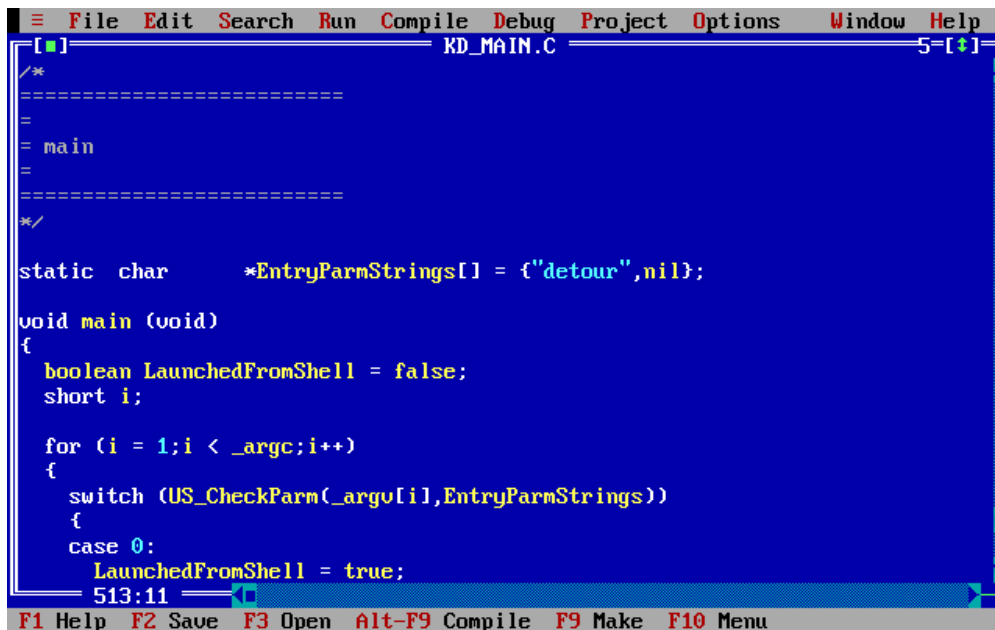


0.1 Programming

Development was done with Borland C++ 3.1 (but the language used was C) which by default ran in EGA mode 3 offering a screen 80 characters wide and 25 characters tall.

John Carmack took care of the runtime code. John Romero programmed many of the tools (TED5 map editor, IGRAB asset packer, MUSE sound packer). Jason Blochowiak wrote important subsystems of the game (Input manager, Sound manager, User manager).

Borland's solution was an all-in-one package. The IDE, `BC.EXE`, despite some instabilities allowed crude multi-windows code editing with pleasant syntax highlights. The compiler and linker were also part of the package under `BCC.EXE` and `TLINK.EXE`¹.



```

[ ] KD_MAIN.C 5-[ ]
/*
=====
=
= main
=
=====
*/

static char    *EntryParmStrings[] = {"detour",nil};

void main (void)
{
    boolean LaunchedFromShell = false;
    short i;

    for (i = 1;i < _argc;i++)
    {
        switch (US_CheckParm(_argv[i],EntryParmStrings))
        {
            case 0:
                LaunchedFromShell = true;
        }
    }
}
513:11
F1 Help F2 Save F3 Open Alt-F9 Compile F9 Make F10 Menu

```

Figure 1: Borland C++ 3.1 editor

¹Source: Borland C++ 3.1 User Guide.

There was no need to enter command-line mode however. The IDE allowed to create a project, build, run and debug.

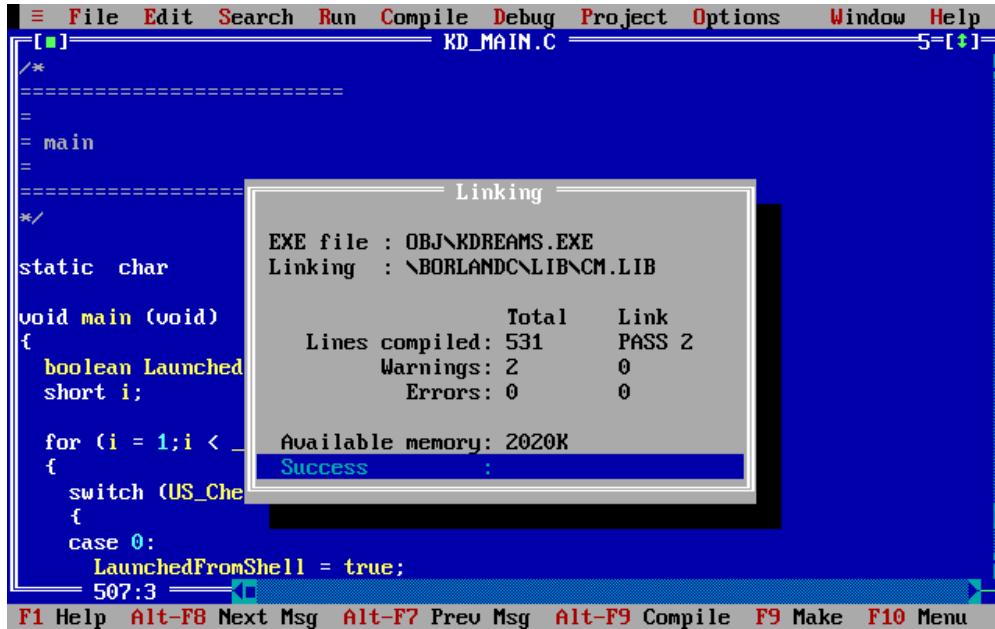
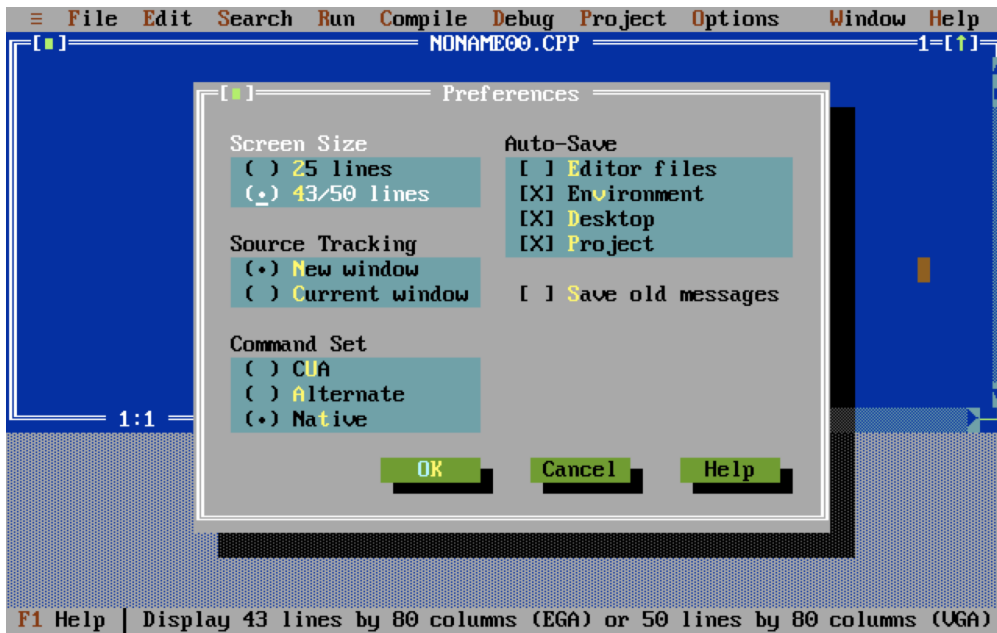
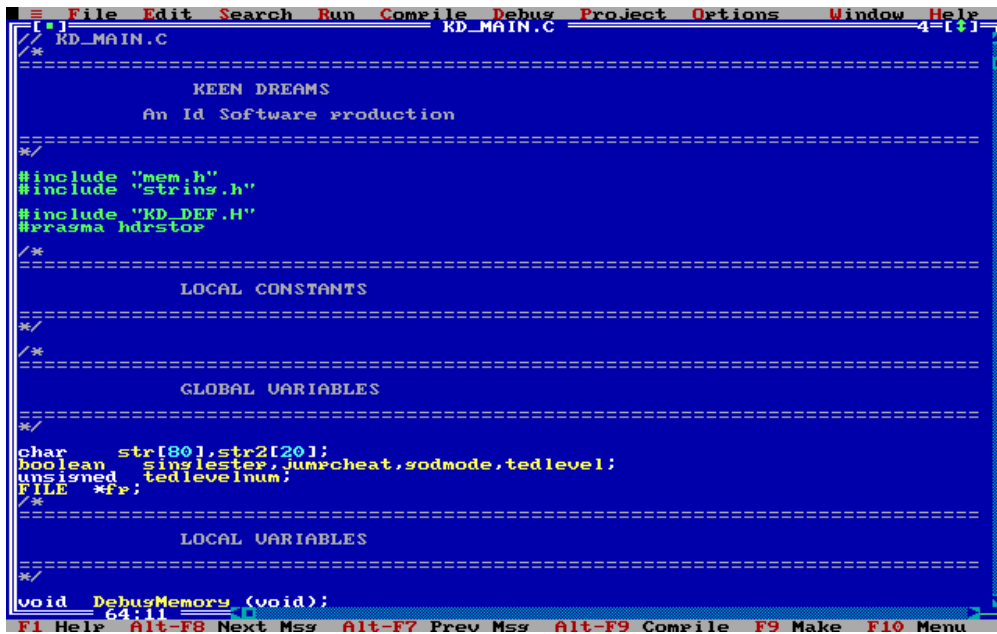


Figure 2: Compiling Keen Dreams with Borland C++ 3.1

Another way to improve screen real estate was to use "high resolution" 50x80 text mode.



The comments still fit perfectly on screen since only the vertical resolution is doubled.



The file KD_MAIN.C opened in both modes demonstrates the readability/visibility trade-off.

```

File Edit Search Run Compile Debug Project Options Window Help
KD_MAIN.C 5-[+]
/*
=====
=
= main
=
=====
*/

static char    *EntryParmStrings[] = {"detour",nil};

void main (void)
{
    boolean LaunchedFromShell = false;
    short i;

    for (i = 1;i < _argc;i++)
    {
        switch (US_CheckParm(_argv[i],EntryParmStrings))
        {
            case 0:
                LaunchedFromShell = true;
        }
    }
}
513:11
F1 Help F2 Save F3 Open Alt-F9 Compile F9 Make F10 Menu

```

```

File Edit Search Run Compile Debug Project Options Window Help
KD_MAIN.C 4-[+]
/*
=====
main
=====
*/

static char    *EntryParmStrings[] = {"detour",nil};

void main (void)
{
    boolean LaunchedFromShell = false;
    short i;

    for (i = 1;i < _argc;i++)
    {
        switch (US_CheckParm(_argv[i],EntryParmStrings))
        {
            case 0:
                LaunchedFromShell = true;
                break;
        }
    }

    if (!LaunchedFromShell)
    {
        clrscr();
        puts("You must type START at the DOS prompt to run KEEN DREAMS.");
        exit(0);
    }

    InitGame();
    DemoLoop(); // DemoLoop calls Quit when everything is done
    Quit("Demo loop exited???");
}
-
530:4
F1 Help Alt-F8 Next Msg Alt-F7 Prev Msg Alt-F9 Compile F9 Make F10 Menu

```

0.2 Graphic Assets

All graphic assets were produced by Adrian Carmack. All of the work was done with Deluxe Paint (by Brent Iverson, Electronic Arts) and saved in ILBM² files (Deluxe Paint proprietary format). All assets were hand drawn with a mouse.



Figure 3: Deluxe Paint was used to draw all assets in the game.

0.2.1 Assets Workflow

After the graphic assets were generated, a tool (IGRAB) packed all ILBMs together in an archive and generated a header table file (KDR-format) and C header file with asset IDs. The engine references an asset directly by using these IDs.

²InterLeaved BitMap.

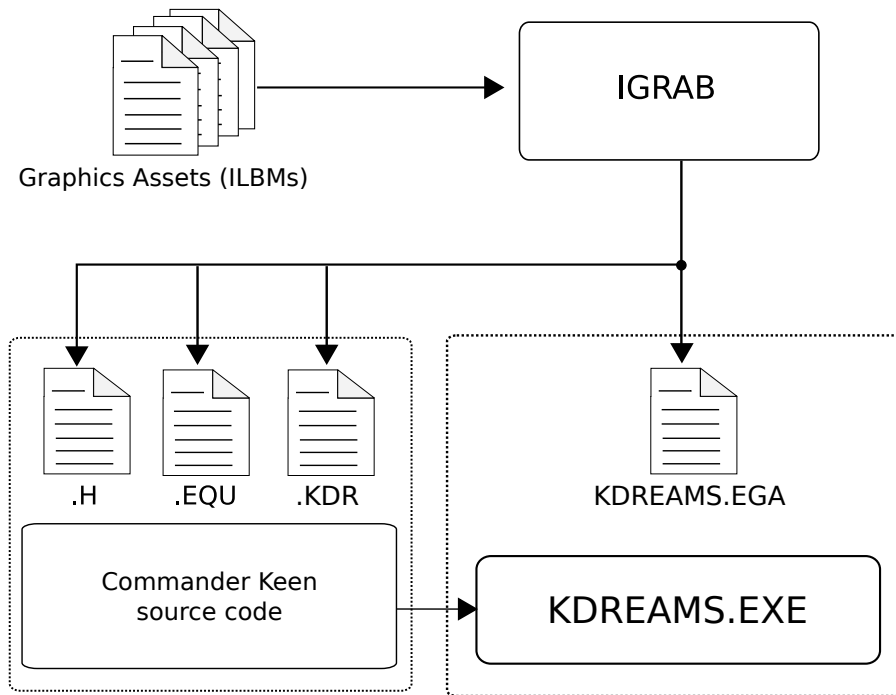


Figure 4: Asset creation pipeline for graphics items

```

////////////////////////////////////
//
// Graphics .H file for .KDR
// IGRAB-ed on Fri Sep 10 11:18:07 1993
//
////////////////////////////////////

typedef enum {
    #define CTL_STARTUPPIC          4
    #define CTL_HELPUPPIC          5
    #define CTL_DISKUPPIC          6
    #define CTL_CONTROLSUPPIC      7
    #define CTL_SOUNDUPPIC         8
    #define CTL_MUSICUPPIC         9
    #define CTL_STARTDNPIC        10
    #define CTL_HELPDNPIC         11
    #define CTL_DISKDNPIC         12
    #define CTL_CONTROLSDNPIC     13
    ...
    #define BOOBUSWALKR4SPR        366
    #define BOOBUSJUMPSR          367
}

```

In the engine code, asset usage is hardcoded via an enum. This enum is an offset into the HEAD table which gives an offset in the DATA archive. The HEAD table files are stored in the \static folder as *.KDR files.

0.2.2 Assets file structure

Figure 5 shows the structure of the KDREAMS.EGA asset file.

pictable[]	STRUCTPIC
picmtable[]	STRUCTPICM
spritetable[]	STRUCTSPRITE
font	STARTFONT
pictures	STARTPICS
mask pictures	STARTPICSM
sprites	STARTSPRITES
tile-8	STARTTILE8
mask tile-8	STARTTILE8M
tile-16	STARTTILE16
mask tile-16	STARTTILE16M

Figure 5: File structure of KDREAMS . EGA asset file.

The `pictable[]` contains the width and height in bytes for each picture in the asset file. Note that a width of 5 bytes means a size of 40 pixels on the screen. The same size structure is applied for mask pictures.

index	width	height
0	5	32
1	5	32
2	5	32
3	5	32
4	5	32
5	5	32
6	5	32
7	5	32
...
64	5	24

Table 1: content of `pictable[]`.

The `spritetable[]` contains beside width and height in bytes also information on the sprite center, hit boundaries and number of shifted sprites (this will be explained in section xxx).

index	width	height	orgx	orgy	xl	yl	xh	yh	shift
0	3	24	0	0	0	0	368	368	4
1	3	32	0	0	64	0	304	496	4
2	3	30	0	16	64	0	304	496	4
3	3	30	0	32	64	48	304	496	4
4	3	32	0	0	64	0	304	496	4
5	3	30	0	32	64	48	304	496	4
...
296	12	103	-128	0	256	128	752	1648	4

Table 2: content of `spritetable[]`.

The font segment contains a table for the height (same for all characters) and width of the font, as well as a reference where the character data is located.

```
// ID_VW.H

typedef struct
{
    int height;
    int location[256];
    char width[256];
} fontstruct;
```

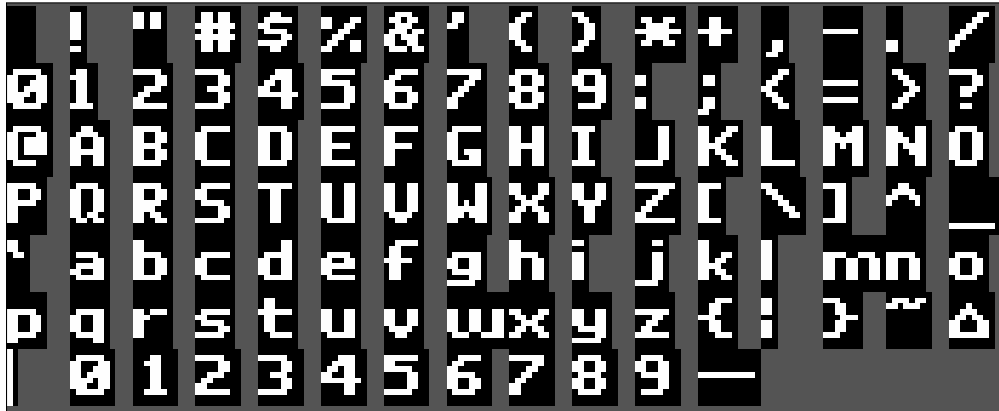


Figure 6: Font assets data.

Since all tiles have fixed dimension (either 8 or 16 pixels), there is no need to store any tile size table structure. From STARTPICS location onwards all graphical assets are stored. Each asset contains four planes, aligned with the EGA architecture. Foreground tiles and sprites include a mask plane as well.



Figure 7: Picture assets data.

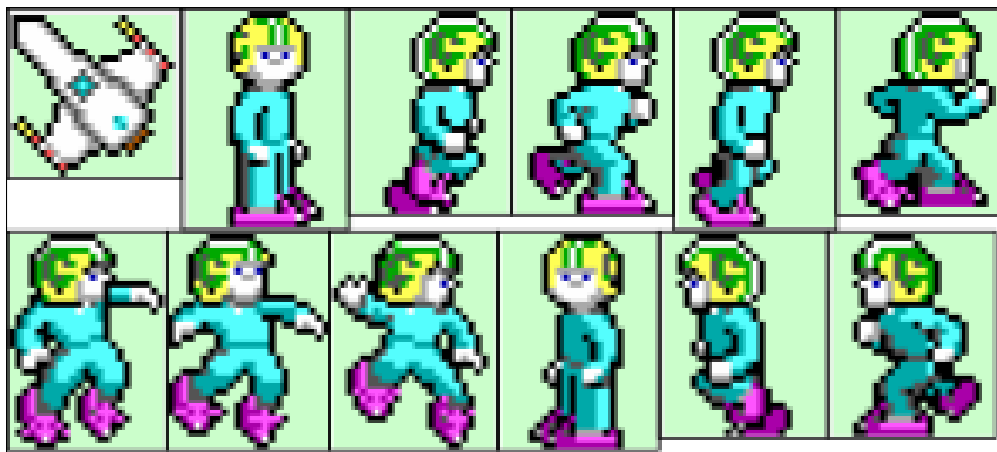


Figure 8: Sprite assets data.

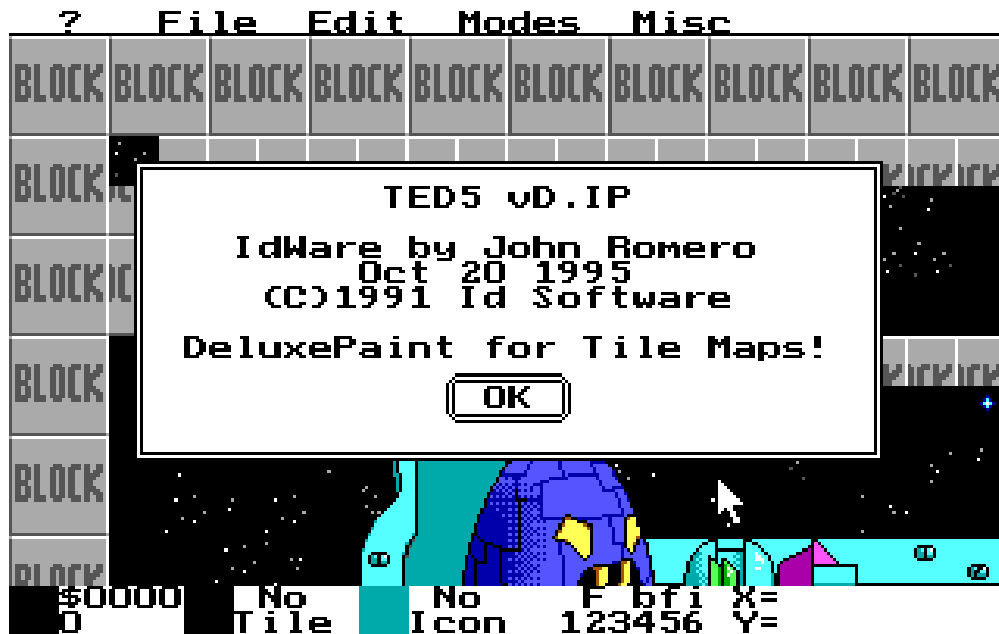


Figure 9: Background (Tile-16) and foreground (masked tile-16) assets data.

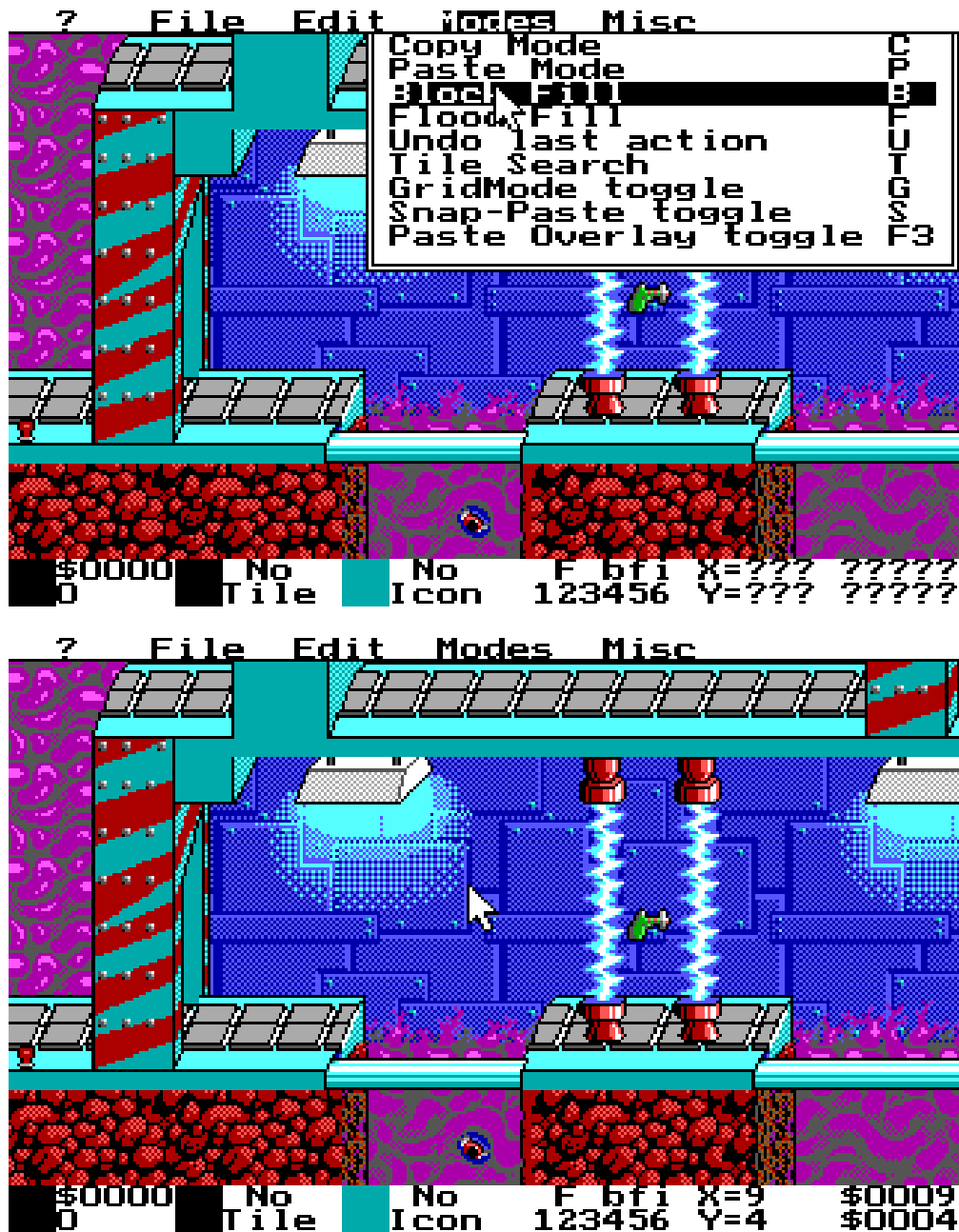
0.3 Maps

Maps were created using an in-house editor called TED5, short for Tile Editor. Over the years TED5 had improvements and the same tool is used for creating maps of both side-scrolling games and top-down games like Wolf 3D.

TED5 is not stand-alone; in order to start, it needs an asset archive and the associated header (as described in the graphic asset workflow Figure 4 on page 6). This way, texture IDs are directly encoded in the map.



Trivia : The suffix, "vD.IP", was put in by the Rise of the Triad team in 1994. It stood for "Developers of Incredible Power".



TED5 allows placement of tiles on layers called "planes". In Commander Keen, layers are used for background, foreground and information tiles. Note that foreground tiles are al-

ways using a mask as they are overlayed with the background. The info plane contains the location of all actors and special places. Each foreground and background tile could also be enriched with additional tile information such as tile clipping and animated tiles. Just like IGRAB, the TED5 tool generated a header table file (KDR-format) and a *.MAP file containing the levels. Figure 10 shows the map header table structure, which is hard-coded in the source code.

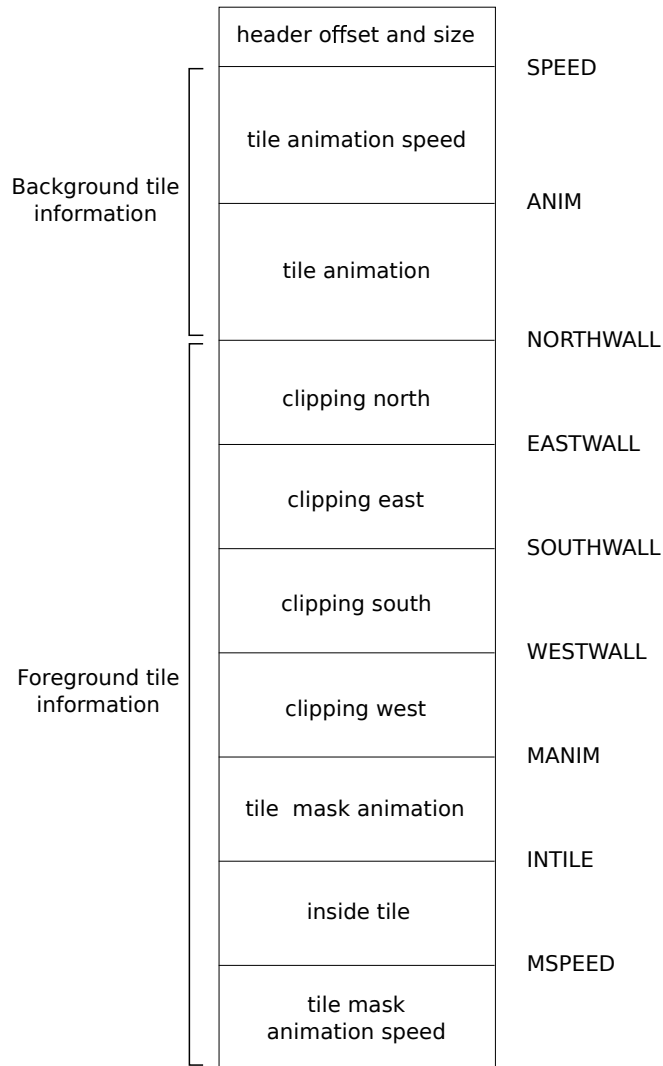


Figure 10: File structure of MAPHEAD.KDR header file.

0.3.1 Map header structure

The header offset and header size refer to the location and size in the `KDREAMS.MAP` file. A total of 100 maps are supported in the game.

```
/*
=====

                LOCAL CONSTANTS

=====
*/

typedef struct
{
    unsigned    RLEWtag;
    long        headeroffsets[100];
    byte        headersize[100];    // headers are very small
    byte        tileinfo[];
} mapfiletype;
```

0.3.2 Background tile information

For background tile animation two information tables are required: tile animation and tile animation speed. The tile animation refers to the next tile in the animation sequence. So in case of tile #90 in Table 3, the next animation tile is #91 (+1), followed by #92 (+1) and #93 (+1). After tile #93 (-3) the sequence is going back to tile #90. The animation speed is expressed in TimeCount, which is the number of ticks before the next tile is displayed.

index	tile animation	tile animation speed
0	0	0
1	0	0
...
57	1	32
58	-1	24
...
90	1	8
91	1	8
92	1	8
93	-3	8
...

Table 3: Background tile animation.

0.3.3 Foreground tile information

The foreground tiles contain some additional information tables. Beside tile animation (tile mask animation and tile mask animation speed, similar like background tiles) it also contains clipping and 'inside' tile information.

The clipping tables contains how Commander Keen is clipped against foreground tiles. 'Inside' tile information is used to climb on a pole and illustrate Commander Keen is going through a floor opening ('inside' the tile). In section ?? both the clipping and 'inside' logic is further explained.

index	clip north	clip east	clip south	clip west	inside tile
...
238	0	1	5	0	0
239	0	0	0	0	0
240	0	0	5	0	0
241	0	0	0	0	128
242	1	1	1	1	128
243	1	0	1	0	0
244	0	0	2	0	0
...

Table 4: Foreground tile clipping and 'inside' tile information.

The size of each tile information block is defined by the amount of tile-16 and mask tile-16 data items in the IGRAB tool.

```
//
// tile info defines, as bytes after tinf the table starts
//

#define SPEED          502
#define ANIM           (SPEED+NUMTILE16)

#define NORTHWALL      (ANIM+NUMTILE16)
#define EASTWALL       (NORTHWALL+NUMTILE16M)
#define SOUTHWALL      (EASTWALL+NUMTILE16M)
#define WESTWALL       (SOUTHWALL+NUMTILE16M)
#define MANIM          (WESTWALL+NUMTILE16M)
#define INTILE         (MANIM+NUMTILE16M)
#define MSPEED         (INTILE+NUMTILE16M)

//=====

typedef struct
{
    long    planestart[3];
    unsigned planelength[3];
    unsigned width,height;
    char    name[16];
} maptype;
```

0.3.4 Map file structure

The structure of `KDREAMS.MAP` is explained in Figure 11. For each map there is a small header containing the width, height and name of the map as well as a reference pointer to each of the three planes. Each plane exists out of a map of tile numbers for foreground, background and info.

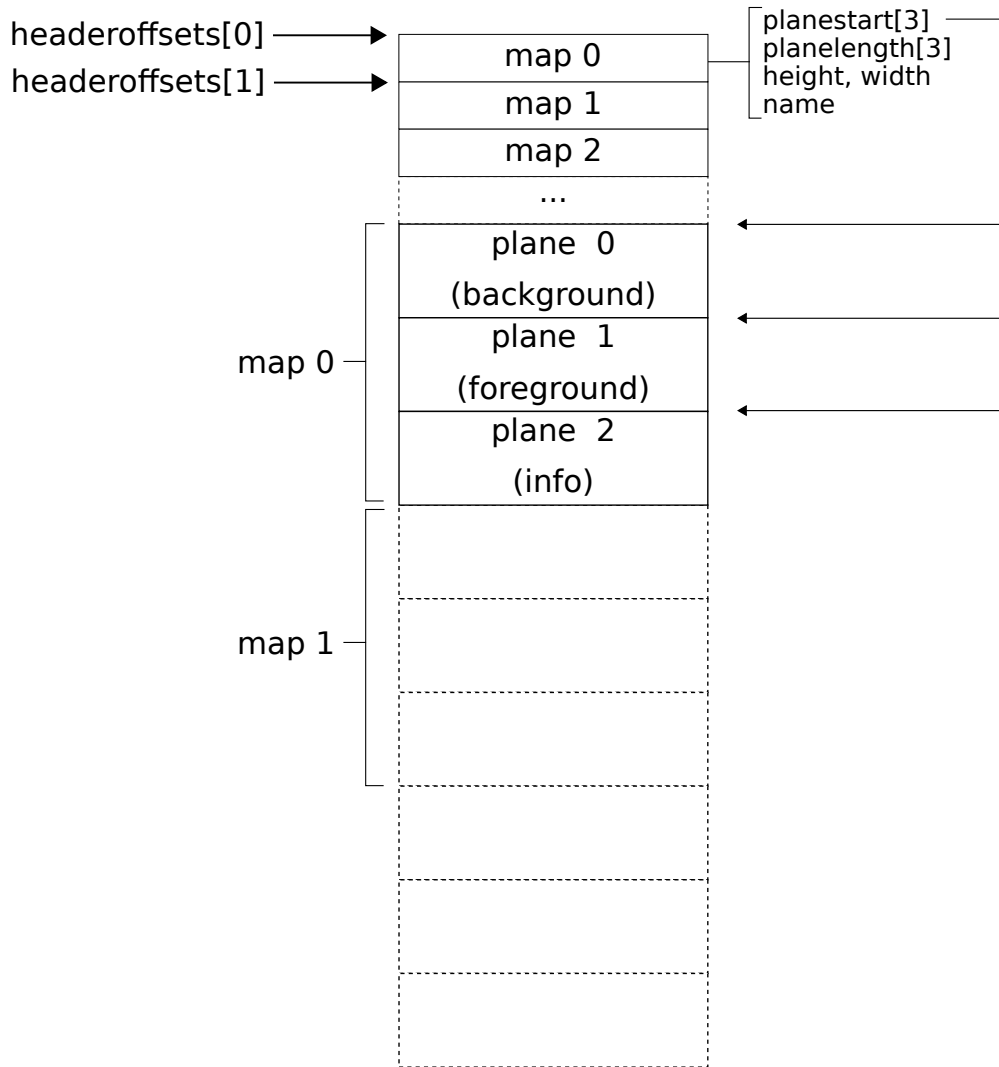


Figure 11: File structure of KDREAMS.MAP file.

0.4 Audio

