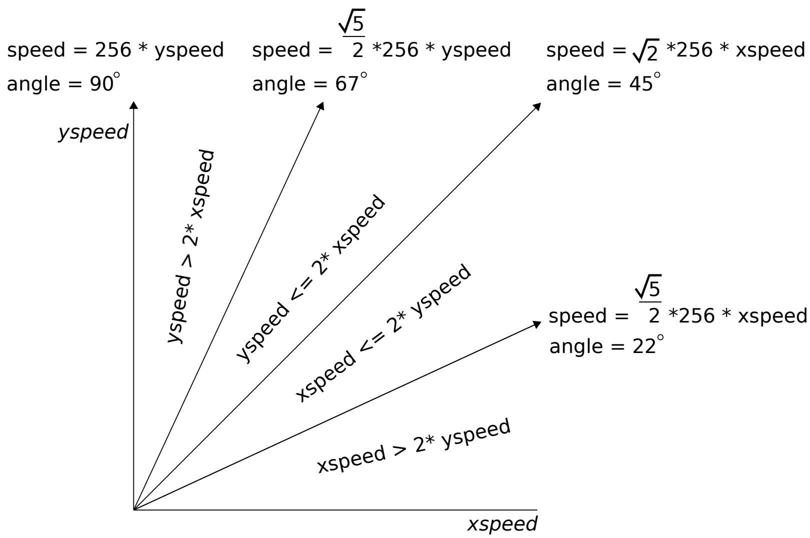
0.1 Tricks

This section describes random tricks used to speed up rendering.

0.1.1 Bouncing Flower

When Keen throws a flower it bounces of the walls. For flat walls and floors the bounce can be easily calculated by reversing either the x-speed (for vertical walls) or y-speed (for horizontal walls). It becomes more complicated for slopes. Making an accurate calculation of the bounce on a slope requires expensive `cos` and `sin` methods.

Instead, the game used a simple algorithm that approximates the angle to either 22°, 45° or 90°. Based on the ratio between the x- and y-speed it calculates the resulting speed and corresponding angle. Notice that for higher precision the speed is multiplied with 256.



For each combination of the eight type of slopes (Figure **??**) and incoming angle, the corresponding bounce angle is calculated using a simple lookup table.

```
// bounceangle[walltype][angle]

unsigned  bounceangle[8][8] =
{
{0,0,0,0,0,0,0,0},
{7,6,5,4,3,2,1,0},
{5,4,3,2,1,0,15,14},
{5,4,3,2,1,0,15,14},
{3,2,1,0,15,14,13,12},
{9,8,7,6,5,4,3,2},
{9,8,7,6,5,4,3,2},
{11,10,9,8,7,6,5,4}
};
```

The value in the table refers to the corresponding bounce angle calculation. As example, waltype 3 with incoming angle of 22°, results in bounce calculation case 5.

$$yspeed = -speed / (\frac{\sqrt{5}}{2} * 256)$$

$$xspeed = yspeed / 2$$

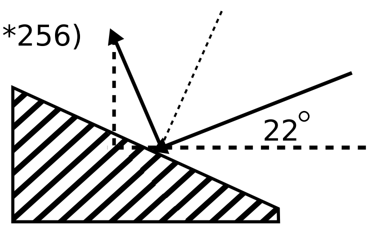
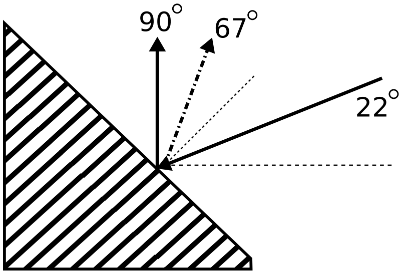


Figure 1: Walltype 3 with incoming angle of 22° (angle=0).

```
absx = abs(ob->xspeed);
absy = ob->yspeed;
if (absx>absy)
{
  if (absx>absy*2)         // 22 degrees
  {
    angle = 0;
    speed = absx*286;      // x*sqrt(5)/2 *256
  }
  else
  [...]                 // Check for 45, 67 and 90 degrees
}

if (ob->xspeed > 0)
  angle = 7-angle;         // mirror angle

speed >>= 1;               // speed / 2 after bounce
newangle = bounceangle[ob->hitnorth][angle];
switch (newangle)
{
[...]

case 5:
  ob->yspeed = -(speed / 286);
  ob->xspeed = ob->yspeed / 2;
  break;

[...]
}
```

Notice that in several cases the bounce angle is not following the laws of physics. As example, for an incoming angle of 22° on a 45° slope the bounce angle is 90°, instead of 67°.



0.1.2 Pseudo Random Generator

Random numbers are necessary for many things during runtime, such as calculating whether an enemy is able to hit the player based on its accuracy. This is achieved with a precalculated pseudo-random series of 256 elements.

```
rndindex   dw   ?

rndtable

db     0,   8, 109, 220, 222, 241, 149, 107,  75, 248, 254, 140,  16,  66
db    74,  21, 211,  47,  80, 242, 154,  27, 205, 128, 161,  89,  77,  36
db    95, 110,  85,  48, 212, 140, 211, 249,  22,  79, 200,  50,  28, 188
db    52, 140, 202, 120,  68, 145,  62,  70, 184, 190,  91, 197, 152, 224
db   149, 104,  25, 178, 252, 182, 202, 182, 141, 197,   4,  81, 181, 242
db   145,  42,  39, 227, 156, 198, 225, 193, 219,  93, 122, 175, 249,   0
db   175, 143,  70, 239,  46, 246, 163,  53, 163, 109, 168, 135,   2, 235
db    25,  92,  20, 145, 138,  77,  69, 166,  78, 176, 173, 212, 166, 113
db    94, 161,  41,  50, 239,  49, 111, 164,  70,  60,   2,  37, 171,  75
db   136, 156,  11,  56,  42, 146, 138, 229,  73, 146,  77,  61,  98, 196
db   135, 106,  63, 197, 195,  86,  96, 203, 113, 101, 170, 247, 181, 113
db    80, 250, 108,   7, 255, 237, 129, 226,  79, 107, 112, 166, 103, 241
db    24, 223, 239, 120, 198,  58,  60,  82, 128,   3, 184,  66, 143, 224
db   145, 224,  81, 206, 163,  45,  63,  90, 168, 114,  59,  33, 159,  95
db    28, 139, 123,  98, 125, 196,  15,  70, 194, 253,  54,  14, 109, 226
db    71,  17, 161,  93, 186,  87, 244, 138,  20,  52, 123, 251,  26,  36
db    17,  46,  52, 231, 232,  76,  31, 221,  84,  37, 216, 165, 212, 106
db   197, 242,  98,  43,  39, 175, 254, 145, 190,  84, 118, 222, 187, 136
db   120, 163, 236, 249
```

Each entry in the array has a dual function. It is an integer within the range [0-255][1] and it is also the index of the next entry to fetch for next call. This works overall as a 255 entry chained list. The pseudo-random series is initialized using the current time modulo 256 when the engine starts up.

[1]Or at least it was intended to!

```
;==================================================
;
;
; void US_InitRndT (boolean randomize)
; Init table based RND generator
; if randomize is false, the counter is set to 0
;
;
;==================================================


PROC  US_InitRndT randomize:word

  uses  si,di
  public  US_InitRndT

  mov ax,[randomize]
  or  ax,ax
  jne @@timeit    ;if randomize is true, really random

  mov dx,0      ;set to a definite value
  jmp @@setit

@@timeit:
  mov ah,2ch
  int 21h      ;GetSystemTime
  and dx,0ffh

@@setit:
  mov [rndindex],dx
  ret

ENDP
```

The random number generator saves the last index in `rndindex`. Upon request for a new number, it simply looks up the new value and updates `rndindex`.

```
;==================================================
;
; int US_RndT (void)
; Return a random # between 0-255
; Exit : AX = value
;
;==================================================
PROC  US_RndT
  public  US_RndT

  mov bx,[rndindex]
  inc bx
  and bx,0ffh
  mov [rndindex],bx
  mov al,[rndtable+BX]
  xor ah,ah
  ret

ENDP
```

0.1.3 Screen fades

When a new level is loaded, the screen fades from black to the level.CHECK WHEN SCREEN FADES TO WHITE. Here it makes use of reassigning the color palette colors. This can easily be done by calling BIOS software interrupt `10h`.

```
_AX = 0x1000 ; Set One Palette Register
_BL = 0      ; index color number to set
_BH = 0x5    ; 6-bit RGB color to display for that index
geninterrupt (0x10) ; Generate Video BIOS interrupt
```

By calling `_AX=1002h` the entire palette can be reprogrammed. In this case `ES:BX` points to 17 bytes; an rgbRGB value for each of 16 palette index plus one for the border.

Earlier in the hardware chapter, Section **??**, it was explained that most EGA monitors did not support the extended 64-color palette and uses the CGA pin assignment. That means applying "rgbRGB" results in wrong color mapping to the monitor. To better understand this, let's have a look at the pin signals.

Pin	EGA modes	CGA modes
1	Ground	Ground
2	Secondary Red (Intensity)	Ground
3	Primary Red	Red
4	Primary Green	Green
5	Primary Blue	Blue
6	Secondary Green (Intensity)	Intensity
7	Secondary Blue (Intensity)	Reserved
8	Horizontal Sync	Horizontal Sync
9	Vertical Sync	Vertical Sync

Figure 2: EGA and CGA DE-9 connector pin signals.

If one assigns the color brown (rgbRGB is `010100b`) to one of the color indexes, the resulting color on the CGA pin assignment is light red; The secondary green pin ("r" in rgbRGB) is mapped to the Intensity pin in CGA mode, which results color red with intensity and not the expected brown color. So mapping the color to one of the indexes is based on "RGB" and setting the Secondary Green ("r") for the intensity color version. The "b" has no meaning and the "r" (Ground) is normally set to 0.

The screen fading is defined with the `colors[7][17]` scheme, where the first 16 columns refer to the color indexes, the last column is the border color. Note that the "b" bit is set for the intensity colors, but this had no effect on the results since the pin is unassigned for CGA.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	0
0	0	0	0	0	0	0	0	0x18	0x19	0x1a	0x1b	0x1c	0x1d	0x1e	0x1f	0
0	1	2	3	4	5	6	7	0x18	0x19	0x1a	0x1b	0x1c	0x1d	0x1e	0x1f	0
0	1	2	3	4	5	6	7	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0
0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f	0x1f

Figure 3: Color fading table.

Fading the screen is rather straight forward.

```
void VW_FadeIn(void)
{
    int i;

    for (i=0;i<4;i++)
    {
        colors[i][16] = bordercolor;
        _ES=FP_SEG(&colors[i]);
        _DX=FP_OFF(&colors[i]);
        _AX=0x1002;
        geninterrupt(0x10);
        VW_WaitVBL(6);
    }
    screenfaded = false;
}
```