

Title page

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I Mark Bowren do not accept any responsibility for any damage done to the reader's files while using the program MDBASIC, utility programs or the information presented in this manual.

If you have any questions about the program MDBASIC or this book, you may write to:

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The program MDBASIC is dedicated to Kevin Dean Earley.

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PREFACE

This documentation is written for a novice BASIC programmer and is not considered an instructional guide for learning programming.

There are many different programs on the market that aid the programmer in certain areas of programming such as debugging, graphics, and sound, but there is no program on the market that puts all the features of the Commodore 64 together like MDBASIC. Finally, the full power of the C64 is available to the BASIC programmer.

MDBASIC stands for "Mark Daniel Bowren's All-Purpose Symbolic Instruction Code." It is a program written to coexist with the Commodore 64's BASIC interpreter. All CBM BASIC commands can be used. MDBASIC augments some existing commands and adds additional commands.

MDBASIC is located at memory address \$8000 (32768) to \$BFFF (43008). Half of the program is written underneath ROM, but there were needs to use 8K of BASIC's RAM area. This leaves the user with 30718 bytes of memory for BASIC programs, but, as you will see when using MDBASIC, your programs will become much shorter and more efficient, which more than makes up for the loss of memory.

MDBASIC comes with 60+ commands, aiding the programmer with I/O, sound, text, sprites, redefined characters, bitmap screens, and programming-debugging. Many of the commands have multiple functions and do more than just one task. Certain operands in a command can be omitted by using commas or truncating the remainder of the parameters. This allows one command to perform several separate functions with only one command token, otherwise there would be over 100 commands to learn using two-byte tokens (Simon's Basic).

Along with the commands offered by MDBASIC is the aid of the eight function keys that can be individually assigned to a string of 15 characters, repeating keys, hexadecimal (\$) binary (%) and octal (@) number representation, and much more.

I feel once you have used MDBASIC and understand most of the commands, you will not want to go back to using standard CBM BASIC.

Sincerely,

Mark Bowren

INSTALLATION

To run MDBASIC from Commodore 64 BASIC, type the following:

```
LOAD"MDBASIC",8,1
```

```
SYS64738
```

MDBASIC will automatically initialize as if a cartridge is plugged in.

The following is a summary of the commands offered by MDBASIC, grouped together according to the tasks they perform:

UTILITIES			
AUTO	DISK	DUMP	DELETE
FILES	FIND	MERGE	OLD
MERGE	RESET	TRACE	VAR
GRAPHICS			
BITMAP	CIRCLE	DRAW	DESIGN
EXPAND	LINE	MAPCOL	MOVE
MULTI	PAINT	PLOT	SCREEN
SPRITE	MOVE	TEXT	
AUDIO			
ENVELOPE	FILTER	PLAY	PULSE
VOICE	WAVE	VOL	
MISCELLANEOUS*			
COLOR	DELAY	ELSE	FILL
KEY	KEY LIST	LINE INPUT	LINE INPUT#
LOCATE	ON ERROR	ON KEY	RESTORE
RESUME	RUN	SCROLL	SWAP
FUNCTIONS			
CSR	ERROR	HEX\$	INSTR
JOY	KEY	PEN	POT
PTR	ROUND		

*RUN and RESTORE are existing CBM BASIC commands that have been augmented. For more details on the extended capabilities refer to the documentation.

MDBASIC comes with the following programs to aid the programmer:

"LISTCMDS"

a simple basic program that displays all commands and functions

"CHARACTER EDITOR"

designs hires/multicolor characters & gives data

"SPRITE EDITOR"

designs hires/multicolor sprites & gives data

FEATURES & ENHANCEMENTS

MDBASIC adds enhanced file loading features described briefly here. See Appendix A for more details.

Device Numbers for loading & saving special data:

- 2 Text screen & colors including background & border
- 3 Character designs (after using DESIGN command)
- 4 Bitmap images complete with color & mode

SAVE "MYSCREEN",8,2 :REM SAVE CURRENT TEXT SCREEN TO FILE

LOAD "MYBITMAP",8,4 :REM LOAD & SHOW BITMAP FROM FILE

When loading files, the start & end address will be displayed after loading is complete. For example:

LOAD"MYPRG",8,1

**SEARCHING FOR MYPRG
LOADING 49152-50059
READY.**

In addition, MDBASIC will load binary files (pictures, machine code, etc.) without corrupting BASIC memory pointers. A LOAD statement can be in a BASIC program to load binary files anywhere in memory (except \$8000-\$BFFF which is reserved for MDBASIC) without losing variable data or causing an OUT OF MEMORY error. It is up to the programmer to be careful about the target memory locations to avoid problems. For example, you would not want to load a file on top of where your program and variables are stored. The safest approach is to load binaries into upper memory (\$C000-\$CFFF). You can load bitmap graphics directly to \$E000-\$FFFF (RAM under Kernel ROM) then use the BITMAP statement to show the image.

MDBASIC supports numeric constants of base 2 (binary), 8 (octal) or hexadecimal. Below are some examples:

**B = %00001111 :REM BINARY 15
H = \$FFFF :REM HEX 65535
O = @20 :REM OCTAL 16
PRINT X AND %1111**

The LIST command has been enhanced with the ability to freeze the listing process by holding down the shift key. The original behavior only supported slowing down the list process when holding down the control key.

AUTO

PURPOSE:

To automatically generate line numbers with a specified increment while typing in a program.

SYNTAX:

```
AUTO
AUTO ON
AUTO OFF
AUTO [increment]
```

DESCRIPTION:

When making a BASIC program, every line must start with a line number. Line numbers may be incremented in any step while programming. AUTO is helpful because it automatically displays the next line number that is to follow the line that was just entered.

AUTO ON turns auto-line numbering on with an increment of 10. This command is not necessary if an increment other than 10 is desired.

AUTO OFF turns auto-line numbering off.

increment is the number of lines that will be added to the last line entered to calculate the next line number. Line numbers range from 0-63999, so it is not advisable to have increments higher than 1000, especially with long programs.

The programmer must type in the first line number, or hit return on the current working line number for the next line to be displayed.

EXAMPLE:

```
AUTO 10      :REM sets auto-line numbering with increments of 10
AUTO 1000    :REM sets auto-line numbering with increments of 1000
AUTO OFF     :REM disables auto-numbering
```

BITMAP

PURPOSE:

Selects bitmap graphics mode, change color mode of a bitmap screen and/or clears the current bitmap.

SYNTAX:

BITMAP [*colorMode*], [*backgroundColor*]

BITMAP CLR

BITMAP FILL [*x1*], [*y1*] **TO** [*x2*], [*y2*], [*plot type*], [*color*]

DESCRIPTION:

Bit Mapping is the method in which each possible dot (pixel) of resolution on the screen is assigned its own bit (location) in memory. There are two types of bitmaps available on the C64, they are:

- 1) Standard (high resolution) bit mapped mode (320 X 200)
- 2) Multicolor bit mapped mode (160 X 200)

Standard has greater resolution, but fewer color selections. Multicolor has a greater number of colors that can fit into an 8 X 8 square at a cost of losing half of its horizontal resolution.

colorMode (0=*hires*, 1=*multicolor*) selects the type of bitmap. In hires mode the resolution is 320x200. In multicolor mode the resolution is 160x100. The first dot is at coordinate 0,0.

backgroundColor (0-15) selects the background color of the bitmap screen. See the COLOR command (page 6) for the list of background colors.

Refer to the MAPCOL command to change the colors being used for plotting. When in multicolor mode, all commands like CIRCLE, LINE, PLOT, etc., can select colors using the optional color operand at the end of each command.

BITMAP CLR is used to clear the dots on a BITMAP.

BITMAP FILL is used to set dots in a rectangle. The coordinates top left corner (*x1*, *y1*) and bottom right corner (*x2*, *y2*) define the rectangle to set the dots based on the *plot type* and *color*, optionally specified as with all graphics commands, which default to the last setting.

EXAMPLE:

```

BITMAP CLR      :REM clear the current bitmap dots
BITMAP 0        :REM switch display to hires bitmap mode
BITMAP 0,1      :REM switch to hires bitmap mode with a white background
BITMAP 1,0      :REM switch to multicolor bitmap mode with black bkgnd

```


CIRCLE

PURPOSE:

To draw circles or ellipsoids on a bitmap screen.

SYNTAX:

CIRCLE [*x*], [*y*], [*xr*], [*yr*], [*plot type*], [*color*]

DESCRIPTION:

x & *y* are the coordinates for the center of the circle to be drawn.
(*x*=0-319 : *y*=0-199) hi-res mode; (*x*=0-159 : *y*=0-99) multicolor mode. Any values out of range in the mode selected will result in an ILLEGAL COORDINATE ERROR.

xr (0-255) & *yr* (0-255) define the size of the *x* radius and *y* radius. This is the distance from the center point to the outer edge of the circle. Many different circle shapes can be drawn by varying these values.

plot type (0-2) is the manner that the dots will be drawn as follows:

- 0 = Erase dot(s)
- 1 = Draw dot(s)
- 2 = Flip dot(s) (reverses current condition: on=off, off=on)

color (0-15 in hires mode; 0-3 in multicolor mode), selects the color for the line. In multicolor mode, the colors 1-3 will correspond to the colors *c1-c3*, which are selected by the MULTI BITMAP or MAPCOL command. If the *color*=0 the dots will be drawn with the color of the background, which is selected using the COLOR command.

EXAMPLE:

```
CIRCLE 160,100,50,40      :REM makes a circle in the center of the screen
CIRCLE 160,100,50,40,0    :REM erases the previous circle
CIRCLE 0,0,10,10,6        :REM draws 1/4 blue circle in top-left corner
```

COLOR

PURPOSE:

To select colors for the character, background, and border; also turns on/off flashing characters.

SYNTAX:

COLOR [*character color*], [*background color*], [*border color*]

DESCRIPTION:

character color (0-31) changes the character color. Colors 0-15 are listed in the table below. Colors 16-31 toggle the flash mode for the colors listed in the table below. For example, to toggle the flashing mode for the color red, add 16 to the value: COLOR 2+16. If the color is not currently flashing it will begin flashing, otherwise it will stop flashing. This effects all characters on the screen having the same color. There is no function to return the state of the flash mode for each color so the programmer will have to track the state in a variable.

background color (0-15) changes the background color.

border color (0-15) changes the border color.

The following is a table of the colors & their numbers:

<u>VALUE</u>	<u>COLOR</u>	<u>VALUE</u>	<u>COLOR</u>
0	black	8	orange
1	white	9	brown
2	red	10	light red
3	cyan	11	gray 1 (dark)
4	purple	12	gray 2 (medium)
5	green	13	light green
6	blue	14	light blue
7	yellow	15	gray 3 (light)

(add 16 to toggle the flashing mode for character color)

EXAMPLE:

```
COLOR ,14      :REM select light blue background only
COLOR 2 OR 16  :REM toggle flashing for all red characters
```

CSR()

PURPOSE:

To return cursor information.

SYNTAX:

`i = CSR([n])`

DESCRIPTION:

n (0-7) selects the piece of information about the cursor. The same information can be read directly from memory registers using PEEK statements. This function helps reduce the use of PEEK statements so that the programmer does not have to concern themselves with which memory locations hold the data. It also makes the program more readable.

VALUE	INFORMATION
0	cursor logical column number (0-79) same as POS function
1	cursor physical line number (0-24)
2	cursor blink mode 0=off, 1=on
3	maximum column number for current line (39 or 79)
4	character scan code under cursor (while blinking)
5	cursor physical column number (0-39)
6	character color (0-15) under cursor (while blinking)
7	address in RAM for the first character on the cursor line

The distinction between logical and physical is based on how the line editor works in the C64. When you type characters beyond the last physical column a new line is inserted giving you up to 80 characters for the logical line. The first character on this second logical line is at the 41st position (value of 40 since it is a zero-based index). The physical column however is at the first position which is 0. This is a calculated value. If the logical column is greater than 39 then the physical column is 40-logical column, otherwise the physical column equals the logical column.

EXAMPLE:

```
L% = CSR(1)      :REM physical line#
C% = CSR(5)      :REM physical column# (not same as logical POS())
```

DELAY

PURPOSE:

Perform a pause in program execution for a specified amount of time.

SYNTAX:

DELAY [*jiffies*]

DESCRIPTION:

DELAY has many applications in programming. Allowing time for the user to read the screen, a tone to sound, and slowing down programming are typical applications of this command. DELAY allows the user to perform a delay without using a FOR/NEXT loop, which would use a variable, and the actual time would have to be calculated through trial & error to see the duration.

jiffies (0-65535) is an unsigned integer of the number jiffies (approximately one sixtieth of a second) to wait. Any value outside this range will result in an ILLEGAL QUANTITY ERROR.

EXAMPLE:

```
DELAY 300      :REM wait for 5 seconds
DELAY 60       :REM wait for one second
DELAY 30       :REM wait for half a second
DELAY 1        :REM wait for 1/60 of a second
```

DELETE

PURPOSE:

To remove a line or range of consecutive lines from a program.

SYNTAX:

```
DELETE  
DELETE [line#]  
DELETE [start]-[stop]  
DELETE [start-]
```

DESCRIPTION:

DELETE aids the programmer when editing a program. Any line or groups of lines may be removed from the program rapidly.

DELETE used alone does the same task as NEW.

line# is the line to delete.

start is the first line to be deleted. This value may be omitted if the first line to delete is the first line in the program.

stop is the last line to be deleted. This value may be omitted if the last line to delete is the last line in the program.

MDBASIC always returns to direct mode after the DELETE command is executed because the program is changed & the variables are lost.

EXAMPLE:

```
DELETE 50      :REM delete line 40  
DELETE        :REM deletes entire program  
DELETE 10-70   :REM deletes lines 10 thru 70  
DELETE -100    :REM deletes all lines up to line 100
```

DESIGN

PURPOSE:

To redefine a character's shape and/or select redefined character mode.

SYNTAX:

DESIGN ON

DESIGN OFF

DESIGN NEW

DESIGN [*scan code*], [*d0*], [*d1*], [*d2*], [*d3*], [*d4*], [*d5*], [*d6*], [*d7*]

DESCRIPTION:

Each character is formed by an 8 x 8 grid of dots, where each dot can be on or off. The data is stored in 8 bytes. The bits that make up each byte will decide what the character looks like. An example of the letter A is shown below:

IMAGE	BINARY	DATA
...**...	00011000	24
..*****.	00111100	60
.***...*	01100110	102
.*****.	01111110	126
.***...*	01100110	102
.***...*	01100110	102
.***...*	01100110	102
.....	00000000	0
(*=bit on . =bit off)		

DESIGN ON turns on redefined character mode allowing the programmer to change any or all of the existing characters in upper & lower case as well as the graphics character set. This mode has its own text screen so upon entry, the screen will consist of the characters that were printed on it, allowing the programmer to have two full screens of text to work with if desired. If this screen has not been used before, most likely garbage is displayed, so it is necessary to clear the screen after executing DESIGN ON.

NEW allows the Commodore character set to be copied for all characters. When used, the current character definitions are replaced with a copy of the Commodore 64 ROM image.

Screen RAM is located from \$CC00-\$CFE7 (52224-53223) rather than \$0400-\$07E7 (1024-2023). Any PEEKs and POKEs relating to screen RAM must be in this area for correct operation.

Sprite data space is from \$C000-\$CBBF (49152-52223) using sprite pointers from 0-47, allowing 48 different sprite shapes.

DESIGN OFF returns the computer to the normal text graphics mode. This task can also be done by using TEXT.

scan code (0-255) AKA: poke code, selects which character to redefine (poke code <> ASCII). This value can be put in parenthesis for separation to avoid confusion with the data.

d0, d1, d2, d3, d4, d5, d6, d7 are the eight data bytes that make up the shape of each character. By using the percent sign (%), the data can be represented as binary numbers, making obtaining the data simple. If any of the data is omitted, a MISSING OPERAND ERROR will result.

EXAMPLE:

```
DESIGN NEW           :REM copy ROM chars to RAM for init design
DESIGN ON           :REM switch to redefined char mode
DESIGN 1,0,0,0,8,8,0,0,0 :REM scan code 1 (ASCII 'A') changes to a dot
DESIGN OFF         :REM return to std text mode
```

DISK

PURPOSE:

To send DOS commands to the disk drive(s).

SYNTAX:

DISK [*command\$*]

DESCRIPTION:

DISK is used to send DOS (Disk Operating System) commands to a selected disk drive. This command eliminates the need for opening & closing the command channel. All commands offered by the DOS version in the disk drive are available. When executed in direct mode (not in a program) the status of the drive is displayed to describe the result of the command. In program mode you will have to open a channel (secondary device 15) to read this carriage return delimited string. The format of this string is as follows:

[Status Code],[Message],[Info1],[Info2]

Examples:

00, OK,00,00

00, FILES SCRATCHED,01,00

command\$ is a string of characters containing the drive number, function to perform, and the parameters to sent to the drive. The following is the commands offered by the 1541 disk drive:

COMMAND	SYNTAX (d=drive number)	DESCRIPTION
NEW	"Nd:disk name,id"	Full format with ID & label
NEW	"Nd:disk name"	Soft format (BAM only) with label
COPY	"Cd:new file=d:original file"	Copy a file
RENAME	"Rd:new name=old name"	Rename a file
SCRATCH	"Sd:file name"	Delete a file
INITIALIZE	"Id"	Initialize a disk (clear errors)
VALIDATE	"Vd"	Validate a disk (find problems)

EXAMPLE:

```
DISK"I0"           :REM initialize drive 0
DISK"N0:JUNK DISK,JD" :REM format drive 0, name="JUNK DISK", id="JD"
DISK"V"           :REM validates diskette in drive 0
DISK"S1:POKER"     :REM erases program "POKER" on drive 1
DISK"C1:DATA=0:DATA" :REM copies "DATA" from drive 0 to drive 1
DISK"C0:DATA.BAK=0:DATA" :REM makes backup copy of "DATA" on drive 0
```


DRAW

PURPOSE:

To draw intricate shapes on a bitmap screen.

SYNTAX:

DRAW [*shape\$*]

DESCRIPTION:

DRAW is used when drawing a picture that has an intricate shape.

The PLOT command can be used to set the start point, the plot type, and the color of the shape that will be drawn. DRAW always draws from the last plotted point using the last used color & plot type.

shape\$ contains the directions and distances for drawing as follows:

COMMAND	FUNCTION
P	Change plot type 0=clear, 1=set, 2=flip, 3=none
C	Change plot color (0-15)
U	UP
D	DOWN
L	LEFT
R	RIGHT
E	UP & RIGHT
F	DOWN & RIGHT
G	LEFT & DOWN
H	RIGHT & DOWN

The values following these commands specify the number of dots (pixels) to draw in the selected direction. If draw reaches the end of the plot area then wrap-around will occur.

To draw without plotting (like lifting the pencil) use plot type 3. This will simply move the current plot coordinates. You will have to set the plot type back to the original value to continue plotting dots.

EXAMPLE:

```
PLOT 10, 10 :REM set current coordinates for draw
DRAW "C2,R30,P3,R30,P1,R30,D25,L90,U25" :REM red box with open top
```

DUMP

PURPOSE:

To print various information including a program listing, a text screen, graphics screen, current variables or user-defined expression.

SYNTAX:

```
DUMP LIST [start]-[stop]  
DUMP SCREEN  
DUMP BITMAP [size]  
DUMP VARS  
DUMP [expression]
```

DESCRIPTION:

This command is very useful when a hard-copy is needed for a program listing, text or bitmap screen.

DUMP LIST works just like the list routine, except the listing goes on the printer. *start-stop* specify the starting & ending line numbers to print.

DUMP SCREEN allows the current text screen to be printed on the printer.

DUMP BITMAP allows the bitmapped screen to be printed on the printer.

size (1 or 2, default=1) selects one of the two sizes to print as follows:
1=normal size, 2=double size

DUMP *expression* represents any variable, string or numeric, to be printed on the printer. When not using the other three configurations, DUMP works just like the PRINT command, except the output is only to the printer.

DUMP VARS lists the currently dimensioned variables to the printer.

EXAMPLE:

```
DUMP LIST 100-           :REM dumps program listing from line 100  
DUMP SPC(3)+"PRINTER OK." :REM simple test for printer  
DUMP SCREEN             :REM dumps everything on the text screen  
DUMP BITMAP 2           :REM print bitmap enlarged 2x
```

ENVELOPE

PURPOSE:

To set the duration of the volume envelop phases (attack, decay, sustain, release) for a given voice.

SYNTAX:

ENVELOPE [*voice#*], [*attack*], [*decay*]

ENVELOPE [*voice#*], [*attack*], [*decay*], [*sustain*], [*release*]

DESCRIPTION:

When a note is played on a musical instrument, the volume does not suddenly rise to a peak and then cut off to zero. Rather, the volume builds to a peak, levels off to an intermediate value, and then fades away. This creates what is known as a volume envelope.

The first phase of the envelope, in which the volume builds to a peak, is known as the attack phase. The second, in which it declines to an intermediate level, is called the decay phase. The third, in which the intermediate level of volume is held, is known as the sustain period. The final interval, in which the sound fades away, is called the release part of the cycle.

voice# (1-3) selects which voice will have the settings.

attack (0-15) is time over which the volume of the tone will rise from 0 to its peak. The 16 durations to choose from set the elapsed time of this cycle as follows:

VALUE	DURATION
0	0.002 seconds
1	0.008 seconds
2	0.016 seconds
3	0.024 seconds
4	0.038 seconds
5	0.056 seconds
6	0.068 seconds
7	0.080 seconds
8	0.10 seconds
9	0.25 seconds
10	0.50 seconds
11	0.08 seconds
12	1.00 seconds
13	3.00 seconds
14	5.00 seconds
15	8.00 seconds

decay is the time over which the volume of the tone declines from the peak reached in the attack phase to the sustain level. The 16 durations to choose from set the elapsed time of this cycle as follows:

VALUE	DURATION	VALUE	DURATION
0	0.006 seconds	8	0.30 seconds
1	0.024 seconds	9	0.75 seconds
2	0.048 seconds	10	1.50 seconds
3	0.972 seconds	11	2.40 seconds
4	0.114 seconds	12	3.00 seconds
5	0.168 seconds	13	9.00 seconds
6	0.204 seconds	14	15.00 seconds
7	0.240 seconds	15	24.00 seconds

sustain (0-15) selects the volume level at which the note is sustained. Following the decay cycle, the volume of the output of the voice will remain at the selected sustain level until the release cycle is started using the WAVE command (page 57).

release (0-15) is the duration of time in which the volume fades from the sustain level to near zero volume. The duration of the release cycle corresponds to the values 0-15 in the decay chart.

The attack, decay, sustain cycle is started by the WAVE command (page 57) by setting the gate operand=1. The sound being emitted will stay at the sustain volume until the release cycle is starting with gate=0.

You may notice the volume of the sound does not quite get to 0 at the end of the release cycle, and you may need to turn off the sound to get rid of the residual noise. This can be done by setting the waveform, frequency or volume to zero.

NOTE: Sound registers cannot be read, only written to. You must supply all parameters for this command even when changing only one of them.

EXAMPLE:

```
ENVELOPE 1,15,15,15,15      :REM maximum values for all settings
ENVELOPE 3,0,0,0,0          :REM clear voice#3's envelope
```

ELSE

PURPOSE:

To act on a false result of an expression in an IF statement on the same line.

SYNTAX:

```
IF [expression] THEN [true statements] :ELSE [false statements]
IF [expression] THEN line1# ELSE line2#
```

DESCRIPTION:

If the *expression* result is non-zero (true), all commands between keywords THEN & ELSE will be executed. If the *expression* result is 0 (false), all commands after the ELSE keyword are executed. The ELSE keyword is optional in the IF statement.

THEN and/or ELSE may be followed by either a line number for branching, or one or more statements to be executed.

Because IF...THEN...ELSE is all one statement, the ELSE keyword must be on the same line as the IF keyword.

ELSE will apply to the first IF/THEN statement having a false *expression* on the same program line. Consider the following example:

```
10 A=1:B=2:C=1
20 IF A=B THEN IF B=C THEN PRINT"A=C" : ELSE PRINT"A<>C"
The output will be:
A<>C
```

EXAMPLE:

```
IF A$="N" THEN PRINT"NO":ELSE PRINT"YES":REM yes or no will be printed
IF X THEN 100 ELSE 200 :REM goto 100 if x<>0, 200 if x=0
IF X=1 THEN 200 ELSE X = 0 :REM goto 200 if x=1, otherwise set x=0
```

ERROR

PURPOSE:

To raise an error during program execution. Also used to clear the last error state or turn off error trapping (from ON ERROR).

SYNTAX:

ERROR [*err#*]
ERROR CLR
ERROR OFF

DESCRIPTION:

err# (1-127) is the error number to raise. Error numbers 1-30 are the CBM BASIC errors. Errors 31-35 are MDBASIC errors. Errors 36-127 are user-defined errors and thus have no associated message. Any attempt to raise an error outside the valid range will always result in error 14 (Illegal Quantity).

1 TOO MANY FILES	18 BAD SUBSCRIPT
2 FILE OPEN	19 REDIM'D ARRAY
3 FILE NOT OPEN	20 DIVISION BY ZERO
4 FILE NOT FOUND	21 ILLEGAL DIRECT
5 DEVICE NOT PRESENT	22 TYPE MISMATCH
6 NOT INPUT FILE	23 STRING TOO LONG
7 NOT OUTPUT FILE	24 FILE DATA
8 MISSING FILENAME	25 FORMULA TOO COMPLEX
9 ILLEGAL DEVICE NUMBER	26 CAN'T CONTINUE
10 NEXT WITHOUT FOR	27 UNDEF'D FUNCTION
11 SYNTAX	28 VERIFY
12 RETURN WITHOUT GOSUB	29 LOAD
13 OUT OF DATA	30 BREAK
14 ILLEGAL QUANTITY	31 MISSING OPERAND
15 OVERFLOW	32 ILLEGAL VOICE NUMBER
16 OUT OF MEMORY	33 ILLEGAL SPRITE NUMBER
17 UNDEF'D STATEMENT	34 ILLEGAL COORDINATE
	35 CAN'T RESUME

ERROR OFF disables error trapping previously enabled using the ON ERROR commands. ERROR CLR clears the info from the last error.

EXAMPLE:

```
10 ON ERROR RESUME NEXT
20 PRINT"HERE WE GO"
30 ERROR 28 :REM RAISE ERROR
40 PRINT "LAST ERROR#:";ERROR(0);" LINE#:";ERROR(1)
```

ERROR()

PURPOSE:

To return information about the last error that was trapped.

SYNTAX:

E = **ERROR**([N])

DESCRIPTION:

This function returns information about the last error that occurred while error trapping was enabled with ON ERROR GOTO.

N (0 or 1) selects the error information to return. When N=0 the error number is returned. When N=1 the line number of statement that caused the error is returned.

See the ERROR and ON ERROR commands for more information.

EXAMPLE:

```
ON ERROR GOTO 1000      :REM if any errors occur, goto line 1000
.(main program here)
1000 PRINT ERROR(0)     :REM print error num
1010 RESUME NEXT        :REM ignore all errors, execute next command
```

EXPAND

PURPOSE:

Double the width and/or height of a sprite.

SYNTAX:

EXPAND [*sprite#*], [*x*], [*y*]

DESCRIPTION:

Sprites can expand their x and/or y size by 2 times their normal size. The only drawback is that whenever an axis has been expanded, the resolution for that axis of that sprite is cut in half. This is similar to sprites in multicolor mode.

sprite# (0-7) defines which sprite to expand.

x (1=expand, 0=normal) is a Boolean expression used to expand the x axis or to not expand the x axis. This value may be skipped by using a comma in its place.

y (1=expand, 0=normal) is a Boolean expression used to expand the y axis or to not expand the y axis. This value may be omitted.

EXAMPLE:

```
EXPAND 0,1,1      :REM expand sprite 0's x & y
EXPAND 6,1        :REM expand sprite 6's x only
EXPAND 1,,1       :REM expand sprite 1's y only
EXPAND 1,0,0      :REM make sure sprite 1 is normal
```


FILES

PURPOSE:

To display the directory of the current diskette.

SYNTAX:

FILES
FILES [*volume\$*]

DESCRIPTION:

FILES allows the listing of the directory without loading it into memory. The directory is displayed in the normal directory format.

FILES, with no parameters, will list the entire directory off drive 0.

volume\$ ("d:volume") is the search string for the directory, allowing parts of the directory to be displayed instead of the full directory. The volume also allows the reading of multiple drives. *d*: (0 or 1, default=0) is the drive number to read from (refer to your disk drive manual for more information.)

The listing of the directory can be paused by pressing the shift key, and stopped by pressing the break key.

EXAMPLE:

```
FILES           :REM display drive 0's directory
FILES"A*"       :REM all files on drive 0 that start with A
FILES"0:A*"     :REM same as above
FILES"1:*"      :REM all files on drive 1
```

FILL

PURPOSE:

To fill a section on a text screen with a selected character and/or color.

SYNTAX:

FILL [*tx1*], [*ty1*] **TO** [*tx2*], [*ty2*], [*poke code*], [*color*]

DESCRIPTION:

FILL is used to fill a text screen with a particular character and/or color. A typical application for this command would be to erase a section of text, or change its color.

tx1 & *ty1* define the upper left hand corner to start the fill process.

tx2 & *ty2* define the lower right hand corner to end the fill process.

These coordinates have the same range as the LOCATE statement. x(0-39) y(0-24). Any value outside this range will result in an ILLEGAL QUANTITY ERROR.

poke code (0-255), AKA: scan code, is the number that represents the character that is to be displayed. (Remember that the poke code (scan code) is not equal to the character code!) This operand can be skipped using a comma in its place, enabling the color to be filled only.

color (0-255) is the color that is to be filled in the defined area of the screen. Note the value ranges to 255. This is for support of the flashing text feature (see COLOR command) and multicolor bitmap mode. Changing the upper & lower nibbles of screen RAM & the lower nibble of color RAM causes a section of the multicolor bitmap screen to change color(s). See the Commodore 64 Programmer's Reference Guide pg. 128 for more details).

EXAMPLE:

```
FILL 0,0,39,0,,2      :REM top line changes color to red
FILL 20,0,39,24,32    :REM fill bottom of screen with spaces
```

FILTER

PURPOSE:

To select filter settings of the Sound Interface Adapter (SID) chip.

SYNTAX:

FILTER [*cutoff*], [*resonance*], [*type*]
FILTER VOICE [*voice#*], [*boolean*]

DESCRIPTION:

The SID chip allows attenuation (make quieter/louder) of a certain range of frequencies. Any combination of the three voices can be filtered but there is only one filter for all voices.

cutoff (29.0 - 11907.3) selects the center frequency (AKA: center frequency for band pass & band reject filters) in Hertz (Hz) that makes any sounds quieter the further above and/or below this frequency depending on the type of filter used.

resonance (0-15) allows peaking the volume of those frequencies nearest the cutoff, creating an even sharper filtering effect.

type (0-4) selects the type of filter used with the center frequency:

0=none	-disable filter (all voices)
1=low pass	-suppress frequencies above the cutoff frequency
2=band pass	-suppress frequencies above & below the cutoff frequency
3=high pass	-suppress frequencies below the cutoff frequency
4=band reject	-cuts off frequencies nearest the cutoff frequency

High & low pass filters reduce the volume of the frequencies furthest away from the cutoff frequency by 12dB per octave.

The band pass filter attenuates the frequencies nearest to the center frequency by 6dB per octave.

The band reject filter reduces the volume of the frequencies furthest away from the center frequency by 6dB per octave.

FILTER VOICE [*voice#*], [*Boolean*] is used to enable or disable filtering on a voice. The Boolean value of 0 = off, 1 = on.

EXAMPLE:

```
FILTER 1500.5, 15, 1 :REM low pass, cutoff=1500.5Hz
FILTER 2145.5, 0, 4  :REM band reject, center=2145.5Hz
FILTER 500          :REM just change the filter frequency
FILTER ,0           :REM just turn off resonance
```

FIND

PURPOSE:

To search through a program for commands or characters.

SYNTAX:

FIND*"string*
FIND*code*

DESCRIPTION:

FIND is used for debugging purposes. When making a large program, it is sometimes necessary to search through it to find things like what strings have been used, commands that have been used, or a miscellaneous string of characters.

"string is used when searching for ASCII text only! Not commands! The ending quotation mark is left off unless it is part of the string that is to be searched for.

code is used when searching for commands. The exact syntax (including any spaces & quotations) will be searched for.

When FIND makes a match, the line is displayed and the search process continues until the end of the program is reached or when the BREAK key is pressed.

NOTE: No other commands can follow FIND. Every character or command will be searched for, including REM, colons, quotations, spaces etc.

EXAMPLE:

FINDA\$=	(finds all 'A\$=')
FINDGOSUB 200	(finds all 'GOSUB 200')
FIND"THE	(finds all 'THE')
FINDPRINTA*B	(finds all 'PRINTA*B')

HEX\$()

PURPOSE:

To convert an unsigned integer into its hexadecimal string equivalent.

SYNTAX:

`v$ = HEX$([x])`

DESCRIPTION:

HEX\$ is a function that returns the hexadecimal equivalent of the expression within parenthesis. The Hexadecimal numbering system has a base of 16, rather than base 10 of the decimal numbering system.

`x` (0-65535) is a numeric expression that is to be converted to a hex string of characters. This value is rounded to an integer before the number `x` is converted to hex.

If `x` is negative or greater than 65535, an ILLEGAL QUANTITY ERROR results.

NOTE: To convert binary to hex, use the percent sign (%) then the binary number to represent `x`.

EXAMPLE:

```
PRINT HEX$(49152): :REM prints "C000"  
V$=HEX$(16)       :REM assigns v$ to "10"  
PRINT HEX$(%10010) :REM prints "12"
```

INSTR()

PURPOSE:

To find the index of the first occurrence of a string that is inside another string.

SYNTAX:

I = **INSTR**(*[index]*, *[source\$]*, *[find\$]*)

DESCRIPTION:

INSTR is a function that returns the index of the position of a string within another string. The index of a string starts at 1. If no match is found the value of -1 is returned.

index (1-255) is an optional numeric expression of where in the string to start the search. If not supplied the start index is 1.

source\$ is the string to search.

find\$ is the string being sought.

EXAMPLE:

```
10 S$ = "MDBASIC IS COOL": F$ = "IS"
20 I% = INSTR(S$, F$) :REM FIND INDEX OF FIRST F$ IN S$
30 IF I%=-1 THEN PRINT "NOT FOUND!" ELSE PRINT MID$(S$, I%, LEN(F$))
```

JOY()

PURPOSE:

To return the status of a joystick in either port.

SYNTAX:

v = JOY([*port*])

DESCRIPTION:

port (0-1) selects the input port that the joystick is plugged in.

v is the variable that will be assigned to the current position of the stick. The number returned will be from 0-10 with no button pressed, and 128-138 if the button is pressed. The number returned corresponds to a direction in the table below. Add 128 to the value to:

<u>NUMBER</u>	<u>DIRECTION</u>
0	no direction
1	up
2	down
3	--n/a--
4	left
5	up & left
6	down & left
7	--n/a--
8	right
9	up & right
10	down & right

TIP: Use the ON statement with the JOY function allows quick joystick translation.

EXAMPLE:

```
REM DISPLAY MSG IF JOYSTICK #1 IS PUSHED UP (IGNORE BUTTON)
IF JOY(1) AND 15 = 2 THEN PRINT"UP"
```

```
REM DISPLAY MSG IF JOYSTICK #2'S BUTTON IS PRESSED
IF JOY(2)>10 THEN PRINT"FIRE"
```

```
REM ACT ON ALL MOVEMENT-NOTE 3 & 7 ARE N/A SO LINE 0 WILL SUFFICE
J% = JOY(0) AND 15
IF J% THEN ON J% GOSUB 100,110,0,130,140,150,0,170,180,190
```

KEY

PURPOSE:

To allow rapid entry of as many as 15 characters with one keystroke by redefining MDBASIC's special function keys.

SYNTAX:

```
KEY [key#], [assign$]  
KEY LIST  
KEY OFF
```

DESCRIPTION:

This command is a helpful feature when programming. At the touch of one key, a message up to fifteen characters long can be displayed. This is helpful for commands line RUN, LIST, TEXT, COLOR, etc.

key# (1-8) selects which function key will be defined.

assign\$ (15 characters) is the string of characters that will be displayed when the selected function key is pressed. Adding CHR\$(13) at the end of this string will act as if the user hit the return key, enabling the command to be automatically printed and executed.

NOTE: Function key assignments are available in direct mode only.

KEY LIST allows the user to read the current key assignments.

KEY OFF turns off key trapping. See the ON KEY command for more info.

EXAMPLE:

```
KEY 1,CHR$(147)+"LIST"+CHR$(13) :REM clears screen & lists program
```


KEY()

PURPOSE:

To return information about the keyboard.

SYNTAX:

K = KEY([N])

DESCRIPTION:

This function returns various information about the keyboard state. It also is used in conjunction with the ON KEY command to return the ASCII value of the key that was pressed.

N (0-4) selects the keyboard information to return:

0 used with ON KEY GOSUB to return the ASCII of last key pressed

1 PEEK(\$028D) Shift/Ctrl/Logo key bit flags:

000=(0) None, 001=(1) Shift, 010=(2) Commodore, 100=(4) Ctrl

Any combination of the above keys can be represented in 3 bits.

For example, bit pattern 011=(3)=Shift and Commodore Keys

2 PEEK(\$C5) Matrix Coordinate of Last Key Pressed

3 PEEK(\$CB) Matrix Coordinate of Current Key Pressed

4 PEEK(\$C6) Number of characters in keyboard buffer

EXAMPLE:

```
10 ON KEY GOSUB 100
20 PRINT"*";
30 DELAY 5:REM SIMULATE PROGRAM PROCESSING
40 REM YOUR PROGRAM CODE GOES HERE
50 DELAY 5
60 GOTO 20
100 PRINT KEY(0)
105 IF KEY(0) = ASCII("X") THEN KEY OFF
110 RETURN
```

LINE

PURPOSE:

To draw a line between two selected points on a bitmap screen.

SYNTAX:

LINE [*x1*], [*y1*] **TO** [*x2*], [*y2*], [*plot type*], [*color*]

DESCRIPTION:

x1 & *y1* define the start point to begin drawing the line.

x2 & *y2* define the end point of where the line ends.

x (0-319), *y* (0-199) in hi-resolution mode. *x* (0-159), *y* (0-99) in multicolor mode.

An ILLEGAL QUANTITY ERROR will result if the values exceed the ranges in the current color mode.

plot type (0-2) determines how the line will be plotted. 0=dots off, 1=dots on, 2=flip pixel (on=off, off=on)

color (0-15 in hi-resolution mode, 0-3 in multicolor mode), sets the color the line will have. In multicolor mode, the colors 1-3 will correspond to the colors c1-c3, selected in the MULTI BITMAP or MAPCOL command. If *color* = 0 the line will be drawn with the color of the background which is selected using the COLOR command.

EXAMPLE:

```
LINE 0,0 TO 319,199      :REM draws diagonal line across screen
LINE 160,100 TO 0,199,2 :REM flips line of dots from center to lower left
```

LINE INPUT

PURPOSE:

To input a string of characters from the keyboard or file.

SYNTAX:

```
LINE INPUT [v$]
LINE INPUT ["prompt"], [v$]
LINE INPUT# [filenum], [v$]
```

DESCRIPTION:

LINE INPUT is much like the INPUT command, except LINE INPUT allows the input of any characters (except return key). This is useful when the string to be entered might have quotations & commas, or the programmer does not want a question mark displayed after, or for the prompt.

"prompt" (optional) is a string of characters that will be displayed as a message to the user. This string cannot be a variable.

v\$ is the variable that the string of characters that will be displayed as a message to the user.

The return key is the only delimiter for the end of the input string.

filenum is the open file to read characters from instead of the keyboard.

EXAMPLE:

```
LINE INPUT "->";A$      :REM displays "->" as prompt
LINE INPUT A$           :REM no prompt
LINE INPUT#1, A$        :REM read from open file 1
```

```
10 REM***READ FROM FILE***
20 OPEN 1,8,0, "MYFILE.SEQ"
30 LINE INPUT #1, A$
40 PRINT A$
50 IF ST AND 64 GOTO 70
60 GOTO 30
70 CLOSE 1
80 END
```

LOCATE

PURPOSE:

To place the cursor anywhere on the text screen for printing. Optional parameters allow the cursor to turn on/off during program execution.

SYNTAX:

LOCATE [*x*], [*y*], [*cursor*]

DESCRIPTION:

LOCATE is mainly used in conjunction with the PRINT statement. It allows the cursor to be placed anywhere on the screen using an x, y coordinate scheme. It is very useful for text manipulation.

x (0-39) represents the column the cursor moves to. If *x* exceeds its range, an ILLEGAL COORDINATE ERROR will result.

y (0-24) represents the line the cursor moves to. If *y* exceed its range, an ILLEGAL COORDINATE ERROR will result.

cursor is a Boolean expression (1 or 0) that will turn the cursor on/off while in program mode.

NOTE: Truncating or using commas allows any one or a combination of these operands to be effected, therefore keeping the other previous values.

EXAMPLE:

```
LOCATE 0,0      :REM cursor at top right corner
LOCATE 15       :REM moves cursor to column 15
LOCATE ,10      :REM moves cursor to line 10
LOCATE ,,1      :REM turn cursor on
```

MAPCOL

PURPOSE:

To set the default colors to be used when plotting dots on a bitmap screen.

SYNTAX:

MAPCOL [*c1*], [*c2*], [*c3*]

DESCRIPTION:

When in using bitmap graphics, the color of the plotted dots can be changed with this command. If a certain color is to be skipped, just put a comma in the place of the color to skip over.

Unless in multi-color mode, every 8 x 8 square can only have one color of plotted dots. When mixing colors on a hires screen, each set of 64 dots must be the same color. This a limitation of the VIC-II chip.

c01 (0-15) changes the default color for plotting dots.

c2 (0-15) changes the default background color of the 8 x 8 square where the plotting dot is located.

c3 (0-15) changes the default color used in multicolor mode only. This color can be in the same 8 x 8 square that the previous colors *c1* & *c2* are in, with the sacrifice of horizontal resolution.

EXAMPLE:

```
MAPCOL 1           :REM change plotted dots color
MAPCOL ,2          :REM change 8 x 8 squares background color
MAPCOL 5,7,10      :REM colors that will reside in 8 x 8 square (multicolor)
```

MERGE

PURPOSE:

To merge a program from disk or tape to the end of a program in memory.

SYNTAX:

MERGE [*filename\$*], [*device*]

DESCRIPTION:

MERGE allows the combining of programs to constitute one program in memory. The process merges the two programs into RAM memory only. If a new file is to be created, the final product must be saved to a new file.

Before two programs are merged, the first program must be in RAM memory, which will be the beginning of the program. The second program must be on tape or disk.

Be sure to renumber the two programs so when they come together, the line numbers are not duplicated, and the merging programs start line number is higher than the last line number of the first program that is in memory. This is not always necessary but is a safe practice.

filename\$ is the file name of the program that is to be connected to the end of the program in RAM memory.

device is the device number that the merging program will come from.

NOTE: No secondary address is used because MERGE is for BASIC programs only.

EXAMPLE:

```
MERGE"SUBROUTINE",8      :REM program "SUBROUTINE" is merged with existing program
                           in memory from the disk drive.
MERGE"PROG2"              :REM program "PROG2" is merged with existing program in
                           memory from the tape drive.
```

MOVE

PURPOSE:

Moves a sprite to any location or from one location to another at a given speed.

SYNTAX:

```
MOVE [sprite#], [x], [y]
MOVE [sprite#], [x1], [y1] TO [x2], [y2], [speed]
MOVE [sprite#] TO [x], [y], [speed]
```

DESCRIPTION:

Any of the eight sprites can be located anywhere on the screen or move from one point to another at a selected speed. MDBASIC can MOVE a sprite many times faster than regular CBM BASIC.

sprite# (0-7) defines which sprite to move.

x (0-511) & *y* (0-255) select the coordinates for the sprites upper left corner. These coordinates are not like bitmapped coordinates because the lowest and highest ranges locate the sprite off screen.

x1, *y1* & *x2*, *y2* allows a sprite to move from point *x1*, *y1* to point *x2*, *y2*. These values have the same range as *x* and *y* stated above. Any coordinate value that exceeds the legal range will cause an ILLEGAL COORDINATE ERROR.

speed (0-255) controls the amount of delay in movement between coordinates when the sprite moves from between points with 0 being the fastest.

EXAMPLE:

```
MOVE 0,180,120           :REM locates sprite#0 to center of screen
MOVE 0,24,50 TO 320,229,20 :REM moves from top-left to bottom right fast
MOVE 0 TO 180,100,50      :REM moves to center screen a bit slower
```

MULTI

PURPOSE:

Set multicolor mode & colors for background, text, sprites, & bitmaps.

SYNTAX:

MULTI COLOR *[eb1], [eb2], [eb3]*

MULTI TEXT *[cc1], [cc2]*

MULTI SPRITE *[sc1], [sc2]*

DESCRIPTION:

This command is used to select multicolor mode and to set the colors, except in the SPRITE command where the colors are just set because there are eight sprites and each individual sprite can have hires or multicolor mode, which is selected in the SPRITE command.

MULTI COLOR enables extended background color mode. This mode lets you select the background color of each text character, as well as its foreground color. This increases the number of background colors displayed by reducing the number of characters that can be shown on the screen. The only displayable characters are the characters with codes from 0-63 (5-bit value). The upper 2 bits are used to select the source of the color. The next three groups of characters (64-127) select a different background color, but still display the codes 0-63.

BITS	CODE	COLOR SOURCE
00	0-63	background color background color reg 0 (4-bit value)
01	64-127	eb1 background color reg 1 (4-bit value)
10	128-191	eb2 background color reg 2 (4-bit value)
11	192-255	eb3 background color reg 3 (4-bit value)

Extended background color mode can be a very useful enhancement for your text displays. It allows the creation of windows, which, because of their different background colors make different bodies of text stand out. The background colors of these windows can be changed using MULTI COLOR, which instantly changes the background of the windows. This is useful for making a particular section of the screen stand out from the rest.

MULTI TEXT enables multi color text mode. This increases the number of background colors available to a character by reducing the number of pixels to display the text. Each pixel is represented by 2 bits. The bit pattern determines the color source. Colors cc1 & cc2 define the first two colors that can occupy the 4 x 8 square. The table below lists the four 2-bit patterns and the associated color:

PIXEL	COLOR	SOURCE
00	background color	background color reg 0 (4-bit value)
01	cc1	background color reg 1 (4-bit value)
10	cc2	background color reg 2 (4-bit value)
11	foreground color	text color RAM byte (3-bit value)

If the character you want to display is not included in scan codes 0-63 then you will need to use the DESGIN command to define your own custom shape. In the following custom character example,

AA=cc1, BB=cc2, CC=foreground color, DD=background color:

IMAGE	BIT PATTERN	DATA
DDAAAADD	00 01 01 00	20
AABBBBAA	01 10 10 01	105
AADDDDDAA	01 00 00 01	65
AAAAAAAA	01 01 01 01	85
AADDDDDAA	01 00 00 01	65
AACCCCAA	01 11 11 01	125
DDAAAADD	00 01 01 00	20
DDDDDDDD	00 00 00 00	0

This data will make a ball, with multicolor stripes.

If a character is printed to the screen using colors 0-7, the character will be in multicolor. If it is printed using colors 8-15, the character is printed in hi-resolution. This allows multicolor & hi-resolution to be displayed on the same screen at the same time, at expense of loosing colors 0-7 for hires mode. This color can be set by using the COLOR command.

While in multicolor text mode, if the colors are changed using MULTI TEXT, all the characters on the screen will change color accordingly, producing a special effect.

MULTI SPRITE colors sc1 & sc2 define the first two colors that can occupy a 24 x 21 sprite. The table below lists the four 2-bit patterns and the associated color:

BIT PAIR	COLOR TO USE
00	background color
01	sc1
10	sc2
11	sprite color

The designing of a multicolor sprite is the same as a multicolor character when arranging the bit-pairs for the corresponding colors (See DESIGN command, page 9).

EXAMPLE:

```

MULTI COLOR 2,6,7      :REM selects extended bkgnd color mode & sets colors
MULTI SPRITE 1,5,6     :REM sprite#1 has multicolor & sets its colors
MULTI TEXT 15,13       :REM selects multicolor text mode & sets colors

```

OLD

PURPOSE:

To bring back a program that has been erased by the NEW command.

SYNTAX:

OLD

DESCRIPTION:

OLD brings back a program that has been NEW-ed, or lost due to the computer being reset.

If a program has been NEW-ed, and a new program has been loaded or typed in, or any variables have been defined, the old program will be lost.

NOTE: if a SYNTAX ERROR occurs because of some user error, prior to the error message, the computer tries to set up a variable because it does not recognize statement. In doing so, a variable has been set up, making OLD work improperly so BE CAREFULL when a program is to be brought back.

ON ERROR

PURPOSE:

To redirect program execution, when an error occurs, to a user routine.

SYNTAX:

```
ON ERROR GOTO [line#]  
ON ERROR RESUME NEXT
```

DESCRIPTION:

ON ERROR allows the programmer to redirect program execution to a specified line number when an error occurs. This is useful when an error like DEVICE NOT PRESENT occurs, which can be trapped to avoid program crashes.

line# is the line number that the program will GOSUB to when an error occurs. If *line#* is not found, an UNDEF'D STATEMENT ERROR will occur.

er = ERROR(0) returns the number of the error that occurred. This must be used to decode which error occurred (see appendix B).

el = ERROR(1) returns the line number that the error occurred.

To return from an ERROR subroutine the RESUME command must be executed. The previous error number and line number will be cleared (set to 0).

ON ERROR is used in program mode only, and has no effect in direct mode.

NOTE: If an error occurs in the subroutine before RESUME is executed, the error message will be displayed and the program will stop. This is to avoid continuous looping through the subroutine.

ON ERROR RESUME NEXT will ignore all errors and skip to the next statement. The last error number and line is available using the ERROR() function. To clear the last error information use the statement ERROR CLR.

EXAMPLE:

```
ON ERROR GOTO 1000      :REM if any errors occur, goto line 1000  
.(main program here)  
1000 PRINT ERROR(0)     :REM print error num  
1010 RESUME NEXT        :REM ignore all errors, execute next command
```

ON KEY

PURPOSE:

To redirect program execution when there is keyboard activity.

SYNTAX:

ON KEY GOSUB [*line#*]

DESCRIPTION:

ON KEY allows the programmer to act on a keypress (except run/stop-restore and control keys) from anywhere in the program. This gives freedom to the programmer to focus on other tasks while still acting on keyboard input.

line# is the first line number of the subroutine to GOSUB. If *line#* is not in the program, an UNDEF'D STATEMENT will occur.

To retrieve the ASCII value of the key that was struck use the KEY function: K = KEY(0). See appendix C for ASCII characters and values.

While in the key trapping subroutine key events are paused to avoid multiple calls at the same time. In this case, the input will go into the keyboard buffer for the next iteration of the subroutine.

Use the RETURN statement as you would with any GOSUB to continue executing statements from where it was called.

KEY OFF turns off key trapping.

EXAMPLE:

```
10 ON KEY GOSUB 1000      :REM when a key is struck, gosub 1000
.
.(main program here)
.
1000 PRINT KEY(0)         :REM display ASCII of char from keyboard
1010 RETURN              :REM return from subroutine
```

PAINT

PURPOSE:

Fills in a certain area of a bitmap screen with a specified color.

SYNTAX:

PAINT [*x*], [*y*], [*plot type*], [*color*]

DESCRIPTION:

PAINT is used in conjunction with the BITMAP command, although to paint on a bitmapped screen, you do not have to be in bitmapped graphics. Note that the plot type is omitted here. This is because PAINT works on boundaries made by bits that are on.

When an area is enclosed, the bits that make up the inside of the enclosure can be filled with plotted dots by selecting a start point to paint.

x, *y* define the coordinates where the filling in of an object on the screen will begin. Remember in hires mode *x*=0-319, *y*=0-199, but in multicolor mode, *x*=0-159, *y*=0-99. Any point in the shape may be selected. Any values out of range in the mode selected will result in an ILLEGAL COORDINATE ERROR.

plot type (0-2) determines how the shape will be painted. 0=dots off, 1=dots on, 2=flip pixel (on=off, off=on)

color (0-15 in hi-resolution mode, 0-3 in multicolor mode), sets the color the dot will have. See the MULTI command using BITMAP, for explanation of the colors for both modes.

EXAMPLE:

```
PAINT 160,100      :REM paint section starting at center of screen
PAINT 0,0,0        :REM erase dots enclosed in off dots
PAINT 300,10,2     :REM flip dots
```

PLAY

PURPOSE:

To play musical notes on any of the three available voices.

SYNTAX:

PLAY [*S\$*]
PLAY STOP

DESCRIPTION:

PLAY allows any of the three voices to play real musical notes at eight different octaves in the background. If the volume is currently set to 0 then it will automatically be set to max (15).

S\$ is the string of notes to play.

There are 12 unique notes in each octave: (C, C#, D, D#, E, F, F#, G, G#, A#, A, B). Sharps (#) and flats (-) can be used to play the notes between notes like the black keys on a piano. Below is the table of symbols available to play music:

A-G[+, -][<i>n</i>]	Note to play in current octave for length <i>n</i> .
<i>Ln</i>	Length (0-99) of a note in Jiffies, default 30.
<i>On</i>	Octave <i>n</i> (1-8) default 4.
P[<i>n</i>]	Pause sound for one note length or length <i>n</i> .
<i>Vn</i>	Voice <i>n</i> (1-3) selects the voice to play the notes.
<i>Wn</i>	Waveform (0-8) changes the waveform. The default is 1 (Triangle). See the WAVE command for the list of available waveforms.

PLAY STOP will abort the current playing notes.

EXAMPLE:

```
REM PLAY MUSIC SCALE IN DEFAULT WAVEFORM OCTAVE 4 AND 5
PLAY "A-AA#10BCCP#DD#EFF#GG# > A-AA#10BCCP#DD#EFF#GG#"
```

```
REM PLAY NOTES ON VOICE 1 WITH SAWTOOTH WAVEFORM
PLAY "V1W2 A- A A# B C99 C# D D# E F F# G G#5 P30 G#5"
```

PLOT

PURPOSE:

Turns a pixel on or off on a bitmap screen.

SYNTAX:

PLOT [*x*], [*y*], [*plot type*], [*color*]

DESCRIPTION:

x (0-319), *y* (0-199) in hi-resolution mode, *x* (0-159), *y* (0-99) in multicolor mode. *x*, *y* are the coordinates referencing a pixel on a bitmap screen. Any values out of range in the mode selected will result in an ILLEGAL COORDINATE ERROR.

plot type (0-2) determines how the dot will be plotted as follows:

PLOT TYPE	FUNCTION
0	erase pixel
1	plot pixel (default)
2	flip pixel (on=off, off=on)

color (0-15 in hi-resolution mode, 0-3 in multicolor mode), sets the color the line will have. In multicolor mode, the colors 1-3 will correspond to the colors c1-c3, selected in the MULTI BITMAP or MAPCOL command. If *color* = 0 the line will be drawn with the color of the background which is selected using the COLOR command. See the MULTI BITMAP command for more information.

EXAMPLE:

```
PLOT 160,100      :REM plot center of hires screen
PLOT 80,50,1,1    :REM plot center of multicolor screen with white dot
PLOT 0,0,0        :REM turn off pixel in top left corner
PLOT 319,199,2    :REM flip bottom right corner pixel's condition
```

POT()

PURPOSE:

Return the current condition of any of the four game paddles.

SYNTAX:

$v = \text{POT}([paddle\#])$

DESCRIPTION:

When making programs to interact with the paddle controllers, the POTentiometer command is used.

paddle# can range from 1-4. Each port controls two paddles.

Input port#0 monitors paddles 1 & 2, input port#1 monitors paddles 3 & 4.

To detect the button being pressed, the value returned for that paddle will be negative, therefore signifying position & button status simultaneously.

NOTE: POT is a function and cannot be used as a statement.

EXAMPLE:

```
PRINT POT(1)           :REM displays port#0's paddle #1
MOVE 1,POT(2),100      :REM sprite#0 x changes with pot#1's position.
IF POT(4)<0 THEN STOP   :REM program stops when paddle#4 button is pushed
P1=ABS(POT(1))          :REM returns pot#1's position w/o fire indication
```


PTR()

PURPOSE:

Returns the memory address of a variable's value or pointer.

SYNTAX:

P = PTR([variable])

DESCRIPTION:

PTR returns the memory address of a variable's value.

Seven bytes of memory are allocated for each variable. The first two bytes are used for the variable name, which consists of the ASCII value of the first two letters of the variable name. If the variable name is a single letter, the second byte will contain a zero.

The seventh bit of one or both of these bytes can be set (which would add 128 to the ASCII value of the letter). This indicates the variable type. If neither byte has the seventh bit set, the variable is the regular floating point type. If only the first byte has its seventh bit set, the variable is a string. If only the second byte has its seventh bit set, the variable is a defined function (FN). If both bytes have the seventh bit set, the variable is an integer.

The use of the other five bytes depends on the type of variable. A floating point variable will use the five bytes to store the value of the variable in floating point format. An integer will have its value stored in the third and fourth bytes, high byte first, and the other three will be unused.

A string variable will use the third byte for its length, and the fourth and fifth bytes for a pointer to the address of the string text, leaving the last two bytes unused. Note that the actual string text that is pointed to is located either in the part of the BASIC program where the string is first assigned a value, or in the string text storage area pointed to by location 51 (\$33).

A function definition will use the third and fourth bytes for a pointer to the address in the BASIC program text where the function definition starts. It uses the fifth and sixth bytes for a pointer to the dependent variable (the X of FN A(X)). The final byte is not used.

EXAMPLE:

```
P = PTR(A$)           :REM P HOLDS THE ADDRESS OF THE STRING DESCRIPTOR OF A$
```

PULSE

PURPOSE:

Sets the pulse value for any of the three voices.

SYNTAX:

PULSE [*voice#*], [*width*]

DESCRIPTION:

PULSE sets the pulse width of any voice. This feature only works when a pulse waveform has been selected, which the output of the signal is a rectangular wave.

voice# (1-3) selects which voice to set the pulse frequency.

width (0-100) determines the duty cycle. This value is expressed in percent (%) of time that the rectangular wave will stay at the high part of the cycle. Changing the pulse width will vastly change the sound created with the pulse waveform.

NOTE: In order for this command to affect the sound, a pulse waveform must be set for the corresponding voice by using the WAVE command.

EXAMPLE:

```
PULSE 1,100      :REM voice#1 stays high continuously
PULSE 3,33.3333  :REM voice#3 will stay high 1/3rd of the time
PULSE 1,50       :REM voice#1 has a square wave output
```

RENUM

PURPOSE:

To renumber a program with a selected increment.

SYNTAX:

RENUM [*start*], [*increment*]

DESCRIPTION:

RENUM allows a programmer to space the number of lines between each program line allowing easy insertion of programming anywhere in the program. It also makes a program look neat and easy to follow.

start is the new start line that the program to renumber will begin with.

increment is the number of lines between every line. If this operand is omitted, it is defaulted to 10.

If RENUM has no operands, then the default value of 10 will be used for the start line number and increment.

RENUM changes all line numbers that have commands referring to line numbers like THEN, ELSE, GOTO, GOSUB, RESTORE, ON ERROR, etc.

If RENUM comes across a reference to a line number that is not in the program, the number is replaced with 65535, and the line number that the referencing command is on is listed.

EXAMPLE:

```
RENUM           :REM program starts with line 10 with 10 increments
RENUM 1000,10    :REM program starts with line 1000 with 10 increments
RENUM 100        :REM program starts with line 100 with 100 increments
```

RESTORE

PURPOSE:

Resets the data pointer to a selected data statement.

SYNTAX:

```
RESTORE  
RESTORE [line#]
```

DESCRIPTION:

When the DATA in a program has been READ, any attempt to read more data will cause an OUT OF DATA ERROR. RESTORE allows re-reading of data at any time, as many times as necessary. It also allows reading of selected data anywhere in the program.

RESTORE can be used the same way in regular Commodore 64 BASIC. The only difference is it has been modified to be able to select which line the next READ statement will read (instead of the first line of program).

line# is a program line that the next READ statement will get the DATA from. If *line#* is not part of the program, an UNDEF'D STATEMENT will occur. If *line#* does not have a DATA statement, READ will search from that point to the end of the program for the next DATA line. If no DATA line is found, then the next READ statement will cause an OUT OF DATA ERROR.

EXAMPLE:

```
RESTORE           :REM sets data pointer at first line in program  
RESTORE 100       :REM data is found starting at line 100
```

RESUME

PURPOSE:

To return from a subroutine called by ON COLLISION, ON ERROR or ON KEY.

SYNTAX:

```
RESUME
RESUME NEXT
RESUME [line#]
```

DESCRIPTION:

RESUME is used in conjunction with the ON COLLISION, ON ERROR, and ON KEY commands. It is used to return from the subroutine to a selected point in the program. RESUME must be used at the end of the subroutine to avoid errors.

RESUME used alone will return program execution to the command that was interrupted. In the ON ERROR command, this would be the command that caused the error. In the ON COLLISION command, this would be the command that caused the collision. And in the ON KEY command, this would be the last command that was executed.

RESUME NEXT returns execution to the statement following the statement that was interrupted or caused the interruption.

RESUME *line#* allows program execution to continue anywhere in the program.

If RESUME is used in the context of an error (ON ERROR GOTO *line*) the previous error number is set to 0 and the line number is set to -1.

If RESUME is executed without ON COLLISION/ERROR/KEY GOSUB calling the routine, a CAN'T RESUME ERROR will occur.

EXAMPLE:

```
10 ON ERROR 1000          :REM if an error occurs, GOSUB 1000
...(main program here)...
1000 PRINT"ERR:";ERROR(0);"LINE:";ERROR(1)
1001 RESUME :REM TRY AGAIN
```

ROUND()

PURPOSE:

Round a floating point number to the desired precision.

SYNTAX:

```
N = ROUND([float])  
N = ROUND([float], [precision])
```

DESCRIPTION:

ROUND is a numeric function that returns the given value rounded to a specified number of decimal places.

float is a floating-point variable (or constant) of the number to round.

precision (optional) is number of digits of precision. If no precision is specified the default is 0, which will return the nearest whole number value. If precision is negative, the whole number portion will be affected.

EXAMPLE:

```
PRINT ROUND(5.0125)      :REM RESULT IS 5  
PRINT ROUND(5.0125,2)    :REM RESULT IS 5.02  
PRINT ROUND(125.23,-1)   :REM RESULT IS 130
```

RUN

PURPOSE:

Execute a program, or load a program into memory and execute it.

SYNTAX:

RUN

RUN [*line#*]

RUN [*filename\$*], [*device*]

DESCRIPTION:

RUN works the same as the Commodore version with one addition, which allows a program to be automatically loaded into memory & run from direct mode or program mode. This command is useful when linking execution of two separate programs.

line# is the line that the program will start execution. If no line number is selected, the program starts execution at the first line.

filename\$ is a string of characters that represent the name of the program that will be loaded into memory and automatically executed.

device is the device number that the information will come from. If no device is selected, the default is 1 (tape drive).

RUN clears all variables that were in memory.

The program that RUN loads and executes will kill any program that is currently in memory, as well as any variables and cannot be retrieved.

EXAMPLE:

```
RUN                :REM execute program at first line#
RUN"PROGAM2",8     :REM loads & executes "program2" from disk
RUN"MENU"          :REM loads & executes "menu" from tape
```

SCREEN

PURPOSE:

To turn on/off the screen or to shrink the visible display area.

SYNTAX:

```
SCREEN ON
SCREEN OFF
SCREEN CLR
SCREEN [columns], [rows]
```

DESCRIPTION:

The screen command is used when the side edges and/or the bottom edges need to be hidden from view. Sprite graphics & fine scrolling text on the 64 commonly use this feature to hide unwanted display. For example, an enlarged sprite will stick out of the border at its zero axis. Also garbage will be seen when using fine scrolling to center text.

SCREEN ON & SCREEN OFF enables/disables the screen output. The color of the full screen will be the color of the border.

SCREEN CLR will clear the text screen. This is the same as PRINT CHR\$(147).

columns (38 or 40) selects the amount of columns the screen will have. When selecting 38 columns, the screen will visually have 40 columns but the other two are just covered and can be printed to. If *columns* is not to be affected, use a comma to skip over it.

rows (23 or 25) selects the amount of rows the screen will have. When selecting 23 rows, the screen will visually have 25 rows but the other two are just covered and can be printed to.

NOTE: SCREEN OFF increases programming speed. It also allows programs to be correctly loaded from the old 1540 disk drives.

EXAMPLE:

```
SCREEN OFF           :REM turn output to screen off
SCREEN ,25           :REM select 25 rows
```


SCROLL

PURPOSE:

Moves a section of text in a selected direction.

SYNTAX:

SCROLL [*x1*], [*y1*] **TO** [*x2*], [*y2*], [*direction*], [*wrap*]

DESCRIPTION:

SCROLL allows any section of the screen to be scrolled up, down, left, or right. This command has many uses and produces dramatic displays.

x1 (0-39), *y1* (0-24) define the coordinates of the first character, on a text screen, to scroll. This is the upper left corner of the display that will be scrolling.

x2 (0-39), *y2* (0-24) define the coordinates of the last character, on a text screen, to scroll. This is the lower right corner of the display that will be scrolling.

direction (0-3, Default=0) defines the direction of scroll as follows:

DIRECTION	MOVEMENT
0	up (default)
1	down
2	left
3	right

wrap (0=truncate, 1=wrap) specifies if the text scrolled off the screen is to wrap around to the other side. For example, scrolling up would wrap the top most line to the bottom. If *wrap*=0 then spaces will fill the bottom.

EXAMPLE:

```
SCROLL 0,0 TO 39,24      :REM scroll whole screen up, no wrapping
SCROLL 0,0 TO 39,0,3     :REM scroll top line right, with wrapping
```

SPRITE

PURPOSE:

To set/change the configuration of any of the eight sprites. The configuration consists of the visibility, color & color mode, foreground priority, and data pointer for the image.

SYNTAX:

SPRITE [*sprite#*], [*visible*], [*color*], [*multi*], [*data pointer*], [*priority*]

DESCRIPTION:

A sprite is a Movable Object Block (MOB) that is 24 bits wide and 21 bits in height, using 64 bytes of memory per shape. Sprites have their own x & y coordinate system which differs from that of the bitmap screen. Any of the eight sprites can be moved anywhere on the screen, even under the border that surrounds the edge of the screen using the MOVE command.

sprite# (0-7) selects the sprite that is affected.

visible (0 or 1) is a Boolean expression that turns the selected sprite on or off. If this operand is greater than 1, an ILLEGAL QUANTITY ERROR will result.

color (0-15) selects the color for the sprite (see COLOR command, page 6).

multi (0 or 1) is a Boolean expression that puts the selected sprite in multicolor mode or high resolution. 0= hires, 1=multicolor. If multicolor mode is selected, more colors can be used in the sprite, but the horizontal resolution is cut in half to allow this feature. See the MULTI SPRITE command for more info.

data pointer (0-255) is the index of the 64-byte data block being used to define the shape of a sprite. The memory address can be calculated by the formula:

$$\text{ADDRESS} = (\text{DATA POINTER} * 64) + (\text{BANK} * 16384)$$

BANK (0-3) is the 16K VIC-II base video memory bank being used. MDBASIC selects the BANK depending on the graphics mode selected:

MDBASIC MODE	BANK	MEMORY RANGE	COMMENTS
Standard Text	0	0-16383	1K SYS RAM, 1K VIDEO RAM, 14K BASIC RAM
n/a	1	16384-32767	16K BASIC RAM
DO NOT USE	2	32768-49151	4K MDBASIC RAM, 4K ROM
Bitmap Graphics & Custom Text*	3	49152-65535	4K HIRAM, 4K DEVICE RAM, 16K KERNEL ROM 1K VIDEO RAM is at 51200-52223

priority (0 or 1) is a Boolean expression that determines the priority of the sprite graphics to foreground graphics. When priority is set to 0 (default) the sprite will appear over all bitmap graphics and text characters; a value of 1 will make the sprite appear underneath. If this operand is greater than 1, an ILLEGAL QUANTITY ERROR will result.

To design a sprite shape, you need 64 bytes of data that represents the sprite and put it into memory starting at the address calculated with the formula on the prior page. MDBASIC comes with a sprite editor that is easy to use and will help develop the sprite shape needed in hires or multicolor mode. The following is an example of how a hires sprite is made and turned into data:

BINARY CODE	DATA
00001111111111111111000000	15,255,192
00111111111111111111110000	63,255,240
00111111111111111111110000	63,255,240
01111100000000000111110000	124,0,248
01110000100001000011110000	112,132,56
111100011000011000111100	241,134,60
1111000000000000000111100	240,0,60
111000000011000000011100	224,48,28
111000000011000000011110	224,48,30
111001100000000110011110	230,1,158
111000110000001100011110	227,3,30
11100001111111000011110	225,254,30
111100000000000000011110	240,0,62
111110000000000000011110	248,0,62
11111100000000011111110	254,0,254
11111110000000011111110	255,1,254
111111100000000111111100	255,1,1,252
111111100000000111111100	255,1,252
110000000000000000000110	192,0,6
100000000000000000000001	128,0,1
100000000000000000000001	128,0,1

These 63 numbers make up the sprite shape. A sprite is three bytes wide and 21 bytes tall. The data can easily be put into DATA statements for a loop to READ and POKE them into memory. Another approach is to read the bytes from a file and poke them into memory.

Since sprite memory is represented in 64-byte blocks you may want to add an additional byte to the end of your data set however it is not used. You could use the byte to hold additional data about the sprite. For example, the color (4 bits), horizontal & vertical expansion (2 bits), visibility (1 bit) and priority (1 bit) could be encoded the bits of the 64th byte which you can apply to the sprite using separate statements.

EXAMPLE:

```

SPRITE 0,1,7,0,13 :REM sprite#0 on, yellow, no multicolor, pointer#13
SPRITE 0,,,,14    :REM change sprite 0's pointer to 14
SPRITE 2,,,,1     :REM change sprite 2's priority to be under text/graphics

```

SWAP

PURPOSE:

Exchange the values of two variables.

SYNTAX:

SWAP [*variable1*], [*variable2*]

DESCRIPTION:

SWAP is very useful in bubble sorts. A bubble sort is a routine that puts numbers or strings in numeric/alphabetic order. SWAP discards the need for a third buffer variable, and reassigning variables, to make the exchange. Reassigning variables eats up free memory space (especially with strings) causing a garbage collection to occur faster than usual. When a garbage collection takes place, the BASIC programming is halted. The computer seems to "lock-up" while it discards variable data that is not used anymore. This process can be very long and is definitely a serious problem.

variable1 is the first variable name that will be exchanged.

variable2 is the second variable name that will be exchanged.

variable1 & *variable2* must be of equal type, such as floating point to floating point, integer to integer, string to string etc. If the variables are of different types, a TYPE MISMATCH ERROR will occur.

EXAMPLE:

```
SWAP A,B           :REM A & B exchange values
SWAP A$(1),A$(2)   :REM A$(1) & A$(2) exchange values
SWAP X%,Y%         :REM X% & Y% exchange values
SWAP N$,K$         :REM N$ & K$ exchange strings
```

TEXT

PURPOSE:

To print characters on a bitmap screen or to set display mode to normal text and color.

SYNTAX:

TEXT

TEXT [*x*], [*y*], [*letters\$*], [*charset*], [*sx*], [*sy*], [*plottype*], [*color*]

DESCRIPTION:

TEXT is a dual function command. When used with no operands, the graphics mode is set to normal text graphics. TEXT also allows the printing of characters anywhere on a bitmap screen with varying sizes.

To return to a graphics screen, the command used to call up the screen must be used. For example: BITMAP 0 will redisplay the prior bitmap screen.

x (0-319 hires, 0-199 multicolor), *y* (0-199 hires, 0-99 multicolor) are the coordinates to print the characters.

letters\$ is the string of characters to be printed on the bitmap screen. Like any string, the maximum number of characters is 255.

charset (0 or 1) is the character set to use when printing the letters or symbols. The default is 0 which uses the upper-case-only set. Refer to the Commodore 64 Programmer's Reference Guide for details.

sx, *sy* (0-31) select the size of the *x* and *y* dimensions. The numbers here are multiples of the normal size. Example: *sx*=2 is 2 times the *x* size.

plottype (0-2) is how the characters will be printed as follows:

PLOT TYPE	FUNCTION
0	erase pixel
1	plot pixel (default)
2	flip pixel (on=off, off=on)

color (0-15) is the color the characters will have.

EXAMPLE:

```
TEXT                               :REM return to text mode.
TEXT 0,0,"CBM",0,1,5              :REM print 'CBM' at top left with tall letters
TEXT 0,0,"CBM",0,1,5,0            :REM erase the letters
TEXT 10,50,"Mark",1               :REM use charset 1
```

TRACE

PURPOSE:

Trace the execution of program statements.

SYNTAX:

TRACE
TRACE [*line#*]

DESCRIPTION:

This command is used for debugging purposes. When a program is running, the line that is being executed can be viewed at the top of the screen, enabling the user to find out what line of programming is responsible for the bug.

TRACE acts just like the run command, except it enables the display of program lines.

line# is optional, and is used to start the program at a particular line of text.

TRACE performs a CLR function before executing the program instructions.

Anytime the program goes back into direct mode, TRACE is not active and there is no need to turn it off.

NOTE: TRACE only supports program lines consisting of two physical screen lines. If there are more than two, the remainder will not be removed from the screen. This is so MDBASIC will not disturb the rest of the screen, which may be needed for the program being debugged.

EXAMPLE:

```
TRACE           :REM run program and trace the lines
TRACE 100       :REM start tracing at line 100
```

VARs

PURPOSE:

List the current variable names and values that have been assigned.

SYNTAX:

VARs

DESCRIPTION:

VARs is short for variables. It is a useful tool when debugging a program. Program execution can be halted either by END, STOP or the BREAK key, and VARs will display all the current variable names and their values in the order they were dimensioned.

VARs does not list any array variables, being that there are usually far too many values assigned in this type of variable storage. Use an inline FOR/NEXT loop to print array variables if needed.

NOTE: Using the shift key pauses the listing allowing the user time to scan through the list for the desired variables. Also, you can DUMP the variables to a printer by using DUMP VARs.

EXAMPLE:

VARs

```
MB$="MARK BOWREN"
X=160
SP$="          "
A=9693868
N%=25
NU$=""
```

READY.

VOICE

PURPOSE:

Sets a frequency (pitch) for any voice or to clear the SID registers.

SYNTAX:

VOICE [*voice#*], [*frequency*]
VOICE CLR

DESCRIPTION:

VOICE is a dual function command that allows initialization of the SID chip, or assigning any voice any frequency offered by the SID to any voice. There are 5 basic steps to produce sounds:

1. Set the volume using the VOL command (page 56).
2. Select the frequency output using the VOICE command.
3. Set the envelope parameters using the ENVELOPE command.
4. Select the type of waveform and start the desired part of the envelope cycle using the WAVE command (page 57).

voice# (1-3) selects which voice will have the frequency.

frequency (0.0 - 3994.97808 {NTSC} or 3848.57410 {PAL}) expressed in Hertz (Hz), selects what the frequency output of the voice. This value may be changed at any time the voice is active to achieve special effects.

VOICE CLR clears the registers that are used to control the sounds for all three voices. This command is commonly used at the beginning of a program. When executed, all sounds will be turned completely off, and all sound registers are set to 0.

EXAMPLE:

```
VOICE CLR           :REM initialize SID chip
VOICE 1,2000        :REM voice#1 at 2KHz
```


VOL

PURPOSE:

Set the volume of the Sound Interface Device (SID) for all voices.

SYNTAX:

VOL [*volume*]

DESCRIPTION:

This command is used to turn up/down the volume of all three voices. Selecting separate values for each voice's attack/decay/sustain/release (using the ENVELOPE command) allows separate volume control of each voice.

volume (0-15) sets the volume of all three voices.

NOTE: No sounds will be heard with any commands unless VOL sets the volume to an audible level.

EXAMPLE:

```
0 REM ** SAMPLE SOUND PROGRAM OF RANDOM STATIC **
10 SOUND CLR           :REM clear all SID registers
20 ENVELOPE 1,0,0,15,0 :REM max sustain volume
30 VOICE 1,2000         :REM set voice#1 at 2KHz
40 WAVE 1,8,1          :REM noise waveform; start ADS cycle
50 VOL 15              :REM volume at max
60 DELAY RND(TI)*25    :REM random delay length
70 VOL 0               :REM turn off noise abruptly
80 DELAY RND(TI)*25    :REM random delay length
90 GOTO 50             :REM loop
```

WAVE

PURPOSE:

Set the waveform and start an envelope cycle.

SYNTAX:

WAVE [*voice#*], [*waveform*], [*gate*], [*sync*], [*ring*], [*disable*]

DESCRIPTION:

WAVE is primarily used to select a waveform for a voice and start the envelope cycle. It also is used to synchronize the waveform output with another voice.

waveform (0-8) sets the waveform for the voice. The waveforms available are as follows:

VALUE	WAVEFORM
0	none
1	triangle
2	saw tooth
3	saw tooth + triangle
4	pulse
5	pulse + triangle
6	pulse + saw tooth
7	pulse + saw tooth + triangle
8	noise

gate (1 or 0) is a Boolean expression used to determine what part of the envelope to produce and when to start it. The first part of the envelope is the Attack, Decay, Sustain cycle. When *gate*=1, the output of the selected voice will follow its envelope settings. After rising to a peak and declining to the sustain volume, the volume will continue at the sustain level until *gate*=0, which will start the release cycle. Thus, the gate has two functions: 1=start attack/decay/sustain cycle; 0=start release cycle.

sync (1 or 0, Default=0) is a Boolean expression used to synchronize the fundamental frequency of the voice# with another voice, allowing the creation of complex harmonic structures from the selected voice. When enabled, the synchronized voice's frequency affects the output of the selected voice. The following is the synchronization combinations:

- a. Voice 1 syncs with voice 3
- b. Voice 2 syncs with voice 1
- c. Voice 3 syncs with voice 2

ring modulation (1 or 0, Default=0) is a Boolean expression used to replace the triangle waveform to be replaced with a ring modulated combination of the voice# with another voice. This produces non-harmonic overtone structures that are useful for creating bell or gong sound effects. The voice selected can ring with one other voice as follows:

- a. Voice 1 rings with voice 3
- b. Voice 2 rings with voice 1
- c. Voice 3 rings with voice 2

disable (1 or 0 Default=0) is a Boolean expression used to disable the oscillator output of the selected voice. This can be useful when generating very complex waveforms (even for speech synthesis). 1=disable, 0=enable.

EXAMPLE:

```
WAVE 1,1           :REM voc#1 has a triangle waveform
WAVE 3,0,0,0,0,1   :REM disable voice 3
WAVE 3,2,1         :REM voc#3 has a saw tooth waveform; start ADS cycle
```

APPENDIX A

LOADING/SAVING SCREENS

SAVE"filename",device,secondary

This is the normal syntax used when saving/loading programs. The only change is in the secondary address. The range of valid secondary address numbers is 0-31 for serial devices; 32-127 are for other devices.

The secondary address numbers 128-130 are used by MDBASIC only. These numbers define which type of screen to save or load. The secondary addresses and the screen they represent are as follows:

128 = SCREEN (current text screen being used)
 129 = TEXT (all character shapes from redefined mode)
 130 = BITMAP (entire bitmap screen & colors)

One of these secondary addresses must be used to load or save the appropriate screen. The following are examples of loading & saving.

```
SAVE"FONTS",8,129 :REM save redefined text characters
LOAD"SCREEN",8,128 :REM load a text screen into screen RAM
LOAD"GRAPHIC",8,130 :REM load a bitmap screen
```

NOTE: If a text screen in redefined character mode is saved, only the scan codes (poke codes) on the screen are saved. In order to save the character shapes, they must be saved separately using a secondary address of 129 with a separate filename.

NOTE: When loading/saving a text screen (secondary=128) the data is loaded loaded/saved from the RAM of the current screen. If in redefined character mode, the screen is at \$CC00-\$CFE7, if in normal text mode, the screen is at \$0400-\$07E7.

APPENDIX B

ERROR CODES & MESSAGES

ERROR#	MESSAGE
1	TOO MANY FILES
2	FILE OPEN
3	FILE NOT OPEN
4	FILE NOT FOUND
5	DEVICE NOT PRESENT
6	NOT INPUT FILE
7	NOT OUTPUT FILE
8	MISSING FILE NAME
9	ILLEGAL DEVICE NUMBER
10	NEXT WITHOUT FOR
11	SYNTAX
12	RETURN WITHOUT GOSUB
13	OUT OF DATA
14	ILLEGAL QUANTITY
15	OVERFLOW
16	OUT OF MEMORY
17	UNDEF'D STATEMENT
18	BAD SUBSCRIPT
19	REDIM'D ARRAY
20	DIVISION BY ZERO
21	ILLEGAL DIRECT
22	TYPE MISMATCH
23	STRING TOO LONG
24	FILE DATA
25	FORMULA TOO COMPLEX
26	CAN'T CONTINUE
27	UNDEF'D FUNCTION
28	VERIFY
29	LOAD
30	BREAK
31	BAD SPRITE NUMBER
32	MISSING OPERAND
33	BAD VOICE NUMBER
34	ILLEGAL COORDINATE
35	CAN'T RESUME

To manually cause an error use the ERROR command followed by the number.

When error trapping is enabled using the ON ERROR command, the function ERROR(0) will return the error number and ERROR(1) will return the line number.

APPENDIX C

DEC/HEX/BIN/ASCII TABLE

DEC	HEX	BINARY	PRINTS
0	00	00000000	
1	01	00000001	
2	02	00000010	
3	03	00000011	
4	04	00000100	
5	05	00000101	WHITE
6	06	00000110	
7	07	00000111	
8	08	00001000	DISABLE SFT/CMDR
9	09	00001001	ENABLE SFT/CMDR
10	0A	00001010	
11	0B	00001011	
12	0C	00001100	
13	0D	00001101	RETURN
14	0E	00001110	LOWER CASE
15	0F	00001111	
16	10	00010000	
17	11	00010001	CRSR DOWN
18	12	00010010	RVS ON
19	13	00010011	HOME
20	14	00010100	DELETE
21	15	00010101	
22	16	00010110	
23	17	00010111	
24	18	00011000	
25	19	00011001	
26	1A	00011010	
27	1B	00011011	
28	1C	00011100	RED
29	1D	00011101	CRSR RIGHT
30	1E	00011110	GREEN
31	1F	00011111	BLUE
32	20	00100000	SPACE
33	21	00100001	!
34	22	00100010	"
35	23	00100011	#
36	24	00100100	\$
37	25	00100101	%

Appendix C (continued)

DEC	HEX	BINARY	PRINTS
38	26	00100110	&
39	27	00100111	'
40	28	00101000	(
41	29	00101001)
42	2A	00101010	*
43	2B	00101011	+
44	2C	00101100	,
45	2D	00101101	-
46	2E	00101110	.
47	2F	00101111	/
48	30	00110000	1
49	31	00110001	2
50	32	00110010	3
51	33	00110011	4
52	34	00110100	5
53	35	00110101	6
54	36	00110110	7
55	37	00110111	8
56	38	00111000	9
57	39	00111001	:
58	3A	00111010	;
59	3B	00111011	{
60	3C	00111100	?
61	3D	00111101	=
62	3E	00111110	}
63	3F	00111111	?
64	40	01000000	`
65	41	01000001	A
66	42	01000010	B
67	43	01000011	C
68	44	01000100	D
69	45	01000101	E
70	46	01000110	F
71	47	01000111	G
72	48	01001000	H
73	49	01001001	I
74	4A	01001010	J
75	4B	01001011	K
76	4C	01001100	L
77	4D	01001101	M
78	4E	01001110	N

APPENDIX D

GLOSSARY

acronym

A word formed by the initial letters of words or by initial letters plus parts of several words.

address

A name, label, or number identifying a register, location or unit where information is stored.

algebraic language

A language whose statements are structured to resemble the structure of algebraic expression. Fortran is an algebraic language.

algorithm

A set of well-defined rules or procedures to be followed in order to obtain the solution of a problem in a finite number of steps. An algorithm can involve arithmetic, algebraic, logical and other types of procedures and instructions. All algorithms must produce a solution within a finite number of steps.

alphanumeric

A contraction of the words alphabetic and numeric; a set of characters including letters, numerals, and special symbols.

argument

1. A type of variable whose value is not a direct function of another variable. It can represent the location of a number in a mathematical operation, or the number with which a function works to produce its results.

2. A known reference factor that is required to find a desired item (function) in a table. For example, in the SQR(x) function, x is the argument, which determines the square root value returned by this function.

APPENDIX D (continued)

array

1. An organized collection of data in which the argument is positioned before the function.
2. A group of items or elements in which the position of each item or element is significant. A multiplication table is a good example of an array.

ASCII

Acronym for American Standard Code for Information Interchange. ASCII is a standardized 8-bit code used by most computers for interfacing.

assembler

The computer program that produces a machine language program which may then be directly executed by the computer's microprocessor.

assembly language

A symbolic language that is machine-oriented rather than problem oriented. A program in assembly language is converted to machine code by an assembler.

BASIC

Acronym for Beginner's All-Purpose Symbolic Instruction Code. BASIC is a computer programming language developed at Dartmouth College as an instructional tool in teaching the fundamental programming concepts.

baud

A unit of measurement of data processing speed. The speed in bauds is the number of signal elements per second. Typical baud rates are 110, 300, 1200, 2400, 4800, and 9600.

binary

1. A characteristic or property involving a choice or condition in which there are two possibilities.
2. A numbering system which uses 2 as its base instead of 10 as in the decimal numbering system. This system uses only two digits, 0 and 1.
3. A device whose design uses only two possible states or levels to perform its functions. A computer executes programs in binary form.

APPENDIX D (continued)

bit

A contraction of "binary digit" which is expressed in the binary digits of 0 and 1, and is the smallest unit of measurement recognizable by the computer.

Boolean logic

Developed by the British mathematician George Boole, which has a field of mathematical analysis in which comparisons are made. A programmed instruction can cause a comparison of two fields of data, and modify one of those fields or another field as a result of comparison. Some Boolean operations are OR, AND, NOT.

buffer

A temporary storage area from which data is transferred to or from various devices.

byte

An element of data which is composed of eight data bits plus a parity bit, and represents either one alphabetic or special character, two decimal digits, or eight binary bits.

CPU (*Central Processing Unit*)

The heart of the computer system, where data is manipulated and calculations are performed. The CPU contains a control unit to interpret and execute the program and an arithmetic-logic unit to perform computations and logical processes. It also routes information, controls input, output, and temporarily stores data. A CPU is also known as a microprocessor.

character

Any single letter of the alphabet, numeral, punctuation mark, or other symbols that a computer can read, write, and store. Character is synonymous with the term byte.

COBOL

Acronym for **CO**mmon **B**usiness-**O**riented **L**anguage, a computer language suitable for writing complicated business applications programs. It was developed by CODASYL, a committee representing the U.S. Department of Defense, certain computer manufacturers, and major users of data processing equipment. It is designed to express data manipulations and processing problems in English narrative form, in a precise and standard manner.

APPENDIX D (continued)

compiler

A computer program that translates a program written in a problem-oriented language into a program of instructions similar to, or in the language of the computer.

concatenate

To link together. To join one or more pieces of data to form one piece of data. Files being merged together, or strings of text being added together are two examples.

configuration

In hardware, a group of interrelated devices that constitute a system. In software, the total of the software modules and their inter-relationships.

constant

A never changing value or data item.

debug

The process of checking the logic of a computer program to isolate and remove mistakes from the program or other software.

default

An action or value that the computer automatically assumes, unless a different instruction or value is given.

delimiter

A character that marks the beginning or end of a unit of data on a storage medium. Commas, semicolons, periods, spaces, and quotations are used as delimiters to separate and organize items of data.

DOS (*Disk Operating System*)

A collection of procedures and techniques that enable the computer to operate using a disk drive system for data entry and storage.

fixed disk

A hard disk enclosed in a permanently-sealed housing that protects it from environmental interference. It is like a floppy disk except it can store and retrieve a larger amount of data at a faster speed.

APPENDIX D (continued)

floating point

A method of calculation in which the computer or program automatically records, and accounts for, the location of the radix point (numbers to the right of the decimal point). The programmer need not consider the radix location.

garbage collection

A process that the computer takes when too many strings have been assigned, and then reassigned, leaving massive amounts of useless data. When the process takes place, the computer will seem to have "locked up". There is no indication to the user what is going on and it is a long process.

hard copy

A printed copy on paper of computer data.

hardware

The physical equipment that comprises a system.

hexadecimal

A number system with a base of 16. The numbering system ranges from 0-9 and then A-F, rather than 0-9 only on the decimal system.

interpreter

A program that reads, translates and executes a user's program, such as one written in the BASIC language, on line at a time. A compiler on the other hand, reads and translates the entire user's program before executing.

integer

A complete entity, having no fractional part. The whole or natural number. For example, 65 is an integer, 65.1 is not.

K

The symbol signifying the quantity of 2 to the 10th power=1024. K is sometimes confused the symbol K (kilo) which is equal to 1000.

APPENDIX D

logarithm

A logarithm of a given number is the value of the exponent indicating the power required to raise a specified constant, known as the base, to produce that given number. That is, if B is the base, N is the given number and L is the logarithm, then $BL=N$.

M

The symbol signifying the quantity 1,000,000 (10^6). When used to denote storage, it more precisely refers to 1,048,576 (2^{20}).

mantissa

The fractional or decimal part of a logarithm of a number. For example, the logarithm of 163 is 2.212. The mantissa is 0.212, and the characteristic is 2.0.

null

Empty or having no members. This is in contrast to a blank or zero, which indicates the presence of no information. For example, `A$=""` assigns the variable A\$ to a null condition.

NTSC (*NATIONAL TELEVISION STANDARD CODE*)

The U.S. standard for timing of the raster scan lines. NTSC has 262 horizontal lines which make a display. Only 200 of these lines are visible (50-249) on the Commodore 64. The European (PAL) standard has 312 lines, making the clock speed slower to sync the sixtieth of a second interrupt.

octal

A representation of values or quantities with octal numbers. The octal number system uses eight digits: 0-7, with each position in an octal numeral system representing a power of 8. The octal system is used in computing as simple means of expressing binary quantities.

operand

A quantity or data item involved in an operation. An operand is usually designated by the address portion of an instruction, but it may also be a result, a parameter or an indication of the name or location of the next instruction to be executed.

APPENDIX D (continued)

operating system

An organized group of computer instructions that manage the overall operation of the computer.

parameter

A variable that is given a value for a specific program to process. A definable item, device, or system.

PAL (*Phase Alternating Line*)

European standard for television scan lines (See NTSC).

peripheral

An external input/output, or storage device.

pixel

The acronym for picture element. A pixel is a single dot on a monitor that can be addressed by a single bit.

RAM (*Random Access Memory*)

The system's high speed work area that provides access to memory storage locations by using a system of vertical and horizontal coordinates. The computer can write or read information to RAM faster than any other input/output process.

raster

On a graphics display screen a raster unit is the horizontal or vertical distance between two adjacent addressable points on the screen. There are 262 horizontal lines which make up the American (NTSC) standard display screen (312 lines in European or PAL standard screens). Every one of these lines is scanned and updated 60 times per second. Only 200 of these lines (50-249) are part of the visible display.

ROM (*Read Only Memory*)

A type of memory that contains permanent data or instructions. The computer can read but not write to ROM.

real number

An ordinary number, either rational or irrational; a number in which there is no imaginary part, a number generated from the single unit, 1; any point in a continuum of natural numbers filled in with all rationales and all irrationals and extended indefinitely, both positive & negative.

APPENDIX D (continued)

software

A list of instructions that, when executed direct the computer to perform certain tasks.

syntax

Rules of statement structure in a programming language.

toggle

Alternation of function between two stable states.

truncation

To end a computation according to a specified rule; for example, to drop numbers at the end of a line instead of rounding them off, or to drop operands off a command syntax when variables do not pertain to the task that is to be performed.

APPENDIX E

SAMPLE PROGRAMS

```

10 REM *** MDBASIC SPRITE DEMO ***
20 REM
30 REM **** BY: MARK BOWREN ****
40 REM
50 PRINT".":SP= 100
55 VOICE CLR
60 VOL15:ENVELOPE1,0,9,0,0:VOICE1,1000
65 MULTI SPRITE 2,6
70 SPRITE0,1,6,1,13:EXPAND0,1,0
75 FORI=832TO832+63 :READA:POKEI,A:NEXT
80 LOCATE7,1:PRINT"*** EXTENDED BASIC V2 ***"
90 LOCATE8,3:PRINT"*** BY: MARK BOWREN ***"
110 MOVE0,24,50TO297,50,SP:WAVE1,0:WAVE1,1,1:SP=SP-5
120 MOVE0 TO 297,231,SP:WAVE1,0:WAVE1,1,1:SP=SP-5
130 MOVE 0 TO 24,231,SP:WAVE1,0:WAVE1,1,1:SP=SP-5
140 MOVE 0 TO 24,50,SP:WAVE1,0:WAVE1,1,1:SP=SP-5
150 IF SP > 0 THEN 110
151 LOCATE 16,6:PRINT".FOR .THE:."
152 LOCATE17,10:PRINT"COMMODORE 64.":MOVE0 TO 160,120, 120
155 FORI=0TO21:DELAY30:EXPAND0,IAND1,IAND1:NEXT
160 DATA 3,240,0
161 DATA 15,252,0
162 DATA 63,255,0
170 DATA 63,63,0
171 DATA 252,15,0
172 DATA 240,0,170
180 DATA 240,0,168
181 DATA 240,0,160
182 DATA 240,0,128
190 DATA 240,0,0
191 DATA 240,0,64
192 DATA 240,0,80
200 DATA 240,0,84
201 DATA 240,0,85
202 DATA 252,15,0
210 DATA 63,63,0
211 DATA 63,255,0
212 DATA 15,248,0
220 DATA 3,224,0
221 DATA 0,0,0
222 DATA 0,0,0,0

```


Appendix E (continued)

```
0 REM *** BITMAP DEMO ***
5 BITMAP CLR
10 BITMAP1,0:REM MC MODE BLK BKGD
15 MAPCOL 2, 1, 6
20 PLOT 16,10,1,1
21 DRAW"R60,D55,L60,U55"
22 PLOT 16,70,1,2
23 DRAW"R60,D30,L60,U30"
25 PLOT 16,120,1,3
26 DRAW"R60,D30,L60,U30"
30 CIRCLE48,37,23,18,1,1
32 PAINT48,27,1,1
35 PAINT17,11,1,2
45 TEXT 0,0,"JAPAN",0, 2,2, 1,1
46 LINE 0,0 TO 159,199, 1,3
51 MAPCOL 7, 8, 13
52 PLOT150,10,1,3
53 DRAW"R9,D40,L9,U40"
55 LINE 0,199TO159,0, 1,2
91 PLOT 85, 65, 1, 1
92 DRAW"F30,C2,H30,C3,G30,C1,E30"
98 DELAY 200
99 TEXT
```

Appendix E (continued)

```

0 REM MDBASIC BASIC DEMO 5
1 REM ** DIXIE **
2 REM MUSIC BY: JIM BUTTERFIELD
3 REM
6 W=7
10 PRINT CHR$(147):LOCATE17,0:COLOR,,2
20 PRINT"DIXIE"
30 LOCATE7,2:COLOR,,2:PRINT"MUSIC BY: JIM BUTTERFIELD"
35 SPRITE0,1,1,0,13
40 RESTORE 380
45 FORI=0TO63:READS:POKE832+I,S:NEXT
50 RESTORE 155
55 VOICE CLR:VOL15
60 ENVELOPE1,0,9,0,0
65 ENVELOPE2,2,4,2,4
70 ENVELOPE3,1,2,10,10
75 WAVE1,1,0
80 WAVE3,2,0
85 WAVE2,1,0
90 READ S:IF S=0 GOTO 145
95 READ F1,F2,F3
100 MOVE0,(F1/4)+30,(F2/4)+30
105 VOICE1,F1
110 VOICE2,F2
115 VOICE3,F3
120 WAVE1,1,1
125 WAVE3,2,1
130 WAVE2,1,1
135 DELAY S*W:W=7
140 GOTO 75
145 END
150 REM ** MUSIC DATA **
155 DATA 1, 801, 0, 0
160 DATA 1, 674, 0, 0
165 DATA 2, 535, 337, 133
170 DATA 2, 535, 400, 0
175 DATA 1, 535, 267, 100
180 DATA 1, 600, 0, 0
185 DATA 1, 674, 400, 0
190 DATA 1, 714, 0, 0
195 DATA 2, 801, 337, 133
200 DATA 2, 801, 400, 0
205 DATA 2, 801, 267, 150
210 DATA 2, 674, 400, 168
215 DATA 2, 900, 357, 178
220 DATA 2, 900, 535, 0
225 DATA 2, 900, 450, 133
230 DATA 1, 0, 535, 0
235 DATA 1, 801, 0, 0
240 DATA 2, 900, 357, 178
245 DATA 1, 0, 535, 0
250 DATA 1, 801, 0, 0

```

```

255 DATA 1, 900, 450, 168
260 DATA 1, 1010, 0, 0
265 DATA 1, 1070, 535, 150
270 DATA 1, 1201, 0, 0
275 DATA 2, 1348, 337, 133
280 DATA 2, 0, 400, 0
285 DATA 2, 0, 267, 100
290 DATA 1, 1070, 400, 0
295 DATA 1, 801, 0, 0
300 DATA 2, 1070, 337, 133
305 DATA 2, 0, 400, 0
310 DATA 2, 0, 267, 126
315 DATA 1, 801, 400, 112
320 DATA 1, 674, 0, 0
325 DATA 2, 801, 357, 100
330 DATA 2, 0, 400, 0
335 DATA 2, 0, 300, 150
340 DATA 1, 600, 400, 0
345 DATA 1, 677, 0, 0
350 DATA 2, 535, 337, 133
355 DATA 2, 0, 400, 100
360 DATA 2, 0, 337, 66
365 DATA 2, 0, 0, 0
370 DATA 0
375 REM ** SPRITE DATA **
380 DATA 224, 14, 0, 248, 62, 0, 255, 254, 0, 255, 254, 0, 199, 198, 0, 192, 6, 0, 248
385 DATA 126, 0, 223, 230, 0, 192, 6, 0, 192, 6, 0, 192, 6, 0, 192, 6, 0, 240, 7, 192
390 DATA 248, 3, 224, 112, 1, 192, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
999 END
```

Appendix E (continued)

```
0 REM *** bitmap graphics demo ***  
10  
20  
30  
40  
50  
60
```

Appendix E (continued)

```
0 REM *** sound demo ***  
10  
20  
30  
40  
50  
60
```

APPENDIX F

BASIC PROGRAMMING GUIDELINES AND SUGGESTIONS FOR PERFORMANCE:

1. Declare all variables at the top of the program with the most used variables first. This is because the name lookup is a sequential process starting from the first declared variable to the last.
2. Always place dimensioned variables at the end of the declare section. This will avoid the need for array information to be moved in memory.
3. Declare constants in a variable if they are used heavily or inside a loop. It is faster to access a variable value than to decode a string of ASCII digits.
4. Integer arrays use less space than non-array integers. If you have many integer variables or constants consider using an array to reference the value instead of individual integer variables.

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