0.1 Programming

Development was done with Borland C++ 3.1 (but the language used was C). 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]. There was no need to enter command-line mode however. The IDE allowed to create a project, build, run and debug. The software came with two thick manuals, explaining everything regarding the IDE and programming in C++.

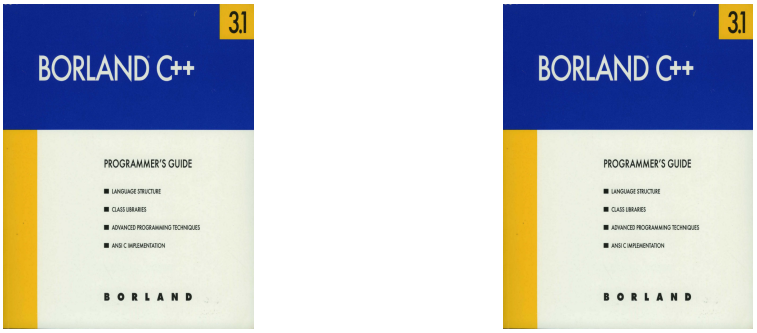
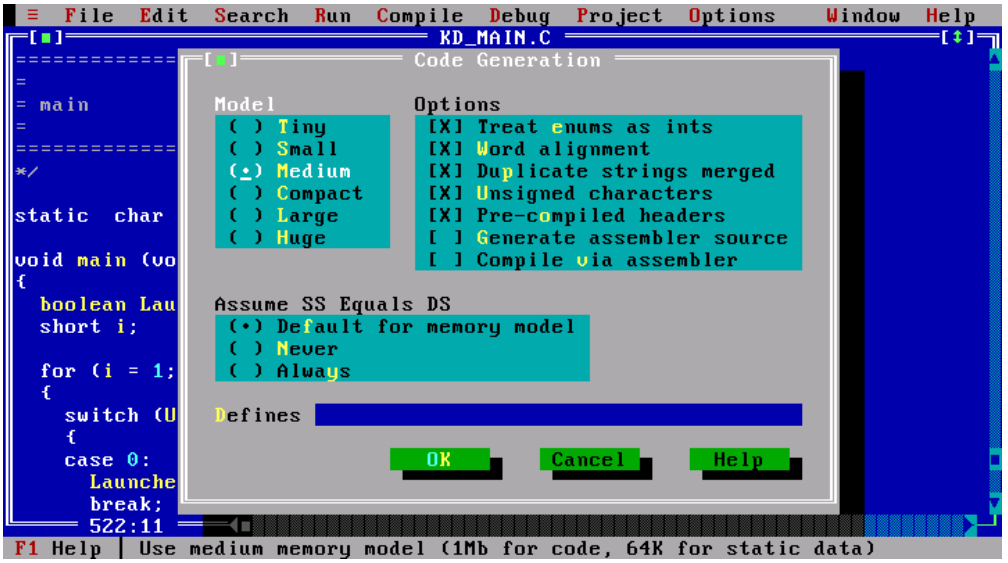


Figure 1: Borland C++ 3.1 User guide (238 pages) and Programmer guide (483 pages).

[1] Source: Borland C++ 3.1 User Guide.



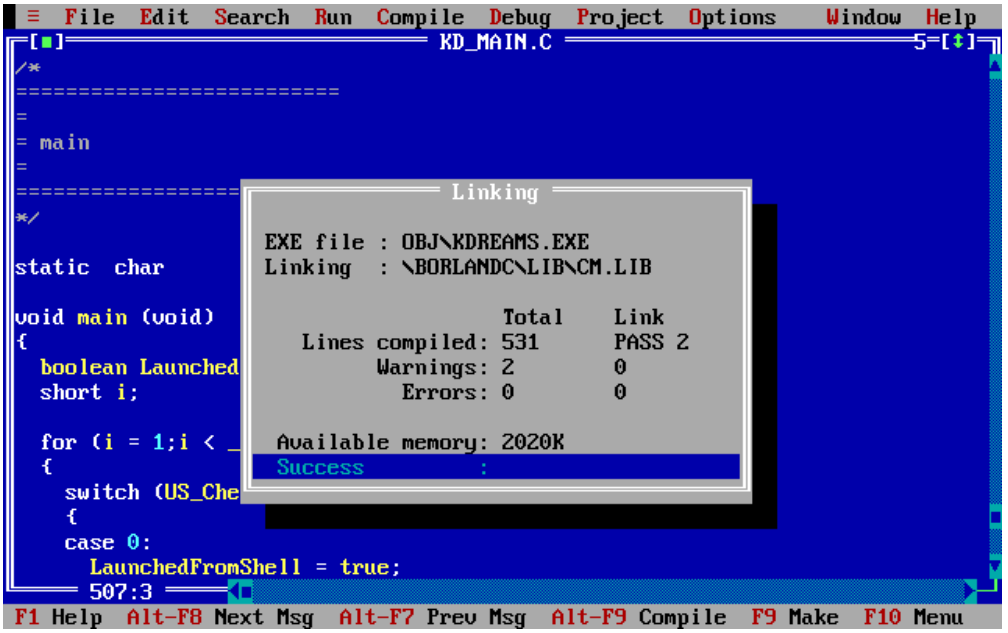


Figure 2: Selecting memory model and compiling Keen Dreams with Borland C++ 3.1

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 ILBM[2] files (Deluxe Paint proprietary format). All assets were hand drawn with a mouse.

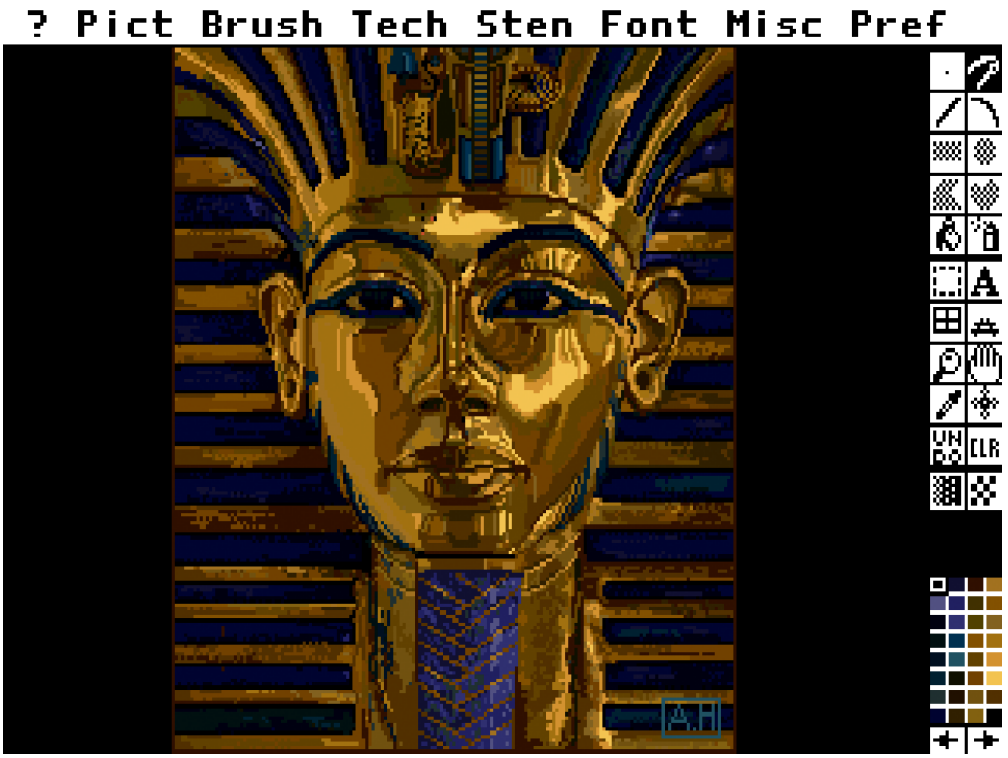


Figure 3: Deluxe Paint was used to draw all assets in the game.

0.2.1 Tile introduction

Before diving into the details of game assets, let's first explore the basic principles behind platform games. Each level, or map, in a platform game is composed of "tiles". In Commander Keen, there are both background and foreground tiles. A background tile, or just "tile", is an image that measures 16x16 pixels. Each tile occupies 128 bytes (2 x 16 x 4 planes) of storage space in the graphics assets file.

[2] InterLeaved BitMap.

Individual tile images are stored in a planar format, with blue, green, red and intensity bits separated. This arrangement, called "graphic planar", stores complete planes sequentially, with each plane containing data for the entire tile.

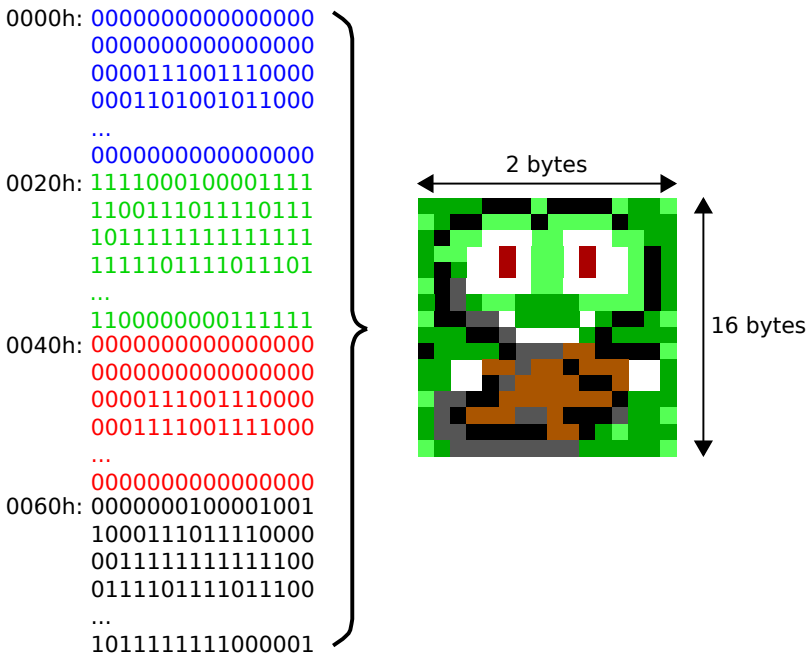


Figure 4: Graphic Planar data storage.

Foreground tiles, or "masked tiles", are similar to normal tiles but contain five planes instead of four. The extra plane stores the mask, and the order of planes is mask, blue, green, red, intensity. Consequently, a single masked tile requires 160 bytes (128 + 32) of storage. A mask bit of '0' means the background tile color is erased and replaced by the foreground tile color, while a mask bit of '1' blends the background color with the foreground color. If the foreground color is '0', the background color remains visible.

By combining tiles on the screen, a map is created. These maps define the entire game world in terms of background and foreground tiles. Maps also contain a list of all actors and their starting positions within the world. Essentially, everything the player encounters while progressing through the levels is specified in a map.

0.2.2 Assets Workflow

After the graphic assets were generated, a tool (IGRAB) packed all ILBM files into a compressed data asset file (`EGA`-file) and generated a `HEAD` table, `DICT` file (`KDR`-files[3]), and a C header file containing asset IDs. The engine references an asset directly using these IDs.

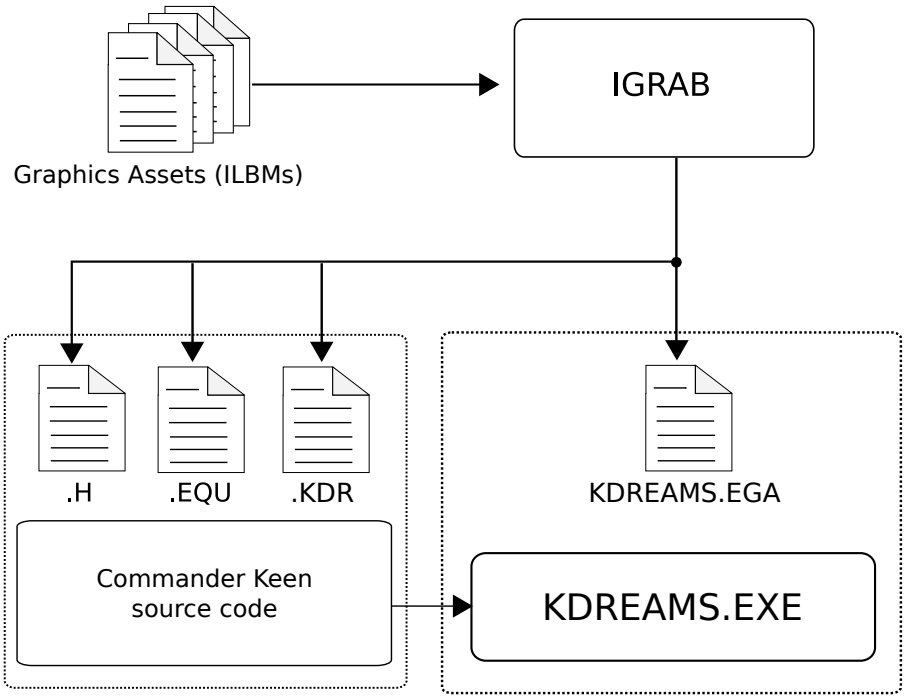


Figure 5: Asset creation pipeline for graphics items

In the engine's code, asset usage is hardcoded via an enum. This enum serves as an offset into the `HEAD` table, which then provides an offset within the data asset file. With this indirection layer, assets could be regenerated and reordered at will with no modification in the source code.

Trivia : The `HEAD` and `DICT` files in the source code must match the data asset file from the shareware version of *Keen Dreams*. However, the latest release of the source code (v1.93) does not match with shareware version v1.13. To ensure that the `HEAD`, `DICT`, and data asset file are compatible, you will need to retrieve a specific git commit, which will be explained in the next chapter.

[3]both `KDR`-files are located in the `static` folder of the source code.

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


#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 CURSORARROWSPR         71
#define KEENSTANDRSPR          72
#define KEENRUNR1SPR           73
#define KEENRUNR2SPR           74
#define KEENRUNR3SPR           75
#define KEENRUNR4SPR           76
...

//
// Data LUMPs
//
#define CONTROLS_LUMP_START         4
#define CONTROLS_LUMP_END          68
#define KEEN_LUMP_START            72
#define KEEN_LUMP_END             212
#define WORLDKEEN_LUMP_START      213
#define WORLDKEEN_LUMP_END        240
#define BROCCOLASH_LUMP_START     241
#define BROCCOLASH_LUMP_END       256
#define TOMATO_LUMP_START         257
#define TOMATO_LUMP_END           260
...
```

0.2.3 Assets file structure

Figure 6 illustrates the structure of the `KDREAMS.EGA` asset file. The first section contains data tables for pictures and sprites, followed by the font, and all sprite and tile graphs.

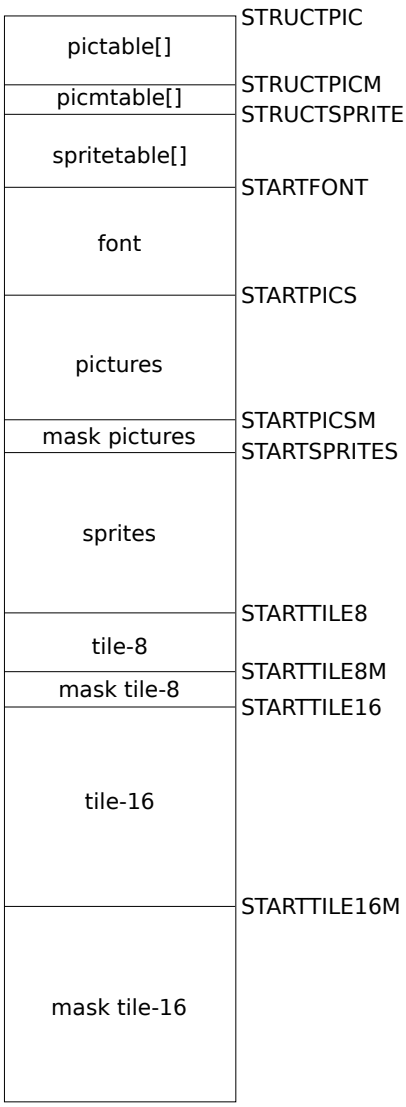


Figure 6: File structure of `KDREAMS.EGA` archive file.

Both the `pictable[]` and `picmtable[]` contain the width and height for each (masked) picture in the asset file.

picture index	width (bytes)	height (bytes)
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

The `spritetable[]` includes not only width and height but also information on the sprite's center, hitbox, and number of bit shifts (explained in Section **??** on page **??**).

```
typedef struct
{
  int width,
  height,
  orgx,orgy,
  xl,yl,xh,yh,
  shifts;
} spritetabletype;
```

All sprite placement occurs from the origin, which is offset by `(orgx, orgy)` from the sprite's top-left corner. The parameters `(xl, xh, yl, yh)` define the sprite's hitbox, used for collision detection. Sprites have an additional layer to indicate transparency, similar to masked tiles.

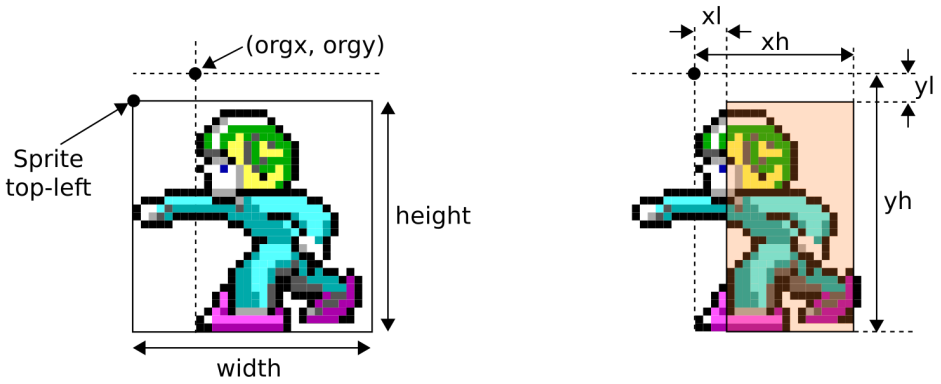


Figure 7: Sprite dimensions, origin and hitbox.

The font segment contains a table that stores the height and the width of the font, along with a reference to where the character data is located in the archive file.

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

Figure 8: Font asset data.

The remainder of the archive file holds all graphic assets, including pictures, sprites, and tiles. Each asset contains four planes, aligned with the EGA architecture. All masked tiles and sprites also include an additional mask plane.

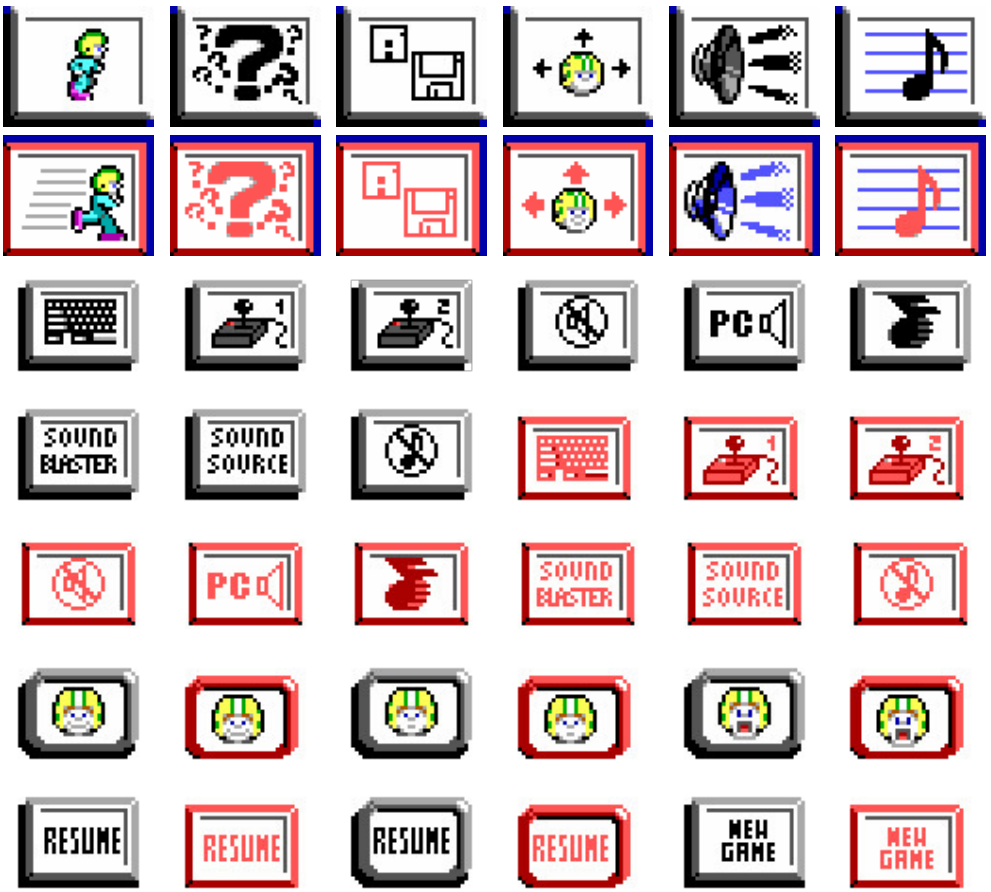


Figure 9: Picture assets.

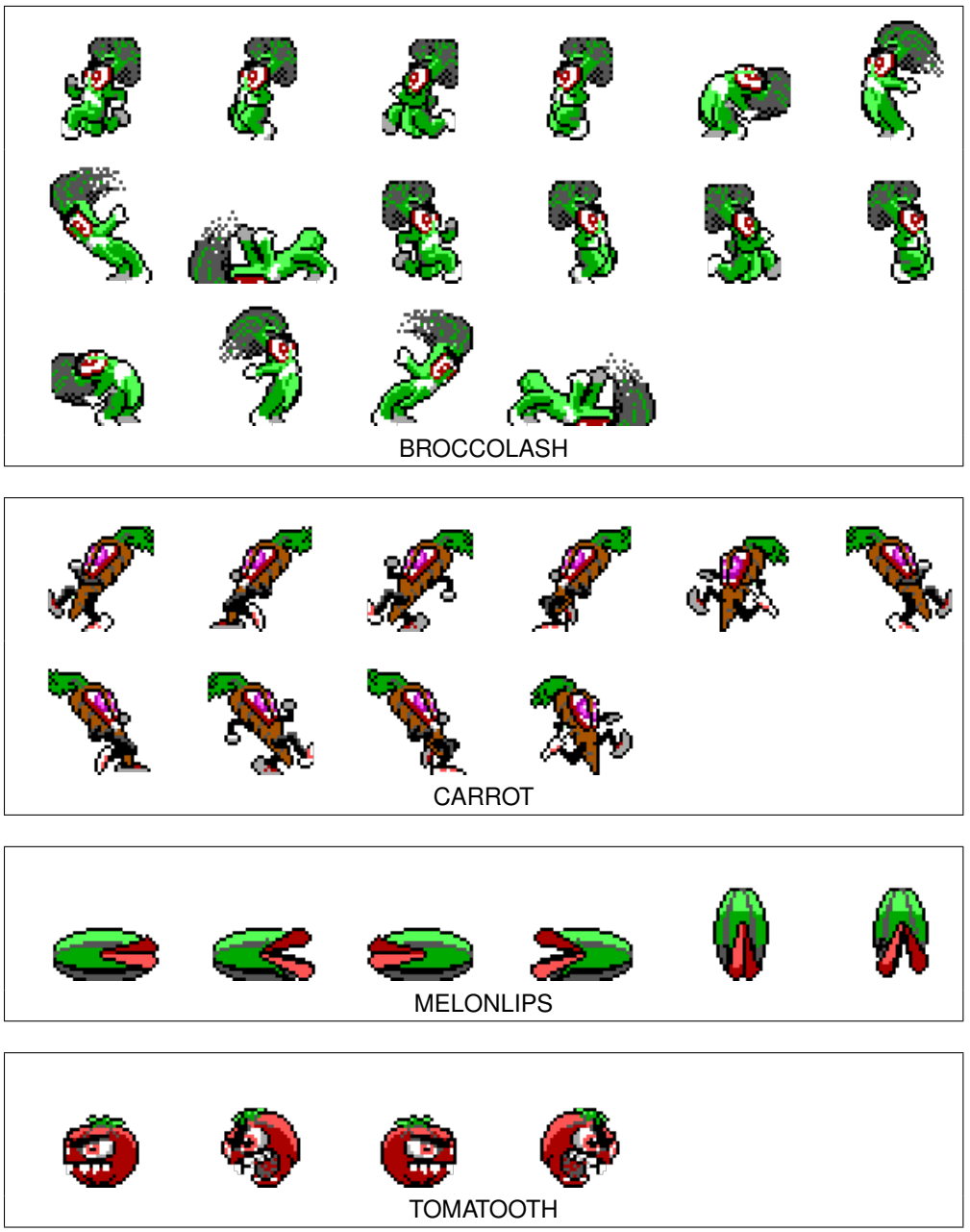


Figure 10: Sprite assets.

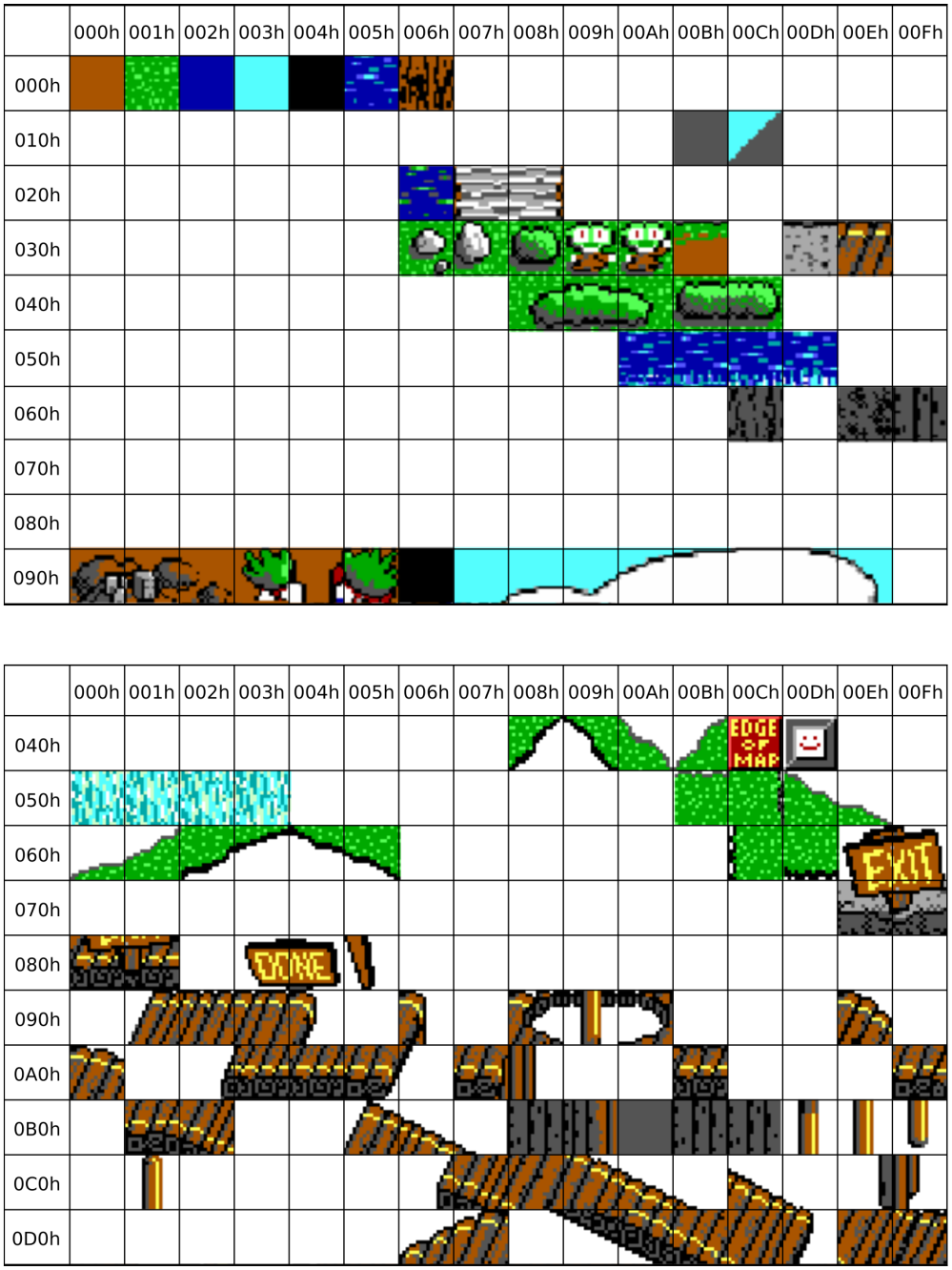
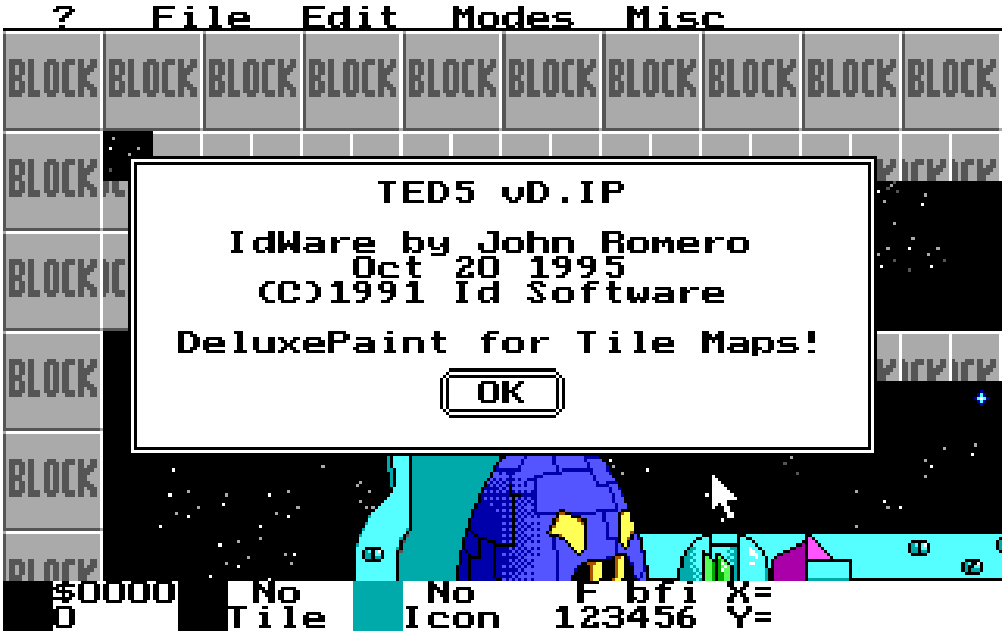


Figure 11: Background (Tile-16) and foreground (masked Tile-16) assets.

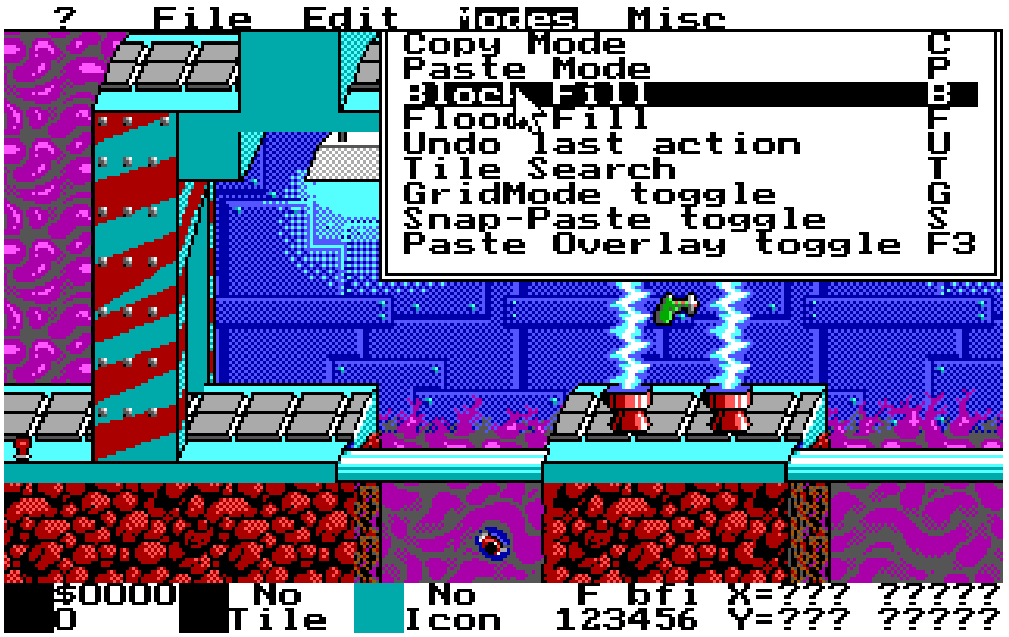
0.3 Maps

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 later used for creating maps for both side-scrolling games and top-down games like *Wolfenstein 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 5 on page 5). This way, tile IDs are directly encoded in the map.



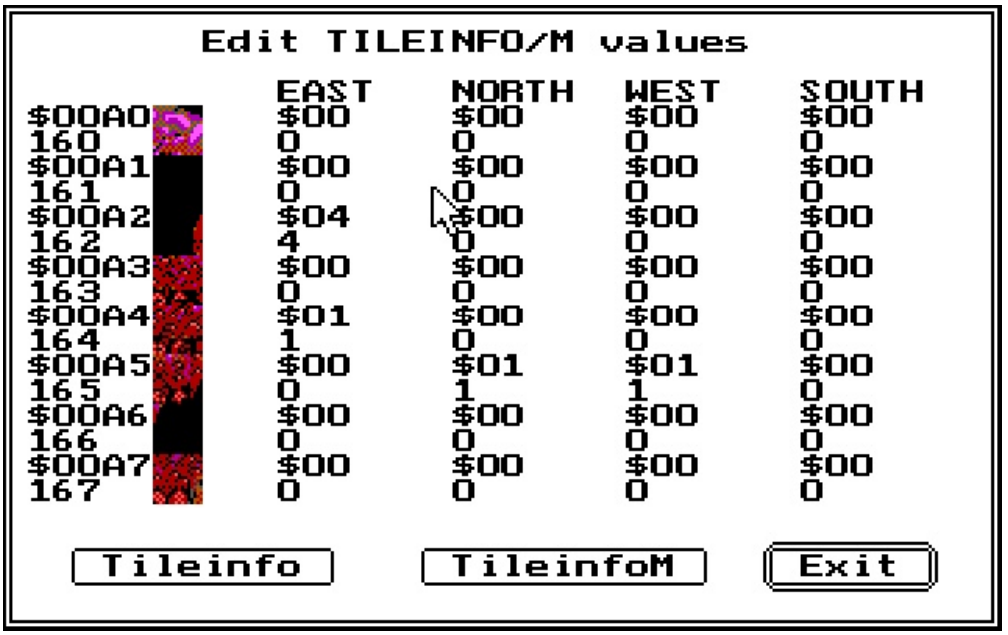
Trivia : The suffix, "vD.IP", was put in by the Rise of the Triad team in 1994. It stood for "Developers of Incredible Power".



TED5 allows the placement of tiles across multiple layers, referred to as "planes". In *Commander Keen*, there are three types of planes:

- Background plane tiles.
- Foreground plane tiles, which act as a mask over the background plane.
- Information plane tiles, which contain actor locations and special areas.

A level is created by placing tiles on each of these three layers. Foreground and background tiles can be enhanced with additional properties ("Tile info"), which controls interactions such as clipping, "deadly" tiles, and animated tiles.



Similar to IGRAB, TED5 compresses all levels into a `MAP` archive and generates corresponding `HEAD` and `DICT` files.

0.3.1 Map header structure

The map header structure is embedded in the engine code and contains a header offset and size, which refer to the location and size within the `KDREAMS.MAP` archive file.

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

The game supports a maximum of 100 maps. The `tileinfo[]` array contains properties data of each tile.

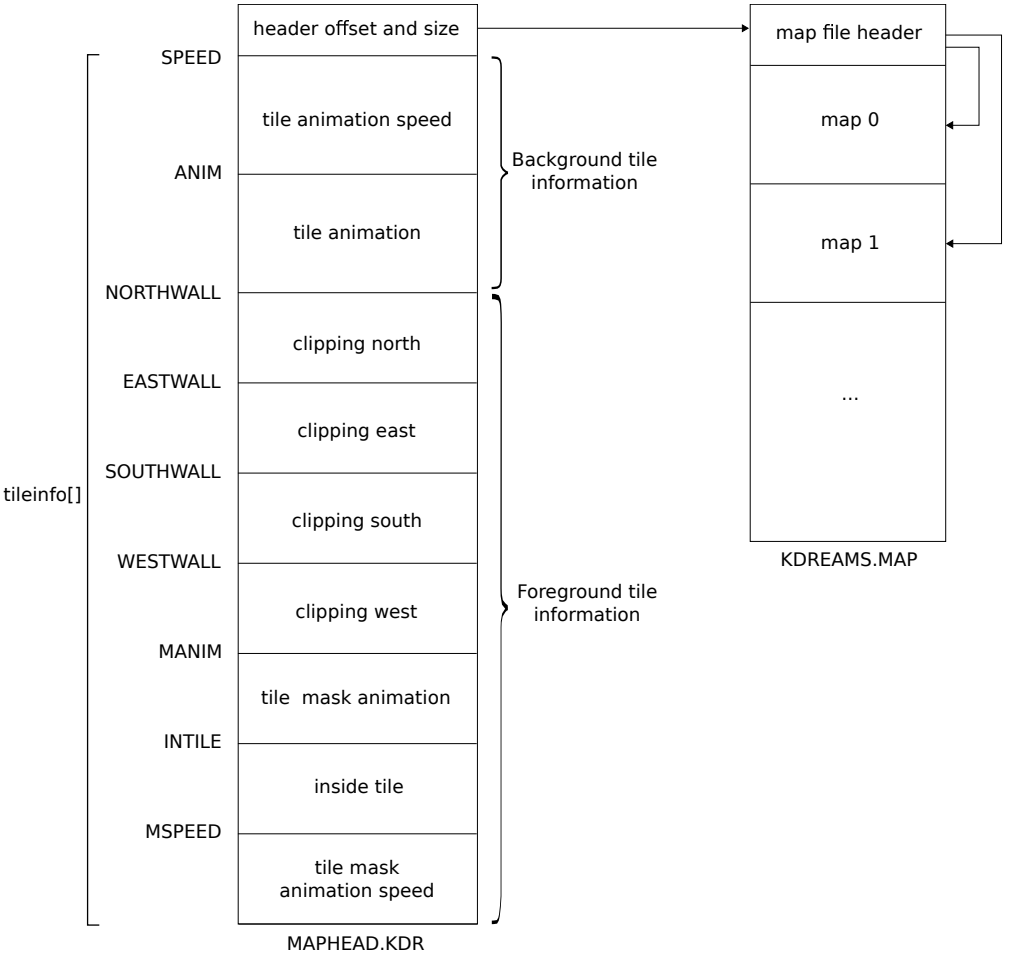


Figure 12: Structure of `MAPHEAD.KDR` header file.

For background tile animations, two information tables are defined: *tile animation* and *tile animation speed*. The tile animation specifies the next tile in the animation sequence, relative to the current tile. For example, in Table 1, tile #90 animates to tile #91 (+1), followed by #92 (+1), and #93 (+1). After tile #93, the sequence returns to tile #90 (-3). The animation speed is expressed in number of ticks before the next tile is displayed.

tile 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 1: Background tile animation.

Foreground tiles also contain clipping information and a column called `intile`. The `intile` column tells what the tile "does" to the player, like kill, climb, points, etc. Values between 128-255 are used for foreground tiles only. The `intile` column is customized for each version of *Commander Keen*. In *Keen Dreams* it is used for e.g. climbing poles.

tile index	clip north	clip east	clip south	clip west	intile
...	...	...	...	...	...
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 2: Foreground tile clipping and 'intile' tile information.

0.3.2 Map archive structure

The structure of the KDREAMS.MAP archive is illustrated in Figure 13. Each map contains a small header that includes the width, height, and name of the map, as well as a reference pointer to each of the three planes. Each plane consists of a map of tile numbers representing the background, foreground, and information planes.

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

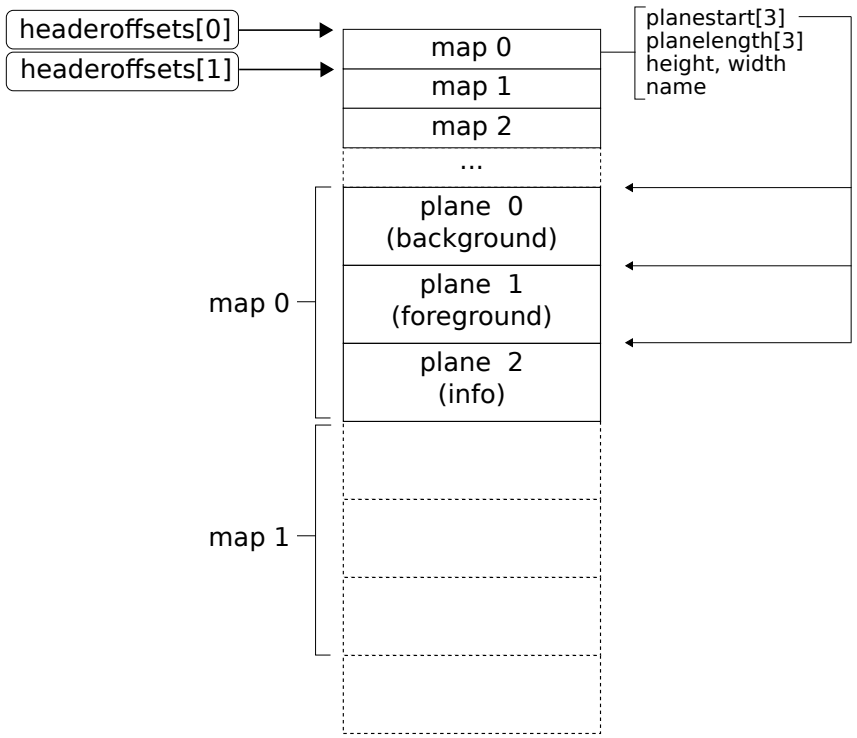


Figure 13: Structure of KDREAMS.MAP file.

0.4 Audio

The original Commander Keen Trilogy did only support the default PC Speaker. With the introduction of Commander Keen in Keen Dreams the team decided to support sound cards as well.

Trivia : Apogee, the publisher of Ideas from the Deep, didn't publish any game with AdLib support until *Dark Ages* in 1991. And even then it still had pc speaker music.

id Software intended for Keen Dreams to have music and digital effects support for the SoundBlaster & Sound Source devices. In fact, Bobby Prince composed the song "You've Got to Eat Your Vegetables!!" for the game's introduction. However, Softdisk Publishing wanted Keen Dreams to fit on a single 360K floppy disk, and in order to do this, id Software had to scrap the game's music at the last minute[4]. The team didn't even have time to remove the music setup menu.

Figure 14: Setup music menu in Keen Dreams, although there is no music in the game.

[4]https://vimeo.com/4022128, at 2:00-4:55.

As a consequence, only two sets of each audio effect are shipped with the game:

1. For PC Speaker
2. For AdLib

Game music was not introduced until Commander Keen IV.

Trivia : The song "You've Got to Eat Your Vegetables!!", written for *Keen Dreams*, would finally make its debut in Commander Keen IV: Secret of the Oracle.

All sound effects are done by Robert Prince. Sound effects are created using Cakewalk and inhouse MUSE tool, which is extensively described in *Wolfenstein 3D Blackbook*[5] Just like described before, the MUSE tool packed all sound effects together in a compressed `SOUND` archive and generated a `HEAD`, `DICT` file and a C header file with asset IDs.

0.5 Distribution

On December 14th, 1990 the first episode was released via Apogee. Episodes 1-5 are all published by Apogee Software. The game engine and first episode were given for free and encourages to be copied and distributed to a maximum number of people. To receive the other episodes, each player had to pay $30 (for Episode 1-3) to *ideas from the Deep*.

Commander Keen in Keen Dreams was published as a retail title by Softdisk, as part of a settlement for using Softdisk resources to make their own game[6].

[5] See Wolfenstein 3D Blackbook, section 3.6 on page 94.
[6] The settlement with Softdisk is explained in Appendix **??**

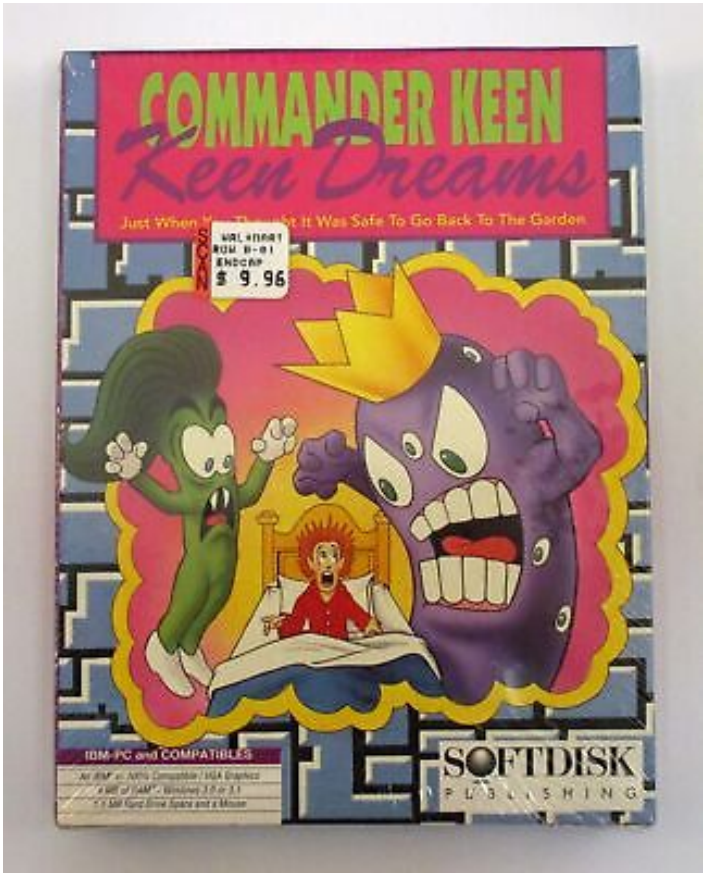


Figure 15: Retail version of Commander Keen in Keen Dreams by Softdisk.

In 1990, the Internet was still in its infancy and the best medium was the 3½-inch floppy disk. The game shipped as follows:

The files can be divided in seven parts:

- KDREAMS.EXE: Game engine.
- KDREAMS.EGA: Contains all the assets (sprites, tiles) needed during the game.
- KDREAMS.AUD: Sound effect files.
- KDREAMS.MAP: Contains all levels layouts.
- KDREAMS.CMP: Introduction picture of the game, which is a compressed LBM image file.

- Softdisk Help Library files, which are text screens, shown when starting the game
  - START.EXE: Decompress and show user guide, and then start the game.
  - LOADSCN.EXE: Shows the closing screen when quitting the game. Decompresses the ENDSCN.SCN chunk in LAST.SHL
  - *.SHL: Text user guide assets.
- Several *.TXT files which can be read in DOS by typing the corresponding *.BAT file.

```
Directory of C:\KDREAMS\.
.            <DIR>           16-05-2023 21:04
..           <DIR>           16-05-2023 20:52
BKGND    SHL               285 16-05-2023 20:59
FILE_ID  DIZ               508 16-05-2023 20:59
HELP     BAT                34 16-05-2023 20:59
HELPINFO TXT             1,038 16-05-2023 20:59
INSTRUCT SHL             2,763 16-05-2023 20:59
KDREAMS  AUD             3,498 16-05-2023 20:59
KDREAMS  CFG               656 16-05-2023 21:00
KDREAMS  CMP            14,189 16-05-2023 20:59
KDREAMS  EGA           213,045 16-05-2023 20:59
KDREAMS  EXE           354,691 04-05-2023 19:40
KDREAMS  MAP            65,673 16-05-2023 20:59
LAST     SHL             1,634 16-05-2023 20:59
LICENSE  DOC             8,347 16-05-2023 20:59
LOADSCN  EXE             9,959 16-05-2023 20:59
MENU     SHL               447 16-05-2023 20:59
NAME     SHL                21 16-05-2023 20:59
ORDER    SHL             1,407 16-05-2023 20:59
PRODUCTS SHL             4,629 16-05-2023 20:59
QUICK    SHL             3,211 16-05-2023 20:59
README   TXT             1,714 16-05-2023 20:59
START    EXE            17,446 16-05-2023 20:59
VENDOR   BAT                32 16-05-2023 20:59
VENDOR   DOC            11,593 16-05-2023 20:59
VENDOR   TXT               810 16-05-2023 20:59
   24 File(s)          717,630 Bytes.
    2 Dir(s)       262,111,744 Bytes free.

C:\KDREAMS>
```

Figure 16: All Keen Dreams files as they appear in DOS command prompt.