Initial patterns may also be entered using the KIM monitor to write directly into the visible memory. Other methods include reading the pattern from cassette tape using the KIM monitor or generating the pattern with another program (such as SWIRL), loading LIFE, and executing it. The entry point LIFE (0100) starts the evolution process. Finally, DEMO will create an appropriate, canned, initial pattern and then execute LIFE to produce an amazingly beautiful life history.

If the reader is not familiar with the Life algorithm and some of the folklore surrounding it, it is instructive to experiment some before executing DEMO (leave it as a supprise!). First load the program from the listing or cassette tape in the same manner as SWIRL. Be sure to load the auxiliary RAM from 1780 to 17DC or KYPT will not function. After loading (and saving on cassette if by hand), execute INIT (009A) to clear the screen. INIT should return to the KIM monitor after the screen is cleared. Next execute KYPT (03C7) (a bug in the program requires that 13 be stored into 0001 before executing KYPT). In the middle of the screen should be a single flashing dot. Note that the dot is off most of the time flashing on for only a short period. This is a signal that the graphic cursor is covering a "dead" cell. Press the + key on the KIM. The flashing should change such that the dot is on most of the time. This signifies that a live cell is being covered. Thus the "+" key is used to set a cell at the current cursor position. Hitting the "F" key will kill the cell under the cursor.

The cursor may be moved horizontally and vertically by hitting the "9" key for up, "1" key for down, "4" for left, and "6" for right. With these movement keys, the + key, and the F key, simple initial patterns may be easily entered or existing patterns may be edited in a limited way. You may notice that the KIM keyboard keys bounce less or none at all using this routine. This is due to a more sophisticated debouncing algorithm than is utilized in the KIM monitor.

Once the desired initial pattern is obtained, the "GO" key may be pressed to start execution of the Life algorithm. Alternatively, KYPT may be interrupted and LIFE may be manually entered at 0100. The succession of generations may be stopped by pressing any keyboard key (except ST or RS) and KYPT will regain control at the conclusion of the current generation (hold the key down until the graphic cursor is seen).

Try the initial patterns shown below and note their fate.

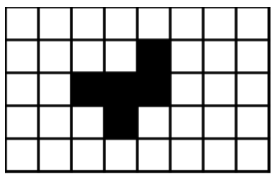


The patterns that evolve from those on the previous page are fundamental and well known to every Life fan. They are so common in the result of many initial patterns that they have been given discriptive names. See if you can match the following names with the corresponding final patterns: Block, Honeyfarm, Glider, Blinker, Beehive, Lifeboat, Rocketship, Traffic Lights.

Another interesting pastime is to note the life history (number of generations before dying off, becoming stable, or becoming cyclic) of simple lines of dots with 3, 4, .... 30 .... dots in a line. Sometimes the addition of a single dot in a long string can have a profound effect on the final result. Another possibility is to trace the history of all possible configurations of three live cells, 4 cells, 5 cells, etc. Note that the majority of the possible configurations are redundant because of symmetry, rotation, or mirror images. Also, sparse initial patterns invariably die off in one or two generations because of starvation.

Note that initial patterns should be placed in the center of the screen to allow maximum room for expansion of the colony. If live cells get within one cell width of the matrix boundaries, the next generation is no longer correctly computed. This only applies to the region where the boundary is touched, the remainder of the screen is unaffected.

Finally, before executing DEMO, try the very simple initial pattern below. As it expands and differentiates, it will leave a litter of the fundamental patterns discussed earlier.



To execute DEMO, simply go to 00A1. An initial pattern will be generated and the Life algorithm will be executed on it. When seen, numerous practical applications for Life should present themselves. The initial pattern generated by DEMO may be changed by altering the table of coordinates that starts at LIST (0335). Note that the line drawing routine that connects the endpoints in the list is limited to horizontal, vertical, and 45 degree lines. Other angles are not harmful but will be displayed as a 45 degree segment followed by a 90 degree segment.

## III. USING SDTXT FOR TEXT DISPLAY ON THE VISIBLE MEMORY

SDTXT stands for Simplified Display TeXT which is a highly optimized text display subroutine for the Visible Memory graphics display. Within the constraints of structured programming technique and overall programming effort, SDTXT is optimized for small size and fast execution speed. It is also designed to fit the maximum practical amount of text into the 320 by 200 display matrix without adversely affecting legibility.

Given that the SDTXT subroutine is resident in memory, either RAM or ROM, it is as easy to generate text on the Visible Memory display as it is with a conventional characters-only display. Note however that SDTXT and the Visible Memory form an "output only" display device as far as the actual ASCII character codes are concerned. Although bit patterns forming the character shape are readily read from the display memory, the actual ASCII codes cannot be retrieved (unless of course one wishes to write a character recognition program to convert dot patterns to ASCII). Thus an actual text editing application would have to maintain a separate text buffer for the ASCII codes. This is discussed in greater detail later.

The basic display format of SDTXT is 22 lines of 53 characters per line. Although it would be nice to have a longer line, the majority of low cost character-only displays actually have less capacity than this such as 16 lines of 32 or 40 characters. The characters themselves are formed from a 5 wide by 7 high dot matrix. Lower case characters are represented as small capital letters in a 5 by 5 matrix. Although normal lower case with descenders is readily handled on a graphic display device, additional room must be allowed for the descender thus reducing the number of possible text lines. Lower case shapes without descenders were judged to be more difficult to read than the small caps. The 5 by 7 matrix is positioned in a 6 wide by 9 high "window" to allow space between adjacent characters and lines. Although 25 lines could be displayed if the interline spacing was reduced to one dot, the sacrifice in legibility was judged to be excessive. If the user disagrees with these choices, reassembly of the subroutine with different values (within limits) of CHHI and CHWID and a slight recoding of CSRTAD is sufficient to change them. The character font table is also readily changed to suit individual tastes. If the user wishes to operate in the half screen mode, NLOC should be changed to 4096 and the program reassembled. This will cut the number of lines displayed to 11 but leave the second 4K half of the VM free for other uses.

SDTXT requires some RAM for parameter and temporary storage. There are three types of storage required. Base page temporary storage <u>must</u> be in page zero since the indirect addressing modes require this. Four bytes are required but they need not be preserved between calls to SDTXT thus they may be used by other programs as well. Four additional bytes of temporary storage may be placed anywhere and also used by other programs. Finally, three bytes are required for the storage of parameters. Since these hold the cursor location and the page number of the VM, they must not be disturbed between calls to SDTXT unless the user desires to change these parameters. Note that if all RAM storage is kept in page 0 and SDTXT is reassembled that the program will be a couple dozen bytes shorter and somewhat faster due to the use of page zero addressing rather than absolute addressing when these locations are accessed.

As given in the program listing, SDTXT is about 1.2K bytes in length. This may be reduced to just under 1K (for storage in a single 2708 PROM) if the lower case characters are deleted from the font table. The routine is completely ROMable since it does not modify itself but it is not reentrant due to the fixed temporary storage locations. If SDTXT is placed in ROM, it is suggested that the 4 bytes that must be in the base page be assigned just below the KIM monitor area. It may even be possible use the KIM monitor area itself since the routine is already debugged and therefore need not be single-stepped. Actually, many other programs could make use of these two address pointers as well . The remaining temporary storage may be put anywhere. Although page zero is a desirable location, the 96 invisible bytes at the end of the VM is also a good choice for this and any other programs associated with the display.

It is unlikely that the user will want SDTXT to reside in the locations it was assembled for, which is the last 1.2K of a 16K expansion starting at 2000. While a full 6502 compatible assembler is best for configuring the program, hand relocation is not difficult. All underlined addresses must be changed if the program itself is relocated. If the temporary storage locations are also moved (quite likely), addresses referencing them will also have to be changed. While not specifically designated in the listing, they are easily spotted simply by noting references to CSRX, CSRY, DCNT1, etc. in the operand field of the instruction.

## USING SDTXT

Using SDTXT is exceptionally simple. The user merely loads the ASCII character code to be displayed or control code to be interpreted into register A and does a JSR SDTXT. The subroutine will then display the character at the present cursor location or do the indicated operation and then return with all registers intact. The condition codes will however be altered. SDTXT expects the decimal mode flag to be OFF.

It cannot be emphasized enough that VMORG must be set to the page number of the first VM location before SDTXT is used. For example, if the VM is jumpered for addresses 2000-3FFF, then VMORG should be $20_{16}$. Failure to set VMORG will change SDTXT into MEMCLR!

It is also important that CSRX and CSRY have valid contents before any printable characters are sent to SDTXT. The best way to accomplish this is to give SDTXT an ASCII FF character (0C) as the very first operation. This action not only initializes the cursor to the top left side, it also clears the screen.

CSRX and CSRY hold the character and line number respectively of the present cursor location. Numbering starts at zero thus the top line is line 0 and the leftmost character is character 0. SDTXT automatically moves the cursor as appropriate. The user may also move the cursor anywhere at any time by directly changing the values of CSRX and CSRY. Before this is done however, a call to CSRCLR must be executed to clear the existing cursor from the screen. The user then can change the cursor location. Following this, a call to CSRSET will display the cursor at its new position. CSRX must always be between 0 and $52_{10}$ and CSRY must be between 0 and 2149 inclusive. Violation of this range restriction is not checked and can cause random storing anywhere in memory.

In the present implementation, if more characters are received than will fit on a line the cursor simply remains at the rightmost character position on the line rather than forcing an automatic carriage return line feed sequence. This capability is easily added but can lead to problems in interfacing with BASIC unless the terminal width is set to 52 rather than 53. A line feed that runs off the bottom of the screen causes an upward scroll of the text instead with the top line being lost.

Two other useful subroutines are available as part of SDTXT. FMOVE is an extremely fast memory move subroutine that can move any number of bytes from anywhere to anywhere in memory at an average speed of 16 microseconds per byte. The address of the first source byte should be stored in ADP1 and the first destination address should be stored in ADP2. A double precision move count should be stored in DCNT1. Although A is destroyed, the index registers are preserved. FCLR is similar except that it can quickly clear any amount of memory. Set up the first address to be cleared in ADP2 and a double precision count in DCNT1 and call FCLR. X and Y are preserved but A is destroyed.

## LIMITATIONS

Unfortunately, even though a lot of effort was put into making SDTXT efficient, it takes a finite amount of time to draw a character and move the cursor. For normal applications, such as displaying text typed in or conversing with BASIC, this time will never be noticed. Using the KIM and the VM to simulate a teletype terminal however will most likely uncover limitations in the maximum baud rate that can be handled.

Approximately 2.68 milliseconds are required to draw a character and move the cursor. All control characters except FF and LF when it causes a scroll take even less time. FF takes nearly 100 milliseconds and an LF that scrolls requires about 120 MS. Ignoring these and only considering characters it is easily determined that the absolute maximum baud rate that can be handled is a little more than 3600 baud. This rate can be closely approached if a standard UART is used for the serial communication. If the timed loop (software UART) serial routines in the KIM monitor are used then only the stop bit duration is available for character generation. This would limit the rate to 300 baud with one stop bit or 600 baud with two stop bits.

Even with a UART, simple one-track programming would only allow 110 baud if LF and FF characters are to be received. Many terminal systems do allow one or more nulls to be sent after such control characters which would directly affect the maximum rate possible without dropping characters. Three nulls would allow operation at 300 baud and 6 would be good for 600 baud. If instead the UART is connected as an interrupting device (such as on the MTU K-1012 PROM/IO board) and a short first-in-first-out queue is programmed, baud rates approaching the theorectical maximum could be handled without the need for extra nulls. In any case the maximum communication speed is highly application dependent.

As mentioned earlier, a text editing application of the VM with SDTXT would require a separate text buffer to hold the ASCII representations of the characters displayed. The most straightforward method of handling this would be to write a text buffer subroutine that parallels the operation of SDTXT except with ASCII codes in an ASCII text buffer. Every character handled would then be given to both routines which would do the same thing with their respective character representations. When text is to be read back or stored on a mass storage device, the ASCII text buffer could then be read to retireve the ASCII codes.

More sophisticated functions such as line and paragraph movement could be performed in one of two ways. Using the movement of one text line to another location as an example, one could do the operation only in the ASCII text buffer and then clear and regenerate the VM image by dumping the ASCII text buffer through SDTXT. Although a second or two would be required to rewrite the screen, this is adequate for many applications and in fact is exactly how storage tube terminals (such as the Tektronix series) work.

The other alternative is to write a move routine that moves the VM image directly and add it to SDTXT to parallel the same operation in the ASCII text buffer. For the one line move example, a routine is needed that would move all text below a given line down one line and open up a single line hole. A second routine that moves a line of characters from elsewhere on the screen into the hole would also be necessary. Finally a "close up" routine to fill the hole left by the line that was moved is needed. All of these routines would be little more than calls to other routines already in SDTXT. Actually the vertical scrolling that occurs after an LF is a similar operation and can be used as an example. Clearly this is a much faster technique than rewriting the screen and can generally be performed in less than 100 milliseconds. Clever programming in which individual scan lines are moved instead of whole character lines can reduce the time required even further as well as reduce the need for "working storage" to hold the overflow line during the move.

## IV. THE GRAPHICS SUPPORT SUBROUTINE PACKAGE

This package combines in one program all of the low level graphic and character drawing functions needed for most applications. Point plotting, line drawing, and character and text display are all provided. For the most part, structured programming discipline and ease of understanding of the code were emphasized more than absolute minimum code size or peak performance. Nevertheless a lot of function has been packed into the 3.2K bytes required by the complete package. Since the programming is modular, unused routines may simply be omitted to reduce the size for specific applications. For example, deleting the "windowed" text display routine will save about 1K. Removing all character display functions will cut the size to less than 1K. Using SDTXT (simplified display text) instead of DTEXT will give a total package size of less than 2K or two 2708 type PROM's.

Some RAM storage is required by the routines in this package. Four bytes of temporary storage must be located on the base page for use as address pointers. An additional 13 bytes of temporary storage may be located anywhere else. All temporary storage may be used by other programs between calls to the graphic support routines. Finally, 17 bytes of permanent storage for parameters are required. These may not be disturbed between calls unless the user wants to specifically change them. Considerable savings in program size and execution time can be realized by assigning all RAM storage to page zero and reassembling the program.

As assembled, this package occupies locations 5500 - 5F75. Base page temporary storage is from 00EA - 00ED and general temporary storage is from 0111 - 011D. Permanent storage is from 0100 - 0110. The program code itself may be hand relocated anywhere in memory by changing all addresses designated by <u>underlining</u> in the listing. Moving the temporary storage by hand is more difficult but can be accomplished by noting all references to locations to be moved and changing accordingly. Hopefully, assignment of temporary storage to the end of the stack area will be appropriate for the majority of users.

### SIGNIFICANCE OF THE PARAMETERS

Information to most of the graphics routines is passed via parameters in memory rather than in the registers. VMORG is the most important parameter. It should be set to the first page number of the Visible Memory before <u>ANY</u> of the graphics routines are called. For example, if the VM is jumpered for addresses 6000 - 7FFF then VMORG should be set to $60_{16}$- Once set it wiil never be changed by any of these routines. Failure to set VMORG will usually cause total program wipeout.

Most graphic routines use one or two sets of coordinates. X1CORD and Y1CORD define one set of coordinates and X2CORD and Y2CORD define another set. All coordinate values are double precision and must always be positive. The double precision representation is with the least significant byte first (lower address) just like memory addresses in the 6502. Furthermore all coordinate values must be in the proper range. This means that $0 \leq X \leq 319$ and $0 \leq Y \leq 199$ (decimal numbers). Although Y never exceeds one byte in size, consistency and future compatibility with even higher resolution displays requires that Y be double precision also. Since both X and Y are positive, all coordinates are in the first quadrant.

Out of range coordinates can cause random storing anywhere in KIM memory. A verification routine is included that can be used in the checkout of an application program to prevent erroneous coordinate values and subsequent program destruction. A call to CKCRD1 will verify and correct if necessary X1CORD and Y1CORD. A call to CKCRD2 will check and correct X2CORD and Y2CORD. Correction, if necessary, is accomplished by subtracting the maximum allowable value of a coordinate until an in range result is obtained. The check routines do not alter any of the registers thus allowing calls to them to be inserted amywhere without problems.

If the text display routine is used, the text margins (TMAR, BMAR, LMAR, and RMAR) must be defined. Text may be written up to <u>and</u> <u>including</u> the margins but will not be written outside of the margins. By suitable manipulation of the margins, multiple, independent blocks of text may be displayed and manipulated on the screen simultaneously. Note that no checking for validity of the margins is performed. TMAR must be greater than BMAR and RMAR must be greater than LMAR. Further, the difference between the margins must be large enough to fit at least 1 line of 2 characters between them.

## USE OF THE GRAPHIC POINT PLOT ROUTINES

All of the point oriented routines work with the point defined by X1CORD,Y1CORD. All of the routines preserve the X and Y index registers and do not change either pair of coordinates. The term "pixel" is used frequently. Pixel is a contracted form of "picture element" which is simply a dot on the display or a bit in the Visible Memory. The routines available are as follows:

- STPIX - Sets the pixel at X1CORD,Y1CORD to a one (white dot)
- CLPIX - Clears the pixel at X1CORD,Y1CORD to zero (black dot)
- FLPIX - Changes the state of the pixel at X1CORD,Y1CORD from black to white or white to black
- WRPIX - Stores bit 0 of the accumulator into the pixel at X1CORD, Y1CORD
- RDPIX - Copies the state of the pixel at X1CORD,Y1CORD into all bits of the accumulator

Proper use of these routines should be self explanatory. For examples, see the Swirl demonstration program listing or some of the higher level routines (such as DRAW) in this package.

An internal subroutine frequently used by other routines in this package is PIXADR. Its purpose is to convert an X,Y coordinate into a VM memory address and a bit number. When called, X1CORD,Y1CORD is converted into an address. The address is stored in ADP1 and the bit number is stored in BTPT. Note that for the purpose of this routine that bit 0 is <u>leftmost</u> in a byte. Either of the indirect addressing modes on the 6502 may then be used to access the designated VM byte and the normal logical AND and OR instructions may be used to select the indicated bit. Mask tables MSKT1 and MSKT2 can be conveniently used as bit selection masks when indexed by the contents of BTPT.

## USE OF THE LINE DRAWING ROUTINE

The line drawing routine is very similar to the point plotting routines. Basically a line is drawn from the point defined by X1CORD,Y1CORD to the point defined by X2CORD,Y2CORD. The line may be any length and at any angle and the routine will determine the best possible series of pixels to turn on between the endpoints. An iterative algorithm that requires no multiplications or divisons is utilized. The index registers are preserved but X1CORD is set equal to X2CORD and Y1CORD is set equal to Y2CORD before the routine returns. If the two sets of coordinates are already equal, the line becomes a single point.

ERASE is exactly like DRAW except that a black line is drawn between the endpoints. ERASE may be used to selectively erase a line that was previously drawn without having to clear the entire screen and regenerate the image. Note however that if a line that crosses other lines is erased a small gap will be left in the lines that it crossed.

## USE OF THE CHARACTER DRAWING ROUTINES

DCHAR can be used to draw an ASCII character anywhere on the screen. X1CORD,Y1CORD determines where the character is drawn by specifying the location of the upper left corner of the character. The ASCII code of the character should be in the accumulator when DCHAR is called. The full 96 character set is supported and standard lower case shapes with descenders are used for lower case characters. ASCII control codes are completely ignored. The normal character baseline is 7 pixels below Y1CORD but lower case characters with descenders go as far down as 9 pixels. In any case, a 5 wide by 9 high rectangle is cleared and then a character is drawn into the space. The index registers and coordinates are preserved.

DTEXT is a more sophisticated text display routine than SDTXT. Major differences are a cursor that works in terms of X and Y graphic coordinates, user defined margins for the text, and the ability to display superscripts and subscripts. A virtual "page" is defined by the margins. The ASCII FF control character for example only clears the display area defined by the margins. Vertical scrolling triggered by LF only scrolls between the margins. Control codes are defined for cursor movement by whole lines and characters in 4 directions or the user may directly position the cursor using the same technique as described for SDTXT. SI and SO control characters effect a 3 pixel baseline shift up and down respectively for super and subscripts.

DTEXT is called just like SDTXT. X1CORD and Y1CORD define the cursor location. These may be conveniently initialized to the upper left corner of the virtual page by giving an ASCII FF character to DTEXT before outputting any text. The cursor is then automatically moved when characters are displayed. DTXTIN is a convenience routine that sets the margins for full screen operation, clears the screen and sets the cursor to the opper left corner. With a full screen, DTEXT can display 18 lines of 53 characters. More details on the use of DTEXT are found in the program listings.

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                        .PAGE  'DOCUMENTATION, EQUATES, STORAGE'
               ;        SWIRL DRAWING DEMONSTRATION FOR THE MICRO TECHNOLOGY UNLIMITED
               ;        VISIBLE MEMORY 320 BY 200 PIXEL DISPLAY

               ;        ENTER AT SWIRL WITH LINES, FREQ, AND DAMP SET TO APPROPRIATE
               ;        VALUES TO GENERATE AN SWIRLING DISPLAY. INTERRUPT WITH RESET
               ;        KEY WHEN PATTERN IS COMPLETED TO DESIRED EXTENT.

               ;        ENTER AT RSWIRL FOR AN ENDLESS SERIES OF PATTERNS USING
               ;        RANDOMLY SELECTED PARAMETERS.

               ;        GENERAL EQUATES

1C22           KIMMON   =      X'1C22       ; RESET ENTRY INTO KIM MONITOR
0140           NX       =      320          ; NUMBER OF BITS IN A ROW
00C8           NY       =      200          ; NUMBER OF ROWS (CHANGE FOR HALF SCREEN
                                            ; OPERATION)
FA00           NPIX     =      NX*NY        ; NUMBER OF PIXELS

0000                    .=     0            ; START PROGRAM AT ZERO

               ;        STORAGE FOR SWIRL GENERATOR PROGRAM

0000 01        LINES:   .BYTE  1            ; CONNECTING LINES IF NON-ZERO
0001 127E      FREQ:    .WORD  X'7E12       ; FREQUENCY
0003 007E      DAMP:    .WORD  X'7E00       ; 1-(DAMPING FACTOR)
0005 0078      COSINT:  .WORD  X'7800       ; INITIAL COSINE VALUE
                                            ; GOOD VALUE FOR GENERAL USE BUT SHOULD BE
                                            ; REDUCED TO X'70 TO PREVENT OVERFLOW WITH
                                            ; RANDOMLY SELECTED PARAMETERS
0007           COS:     .=.+   2            ; COSINE VALUE
0009           SIN:     .=.+   2            ; SINE VALUE

               ;        GENERAL STORAGE

000B 20        VMORG:   .BYTE  X'20         ; PAGE NUMBER OF FIRST VISIBLE MEMORY
                                            ; LOCATION
000C 3412      RANDNO:  .WORD  X'1234       ; INITIAL RANDON NUMBER, MUST NOT BE ZERO
000E           ADP1:    .=.+   2            ; ADDRESS POINTER 1
0010           ADP2:    .=.+   2            ; ADDRESS POINTER 2
0012           BTPT:    .=.+   1            ; BIT NUMBER
0013           X1CORD:  .=.+   2            ; COORDINATE PAIR 1
0015           Y1CORD:  .=.+   2
0017           X2CORD:  .=.+   2            ; COORDINATE PAIR 2
0019           Y2CORD:  .=.+   2

               ;        STORAGE FOR ARBITRARY LINE DRAW ROUTINE

001B           DELTAX:  .=.+   2            ; DELTA X
001D           DELTAY:  .=.+   2            ; DELTA Y
001F           ACC:     .=.+   2            ; ACCUMULATOR
0021           XDIR:    .=.+   1            ; X MOVEMENT DIRECTION, ZERO=+
0022           YDIR:    .=.+   1            ; Y MOVEMENT DIRECTION, ZERO=+
0023           XCHFLG:  .=.+   1            ; EXCHANGE X AND Y FLAG, EXCHANGE IF NOT 0
0024           COLOR:   .=.+   1            ; COLOR OF LINE DRAWN -1=WHITE
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0025           TEMP:    .=.+   2            ; TEMPORARY STORAGE

               ;        STORAGE FOR THE ARITHMETIC SUBROUTINES

0027           PROD:    .=.+   4            ; PRODUCT FOR ARITHMETIC ROUTINES
002B           MPCD:    .=.+   2            ; MUPTIPLICAND FOR ARITHMETIC
002D           MPLR     =      PROD         ; MULTIPLIER FOR ARITHMETIC ROUTINES
002D           MPSAVE:  .=.+   2            ; TEMPORARY STORAGE FOR MULTIPLY
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                          .PAGE  'MAIN SWIRL GENERATION ROUTINE'
                 ;        SWIRL ROUTINE FOR STRAIGHT LINES CONNECTING THE POINTS
 002F 208D00    SWIRL:   JSR    SWINIT       ; INITIALIZE COS AND SIN
 0032 20A500    SWIRL1:  JSR    SCALE        ; SCALE SIN AND COS FOR DISPLAY
 0035 A500               LDA    LINES        ; TEST IF LINES BETWEEN POINTS DESIRED
 0037 D003               BNE    SWIRL2       ; SKIP IF SO
 0039 205D01             JSR    C2TOC1       ; IF NOT, SET LINE LENGTH TO ZERO
 003C 202202    SWIRL2:  JSR    DRAW         ; DRAW THE LINE OR POINT
 003F 200001             JSR    POINT        ; COMPUTE THE NEXT POINT
 0042 4C3200             JMP    SWIRL1
                 ;        SWIRL ROUTINE WITH RANDOM PARAMETERS
 0045 208D00    RSWIRL:  JSR    SWINIT       ; INITIALIZE COS AND SIN
 0048 209503    RSWR1:   JSR    RAND         ; INITIALIZE FREQ RANDOMLY WITH UNIFORM
 004B 8501               STA    FREQ         ; DISTRIBUTION
 004D 209503             JSR    RAND
 0050 8502               STA    FREQ+1
 0052 20B103             JSR    RNDEXP       ; INITIALIZE DAMP RANDOMLY WITH A NEGATIVE
 0055 4A                 LSRA                ; EXPONENTIAL DISTRIBUTION
 0056 497F               EOR    #X'7F        ; IN THE UPPER BYTE AND UNIFORM
 0058 8504               STA    DAMP+1       ; DISTRIBUTION IN THE LOWER BYTE
 005A 209503             JSR    RAND
 005D 8503               STA    DAMP
 005F 209503             JSR    RAND         ; RANDOMLY DETERMINE PRESENCE OF
 0062 2901               AND    #1           ; CONNECTING LINES
 0064 8500               STA    LINES
 0066 20CB03             JSR    RANGCK       ; VERIFY ACCEPTABLE RANGES OF PARAMETERS
 0069 B0DD               BCS    RSWR1        ; TRY AGAIN IF NOT ACCEPTABLE
 006B 20A500    RSWR2:   JSR    SCALE        ; SCALE THE CURRENT POINT FOR PLOTTING
 006E A500               LDA    LINES        ; TEST IF CONNECTING LINES SPECIFIED
 0070 D003               BNE    RSWR3        ; SKIP AHEAD IF SO
 0072 205D01             JSR    C2TOC1       ; IF NOT, SET ZERO LINE LENGTH
 0075 202202    RSWR3:   JSR    DRAW         ; ORAW A LINE FROM THE LAST POINT PLOTTED
 0078 200001             JSR    POINT        ; COMPUTE THE NEXT POINT
 007B A50A      RSWR4:   LDA    SIN+1        ; TEST IF PATTERN HAS DECAYED TO NEARLY
 007D F004               BEQ    RSWR5        ; ZERO
 007F C9FF               CMP    #X'FF
 0081 D0E8               BNE    RSWR2
 0083 A508      RSWR5:   LDA    COS+1
 0085 F0BE               BEQ    RSWIRL       ; GO START A NEW PATTERN IF SO
 0087 C9FF               CMP    #X'FF
 0089 F0BA               BEQ    RSWIRL
 008B D0DE               BNE    RSWR2        ; GO COMPUTE NEXT POINT IF NOT
                 ;        SWINIT - INITIALIZE COS FROM COSINT, ZERO SIN, CLEAR SCREEN
 008D A505      SWINIT:  LDA    COSINT       ; INITIALIZE COS
 008F 8507               STA    COS
 0091 A506               LDA    COSINT+1
 0093 8508               STA    COS+1
 0095 A900               LDA    #0           ; ZERO SIN
 0097 8509               STA    SIN
 0099 850A               STA    SIN+1
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009B 200002             JSR    CLEAR         ; CLEAR THE VM SCREEN
009E 20A500             JSR    SCALE         ; SCALE THE INITIAL POINT AND PUT INTO
00A1 205D01             JSR    C2TOC1        ; IN BOTH SETS OF COORDINATES
00A4 60                 RTS                  ; RETURN

               ;        SCALE - TAKE VALUE OF SIN, SCALE ACCORDING TO NX, AND PUT INTO
               ;        X2CORD. THEN TAKE VALUE OF COS, SCALE ACCORDING TO NY, AND
               ;        PUT INTO Y2CORD.
               ;        SIN AND COS ARE ASSUMED TO BE DOUBLE LENGTH BINARY FRACTIONS
               ;        BETWEEN -1 AND +1.

00A5 A507      SCALE:   LDA    COS           ; X2CORD=NX/2*SIN4NX/2
00A7 852B               STA    MPCD          ; TRANSFER SIN TO MULTIPLICAND
00A9 A508               LDA    COS+1         ; (BINARY FRACTION)
00AB 852C               STA    MPCD+1
00AD A9A0               LDA    #NX/2&X'FF    ; TRANSFER NX/2 TO MULTIPLIER
00AF 8527               STA    MPLR          ; (INTEGER)
00B1 A900               LDA    #NX/2/256
00B3 8528               STA    MPLR+1
00B5 202B03             JSR    SGNMPY        ; PERFORM A SIGNED MULTIPLICATION
00B8 208B03             JSR    SLQL
00BB A529               LDA    PROD+2        ; SIGNED INTEGER RESULT IN PROD+2 (LOW)
00BD 18                 CLC                  ; AND PROD+3 (HIGH)
00BE 69A0               ADC    #NX/2&X'FF    ; ADD NX/2 TO PRODUCT AND PUT INTO X2CORD
00C0 8517               STA    X2CORD
00C2 A52A               LDA    PROD+3
00C4 6900               ADC    #NX/2/256
00C6 8518               STA    X2CORD+1

00C8 A509               LDA    SIN           ; Y2CORD=NY/2*COS+NX/2
00CA 852B               STA    MPCD          ; TRANSFER COS TO MULTIPLICAND
00CC A50A               LDA    SIN+1         ; (BINARY FRACTION)
00CE 852C               STA    MPCD+1
00D0 A964               LDA    #NY/2&X'FF    ; TRANSFER NY/2 TO MULTIPLIER
00D2 8527               STA    MPLR          ; (INTEGER)
00D4 A900               LDA    #NY/2/256
00D6 8528               STA    MPLR+1
00D8 202B03             JSR    SGNMPY        ; PERFORM A SIGNED MULTIPLICATION
00DB 208B03             JSR    SLQL
00DE A529               LDA    PROD+2        ; SIGNED INTEGER RESULT IN PROD+2 (LOW)
00E0 18                 CLC                  ; AND PROD+3 (HIGH)
00E1 6964               ADC    #NY/2&X'FF    ; ADD NY/2 TO PRODUCT AND PUT INTO Y2CORD
00E3 8519               STA    Y2CORD
00E5 A52A               LDA    PROD+3
00E7 6900               ADC    #NY/2/256
00E9 851A               STA    Y2CORD+1
00EB 60                 RTS                  ; RETURN
```

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                           .PAGE  'POINT - COMPUTE NEXT POINT'
                  ;        POINT - COMPUTE NEXT VALUE OF COS,SIN FROM CURRENT VALUE OF
                  ;        COS,SIN ACCORDING TO FREQ AND DAMP. DIFFERENCE EQUATION FOR
                  ;        AN ELIPSE IS USED

    00EC                   .=     X'100

    0100 A509     POINT:   LDA    SIN           ; FIRST COMPUTE DAMP*SIN AND PUT INTO SIN
    0102 852B              STA    MPCD
    0104 A50A              LDA    SIN+1
    0106 852C              STA    MPCD+1
    0108 A503              LDA    DAMP
    010A 8527              STA    MPLR
    010C A504              LDA    DAMP+1
    010E 8528              STA    MPLR+1
    0110 202B03            JSR    SGNMPY
    0113 208B03            JSR    SLQL          ; SHIFT PRODUCT LEFT ONE FOR FRACTIONAL
    0116 A529              LDA    PROD+2        ; RESULT
    0118 8509              STA    SIN           ; AND PUT BACK INTO SIN
    011A A52A              LDA    PROD+3
    011C 850A              STA    SIN+1

    011E A507              LDA    COS           ; NEXT COMPUTE COS*FREQ
    0120 8527              STA    MPLR
    0122 A508              LDA    COS+1
    0124 8528              STA    MPLR+1
    0126 A501              LDA    FREQ
    0128 852B              STA    MPCD
    012A A502              LDA    FREQ+1
    012C 852C              STA    MPCD+1
    012E 202B03            JSR    SGNMPY
    0131 208B03            JSR    SLQL
    0134 A509              LDA    SIN           ; ADD RESULT TO SIN AND PUT SUM BACK INTO
    0136 18                CLC                  ; SIN
    0137 6529              ADC    PROD+2
    0139 8509              STA    SIN
    013B A50A              LDA    SIN+1
    013D 652A              ADC    PROD+3
    013F 850A              STA    SIN+1

    0141 A509              LDA    SIN           ; NEXT COMPUTE FREQ*SIN
    0143 8527              STA    MPLR
    0145 A50A              LDA    SIN+1
    0147 8528              STA    MPLR+1        ; FREQ ALREADY IN MPCD
    0149 202B03            JSR    SGNMPY
    014C 208B03            JSR    SLQL

    014F A507              LDA    COS           ; SUBSTRACT RESULT FROM COS AND PUT RESULT
    0151 38                SEC                  ; IN COS
    0152 E529              SBC    PROD+2
    0154 8507              STA    COS
    0156 A508              LDA    COS+1
    0158 E52A              SBC    PROD+3
    015A 8508              STA    COS+1
    015C 60                RTS                  ; RETURN
```

```

                   ;        SUBROUTINE TO MOVE THE CONTENTS OF COORDINATE PAIR 2 TO
                   ;        COORDINATE PAIR 1.

0156D A517      C2TOC1:  LDA    X2CORD       ; DO THE MOVING
015F 8513               STA    X1CORD
0161 A518               LDA    X2CORD+1
0163 8514               STA    X1CORD+1
0165 A519               LDA    Y2CORD
0167 8515               STA    Y1CORD
0169 A51A               LDA    Y2CORD+1
016B 8516               STA    Y1CORD+1
016D 60                 RTS                  ; RETURN

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                          .PAGE  'ABBREVIATED GRAPHICS ROUTINES'
                 ;        PIXADR - FIND THE BYTE ADDRESS AND BIT NUMBER OF PIXEL AT
                 ;                 X1CORD, Y1CORD
                 ;        PUTS BYTE ADDRESS IN ADP1 AND BIT NUMBER (BIT 0 IS LEFTMOST)
                 ;        IN BTPT.
                 ;        DOES NOT CHECK MAGNITUDE OF COORDINATES FOR MAXIMUM SPEED
                 ;        PRESERVES X AND Y REGISTERS, DESTROYS A
                 ;        BYTE ADDRESS = VMORG*256+(199-Y1CORD)*40+INT(XCORD/8)
                 ;        BIT ADDRESS = REM(XCORD/8)
                 ;        OPTIMIZED FOR SPEED THEREFORE CALLS TO A DOUBLE SHIFT ROUTINE
                 ;        ARE NOT DONE
016E A513        PIXADR:  LDA    X1CORD       ; COMPUTE BIT ADDRESS FIRST
0170 850E                 STA    ADP1         ; ALSO TRANSFER X1CORD TO ADP1
0172 2907                 AND    #X'07        ; WHICH IS SIMPLY THE LOW 3 BITS OF X
0174 8512                 STA    BTPT
0176 A514                 LDA    X1CORD+1     ; FINISH TRANSFERRING X1CORD TO ADP1
0178 850F                 STA    ADP1+1
017A 460F                 LSR    ADP1+1       ; DOUBLE SHIFT ADP1 RIGHT 3 TO GET
017C 660E                 ROR    ADP1         ; INT(XCORD/8)
017E 460F                 LSR    ADP1+1
0180 660E                 ROR    ADP1
0182 460F                 LSR    ADP1+1
0184 660E                 ROR    ADP1
0186 A9C7                 LDA    #199         ; TRANSFER (199-Y1CORD) TO ADP2
0188 38                   SEC                 ; AND TEMPORARY STORAGE
0189 E515                 SBC    Y1CORD
018B 8510                 STA    ADP2
018D 8525                 STA    TEMP
018F A900                 LDA    #0
0191 E516                 SBC    Y1CORD+1
0193 8511                 STA    ADP2+1
0195 8526                 STA    TEMP+1
0197 0610                 ASL    ADP2         ; COMPUTE 40*(199-Y1CORD)
0199 2611                 ROL    ADP2+1       ;  2*(199-Y1CORD)
019B 0610                 ASL    ADP2
019D 2611                 ROL    ADP2+1       ;  4*(199+Y1CORD)
019F A510                 LDA    ADP2         ;  ADD IN TEMPORARY SAVE OF (199-Y1CORD)
01A1 18                   CLC                 ;  TO MAKE 5*(199-Y1CORD)
01A2 6525                 ADC    TEMP
01A4 8510                 STA    ADP2
01A6 A511                 LDA    ADP2+1
01A8 6526                 ADC    TEMP+1
01AA 8511                 STA    ADP2+1       ;  5*(199-Y1CORD)
01AC 0610                 ASL    ADP2         ;  10*(199-Y1CORD)
01AE 2611                 ROL    ADP2+1
01B0 0610                 ASL    ADP2         ;  20*(199-Y1CORD)
01B2 2611                 ROL    ADP2+1
01B4 0610                 ASL    ADP2         ;  40*(199-Y1CORD)
01B6 2611                 ROL    ADP2+1
01B8 A510                 LDA    ADP2         ; ADD IN INT(X1CORD/8) COMPUTED EARLIER
01BA 18                   CLC
01BB 650E                 ADC    ADP1
01BD 850E                 STA    ADP1
01BF A511                 LDA    ADP2+1
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01C1 650F                ADC    ADP1+1
01C3 650B                ADC    VMORG         ; ADD IN VMORG*256
01C5 850F                STA    ADP1+1        ; FINAL RESULT
01C7 60                  RTS                  ; RETURN
               ;         STPIX - SETS THE PIXEL AT X1CORD,Y1CORD TO A ONE (WHITE DOT)
               ;         DOES NOT ALTER X1CORD OR Y1CORD
               ;         PRESERVES X AND Y
               ;         ASSUMES IN RANGE CORRDINATES
01C8 206E01    STPIX:    JSR    PIXADR        ; GET BYTE ADDRESS AND BIT NUMBER OF PIXEL
                                              ; INTO ADP1
01CB 98                  TYA                  ; SAVE Y
01CC 48                  PHA
01CD A412                LDY    BTPT          ; GET BIT NUMBER IN Y
01CF B91A02              LDA    MSKTB1,Y      ; GET A BYTE WITH THAT BIT =1, OTHERS =0
01D2 A000                LDY    #0            ; ZERO Y
01D4 110E                ORA    (ADP1),Y      ; COMBINE THE BIT WITH THE ADDRESSED VM
01D6 910E                STA    (ADP1),Y      ; BYTE
01D8 68                  PLA                  ; RESTORE Y
01D9 A8                  TAY
01DA 60                  RTS                  ; AND RETURN
01DB                     .=     X'200
               ;         CLEAR DISPLAY MEMORY ROUTINE
0200 A000      CLEAR:    LDY    #0            ; INITIALIZE ADDRESS POINTER
0202 840E                STY    ADP1          ; AND ZERO INDEX Y
0204 A50B                LDA    VMORG
0206 850F                STA    ADP1+1
0208 18                  CLC
0209 6920                ADC    #X'20
020B AA                  TAX
020C 98        CLEAR1:   TYA                  ; CLEAR A BYTE
020D 910E                STA    (ADP1),Y
020F E60E                INC    ADP1          ; INCREMENT ADDRESS POINTER
0211 D0F9                BNE    CLEAR1
0213 E60F                INC    ADP1+1
0215 E40F                CPX    ADP1+1        ; TEST IF DONE
0217 D0F3                BNE    CLEAR1
0219 60                  RTS                  ; RETURN
               ;         MASK TABLES FOR INDIVIDUAL PIXEL SUBROUTINES
               ;         MSKTB1 IS A TABLE OF 1 BITS CORRESPONDING TO BIT NUMBERS
021A 80402010  MSKTB1:   .BYTE  X'80,X'40,X' 20,X'10
021E 08040201            .BYTE  X'08,X'04,X' 02,X'01
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                           .PAGE  'LINE DRAWING ROUTINES'
                 ;         DRAW - DRAW THE BEST STRAIGHT LINE FROM X1CORD,Y1CORD TO
                 ;         X2CORD, Y2CORD.
                 ;         X2CORD,Y2CORD COPIED TO X1CORD,Y1CORD AFTER DRAWING
                 ;         PRESERVES X AND Y
                 ;         USES AN ALGORITHM THAT REQUIRES NO MULTIPLICATION OR DIVISON
    0222 8A      DRAW:     TXA                 ; SAVE X AND Y
    0223 48                PHA
    0224 98                TYA
    0225 48                PHA
                 ;         COMPUTE SIGN AND MAGNITUDE OF DELTA X = X2-X1
                 ;         PUT MAGNITUDE IN DELTAX AND SIGN IN XDIR
    0226 A900              LDA    #0           ; FIRST ZERO XDIR
    0228 8521              STA    XDIR
    022A A517              LDA    X2CORD       ; NEXT COMPUTE TWOS COMPLEMENT DIFFERENCE
    022C 38                SEC
    022D E513              SBC    X1CORD
    022F 851B              STA    DELTAX
    0231 A518              LDA    X2CORD+1
    0233 E514              SBC    X1CORD+1
    0235 851C              STA    DELTAX+1
    0237 100F              BPL    DRAW2        ; SKIP AHEAD IF DIFFERENCE IS POSITIVE
    0239 C621              DEC    XDIR         ; SET XDIR TO -1
    023B 38                SEC                 ; NEGATE DELTAX
    023C A900              LDA    #0
    023E E51B              SBC    DELTAX
    0240 851B              STA    DELTAX
    0242 A900              LDA    #0
    0244 E51C              SBC    DELTAX+1
    0246 851C              STA    DELTAX+1
                 ;         COMPUTE SIGN AND MAGNITUDE OF DELTA Y = Y2-Y1
                 ;         PUT MAGNITUDE IN DELTAY AND SIGN IN YDIR
    0248 A900    DRAW2:    LDA    #0           ; FIRST ZERO YDIR
    024A 8522              STA    YDIR
    024C A519              LDA    Y2CORD       ; NEXT COMPUTE TWOS COMPLEMENT DIFFERENCE
    024E 38                SEC
    024F E515              SBC    Y1CORD
    0251 851D              STA    DELTAY
    0253 A51A              LDA    Y2CORD+1
    0255 E516              SBC    Y1CORD+1
    0257 851E              STA    DELTAY+1
    0259 100F              BPL    DRAW3        ; SKIP AHEAD IF DIFFERENCE IS POSITIVE
    025B C622              DEC    YDIR         ; SET YDIR TO -1
    025D 38                SEC                 ; NEGATE DELTAX
    025E A900              LDA    #0
    0260 E51D              SBC    DELTAY
    0262 851D              STA    DELTAY
    0264 A900              LDA    #0
    0266 E51E              SBC    DELTAY+1
    0268 851E              STA    DELTAY+1
```

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                ;       DETERMINE IF DELTAY IS LARGER-THAN DELTAX
                ;       IF SO, EXCHANGE DELTAY AND DELTAX AND SET XCHFLG NONZERO
                ;       ALSO INITIALIZE ACC TO DELTAX
                ;       PUT A DOT AT THE INITIAL ENDPOINT
026A A900      DRAW3:  LDA    #0            ; FIRST ZERO XCHFLG
026C 8523              STA    XCHFLG
026E A51D              LDA    DELTAY        ; COMPARE DELTAY WITH DELTAX
0270 38                SEC
0271 E51B              SBC    DELTAX
0273 A51E              LDA    DELTAY+1
0275 E51C              SBC    DELTAX+1
0277 9012              BCC    DRAW4         ; SKIP EXCHANGE IF DELTAX IS GREATER THAN
                                            ; DELTAY
0279 A61D              LDX    DELTAY        ; EXCHANGE DELTAX AND DELTAY
027B A51B              LDA    DELTAX
027D 851D              STA    DELTAY
027F 861B              STX    DELTAX
0281 A61E              LDX    DELTAY+1
0283 A51C              LDA    DELTAX+1
0285 851E              STA    DELTAY+1
0287 861C              STX    DELTAX+1
0289 C623              DEC    XCHFLG        ; SET XCHFLG TO -1
028B A51B      DRAW4:  LDA    DELTAX        ; INITIALIZE ACC TO DELTAX
028D 851F              STA    ACC
028F A51C              LDA    DELTAX+1
0291 8520              STA    ACC+1
0293 20C801            JSR    STPIX         ; PUT A DOT AT THE INITIAL ENDPOINT;
                                            ; X1CORD, Y1CORD

                ;       HEAD OF MAIN DRAWING LOOP
                ;       TEST IF DONE

0296 A523      DRAW45: LDA    XCHFLG        ; TEST IF X AND Y EXCHANGED
0298 D00E              BNE    DRAW5         ; JUMP AHEAD IF SO
029A A513              LDA    X1CORD        ; TEST FOR X1CORD=X2CORD
029C C517              CMP    X2CORD
029E D019              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
02A0 A514              LDA    X1CORD+1
02A2 C518              CMP    X2CORD+1
02A4 D013              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
02A6 F00C              BEQ    DRAW6         ; GO RETURN IF SO
02A8 A515      DRAW5:  LDA    Y1CORD        ; TEST FOR Y1CORD=Y2CORD
02AA C519              CMP    Y2CORD
02AC D00B              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
02AE A516              LDA    Y1CORD+1
02B0 C51A              CMP    Y2CORD+1
02B2 D005              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
02B4 68        DRAW6:  PLA                  ; RESTORE INDEX REGISTERS
02B5 A8                TAY
02B6 68                PLA
02B7 AA                TAX
02B8 60                RTS                  ; AND RETURN
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```
                   ;         DO A CLACULATION TO DETERMINE IF ONE OR BOTH AXES ARE TO BE
                   ;         BUMPED (INCREMENTED OR DECREMENTED ACCORDING TO XDIR AND YDIR)
                   ;         AND DO THE BUMPING
02B9 A523      DRAW7:    LDA    XCHFLG       ; TEST IF X AND Y EXCHANGED
02BB D006                BNE    DRAW8        ; JUMP IF SO
02BD 200303              JSR    BMPX         ; BUMP X IF NOT
02C0 4CC602              JMP    DRAW9
02C3 201703    DRAW8:    JSR    BMPY         ; BUMP Y IF SO
02C6 20E702    DRAW9:    JSR    SBDY         ; SUBSTRACT DY FROM ACC TWICE
02C9 20E702              JSR    SBDY
02CC 1013                BPL    DRAW12       ; SKIP AHEAD IF ACC IS NOT NEGATIVE
02CE A523                LDA    XCHFLG       ; TEST IF X AND Y EXCHANGED
02D0 D006                BNE    DRAW10       ; JUMP IF SO
02D2 201703              JSR    BMPY         ; BUMP Y IF NOT
02D5 4CDB02              JMP    DRAW11
02D8 200303    DRAW10:   JSR    BMPX         ; BUMP X IF SO
02DB 20F502    DRAW11:   JSR    ADDX         ; ADD DX TO ACC TWICE
02DE 20F502              JSR    ADDX
02E1 20C801    DRAW12:   JSR    STPIX        ; OUTPUT THE NEW POINT
02E4 4C9602              JMP    DRAW45       ; GO TEST IF DONE
                   ;         SUBROUTINES FOR DRAW
02E7 A51F      SBDY:     LDA    ACC          ; SUBSTRACT DELTAY FROM ACC AND PUT RESULT
02E9 38                  SEC                 ; IN ACC
02EA E51D                SBC    DELTAY
02EC 851F                STA    ACC
02EE A520                LDA    ACC+1
02F0 E51E                SBC    DELTAY+1
02F2 8520                STA    ACC+1
02F4 60                  RTS
02F5 A51F      ADDX:     LDA    ACC          ; ADD DELTAX TO ACC AND PUT RESULT IN ACC
02F7 18                  CLC
02F8 651B                ADC    DELTAX
02FA 851F                STA    ACC
02FC A520                LDA    ACC+1
02FE 651C                ADC    DELTAX+1
0300 8520                STA    ACC+1
0302 60                  RTS
0303 A521      BMPX:     LDA    XDIR         ; BUMP X1CORD BY +1 OR -1 ACCORDING TO
0305 D007                BNE    BMPX2        ; XDIR
0307 E613                INC    X1CORD       ; DOUBLE INCREMENT X1CORD IF XDIR=0
0309 D002                BNE    BMPX1
030B E614                INC    X1CORD+1
030D 60        BMPX1:    RTS
030E A513      BMPX2:    LDA    X1CORD       ; DOUBLE DECREMENT X1CORD IF XDIR<>0
0310 D002                BNE    BMPX3
0312 C614                DEC    X1CORD+1
0314 C613      BMPX3:    DEC    X1CORD
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0316 60                 RTS
0317 A522      BMPY:    LDA    YDIR          ; BUMP Y1CORD BY +1 OR -1 ACCORDING TO
0319 D007               BNE    BMPY2         ; YDIR
031B E615               INC    Y1CORD        ; DOUBLE INCREMENT Y1CORD IF YDIR=0
031D D002               BNE    BMPY1
031F E616               INC    Y1CORD+1
0321 60        BMPY1:   RTS
0322 A515      BMPY2:   LDA    Y1CORD        ; DOUBLE DECREMENT Y1CORD IF YDIR<>0
0324 D002               BNE    BMPY3
0326 C616               DEC    Y1CORD+1
0328 C615      BMPY3:   DEC    Y1CORD
032A 60                 RTS
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                             .PAGE  'MULTIPLY, SHIFT, AND RANDOM NUMBER ROUTINES'
                    ;        SIGNED MULTIPLY SUBROUTINE
                    ;        ENTER WITH SIGNED MULTIPLIER IN PROD AND PROD+1
                    ;        ENTER WITH SIGNED MULTIPLICAND IN MPCD AND MPCD+1
                    ;        RETURN WITH 16 BIT SIGNED PRODUCT IN PROD (LOW) THROUGH
                    ;        PROD+3 (HIGH)
                    ;        A DESTROYED, X AND Y PRESERVED

 032B A527          SGNMPY:  LDA    PROD          ; GET MULTIPLIER
 032D 852D                   STA    MPSAVE        ; AND SAVE IT
 032F A528                   LDA    PROD+1
 0331 852E                   STA    MPSAVE+1
 0333 205903                 JSR    UNSMPY        ; DO AN UNSIGNED MULTIPLY
 0336 A52C                   LDA    MPCD+1        ; TEST SIGN OF MULTIPLICAND
 0338 100D                   BPL    SGNMP1        ; JUMP IF POSITIVE
 033A A529                   LDA    PROD+2        ; SUBTRACT MULTIPLIER FROM HIGH PRODUCT IF
 033C 38                     SEC                  ; NEGATIVE
 033D E52D                   SBC    MPSAVE
 033F 8529                   STA    PROD+2
 0341 A52A                   LDA    PROD+3
 0343 E52E                   SBC    MPSAVE+1
 0345 852A                   STA    PROD+3
 0347 A52E          SGNMP1:  LDA    MPSAVE+1      ; TEST SIGN OF MULTIPLIER
 0349 100D                   BPL    SGNMP2        ; GO RETURN IF POSITIVE
 034B A529                   LDA    PROD+2        ; SUBTRACT MULTIPLICAND FROM HIGH PRODUCT
 034D 38                     SEC                  ; IF NEGATIVE
 034E E52B                   SBC    MPCD
 0350 8529                   STA    PROD+2
 0352 A52A                   LDA    PROD+3
 0354 E52C                   SBC    MPCD+1
 0356 852A                   STA    PROD+3
 0358 60            SGNMP2:  RTS                  ; RETURN

                    ;        16 X 16 UNSIGNED MULTIPLY SUBROUTINE
                    ;        ENTER WITH UNSIGNED MULTIPLIER IN PROD AND PROD+1
                    ;        ENTER WITH UNSIGNED MULTIPLICAND IN MPCD AND MPCD+1
                    ;        RETURN WITH 16 BIT UNSIGNED PRODUCT IN PROD (LOW) THROUGH
                    ;        PROD+3 (HIGH)
                    ;        A DESTROYED, X AND Y PRESERVED

 0359 8A            UNSMPY:  TXA                  ; SAVE X INDEX
 035A 48                     PHA
 035B A900                   LDA    #0            ; CLEAR UPPER PRODUCT
 035D 852A                   STA    PROD+3
 035F 8529                   STA    PROD+2
 0361 A211                   LDX    #17           ; SET 17 MULTIPLY CYCLE COUNT
 0363 18                     CLC                  ; INITIALLY CLEAR CARRY
 0364 208203        UNSM1:   JSR    SRQL          ; SHIFT MULTIPLIER AND PRODUCT RIGHT 1
                                                  ; PUTTING A MULTIPLIER BIT IN CARRY
 0367 CA                     DEX                  ; DECREMENT AND CHECK CYCLE COUNT
 0368 F012                   BEQ    UNSM2         ; JUMP OUT IF DONE
 036A 90F8                   BCC    UNSM1         ; SKIP MULTIPLICAND ADD IF MULTIPLIER BIT
                                                  ; IS ZERO
 036C A529                   LDA    PROD+2        ; ADD MULTIPLICAND TO UPPER PRODUCT
 036E 18                     CLC
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036F 652B              ADC    MPCD
0371 8529              STA    PROD+2
0373 A52A              LDA    PROD+3
0375 652C              ADC    MPCD+1
0377 852A              STA    PROD+3
0379 4C6403            JMP    UNSM1         ; GO FOR NEXT CYCLE
037C 68       UNSM2:   PLA                  ; RESTORE X
037D AA                TAX
037E 60                RTS                  ; RETURN

              ;        QUAD SHIFT RIGHT SUBROUTINE
              ;        ENTER AT SRQA FOR ALGEBRAIC SHIFT RIGHT
              ;        ENTER AT SRQL FOR LOGICAL SHIFT
              ;        ENTER WITH QUAD PRECISION VALUE TO SHIFT IN PROD THROUGH PROD+3
              ;        DESTROYS A, PRESERVES X AND Y, RETURNS BIT SHIFTED OUT IN CARRY

037F A52A     SRQA:    LDA    PROD+3        ; GET SIGN BIT OF PROD IN CARRY
0381 0A                ASLA
0382 662A     SRQL:    ROR    PROD+3        ; LOGICAL SHIFT RIGHT ENTRY
0384 6629              ROR    PROD+2
0386 6628              ROR    PROD+1
0388 6627              ROR    PROD
038A 60                RTS                  ; RETURN


              ;        QUAD SHIFT LEFT SUBROUTINE
              ;        ENTER AT SLQL TO SHIFT IN A ZERO BIT
              ;        ENTER AT RLQL TO SHIFT IN THE CARRY
              ;        ENTER WITH QUAD PRECISION VALUE TO SHIFT IN PROD THROUGH PROD+3
              ;        DESTROYS A, PRESERVES X AND Y, RETURNS BIT SHIFTED OUT IN CARRY

038B 18       SLQL:    CLC                  ; SHIFT IN ZERO BIT ENTRY; CLEAR CARRY
038C 2627     RLQL:    ROL    PROD          ; SHIFT IN CARRY ENTRY
038E 2628              ROL    PROD+1
0390 2629              ROL    PROD+2
0392 262A              ROL    PROD+3
0394 60                RTS                  ; RETURN

              ;        RANDOM NUMBER GENERATOR SUBROUTINE
              ;        ENTER WITH SEED IN RANDNO
              ;        EXIT WITH NEW RANDOM NUMBER IN RANDNO AND A
              ;        USES 16 BIT FEEDBACK SHIFT REGISTER METHOD
              ;        DESTROYS REGISTER A AND Y

0395 A008     RAND:    LDY    #8            ; SET COUNTER FOR 8 RANDOM BITS
0397 A50C     RAND1:   LDA    RANDNO        ; EXCLUSIVE-OR BITS 3, 12, 14, AND 15
0399 4A                LSRA                 ; OF SEED
039A 450C              EOR    RANDNO
039C 4A                LSRA
039D 4A                LSRA
039E 450C              EOR    RANDNO
03A0 4A                LSRA
03A1 450D              EOR    RANDNO+1      ; RESULT IS IN BIT 3 OF A
03A3 4A                LSRA                 ; SHIFT INTO CARRY
03A4 4A                LSRA
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03A5 4A                  LSRA
03A6 4A                  LSRA
03A7 260D                ROL    RANDNO+1     ; SHIFT RANDNO LEFT ONE BRINGING IN CARRY
03A9 260C                ROL    RANDNO
03AB 88                  DEY                 ; TEST IF 8 NEW RANDOM BITS COMPUTED
03AC D0E9                BNE    RAND1        ; LOOP FOR MORE IF NOT
03AE A50C                LDA    RANDNO
03B0 60                  RTS                 ; RETURN

              ;          EXPONENTIALLY DISTRIBUTED RANDOM NUMBER SUBROUTINE
              ;          RULES OF USE SAME AS RAND, 8 BIT RESULT RETURNED IN A
              ;          AN EXPONENTIAL DISTRIBUTION MEANS THAT THE PROBABILITY OF A
              ;          RESULT BETWEEN 10 AND 20 IS THE SAME AS THE PROBABILITY OF A
              ;          RESULT BETWEEN 100 AND 200.
              ;          NOTE THAT THE PROBABILITY OF A ZERO RESULT IS ZERO.

03B1 209503   RNDEXP:    JSR    RAND         ; GET TWO NEW RANDOM BYTES
03B4 209503              JSR    RAND
03B7 A50C                LDA    RANDNO       ; CONVERT ONE OF THE BYTES TO A RANDOM
03B9 2907                AND    #7           ; VALUE BETWEEN 0 AND 7 AND PUT IN Y AS A
03BB A8                  TAY                 ; SHIFT COUNT
03BC C8                  INY
03BD A50D                LDA    RANDNO+1     ; GET THE OTHER RANDOM NUMBER AND SHIFT IT
03BF 88       RNDXP1:    DEY                 ; RIGHT ACCORDING TO Y
03C0 F004                BEQ    RNDXP2
03C2 4A                  LSRA
03C3 4CBF03              JMP    RNDXP1
03C6 0900     RNDXP2:    ORA    #0           ; TEST FOR A ZERO RESULT
03C8 F0E7                BEQ    RNDEXP       ; PROHIBIT ZERO RESULTS
03CA 60                  RTS                 ; RETURN

              ;          RANGCK - CHECK FOR ACCEPTABLE RANGE OF FREQ AND DAMP PARAMETERS
              ;          RETURN WITH CARRY OFF IF OK

03CB A502     RANGCK:    LDA    FREQ+1       ; MINIMUM ABSOLUTE VALUE FOR FREQ IS X'0100
03CD F01C                BEQ    RANGNK       ; GO TO FAILURE RETURN IF HIGH BYTE IS 0
03CF C9FF                CMP    #X'FF
03D1 F018                BEQ    RANGNK       ; GO TO FAILURE RETURN IF HIGH BYTE IS FF
03D3 A504     RANG2:     LDA    DAMP+1       ; CHECK THAT DAMP IS NOT GREATER THAN
03D5 C97F                CMP    #X'7F        ; X'7EFF
03D7 F012                BEQ    RANGNK       ; GO TO FAILURE RETURN IF SO
03D9 A502     RANG3:     LDA    FREQ+1       ; IF FREQ AND DAMP ARE INDIVIDUALLY OK,
03DB 1002                BPL    RANG4        ; VERIFY THAT DAMP IS ACCEPTABLY HIGH IF
03DD 45FF                EOR    X'FF         ; ABSOLUTE VALUE OF FREQ IS SMALL
03DF C908     RANG4:     CMP    #8
03E1 1006                BPL    RANGOK       ; GO TO SUCCESS RETURN IF FREQ IS HIGH
03E3 A504                LDA    DAMP+1       ; IF FREQ IS LOW, REQUIRE DAMP TO BE HIGH
03E5 C97E                CMP    #X'7E
03E7 3002                BMI    RANGNK       ; GO TO FAILURE RETURN IF DAMP NOT HIGH
                                             ; ENOUGH WHEN FREQ IS LESS THAN X'10
03E9 18       RANGOK:    CLC                 ; CLEAR CARRY TO INDICATE SUCCESS
03EA 60                  RTS                 ; RETURN
03EB 38       RANGNK:    SEC                 ; SET CARRY TO INDICATE FAILURE
03EC 60                  RTS                 ; RETURN


0000                     .END
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                          .PAGE 'DOCUMENTATION, EQUATES, STORAGE'
                 ;        MTU VISIBLE MEMORY DEMONSTRATION PROGRAM
                 ;        JOSEPH CONWAY'S GAME OF LIFE ON A 320 BY 200 MATRIX

                 ;        ENTRY POINT "DEMO" GENERATES AN INITIAL PATTERN OF CELLS AND
                 ;        THEN EXECUTES THE LIFE ALGORITHM ON IT.

                 ;        FOR USER ENTERED PATTERNS, THE SCREEN SHOULD FIRST BE CLEARED
                 ;        BY EXECUTING "INIT". THE KIM KEYBOARD MONITOR OR "KYPT" MAY
                 ;        THEN BE USED TO ENTER THE INITIAL CELL PATTERN. AFTER PATTERN
                 ;        ENTRY, A JUMP TO "LIFE" WILL START COMPUTING THE SUCCEEDING
                 ;        GENERATIONS.

                 ;        LIFE MAY BE INTERRUPTED AT THE END OF A GENERATION BY PRESSING
                 ;        ANY KEY (EXCEPT RESET OR ST) ON THE KIM KEYPAD AND HOLDING
                 ;        UNTIL THE END OF THE GENERATION. THIS WILL TRANSFER CONTROL
                 ;        TO "KYPT" FOR USER MODIFICATION OF THE DISPLAYED PATTERN.

                 ;        KYPT IS USED FOR CONVENIENT ENTRY AND MODIFICATION OF CELL
                 ;        PATTERNS. WHEN ENTERED, A BLINKING GRAPHIC CURSOR IS
                 ;        DISPLAYED IN THE MIDDLE OF THE SCREEN. THE USER MAY MOVE THE
                 ;        CURSOR IN ANY DIRECTION AND EITHER SET OR CLEAR CELLS AT THE
                 ;        CURRENT CURSOR POSITION. THE CURSOR IS MOSTLY ON IF IT COVERS
                 ;        A LIVE CELL AND MOSTLY OFF OTHERWISE.
                 ;            THE KIM KEYBOARD IS USED FOR CONTROL OF THE PROGRAM. THE
                 ;        FOLLOWING KEYS ARE ACTIVE:
                 ;               1  CURSOR DOWN
                 ;               6  CURSOR RIGHT
                 ;               9  CURSOR UP
                 ;               4  CURSOR LEFT
                 ;               +  SET A CELL
                 ;               F  CLEAR A CELL
                 ;               GO GO TO LIFE ROUTINE USING THE CURRENT PATTERN
                 ;        PARTICULARLY INTERESTING INITIAL PATTERNS MAY BE SAVED ON KIM
                 ;        CASSETTE AND RELOADED LATER FOR DEMONSTRATIONS, ETC.

                 ;        GENERAL EQUATES

1C22             KIMMON   =      X'1C22       ; ENTRY TO KIM MONITOR
1F6A             GETKEY   =      X'1F6A       ; ADDRESS OF MONITOR KEYBOARD READ ROUTINE
0140             NX       =      320          ; NUMBER OF BITS IN A ROW
00C8             NY       =      200          ; NUMBER OF ROWS  (CHANGE FOR HALF SCREEN
                                              ; OPERATION)
FA00             NPIX     =      NX*NY        ; NUMBER OF PIXELS
0032             DBCDLA   =      50           ; KIM KEYBOARD DEBOUNCE DELAY TIME

0000                      .=     0            ; START DEMO PROGRAM AT LOCATION ZERO

                 ;        PARAMETER STORAGE

0000 20          VMORG:   .BYTE  X'20         ; FIRST PAGE IN DISPLAY MEMORY

                 ;        MISCELLANEOUS STORAGE

0001             NCYSV:   .=.+   1            ; TEMPORARY STORAGE FOR NEIGHBOR COUNT
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                                                  ; ROUTINE
0002           NCNT:    .=.+   1             ; COUNT OF LIVE NEIGHBORS
0003           LNCNT:   .=.+   1             ; CELL LINE COUNTER
0004           NGEN:    .=.+   1             ; BYTE TO ACCUMULATE NEW CELLS
0005           ADP1:    .=.+   2             ; ADDRESS POINTER 1
0007           ADP2:    .=.+   2             ; ADDRESS POINTER 2
0009           BTPT:    .=.+   1             ; BIT NUMBER
000A           X1CORD:  .=.+   2             ; COORDINATE PAIR 1
000C           Y1CORD:  .=.+   2
000E           X2CORD:  .=.+   2             ; COORDINATE PAIR 2
0010           Y2CORD:  .=.+   2
0012           TEMP:    .=.+   2             ; TEMPORARY STORAGE
0014           FLASHC:  .=.+   2             ; TIME DELAY COUNTER FOR CURSOR FLASHING
0016           LSTKEY   =      NCYSV         ; CODE OF LAST KEY PRESSED ON KIM KEYBOARD
0016           DBCNT    =      NCNT          ; KIM KEYBOARD DEBOUNCE COUNTER
0016           REALST   =      LNCNT         ; STATE OF CELL UNDER THE CURSOR

               ;        TABLE OF MASKS FOR NEIGHBOR COUNTING

0016 01                 .BYTE  X'01
0017 80402010  MSK:     .BYTE  X'80,X'40,X'20,X'10
001B 08040201           .BYTE  X'08,X'04,X'02,X'01
001F 80                 .BYTE  X'80

               ;        STORAGE TO BUFFER 3 FULL SCAN LINES OF CELLS

0020 00                 .BYTE  0
0021           TR:      .=.+   40            ; ROW ABOVE CENTRAL ROW
0049           CR:      .=.+   40            ; CENTRAL ROW
0071           BR:      .=.+   40            ; ROW BELOW CENTRAL ROW
0099 00                 .BYTE  0

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                            .PAGE  'INITIAL PATTERN GENERATION ROUTINES'
                  ;         CLEAR DISPLAY MEMORY AND INITIALIZE ROUTINE
                  ;         USED TO PREPARE SCREEN FOR USER ENTERED PATTERN

 009A D8          INIT:     CLD                 ; INITIALIZE MACHINE AND DISPLAY
 009B 202C02                JSR    CLEAR        ; CLEAR THE SCREEN
 009E 4C221C                JMP    KIMMON       ; RETURN TO THE MONITOR

                  ;         MAIN DEMO ROUTINE, DRAW INITIAL PATTERN
                  ;         DRAWS A FIGURE DEFINED BY "LIST" AND THEN JUMPS TO LIFE

 00A1 D8          DEMO:     CLD                 ; CLEAR DECIMAL MODE
 00A2 202C02                JSR    CLEAR        ; CLEAR THE SCREEN
 00A5 A200                  LDX    #0           ; INITIALIZE INDEX FOR COORDINATE LIST
 00A7 BD3603      DEMO1:    LDA    LIST+1,X     ; GET HIGH BYTE OF X COORDINATE
 00AA 101A                  BPL    DEMO2        ; JUMP IF A DRAW COMMAND
 00AC C9FF                  CMP    #X'FF        ; IF MOVE, TEST FOR END OF LIST FLAG
 00AE F050                  BEQ    LIFE         ; GO TO LIFE IF SO
 00B0 297F                  AND    #X'7F        ; DELETE SIGN BIT
 00B2 850B                  STA    X1CORD+1     ; FOR MOVE JUST COPY COORDINATES FROM LIST
 00B4 BD3503                LDA    LIST,X       ; INTO X1CORD,Y1CORD
 00B7 850A                  STA    X1CORD
 00B9 BD3703                LDA    LIST+2,X
 00BC 850C                  STA    Y1CORD
 00BE BD3803                LDA    LIST+3,X
 00C1 850D                  STA    Y1CORD+1
 00C3 4CDA00                JMP    DEMO3
 00C6 850F        DEMO2:    STA    X2CORD+1     ; FOR DRAW, COPY COORDINATES FROM LIST
 00C8 BD3503                LDA    LIST,X       ; INTO X2CORD,Y2CORD
 00CB 850E                  STA    X2CORD
 00CD BD3703                LDA    LIST+2,X
 00D0 8510                  STA    Y2CORD
 00D2 BD3803                LDA    LIST+3,X
 00D5 8511                  STA    Y2CORD+1
 00D7 20F502                JSR    SDRAW        ; DRAW LINE FROM X1CORD,Y1CORD TO X2CORD,
 00DA E8          DEMO3:    INX                 ; Y2CORD
 00DB E8                    INX                 ; BUMP INDEX TO NEXT SET OF COORDINATES
 00DC E8                    INX
 00DD E8                    INX
 00DE D0C7                  BNE    DEMO1        ; LOOP UNTIL END OF LIST REACHED
 00E0 F01E                  BEQ    LIFE         ; GO TO LIFE ROUTINE WHEN DONE

                  ;         CSRINS - INSERT GRAPHIC CURSOR AT X1CORD,Y1CORD
                  ;         SAVES STATE OF THE CELL ALREADY THERE IN REALST

 00E2 20CC02      CSRINS:   JSR    RDPIX        ; READ CURRENT STATE OF CELL UNDER CURSOR
 00E5 8503                  STA    REALST       ; SAVE THE STATE
 00E7 60                    RTS                 ; RETURN

                  ;         CSRDEL - DELETE THE GRAPHIC CURSOR AT X1CORD,Y1CORD
                  ;         AND RESTORE THE CELL THAT WAS ORIGINALLY THERE

 00E8 A503        CSRDEL:   LDA    REALST       ; GET SAVED CELL STATE
 00EA 20C402                JSR    WRPIX        ; PUT IT BACK INTO DISPLAY MEMORY
 00ED 60                    RTS                 ; RETURN
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                                .PAGE  'MAIN LIFE ROUTINE'
00EE                            .=     X'100
0100 A900       LIFE:    LDA    #0            ; PRIME THE THREE LINE BUFFERS
0102 8505                STA    ADP1          ; INITIALIZE VM POINTER TO TOP OF SCREEN
0104 A500                LDA    VMORG
0106 8506                STA    ADP1+1
0108 201D02              JSR    PRIME         ; DO THE PRIMING
                ;        MAIN LIFE LOOP
010B A9C6                LDA    #198          ; SET THE COUNT OF ROWS TO PROCESS
010D 8503                STA    LNCNT
010F A505       LIFE1:   LDA    ADP1          ; INCREMENT THE ADDRESS POINTER TO THE
0111 18                  CLC                  ; NEXT LINE
0112 6928                ADC    #40
0114 8505                STA    ADP1
0116 9002                BCC    LIFE2
0118 E606                INC    ADP1+1
011A 203101     LIFE2:   JSR    LFBUF         ; EXECUTE LIFE ALGORITHM ON CENTRAL ROW
                                              ; IN BUFFER AND UPDATE THE CURRENT ROW IN
                                              ; DISPLAY MEMORY
011D C603                DEC    LNCNT         ; DECREMENT THE LINE COUNT
011F F006                BEQ    LIFE3         ; JUMP OUT IF 198 LINES BEEN PROCESSED
0121 200002              JSR    ROLL          ; ROLL THE BUFFERS UP ONE POSITION
0124 4C0F01              JMP    LIFE1         ; GO PROCESS THE NEXT LINE
                ;        END OF GENERATION, TEST KIM KEYBOARD
0127 206A1F     LIFE3:   JSR    GETKEY
012A C915                CMP    #21
012C B0D2                BCS    LIFE          ; GO FOR NEXT GENERATION IF NO KET PRESSED
012E 4CC703              JMP    KYPT          ; GO TO KEYBOARD PATTERN ENTRY IF A
                                              ; KEY WAS PRESSED
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                            .PAGE  'LIFE NEXT GENERATION ROUTINE FOR BUFFER CONTENTS'
                   ;        LIFE NEXT GENERATION ROUTINE
                   ;        THE CELLS IN THE MIDDLE LINE BUFFER ARE SCANNED AND THEIR
                   ;        NEIGHBORS COUNTED TO DETERMINE IF THEY LIVE, DIE, OR GIVE
                   ;        BIRTH. THE UPDATED CENTRAL LINE IS STORED BACK INTO DISPLAY
                   ;        MEMORY STARTING AT (ADP1).
                   ;        TO IMPROVE SPEED, WHEN PROCESSING THE CENTRAL 6 BITS IN A BYTE
                   ;        THE ENTIRE BYTE AND ITS NEIGHBORS ARE CHECKED FOR ZERO.
                   ;        IF ALL ARE ZERO, THE 6 BITS ARE SKIPPED.

 0131 A000        LFBUF:   LDY    #0            ; INITIALIZE BYTE ADDRESS
 0133 A207        LFBUF1:  LDX    #7            ; PREPARE FOR THE NEXT BYTE
 0135 A900                 LDA    #0            ; ZERO NEXT GEN BYTE
 0137 8504                 STA    NGEN
 0139 E006        LFBUF2:  CPX    #6            ; TEST IF TO PROCESS BIT 6
 013B D00D                 BNE    LFBUF3        ; JUMP IF NOT
 013D B92100               LDA    TR,Y          ; TEST IF CENTRAL BYTE AND ITS NEIGHBORS
 0140 194900               ORA    CR,Y          ; ARE ALL ZEROES MEANING THAT NO CHANGE IS
 0143 197100               ORA    BR,Y          ; POSSIBLE IN THE CENTRAL 6 BITS OF THE
 0146 D002                 BNE    LFBUF3        ; CURRENT BYTE
 0148 A200                 LDX    #0            ; IF ZEROES, SKIP 6 CENTRAL BITS
 014A 207501      LFBUF3:  JSR    NCNTC         ; COUNT NEIGHBORS
 014D A502                 LDA    NCNT
 014F F01B                 BEQ    LFBUF6        ; JUMP IF EXACTLY 3 LIVE NEIGHBORS
 0151 3004                 BMI    LFBUF4        ; JUMP IF MORE THAN 3 LIVE NEIGHBORS
 0153 C901                 CMP    #1
 0155 F00D                 BEQ    LFBUF5        ; JUMP IF EXACTLY 2 LIVE NEIGHBORS
 0157 CA          LFBUF4:  DEX                  ; DECREMENT BIT NUMBER
 0158 10DF                 BPL    LFBUF2        ; GO PROCESS NEXT BIT IF NOT DONE WITH BYTE
 015A A504                 LDA    NGEN          ; STORE NEXT GENERATION BYTE INTO DISPLAY
 015C 9105                 STA    (ADP1),Y      ; MEMORY
 015E C8                   INY                  ; GO TO NEXT BYTE
 015F C028                 CPY    #40           ; TEST IF DONE
 0161 D0D0                 BNE    LFBUF1        ; LOOP IF NOT
 0163 60                   RTS                  ; OTHERWISE RETURN

 0164 B94900      LFBUF5:  LDA    CR,Y          ; WHEN EXACTLY 2 NEIGHBORS, TEST CURRENT
 0167 3517                 AND    MSK,X         ; CELL
 0169 4C6E01               JMP    LFBUF7        ; NEW CELL IF CURRENT CELL IS ALIVE

 016C B517        LFBUF6:  LDA    MSK,X         ; CREATE A CELL IN THE NEXT GENERATION
 016E 0504        LFBUF7:  ORA    NGEN
 0170 8504                 STA    NGEN
 0172 4C5701               JMP    LFBUF4
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                                .PAGE 'NEIGHBOR COUNT ROUTINE'
                      ;         NEIGHBOR COUNT ROUTINE FOR ALL EIGHT NEIGHBORS OF A CENTRAL
                      ;         CELL. USES THREE SCAN LINE BUFFER IN BASE PAGE FOR MAXIMUM
                      ;         SPEED. INDEX Y POINTS TO BYTE CONTAINING CENTRAL CELL
                      ;         RELATIVE TO BEGINNING OF CENTRAL SCAN LINE. INDEX X HAS BIT
                      ;         NUMBER OF CENTRAL CELL, O=LEFTMOST IN BYTE. EXITS WITH 3-N IN
                      ;         NCNT WHERE N IS NUMBER OF LIVE NEIGHBORS. PRESERVES X AND Y.

0175 8401             NCNTC:    STY    NCYSV          ; SAVE Y
0177 A903                       LDA    #3             ; INITIALIZE THE NEIGHBOR COUNT
0179 8502                       STA    NCNT
017B B92100           N1:       LDA    TR,Y           ; CHECK CELLS DIRECTLY ABOVE AND BELOW
017E 3517                       AND    MSK,X          ; CENTRAL CELL FIRST
0180 F002                       BEQ    N2
0182 C602                       DEC    NCNT
0184 B97100           N2:       LDA    BR,Y
0187 3517                       AND    MSK,X
0189 F002                       BEQ    N3
018B C602                       DEC    NCNT
018D E000             N3:       CPX    #0             ; TEST COLUMN OF 3 LEFT CELLS NEXT
018F D001                       BNE    N3A            ; SKIP AHEAD IF IN THE SAME BYTE
0191 88                         DEY                   ; OTHERWISE MOVE 1 BYTE LEFT
0192 B92100           N3A:      LDA    TR,Y
0195 3516                       AND    MSK-1,X
0197 F002                       BEQ    N4
0199 C602                       DEC    NCNT
019B B94900           N4:       LDA    CR,Y
019E 3516                       AND    MSK-1,X
01A0 F004                       BEQ    N5
01A2 C602                       DEC    NCNT
01A4 302F                       BMI    NCXIT          ; QUICK EXIT IF MORE THAN 3 NEIGHBORS
01A6 B97100           N5:       LDA    BR,Y
01A9 3516                       AND    MSK-1,X
01AB F004                       BEQ    N6
01AD C602                       DEC    NCNT
01AF 3024                       BMI    NCXIT          ; QUICK EXIT IF MORE THAN 3 NEIGHBORS
01B1 A401             N6:       LDY    NCYSV          ; RESTORE Y
01B3 E007                       CPX    #7             ; TEST COLUMN OF 3 RIGHT CELLS LAST
01B5 D001                       BNE    N6A            ; SKIP AHEAD IF IN THE SAME BYTE
01B7 C8                         INY                   ; OTHERWISE MOVE 1 BYTE RIGHT
01B8 B92100           N6A:      LDA    TR,Y
01BB 3518                       AND    MSK+1,X
01BD F004                       BEQ    N7
01BF C602                       DEC    NCNT
01C1 3012                       BMI    NCXIT          ; QUICK EXIT IF MORE THAN 3 NEIGHBORS
01C3 B94900           N7:       LDA    CR,Y
01C6 3518                       AND    MSK+1,X
01C8 F002                       BEQ    N8
01CA C602                       DEC    NCNT
01CC B97100           N8:       LDA    BR,Y
01CF 3518                       AND    MSK+1,X
01D1 F002                       BEQ    NCXIT
01D3 C602                       DEC    NCNT
01D5 A401             NCXIT:    LDY    NCYSV          ; RESTORE Y
01D7 60                         RTS                   ; AND RETURN
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                              .PAGE  'CELL LINE MOVE ROUTINES'
                      ;       ROLL THE THREE LINE BUFFERS UP ONE POSITION
                      ;       AND BRING IN A NEW LINE FROM DISPLAY MEMORY STARTING AT
                      ;       (ADP1) +80 PRESERVES INDEX REGISTERS

     01D8                     .=     X'200
     0200 98          ROLL:   TYA                 ; SAVE INDEX Y
     0201 48                  PHA
     0202 A050                LDY    #80          ; INITIALIZE INDEX
     0204 B9F9FF      ROLL1:  LDA    CR-80,Y      ; ROLL A BYTE
     0207 99D1FF              STA    TR-80,Y
     020A B92100              LDA    BR-80,Y
     020D 99F9FF              STA    CR-80,Y
     0210 B105                LDA    (ADP1),Y
     0212 992100              STA    BR-80,Y
     0215 C8                  INY                 ; INCREMENT INDEX
     0216 C078                CPY    #120         ; TEST IF 40 BYTES ROLLED
     0218 D0EA                BNE    ROLL1        ; LOOP IF NOT
     021A 68                  PLA                 ; RESTORE Y
     021B A8                  TAY
     021C 60                  RTS                 ; RESTURN

                      ;       PRIME THE LINE BUFFERS WITH THE FIRST THREE LINES OF DISPLAY
                      ;       MEMORY
                      ;       MOVES 120 BYTES STARTING AT (ADP1) INTO LINE BUFFERS STARTING
                      ;       AT TR

     021D 98          PRIME:  TYA                 ; SAVE INDEX Y
     021E 48                  PHA
     021F A077                LDY    #119         ; INITIALIZE INDEX
     0221 B105        PRIME1: LDA    (ADP1),Y     ; MOVE A BYTE
     0223 992100              STA     TR,Y
     0226 88                  DEY                 ; DECREMENT INDEX
     0227 10F8                BPL    PRIME1       ; LOOP IF NOT DONE
     0229 68                  PLA                 ; RESTORE Y
     022A A8                  TAY
     022B 60                  RTS                 ; RETURN

                      ;       CLEAR DISPLAY MEMORY ROUTINE

     022C A000        CLEAR:  LDY    #0           ; INITIALIZE ADDRESS POINTER
     022E 8405                STY    ADP1         ; AND ZERO INDEX Y
     0230 A500                LDA    VMORG
     0232 8506                STA    ADP1+1
     0234 18                  CLC
     0235 6920                ADC    #X'20
     0237 AA                  TAX
     0238 98          CLEAR1: TYA                 ; CLEAR A BYTE
     0239 9105                STA    (ADP1),Y
     023B E605                INC    ADP1         ; INCREMENT ADDRESS POINTER
     023D D0F9                BNE    CLEAR1
     023F E606                INC    ADP1+1
     0241 E406                CPX    ADP1+1       ; TEST IF DONE
     0243 D0F3                BNE    CLEAR1
     0245 60                  RTS                 ; RETURN
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                            .PAGE  'GRAPHICS ROUTINES FOR GENERATING THE INITIAL PATTERN'
                   ;        PIXADR - FIND THE BYTE ADDRESS AND BIT NUMBER OF PIXEL AT
                   ;                 X1CORD, Y1CORD
                   ;        PUTS BYTE ADDRESS IN ADP1 AND BIT NUMBER (BIT 0 IS LEFTMOST)
                   ;        IN BTPT.
                   ;        DOES NOT CHECK MAGNITUDE OF COORDINATES FOR MAXIMUM SPEED
                   ;        PRESERVES X AND Y REGISTERS, DESTROYS A
                   ;        BYTE ADDRESS = VMORG*256+(199-Y1CORD)*40+INT(XCORD/8)
                   ;        BIT ADDRESS = REM(XCORD/8)
                   ;        OPTIMIZED FOR SPEED THEREFORE CALLS TO A DOUBLE SHIFT ROUTINE
                   ;        ARE NOT DONE

0246 A50A          PIXADR:  LDA    X1CORD       ; COMPUTE BIT ADDRESS FIRST
0248 8505                   STA    ADP1         ; ALSO TRANSFER X1CORD TO ADP1
024A 2907                   AND    #X'07        ; WHICH IS SIMPLY THE LOW 3 BITS OF X
024C 8509                   STA    BTPT
024E A50B                   LDA    X1CORD+1     ; FINISH TRANSFERRING X1CORD TO ADP1
0250 8506                   STA    ADP1+1
0252 4606                   LSR    ADP1+1       ; DOUBLE SHIFT ADP1 RIGHT 3 TO GET
0254 6605                   ROR    ADP1         ; INT(XCORD/8)
0256 4606                   LSR    ADP1+1
0258 6605                   ROR    ADP1
025A 4606                   LSR    ADP1+1
025C 6605                   ROR    ADP1
025E A9C7                   LDA    #199         ; TRANSFER (199-Y1CORD) TO ADP2
0260 38                     SEC                 ; AND TEMPORARY STORAGE
0261 E50C                   SBC    Y1CORD
0263 8507                   STA    ADP2
0265 8512                   STA    TEMP
0267 A900                   LDA    #0
0269 E50D                   SBC    Y1CORD+1
026B 8508                   STA    ADP2+1
026D 8513                   STA    TEMP+1
026F 0607                   ASL    ADP2         ; COMPUTE 40*(199-Y1CORD)
0271 2608                   ROL    ADP2+1       ;  2*(199-Y1CORD)
0273 0607                   ASL    ADP2
0275 2608                   ROL    ADP2+1       ;  4*(199+Y1CORD)
0277 A507                   LDA    ADP2         ;  ADD IN TEMPORARY SAVE OF (199-Y1CORD)
0279 18                     CLC                 ;  TO MAKE 5*(199-Y1CORD)
027A 6512                   ADC    TEMP
027C 8507                   STA    ADP2
027E A508                   LDA    ADP2+1
0280 6513                   ADC    TEMP+1
0282 8508                   STA    ADP2+1       ;  5*(199-Y1CORD)
0284 0607                   ASL    ADP2         ;  10*(199-Y1CORD)
0286 2608                   ROL    ADP2+1
0288 0607                   ASL    ADP2         ;  20*(199-Y1CORD)
028A 2608                   ROL    ADP2+1
028C 0607                   ASL    ADP2         ;  40*(199-Y1CORD)
028E 2608                   ROL    ADP2+1
0290 A507                   LDA    ADP2         ; ADD IN INT(X1CORD/8) COMPUTED EARLIER
0292 18                     CLC
0293 6505                   ADC    ADP1
0295 8505                   STA    ADP1
0297 A508                   LDA    ADP2+1
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0299 6506             ADC   ADP1+1
029B 6500             ADC   VMORG        ; ADD IN VMORG*256
029D 8506             STA   ADP1+1       ; FINAL RESULT
029F 60               RTS                ; RETURN

             ;        STPIX - SETS THE PIXEL AT X1CORD,Y1CORD TO A ONE (WHITE DOT)
             ;        DOES NOT ALTER X1CORD OR Y1CORD
             ;        PRESERVES X AND Y
             ;        ASSUMES IN RANGE CORRDINATES

02A0 204602  STPIX:   JSR   PIXADR       ; GET BYTE ADDRESS AND BIT NUMBER OF PIXEL
                                         ; INTO ADP1
02A3 98               TYA                ; SAVE Y
02A4 48               PHA
02A5 A409             LDY   BTPT         ; GET BIT NUMBER IN Y
02A7 B9E502           LDA   MSKTB1,Y     ; GET A BYTE WITH THAT BIT =1, OTHERS =0
02AA A000             LDY   #0           ; ZERO Y
02AC 1105             ORA   (ADP1),Y     ; COMBINE THE BIT WITH THE ADDRESSED VM
                                         ; BYTE
02AE 4CBF02           JMP   CLPIX1       ; GO STORE RESULT, RESTORE Y, AND RETURN

             ;        CLPIX - CLEARS THE PIXEL AT X1CORD,Y1CORD TO A ZERO (BLACK DOT
             ;        DOES NOT ALTER X1CORD OR Y1CORD
             ;        PRESERVES X AND Y
             ;        ASSUMES IN RANGE COORDINATES

02B1 204602  CLPIX:   JSR   PIXADR       ; GET BYTE ADDRESS AND BIT NUMBER OF PIXEL
                                         ; INTO ADP1
02B4 98               TYA                ; SAVE Y
02B5 48               PHA
02B6 A409             LDY   BTPT         ; GET BIT NUMBER IN Y
02B8 B9ED02           LDA   MSKTB2,Y     ; GET A BYTE WITH THAT BIT =0, OTHERS =1
02BB A000             LDY   #0           ; ZERO Y
02BD 3105             AND   (ADP1),Y     ; REMOVE THE BIT FROM THE ADDRESSED VM
02BF 9105    CLPIX1:  STA   (ADP1),Y     ; BYTE
02C1 68               PLA                ; RESTORE Y
02C2 A8               TAY
02C3 60               RTS                ; AND RETURN

             ;        WRPIX - SETS THE PIXEL AT X1CORD,Y1CORD ACCORDING TO THE STATE
             ;        OF BIT 0 (RIGHTMOST) OF A
             ;        DOES NOT ALTER X1CORD OR Y1CORD
             ;        PRESERVES X AND Y
             ;        ASSUMES IN RANGE CORRDINATES

02C4 2CCB02  WRPIX:   BIT   WRPIXM       ; TEST LOW BIT OF A
02C7 F0E8             BEQ   CLPIX        ; JUMP IF A ZERO TO BE WRITTEN
02C9 D0D5             BNE   STPIX        ; OTHERWISE WRITE A ONE

02CB 01      WRPIXM:  .BYTE 1            ; BIT TEST MASK FOR BIT 0

             ;        RDPIX - READS THE PIXEL AT X1CORD,Y1CORD AND SETS A TO ALL
             ;        ZEROES IF IT IS A ZERO OR TO ALL ONES IF IT IS A ONE
             ;        LOW BYTE OF ADP1 IS EQUAL TO A ON RETURN
             ;        DOES NOT ALTER X1CORD OR Y1CORD
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                   ;        PRESERVES X AND Y
                   ;        ASSUMES IN RANGE CORRDINATES

02CC 204602    RDPIX:   JSR    PIXADR       ; GET BYTE AND BIT ADDRESS OF PIXEL
02CF 98                 TYA                 ; SAVE Y
02D0 48                 PHA
02D1 A000               LDY    #0           ; GET ADDRESSED BYTE FROM VM
02D3 B105               LDA    (ADP1),Y
02D5 A409               LDY    BTPT         ; GET BIT NUMBER IN Y
02D7 39E502             AND    MSKTB1,Y     ; CLEAR ALL BUT ADDRESSED BIT
02DA F002               BEQ    RDPIX1       ; SKIP AHEAD IF IT WAS A ZERO
02DC A9FF               LDA    #X'FF        ; SET TO ALL ONES IF IT WAS A ONE
02DE 8505      RDPIX1:  STA    ADP1         ; SAVE A TEMPORARILY IN ADP1 WHILE
02E0 68                 PLA                 ; RESTORING Y
02E1 A8                 TAY
02E2 A505               LDA    ADP1
02E4 60                 RTS                 ; RETURN

               ;        MASK TABLES FOR INDIVIDUAL PIXEL SUBROUTINES
               ;        MSKTB1 IS A TABLE OF 1 BITS CORRESPONDING TO BIT NUMBERS
               ;        MSKTB2 IS A TABLE OF 0 BITS CORRESPONDING TO BIT NUMBERS

02E5 80402010  MSKTB1:  .BYTE  X'80,X'40,X'20,X'10
02E9 08040201           .BYTE  X'08,X'04,X'02,X'01
02ED 7FBFDFEF  MSKTB2:  .BYTE  X'7F,X'BF,X'DF,X'EF
02F1 F7FBFDFE           .BYTE  X'F7,X'FB,X'FD,X'FE

               ;        SDRAW - SIMPLIFIED DRAW ROUTINE
               ;        DRAWS A LINE FROM X1CORD,Y1CORD TO X2CORD,Y2CORD
               ;        WHEN DONE COPIES X2CORD AND Y2CORD INTO X1CORD AND Y1CORD
               ;        RESTRICTED TO HORIZONTAL, VERTICAL, AND 45 DEGREE DIAGONAL
               ;        LINES (SLOPE=1)
               ;        PRESERVES BOTH INDEX REGISTERS

02F5 8A        SDRAW:   TXA                 ; SAVE INDEX REGS
02F6 48                 PHA
02F7 98                 TYA
02F8 48                 PHA
02F9 20A002             JSR    STPIX        ; PUT A DOT AT INITIAL ENDPOINT
02FC A000      SDRAW1:  LDY    #0           ; CLEAR "SOMETHING DONE" FLAG
02FE A200               LDX    #0           ; UPDATE X COORDINATE
0300 201303             JSR    UPDC
0303 A202               LDX    #Y1CORD-X1CORD;UPDATE Y COORDINATE
0305 201303             JSR    UPDC
0308 20A002             JSR    STPIX        ; PUT A DOT AT INTERMEDIATE POINT
030B 88                 DEY                 ; TEST IF EITHER COORDINATE CHANGED
030C 10EE               BPL    SDRAW1       ; ITERATE AGAIN IF SO
030E 68                 PLA                 ; RESTORE INDEX REGISTERS
030F A8                 TAY
0310 68                 PLA
0311 AA                 TAX
0312 60                 RTS                 ; RETURN

               ;        INTERNAL SUBROUTINE FOR UPDATING COORDINATES
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0313 B50F      UPDC:    LDA    X2CORD+1,X   ; COMPARE ENDPOINT WITH CURRENT POSITION
0315 D50B               CMP    X1CORD+1,X
0317 9012               BCC    UPDC3        ; JUMP IF CURRENT POSITION IS LARGER
0319 D008               BNE    UPDC1        ; JUMP IF ENDPOINT IS LARGER
031B B50E               LDA    X2CORD,X
031D D50A               CMP    X1CORD,X
031F 900A               BCC    UPDC3        ; JUMP IF CURRENT POSITION IS LARGER
0321 F011               BEQ    UPDC5        ; GO RETURN IF EQUAL
0323 F60A      UPDC1:   INC    X1CORD,X     ; ENDPOINT IS LARGER, INCREMENT CURRENT
0325 D002               BNE    UPDC2        ; POSITION
0327 F60B               INC    X1CORD+1,X
0329 C8        UPDC2:   INY                 ; SET "DONE SOMETHING" FLAG
032A 60                 RTS                 ; RETURN
032B B50A      UPDC3:   LDA    X1CORD,X     ; CURRENT POSITION IS LARGER, DECREMENT
032D D002               BNE    UPDC4        ; CURRENT POSITION
032F D60B               DEC    X1CORD+1,X
0331 D60A      UPDC4:   DEC    X1CORD,X
0333 C8                 INY                 ; SET "DONE SOMETHING" FLAG
0334 60        UPDC5:   RTS                 ; RETURN
```

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                              .PAGE  'COORDINATE LIST FOR DRAWING INITIAL FIGURE'
                     ;        COORDINATE LIST DEFINING THE INITIAL PATTERN FOR LIFE
                     ;        EACH VERTEX IN THE FIGURE IS REPRESENTED BY 4 BYTES
                     ;        THE FIRST TWO BYTES ARE THE X COORDINATE OF THE NEXT ENDPOINT
                     ;        AND THE NEXT TWO BYTES ARE THE Y COORDINATE.
                     ;        IF THE HIGH BYTE OF X HAS THE SIGN BIT ON, A MOVE FROM THE
                     ;        CURRENT POSITION TO THE NEW POSITION IS DONE (THE SIGN BIT IS
                     ;        IS DELETED BEFORE MOVING)
                     ;        IF THE HIGH BYTE OF X HAS THE SIGN BIT OFF, A DRAW FROM THE
                     ;        CURRENT POSITION TO THE NEW POSITION IS DONE.
                     ;        IF THE HIGH BYTE OF X = X'FF, IT IS THE END OF THE LIST.

0335 38803C00  LIST:     .WORD  56+X'8000,60   ; 1     MOVE
0339 38008C00            .WORD  56,140         ; 2     DRAW
033D 48008C00            .WORD  72,140         ; 3     DRAW
0341 48004C00            .WORD  72,76          ; 4
0345 68004C00            .WORD  104,76         ; 5
0349 68003C00            .WORD  104,60         ; 6
034D 38003C00            .WORD  56,60          ; 7
0351 78803C00            .WORD  120+X'8000,60  ; 8     MOVE
0355 78008C00            .WORD  120,140        ; 9
0359 88008C00            .WORD  136,140        ; 10
035D 88003C00            .WORD  136,60         ; 11
0361 78003C00            .WORD  120,60         ; 12
0365 98803C00            .WORD  152+X'8000,60  ; 13    MOVE
0369 98008C00            .WORD  152,140        ; 14
036D C8008C00            .WORD  200,140        ; 15
0371 C8007C00            .WORD  200,124        ; 16
0375 A8007C00            .WORD  168,124        ; 17
0379 A8006C00            .WORD  168,108        ; 18
037D C0006C00            .WORD  192,108        ; 19
0381 C0005C00            .WORD  192,92         ; 20
0385 A8005C00            .WORD  168,92         ; 21
0389 A8003C00            .WORD  168,60         ; 22
038D 98003C00            .WORD  152,60         ; 23
0391 D8803C00            .WORD  216+X'8000,60  ; 24    MOVE
0395 D8008C00            .WORD  216,140        ; 25
0399 08018C00            .WORD  264,140        ; 26
039D 08017C00            .WORD  264,124        ; 27
03A1 E8007C00            .WORD  232,124        ; 28
03A5 E8006C00            .WORD  232,108        ; 29
03A9 00016C00            .WORD  256,108        ; 30
03AD 00015C00            .WORD  256,92         ; 31
03B1 E8005C00            .WORD  232,92         ; 32
03B5 E8004C00            .WORD  232,76         ; 33
03B9 08014C00            .WORD  264,76         ; 34
03BD 08013C00            .WORD  264,60         ; 35
03C1 D8003C00            .WORD  216,60         ; 36
03C5 FFFF                .WORD  X'FFFF         ; END OF LIST
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                              .PAGE  'KEYBOARD PATTERN ENTRY ROUTINES'
                   ;          KEYBOARD PATTERN ENTRY ROUTINES
                   ;          USES THE KIM KEYBOARD AND A CURSOR TO SIMPLIFY THE ENTRY
                   ;          OF INITIAL LIFE PATTERNS

    03C7 A900      KYPT:      LDA    #0            ; SET INITIAL CURSOR POSITION IN CENTER
    03C9 850B                 STA    X1CORD+1      ; OF SCREEN
    03CB 850D                 STA    Y1CORD+1
    03CD A9A0                 LDA    #160
    03CF 850A                 STA    X1CORD
    03D1 A964                 LDA    #100
    03D3 850C                 STA    Y1CORD
    03D5 20E200               JSR    CSRINS        ; INSERT A CURSOR ON THE SCREEN
    03D8 A932      KYPT0:     LDA    #DBCDLA       ; RESET THE DEBOUNCE COUNT
    03DA 8502                 STA    DBCNT
    03DC E614      KYPT1:     INC    FLASHC        ; DOUBLE INCREMENT CURSOR FLASH COUNT
    03DE D002                 BNE    KYPT2
    03E0 E615                 INC    FLASHC+1

                   ;          GENERATE A 25% DUTY CURSOR IF CELL IS DEAD AND 75% IF ALIVE

    03E2 A515      KYPT2:     LDA    FLASHC+1      ; GET HIGH BYTE OF FLASH COUNTER
    03E4 4A                   LSRA                 ; COMPUTE LOGICAL "AND" OF BITS 0 AND 1
    03E5 2515                 AND    FLASHC+1      ; IN ACC BIT 0
    03E7 4503                 EOR    REALST        ; EXCLUSIVE-OR WITH REAL STATE OF CELL
    03E9 20C402               JSR    WRPIX         ; DISPLAY THE CURSOR

                   ;          READ KIM KEYBOARD AND DETECT ANY CHANGE IN KEYS PRESSED

    03EC 206A1F               JSR    GETKEY        ; GET CURRENT PRESSED KEY
    03EF C501                 CMP    LSTKEY        ; TEST IF SAME AS BEFORE
    03F1 F0E5                 BEQ    KYPT0         ; IGNORE IF SO
    03F3 C602                 DEC    DBCNT         ; IF DIFFERENT, DECREMENT AND TEST
    03F5 10E5                 BPL    KYPT1         ; DEBOUNCE COUNT AND IGNORE KEY IF NOT RUN
                                                   ; OUT
    03F7 8501                 STA    LSTKEY        ; AFTER DEBOUNCE, UPDATE KEY LAST PRESSED
    03F9 4C8017               JMP    KYPT6         ; AND GO PROCESS THE KEYSTROKE

    03FC                      .=     X'1780        ; CONTINUE PROGRAM IN 6530 RAM

    1780 C901      KYPT6:     CMP    #1            ; TEST "1" KEY
    1782 F01B                 BEQ    CSRD          ; JUMP IF CURSOR DOWN
    1784 C909                 CMP    #9            ; TEST "9" KEY
    1786 F01F                 BEQ    CSRU          ; JUMP IF CURSOR UP
    1788 C904                 CMP    #4            ; TEST "4" KEY
    178A F023                 BEQ    CSRL          ; JUMP IF CURSOR LEFT
    178C C906                 CMP    #6            ; TEST "6" KEY
    178E F02D                 BEQ    CSRR          ; JUMP IF CURSOR RIGHT
    1790 C913                 CMP    #19           ; TEST "GO" KEY
    1792 F043                 BEQ    GO            ; JUMP IF GO KEY
    1794 C912                 CMP    #18           ; TEST "+" KEY
    1796 F034                 BEQ    SETCEL        ; JUMP IF SET CELL KEY
    1798 C90F                 CMP    #15           ; TEST "F" KEY
    179A F034                 BEQ    CLRCEL        ; JUMP IF CLEAR CELL KEY
    179C 4CD803               JMP    KYPT0         ; IGNORE ANY OTHER KEYS
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179F 20E800    CSRD:    JSR    CSRDEL       ; DELETE EXISTING CURSOR
17A2 C60C               DEC    Y1CORD       ; DECREMENT Y COORDINATE FOR CURSOR DOWN
17A4 4CC617             JMP    CSRMOV

17A7 20E800    CSRU:    JSR    CSRDEL       ; DELETE EXISTING CURSOR
17AA E60C               INC    Y1CORD       ; INCREMENT Y COORDINATE FOR CURSOR UP
17AC 4CC617             JMP    CSRMOV

17AF 20E800    CSRL:    JSR    CSRDEL       ; DELETE EXISTING CURSOR
17B2 A50A               LDA    X1CORD       ; DECREMENT X COORDINATE FOR CURSOR LEFT
17B4 D002               BNE    CSRL1
17B6 C60B               DEC    X1CORD+1
17B8 C60A      CSRL1:   DEC    X1CORD
17BA 4CC617             JMP    CSRMOV

17BD 20E800    CSRR:    JSR    CSRDEL       ; DELETE EXISTING CURSOR
17C0 E60A               INC    X1CORD       ; INCREMENT X COORDINATE FOR CURSOR RIGHT
17C2 D002               BNE    CSRMOV
17C4 E60B               INC    X1CORD+1

17C6 20E200    CSRMOV:  JSR    CSRINS       ; INSERT CURSOR AT NEW LOCATION
17C9 4CD803             JMP    KYPT0        ; GO BACK TO KEYBOARD INPUT LOOP

17CC A9FF      SETCEL:  LDA    #X'FF        ; SET REAL CELL STATE TO LIVE
17CE D002               BNE    CLRCL1

17D0 A900      CLRCEL:  LDA    #0           ; SET REAL CELL STATE TO DEAD
17D2 8503      CLRCL1:  STA    REALST
17D4 4CD803             JMP    KYPT0        ; GO BACK TO KEYBOARD INPUT LOOP

17D7 20E800    GO:      JSR    CSRDEL       ; DELETE CURSOR AND RESTORE THE CELL UNDER
                                            ; THE CURSOR
17DA 4C0001             JMP    LIFE         ; AND GO EXECUTE LIFE


0000                    .END
```

NO ERROR LINES

```
                          .PAGE  'SIMPLIFIED VISABLE MEMORY TEXT DISPLAY SUBROUTINE'
                 ;        THIS SUBROUTINE TURNS THE VISABLE MEMORY INTO A DATA DISPLAY
                 ;        TERMINAL (GLASS TELETYPE).
                 ;        CHARACTER SET IS 96 FULL ASCII UPPER AND LOWER CASE.
                 ;        CHARACTER MATRIX IS 5 BY 7 SET INTO A 6 BY 9 RECTANGLE.
                 ;        LOWER CASE IS REPRESENTED AS SMALL (5 BY 5) CAPITALS.
                 ;        SCREEN CAPACITY IS 22 LINES OF 53 CHARACTERS FOR FULL SCREEW
                 ;        OR 11 LINES FOR HALF SCREEN.
                 ;        CURSOR IS A NON-BLINKING UNDERLINE.
                 ;        CONTROL CODES RECOGNIZED:
                 ;        CR     X'0D         SETS CURSOR TO LEFT SCREEN EDGE
                 ;        LF     X'0A         MOVES CURSOR DOWN ONE LINE, SCROLLS
                 ;                            DISPLAY UP ONE LINE IF ALREADY ON BOTTOM
                 ;                            LINE
                 ;        BS     X'08         MOVES CURSOR ONE CHARACTER LEFT, DOES
                 ;                            NOTHING IF ALREADY AT LEFT SCREEN EDGE
                 ;        FF     X'0C         CLEARS SCREEN AND PUTS CURSOR AT TOP LEFT
                 ;                            OF SCREEN, SHOULD BE CALLED FOR
                 ;                            INITIALIZATION
                 ;        ALL OTHER CONTROL CODES IGNORED.
                 ;        ENTER WITH CHARACTER TO BE DISPLAYED IN A.
                 ;        X AND Y PRESERVED.
                 ;        3 BYTES OF RAM STORAGE REQUIRED FOR KEEPING TRACK OF THE
                 ;        CURSOR
                 ;        4 BYTES OF TEMPORARY STORAGE IN BASE PAGE REQUIRED FOR ADDRESS
                 ;        POINTERS. (CAN BE DESTROYED BETWEEN CALLS TO SDTXT
                 ;        4 BYTES OF TEMPORARY STORAGE ANYWHERE (CAN BE DESTROYED
                 ;        BETWEEN CALLS TO SDTXT)

                 ;        * **** VMORG #MUST# BE SET TO THE PAGE NUMBER OF THE VISIBLE *
                 ;        * MEMORY BEFORE CALLING SDTXT ****                           *

                 ;        GENERAL EQUATES

   1F40          NLOC     =      8000         ; NUMBER OF VISIBLE LOCATIONS
   0009          CHHI     =      9            ; CHARACTER WINDOW HEIGHT
   0006          CHWID    =      6            ; CHARACTER WINDOW WIDTH
   0035          NCHR     =      320/CHWID    ; NUMBER OF CHARACTERS PER LINE
   0016          NLIN     =      NLOC/40/CHHI ; NUMBER OF TEXT LINES
   1D88          NSCRL    =      NLIN-1*CHHI*40 ; NUMBER OF LOCATIONS TO SCROLL
   01B8          NCLR     =      NLOC-NSCRL   ; NUMBER OF LOCATIONS TO CLEAR AFTER SCROLL

                 ;        BASE PAGE TEMPORARY STORAGE

   0000                   .=     X'EA
   00EA          ADP1     .=.+   2            ; ADDRESS POINTER 1
   00EC          ADP2     .=.+   2            ; ADDRESS POINTER 2

                 ;        GENERAL TEMPORARY STORAGE

   00EE                   .=     X'5B00       ; PLACE AT END OF 16K EXPANSION

   5B00          BTPT:    .=.+   1            ; BIT NUMBER TEMPORARY STORAGE
   5B01          DCNT1:   .=.+   2            ; DOUBLE PRECISION COUNTER
   5B03          MRGT1:   .=.+   1            ; TEMPORARY STORAGE FOR MERGE
```

```

                 ;       PERMANENT RAM STORAGE

5B04             CSRX:   .=.+   1          ; CURRENT CHARACTER NUMBER (0=LEFT CHAR)
5B05             CSRY:   .=.+   1          ; CURRENT LINE NUMBER (0=TOP LINE)
5B06             VMORG:  .=.+   1          ; FIRST PAGE NUMBER OF VISIBLE MEMORY

5B07 48          SDTXT:  PHA               ; SAVE REGISTERS
5B08 8A                  TXA
5B09 48                  PHA
5B0A 98                  TYA
5B0B 48                  PHA
5B0C A900                LDA    #0         ; CLEAR UPPER ADP2
5B0E 85ED                STA    ADP2+1
5B10 BA                  TSX               ; GET INPUT BACK
5B11 BD0301              LDA    X'103,X
5B14 297F                AND    #X'7F      ; INSURE 7 BIT ASCII INPUT
5B16 38                  SEC
5B17 E920                SBC    #X'20      ; TEST IF A CONTROL CHARACTER
5B19 3047                BMI    SDTX10     ; JUMP IF SO

                 ;       CALCULATE TABLE ADDRESS FOR CHAR SHAPE AND PUT IT INTO ADPL

5B1B 85EC        SDTXT1: STA    ADP2       ; SAVE CHARACTER CODE IN ADP2
5B1D 20225C              JSR    SADP2L     ; COMPUTE 8*CHARACTER CODE IN ADP2
5B20 20225C              JSR    SADP2L
5B23 20225C              JSR    SADP2L
5B26 49FF                EOR    #X'FF      ; NEGATE CHARACTER CODE
5B28 38                  SEC               ; SUBSTRACT CHARACTER CODE FROM ADP2 AND
5B29 65EC                ADC    ADP2       ; PUT RESULT IN ADP1 FOR A FINAL RESULT OF
5B2B 85EA                STA    ADP1       ; 7*CHARACTER CODE
5B2D A5ED                LDA    ADP2+1
5B2F 69FF                ADC    #X'FF
5B31 85EB                STA    ADP1+1
5B33 A5EA                LDA    ADP1       ; ADD IN ORIGIN OF CHARACTER TABLE
5B35 18                  CLC
5B36 6921                ADC    #CHTB&X'FF
5B38 85EA                STA    ADP1
5B3A A5EB                LDA    ADP1+1
5B3C 695D                ADC    #CHTB/256
5B3E 85EB                STA    ADP1+1     ; ADP1 NOW HAS ADDRESS OF TOP ROW OF
                                           ; CHARACTER SHAPE
                 ;       COMPUTE BYTE AND BIT ADDRESS OF FIRST SCAN LINE OF
                 ;       CHARACTER AT CURSOR POSITION

5B40 20355C              JSR    CSRTAD     ; COMPUTE BYTE AND BIT ADDRESSES OF FIRST
                                           ; SCAN LINE OF CHARACTER AT CURSOR POS.

                 ;       SCAN OUT THE 7 CHARACTER ROWS

5B43 A000                LDY    #0         ; INITIALIZE Y INDEX=FONT TABLE POINTER
5B45 B1EA        SDTX2:  LDA    (ADP1),Y   ; GET A DOT ROW FROM THE FONT TABLE
5B47 20805C              JSR    MERGE      ; MERGE IT WITH GRAPHIC MEMORY AT (ADP2)
5B4A 20275C              JSR    DN1SCN     ; ADD 40 TO ADP2 TO MOVE DOWN ONE SCAN
                                           ; LINE IN GRAPHIC MEMORY
```

```
5B4D C8                 INY                ; BUMP UP POINTER INTO FONT TABLE
5B4E C007               CPY     #7         ; TEST IF DONE
5B50 D0F3               BNE     SDTX2      ; GO DO NEXT SCAN LINE IF NOT
5B52 AD045B             LDA     CSRX       ; DO A CURSOR RIGHT
5B55 C934               CMP     #NCHR-1    ; TEST IF LAST CHARACTER ON THE LINE
5B57 1006               BPL     SDTX3      ; SKIP CURSOR RIGHT IF SO
5B59 201A5C             JSR     CSRCLR     ; CLEAR OLD CURSOR
5B5C EE045B             INC     CSRX       ; MOVE CURSOR ONE POSITION RIGHT
5B5F 4CF85B    SDTX3:   JMP     SDTXRT     ; GO INSERT CURSOR, RESTORE REGISTERS,
                                           ; AND RETURN


               ;        INTERPRET CONTROL CODES

5B62 C9ED      SDTX10:  CMP     #X'0D-X'20 ; TEST IF CR
5B64 F00F               BEQ     SDTXCR     ; JUMP IF SO
5B66 C9EA               CMP     #X'0A-X'20 ; TEST IF LF
5B68 F047               BEQ     SDTXLF     ; JUMP IF SO
5B6A C9E8               CMP     #X'08-X'20 ; TEST IF BS
5B6C F012               BEQ     SDTXCL     ; JUMP IF SO
5B6E C9EC               CMP     #X'0C-X'20 ; TEST IF FF
5B70 F01E               BEQ     SDTXFF     ; JUMP IF SO
5B72 4CF85B             JMP     SDTXRT     ; GO RETURN IF UNRECOGNIZABLE CONTROL

5B75 201A5C    SDTXCR:  JSR     CSRCLR     ; CARRIAGE RETURN, FIRST CLEAR CURSOR
5B78 A900               LDA     #0         ; ZERO CURSOR HORIZONTAL POSITION
5B7A 8D045B             STA     CSRX
5B7D 4CF85B             JMP     SDTXRT     ; GO SET CURSOR AND RETURN

5B80 201A5C    SDTXCL:  JSR     CSRCLR     ; CURSOR LEFT, FIRST CLEAR CURSOR
5B83 AD045B             LDA     CSRX       ; GET CURSOR HORIZONTAL POSITION
5B86 C900               CMP     #0         ; TEST IF AGAINST LEFT EDGE
5B88 F003               BEQ     SDTX20     ; SKIP UPDATE IF SO
5B8A CE045B             DEC     CSRX       ; OTHERWISE DECREMENT CURSOR X POSITION
5B8D 4CF85B    SDTX20:  JMP     SDTXRT     ; GO SET CURSOR AND RETURN

5B90 AD065B    SDTXFF:  LDA     VMORG      ; FORM FEED, CLEAR SCREEN TO ZEROES
5B93 85ED               STA     ADP2+1     ; TRANSFER VISIBLE MEMORY ORIGIN ADDRESS
5B95 A900               LDA     #0         ; TO ADP2
5B97 85EC               STA     ADP2
5B99 A940               LDA     #NLOC&X'FF ; SET COUNT OF LOCATIONS TO CLEAR IN DCNT1
5B9B 8D015B             STA     DCNT1
5B9E A91F               LDA     #NLOC/256
5BA0 8D025B             STA     DCNT1+1
5BA3 20015D             JSR     FCLR       ; CLEAR THE SCREEN
5BA6 A900               LDA     #0
5BA8 8D045B             STA     CSRX       ; PUT CURSOR IN UPPER LEFT CORNER
5BAB 8D055B             STA     CSRY
5BAE 4CF85B             JMP     SDTXRT     ; GO SET CURSOR AND RETURN

5BB1 201A5C    SDTXLF:  JSR     CSRCLR     ; LINE FEED, FIRST CLEAR CURSOR
5BB4 AD055B             LDA     CSRY       ; GET CURRENT LINE POSITION
5BB7 C915               CMP     #NLIN-1    ; TEST IF AY BOTTOM OF SCREEN
5BB9 1005               BPL     SDTX40     ; GO SCROLL IF SO
5BBB EE055B             INC     CSRY       ; INCREMENT LINE NUMBER IF NOT AT BOTTOM
5BBE D038               BNE     SDTXRT     ; GO INSERT CURSOR AND RETURN
```

```
5BC0 A900      SDTX40:  LDA    #0            ; SET UP ADDRESS POINTERS FOR MOVE
5BC2 85EC               STA    ADP2          ; ADP1 - SOURCE FOR MOVE = FIRST BYTE OF
5BC4 AD065B             LDA    VMORG         ; SECOND LINE OF TEXT
5BC7 85ED               STA    ADP2+1        ; ADP2 = DESTINATION FOR MOVE = FIRST BYTE
5BC9 18                 CLC                  ; IN VISIBLE MEMORY
5BCA 6901               ADC    #CHHI*40/256
5BCC 85EB               STA    ADP1+1
5BCE A968               LDA    #CHHI*40&X'FF
5BD0 85EA               STA    ADP1
5BD2 A988               LDA    #NSCRL&X'FF  ; SET NUMBER OF LOCATIONS TO MOVE
5BD4 8D015B             STA    DCNT1         ; LOW PART
5BD7 A91D               LDA    #NSCRL/256    ; HIGH PART
5BD9 8D025B             STA    DCNT1+1
5BDC 20D35C             JSR    FMOVE         ; EXECUTE MOVE USING AN OPTIMIZED, HIGH
                                             ; SPEED MEMORY MOVE ROUTINE

                                             ; CLEAR LAST LINE OF TEXT
5BDF A988               LDA    #NLIN-1*CHHI*40&X'FF  ; SET ADDRESS POINTER
5BE1 85EC               STA    ADP2          ; LOW BYTE
5BE3 A91D               LDA    #NLIN-1*CHHI*40/256
5BE5 18                 CLC
5BE6 6D065B             ADC    VMORG
5BE9 85ED               STA    ADP2+1        ; HIGH BYTE
5BEB A9B8               LDA    #NCLR&X'FF    ; SET LOW BYTE OF CLEAR COUNT
5BED 8D015B             STA    DCNT1
5BF0 A901               LDA    #NCLR/256     ; SET HIGH BYTE OF CLEAR COUNT
5BF2 8D025B             STA    DCNT1+1
5BF5 20015D             JSR    FCLR          ; CLEAR THE DESIGNATED AREA

               ;        NO EFFECTIVE CHANGE IN CURSOR POSITION

5BF8 20125C    SDTXRT:  JSR    CSRSET        ; RETURN SEQUENCE, INSERT CURSOR
5BFB 68                 PLA                  ; RESTORE REGISTERS FROM THE STACK
5BFC A8                 TAY
5BFD 68                 PLA
5BFE AA                 TAX
5BFF 68                 PLA
5C00 60                 RTS                  ; RETURN
```

```
                           .PAGE  'SUBROUTINES FOR SDTXT'
                  ;        COMPUTE ADDRESS OF BYTE CONTAINING LAST SCAN LINE OF
                  ;        CHARACTER AT CURSOR POSITION
                  ;        ADDRESS = CSRTAD+(CHHI-1)*40   SINCE CHHI IS A CONSTANT 9,
                  ;        (CHHI-1)*40=320
                  ;        BTPT HOLDS BIT ADDRESS, 0=LEFTMOST

5C01 20355C       CSRBAD:  JSR    CSRTAD       ; COMPUTE ADDRESS OF TOP OF CHARACTER CELL
                                               ; FIRST
5C04 A5EC                  LDA    ADP2         ; ADD 320 TO RESULT = 8 SCAN LINES
5C06 18                    CLC
5C07 6940                  ADC    #320&X'FF
5C09 85EC                  STA    ADP2
5C0B A5ED                  LDA    ADP2+1
5C0D 6901                  ADC    #320/256
5C0F 85ED                  STA    ADP2+1
5C11 60                    RTS

                  ;        SET CURSOR AT CURRENT POSITION

5C12 20015C       CSRSET:  JSR    CSRBAD       ; GET BYTE AND BIT ADDRESS OF CURSOR
5C15 A9F8                  LDA    #X'F8        ; DATA = UNDERLINE CURSOR
5C17 4C805C       CSRST1:  JMP    MERGE        ; MERGE CURSOR WITH GRAPHIC MEMORY
                                               ; AND RETURN

                  ;        CLEAR CURSOR AT CURRENT POSITION

5C1A 20015C       CSRCLR:  JSR    CSRBAD       ; GET BYTE AND BIT ADDRESS OF CURSOR
5C1D A900                  LDA    #0           ; DATA = BLANK DOT ROW
5C1F 4C805C                JMP    MERGE        ; REMOVE DOT ROW FROM GRAPHIC MEMORY
                                               ; AND RETURN

                  ;        SHIFT ADP2 LEFT ONE BIT POSITION

5C22 06EC         SADP2L:  ASL    ADP2
5C24 26ED                  ROL    ADP2+1
5C26 60                    RTS

                  ;        MOVE DOWN ONE SCAN LINE      DOUBLE ADDS 40 TO ADP2

5C27 A5EC         DN1SCN:  LDA    ADP2         ; ADD 40 TO LOW BYTE
5C29 18                    CLC
5C2A 6928                  ADC    #40
5C2C 85EC                  STA    ADP2
5C2E A900                  LDA    #0           ; EXTEND CARRY TO UPPER BYTE
5C30 65ED                  ADC    ADP2+1
5C32 85ED                  STA    ADP2+1
5C34 60                    RTS                 ; RETURN

                  ;        COMPUTE BYTE ADDRESS CONTAINING FIRST SCAN LINE OF
                  ;        CHARACTER AT CURSOR POSITION AND PUT IN ADP2
                  ;        BIT ADDRESS (BIT 0 IS LEFTMOST) AT BTPT
                  ;        BYTE ADDRESS =VMORG*256+CHHI*40*CSRY+INT(CSRX*6/8)
                  ;        SINCE CHHI IS A CONSTANT 9, THEN CHHI*40=360
                  ;        BIT ADDRESS=REM(CSRX*5/8)
```

```

5C35 A900      CSRTAD: LDA    #0            ; AERO UPPER ADP2
5C37 85ED              STA    ADP2+1
5C39 AD055B            LDA    CSRY          ; FIRST COMPUTE 360*CSRY
5C3C 0A                ASLA                 ;   COMPUTE 9*CSRY DIRECTLY IN A
5C3D 0A                ASLA
5C3E 0A                ASLA
5C3F 6D055B            ADC    CSRY
5C42 85EC              STA    ADP2          ;   STORE 9*CSRY IN LOWER ADP2
5C44 20225C            JSR    SADP2L        ;   18*CSRY IN ADP2
5C47 20225C            JSR    SADP2L        ;   36*CSRY IN ADP2
5C4A 65EC              ADC    ADP2          ;   ADD IN 9*CSRY TO MAKE 45*CSRY
5C4C 85EC              STA    ADP2
5C4E A900              LDA    #0
5C50 65ED              ADC    ADP2+1
5C52 85ED              STA    ADP2+1        ;   45*CSRY IN ADP2
5C54 20225C            JSR    SADP2L        ;   90*CSRY IN ADP2
5C57 20225C            JSR    SADP2L        ;   180*CSRY IN ADP2
5C5A 20225C            JSR    SADP2L        ;   360*CSRY IN ADP2
5C5D AD045B            LDA    CSRX          ; NEXT COMPUTE 6*CSRX WHICH IS A 9 BIT
5C60 0A                ASLA                 ; VALUE
5C61 6D045B            ADC    CSRX
5C64 0A                ASLA
5C65 8D005B            STA    BTPT          ;   SAVE RESULT TEMPORARILY
5C68 6A                RORA                 ;   DIVIDE BY 8 AND TRUNCATE FOR INT
5C69 4A                LSRA                 ;   FUNCTION
5C6A 4A                LSRA                 ;   NOW HAVE INT(CSRX*6/8)
5C6B 18                CLC                  ; DOUBLE ADD TO ADP2
5C6C 65EC              ADC    ADP2
5C6E 85EC              STA    ADP2
5C70 A5ED              LDA    ADP2+1
5C72 6D065B            ADC    VMORG         ; ADD IN VMORG*256
5C75 85ED              STA    ADP2+1        ; FINISHED WITH ADP2
5C77 AD005B            LDA    BTPT          ; COMPUTE REM(CSRX*6/8) WHICH IS LOW 3
5C7A 2907              AND    #7            ; BITS OF CSRX*6
5C7C 8D005B            STA    BTPT          ; KEEP IN BTPT
5C7F 60                RTS                  ; FINISHED

               ;       MERGE A ROW OF 5 DOTS WITH GRAPHIC MEMORY STARTING AT BYTE
               ;       ADDRESS AND BIT NUMBER IN ADP2 AND BTPT
               ;       5 DOTS TO MERGE LEFT JUSTIFIED IN A
               ;       PRESERVES X AND Y

5C80 8D035B    MERGE:  STA    MRGT1         ; SAVE INPUT DATA
5C83 98                TYA                  ; SAVE Y
5C84 48                PHA
5C85 AC005B            LDY    BTPT          ; OPEN UP A 5 BIT WINDOW IN GRAPHIC MEMORY
5C88 B9C35C            LDA    MERGT, Y      ; LEFT BITS
5C8B A000              LDY    #0            ; ZERO Y
5C8D 31EC              AND    (ADP2),Y
5C8F 91EC              STA    (ADP2),Y
5C91 AC005B            LDY    BTPT
5C94 B9CB5C            LDA    MERGT+8,Y     ; RIGHT BITS
5C97 A001              LDY    #1
5C99 31EC              AND    (ADP2),Y
```

```
5C9B 91EC               STA    (ADP2),Y
5C9D AD035B             LDA    MRGT1         ; SHIFT DATA RIGHT TO LINE UP LEFTMOST
5CA0 AC005B             LDY    BTPT          ; DATA BIT WITH LEFTMOST GRAPHIC FIELD
5CA3 F004               BEQ    MERGE2        ; SHIFT BTPT TIMES
5CA5 4A        MERGE1:  LSRA
5CA6 88                 DEY
5CA7 D0FC               BNE    MERGE1
5CA9 11EC      MERGE2:  ORA    (ADP2),Y      ; OVERLAY WITH GRAPHIC MEMORY
5CAB 91EC               STA    (ADP2),Y
5CAD A908               LDA    #8            ; SHIFT DATA LEFT TO LINE UP RIGHTMOST
5CAF 38                 SEC                  ; DATA BIT WITH RIGHTMOST GRAPHIC FIELD
5CB0 ED005B             SBC    BTPT          ; SHIFT (8-BTPT) TIMES
5CB3 A8                 TAY
5CB4 AD035B             LDA    MRGT1
5CB7 0A        MERGE3:  ASLA
5CB8 88                 DEY
5CB9 D0FC               BNE    MERGE3
5CBB C8                 INY
5CBC 11EC               ORA    (ADP2),Y      ; OVERLAY WITH GRAPHIC MEMORY
5CBE 91EC               STA    (ADP2),Y
5CC0 68                 PLA                  ; RESTORE y
5CC1 A8                 TAY
5CC2 60                 RTS                  ; RETURN
5CC3 0783C1E0  MERGT:   .BYTE  X'07,X'83,X'C1,X'E0  ; TABLE OF MASKS FOR OPENING UP
5CC7 F0F8FCFE           .BYTE  X'F0,X'F8,X'FC,X'FE  ; A 5 BIT WINDOW ANYWHERE
5CCB FFFFFFFF           .BYTE  X'FF,X'FF,X'FF,X'FF  ; IN GRAPHIC MEMORY
5CCF 7F3F1F0F           .BYTE  X'7F,X'3F,X'1F,X'0F
               ;        FAST MEMORY MOVE ROUTINE
               ;        ENTER WITH SOURCE ADDRESS IN ADPT1 AND DESTINATION ADDRESS IN
               ;        ADPT2 AND MOVE COUNT (DOUBLE PRECISION) IN DCNT1.
               ;        MOVE PROCEEDS FROM LOW TO HIGH ADDRESSES AT APPROXIMATELY 16US
               ;        PER BYTE.
               ;        EXIT WITH ADDRESS POINTERS AND COUNT IN UNKNOWN STATE.
               ;        PRESERVES X AND Y REGISTERS.
5CD3 8A        FMOVE:   TXA                  ; SAVE X AND Y ON THE STACK
5CD4 48                 PHA
5CD5 98                 TYA
5CD6 48                 PHA
5CD7 CE025B    FMOVE1:  DEC    DCNT1+1       ; TEST IF LESS THAN 256 LEFT TO MOVE
5CDA 3015               BMI    FMOVE3        ; JUMP TO FINAL MOVE IF SO
5CDC A000               LDY    #0            ; MOVE A BLOCK OF 256 BYTES QUICKLY
5CDE B1EA      FMOVE2:  LDA    (ADP1),Y      ; TWO BYTES AT A TIME
5CE0 91EC               STA    (ADP2),Y
5CE2 C8                 INY
5CE3 B1EA               LDA    (ADP1),Y
5CE5 91EC               STA    (ADP2),Y
5CE7 C8                 INY
5CE8 D0F4               BNE    FMOVE2        ; CONTINUE UNTIL DONE
5CEA E6EB               INC    ADP1+1        ; BUMP ADDRESS POINTERS TO NEXT PAGE
5CEC E6ED               INC    ADP2+1
5CEE 4CD75C             JMP    FMOVE1        ; GO MOVE NEXT PAGE
5CF1 AE015B    FMOVE3:  LDX    DCNT1         ; GET REMAINING BYTE COUNT INTO X
```

```
5CF4 B1EA      FMOVE4:  LDA    (ADP1),Y      ; MOVE A BYTE
5CF6 91EC               STA    (ADP2),Y
5CF8 C8                 INY
5CF9 CA                 DEX
5CFA D0F8               BNE    FMOVE4        ; CONTINUE UNTIL DONE
5CFC 68                 PLA                  ; RESTORE INDEX REGISTERS
5CFD A8                 TAY
5CFE 68                 PLA
5CFF AA                 TAX
5D00 60                 RTS                  ; AND RETURN

               ;        FAST MEMORY CLEAR ROUTINE
               ;        ENTER WITH ADDRESS OF BLOCK TO CLEAR IN ADP2 AND CLEAR COUNT
               ;        IN DCNT1.
               ;        EXIT WITH ADDRESS POINTERS AND COUNT IN UNKNOWN STATE
               ;        PRESERVES X AND Y REGISTERS

5D01 98        FCLR:    TYA                  ; SAVE Y
5D02 48                 PHA
5D03 A000      FCLR1:   LDY    #0
5D05 CE025B             DEC    DCNT1+1       ; TEST IF LESS THAN 256 LEFT TO MOVE
5D08 300B               BMI    FCLR3         ; JUMP INTO FINAL CLEAR IF SO
5D0A 98                 TYA                  ; CLEAR A BLOCK OF 256 QUICKLY
5D0B 91EC      FCLR2:   STA    (ADP2),Y      ; CLEAR A BYTE
5D0D C8                 INY
5D0E D0FB               BNE    FCLR2
5D10 E6ED               INC    ADP2+1        ; BUMP ADDRESS POINTER TO NEXT PAGE
5D12 4C035D             JMP    FCLR1         ; GO CLEAR NEXT PAGE
5D15 98        FCLR3:   TYA                  ; CLEAR REMAINING PARTIAL PAGE
5D16 91EC      FCLR4:   STA    (ADP2),Y
5D18 C8                 INY
5D19 CE015B             DEC    DCNT1
5D1C D0F8               BNE    FCLR4
5D1E 68                 PLA                  ; RESTORE Y
5D1F A8                 TAY
5D20 60                 RTS                  ; RETURN
```

```
                                .PAGE    'CHARACTER FONT TABLE'
                        ;       CHARACTER FONT TABLE
                        ;       ENTRIES IN ORDER STARTING AT ASCII BLANK
                        ;       96 ENTRIES
                        ;       EACH ENTRY CONTAINS 7 BYTES
                        ;       7 BYTES ARE CHARACTER MATRIX, TOP ROW FIRST, LEFTMOST DOT
                        ;       IS LEFTMOST IN BYTE
                        ;       LOWER CASE FONT IS SMALL UPPER CASE, 5 BY 5 MATRIX

 5D21 000000    CHTB:   .BYTE       X'00,X'00,X'00    ; BLANK
 5D24 00000000          .BYTE  X'00,X'00,X'00,X'00
 5D28 202020            .BYTE       X'20,X'20,X'20    ; !
 5D2B 20200020          .BYTE  X'20,X'20,X'00,X'20
 5D2F 505050            .BYTE       X'50,X'50,X'50    ; "
 5D32 00000000          .BYTE  X'00,X'00,X'00,X'00
 5D36 5050F8            .BYTE       X'50,X'50,X'F8    ; #
 5D39 50F85050          .BYTE  X'50,X'F8,X'50,X'50
 5D3D 2078A0            .BYTE       X'20,X'78,X'A0    ; X'
 5D40 7028F020          .BYTE  X'70,X'28,X'F0,X'20
 5D44 C8C810            .BYTE       X'C8,X'C8,X'10    ; %
 5D47 20409898          .BYTE  X'20,X'40,X'98,X'98
 5D4B 40A0A0            .BYTE       X'40,X'A0,X'A0    ; &
 5D4E 40A89068          .BYTE  X'40,X'A8,X'90,X'68
 5D52 303030            .BYTE       X'30,X'30,X'30    ; '
 5D55 00000000          .BYTE  X'00,X'00,X'00,X'00
 5D59 204040            .BYTE       X'20,X'40,X'40    ; (
 5D5C 40404020          .BYTE  X'40,X'40,X'40,X'20
 5D60 201010            .BYTE       X'20,X'10,X'10    ; )
 5D63 10101020          .BYTE  X'10,X'10,X'10,X'20
 5D67 20A870            .BYTE       X'20,X'A8,X'70    ; *
 5D6A 2070A820          .BYTE  X'20,X'70,X'A8,X'20
 5D6E 002020            .BYTE       X'00,X'20,X'20    ; +
 5D71 F8202000          .BYTE  X'F8,X'20,X'20,X'00
 5D75 000000            .BYTE       X'00,X'00,X'00    ; ,
 5D78 30301020          .BYTE  X'30,X'30,X'10,X'20
 5D7C 000000            .BYTE       X'00,X'00,X'00    ; -
 5D7F F8000000          .BYTE  X'F8,X'00,X'00,X'00
 5D83 000000            .BYTE       X'00,X'00,X'00    ; .
 5D86 00003030          .BYTE  X'00,X'00,X'30,X'30
 5D8A 080810            .BYTE       X'08,X'08,X'10    ; /
 5D8D 20408080          .BYTE  X'20,X'40,X'80,X'80
 5D91 609090            .BYTE       X'60,X'90,X'90    ; 0
 5D94 90909060          .BYTE  X'90,X'90,X'90,X'60
 5D98 206020            .BYTE       X'20,X'60,X'20    ; 1
 5D9B 20202070          .BYTE  X'20,X'20,X'20,X'70
 5D9F 708810            .BYTE       X'70,X'88,X'10    ; 2
 5DA2 204080F8          .BYTE  X'20,X'40,X'80,X'F8
 5DA6 708808            .BYTE       X'70,X'88,X'08    ; 3
 5DA9 30088870          .BYTE  X'30,X'08,X'88,X'70
 5DAD 103050            .BYTE       X'10,X'30,X'50    ; 4
 5DB0 90F81010          .BYTE  X'90,X'F8,X'10,X'10
 5DB4 F880F0            .BYTE       X'F8,X'80,X'F0    ; 5
 5DB7 080808F0          .BYTE  X'08,X'08,X'08,X'F0
 5DBB 708080            .BYTE       X'70,X'80,X'80    ; 6
 5DBE F0888870          .BYTE  X'F0,X'88,X'88,X'70
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5DC2 F80810              .BYTE        X'F8,X'08,X'10    ; 7
5DC5 20408080            .BYTE  X'20,X'40,X'80,X'80
5DC9 708888              .BYTE        X'70,X'88,X'88    ; 8
5DCC 70888870            .BYTE  X'70,X'88,X'88,X'70
5DD0 708888              .BYTE        X'70,X'88,X'88    ; 9
5DD3 78080870            .BYTE  X'78,X'08,X'08,X'70
5DD7 303000              .BYTE        X'30,X'30,X'00    ; :
5DDA 00003030            .BYTE  X'00,X'00,X'30,X'30
5DDE 303000              .BYTE        X'30,X'30,X'00    ; ;
5DE1 30301020            .BYTE  X'30,X'30,X'10,X'20
5DE5 102040              .BYTE        X'10,X'20,X'40    ; LESS THAN
5DE8 80402010            .BYTE  X'80,X'40,X'20,X'10
5DEC 0000F8              .BYTE        X'00,X'00,X'F8    ; =
5DEF 00F80000            .BYTE  X'00,X'F8,X'00,X'00
5DF3 402010              .BYTE        X'40,X'20,X'10    ; GREATER THAN
5DF6 08102040            .BYTE  X'08,X'10,X'20,X'40
5DFA 708808              .BYTE        X'70,X'88,X'08    ; ?
5DFD 10200020            .BYTE  X'10,X'20,X'00,X'20
5E01 708808              .BYTE        X'70,X'88,X'08    ; @
5E04 68A8A8D0            .BYTE  X'68,X'A8,X'A8,X'D0
5E08 205088              .BYTE        X'20,X'50,X'88    ; A
5E0B 88F88888            .BYTE  X'88,X'F8,X'88,X'88
5E0F F04848              .BYTE        X'F0,X'48,X'48    ; B
5E12 704848F0            .BYTE  X'70,X'48,X'48,X'F0
5E16 708880              .BYTE        X'70,X'88,X'80    ; C
5E19 80808870            .BYTE  X'80,X'80,X'88,X'70
5E1D F04848              .BYTE        X'F0,X'48,X'48    ; D
5E20 484848F0            .BYTE  X'48,X'48,X'48,X'F0
5E24 F88080              .BYTE        X'F8,X'80,X'80    ; E
5E27 F08080F8            .BYTE  X'F0,X'80,X'80,X'F8
5E2B F88080              .BYTE        X'F8,X'80,X'80    ; F
5E2E F0808080            .BYTE  X'F0,X'80,X'80,X'80
5E32 708880              .BYTE        X'70,X'88,X'80    ; G
5E35 B8888870            .BYTE  X'B8,X'88,X'88,X'70
5E39 888888              .BYTE        X'88,X'88,X'88    ; H
5E3C F8888888            .BYTE  X'F8,X'88,X'88,X'88
5E40 702020              .BYTE        X'70,X'20,X'20    ; I
5E43 20202070            .BYTE  X'20,X'20,X'20,X'70
5E47 381010              .BYTE        X'38,X'10,X'10    ; J
5E4A 10109060            .BYTE  X'10,X'10,X'90,X'60
5E4E 8890A0              .BYTE        X'88,X'90,X'A0    ; K
5E51 C0A09088            .BYTE  X'C0,X'A0,X'90,X'88
5E55 808080              .BYTE        X'80,X'80,X'80    ; L
5E58 808080F8            .BYTE  X'80,X'80,X'80,X'F8
5E5C 88D8A8              .BYTE        X'88,X'D8,X'A8    ; M
5E5F A8888888            .BYTE  X'A8,X'88,X'88,X'88
5E63 8888C8              .BYTE        X'88,X'88,X'C8    ; N
5E66 A8988888            .BYTE  X'A8,X'98,X'88,X'88
5E6A 708888              .BYTE        X'70,X'88,X'88    ; O
5E6D 88888870            .BYTE  X'88,X'88,X'88,X'70
5E71 F08888              .BYTE        X'F0,X'88,X'88    ; P
5E74 F0808080            .BYTE  X'F0,X'80,X'80,X'80
5E78 708888              .BYTE        X'70,X'88,X'88    ; Q
5E7B 88A89068            .BYTE  X'88,X'A8,X'90,X'68
5E7F F08888              .BYTE        X'F0,X'88,X'88    ; R
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5E82 F0A09088        .BYTE  X'F0,X'A0,X'90,X'88
5E86 788080          .BYTE       X'78,X'80,X'80    ; S
5E89 700808F0        .BYTE  X'70,X'08,X'08,X'F0
5E8D F82020          .BYTE       X'F8,X'20,X'20    ; T
5E90 20202020        .BYTE  X'20,X'20,X'20,X'20
5E94 888888          .BYTE       X'88,X'88,X'88    ; U
5E97 88888870        .BYTE  X'88,X'88,X'88,X'70
5E9B 888888          .BYTE       X'88,X'88,X'88    ; V
5E9E 50502020        .BYTE  X'50,X'50,X'20,X'20
5EA2 888888          .BYTE       X'88,X'88,X'88    ; W
5EA5 A8A8D888        .BYTE  X'A8,X'A8,X'D8,X'88
5EA9 888850          .BYTE       X'88,X'88,X'50    ; X
5EAC 20508888        .BYTE  X'20,X'50,X'88,X'88
5EB0 888850          .BYTE       X'88,X'88,X'50    ; Y
5EB3 20202020        .BYTE  X'20,X'20,X'20,X'20
5EB7 F80810          .BYTE       X'F8,X'08,X'10    ; Z
5EBA 204080F8        .BYTE  X'20,X'40,X'80,X'F8
5EBE 704040          .BYTE       X'70,X'40,X'40    ; LEFT BRACKET
5EC1 40404070        .BYTE  X'40,X'40,X'40,X'70
5EC5 808040          .BYTE       X'80,X'80,X'40    ; BACKSLASH
5EC8 20100808        .BYTE  X'20,X'10,X'08,X'08
5ECC 701010          .BYTE       X'70,X'10,X'10    ; RIGHT BRACKET
5ECF 10101070        .BYTE  X'10,X'10,X'10,X'70
5ED3 205088          .BYTE       X'20,X'50,X'88    ; CARROT
5ED6 00000000        .BYTE  X'00,X'00,X'00,X'00
5EDA 000000          .BYTE       X'00,X'00,X'00    ; UNDERLINE
5EDD 000000F8        .BYTE  X'00,X'00,X'00,X'F8
5EE1 C06030          .BYTE       X'C0,X'60,X'30    ; GRAVE ACCENT
5EE4 00000000        .BYTE  X'00,X'00,X'00,X'00
5EE8 000020          .BYTE       X'00,X'00,X'20    ; A (LC)
5EEB 5088F888        .BYTE  X'50,X'88,X'F8,X'88
5EEF 0000F0          .BYTE       X'00,X'00,X'F0    ; B (LC)
5EF2 487048F0        .BYTE  X'48,X'70,X'48,X'F0
5EF6 000078          .BYTE       X'00,X'00,X'78    ; C (LC)
5EF9 80808078        .BYTE  X'80,X'80,X'80,X'78
5EFD 0000F0          .BYTE       X'00,X'00,X'F0    ; D (LC)
5F00 484848F0        .BYTE  X'48,X'48,X'48,X'F0
5F04 0000F8          .BYTE       X'00,X'00,X'F8    ; E (LC)
5F07 80E080F8        .BYTE  X'80,X'E0,X'80,X'F8
5F0B 0000F8          .BYTE       X'00,X'00,X'F8    ; F (LC)
5F0E 80E08080        .BYTE  X'80,X'E0,X'80,X'80
5F12 000078          .BYTE       X'00,X'00,X'78    ; G (LC)
5F15 80988878        .BYTE  X'80,X'98,X'88,X'78
5F19 000088          .BYTE       X'00,X'00,X'88    ; H (LC)
5F1C 88F88888        .BYTE  X'88,X'F8,X'88,X'88
5F20 000070          .BYTE       X'00,X'00,X'70    ; I (LC)
5F23 20202070        .BYTE  X'20,X'20,X'20,X'70
5F27 000038          .BYTE       X'00,X'00,X'38    ; J (LC)
5F2A 10105020        .BYTE  X'10,X'10,X'50,X'20
5F2E 000090          .BYTE       X'00,X'00,X'90    ; K (LC)
5F31 A0C0A090        .BYTE  X'A0,X'C0,X'A0,X'90
5F35 000080          .BYTE       X'00,X'00,X'80    ; L (LC)
5F38 808080F8        .BYTE  X'80,X'80,X'80,X'F8
5F3C 000088          .BYTE       X'00,X'00,X'88    ; M (LC)
5F3F D8A88888        .BYTE  X'D8,X'A8,X'88,X'88
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5F43 000088             .BYTE       X'00,X'00,X'88    ; N (LC)
5F46 C8A89888           .BYTE  X'C8,X'A8,X'98,X'88
5F4A 000070             .BYTE       X'00,X'00,X'70    ; O (LC)
5F4D 88888870           .BYTE  X'88,X'88,X'88,X'70
5F51 0000F0             .BYTE       X'00,X'00,X'F0    ; P (LC)
5F54 88F08080           .BYTE  X'88,X'F0,X'80,X'80
5F58 000070             .BYTE       X'00,X'00,X'70    ; Q (LC)
5F5B 88A89068           .BYTE  X'88,X'A8,X'90,X'68
5F5F 0000F0             .BYTE       X'00,X'00,X'F0    ; R (LC)
5F62 88F0A090           .BYTE  X'88,X'F0,X'A0,X'90
5F66 000078             .BYTE       X'00,X'00,X'78    ; S (LC)
5F69 807008F0           .BYTE  X'80,X'70,X'08,X'F0
5F6D 0000F8             .BYTE       X'00,X'00,X'F8    ; T (LC)
5F70 20202020           .BYTE  X'20,X'20,X'20,X'20
5F74 000088             .BYTE       X'00,X'00,X'88    ; U (LC)
5F77 88888870           .BYTE  X'88,X'88,X'88,X'70
5F7B 000088             .BYTE       X'00,X'00,X'88    ; V (LC)
5F7E 88885020           .BYTE  X'88,X'88,X'50,X'20
5F82 000088             .BYTE       X'00,X'00,X'88    ; W (LC)
5F85 88A8D888           .BYTE  X'88,X'A8,X'D8,X'88
5F89 000088             .BYTE       X'00,X'00,X'88    ; X (LC)
5F8C 50205088           .BYTE  X'50,X'20,X'50,X'88
5F90 000088             .BYTE       X'00,X'00,X'88    ; Y (LC)
5F93 50202020           .BYTE  X'50,X'20,X'20,X'20
5F97 0000F8             .BYTE       X'00,X'00,X'F8    ; Z (LC)
5F9A 102040F8           .BYTE  X'10,X'20,X'40,X'F8
5F9E 102020             .BYTE       X'10,X'20,X'20    ; LEFT BRACE
5FA1 60202010           .BYTE  X'60,X'20,X'20,X'10
5FA5 202020             .BYTE       X'20,X'20,X'20    ; VERTICAL BAR
5FA8 20202020           .BYTE  X'20,X'20,X'20,X'20
5FAC 402020             .BYTE       X'40,X'20,X'20    ; RIGHT BRACE
5FAF 30202040           .BYTE  X'30,X'20,X'20,X'40
5FB3 10A840             .BYTE       X'10,X'A8,X'40    ; TILDA
5FB6 00000000           .BYTE  X'00,X'00,X'00,X'00
5FBA A850A8             .BYTE       X'A8,X'50,X'A8    ; RUBOUT
5FBD 50A850A8           .BYTE  X'50,X'A8,X'50,X'A8

0000                    .END
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NO ERROR LINES

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                        .PAGE 'DOCUMENTATION, EQUATES, STORAGE'

                ;       THIS PACKAGE PROVIDES FUNDAMENTAL GRAPHICS ORIENTED
                ;       SUBROUTINES NEEDED FOR EFFECTIVE USE OF THE VISIBLE MEMORY AS
                ;       A GRAPHIC DISPLAY DEVICE.  MAJOR SUBROUTINES INCLUDED ARE AS
                ;       FOLLOWS:
                ;          CLEAR - CLEARS THE ENTIRE VISIBLE MEMORY AS DEFINED BY
                ;                  NPIX/8
                ;          PIXADR- RETURNS BYTE AND BIT ADDRESS OF PIXEL AT X1CORD,
                ;                  Y1CORD
                ;          CKCRD1- PERFORM A RANGE CHECK ON X1CORD,Y1CORD
                ;          CKCRD2- PERFORM A RANGE CHECK ON X2CORD,Y2CORD
                ;          STPIX - SET PIXEL AT X1CORD,Y1CORD TO A ONE (WHITE DOT)
                ;          CLPIX - CLEAR PIXEL AT X1CORD,Y1CORD TO ZERO (BLACK DOT)
                ;          FLPIX - FLIP THE PIXEL AT X1CORD,Y1CORD
                ;          WRPIX - UPDATE PIXEL AT X1CORD,Y1CORD ACCORDING TO THE
                ;                  STATE OF THE ACCUMULATOR
                ;          RDPIX - COPY THE STATE OF THE PIXEL AT X1CORD,Y1CORD INTO
                ;                  THE ACCUMULATOR
                ;          DRAW -  DRAW THE BEST STRAIGHT LINE FROM X1CORD,Y1CORD
                ;                  TO X2CORD,Y2CORD. X2CORD,Y2CORD COPIED TO
                ;                  X1CORD,Y1CORD AFTER DRAWING
                ;          ERASE - SAME AS DRAW EXCEPT A BLACK LINE IS DRAWN
                ;          DCHAR - DISPLAYS A CHARACTER WHOSE UPPER LEFT CORNER IS
                ;                  X1CORD,Y1CORD. CHARACTER MATRIX IS 5 WIDE BY 9
                ;                  HIGH INCLUDING LOWER CASE DESCENDERS BUT NOT
                ;                  INCLUDING CHARACTER AND LINE SPACING.
                ;          DTEXT - ACCEPTS ASCII CHARACTERS AND FORMATS THEM INTO
                ;                  TEXT. A STANDARD (BUT EASILY MODIFIED) CHARACTER
                ;                  FIELD 6 WIDE BY 11 HIGH ALLOWS UP TO 18 LINES OF 53
                ;                  CHARACTERS. SUBSCRIPT AND SUPERSCRIPT VIA CONTROL
                ;                  CHARACTERS IS IMPLEMENTED.
                ;          DTXTIN- INITIALIZE PARAMETERS FOR USE OF DTEXT ON FULL
                ;                  SCREEN.
                ;
                ;       ALL SUBROUTINES DEPEND ON ONE OR TWO PAIRS OF COORDINATES.
                ;       EACH COORDINATE IS A DOUBLE PRECISION, UNSIGNED NUMBER WITH
                ;       THE LOW BYTE FIRST (I.E.  LIKE MEMORY ADDRESSES IN THE 6502)
                ;       THE ORIGIN OF THE COORDINATE SYSTEM IS AT THE LOWER LEFT
                ;       CORNER OF THE SCREEN THEREFORE THE ENITRE SCREEN IS IN THE
                ;       FIRST QUADRANT.  ALLOWABLE RANGE OF THE X COORDINATE IS 0 TO
                ;       319 (DECIMAL) AND THE RANGE OF THE Y COORDINATE IS 0 TO 199.
                ;       FOR MAXIMUM SPEED ALL SUBROUTINES ASSUME THAT THE COORDINATE
                ;       VALUES ARE IN RANGE.  IF THEY ARE NOT, WILD STORING INTO ANY
                ;       PART OF KIM RAM IS POSSIBLE.  FOR DEBUGGING, CALLS TO CKCRD1
                ;       AND CKCRD2 SHOULD BE PERFORMED PRIOR TO GRAPHIC ROUTINE CALLS
                ;       IN ORDER TO DETECT AND CORRECT ERRONEOUS COORDINATE VALUES.

                ;       GENERAL EQUATES

   0140         NX      =      320          ; NUMBER OF BITS IN A ROW
   00C8         NY      =      200          ; NUMBER OF ROWS  (CHANGE FOR HALF SCREEN
                                            ; OPERATION)
   FA00         NPIX    =      NX*NY        ; NUMBER OF PIXELS
   000B         CHHIW   =      11           ; HEIGHT OF CHARACTER WINDOW
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0006           CHWIDW   =      6            ; WIDTH OF CHARACTER WINDOW
0009           CHHIM    =      9            ; HEIGHT OF CHARACTER MATRIX
0005           CHWIDM   =      5            ; WIDTH OF CHARACTER MATRIX

               ;        BASE PAGE TEMPORARY STORAGE (MAY BE DESTROYED BETWEEN CALLS)

0000                    .=     X'EA

00EA           ADP1:    .=.+   2            ; ADDRESS POINTER 1
00EC           ADP2:    .=.+   2            ; ADDRESS POINTER 2

               ;        PERMANENT RAM STORAGE  (MUST BE PRESERVED BETWEEN CALLS)
               ;******* THESE PARAMETERS MUST BE SET BEFORE USING GRAPHIC ************
               ;******************* ROUTINES THAT REFERENCE THEM *********************

00EE                    .=     X'100        ; PUT IN STACK AREA FOR CONVENIENCE

0100           VMORG:   .=.+   1            ; PAGE NUMBER OF FIRST VISIBLE MEMORY
                                            ; LOCATION
0101           X1CORD:  .=.+   2            ; COORDINATE PAIR 1 AND CURSOR LOCATION
0103           Y1CORD:  .=.+   2
0105           X2CORD:  .=.+   2            ; COORDINATE PAIR 2
0107           Y2CORD:  .=.+   2
0109           TMAR:    .=.+   2            ; TOP MARGIN FOR DTEXT
010B           BMAR:    .=.+   2            ; BOTTOM MARGIN FOR DTEXT
010D           LMAR:    .=.+   2            ; LEFT MARGIN FOR DTEXT
010F           RMAR:    .=.+   2            ; RIGHT MARGIN FOR DTEXT

               ;        GENERAL TEMPORARY STORAGE (CAN BE DESTROYED BETWEEN CALLS)

0111           BTPT:    .=.+   1            ; BIT NUMBER
0112           DELTAX:  .=.+   2            ; DELTA X FOR LINE DRAW
0114           DELTAY:  .=.+   2            ; DELTA Y FOR LINE DRAW
0116           ACC:     .=.+   2            ; ACCUMULATOR FOR LINE DRAW
0118           XDIR:    .=.+   1            ; X MOVEMENT DIRECTION, ZERO=+
0119           YDIR:    .=.+   1            ; Y MOVEMENT DIRECTION, ZERO=+
011A           XCHFLG:  .=.+   1            ; EXCHANGE X AND Y FLAG, EXCHANGE IF NOT 0
011B           COLOR:   .=.+   1            ; COLOR OF LINE DRAWN -1=WHITE
011C           TEMP:    .=.+   2            ; TEMPORARY STORAGE
0112           TLBYT    =      DELTAX       ; TOP LEFT BYTE ADDRESS FOR TEXT WINDOW
0118           TLBIT    =      XDIR         ; TOP LEFT BIT ADDRESS FOR TEXT WINDOW
0114           TRBYT    =      DELTAY       ; TOP RIGHT BYTE ADDRESS FOR TEXT WINDOW
0119           TRBIT    =      YDIR         ; TOP RIGHT BIT ADDRESS FOR TEXT WINDOW
0116           BRBYT    =      ACC          ; BOTTOM RIGHT BYTE ADDRESS FOR TXT WINDOW
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                            .PAGE  'CLEAR ENTIRE SCREEN ROUTINE'
                  ;         CLEAR ENTIRE SCREEN ROUTINE
                  ;         USES BOTH INDICES AND ADP1

    011E                    .=     X'5500         ; PUT AT END OF 16K EXPANSION

    5500 A000     CLEAR:    LDY    #0             ; INITIALIZE ADDRESS POINTER
    5502 84EA               STY    ADP1           ; AND ZERO INDEX Y
    5504 AD0001             LDA    VMORG
    5507 85EB               STA    ADP1+1
    5509 18                 CLC                   ; COMPUTE END ADDRESS
    550A 691F               ADC    #NPIX/8/256
    550C AA                 TAX                   ; KEEP IT IN X
    550D 98       CLEAR1:   TYA                   ; CLEAR A BYTE
    550E 91EA               STA    (ADP1),Y
    5510 E6EA               INC    ADP1           ; INCREMENT ADDRESS POINTER
    5512 D002               BNE    CLEAR2
    5514 E6EB               INC    ADP1+1
    5516 A5EA     CLEAR2:   LDA    ADP1           ; TEST IF DONE
    5518 C940               CMP    #NPIX/8&X'FF
    551A D0F1               BNE    CLEAR1         ; LOOP IF NOT
    551C E4EB               CPX    ADP1+1
    551E D0ED               BNE    CLEAR1         ; LOOP IF NOT
    5520 60                 RTS                   ; RETURN
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                                .PAGE  'PIXADR - BYTE AND BIT ADDRESS OF A PIXEL'
                     ;          PIXADR - FIND THE BYTE ADDRESS AND BIT NUMBER OF PIXEL AT
                     ;                   X1CORD,Y1CORD
                     ;          PUTS BYTE ADDRESS IN ADP1 AND BIT MUMBER (BIT 0 IS LEFTMOST)
                     ;          IN BTPT.
                     ;          DOES NOT CHECK MAGNITUDE OF COORDINATES FOR MAXIMUM SPEED
                     ;          PRESERVES X AND Y REGISTERS, DESTROYS A
                     ;          BYTE ADDRESS = VMORG*256+(199-Y1CORD)*40+INT(XCORD/8)
                     ;          BIT ADDRESS = REM(XCORD/8)
                     ;          OPTIMIZED FOR SPEED THEREFORE CALLS TO A DOUBLE SHIFT ROUTINE
                     ;          ARE NOT DONE

 5521 AD0101    PIXADR: LDA    X1CORD        ; COMPUTE BIT ADDRESS FIRST
 5524 85EA              STA    ADP1          ; ALSO TRANSFER X1CORD TO ADP1
 5526 2907              AND    #X'07         ; WHICH IS SIMPLY THE LOW 3 BITS OF X
 5528 8D1101            STA    BTPT
 552B AD0201            LDA    X1CORD+1      ; FINISH TRANSFERRING X1CORD TO ADP1
 552E 85EB              STA    ADP1+1
 5530 46EB              LSR    ADP1+1        ; DOUBLE SHIFT ADP1 RIGHT 3 TO GET
 5532 66EA              ROR    ADP1          ; INT(XCORD/8)
 5534 46EB              LSR    ADP1+1
 5536 66EA              ROR    ADP1
 5538 46EB              LSR    ADP1+1
 553A 66EA              ROR    ADP1
 553C A9C7              LDA    #199          ; TRANSFER (199-Y1CORD) TO ADP2
 553E 38                SEC                  ; AND TEMPORARY STORAGE
 553F ED0301            SBC    Y1CORD
 5542 85EC              STA    ADP2
 5544 8D1C01            STA    TEMP
 5547 A900              LDA    #0
 5549 ED0401            SBC    Y1CORD+1
 554C 85ED              STA    ADP2+1
 554E 8D1D01            STA    TEMP+1
 5551 06EC              ASL    ADP2          ; COMPUTE 40*(199-Y1CORD)
 5553 26ED              ROL    ADP2+1        ;  2*(199-Y1CORD)
 5555 06EC              ASL    ADP2
 5557 26ED              ROL    ADP2+1        ;  4*(199+Y1CORD)
 5559 A5EC              LDA    ADP2          ;  ADD IN TEMPORARY SAVE OF (199-Y1CORD)
 555B 18                CLC                  ;  TO MAKE 5*(199-Y1CORD)
 555C 6D1C01            ADC    TEMP
 555F 85EC              STA    ADP2
 5561 A5ED              LDA    ADP2+1
 5563 6D1D01            ADC    TEMP+1
 5566 85ED              STA    ADP2+1        ;  5*(199-Y1CORD)
 5568 06EC              ASL    ADP2          ;  10*(199-Y1CORD)
 556A 26ED              ROL    ADP2+1
 556C 06EC              ASL    ADP2          ;  20*(199-Y1CORD)
 556E 26ED              ROL    ADP2+1
 5570 06EC              ASL    ADP2          ;  40*(199-Y1CORD)
 5572 26ED              ROL    ADP2+1
 5574 A5EC              LDA    ADP2          ; ADD IN INT(X1CORD/8) COMPUTED EARLIER
 5576 18                CLC
 5577 65EA              ADC    ADP1
 5579 85EA              STA    ADP1
 557B A5ED              LDA    ADP2+1
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557D 65EB                ADC    ADP1+1
557F 6D0001              ADC    VMORG        ; ADD IN VMORG*256
5582 85EB                STA    ADP1+1       ; FINAL RESULT
5584 60                  RTS                 ; RETURN
```

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                                .PAGE  'INDIVIDUAL PIXEL SUBROUTINES'
                     ;          STPIX - SETS THE PIXEL AT X1CORD,Y1CORD TO A ONE (WHITE DOT)
                     ;          DOES NOT ALTER X1CORD OR Y1CORD
                     ;          PRESERVES X AND Y
                     ;          ASSUMES IN RANGE CORRDINATES

     5585 202155     STPIX:     JSR    PIXADR        ; GET BYTE ADDRESS AND BIT NUMBER OF PIXEL
                                                     ; INTO ADP1
     5588 98                    TYA                  ; SAVE Y
     5589 48                    PHA
     558A AC1101                LDY    BTPT          ; GET BIT NUMBER IN Y
     558D B9EC55                LDA    MSKTB1,Y      ; GET A BYTE WITH THAT BIT =1, OTHERS =0
     5590 A000                  LDY    #0            ; ZERO Y
     5592 11EA                  ORA    (ADP1),Y      ; COMBINE THE BIT WITH THE ADDRESSED VM
     5594 91EA                  STA    (ADP1),Y      ; BYTE
     5596 68                    PLA                  ; RESTORE Y
     5597 A8                    TAY
     5598 60                    RTS                  ; AND RETURN

                     ;          CLPIX - CLEARS THE PIXEL AT X1CORD,Y1CORD TO A ZERO (BLACK DOT
                     ;          DOES NOT ALTER X1CORD OR Y1CORD
                     ;          PRESERVES X AND Y
                     ;          ASSUMES IN RANGE COORDINATES

     5599 202155     CLPIX:     JSR    PIXADR        ; GET BYTE ADDRESS AND BIT NUMBER OF PIXEL
                                                     ; INTO ADP1
     559C 98                    TYA                  ; SAVE Y
     559D 48                    PHA
     559E AC1101                LDY    BTPT          ; GET BIT NUMBER IN Y
     55A1 B9F455                LDA    MSKTB2,Y      ; GET A BYTE WITH THAT BIT =0, OTHERS =1
     55A4 A000                  LDY    #0            ; ZERO Y
     55A6 31EA                  AND    (ADP1),Y      ; REMOVE THE BIT FROM THE ADDRESSED VM
     55A8 91EA       CLPIX1:    STA    (ADP1),Y      ; BYTE
     55AA 68                    PLA                  ; RESTORE Y
     55AB A8                    TAY
     55AC 60                    RTS                  ; AND RETURN

                     ;          FLPIX - FLIPS THE PIXEL AT X1CORD,Y1CORD
                     ;          DOES NOT ALTER X1CORD OR Y1CORD
                     ;          PRESERVES X AND Y
                     ;          ASSUMES IN RANGE COORDINATES

     55AD 202155     FLPIX:     JSR    PIXADR        ; GET BYTE ADDRESS AND BIT NUMBER OF PIXEL
                                                     ; INTO ADP1
     55B0 98                    TYA                  ; SAVE Y
     55B1 48                    PHA
     55B2 AC1101                LDY    BTPT          ; GET BIT NUMBER IN Y
     55B5 B9EC55                LDA    MSKTB1,Y      ; GET A BYTE WITH THAT BIT =1, OTHERS =0
     55B8 A000                  LDY    #0            ; ZERO Y
     55BA 51EA                  EOR    (ADP1),Y      ; FLIP THAT BIT IN THE ADDRESSED VM BYTE
     55BC 91EA                  STA    (ADP1),Y
     55BE 68                    PLA                  ; RESTORE Y
     55BF A8                    TAY
     55C0 60                    RTS                  ; AND RETURN
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                   ;        WRPIX - SETS THE PIXEL AT X1CORD,Y1CORD ACCORDING TO THE STATE
                   ;        OF BIT 0 (RIGHTMOST) OF A
                   ;        DOES NOT ALTER X1CORD OR Y1CORD
                   ;        PRESERVES X AND Y AND A
                   ;        ASSUMES IN RANGE CORRDINATES

55C1 2CD155    WRPIX:   BIT    WRPIXM       ; TEST LOW BIT OF A
55C4 48                 PHA
55C5 F005               BEQ    WRPIX1       ; JUMP IF A ZERO TO BE WRITTEN
55C7 208555             JSR    STPIX        ; OTHERWISE WRITE A ONE
55CA 68                 PLA                 ; RESTORE A AND RETURN
55CB 60                 RTS
55CC 209955    WRPIX1:  JSR    CLPIX        ; CLEAR THE PIXEL
55CF 68                 PLA                 ; RESTORE A AND RETURN
55D0 60                 RTS

55D1 01        WRPIXM:  .BYTE  1            ; BIT TEST MASK FOR BIT 0

                   ;        RDPIX - READS THE PIXEL AT X1CORD,Y1CORD AND SETS A TO ALL
                   ;        ZEROES IF IT IS A ZERO OR TO ALL ONES IF IT IS A ONE
                   ;        LOW BYTE OF ADP1 IS EQUAL TO A ON RETURN
                   ;        DOES NOT ALTER X1CORD OR Y1CORD
                   ;        PRESERVES X AND Y
                   ;        ASSUMES IN RANGE CORRDINATES

55D2 202155    RDPIX:   JSR    PIXADR       ; GET BYTE AND BIT ADDRESS OF PIXEL
55D5 98                 TYA                 ; SAVE Y
55D6 48                 PHA
55D7 A000               LDY    #0           ; GET ADDRESSED BYTE FROM VM
55D9 B1EA               LDA    (ADP1),Y
55DB AC1101             LDY    BTPT         ; GET BIT NUMBER IN Y
55DE 39EC55             AND    MSKTB1,Y     ; CLEAR ALL BUT ADDRESSED BIT
55E1 F002               BEQ    RDPIX1       ; SKIP AHEAD IF IT WAS A ZERO
55E3 A9FF               LDA    #X'FF        ; SET TO ALL ONES IF IT WAS A ONE
55E5 85EA      RDPIX1:  STA    ADP1         ; SAVE A TEMPORARILY IN ADP1 WHILE
55E7 68                 PLA                 ; RESTORING Y
55E8 A8                 TAY
55E9 A5EA               LDA    ADP1
55EB 60                 RTS                 ; RETURN

                   ;        MASK TABLES FOR INDIVIDUAL PIXEL SUBROUTINES
                   ;        MSKTB1 IS A TABLE OF 1 BITS CORRESPONDING TO BIT NUMBERS
                   ;        MSKTB2 IS A TABLE OF 0 BITS CORRESPONDING TO BIT NUMBERS

55EC 80402010  MSKTB1:  .BYTE  X'80,X'40,X'20,X'10
55F0 08040201           .BYTE  X'08,X'04,X'02,X'01
55F4 7FBFDFEF  MSKTB2:  .BYTE  X'7F,X'BF,X'DF,X'EF
55F8 F7FBFDFE           .BYTE  X'F7,X'FB,X'FD,X'FE
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                            .PAGE  'COORDINATE CHECK ROUTINES'
                   ;        CKCRD1 - CKECK X1CORD,Y1CORD TO VERIFY THAT THEY ARE IN THE
                   ;                 PROPER RANGE.  IF NOT, THEY ARE REPLACED BY A VALUE
                   ;                 MODULO THE MAXIMUM VALUE+1.
                   ;        NOTE THAT THESE ROUTINES CAN BE VERY SLOW WHEN CORRECTIONS ARE
                   ;        NECESSARY BECAUSE A BRUTE FORCE DIVISON ROUTINE IS USED TO
                   ;        COMPUTE THE MODULUS.
                   ;        FOR MAXIMUM FLEXIBILITY IN USE, ALL REGISTERS ARE PRESERVED

 55FC 48           CKCRD1:  PHA                   ; SAVE ALL REGISTERS
 55FD 8A                    TXA
 55FE 48                    PHA
 55FF 98                    TYA
 5600 48                    PHA
 5601 A200                  LDX    #X1CORD-X1CORD ; CHECK X1CORD
 5603 A000                  LDY    #XLIMIT-LIMTAB
 5605 202B56                JSR    CK
 5608 A202                  LDX    #Y1CORD-X1CORD ; CHECK Y1CORD
 560A A002                  LDY    #YLIMIT-LIMTAB
 560C 202B56                JSR    CK
 560F 68           CKCRDR:  PLA                   ; RESTORE REGISTERS
 5610 A8                    TAY
 5611 68                    PLA
 5612 AA                    TAX
 5613 68                    PLA
 5614 60                    RTS                   ; AND RETURN

                   ;        CKCRD2 - SAME AS CKCRD1 EXCEPT CHECKS X2CORD,Y2CORD

 5615 48           CKCRD2:  PHA                   ; SAVE ALL REGISTERS
 5616 8A                    TXA
 5617 48                    PHA
 5618 98                    TYA
 5619 48                    PHA
 561A A204                  LDX    #X2CORD-X1CORD ; CHECK X2CORD
 561C A000                  LDY    #XLIMIT-LIMTAB
 561E 202B56                JSR    CK
 5621 A206                  LDX    #Y2CORD-X1CORD ; CHECK Y2CORD
 5623 A002                  LDY    #YLIMIT-LIMTAB
 5625 202B56                JSR    CK
 5628 4C0F56                JMP    CKCRDR         ; GO RESTORE REGISTERS AND RETURN

 562B BD0201       CK:      LDA    X1CORD+1,X     ; CHECK UPPER BYTE
 562E D95556                CMP    LIMTAB+1,Y     ; AGAINST UPPER BYTE OF LIMIT
 5631 9020                  BCC    CK4            ; OK IF LESS THAN UPPER BYTE OF LIMIT
 5633 F016                  BEQ    CK3            ; GO CHECK LOWER BYTE IF EQUAL TO
                                                  ; UPPER BYTE OF LIMIT
 5635 BD0101       CK2:     LDA    X1CORD,X       ; SUBTRACT THE LIMIT
 5638 38                    SEC                   ; LOWER BYTE FIRST
 5639 F95456                SBC    LIMTAB,Y
 563C 9D0101                STA    X1CORD,X
 563F BD0201                LDA    X1CORD+1,X
 5642 F95556                SBC    LIMTAB+1,Y
 5645 9D0201                STA    X1CORD+1,X
 5648 4C2B56                JMP    CK             ; AND THEN GO CHECK RANGE AGAIN
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564B BD0101    CK3:     LDA    X1CORD,X      ; CHECK LOWER BYTE OF X
564E D95456             CMP    LIMTAB,Y
5651 B0E2               BCS    CK2           ; GO ADJUST IF TOO LARGE
5653 60        CK4:     RTS                  ; RETURN

               LIMTAB:                       ; TABLE OF LIMITS
5654 4001      XLIMIT:  .WORD  NX
5656 C800      YLIMIT:  .WORD  NY

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                                .PAGE  'LINE DRAWING ROUTINES'
                      ;         DRAW - DRAW THE BEST STRAIGHT LINE FROM X1CORD,Y1CORD TO
                      ;         X2CORD, Y2CORD.
                      ;         X2CORD,Y2CORD COPIED TO X1CORD,Y1CORD AFTER DRAWING
                      ;         PRESERVES X AND Y
                      ;         USES AN ALGORITHM THAT REQUIRES NO MULTIPLICATION OR DIVISON

     5658 A900        ERASE:    LDA    #X'00         ; SET LINE COLOR TO BLACK
     565A F002                  BEQ    DRAW1         ; GO DRAW THE LINE

     565C A9FF        DRAW:     LDA    #X'FF         ; SET LINE COLOR TO WHITE
     565E 8D1B01      DRAW1:    STA    COLOR
     5661 8A                    TXA                  ; SAVE X AND Y
     5662 48                    PHA
     5663 98                    TYA
     5664 48                    PHA

                      ;         COMPUTE SIGN AND MAGNITUDE OF DELTA X = X2-X1
                      ;         PUT MAGNITUDE IN DELTAX AND SIGN IN XDIR

     5665 A900                  LDA    #0            ; FIRST ZERO DIR
     5667 8D1801                STA    XDIR
     566A AD0501                LDA    X2CORD        ; NEXT COMPUTE TWOS COMPLEMENT DIFFERENCE
     566D 38                    SEC
     566E ED0101                SBC    X1CORD
     5671 8D1201                STA    DELTAX
     5674 AD0601                LDA    X2CORD+1
     5677 ED0201                SBC    X1CORD+1
     567A 8D1301                STA    DELTAX+1
     567D 1014                  BPL    DRAW2         ; SKIP AHEAD IF DIFFERENCE IS POPSITIVE
     567F CE1801                DEC    XDIR          ; SET XDIR TO -1
     5682 38                    SEC                  ; NEGATE DELTAX
     5683 A900                  LDA    #0
     5685 ED1201                SBC    DELTAX
     5688 8D1201                STA    DELTAX
     568B A900                  LDA    #0
     568D ED1301                SBC    DELTAX+1
     5690 8D1301                STA    DELTAX+1

                      ;         COMPUTE SIGN AND MAGNITUDE OF DELTA Y = Y2-Y1
                      ;         PUT MAGNITUDE IN DELTAY AND SIGN IN YDIR

     5693 A900        DRAW2:    LDA    #0            ; FIRST ZERO YDIR
     5695 8D1901                STA    YDIR
     5698 AD0701                LDA    Y2CORD        ; NEXT COMPUTE TWOS COMPLEMENT DIFFERENCE
     569B 38                    SEC
     569C ED0301                SBC    Y1CORD
     569F 8D1401                STA    DELTAY
     56A2 AD0801                LDA    Y2CORD+1
     56A5 ED0401                SBC    Y1CORD+1
     56A8 8D1501                STA    DELTAY+1
     56AB 1014                  BPL    DRAW3         ; SKI AHEAD IF DIFFERENCE IS POSITIVE
     56AD CE1901                DEC    YDIR          ; SET YDIR TO -1
     56B0 38                    SEC                  ; NEGATE DELTAX
     56B1 A900                  LDA    #0
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56B3 ED1401            SBC    DELTAY
56B6 8D1401            STA    DELTAY
56B9 A900              LDA    #0
56BB ED1501            SBC    DELTAY+1
56BE 8D1501            STA    DELTAY+1

                ;      DETERMINE IF DELTAY IS LARGER THAN DELTAX
                ;      IF SO, EXCHANGE DELTAY AND DELTAX AND SET XCHFLG NONZERO
                ;      ALSO INITIALIZE ACC TO DELTAX
                ;      PUT A DOT AT THE INITIAL DENPOINT

56C1 A900       DRAW3: LDA    #0            ; FIRST ZERO XCHFLG
56C3 8D1A01            STA    XCHFLG
56C6 AD1401            LDA    DELTAY        ; COMPARE DELTAY WITH DELTAX
56C9 38                SEC
56CA ED1201            SBC    DELTAX
56CD AD1501            LDA    DELTAY+1
56D0 ED1301            SBC    DELTAX+1
56D3 901B              BCC    DRAW4         ; SKIP EXCHANGE IF DELTAX IS GREATER THAN
                                            ; DELTAY
56D5 AE1401            LDX    DELTAY        ; EXCHANGE DELTAX AND DELTAY
56D8 AD1201            LDA    DELTAX
56DB 8D1401            STA    DELTAY
56DE 8E1201            STX    DELTAX
56E1 AE1501            LDX    DELTAY+1
56E4 AD1301            LDA    DELTAX+1
56E7 8D1501            STA    DELTAY+1
56EA 8E1301            STX    DELTAX+1
56ED CE1A01            DEC    XCHFLG        ; SET XCHFLG TO -1
56F0 AD1201     DRAW4: LDA    DELTAX        ; INITIALIZE ACC TO DELTAX
56F3 8D1601            STA    ACC
56F6 AD1301            LDA    DELTAX+1
56F9 8D1701            STA    ACC+1
56FC AD1B01            LDA    COLOR         ; PUT A DOT AT THE INITIAL ENDPOINT
56FF 20C155            JSR    WRPIX         ; X1CORD,Y1CORD

                ;      HEAD OF MAIN DRAWING LOOP
                ;      TEST IF DONE

5702 AD1A01     DRAW45: LDA   XCHFLG        ; TEST IF X AND Y EXCHANGED
5705 D012              BNE    DRAW5         ; JUMP AHEAD IF SO
5707 AD0101            LDA    X1CORD        ; TEST FOR X1CORD=X2CORD
570A CD0501            CMP    X2CORD
570D D01F              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
570F AD0201            LDA    X1CORD+1
5712 CD0601            CMP    X2CORD+1
5715 D017              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
5717 F010              BEQ    DRAW6         ; GO RETURN IF SO
5719 AD0301     DRAW5: LDA    Y1CORD        ; TEST FOR Y1CORD=Y2CORD
571C CD0701            CMP    Y2CORD
571F D00D              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
5721 AD0401            LDA    Y1CORD+1
5724 CD0801            CMP    Y2CORD+1
5727 D005              BNE    DRAW7         ; GO FOR ANOTHER ITERATION IF NOT
5729 68         DRAW6: PLA                  ; RESTORE INDEX REGISTERS
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572A A8                 TAY
572B 68                 PLA
572C AA                 TAX
572D 60                 RTS                 ; AND RETURN

              ;         DO A CLACULATION TO DETERMINE IF ONE OR BOTH AXES ARE TO BE
              ;         BUMPED (INCREMENTED OR DECREMENTED ACCORDING TO XDIR AND YDIR)
              ;         AND DO THE BUMPING

572E AD1A01   DRAW7:    LDA    XCHFLG       ; TEST IF X AND Y EXCHANGED
5731 D006               BNE    DRAW8        ; JUMP IF SO
5733 208957             JSR    BMPX         ; BUMP X IF NOT
5736 4C3C57             JMP    DRAW9
5739 20A357   DRAW8:    JSR    BMPY         ; BUMP Y IF SO
573C 206157   DRAW9:    JSR    SBDY         ; SUBTRACT DY FROM ACC TWICE
573F 206157             JSR    SBDY
5742 1014               BPL    DRAW12       ; SKIP AHEAD IF ACC IS NOT NEGATIVE
5744 AD1A01             LDA    XCHFLG       ; EST IF X AND Y EXCHANGED
5747 D006               BNE    DRAW10       ; JUMP IF SO
5749 20A357             JSR    BMPY         ; BUMP Y IF NOT
574C 4C5257             JMP    DRAW11
574F 208957   DRAW10:   JSR    BMPX         ; BUMP X IF SO
5752 207557   DRAW11:   JSR    ADDX         ; ADD DX TO ACC TWICE
5755 207557             JSR    ADDX

5758 AD1B01   DRAW12:   LDA    COLOR        ; OUTPUT THE NEW POINT
575B 20C155             JSR    WRPIX
575E 4C0257             JMP    DRAW45       ; GO TEST IF DONE

              ;         SUBROUTINES FOR DRAW

5761 AD1601   SBDY:     LDA    ACC          ; SUBTRACT DELAY FROM ACC AND PUT RESULT
5764 38                 SEC                 ; IN ACC
5765 ED1401             SBC    DELTAY
5768 8D1601             STA    ACC
576B AD1701             LDA    ACC+1
576E ED1501             SBC    DELTAY+1
5771 8D1701             STA    ACC+1
5774 60                 RTS


5775 AD1601   ADDX:     LDA    ACC          ; ADD DELTAX TO ACC AND PUT RESULT IN ACC
5778 18                 CLC
5779 6D1201             ADC    DELTAX
577C 8D1601             STA    ACC
577F AD1701             LDA    ACC+1
5782 6D1301             ADC    DELTAX+1
5785 8D1701             STA    ACC+1
5788 60                 RTS


5789 AD1801   BMPX:     LDA    XDIR         ; BUMP X1CORD BY +1 OR -1 ACCORDING
578C D009               BNE    BMPX2        ; XDIR
578E EE0101             INC    X1CORD       ; DOUBLE INCREMENT X1CORD IF XDIR=0
5791 D003               BNE    BMPX1
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5793 EE0201             INC    X1CORD+1
5796 60        BMPX1:   RTS
5797 AD0101    BMPX2:   LDA    X1CORD        ; DOUBLE DECREMENT X1CORD IF XDIR<>0
579A D003               BNE    BMPX3
579C CE0201             DEC    X1CORD+1
579F CE0101    BMPX3:   DEC    X1CORD
57A2 60                 RTS


57A3 AC1901    BMPY:    LDY    YDIR          ; BUMP Y1CORD BY +1 OR -1 ACCORDING TO
57A6 D009               BNE    BMPY2         ; YDIR
57A8 EE0301             INC    Y1CORD        ; DOUBLE INCREMENT Y1CORD IF YDIR=0
57AB D003               BNE    BMPY1
57AD EE0401             INC    Y1CORD+1
57B0 60        BMPY1:   RTS
57B1 AD0301    BMPY2:   LDA    Y1CORD        ; DOUBLE DECREMENT Y1CORD IF YDIR<>0
57B4 D003               BNE    BMPY3
57B6 CE0401             DEC    Y1CORD+1
57B9 CE0301    BMPY3:   DEC    Y1CORD
57BC 60                 RTS

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                           .PAGE  'DCHAR - DRAW A CHARACTER'
                  ;        DCHAR - DRAW A CHARACTER WHOSE UPPER LEFT CORNER IS AT
                  ;        X1CORD,Y1CORD
                  ;        X1CORD AND Y1CORD ARE NOT ALTERED
                  ;        THIS ROUTINE DISPLAYS A 5 BY 9 DOT MATRIX CHARACTER AT THE
                  ;        SPECIFIED LOCATION.  THE 5 BY 9 BLOCK IS CLEARED AND THEN THE
                  ;        CHARACTER IS WRITTEN INTO IT.
                  ;        THE 5 BY 9 MATRIX INCLUDES 2 LINE DESCENDERS ON LOWER CASE
                  ;        CHARACTERS.
                  ;        BOTH INDEX REGISTERS AND THE ACCUMULATOR ARE PRESERVED.
                  ;        THE CHARACTER CODE TO BE DISPLAYED SHOULD BE IN A.
                  ;        ASCII CONTROL CODES ARE IGNORED AND NO DRAWING IS DONE
                  ;        THIS ROUTINE ASSUMES IN RANGE COORDINATES INCLUDING WIDTH AND
                  ;        HEIGHT OF CHARACTER.

57BD 48           DCHAR:   PHA                    ; SAVE REGISTERS
57BE 8A                    TXA
57BF 48                    PHA
57C0 98                    TYA
57C1 48                    PHA
57C2 BA                    TSX                    ; GET IMPUT CHARACTER BACK
57C3 BD0301                LDA    X'103,X
57C6 297F                  AND    #X'7F           ; INSURE 7 BIT ASCII INPUT
57C8 38                    SEC
57C9 E920                  SBC    #X'20           ; TEST IF A CONTROL CHARACTER
57CB 3062                  BMI    DCHAR5          ; DO A QUICK RETURN IF SO

                  ;        CALCULATE FONT TABLE ADDRESS FOR CHAR

57CD 48                    PHA                    ; SAVE VERIFIED, ZERO ORIGIN CHAR CODE
57CE 202155                JSR    PIXADR          ; GET BYTE AND BIT ADDRESS OF FIRST SCAN
                                                  ; LINE OF CHARACTER INTO ADP1 AND BTPT
57D1 68                    PLA                    ; RESTORE ZERO ORIGIN CHARACTER CODE
57D2 85EC                  STA    ADP2            ; PUT IT INTO ADP2
57D4 A900                  LDA    #0
57D6 85ED                  STA    ADP2+1
57D8 20DC5A                JSR    SADP2L          ; COMPUTE 8*CHARACTER CODE IN ADP2
57DB 20DC5A                JSR    SADP2L
57DE 20DC5A                JSR    SADP2L
57E1 A5EC                  LDA    ADP2            ; ADD IN ORIGIN FOR CHARACTER TABLE
57E3 18                    CLC
57E4 6976                  ADC    #CHTB&X'FF
57E6 85EC                  STA    ADP2
57E8 A5ED                  LDA    ADP2+1
57EA 695C                  ADC    #CHTB/256
57EC 85ED                  STA    ADP2+1          ; ADP2 NOW HAS ADDRESS OF TOP ROW OF
                                                  ; CHARACTER SHAPE



57EE A000                  LDY    #0              ; INITIALIZE Y INDEX = FONT TABLE POINTER
57F0 A200                  LDX    #0              ; INITIALIZE X = SCAN LINE COUNTER

                  ;        CLEAR THE FIRST TWO SCAN LINES OF DESCENDING CHARACTERS
                  ;        FOR LOWER CASE "J", PUT IN THE DOT AS A SPECIAL CASE

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57F2 B1EC                LDA    (ADP2),Y     ; GET THE FIRST ROW FROM THE TABLE
57F4 F01C                BEQ    DCHAR3       ; SKIP AHEAD IF NOT A DESCENDING CHARACTER
57F6 A5EC                LDA    ADP2         ; IF DESCENDING, TEST IF LOWER CASE J
57F8 C9C6                CMP    #X'6A-X'20*8+CHTB&X'FF
57FA D004                BNE    DCHAR1       ; CLEAR FIRST SCAN LINE IF NOT
57FC A920                LDA    #X'20        ; LOAD THE DOT FOR THE J IF A J
57FE D002                BNE    DCHAR2
5800 A900       DCHAR1:  LDA    #0           ; DO THE FIRST SCAN LINE
5802 208558     DCHAR2:  JSR    MERGE5
5805 20E15A              JSR    DN1SCN       ; GO DOWN 1 SCAN LINE
5808 E8                  INX                 ; COUNT SCAN LINES DONE
5809 A900                LDA    #0           ; CLEAR THE SECOND SCAN LINE
580B 208558              JSR    MERGE5
580E 20E15A              JSR    DN1SCN       ; GO DOWN ANOTHER SCAN LINE
5811 E8                  INX                 ; COUNT SCAN LINES DONE

                ;        SCAN QUT THE BODY OF THE CHARACTER

5812 C8         DCHAR3:  INY                 ; GO TO NEXT SCAN LINE OF THE FRONT
5813 B1EC                LDA    (ADP2),Y     ; GET THE SCAN LINE
5815 208558              JSR    MERGE5       ; MERGE IT WITH GRAPHIC MEMORY AT (ADP1)
5818 20E15A              JSR    DN1SCN       ; GO DOWN 1 SCAN LINE
581B E8                  INX                 ; COUNT SCAN LINES OUTPUTTED
581C C007                CPY    #7           ; TEST IF WHOLE CHARACTER SCANNED OUT
581E D0F2                BNE    DCHAR3       ; GO SCAN OUT ANOTHER ROW IF NOT
5820 E009       DCHAR4:  CPX    #9           ; TEST IF THE WHOLE CHARACTER CELL SCANNED
5822 F00B                BEQ    DCHAR5       ; JUMP OUT IF SO
5824 A900                LDA    #0           ; CLEAR TRAILING SCAN LINES ON
5826 208558              JSR    MERGE5       ; NON-DESDENDING CHARACTERS
5829 20E15A              JSR    DN1SCN       ; TO NEXT LINE
582C E8                  INX                 ; COUNT LINES
582D D0F1                BNE    DCHAR4       ; LOOP UNTIL DONE

                ;        RESTORE REGISTERS AND RETURN

582F 68         DCHAR5:  PLA
5830 A8                  TAY
5831 68                  PLA
5832 AA                  TAX
5833 68                  PLA
5834 60                  RTS
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                                .PAGE  'GRAPHIC MERGE ROUTINES'
                       ;        MERGEL - MERGE LEFT ROUTINE
                       ;        MERGES ACCUMULATOR CONTENTS WITH A BYTE OF GRAPHIC MEMORY
                       ;        ADDRESSED BY ADP1 AND BTPT.
                       ;        BITS TO THE LEFT OF (BTPT) ARE PRESERVED IN GRAPHIC MEMORY.
                       ;        BIT (BTPT) AND BITS TO THE RIGHT ARE SET EQUAL TO
                       ;        CORRESPONDING BIT POSITIONS IN THE ACCUMULATOR.
                       ;        NO REGISTERS ARE BOTHERED.

 5835 48               MERGEL:  PHA                   ; SAVE REGISTERS
 5836 8A                        TXA
 5837 48                        PHA
 5838 98                        TYA
 5839 48                        PHA
 583A BA                        TSX                   ; GET INPUT BACKK
 583B BD0301                    LDA    X'103,X
 583E AC1101                    LDY    BTPT           ; GET BIT NUMBER INTO Y
 5841 39D058                    AND    MERGTR-1,Y     ; CLEAR BITS TO BE PRESERVED IN MEMORY
 5844 9D0301                    STA    X'103,X        ; FROM A
 5847 A000                      LDY    #0             ; CLEAR BITS FROM MEMORY TO BE CHANGED
 5849 AE1101                    LDX    BTPT
 584C B1EA                      LDA    (ADP1),Y       ; GET MEMORY BYTE
 584E 3DC858                    AND    MERGTL,X       ; CLEAR THE BITS
 5851 BA                        TSX                   ; DO THE MERGING
 5852 1D0301                    ORA    X'103,X
 5855 91EA                      STA    (ADP1),Y
 5857 68                        PLA                   ; RESTORE REGISTERS
 5858 A8                        TAY
 5859 68                        PLA
 585A AA                        TAX
 585B 68                        PLA
 585C 60                        RTS                   ; RETURN

                       ;        MERGR - MERGE RIGHT ROUTINE
                       ;        MERGES ACCUMULATOR CONTENTS WITH A BYTE OF GRAPHIC MEMORY
                       ;        ADDRESSED BY ADP1 AND BTPT.
                       ;        BITS TO THE RIGHT OF (BTPT) ARE PRESERVED IN GRAPHIC MEMORY.
                       ;        BIT (BTPT) AND BITS TO THE LEFT ARE SET EQUAL TO CORRESPONDING
                       ;        BIT POSITIONS IN THE ACCUMULATOR.
                       ;        NO REGISTERS ARE BOTHERED.

 585D 48               MERGER:  PHA                   ; SAVE REGISTERS
 585E 8A                        TXA
 585F 48                        PHA
 5860 98                        TYA
 5861 48                        PHA
 5862 BA                        TSX                   ; GET INPUT BACKK
 5863 BD0301                    LDA    X'103,X
 5866 AC1101                    LDY    BTPT           ; GET BIT NUMBER INTO Y
 5869 39C758                    AND    MERGTL-1,Y     ; CLEAR BITS TO BE PRESERVED IN MEMORY
 586C 9D0301                    STA    X'103,X        ; FROM A
 586F A000                      LDY    #0             ; CLEAR BITS FROM MEMORY TO BE CHANGED
 5871 AE1101                    LDX    BTPT
 5874 B1EA                      LDA    (ADP1),Y       ; GET MEMORY BYTE
 5876 3DD158                    AND    MERGTR,X       ; CLEAR THE BITS
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```
5879 BA                   TSX                    ; DO THE MERGING
587A 1D0301               ORA    X'103,X
587D 91EA                 STA    (ADP1),Y
587F 68                   PLA                    ; RESTORE REGISTERS
5880 A8                   TAY
5881 68                   PLA
5882 AA                   TAX
5883 68                   PLA
5884 60                   RTS                    ; RETURN

                 ;        MERGE A ROW OF 5 DOTS WITH GRAPHIC MEMORY STARTING AT BYTE
                 ;        ADDRESS AND BIT NUMBER IN ADP1 AND BTPT
                 ;        5 DOTS TO MERGE LEFT JUSTIFIED IN A
                 ;        PRESERVES X AND Y

5885 8D1D01      MERGE5:  STA    TEMP+1          ; SAVE INPUT DATA
5888 98                   TYA                    ; SAVE Y
5889 48                   PHA
588A AC1101               LDY    BTPT            ; OPEN UP A 5 BIT WINDOW IN GRAPHIC MEMORY
588D B9D958               LDA    MERGT5,Y        ; LEFT BITS
5890 A000                 LDY    #0              ; ZERO Y
5892 31EA                 AND    (ADP1),Y
5894 91EA                 STA    (ADP1),Y
5896 AC1101               LDY    BTPT
5899 B9E158               LDA    MERGT5+8,Y      ; RIGHT BITS
589C A001                 LDY    #1
589E 31EA                 AND    (ADP1),Y
58A0 91EA                 STA    (ADP1),Y
58A2 AD1D01               LDA    TEMP+1          ; SHIFT DATA RIGHT TO LINE UP LEFTMOST
58A5 AC1101               LDY    BTPT            ; DATA BIT WITH LEFTMOST GRAPHIC FIELD
58A8 F004                 BEQ    MERGE2          ; SHIFT BTPT TIMES
58AA 4A          MERGE1:  LSRA
58AB 88                   DEY
58AC D0FC                 BNE    MERGE1
58AE 11EA        MERGE2:  ORA    (ADP1),Y        ; OVERLAY WITH GRAPHIC MEMORY
58B0 91EA                 STA    (ADP1),Y
58B2 A908                 LDA    #8              ; SHIFT DATA LEFT TO LINE UP RIGHTMOST
58B4 38                   SEC                    ; DATA BIT WITH RIGHTMOST GRAPHIC FIELD
58B5 ED1101               SBC    BTPT            ; SHIFT (8-BTPT) TIMES
58B8 A8                   TAY
58B9 AD1D01               LDA    TEMP+1
58BC 0A          MERGE3:  ASLA
58BD 88                   DEY
58BE D0FC                 BNE    MERGE3
58C0 C8                   INY
58C1 11EA                 ORA    (ADP1),Y        ; OVERLAY WITH GRAPHIC MEMORY
58C3 91EA                 STA    (ADP1),Y
58C5 68                   PLA                    ; RESTORE Y
58C6 A8                   TAY
58C7 60                   RTS                    ; RETURN

58C8 0080C0E0    MERGTL:  .BYTE  X'00,X'80,X'C0,X'E0  ; MASKS FOR MERGE LEFT
58CC F0F8FCFE             .BYTE  X'F0,X'F8,X'FC,X'FE  ; CLEAR ALL BITS TO THE RIGHT OF
58D0 FF                   .BYTE  X'FF                 ; AND INCLUDING BIT N (0=MSB)

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58D1 7F3F1F0F  MERGTR:  .BYTE  X'7F,X'3F,X'1F,X'0F  ; MASKS FOR MERGE RIGHT
58D5 07030100           .BYTE  X'07,X'03,X'01,X'00  ; CLEAR ALL BITS TO THE LEFT OF
                                                    ; AND INCLUDING BIT N (0=MSB)

58D9 0783C1E0  MERGT5:  .BYTE  X'07,X'83,X'C1,X'E0  ; TABLE OF MASKS FOR OPENING UP
58DD F0F8FCFE           .BYTE  X'F0,X'F8,X'FC,X'FE  ; A 5 BIT WINDOW ANYWHERE
58E1 FFFFFFFF           .BYTE  X'FF,X'FF,X'FF,X'FF  ; IN GRAPHIC MEMORY
58E5 7F3F1F0F           .BYTE  X'7F,X'3F,X'1F,X'0F
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                .PAGE  'DTEXT - SOPHISTICATED TEXT DISPLAY ROUTINE'
        ;       DTEXT - SOPHISTICATED TEXT DISPLAY ROUTINE
        ;       CURSOR IS ADDRESSED IN TERMS OF X AND Y COORDINATES.
        ;       CURSOR POSITION IS IN X1CORD AND Y1CORD WHICH IS THE
        ;       COORDINATES OF THE UPPER LEFT CORNER OF THE CHARACTER POINTED
        ;       TO BY THE CURSOR.
        ;       CURSOR POSITIONING MAY BE ACCOMPLISHED BY DIRECTLY
        ;       MODIFYING X1CORD,Y1CORD OR BY ASCII CONTROL CODES OR BY
        ;       CALLING THE CURSOR MOVEMENT SUBROUTINES DIRECTLY.
        ;       LIKEWISE BASELINE SHIFT FOR SUB AND SUPERSCRIPT MAY BE DONE
        ;       DIRECTLY OR WITH CONTROL CHARACTERS.
        ;       ADDITIONAL CONTROL CHARACTER FUNCTIONS ARE EASILY ADDED BY
        ;       ADDING ENTRIES TO A DISPATCH TABLE AND CORRESPONDING SERVICE
        ;       ROUTINES
        ;       CURSOR IS A NON-BLINKING UNDERLINE

        ;       CONTROL CODES RECOGNIZED:
        ;       CR  X'0D  SETS CURSOR TO LEFT SCREEN EDGE
        ;       LF  X'0A  MOVES CURSOR DOWN ONE LINE, SCROLLS DISPLAY BOUNDED
        ;                 BY THE MARGINS UP ONE LINE IF ALREADY ON BOTTOM LINE
        ;       BS  X'08  MOVES CURSOR ONE CHARACTER LEFT
        ;       FF  X'0C  CLEARS SCREEN BETWEEN THE MARGINS AND PUTS CURSOR AT
        ;                 TOP AND LEFT MARGIN
        ;       SI  X'0F  MOVES BASELINE UP 3 SCAN LINES FOR SUPERSCRIPTS
        ;       SO  X'0E  MOVES BASELINE DOWN 3 SCAN LINES FOR SUBSCRIPTS
        ;       DC1 X'11  MOVES CURSOR LEFT ONE CHARACTER WIDTH
        ;       DC2 X'12  MOVES CURSOR RIGHT ONE CHARACTER WIDTH
        ;       DC3 X'13  MOVES CURSOR UP ONE CHARACTER HEIGHT
        ;       DC4 X'14  MOVES CURSOR DOWN ONE CHARACTER HEIGHT
        ;                 NO WRAPAROUND OR SCROLLING IS DONE WHEN DC1-DC4 IS
        ;                 USED TO MOVE THE CURSOR.

        ;       WHEN CALLS TO DTEXT ARE INTERMINGLED WITH CALLS TO THE GRAPHIC
        ;       ROUTINES, CSRINS AND CSRDEL SHOULD BE CALLED TO INSERT AND
        ;       DELETE THE CURSOR RESPECTIVELY.  LIKEWISE THESE ROUTINES
        ;       SHOULD BE USED WHEN THE USER PROGRAM DIRECTLY MODIFIES THE
        ;       CURSOR POSITION BY CHANGING X1CORD AND YICORD. IF THIS IS
        ;       NOT DONE, THE CURSOR SYMBOL MAY NOT SHOW UNTIL THE FIRST
        ;       CHARACTER HAS BEEN DRAWN OR MAY REMAIN AT THE LAST CHARACTER
        ;       DRAWN.

        ;       DTEXT USES A VIRTUAL PAGE DEFINED BY TOP, BOTTOM, LEFT, AND
        ;       RIGHT MARGINS.  CURSOR MOVEMENT, SCROLLING, CLEARING, AND TEXT
        ;       DISPLAY IS RESTRICTED TO THE AREA DEFINED BY TMAR, BMAR, LMAR,
        ;       AND RMAR RESPECTIVELY.  VALID MARGIN SETTINGS ARE ASSUMED
        ;       WHICH MEANS THAT THE MARGINS DEFINE SPACE AT LEAST TWO
        ;       CHARACTERS WIDE BY ONE LINE HIGH AND THAT ALL OF THEM ARE
        ;       VALID COORDINATES.  A CONVENIENCE ROUTINE, DTXTIN, MAY BE
        ;       CALLED TO INITIALIZE THE MARGINS FOR USE OF THE FULL SCREEN IN
        ;       PURE TEXT DISPLAY APPLICATIONS.

        ;       AUTOMATIC SCROLLING IS PERFORMED BY THE LINE FEED CONTROL
        ;       CHARACTER PROCESSOR.  FOR SCROLLING TO FUNCTION PROPERLY, AT
        ;       LEAST TWO LINES OF CHARACTERS MUST FIT BETWEEN THE TOP AND
        ;       BOTTOM MARGINS AND SUPERSCRIPTS AND SUBSCRIPTS SHOULD BE
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                   ;        AVOIDED UNLESS CHHIW IS REDEFINED TO PROVIDE ENOUGH WINDOW
                   ;        AREA TO HOLD THE SHIFTED CHARACTERS WITHOUT OVERLAP WITH
                   ;        ADJECANT LINES.

                   ;        DTXTIN MAY BE CALLED TO INITIALIZE DTEXT FOR USE AS A FULL
                   ;        SCREEN TEXT DISPLAY ROUTINE.  SETS MARGINS FOR FULL SCREEN
                   ;        OPERATION, CLEARS THE SCREEN, AND SETS THE CURSOR AT THE UPPER
                   ;        LEFT CORNER OF THE SCREEN. THE USER MUST STILL SET VMORG
                   ;        HOWEVER!

                   ;        DTXTIN - CONVENIENT INITIALIZE ROUTINE FOR FULL SCREEN USE OF
                   ;        DTEXT.

58E9 A900          DTXTIN:  LDA    #0            ; SET LEFT AND BOTTOM MARGINS TO ZERO
58EB 8D0D01                 STA    LMAR
58EE 8D0E01                 STA    LMAR+1
58F1 8D0B01                 STA    BMAR
58F4 8D0C01                 STA    BMAR+1
58F7 A9C7                   LDA    #NY-1&X'FF    ; SET TOP MARGIN TO TOP OF SCREEN
58F9 8D0901                 STA    TMAR
58FC A900                   LDA    #NY-1/256
58FE 8D0A01                 STA    TMAR+1
5901 A93F                   LDA    #NX-1&X'FF    ; SET RIGHT MARGIN TO RIGHT EDGE OF SCREEN
5903 8D0F01                 STA    RMAR
5906 A901                   LDA    #NX-1/256
5908 8D1001                 STA    RMAR+1
590B A90C                   LDA    #X'0C         ; CLEAR SCREEN AND PUT CURSOR AT UPPER
                                                 ; LEFT CORNER BY SENDING AN ASCII FF
                                                 ; CONTROL CHARACTER TO DTEXT.  THEN FALL
                                                 ; INTO DTEXT.

                   ;        DTEXT - DISPLAY ASCII TEXT ROUTINE
                   ;        ENTER WITH ASCII CHARACTER CODE TO DISPLAY OR INTERPRET IN A.
                   ;        PRESERVES ALL REGISTERS.

590D 48            DTEXT:   PHA                  ; SAVE THE REGISTERS
590E 8A                     TXA
590F 48                     PHA
5910 98                     TYA
5911 48                     PHA
5912 BA                     TSX                  ; GET INPUT BACK
5913 BD0301                 LDA    X'103,X       ; FROM THE STACK
5916 297F                   AND    #X'7F         ; INSURE 7 BIT ASCII INPUT
5918 C920                   CMP    #X'20         ; TEST IF A CONTROL CHARACTER
591A 300C                   BMI    DTEXT1        ; JUMP AHEAD IF SO
591C 20BD57                 JSR    DCHAR         ; FOR A REGULAR TEXT CHARACTER, DISPLAY IT
591F 20F05B                 JSR    CSRR          ; DO A CURSOR RIGHT
5922 68            DTEXTR:  PLA                  ; RESTORE THE REGISTERS
5923 A8                     TAY
5924 68                     PLA
5925 AA                     TAX
5926 68                     PLA
5927 60                     RTS                  ; AND RETURN

5928 A200          DTEXT1:  LDX    #0            ; SET UP A LOOP TO SEARCH THE CONTROL
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592A DD585C    DTEXT2:  CMP    CCTAB,X       ; CHARACTER TABLE FOR A MATCH
592D F009               BEQ    DTEXT3        ; JUMP IF A MATCH
592F E8                 INX                  ; BUMP X TO POINT TO NEXT TABLE ENTRY
5930 E8                 INX
5931 E8                 INX
5932 E01E               CPX    #CCTABE-CCTAB; TEST IF ENTIRE TABLE SEARCHED
5934 D0F4               BNE    DTEXT2        ; LOOP IF NOT
5936 F0EA               BEQ    DTEXTR        ; GO RETURN IF ENTIRE TABLE SEARCHED

5938 BD5A5C    DTEXT3:  LDA    CCTAB+2,X     ; JUMP TO THE ADDRESS IN THE NEXT TWO
593B 48                 PHA                  ; TABLE BYTES
593C BD595C             LDA    CCTAB+1,X
593F 48                 PHA
5940 60                 RTS

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                                .PAGE 'SERVICE ROUTINES FOR CONTROL CHARACTERS'
                      ;         SERVICE ROUTINES FOR CONTROL CHARACTERS.  DO THE INDICATED
                      ;         FUNCTION AND JUMP TO DTEXTR TO RESTORE REGISTERS AND RETURN.

                      ;         CRR - CURSOR RIGHT

5941 20F05B           CRR:      JSR    CSRR          ; NOVE CURSOR RIGHT
5944 4C2259                     JMP    DTEXTR        ; GO RETURN

                      ;         CRL - CURSOR LEFT AND BACKSPACE

5947 200A5C           CRL:      JSR    CSRL          ; MOVE CURSOR LEFT
594A 4C2259                     JMP    DTEXTR        ; GO RETURN

                      ;         CRU - CURSOR UP

594D 20245C           CRU:      JSR    CSRU          ; NOVE CURSOR UP
5950 4C2259                     JMP    DTEXTR        ; GO RETURN

                      ;         CRD - CURSOR DOWD

5953 203E5C           CRD:      JSR    CSRD          ; NOVE CURSOR DOWN
5956 4C2259                     JMP    DTEXTR        ; GO RETURN

                      ;         BASUP - SHIFT BASELINE UP 3 SCAN LINES
                      ;         NOTE - NO RANGE CHECK ON THE Y COORDINATE IS MADE
                      ;         BASELINE SHIFTING SHOULD ONLY BE DONE AT A BLANK CHARACTER
                      ;         POSITION

5959 20C95B           BASUP:    JSR    CSRDEL        ; DELETE CURRENT CURSOR
595C AD0301                     LDA    Y1CORD        ; INCREMENT COORDINATE BY 3
595F 18                         CLC
5960 6903                       ADC    #3
5962 8D0301                     STA    Y1CORD
5965 9003                       BCC    BASUP1
5967 EE0401                     INC    Y1CORD+1
596A 20C55B           BASUP1:   JSR    CSRINS        ; DISPLAY CURSOR AT NEW LOCATION
596D 4C2259                     JMP    DTEXTR        ; GO RETURN

                      ;         BASDN - SHIFT BASELINE DOEN 3 SCAN LINES
                      ;         NOTE - NO RANGE CHECK ON THE Y COORDINATE IS MADE
                      ;         BASELINE SHIFTING SHOULD ONLY BE DONE AT A BLANK CHARACTER
                      ;         POSITION

5970 20C95B           BASDN:    JSR    CSRDEL        ; DELETE CURRENT CURSOR
5973 AD0301                     LDA    Y1CORD        ; INCREMENT COORDINATE BY 3
5976 38                         SEC
5977 E903                       SBC    #3
5979 8D0301                     STA    Y1CORD
597C B003                       BCS    BASDN1
597E CE0401                     DEC    Y1CORD+1
5981 20C55B           BASDN1:   JSR    CSRINS        ; DISPLAY CURSOR AT NEW LOCATION
5984 4C2259                     JMP    DTEXTR        ; GO RETURN

                      ;         CARRET - CARRIAGE RETURN
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5987 20C95B    CARRET:  JSR    CSRDEL        ; DELETE CURRENT CURSOR
598A AD0D01             LDA    LMAR          ; SET X1CORD TO THE LEFT MARGIN
598D 8D0101             STA    X1CORD
5990 AD0E01             LDA    LMAR+1
5993 8D0201             STA    X1CORD+1
5996 20C55B             JSR    CSRINS        ; DISPLAY CURSOR AT NEW LOCATION
5999 4C2259             JMP    DTEXTR        ; GO RETURN

               ;        LNFED - LINE FEED ROUTINE, SCROLLS IF NOT SUFFICIENT SPACE
               ;                AT THE BOTTOM FOR A NEW LINE

599C 20695B    LNFED:   JSR    DNTST         ; TEST IF CURSOR IS TOO FAR DOWN TO ALLOW
599F 9006               BCC    LNFED1        ; MOVEMENT
59A1 203E5C             JSR    CSRD          ; IF OK, DO A SIMPLE CURSOR DOWN
59A4 4C2259             JMP    DTEXTR        ; AND GO RETURN
59A7 20C95B    LNFED1:  JSR    CSRDEL        ; DELETE CURRENT CURSOR
59AA 20ED5A             JSR    RECTP         ; SAVE CURSOR COORDINATES AND PROCESS
                                             ; CORNER DATA
59AD AD1201    LNFED0:  LDA    TLBYT         ; ADD CHHIW SCAN LINES TO ADDRESS OF TOP
59B0 18                 CLC                  ; LEFT CORNER TO ESTABLISH ADDRESS OF
59B1 69B8               ADC    #CHHIW*NX/8&X'FF  ; FIRST SCAN LINE TO SCROLL
59B3 85EC               STA    ADP2          ; AND PUT INTO ADP2
59B5 AD1301             LDA    TLBYT+1
59B8 6901               ADC    #CHHIW*NX/8/256
59BA 85ED               STA    ADP2+1

               ;        MOVE LEFT PARTIAL BYTE

59BC AD1201    LNFED2:  LDA    TLBYT         ; MOVE CURRENT TOP LEFT BYTE ADDRESS INTO
59BF 85EA               STA    ADP1          ; ADP1
59C1 AD1301             LDA    TLBYT+1
59C4 85EB               STA    ADP1+1
59C6 AD1801             LDA    TLBIT         ; MOVE LEFT BIT ADDRESS TO BTPT
59C9 8D1101             STA    BTPT
59CC A000               LDY    #0
59CE B1EC               LDA    (ADP2),Y      ; MOVE A PARTIAL BYTE FROM (ADP2)
59D0 203558             JSR    MERGEL        ; TO (ADP1) ACCORDING TO BTPT

               ;        MOVE FULL BYTES IN THE MIDDLE

59D3 E6EA      LNFED3:  INC    ADP1          ; INCREMENT ADP1
59D5 D002               BNE    LNFED4
59D7 E6EB               INC    ADP1+1
59D9 E6EC      LNFED4:  INC    ADP2          ; INCREMENT ADP2
59DB D002               BNE    LNFED5
59DD E6ED               INC    ADP2+1
59DF E6EA      LNFED5:  INC    ADP1          ; TEST IF EQUAL TO CURRENT TOP RIGHT BYTE
59E1 CD1401             CMP    TRBYT         ; ADDRESS
59E4 D007               BNE    LNFED6        ; SKIP AHEAD IF NOT
59E6 A5EB               LDA    ADP1+1
59E8 CD1501             CMP    TRBYT+1
59EB F007               BEQ    LNFED7        ; GO TO RIGHT PARTIAL BYTE PROCESSING IF =
59ED B1EC      LNFED6:  LDA    (ADP2),Y      ; MOVE A BYTE
59EF 91EA               STA    (ADP1),Y
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59F1 4CD359            JMP    LNFED3       ; GO PROCESS NEXT BYTE

              ;        MOVE RIGHT PARTIAL BYTE

59F4 AD1901   LNFED7:  LDA    TRBIT        ; MOVE RIGHT BIT ADDRESS TO BTPT
59F7 8D1101            STA    BTPT
59FA B1EC              LDA    (ADP2),Y     ; MOVE A PARTIAL BYTE FROM (ADP2) TO
59FC 205D58            JSR    MERGER       ; (ADP1) ACCORDING TO BTPT
59FF A5EC              LDA    ADP2         ; TEST IF ADP2 = BRBYT
5A01 CD1601            CMP    BRBYT
5A04 D009              BNE    LNFED8       ; JUMP AHEAD IF NOT
5A06 A5ED              LDA    ADP2+1
5A08 CD1701            CMP    BRBYT+1
5A0B D002              BNE    LNFED8       ; JUMP AHEAD IF NOT
5A0D F01F              BEQ    LNFEDB       ; FINISHED WITH MOVE PART OF SCROLL, GO
                                           ; CLEAR AREA LEFT AT BOTTOM OF RECTANGLE

              ;        PREPARE TO START NEXT LINE

5A0F AD1201   LNFED8:  LDA    TLBYT        ; ADD NX/8 TO TOP LEFT BYTE ADDRESS
5A12 18                CLC
5A13 6928              ADC    #NX/8
5A15 8D1201            STA    TLBYT
5A18 9003              BCC    LNFED9
5A1A EE1301            INC    TLBYT+1
5A1D AD1401   LNFED9:  LDA    TRBYT        ; ADD NX/8 TO TOP RIGHT BYTE ADDRESS
5A20 18                CLC
5A21 6928              ADC    #NX/8
5A23 8D1401            STA    TRBYT
5A26 9085              BCC    LNFED0
5A28 EE1501            INC    TRBYT+1
5A2B 4CAD59            JMP    LNFED0       ; GO MOVE NEXT SCAN LINE

              ;        CLEAR REGION AT BOTTOM OF RECTANGLE FOR NEW LINE OF TEXT
              ;        AND REINSERT CURSOR

5A2E 20735A   LNFEDB:  JSR    LNCLR        ; DO THE CLEARING
5A31 AD0501            LDA    X2CORD       ; RESTORE CURSOR COORDINATES
5A34 8D0101            STA    X1CORD
5A37 AD0601            LDA    X2CORD+1
5A3A 8D0201            STA    X1CORD+1
5A3D AD0701            LDA    Y2CORD
5A40 8D0301            STA    Y1CORD
5A43 AD0801            LDA    Y2CORD+1
5A46 8D0401            STA    Y1CORD+1
5A49 20C55B            JSR    CSRINS       ; INSERT CURSOR AT THE SAME POSITION
5A4C 4C2259            JMP    DTEXTR       ; GO RETURN

              ;        FMFED - FORM FEED ROUTINE, CLEARS THE SCREEN BETWEEN THE
              ;                MARGINS AND PLACES CURSOR AT UPPER LEFT CORNER OF
              ;                RECTANGLE DEFINED BY THE MARGINS.
              ;        NOTE: ROUTINE MODIFIES BOTH ADDRESS POINTERS AND BOTH SETS OF
              ;        COORDINATES.

5A4F 20ED5A   FMFED:   JSR    RECTP        ; PROCESS MARGIN DATA INTO CORNER
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                                                ; BYTE AND BIT ADDRESSES
5A52 20735A             JSR    LNCLR            ; CLEAR THE AREA DEFINED BY THE CORNERS
5A55 AD0D01             LDA    LMAR             ; POSITION CURSOR AT TOP AND LEFT MARGINS
5A58 8D0101             STA    X1CORD
5A5B AD0E01             LDA    LMAR+1
5A5E 8D0201             STA    X1CORD+1
5A61 AD0901             LDA    TMAR
5A64 8D0301             STA    Y1CORD
5A67 AD0A01             LDA    TMAR+1
5A6A 8D0401             STA    Y1CORD+1
5A6D 20C55B             JSR    CSRINS           ; INSERT CURSOR
5A70 4C2259             JMP    DTEXTR           ; FINISGED WITH FORM FEED
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                               .PAGE 'MISCELLANEOUS INTERNAL SUBROUTINES'
                     ;         LNCLR - SUBROUTINE TO CLEAR AREA INSIDE OF THE MARGINS
                     ;         DEFINED BY TLBYT,TLBIT; TRBYT,TRBIT; BRBYT
                     ;         USED BY FORM FEED AND SCROLL TO CLEAR BETWEEN THE MARGINS
                     ;         CLEAR LEFT PARTIAL BYTE
                     ;         USES INDEX Y

     5A73 AD1201     LNCLR:    LDA    TLBYT         ; MOVE CURRENT TOP LEFT BYTE ADDRESS INTO
     5A76 85EA                 STA    ADP1          ; ADP1
     5A78 AD1301               LDA    TLBYT+1
     5A7B 85EB                 STA    ADP1+1
     5A7D AD1801               LDA    TLBIT         ; MOVE LEFT BIT ADDRESS TO BTPT
     5A80 8D1101               STA    BTPT
     5A83 A900                 LDA    #0            ; CLEAR LEFT PARTIAL BYTE
     5A85 203558               JSR    MERGEL

                     ;         CLEAR FULL BYTES IN THE MIDDLE

     5A88 E6EA       LNCLR1:   INC    ADP1          ; INCREMENT ADP1
     5A8A D002                 BNE    LNCLR2
     5A8C E6EB                 INC    ADP1+1
     5A8E A5EA       LNCLR2:   LDA    ADP1          ; TEST IF EQUAL TO CURRENT TOP RIGHT BYTE
     5A90 CD1401               CMP    TRBYT         ; ADDRESS
     5A93 D007                 BNE    LNCLR3        ; SKIP AHEAD IF NOT
     5A95 A5EB                 LDA    ADP1+1
     5A97 CD1501               CMP    TRBYT+1
     5A9A F007                 BEQ    LNCLR4        ; GO TO RIGHT PARTIAL BYTE PROCESSING IF =
     5A9C A900       LNCLR3:   LDA    #0            ; ZERO A BYTE
     5A9E A8                   TAY
     5A9F 91EA                 STA    (ADP1),Y
     5AA1 F0E5                 BEQ    LNCLR1        ; LOOP UNTIL ALL FULL BYTES ON THIS LINE
                                                    ; HAVE BEEN CLEARED

                     ;         CLEAR RIGHT PARTIAL BYTE

     5AA3 AD1901     LNCLR4:   LDA    TRBIT         ; MOVE RIGHT BIT ADDRESS TO BTPT
     5AA6 8D1101               STA    BTPT
     5AA9 A900                 LDA    #0            ; CLEAR RIGHT PARTIAL BYTE
     5AAB 205D58               JSR    MERGER
     5AAE A5EA                 LDA    ADP1          ; TEST IF ADP1 = BRBYT
     5AB0 CD1601               CMP    BRBYT
     5AB3 D008                 BNE    LNCLR5        ; JUMP AHEAD IF NOT
     5AB5 A5EB                 LDA    ADP1+1
     5AB7 CD1701               CMP    BRBYT+1
     5ABA D001                 BNE    LNCLR5        ; JUMP AHEAD IF NOT
     5ABC 60                   RTS                  ; FINISHED WITH CLEAR IF SO

                     ;         PREPARE TO STAR NEXT LINE

     5ABD AD1201     LNCLR5:   LDA    TLBYT         ; ADD NX/8 TO TOP LEFT BYTE ADDRESS
     5AC0 18                   CLC
     5AC1 6928                 ADC    #NX/8
     5AC3 8D1201               STA    TLBYT
     5AC6 9003                 BCC    LNCLR6
     5AC8 EE1301               INC    TLBYT+1
```

```
5ACB AD1401    LNCLR6:  LDA    TRBYT         ; ADD NX/8 TO TOP RIGHT BYTE ADDRESS
5ACE 18                 CLC
5ACF 6928               ADC    #NX/8
5AD1 8D1401             STA    TRBYT
5AD4 909D               BCC    LNCLR         ; GO PROCESS NEXT LINE
5AD6 EE1501             INC    TRBYT+1
5AD9 4C735A             JMP    LNCLR

               ;        SADP2L - SHIFT ADP2 LEFT 1 BIT POSITION
               ;        NO REGISTERS BOTHERED

5ADC 06EC      SADP2L:  ASL    ADP2          ; SHIFT LOW PART
5ADE 26ED               ROL    ADP2+1        ; SHIFT HIGH PART
5AE0 60                 RTS                  ; RETURN

               ;        DN1SCN - SUBROUTINE TO ADD NX/8 TO ADP1 TO EFFECT A DOWN
               ;        SHIFT OF ONE SCAN LINE
               ;        INDEX REGISTERS PRESERVED

5AE1 A5EA      DN1SCN:  LDA    ADP1          ; ADD NX/8 TO LOW ADP1
5AE3 18                 CLC
5AE4 6928               ADC    #NX/8
5AE6 85EA               STA    ADP1
5AE8 9002               BCC    DN1SC1
5AEA E6EB               INC    ADP1+1        ; INCREMENT HIGH PART IF CARRY FROM LOW
5AEC 60        DN1SC1:  RTS                  ; RETURN

               ;        SUBROUTINE TO ESTABLISH USEFUL DATA ABOUT THE RECTANGLE
               ;        DEFINED BY THE TEXT MARGINS IN TERMS OF BYTE AND BIT ADDR.
               ;        TLBYT AND TLBIT DEFINE THE UPPER LEFT CORNER, TRBYT AND TRBIT
               ;        DEFINE UPPER RIGHT CORNER, BRBYT DEFINES BOTTOM RIGHT CORNER

5AED AD0101    RECTP:   LDA    X1CORD        ; SAVE CURRENT CURSOR POSITION IN
5AF0 8D0501             STA    X2CORD        ; X2CORD AND Y2CORD
5AF3 AD0201             LDA    X1CORD+1
5AF6 8D0601             STA    X2CORD+1
5AF9 AD0301             LDA    Y1CORD
5AFC 8D0701             STA    Y2CORD
5AFF AD0401             LDA    Y1CORD+1
5B02 8D0801             STA    Y2CORD+1
5B05 AD0D01             LDA    LMAR          ; ESTABLISH BYTE AND BIR ADDRESSES OF
5B08 8D0101             STA    X1CORD        ; TOP LEFT CORNER
5B0B AD0E01             LDA    LMAR+1
5B0E 8D0201             STA    X1CORD+1
5B11 AD0901             LDA    TMAR
5B14 8D0301             STA    Y1CORD
5B17 AD0A01             LDA    TMAR+1
5B1A 8D0401             STA    Y1CORD+1
5B1D 202155             JSR    PIXADR
5B20 A5EA               LDA    ADP1
5B22 8D1201             STA    TLBYT
5B25 A5EB               LDA    ADP1+1
5B27 8D1301             STA    TLBYT+1
5B2A AD1101             LDA    BTPT
5B2D 8D1801             STA    TLBIT
```

```
5B30 AD0F01          LDA    RMAR          ; ESTABLISH BYTE AND BIT ADDRESSES OF TOP
5B33 8D0101          STA    X1CORD        ; RIGHT CORNER
5B36 AD1001          LDA    RMAR+1
5B39 8D0201          STA    X1CORD+1
5B3C 202155          JSR    PIXADR
5B3F A5EA            LDA    ADP1
5B41 8D1401          STA    TRBYT
5B44 A5EB            LDA    ADP1+1
5B46 8D1501          STA    TRBYT+1
5B49 AD1101          LDA    BTPT
5B4C 8D1901          STA    TRBIT
5B4F AD0B01          LDA    BMAR          ; ESTABLISH BYTE ADDRESS OF BOTTOM RIGHT
5B52 8D0301          STA    Y1CORD        ; CORNER; BIT ADDRESS IS SAME AS BIT
5B55 AD0C01          LDA    BMAR+1        ; ADDRESS OF TOP RIGHT CORNER
5B58 8D0401          STA    Y1CORD+1
5B5B 202155          JSR    PIXADR
5B5E A5EA            LDA    ADP1
5B60 8D1601          STA    BRBYT
5B63 A5EB            LDA    ADP1+1
5B65 8D1701          STA    BRBYT+1
5B68 60              RTS                  ; RETURN
```

```
                              .PAGE  'CURSOR-BORDER LIMIT TEST ROUTINES'
                     ;        CURSOR-BORDER LIMIT TEST ROUTINES
                     ;        TESTS IF ENOUGH SPACE TO ALLOW CURSOR MOVEMENT IN ANY OF 4
                     ;        RETURNS WITH POSITIVE OR ZERO RESULT IF ENOUGH
                     ;        SPACE AND A NEGATIVE RESULT IF NOT ENOUGH SPACE.
                     ;        SUBROUTINES USE A AND X

5B69 AD0301    DNTST:  LDA    Y1CORD        ; COMPUTE Y1CORD-BMAR-(2*CHHIW-2)
5B6C 38                SEC
5B6D ED0B01            SBC    BMAR          ; SIGN OF RESULT
5B70 AA                TAX                  ; - NOT OK
5B71 AD0401            LDA    Y1CORD+1      ; Z OK
5B74 ED0C01            SBC    BMAR+1        ; + OK
5B77 48                PHA
5B78 8A                TXA
5B79 38                SEC
5B7A E914              SBC    #2*CHHIW-2
5B7C 68                PLA
5B7D E900              SBC    #0
5B7F 60                RTS

5B80 AD0901    UPTST:  LDA    TMAR          ; COMPUTE TMAR-Y1CORD-CHHIW
5B83 38                SEC
5B84 ED0301            SBC    Y1CORD        ; SIGN OF RESULT
5B87 AA                TAX                  ; - NOT OK
5B88 AD0A01            LDA    TMAR+1        ; Z OK
5B8B ED0401            SBC    Y1CORD+1      ; + OK
5B8E 48                PHA
5B8F 8A                TXA
5B90 38                SEC
5B91 E90B              SBC    #CHHIW
5B93 68                PLA
5B94 E900              SBC    #0
5B96 60                RTS

5B97 AD0101    LFTST:  LDA    X1CORD        ; COMPUTE X1CORD-LMAR-CHWIDW
5B9A 38                SEC
5B9B ED0D01            SBC    LMAR          ; SIGN OF RESULT
5B9E AA                TAX                  ; - NOT OK
5B9F AD0201            LDA    X1CORD+1      ; Z OK
5BA2 ED0E01            SBC    LMAR+1        ; + OK
5BA5 48                PHA
5BA6 8A                TXA
5BA7 38                SEC
5BA8 E906              SBC    #CHWIDW
5BAA 68                PLA
5BAB E900              SBC    #0
5BAD 60                RTS

5BAE AD0F01    RTTST:  LDA    RMAR          ; COMPUTE RMAR-X1CORD-(2*CHWIDW-2)
5BB1 38                SEC
5BB2 ED0101            SBC    X1CORD        ; SIGN OF RESULT
5BB5 AA                TAX                  ; - NOT OK
5BB6 AD1001            LDA    RMAR+1        ; Z OK
5BB9 ED0201            SBC    X1CORD+1      ; + OK
```

```
5BBC 48                  PHA
5BBD 8A                  TXA
5BBE 38                  SEC
5BBF E90A                SBC    #2*CHWIDW-2
5BC1 68                  PLA
5BC2 E900                SBC    #0
5BC4 60                  RTS
```

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                                 .PAGE  'CURSOR MANIPULATION ROUTINES'
                       ;         CSRINS - INSERT A CURSOR AT THE CURRENT CURSOR POSITION
                       ;                  WHICH IS DEFINED BY X1CORD,Y1CORD
                       ;         CSRDEL - REMOVE THE CURSOR WHICH IS ASSUMED TO BE AT THE
                       ;                  CURRENT CURSOR POSITION
                       ;         CURSOR IS DISPLAYED AS AN UNDERLINE CHHIM+1 SCAN LINES BELOW
                       ;         ACTUAL CHARACTER COORDINATES WHICH SPECIFY THE LOCATION OF THE
                       ;         UPPER LEFT CORNER OF THE CHARACTER
                       ;         INDEX REGISTERS PRESERVED

     5BC5 A9F8         CSRINS:   LDA    #X'F8         ; SET A FOR INSERTING THE CURSOR
     5BC7 D002                   BNE    CSR
     5BC9 A900         CSRDEL:   LDA    #0            ;  SET A FOR DELETING THE CURSOR

     5BCB 48           CSR:      PHA                  ; SAVE A
     5BCC AD0301                 LDA    Y1CORD        ; TEMPORARILY SUBTRACT CHHIM FROM Y1CORD
     5BCF 38                     SEC
     5BD0 E909                   SBC    #CHHIM
     5BD2 8D0301                 STA    Y1CORD
     5BD5 B003                   BCS    CSR1
     5BD7 CE0201                 DEC    Y1CORD-1
     5BDA 202155       CSR1:     JSR    PIXADR        ; COMPUTE ADDRESS OF CURSOR MARK
     5BDD 68                     PLA                  ; RESTORE SAVED A
     5BDE 208558                 JSR    MERGE5        ; MERGE CURSOR DATA WITH DISPLAY MEMORY
     5BE1 AD0301                 LDA    Y1CORD        ; RESTORE YICORD BY ADDING CHHIM BACK
     5BE4 18                     CLC
     5BE5 6909                   ADC    #CHHIM
     5BE7 8D0301                 STA    Y1CORD
     5BEA 9003                   BCC    CSR2
     5BEC EE0401                 INC    Y1CORD+1
     5BEF 60           CSR2:     RTS                  ; RETURN

                       ;         CSRR - MOVE CURSOR RIGHT ROUTINE
                       ;         DO NOTHING IF AGAINST RIGHT MARGIN
                       ;         USES X AND A

     5BF0 20AE5B       CSRR:     JSR    RTTST         ; TEST IF CURSOR CAN GO RIGHT
     5BF3 3014                   BMI    CSRR2         ; GO RETURN IF NOT ENOUGH ROOM
     5BF5 20C95B                 JSR    CSRDEL        ; DELETE THE PRESENT CURSOR
     5BF8 AD0101                 LDA    X1CORD        ; ADD CHARACTER WINDOW WIDTH TO X
     5BFB 18                     CLC                  ; COORDINATE
     5BFC 6906                   ADC    #CHWIDW
     5BFE 8D0101                 STA    X1CORD
     5C01 9003                   BCC    CSRR1
     5C03 EE0201                 INC    X1CORD+1
     5C06 20C55B       CSRR1:    JSR    CSRINS        ; DISPLAY CURSOR AT THE NEW LOCATION
     5C09 60           CSRR2:    RTS                  ; RETURN

                       ;         CSRL - MOVE CURSOR LEFT
                       ;         DO NOTHING IF AGAINST LEFT MARGIN
                       ;         USES A AND X

     5C0A 20975B       CSRL:     JSR    LFTST         ; TEST IF CURSOR IS TOO FAR LEFT
     5C0D 3014                   BMI    CSRL2         ; JUMP IF IT IS TOO FAR LEFT
     5C0F 20C95B                 JSR    CSRDEL        ; DELETE THE PRESENT CURSOR
```

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5C12 AD0101            LDA    X1CORD        ; SUBTRACT CHARACTER WINDOW WIDTH FROM
5C15 38                SEC                  ; X COORDINATE
5C16 E906              SBC    #CHWIDW
5C18 8D0101            STA    X1CORD
5C1B B003              BCS    CSRL1
5C1D CE0201            DEC    X1CORD+1
5C20 20C55B   CSRL1:   JSR    CSRINS        ; DISPLAY CURSOR AT THE NEW LOCATION
5C23 60       CSRL2:   RTS                  ; RETURN

              ;        CSRU - CURSOR UP F
              ;        DO NOTHING IF AGAINST TOP MARGIN
              ;        USES A AND X

5C24 20805B   CSRU:    JSR    UPTST         ; TEST IF CURSOR IS TOO FAR UP
5C27 3014              BMI    CSRU2         ; JUMP IF IT IS TOO HIGH
5C29 20C95B            JSR    CSRDEL        ; DELETE THE PRESENT CURSOR
5C2C AD0301            LDA    Y1CORD        ; ADD CHARACTER WINDOW HEIGHT TO Y
5C2F 18                CLC                  ; COORDINATE
5C30 690B              ADC    #CHHIW
5C32 8D0301            STA    Y1CORD
5C35 9003              BCC    CSRU1
5C37 EE0401            INC    Y1CORD+1
5C3A 20C55B   CSRU1:   JSR    CSRINS        ; DISPLAY CURSOR AT THE NEW LOCATION
5C3D 60       CSRU2:   RTS                  ; RETURN

              ;        CSRD - CURSOR DOWN
              ;        DO NOTHING IF AGAINST
              ;        USES X AND A

5C3E 20695B   CSRD:    JSR    DNTST         ; TEST IF CURSOR IS TOO FAR DOWN
5C41 3014              BMI    CSRD2         ; JUMP IF NOT ENOUGH SPACE
5C43 20C95B            JSR    CSRDEL        ; DELETE THE CURRENT CURSOR
5C46 AD0301            LDA    Y1CORD        ; SUBTRACT CHARACTER WINDOW HEIGHT FROM
5C49 38                SEC                  ; Y COORDINATE
5C4A E90B              SBC    #CHHIW
5C4C 8D0301            STA    Y1CORD
5C4F B003              BCS    CSRD1
5C51 CE0401            DEC    Y1CORD+1
5C54 20C55B   CSRD1:   JSR    CSRINS        ; DISPLAY CURSOR AT THE NEW LOCATION
5C57 60       CSRD2:   RTS                  ; RETURN
```

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                          .PAGE  'CONTROL CHARACTER DISPATCH TABLE'
                 ;        CONTROL CHARACTER DISPATCH TABLE FOR DTEXT
                 ;        FIRST BYTE IS ASCII CONTROL CHARACTER CODE
                 ;        AND THIRD BYTES ARE ADDRESS OF SERVICE ROUTINE

5C58 0D          CCTAB:   .BYTE  X'0D          ; CR
5C59 8659                 .WORD  CARRET-1      ; CARRIAGE RETURN
5C5B 0A                   .BYTE  X'0A          ; LF
5C5C 9B59                 .WORD  LNFED-1       ; LINE FEED
5C5E 08                   .BYTE  X'08          ; BS
5C5F 4659                 .WORD  CRL-1         ; BACKSPACE
5C61 0C                   .BYTE  X'0C          ; FF
5C62 4E5A                 .WORD  FMFED-1       ; FORMFEED (CLEAR SCREEN)
5C64 0F                   .BYTE  X'0F          ; SI
5C65 5859                 .WORD  BASUP-1       ; BASELINE SHIFT UP
5C67 0E                   .BYTE  X'0E          ; SO
5C68 6F59                 .WORD  BASDN-1       ; BASELINE SHIFT DOWN
5C6A 11                   .BYTE  X'11          ; DC1
5C6B 4659                 .WORD  CRL-1         ; CURSOR LEFT
5C6D 12                   .BYTE  X'12          ; DC2
5C6E 4059                 .WORD  CRR-1         ; CURSOR RIGHT
5C70 13                   .BYTE  X'13          ; DC3
5C71 4C59                 .WORD  CRU-1         ; CURSOR UP
5C73 14                   .BYTE  X'14          ; DC4
5C74 5259                 .WORD  CRD-1         ; CURSOR DOWN
                 CCTABE:                       ; END OF LIST

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                                .PAGE    'CHARACTER FONT TABLE'
                      ;         CHARACTER FONT TABLE 5 WIDE BY 7 HIGH PLUS 2 DESCENDING
                      ;         ENTRIES IN ORDER STARTING AT ASCII BLANK
                      ;         96 ENTRIES
                      ;         EACH ENTRY CONTAINS 8 BYTES
                      ;         SIGN BIT OF FIRST BYTE IS A DESCENDER FLAG, CHARACTER DESCENDS
                      ;         2 ROWS IF IT IS A ONE
                      ;         NEXT 7 BYTES ARE CHARACTER MATRIX, TOP ROW FIRST, LEFTMOST DOT
                      ;         IS LEFTMOST IN BYTE

5C76 00000000  CHTB:    .BYTE  X'00,X'00,X'00,X'00    ; BLANK
5C7A 00000000           .BYTE  X'00,X'00,X'00,X'00
5C7E 00202020           .BYTE  X'00,X'20,X'20,X'20    ; !
5C82 20200020           .BYTE  X'20,X'20,X'00,X'20
5C86 00505050           .BYTE  X'00,X'50,X'50,X'50    ; "
5C8A 00000000           .BYTE  X'00,X'00,X'00,X'00
5C8E 005050F8           .BYTE  X'00,X'50,X'50,X'F8    ; #
5C92 50F85050           .BYTE  X'50,X'F8,X'50,X'50
5C96 002078A0           .BYTE  X'00,X'20,X'78,X'A0    ; X'
5C9A 7028F020           .BYTE  X'70,X'28,X'F0,X'20
5C9E 00C8C810           .BYTE  X'00,X'C8,X'C8,X'10    ; %
5CA2 20409898           .BYTE  X'20,X'40,X'98,X'98
5CA6 0040A0A0           .BYTE  X'00,X'40,X'A0,X'A0    ; &
5CAA 40A89068           .BYTE  X'40,X'A8,X'90,X'68
5CAE 00303030           .BYTE  X'00,X'30,X'30,X'30    ; '
5CB2 00000000           .BYTE  X'00,X'00,X'00,X'00
5CB6 00204040           .BYTE  X'00,X'20,X'40,X'40    ; (
5CBA 40404020           .BYTE  X'40,X'40,X'40,X'20
5CBE 00201010           .BYTE  X'00,X'20,X'10,X'10    ; )
5CC2 10101020           .BYTE  X'10,X'10,X'10,X'20
5CC6 0020A870           .BYTE  X'00,X'20,X'A8,X'70    ; *
5CCA 2070A820           .BYTE  X'20,X'70,X'A8,X'20
5CCE 00002020           .BYTE  X'00,X'00,X'20,X'20    ; +
5CD2 F8202000           .BYTE  X'F8,X'20,X'20,X'00
5CD6 80000000           .BYTE  X'80,X'00,X'00,X'00    ; ,
5CDA 30301020           .BYTE  X'30,X'30,X'10,X'20
5CDE 00000000           .BYTE  X'00,X'00,X'00,X'00    ; -
5CE2 F8000000           .BYTE  X'F8,X'00,X'00,X'00
5CE6 00000000           .BYTE  X'00,X'00,X'00,X'00    ; .
5CEA 00003030           .BYTE  X'00,X'00,X'30,X'30
5CEE 00080810           .BYTE  X'00,X'08,X'08,X'10    ; /
5CF2 20408080           .BYTE  X'20,X'40,X'80,X'80
5CF6 00609090           .BYTE  X'00,X'60,X'90,X'90    ; 0
5CFA 90909060           .BYTE  X'90,X'90,X'90,X'60
5CFE 00206020           .BYTE  X'00,X'20,X'60,X'20    ; 1
5D02 20202070           .BYTE  X'20,X'20,X'20,X'70
5D06 00708810           .BYTE  X'00,X'70,X'88,X'10    ; 2
5D0A 204080F8           .BYTE  X'20,X'40,X'80,X'F8
5D0E 00708808           .BYTE  X'00,X'70,X'88,X'08    ; 3
5D12 30088870           .BYTE  X'30,X'08,X'88,X'70
5D16 00103050           .BYTE  X'00,X'10,X'30,X'50    ; 4
5D1A 90F81010           .BYTE  X'90,X'F8,X'10,X'10
5D1E 00F880F0           .BYTE  X'00,X'F8,X'80,X'F0    ; 5
5D22 080808F0           .BYTE  X'08,X'08,X'08,X'F0
5D26 00708080           .BYTE  X'00,X'70,X'80,X'80    ; 6
```

```
5D2A F0888870          .BYTE  X'F0,X'88,X'88,X'70
5D2E 00F80810          .BYTE  X'00,X'F8,X'08,X'10    ; 7
5D32 20408080          .BYTE  X'20,X'40,X'80,X'80
5D36 00708888          .BYTE  X'00,X'70,X'88,X'88    ; 8
5D3A 70888870          .BYTE  X'70,X'88,X'88,X'70
5D3E 00708888          .BYTE  X'00,X'70,X'88,X'88    ; 9
5D42 78080870          .BYTE  X'78,X'08,X'08,X'70
5D46 00303000          .BYTE  X'00,X'30,X'30,X'00    ; :
5D4A 00003030          .BYTE  X'00,X'00,X'30,X'30
5D4E 00303000          .BYTE  X'00,X'30,X'30,X'00    ; ;
5D52 30301020          .BYTE  X'30,X'30,X'10,X'20
5D56 00102040          .BYTE  X'00,X'10,X'20,X'40    ; LESS THAN
5D5A 80402010          .BYTE  X'80,X'40,X'20,X'10
5D5E 000000F8          .BYTE  X'00,X'00,X'00,X'F8    ; =
5D62 00F80000          .BYTE  X'00,X'F8,X'00,X'00
5D66 00402010          .BYTE  X'00,X'40,X'20,X'10    ; GREATER THAN
5D6A 08102040          .BYTE  X'08,X'10,X'20,X'40
5D6E 00708808          .BYTE  X'00,X'70,X'88,X'08    ; ?
5D72 10200020          .BYTE  X'10,X'20,X'00,X'20
5D76 00708808          .BYTE  X'00,X'70,X'88,X'08    ; @
5D7A 68A8A8D0          .BYTE  X'68,X'A8,X'A8,X'D0
5D7E 00205088          .BYTE  X'00,X'20,X'50,X'88    ; A
5D82 88F88888          .BYTE  X'88,X'F8,X'88,X'88
5D86 00F04848          .BYTE  X'00,X'F0,X'48,X'48    ; B
5D8A 704848F0          .BYTE  X'70,X'48,X'48,X'F0
5D8E 00708880          .BYTE  X'00,X'70,X'88,X'80    ; C
5D92 80808870          .BYTE  X'80,X'80,X'88,X'70
5D96 00F04848          .BYTE  X'00,X'F0,X'48,X'48    ; D
5D9A 484848F0          .BYTE  X'48,X'48,X'48,X'F0
5D9E 00F88080          .BYTE  X'00,X'F8,X'80,X'80    ; E
5DA2 F08080F8          .BYTE  X'F0,X'80,X'80,X'F8
5DA6 00F88080          .BYTE  X'00,X'F8,X'80,X'80    ; F
5DAA F0808080          .BYTE  X'F0,X'80,X'80,X'80
5DAE 00708880          .BYTE  X'00,X'70,X'88,X'80    ; G
5DB2 B8888870          .BYTE  X'B8,X'88,X'88,X'70
5DB6 00888888          .BYTE  X'00,X'88,X'88,X'88    ; H
5DBA F8888888          .BYTE  X'F8,X'88,X'88,X'88
5DBE 00702020          .BYTE  X'00,X'70,X'20,X'20    ; I
5DC2 20202070          .BYTE  X'20,X'20,X'20,X'70
5DC6 00381010          .BYTE  X'00,X'38,X'10,X'10    ; J
5DCA 10109060          .BYTE  X'10,X'10,X'90,X'60
5DCE 008890A0          .BYTE  X'00,X'88,X'90,X'A0    ; K
5DD2 C0A09088          .BYTE  X'C0,X'A0,X'90,X'88
5DD6 00808080          .BYTE  X'00,X'80,X'80,X'80    ; L
5DDA 808080F8          .BYTE  X'80,X'80,X'80,X'F8
5DDE 0088D8A8          .BYTE  X'00,X'88,X'D8,X'A8    ; M
5DE2 A8888888          .BYTE  X'A8,X'88,X'88,X'88
5DE6 008888C8          .BYTE  X'00,X'88,X'88,X'C8    ; N
5DEA A8988888          .BYTE  X'A8,X'98,X'88,X'88
5DEE 00708888          .BYTE  X'00,X'70,X'88,X'88    ; O
5DF2 88888870          .BYTE  X'88,X'88,X'88,X'70
5DF6 00F08888          .BYTE  X'00,X'F0,X'88,X'88    ; P
5DFA F0808080          .BYTE  X'F0,X'80,X'80,X'80
5DFE 00708888          .BYTE  X'00,X'70,X'88,X'88    ; Q
5E02 88A89068          .BYTE  X'88,X'A8,X'90,X'68
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5E06 00F08888           .BYTE  X'00,X'F0,X'88,X'88    ; R
5E0A F0A09088           .BYTE  X'F0,X'A0,X'90,X'88
5E0E 00788080           .BYTE  X'00,X'78,X'80,X'80    ; S
5E12 700808F0           .BYTE  X'70,X'08,X'08,X'F0
5E16 00F82020           .BYTE  X'00,X'F8,X'20,X'20    ; T
5E1A 20202020           .BYTE  X'20,X'20,X'20,X'20
5E1E 00888888           .BYTE  X'00,X'88,X'88,X'88    ; U
5E22 88888870           .BYTE  X'88,X'88,X'88,X'70
5E26 00888888           .BYTE  X'00,X'88,X'88,X'88    ; V
5E2A 50502020           .BYTE  X'50,X'50,X'20,X'20
5E2E 00888888           .BYTE  X'00,X'88,X'88,X'88    ; W
5E32 A8A8D888           .BYTE  X'A8,X'A8,X'D8,X'88
5E36 00888850           .BYTE  X'00,X'88,X'88,X'50    ; X
5E3A 20508888           .BYTE  X'20,X'50,X'88,X'88
5E3E 00888850           .BYTE  X'00,X'88,X'88,X'50    ; Y
5E42 20202020           .BYTE  X'20,X'20,X'20,X'20
5E46 00F80810           .BYTE  X'00,X'F8,X'08,X'10    ; Z
5E4A 204080F8           .BYTE  X'20,X'40,X'80,X'F8
5E4E 00704040           .BYTE  X'00,X'70,X'40,X'40    ; LEFT BRACKET
5E52 40404070           .BYTE  X'40,X'40,X'40,X'70
5E56 00808040           .BYTE  X'00,X'80,X'80,X'40    ; BACKSLASH
5E5A 20100808           .BYTE  X'20,X'10,X'08,X'08
5E5E 00701010           .BYTE  X'00,X'70,X'10,X'10    ; RIGHT BRACKET
5E62 10101070           .BYTE  X'10,X'10,X'10,X'70
5E66 00205088           .BYTE  X'00,X'20,X'50,X'88    ; CARROT
5E6A 00000000           .BYTE  X'00,X'00,X'00,X'00
5E6E 00000000           .BYTE  X'00,X'00,X'00,X'00    ; UNDERLINE
5E72 000000F8           .BYTE  X'00,X'00,X'00,X'F8

5E76 00C06030           .BYTE  X'00,X'C0,X'60,X'30    ; GRAVE ACCENT
5E7A 00000000           .BYTE  X'00,X'00,X'00,X'00
5E7E 00006010           .BYTE  X'00,X'00,X'60,X'10    ; A (LC)
5E82 70909068           .BYTE  X'70,X'90,X'90,X'68
5E86 008080F0           .BYTE  X'00,X'80,X'80,X'F0    ; B (LC)
5E8A 888888F0           .BYTE  X'88,X'88,X'88,X'F0
5E8E 00000078           .BYTE  X'00,X'00,X'00,X'78    ; C (LC)
5E92 80808078           .BYTE  X'80,X'80,X'80,X'78
5E96 00080878           .BYTE  X'00,X'08,X'08,X'78    ; D (LC)
5E9A 88888878           .BYTE  X'88,X'88,X'88,X'78
5E9E 00000070           .BYTE  X'00,X'00,X'00,X'70    ; E (LC)
5EA2 88F08078           .BYTE  X'88,X'F0,X'80,X'78
5EA6 00304040           .BYTE  X'00,X'30,X'40,X'40    ; F (LC)
5EAA E0404040           .BYTE  X'E0,X'40,X'40,X'40
5EAE 80708888           .BYTE  X'80,X'70,X'88,X'88    ; G (LC)
5EB2 98680870           .BYTE  X'98,X'68,X'08,X'70
5EB6 008080B0           .BYTE  X'00,X'80,X'80,X'B0    ; H (LC)
5EBA C8888888           .BYTE  X'C8,X'88,X'88,X'88
5EBE 00200060           .BYTE  X'00,X'20,X'00,X'60    ; I (LC)
5EC2 20202070           .BYTE  X'20,X'20,X'20,X'70
5EC6 80701010           .BYTE  X'80,X'70,X'10,X'10    ; J (LC)
5ECA 10109060           .BYTE  X'10,X'10,X'90,X'60
5ECE 00808090           .BYTE  X'00,X'80,X'80,X'90    ; K (LC)
5ED2 A0C0A090           .BYTE  X'A0,X'C0,X'A0,X'90
5ED6 00602020           .BYTE  X'00,X'60,X'20,X'20    ; L (LC)
5EDA 20202020           .BYTE  X'20,X'20,X'20,X'20
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5EDE 000000D0          .BYTE  X'00,X'00,X'00,X'D0    ; M (LC)
5EE2 A8A8A8A8          .BYTE  X'A8,X'A8,X'A8,X'A8
5EE6 000000B0          .BYTE  X'00,X'00,X'00,X'B0    ; N (LC)
5EEA C8888888          .BYTE  X'C8,X'88,X'88,X'88
5EEE 00000070          .BYTE  X'00,X'00,X'00,X'70    ; O (LC)
5EF2 88888870          .BYTE  X'88,X'88,X'88,X'70
5EF6 80F08888          .BYTE  X'80,X'F0,X'88,X'88    ; P (LC)
5EFA 88F08080          .BYTE  X'88,X'F0,X'80,X'80
5EFE 80788888          .BYTE  X'80,X'78,X'88,X'88    ; Q (LC)
5F02 88780808          .BYTE  X'88,X'78,X'08,X'08
5F06 000000B0          .BYTE  X'00,X'00,X'00,X'B0    ; R (LC)
5F0A C8808080          .BYTE  X'C8,X'80,X'80,X'80
5F0E 00000078          .BYTE  X'00,X'00,X'00,X'78    ; S (LC)
5F12 807008F0          .BYTE  X'80,X'70,X'08,X'F0
5F16 004040E0          .BYTE  X'00,X'40,X'40,X'E0    ; T (LC)
5F1A 40405020          .BYTE  X'40,X'40,X'50,X'20
5F1E 00000090          .BYTE  X'00,X'00,X'00,X'90    ; U (LC)
5F22 90909068          .BYTE  X'90,X'90,X'90,X'68
5F26 00000088          .BYTE  X'00,X'00,X'00,X'88    ; V (LC)
5F2A 88505020          .BYTE  X'88,X'50,X'50,X'20
5F2E 000000A8          .BYTE  X'00,X'00,X'00,X'A8    ; W (LC)
5F32 A8A8A850          .BYTE  X'A8,X'A8,X'A8,X'50
5F36 00000088          .BYTE  X'00,X'00,X'00,X'88    ; X (LC)
5F3A 50205088          .BYTE  X'50,X'20,X'50,X'88
5F3E 80888888          .BYTE  X'80,X'88,X'88,X'88    ; Y (LC)
5F42 50204080          .BYTE  X'50,X'20,X'40,X'80
5F46 000000F8          .BYTE  X'00,X'00,X'00,X'F8    ; Z (LC)
5F4A 102040F8          .BYTE  X'10,X'20,X'40,X'F8
5F4E 00102020          .BYTE  X'00,X'10,X'20,X'20    ; LEFT BRACE
5F52 60202010          .BYTE  X'60,X'20,X'20,X'10
5F56 00202020          .BYTE  X'00,X'20,X'20,X'20    ; VERTICAL BAR
5F5A 20202020          .BYTE  X'20,X'20,X'20,X'20
5F5E 00402020          .BYTE  X'00,X'40,X'20,X'20    ; RIGHT BRACE
5F62 30202040          .BYTE  X'30,X'20,X'20,X'40
5F66 0010A840          .BYTE  X'00,X'10,X'A8,X'40    ; TILDA
5F6A 00000000          .BYTE  X'00,X'00,X'00,X'00
5F6E 00A850A8          .BYTE  X'00,X'A8,X'50,X'A8    ; RUBOUT
5F72 50A850A8          .BYTE  X'50,X'A8,X'50,X'A8

0000                   .END
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NO ERROR LINES