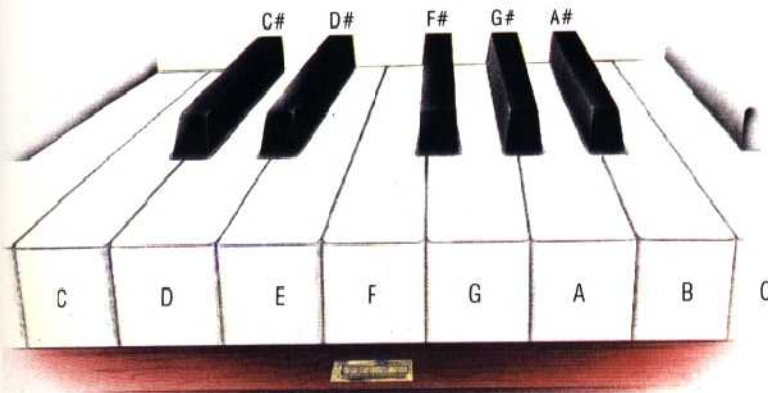




where 'ms' represents the time in units of 0.001 second (milliseconds). To play an octave in a key of C major (C, D, E, F, G, A, B, C) from middle C, with each note lasting half a second and a PAUSE of a quarter second between notes, the following format can be used:

```
10 FOR I = 1 TO 8
20 READ N
30 BEEP .5,N
40 PAUSE 250
50 NEXT I
60 DATA 0,2,4,5
70 DATA 7,9,11,12
```

This program is a good illustration of the format of a scale. An octave extends from the root note (in this case middle C) to the next note with the same name (the next C above) and spans 12 semitones. It is called an octave because it consists of eight notes in a major scale.



C major

circles, and numerous other symbols that can be put together on the screen to draw graphs, make up tables, produce large lettering and create other effects. Each character can be displayed inverted (black on white instead of white on black), further increasing the possibilities. With patience and imagination, high-quality displays can be produced.

Characters can be made to appear on the screen either by use of the PRINT statement or by POKEing the required codes into the Vic-20's screen and colour memories. Commodore's version of the PRINT statement is extremely powerful, allowing the user to define the colour of each character individually. Cursor movement can also be controlled from within the PRINT statement to produce moving displays with ease. POKEing characters to the screen is not as fast as PRINTing them but this method can be useful in certain circumstances.

## High Resolution Capabilities

High resolution graphics are possible on an unexpanded Vic-20, but there is enough memory available to utilise only about half the screen. The process by which high resolution can be achieved is known as 'bit-mapping', a technique that

enables the programmer to control each individual pixel within a given area of the screen. Each character cell on the grid of 23 rows by 22 columns consists of 64 pixels arranged as eight rows of eight. There is a mathematical relationship between the given co-ordinates of a pixel dot (x,y) and the corresponding bit in the character matrix. This may be used, together with a combination of POKE commands, to produce displays made up of individual pixels.

## Super Expander Cartridge

Producing high resolution graphics by bit-mapping can be a long and difficult process. An alternative approach is to buy Commodore's Super Expander cartridge, which gives the user high resolution, colour and music commands in BASIC. High resolution commands include GRAPHIC to set the display mode, POINT to plot a pixel dot on the screen, and PAINT.

There are two main drawbacks to using the cartridge: there is no UNPOINT command to rub out the pixel dot, and it is not possible to PAINT both sides of a diagonal line without disturbing the line itself.

The Vic-20's low resolution graphics are well designed and very flexible, but high resolution graphics are difficult to use without incurring the expense of a plug-in cartridge.

## Scales And Pianos

By using the INKEY\$ command, the Spectrum keyboard can be used to approximate the keyboard of a piano:

```
10 REM *****
20 REM *OCTAVE PIANO*
30 REM *****
40 IF INKEY$="Q" THEN BEEP1,0
50 IF INKEY$="2" THEN BEEP1,1
60 IF INKEY$="W" THEN BEEP1,2
70 IF INKEY$="3" THEN BEEP1,3
80 IF INKEY$="E" THEN BEEP1,4
90 IF INKEY$="R" THEN BEEP1,5
100 IF INKEY$="5" THEN BEEP1,6
110 IF INKEY$="T" THEN BEEP1,7
120 IF INKEY$="6" THEN BEEP1,8
130 IF INKEY$="Y" THEN BEEP1,9
140 IF INKEY$="7" THEN BEEP1,10
150 IF INKEY$="U" THEN BEEP1,11
160 IF INKEY$="I" THEN BEEP1,12
170 GOTO 40
```

Many improvements can be made to a program like this in order to create a more efficient keyboard 'instrument'. Generally, the Spectrum is of little use as a sound source because of its lack of facilities for reasonable sound generation. It does, however, make a very useful aid to teaching music. The only way that acceptable sound can be obtained is by purchasing additional sound generating hardware that is compatible with the machine.

```
100 REM ** VIC 20 RABBIT **
110 POKE36879,110
120 PRINT"
130 PRINT"
140 PRINT"
150 PRINT"
160 PRINT"
170 PRINT"
180 PRINT"
190 PRINT"
200 PRINT"
210 PRINT"
220 PRINT"
230 PRINT"
240 PRINT"
250 PRINT"
260 PRINT"
270 PRINT"
280 PRINT"
290 PRINT"
300 PRINT"
310 PRINT"
320 GOTO320
```

### Run Rabbit

This program listing for the Vic-20 demonstrates the versatility of the special set of Commodore characters. The rabbit figure created is constructed entirely from this predefined character set. It is easier to see exactly how it is made up by moving the cursor over the screen display when the program has been typed in and run