NERVOUS SYSTEM: JUST THE FAX, MA'AM

'Nervous System,' which approaches data privacy and cybersecurity issues from the context of history, tells the story of how the fax machine actually pre-dates the U.S. Civil War.

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With the aggressive pace of technological change and the onslaught of news regarding data breaches, cyber-attacks, and technological threats to privacy and security, it is easy to assume these are fundamentally new threats. The pace of technological change is slower than it feels, and many seemingly new categories of threats have actually been with us longer than we remember. Nervous System is a monthly blog that approaches issues of data privacy and cybersecurity from the context of history—to look to the past for clues about how to interpret the present and prepare for the future.

The facsimile (fax) is a quaint technological relic. While it is still an integral part of communications networks used by the medical community and health services providers, as well as many restaurants, it is little used outside those contexts. Other technologies have largely taken its place—it is too easy to transmit written content, pictures, sound files, video clips, emojis, and hyperlinks in emails or text messages to feel compelled to hassle with the special toner and paper, dedicated transmission lines, and high-pitched whine of the fax machine. In its day, though, the ability to transmit written documents across

vast distances was the cutting edge of communications technology.

Readers of a certain age may be imagining that day to have been in the 1980s, perhaps. Certainly, fax usage surged in the 1980s and peaked in the 1990s. As advanced as this telecommunications technology must have seemed in those days, just imagine how magical it must have appeared when the first faxes were sent over *170* years ago!

That is not a misprint. The first working fax machine was built, used, and patented in 1843, decades before the invention of the telephone.

The mad genius at the heart of this tale was Alexander Bain. After proving himself to be a poor student and a feckless farmer, he worked as a clockmaker's apprentice in rural Scotland. In 1830, he had a life-changing experience: He attended a lecture on electricity. Seven years later, having absorbed all he could about the nascent science of electricity in the parochial town where he then lived, Bain moved to London to immerse himself in the new field.

Bain proceeded to explore ways of bringing his profession and his passion together—to make electric clocks, and to apply clockwork principles to electric devices.

At the time, the only "electric devices" worth the name were telegraphs. The telegraph was itself an extraordinary leap forward in communications technology when first introduced—but the instantaneous long-distance communications enabled by the telegraph were awkward. The system could only transmit simple pulses (Morse code was ideal), meaning that users had to translate their messages into and then back out of Morse code to be telegraphed.

Bain was arguably the first to make an electric clock. Certainly he argued this; another British inventor disagreed. In either event, Bain was a pioneer with few peers. He also developed a new kind of telegraph. On one end, a user fed a strip of perforated paper into a clockwork transmission unit, which connected an electrical circuit every time it encountered a hole in the paper. The receiving unit

reacted to those electrical pulses by exposing a strip of chemically treated paper to an electrical probe, which stained the paper with a corresponding mark. The "Chemical Telegraph" still required users to translate their messages into Morse or some similar code, but Bain was onto something. Meanwhile, he continued to refine his electrical clocks and worked out a way of synchronizing them. He proposed using these electrically synchronized clocks to regulate Greenwich Mean Time and ensure every clock in the British Empire was in lockstep.

In 1843, Bain had the notion of bringing these two inventions together in the same device. He constructed two electric clocks that could be kept in perfect synchrony—meaning that the pendulum of one clock was an identical mirror of the other, regardless of how close to or far apart the two clocks were from one another. He then affixed an electrically sensitive probe to one pendulum and let it swing back and forth across a metal plate with metal type on it. The swinging probe perceived

the type as electrical patterns and transmitted those patterns down the wire. Meanwhile, the synchronized companion pendulum on the other clock passed back and forth across chemically treated paper. The electrical signals stained the paper, leaving dark marks that corresponded with the dark spots "seen" by the other probe.

At the Great Exhibition of 1851, Bain demonstrated several of his inventions, including the "ElectroChemical Copying Telegraph" (his fax machine) and various electric clocks and telegraphs. A competing inventor, Frederick Bakewell, was exhibiting his own fax machine, adapted from Bain's, at an adjacent booth, but Bain was already touting his latest system upgrades: Bain's fax machine now transmitted handwriting and drawings, not just raised type. The reproduction quality was limited, especially by modern standards, but conceptually the device worked to transmit *anything*, really, to a remote location.

Bain took home the Exhibition Medal Class X for his work—but his was not to be an illustrious legacy. He got neither rich nor famous; he wound himself up in fruitless patent disputes and arguments with fellow inventors, became estranged from his family, and ended up a poor watchmaker, just like where he started.

Other inventors took his idea and ran with it. Giovanni Caselli demonstrated his fax machine to Napoleon in 1860, and by 1865 Caselli set up the first commercial fax service, connecting Paris to Lyon using electrically synchronized clocks (and some 12 years later, Alexander Graham Bell patented the telephone).

These early fax systems were most commonly used by financial and legal institutions to verify signatures. The need to have the transmitter and receiver directly synchronized with one another imposed limitations on how widely the concept could be implemented. In 1964, a century after Caselli's first net-

work, Xerox introduced the first modern commercial fax machine, but it was not until international and industrial standards were put in place in the late 1970s and early 1980s that the technology was widely adopted.

Nowadays, faxes have been largely supplanted by newer forms of communication: email, texts, and tweets. The surprise is not that other technologies came along to push the fax aside, but that it took the better part of two centuries to happen.

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