# Hell: Been There, Done That, Love It!

*Part I*

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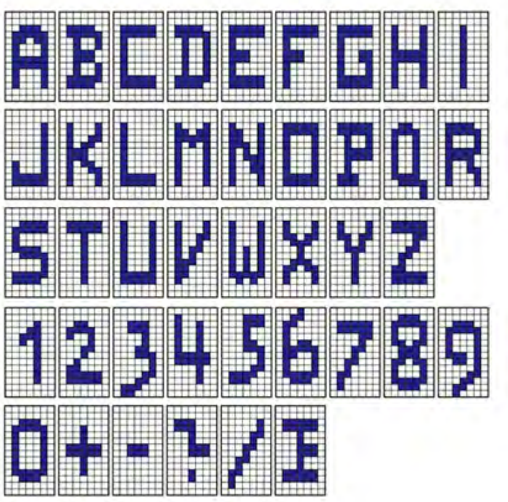


The 14x7 Hell Bitmap Font

Digital fonts date back to the advent of the PC in the early 1980s, or to the monochrome CRT monitors of the 1970s, right? Nope. The first digital typesetting machine was the 1966 *Digiset*. It was the first true revolution in the printed media world since Gutenberg's invention of movable type in the mid-1400s.

OK then, CRT terminals of early computers in the 1950s? Wrong again! The bit-map font goes back to the 1929 patent of German engineer Rudolf Hell (1901-2002)!

He dedicated his professional life to all technologies related to decomposing, processing and recomposing text and images for communication and press media. An avid inventor too, including the video camera tube (1925), fax technology and the aforementioned Digiset. As a pioneer of teleprinting, television, fax, scanner and printing technology, he is revered as "the Edison of the Graphics Industry," "Father of digital word processing," and "Engineer of the Century."

*"Engineer of the Century"*

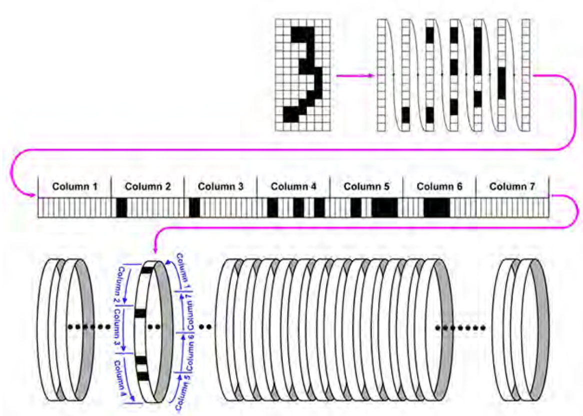
During the 1920s and 30s, teleprinters were rather complex machines (= $$$), and they were primarily used over dedicated subscriber lines (= $$$). Their operation is based on synchronization via start and stop bits, and the printers have to mechanically interpret the received bit patterns–typically a 5-bit Baudot code (ITA2). If the transmission channel (wired or wireless) has noise, fading, or multipath echoes, bits may be distorted. This causes incorrect characters to be printed, or characters to be omitted.

This is where Hell's 1929 invention comes in. He realized the above disadvantages of teleprinters are overcome by simply transmitting a line of text in the form of low-resolution fax. To make this work for keyboard-to-printer communication, he conceived the bitmap font. The font is created by rasterizing each character of the keyboard as a dot matrix with a fixed number of rows and columns. Initially the matrix size was 14x11 pixels, later 12x12, and then settled on 14x7.

For transmission, the matrix of each selected character is scanned, column-by-column. Black pixels are sent as a tone pulse ("mark" in teleprinter parlance), white pixels as "no tone" ("space"). To make this work with a keyboard sender, the rasterized font must somehow be stored. Hell used a mechanical memory. The matrix of each character is decomposed into pixel-columns that are lined up head-to-tail. The resulting pixel string is captured as a notched disk. The complete character set is then a stack of such disks. This is generally referred to as the "character drum."

In some of Hell's machines, the drum is smooth, and the pixels are represented by conductive metal patches. The 14x7 font has 14x7=98 pixels. The original character set counts 41 characters x 98 = 4,118 pixels. Such a 4-kilobit non-volatile ROM weighed about two pounds.

For each disk of the drum, there is a contact that can be actuated by the notches of that ring. The smooth drum uses slip-contacts. All contacts are connected in parallel. The characters to be transmitted are selected by pressing the corresponding key of the




Serialized Font-Columns Are Captured as Disks or Rings

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keyboard. In turn, this enables the contact of the associated disk or ring of the drum. To keep things mechanically very simple, the drum spins continuously. But wait! Transmission of each character must start with the first pixel of the first column, not somewhere in the middle. Indeed! Well, this makes the keyboard mechanism just a little more complicated: a cam on the drum's shaft enables and locks-out the keys, such that they can only be pressed just before the start of the first column.

Yes, this requires a particular typing technique that takes some getting used to. Standard speed for keyboard Hell-transmission is 2.5 characters/sec = 150 chars/min. Hence, the drum turns at 150 rpm. This is actually a quite comfortable typing speed, about 30 wpm. Transmission speed could be doubled (or more) by using a conventional keyboard tape-puncher and a punch-tape reader with a character-drum for conversion to pixel streams in Hell-format.

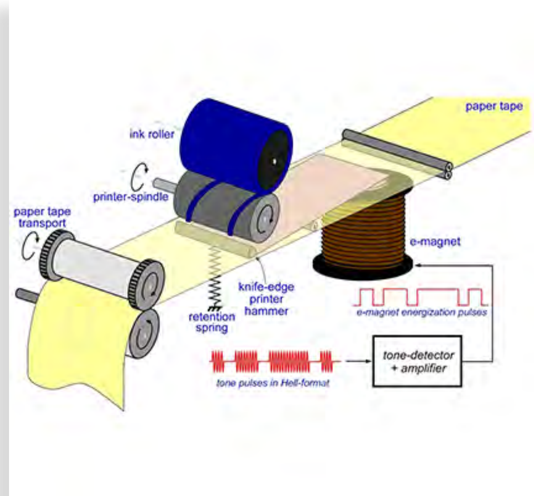
The character-drum sender's output is just a sequence of on-off keying. Like Morse code telegraphy, but just a *little* faster than the average "fist." The on-off signal was used to directly key a CW transmitter, or to key a tone oscillator (original standard: 900 Hz). The tone pulses were then sent via ordinary phone lines (no need for special teleprinter lines), power lines, or radio. All rather conventional.

*"But wait!"*

Now, how do we print the received stream of tone pulses? This is where Rudolf Hell came up with a very simple, clever and elegant solution. Remember that: 1) the characters are transmitted as if scanning the consecutive columns of their bit-map, and 2) the character-drum spins continuously. This is the same as a continuous column-scanning process, where once in a while a character is scanned-in. So the printer should also mimic a continuous scanning motion. Have a look at a simple one-turn spindle from the side. As it turns continuously, the thread is a point that moves with a constant speed, parallel to the axis of rotation. And then starts all over again. Exactly what we need! This method was already used in helix-printers of the 1860s.

Hell Printer Spindle

The two-turn spindle has to turn at 150 chars/min x 7 columns/char x 1 rev/column = 1,050 rpm. The Hell-spindle shown below has another little trick. Look closely: the spindle does not have a single thread that makes two turns. Instead, it has two entwined threads so that each makes only one turn. The two threads are shifted 180° around the circumference of the spindle hub. The printed pattern is exactly the same, but the spindle only has to turn at half the speed: 525 rpm (or 300 x 7 / 2 = 1,050 rpm in a 5 char/sec printer).




*Hellschreiber Printer Concept*

We have to print onto something. Text is written and printed as a line of characters, so let's print onto a paper tape. The spindle has to move relative to the tape. The easiest way to do this is by moving the tape past the spindle at a constant speed. We'll borrow an off-the-shelf solution from 19th century Morse "tickers." The spindle has to print pixel columns across the paper tape, so it has to be installed across that tape, and just above it. A felt roller, impregnated with ink, rests on top of the turning spindle. It keeps the spindle's thread covered with ink.

Finally, we take a fast electromechanical relay (≈1 msec), and place it underneath the paper tape. The relay's armature has a hammer blade at its tip. The blade is aligned with the spindle's shaft. It barely touches the paper tape from below. As soon as, and as long as, the solenoid is energized, the armature pushes the paper tape against the inked spindle. This causes the spindle to print a dot or line segment across the paper tape, thereby reconstructing the characters' bit-map, column by column.

Such a printer is called a *Typenbildfernschreiber* ("System Hell") or *Hellschreiber* for short. Literally, it just means "Hell-system character-image telegraph" and "Hell-printer," after its creator. Contrary to what you may find in several popular publications in the English language, "Hellschreiber" does not mean "Bright(ly) Writer" and is not a pun on Rudolf's last name. Through the mid-1900s, it was customary to attach the name of the inventor to the name of the product or system (at least in Germany). ■

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