History of Mark and Space

Harvey
1990

(Document Notes)

DECUServe Journal, May, 1993 issue (09/22/90 Harvey: Mark and Space)

"Mark" and "space" are curious terms to find in a hardware topic discussing data communication. They seem more appropriate for the Windows conference. But they are truly electrical communication terminology and have many related forms, such as "steady mark", "continuous spacing" and a seemingly unrelated term: "running open".

I thought their origin might be of interest and along the way, we'll discover where that curious "break" key came from that many of us have on our keyboards and these days often use to get the attention of the terminal server.

These terms are very old and originated with an early graphical device. People never think of the telegraph as graphical communication, but that's the way it was originally conceived. Our impression of the telegraph comes largely from movie stories of times a century ago, when telegraph operators listened to the strange ticks, tocks and rattles from the telegraph sounder and converted them into urgent messages that pushed the plot forward.

Morse didn't invent it that way. His original device was an electromagnet that pulled a pen (possibly a quill) against a moving strip of paper. When current flowed through the electromagnet, the pen touched the moving paper and made a mark. When the current was off, a spring retracted the pen and there was a space on the paper. Short marks were called dots. Long marks were called dashes.

Now this explanation is so simple and pat, it just has to be largely legend and over-simplification. There were many different schemes, such as keeping the pen in contact with the paper and moving it sideways by the electromagnet. But the mark/space concept seems to have stuck, because it appears in very early communication literature.

This graphical device was actually used in production communi- cation for a while. Some of the operators of the machines found that they could recognize the "call letters" of their telegraph office when the electromagnet and pen started tapping out a message on the strip of paper.

If the message was for another office, they didn't need to get up to see if the message was for

them. Soon, they were able to just write the message down on the telegraph form as it came in without needing to "read" the tape. When the operators were able to fully "read" Morse code with their ears, they could stop putting ink in the pen. The telegraph sounder was born.

You couldn't see the marks and the spaces between them anymore, but they were still there in the minds of the engineers designing telegraph systems.

For good electrical engineering reasons, telegraph offices were wired in series. At one end of the railroad (for example) there was a powerful battery with one pole connected to a rail and the other connected to a wire that ran on posts for the length of the railway, where it was also connected to the rail. This constituted a simple series circuit with the battery current flowing through the wire, into the rail at the far end, and back through the rail to the battery.

At each telegraph office along the line, the wire was cut, brought into the office, sent through the coil of the electromagnet of the sounder, then through the telegraph key, then back up to the pole and on down the line to the next office.

But you may have noticed a problem. The telegraph key is normally an open circuit. When the operator pressed down on the key, the circuit was closed and the current flowed. How, then, did the current flow when everything was hooked in series and all those keys were open circuits?

If you've ever looked closely at a real telegraph key, you may have noticedthat it has a knife switch build into it, and that switch is arranged to short the contacts of the key. When the operator was not actually sending a message, he or she (many early telegraph operators were women) would close the knife switch so that the key contacts were shorted and the whole series circuit was unbroken.

Thus the normal idle telegraph line was in a "steady mark" condition - a current flowed through all the sounders which if the pen was still there would have caused a mark to be made on the moving strip of paper. The knife switch on each telegraph key was perhaps the first "push to talk" button. The operator had to "open" the knife and break the circuit so the key could turn the current on and off and send a message.

Not surprisingly, this knife was called the break switch. When an operator opened the knife the current stopped flowing in all the sounder electromagnets and they went tock. Everyone up and down the line knew someone was about to start sending a message. The break switch alerted them.

When the Indians cut the telegraph wire, the circuit was open and all the sounders went tock. "Open" meant trouble.

The graphical device didn't disappear, however. The interest in having the message automatically recorded on paper that could be read without having to learn the arcane art of "reading" Morse code by ear remained. The inventors worked to improve on the simple marks separated by spaces and actually make letters and figures appear.

One early attempt was the telautograph. It attempted to servo the up/down and sideways movements of a pen being used to write a message in longhand to a remote pen reproducing the motion and hence re-creating the longhand. It worked well for very short distances but they didn't have the technology to send the control signals useful distances. There were other schemes using many wires. Expensive.

The big winner was the stock ticker. It was the ancestor of all the various asynchronous communication gadgets we have today. It was a triumph of mechanical ingenuity that enabled an ordinary telegraph wire (and there were many) to be converted to actually print a message in letters and figures on that moving strip of paper. You didn't need an expensive telegraph operator hanging around to "read" Morse and you didn't have to puzzle out the strange patterns of marks and spaces. But the communication technology was telegraph and the marks and spaces were still there in the minds of the engineers.

The stock ticker used the same series circuit technology of the telegraph. The wire ran from the floor of the exchange to the nearest broker's office, through an electromagnet in the ticker machine, and then on to the next office. And yes, if the Indians (or a cleaning lady) broke the wire anywhere, all the tickers went dead.

Dead? No, they went crazy. The continuous telegraph current when there were no stock trades being reported kept the ticker mechanisms idle. Steady mark. Good. The start of a trade message was a break in the circuit (start pulse) which caused the ticker mechanism to start spinning. The following sequence of marks and spaces caused the mechanism to select a particular character on its wheel and a hammer struck the paper strip against it.

When the circuit was broken by the cleaning lady, it was in a "continuous space" condition, causing all the ticker machines to spin their clockwork, "running open" until someone fixed the break. These terms stayed with communication technology to the first minicomputers. The venerable ASR 33 Teletype, one of the foundation stones of the minicomputer industry, used telegraph series current loop technology, marks and spaces, and "ran open" when you disconnected it from the PDP-5.

Well, if you got this far, you're probably wanting to know about where your break key came from if you haven't figured it out already. Yep, it's that knife switch on the side of the telegraph key. You didn't know you're a telegrapher, did you?

Document Notes

This document was formatted (and edited somewhat) by Gil Smith, July 2001. The original file, harvey--mark-and-space.txt, is from the Telecom Digest.