the Hellschreiber
a rediscovery

European Amateurs are using a teleprinting system made from World-War II surplus — will it replace RTTY?

The Hellschreiber is a teleprinting machine based on a principle entirely different from that of the RTTY teleprinter. The Hell sytem (named after its inventor, Dr. Rudolf Hell) could have been invented with the requirements of the Radio Amateur in mind, but strangely enough the Hell system has never been fully accepted by the Amateur fraternity. The reason may be that an enormous number of used RTTY machines flooded the market at low prices after World War II.

Hell and RTTY existed simultaneously for a long time for both military and commercial use. However, Hellschreibers have now disappeared, mainly as a result of the introduction of protected RTTY systems with automatic-request and error-correcting circuits. Most hams have probably never heard of the Hell system as a means of communications.

the Hellschreiber

What is the Hellschreiber? In contrast to the RTTY machine, in which received pulses determine the character to be printed, the Hellschreiber uses the transmitted pulses to *directly* write images of characters on paper tape. Thus, Hell writing could be considered a simple form of facsimile, covering seven image lines per character, with seven elements per line.

Not only has this system of printing character images some very important advantages to offer, but the simple way in which the Hell teleprinter works is extraordinarily elegant. The thread of a fast-turning worm shaft wipes, with high speed, transversely across a slowly moving paper tape. This worm thread is wet with printing ink. Every time the paper is

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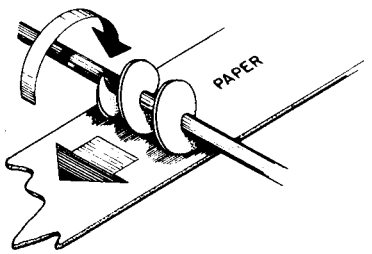
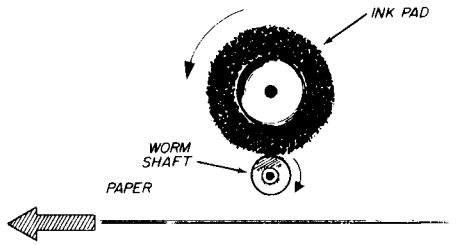
How The Hellschreiber Works

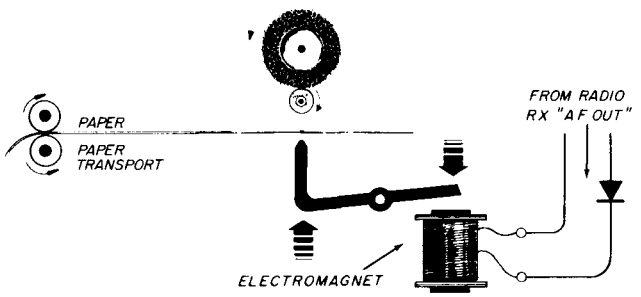
A. Imagine a fast turning worm shaft above a relatively slow-moving paper tape:



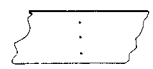
B. The thread on this worm shaft is kept wet with printing ink:



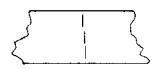
C. Under the paper is a mechanism that taps the paper against the worm shaft by means of an electromagnet:



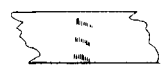
D. What is printed on the paper depends upon the rhythm and the length of time the electromagnet is actuated. For example, if the paper is just tapped, one gets:



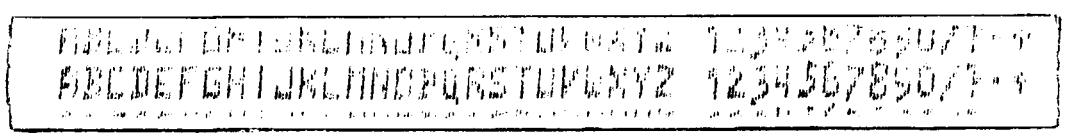
What you see are the little dots where the paper touched the fast-turning worm shaft. If the thread sweeps fast over the paper, and if the electromagnet pushes a bit longer, a little line is printed:



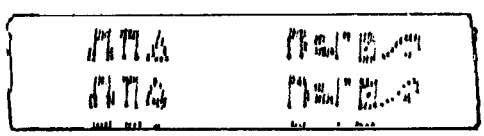
If the tape is tapped in rhythm with the revolutions of the worm shaft, a sequence of little dots is printed:



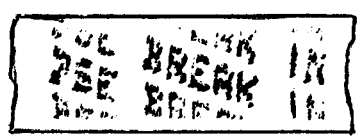
E. Thus, all sorts of simple images can be written; for instance, all the characters of the alphabet:



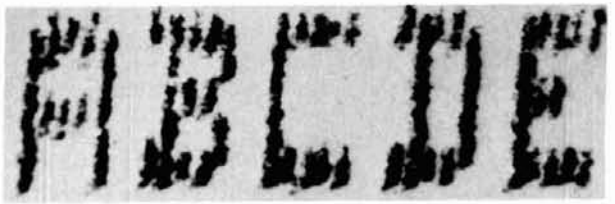
F. Or, if necessary, the characters of anybody else's alphabet, such as Greek, Arabic, or Chinese:



G. What happens if the worm-shaft speed is not quite correct? Nothing serious; the lines of the Hell text threaten to run off the paper tape:



This provides a simple method for determining the correct speed. If, for example, the lines show a tendency to drop, the motor speed must be increased until the lines run straight again. But whatever happens, the text remains legible.



Hell writing. This enlargement shows how each character takes the space of seven image lines. As a result of the relatively slow-moving tape, the characters hang slightly over.

tapped against the turning worm shaft, little lines are formed across the paper tape. Several of these lines together form a character.

The Hellschreiber of the World War II Wehrmacht type we're using runs somewhat slower than the RTTY machine: 2 ½ characters per second. Nevertheless, a respectable 25 words per minute is achieved. This CW terminology is not misplaced, as Hell and CW have much in common. In fact, given a certain bandwidth, the reliability of Hell communications approaches that of CW.

QRM proof?

During World War II the Hellschreiber proved its reliability. Users recognized that a Hellschreiber could be the only link between an isolated military unit and its headquarters. When all other means of communications failed, often the Hellschreiber managed to get the message through, even when only barbed wire and an earth connection were available as a signal path.

Amateur applications

Our Hell QSOs occur on 80 meters (over here, the official RTTY segment is between 3575-3625 kHz). It's difficult to think of a better part of the radio spectrum for putting the Hell system to the test because of the high QRM level in this portion of the band.

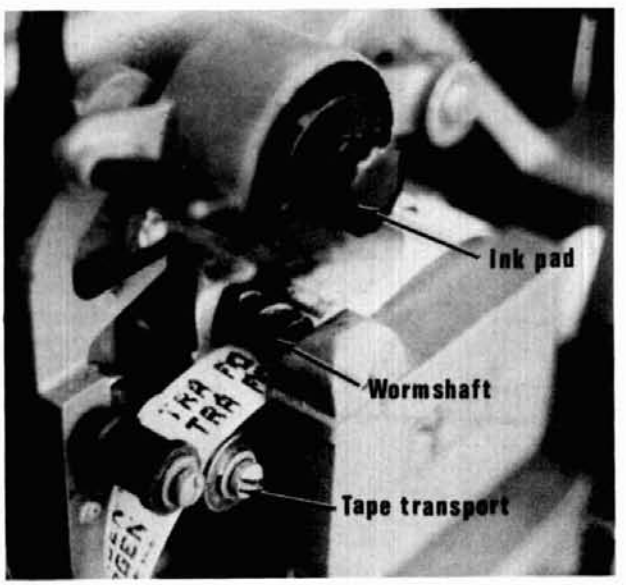
In this context I'd like to mention an interesting side effect. Our modest *prrt, prrt, prrt* Hell signals apparently tend to provoke fury among some hams, who seem to be convinced that the unusual sounds are caused by commercial stations. This turns our little Hell channel into the center of zero-beating and QRZ-blaring stations. This intentional interference does, however, provide us with an invaluable opportunity to test the communications system under highly adverse conditions and is, therefore, to some extent, not unwelcome.

Of course, the interfering transmitter determined to cause serious trouble by tuning carefully zero-beat with our Hell signals may eventually manage to temporarily destroy our communications, provided, of course, that the signal is stronger than ours. By maneuvering with tuning, bandwidth, and threshold level it's possible to get through. We might lose contact for a moment; however, contact is restored through the foggy QRM clouds on our printouts, and we pick up the text as soon as the characters become distinguishable again. This sort of working on the threshold is possible with Hell: The text, even under the worst conditions, is never subject to errors of a substitution-of-characters type. The character may, however, be difficult to read because of mutilation.

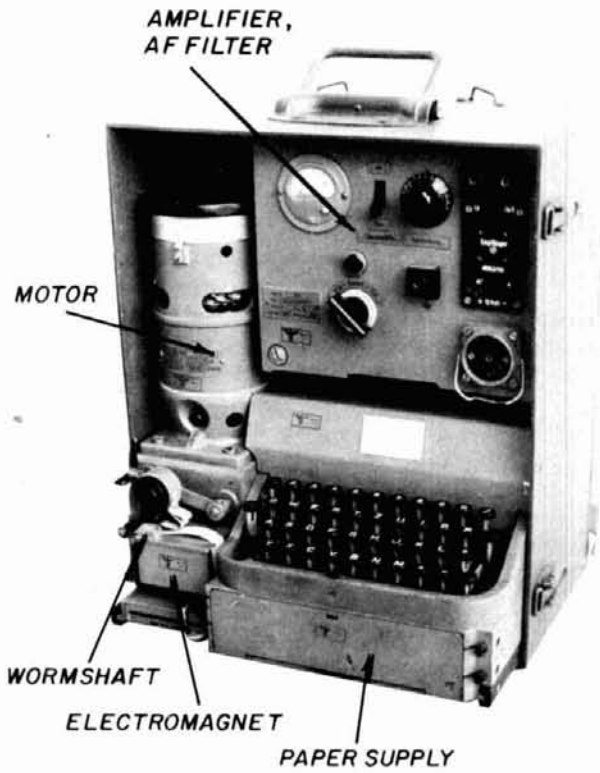
Hell *versus* RTTY

Under certain circumstances the communications reliability of Hell can be even better than that of CW. The received Hell signal is printed in its original form. At the moment of reception no decision has to be made such as, "Did I hear correctly?" Thus wrong decisions are avoided. The Hell printer enables the reader to decide later on, at his ease, what was actually sent by the distant station.

Some examples are shown of radio Hell-communications in which the printer obviously has great trouble in keeping the text intelligible because of a high noise level or heavy QRM. The examples contain considerably more information than can be deciphered on first sight. If you really take the trouble to read the text, you immediately realize to what the Hellschreiber owes its superior qualities: it calls in the services of a computer, *i.e.*, our human ability to recognize pictures in a chaos of little specks and lines.



Printing mechanism of the Hellschreiber. The ink pad (felt roll) has been lifted to show the worm shaft. The paper tape is slowly moved by the transport capstan. The electromagnet (not visible) taps the paper tape from below against the fast turning worm shaft.



The Feldfernschreiber. Hellschreiber of the German Wehrmacht (1938) as used on a large scale during World War II. It is with this type of machine that such remarkable results were obtained on the Amateur bands.

The Hell system is less sensitive to interference than RTTY because the Hellschreiber prints the interfering clutter as well as the desired text. This may sound paradoxical, but it becomes understandable if you realize that a teletype printer must translate its received signal into a character before it can decide which key must be pressed. It cannot count upon the services of a "computer." Thus, with RTTY, a single interfering rf spike may result in a wrong decision, turning out a character that has no resemblance whatever to the actual character transmitted. The unprotected teletype character can't warn the reader that it is in error; it can't even indicate that a certain amount of doubt existed during the moment of its selection!

The Hellschreiber, on the other hand, requires no such decisions. The machine just prints, complete with all the received interference. But (and this is the important distinction) although the interference may give the image of the characters an untidy appearance, the Hellschreiber is not capable of changing it. In other words, the Hellschreiber simply leaves to the boss the problem of sorting out the text from the rubbish and doesn't try to disguise the difficult reception conditions.

This is the explanation for the rather amazing fact that you may read Hell text from signals that are only barely audible through an overwhelming amount of QRM; indeed, that it's even possible to decipher Hell signals received *under* the noise level. No wonder we're highly enthusiastic about this fantastic system.

experience with Hell

For three years, almost every week, our little international Hell group (five Dutch, one German, one French, one British) make our regular Hell QSO of an hour or so, using one of the most crowded portions of the 80- and 40-meter bands. Our Hellschreibers are ex-Wehrmacht printers, some of them 40 years old and in fact valuable museum pieces.

As with CW and RTTY, the modest bandwidth requirements of Hell are a great advantage. They are determined by the shortest pulses contained in the signal, being 8.16 ms. This produces a speed of 122.5 baud, requiring a minimum bandwidth of 61 Hz. Even in an overcrowded band it's possible, with a sharp CW filter, to remove most of the QRM or, in case of telephony interference, to keep the bulk of the speech sidebands out of the picture.

Watching a Hellschreiber printer in operation, you can't help being impressed by its imperturbability: While the radio receiver produces the most frightening sort of QRM noises, the machine swallows it all. Quietly, apparently hardly disturbed by it all, it goes on spelling out its characters. Often the QRM is so bad that you need a Hellschreiber to establish that there's still a Hell signal in the air.

Transmitter section of the original Hellschreiber. The coded drum turns one revolution per character. Every time a key is pressed, one turn of the drum produces a series of pulses by the contact with one series of lamellas.

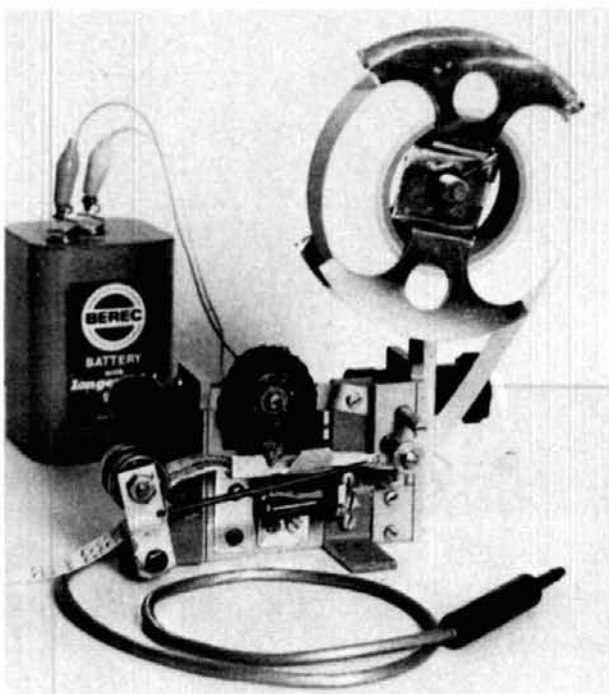
Between transmitter and receiver a certain amount of synchronization is needed, which requires a means of regulating receiver-motor speed. Not that this synchronization is very critical; contrary to what you might expect from a synchronous image-line system, the good old Hell machine is not so easily disturbed by the wrong motor speed. The only thing that might happen is that the written text might drop over the edge of the paper. The text remains legible, however, and, while continuing to read the text, you correct the motor speed by hand until the text prints correctly along the plane of the paper strip. It is this reliable, almost undisturbable, character of the Hellschreiber that makes it such a fine instrument for Amateur Radio communications.

The CW-like disposition of Hell signals permits break-in. Spaces don't produce signals (the tape just runs without printing), so it's possible to cut in between words of the distant station's text. You can even keep watch on the QRM situation between transmitted words.

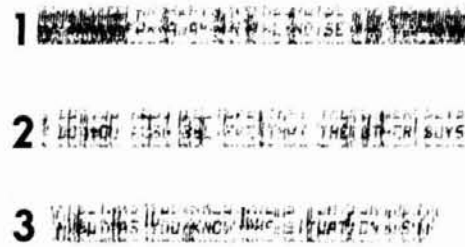
Hell is economical with transmitted energy. With considerable fewer marks than spaces in its signals, and without start and stop pulses, the average output is about 25 per cent of the maximum output. This low duty cycle permits increased transmitting power.

quo vadis?

It's possible to make a Hellschreiber yourself — something that can't be said for any ordinary teleprinter. The actual printer consists of only a simple mechanism. This is another advantage of the Hellschreiber. The receiving part is easy to build and may be a good starting point. After gaining some experience with receiving Hell QSOs, you can decide whether it is worthwhile building a Hell transmitter.



Home made Hellschreiber.



Reception of Hell signals under extreme conditions.

1. Very weak signal, drowning in the noise. On first sight it's unusable; however, our ability to recognize pictures in a chaos of little specks permits us to read the text into the noise.

2. Interference by a strong SSB telephony signal on the same channel. (Text: "Do you also believe that the other boys are there".)

3. Hell signal exactly zero-beat with equally strong 14-wpm CW signal. (Text: "but as you know the situation is".)

We have already built some mechanical Hell printers. Of course, electronics have advanced considerably since 1938, and the dimensions of our modern Hellschreiber can no longer be compared with those of that bulky German design. We now have small electric motors with solid-state speed regulation and we can use refinements such as coils with ferrite cores to pick Hell signals out of overwhelming QRM. Accurately defined Schmitt-triggers are available for separating signals of different levels.

You could even go as far as PAØWV, who has developed a microprocessor displaying received signals as a slowly moving line of characters, complete with interfering pulses (thus fully maintaining all qualities of the Hell system) on an oscilloscope screen.

The transmitter part, "pulse machine," is somewhat more complex to build. In the original Hellschreiber the transmit pulses were produced by a coded drum requiring some mechanical refinements. But a solid-state solution exists here. It was PAØWV again who built the first clock-plus-matrix system that can be hidden under a small keyboard, producing all characters in complete silence.

A converter isn't required for receiving Hell signals. The Hellschreiber can be plugged directly into the headphone jack of any radio receiver (or any telephone line, for that matter). The transmitter output plugs into the KEY jack of any CW transmitter, that's all.

ham radio