Chapter 1

An Illustrated History of Wired Markets

Progress might have been all right once,
but it has gone on too long.

—Ogden Nash

This chapter is based on a number of ever-evolving dinner and lunch talks I have given over many years, all called "Nerds on Wall Street" irrespective of their actual subject. Many financial conference speakers, including those talking to mixed professional/spousal audiences after open-bar events, are deadly dull; hardly anyone really wants to see yield curves over dessert and that last glass of wine. I started collecting photographs about markets and technology in the early 1990s, and tried to mix in some actual informative content. That, along with the natural sensibilities of a borscht belt comic, made me a popular alternative to the yield curve guys. Given the 20-minute rule for these talks, none of them were as voluminous as this chapter. Still, this is not intended in any way to be a complete history of market technology, but rather an easily digestible introduction. I occasionally still do these talks on what remains of greater Wall Street. I am also open to weddings, *quinceañeras*, and bar mitzvahs, since we all need diversified portfolios these days.

Looking into the workings of modern securities markets is like looking under the hood of a Prius hybrid car. There are so many complex and obscure parts it's hard to discern what's going on. If you look under the hood of an auto from a simpler era, for example a '64 Mustang, you can see the parts and what they do, and have a better chance at understanding their complex modern replacements.

History repeats and informs in market technologies. From the days when front-running involved actual running to the "Victorian Internet era" brought on by telegraphy, we can learn a great deal from looking back at a simpler era.

We think that the overwhelming influence of computers remaking the landscape around Wall Street today is something new, but a pair of before-and-after photographs show an even more dramatic technological invasion. Before telegraphy, in the 1850s, the sky over Wall Street was open and clear:

It took only a short time for telegraphy's compression of time and space to transform the scenery. Here's what the Street looked like shortly thereafter when everybody had to have it:

In its day, telegraphy was seen as the same kind of overwhelming transformation that the Internet is today. In many ways, the telegraph was more dramatic since it was the first time in human history that a message could be sent beyond the horizon instantaneously.

Technological transformations create problems. If we are lucky, more technology solves them.

Changes in markets brought about by technology are anything but subtle: The exchange floor in Tokyo closed down and was replaced by electronics in 1998. Here's an earlier example, the London Stock Exchange trading floor the day before . . .

. . . and the day of the introduction of screen trading—the so-called Big Bang—on October 27, 1986.

You could have gone bowling and no one would have noticed.

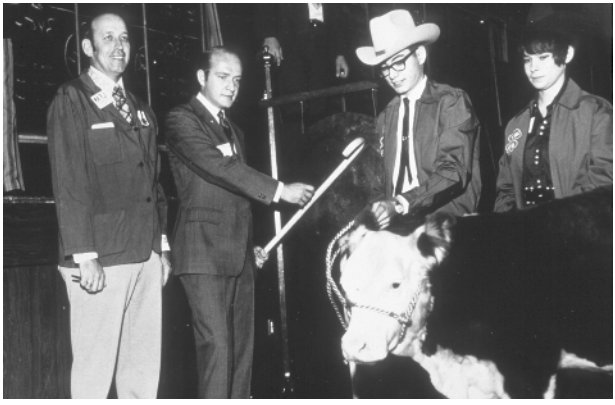
The trading floors that have been emblematic of financial markets around the world are an endangered species. Brokers and traders who used to rely on fast reflexes and agile elbows and knees now rely on computer programs, tweaked to be milliseconds faster than the next guy's program.

Clearing the floor and rolling in the machines has a sentimental cost. When markets become technology, the human price of progress is high. Anyone who has been on the floor in New York or Chicago knows our markets are really personal, face-to-face, elbow-to-elbow, and knee-to-knee experiences. People are justifiably worried that when too much technology gets mixed up with markets, we're going to lose some of the vibrancy that makes them so fascinating.

I have to admit, I'm a little sad when I hear about an exchange floor closing and being replaced by some screen trading system. Let's face it. Having all those real traders in one place provides a sense of community and continuity.

A trading floor peopled with traders and brokers also makes for some colorful moments in market history, such as the opening of the live hog futures contract on the Chicago Mercantile Exchange (CME) in 1966. (These guys are definitely having more fun than loading the hog program on some Unix box in Amarillo—and on witnessing this, one wag asked, "Which ones are the brokers?")

Or live cattle futures in 1964.



Or dead cattle futures in 1965.

Isn't a dead cattle future sort of a contradiction in terms?

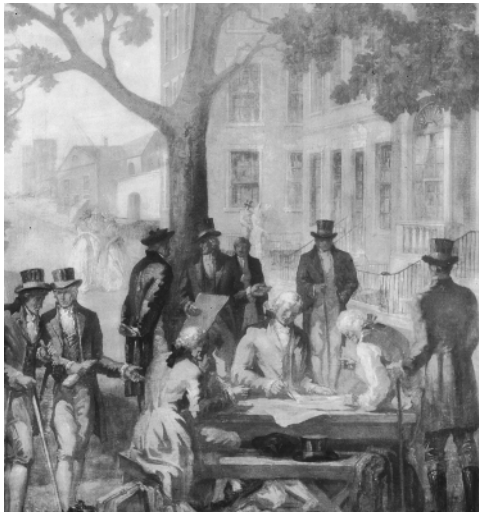
Or turkey futures in 1961.

Or Dutch guilder futures in 1973.

Or boneless beef futures in 1970, whatever that is.

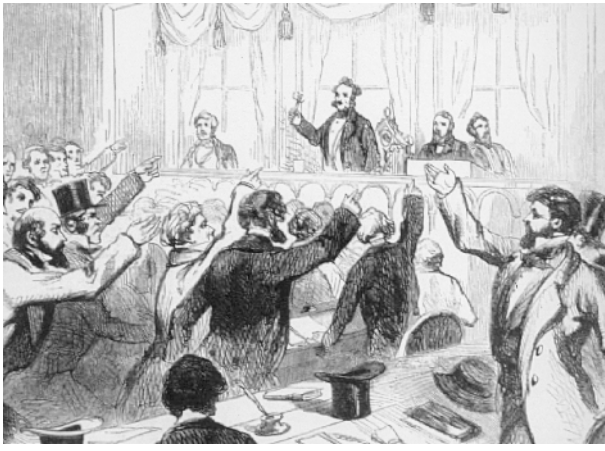
Notice the same distinguished-looking CME official, Everett Harris, then president of the Merc, banging on the gong with a salami. This guy had a great job. These are the little details that make market history come alive for me.

There's so much technology in modern markets that it's easy to forget that some of our favorite markets, like the New York Stock Exchange (NYSE), started out as very low-tech places. In 1792, the New York Stock Exchange was a bunch of guys standing around a buttonwood tree at 68 Wall Street shouting at each other on days when it didn't rain or snow:



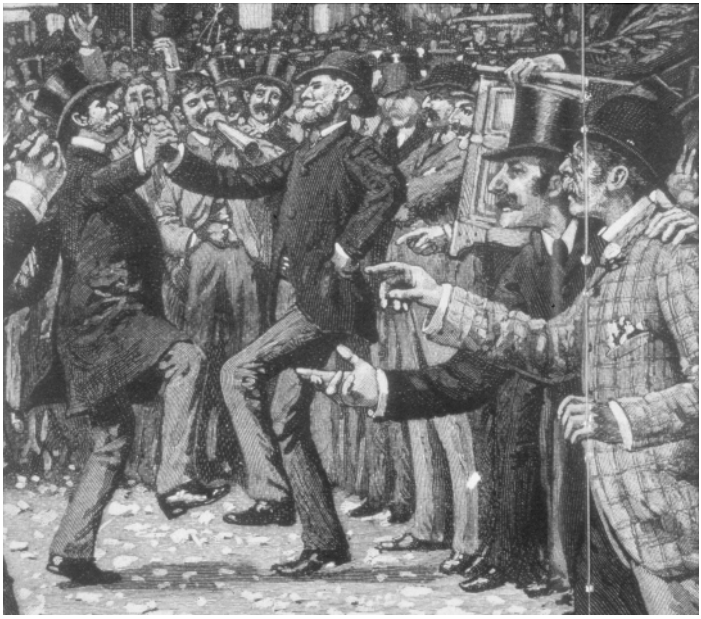
We like our markets to be liquid, efficient, resilient, and robust. But this is hard to do when all the participants have to crowd around a tree and hope for good weather. So in 1794, we see the first big technological solution: the roof.

Everybody moves inside, to the Tontine Coffee House at the corner of Water and Wall streets. They're still shouting, but they're dry. Even when they're warm and dry under a nice cozy roof, you can have only so many shouters participating in a market, and more participants is a good thing. Pretty soon technology solves this problem.

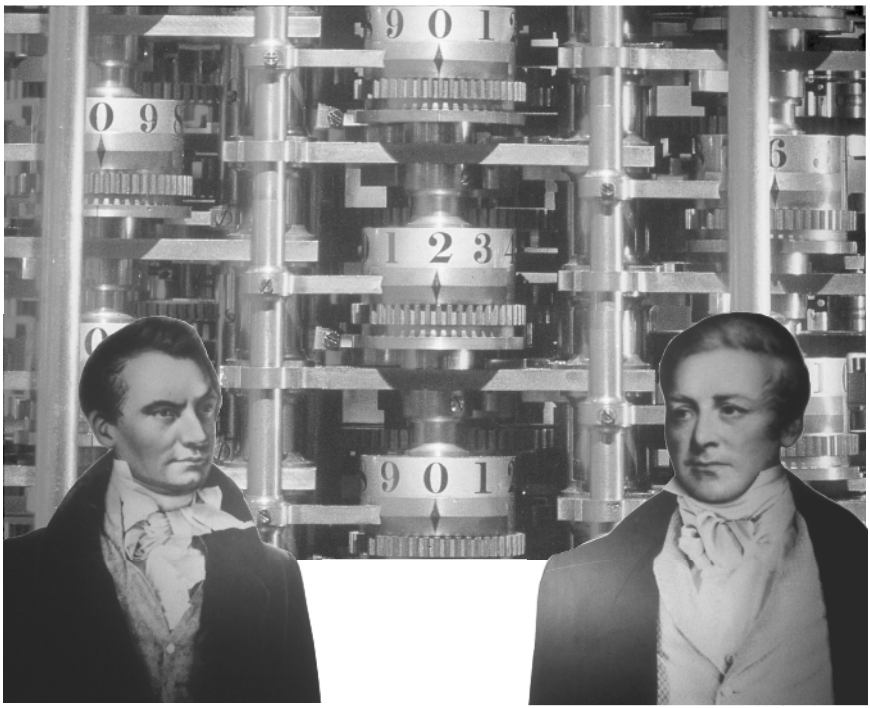


Hand signals and chalkboards worked really well. Now hundreds of people could participate in the market. Of course, this made for more broken trades. Here we see how they resolved them back in those days: the buyer dresses up in a bull suit, the seller dresses like a bear, and they duke it out up front. This was before all those beeping tape machines recorded everything everybody said.

When you're indoors, you can also have dinners and parties to commemorate important events. Here we see two specialists celebrating the first bagging[1] of a buy-side trader.



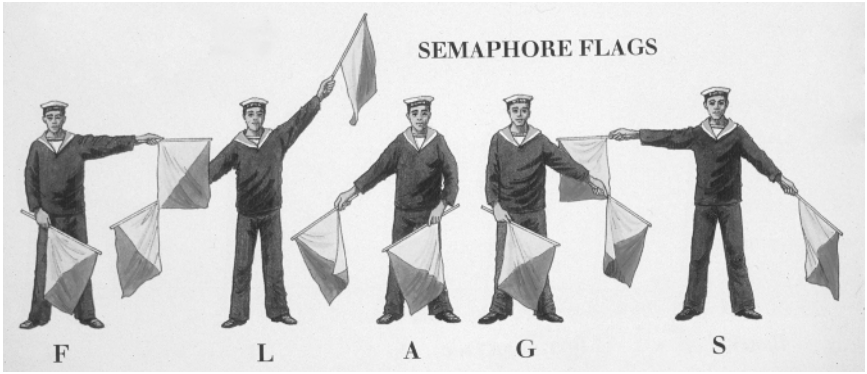
So far, the technologies we're talking may sound rather low-tech: roofs, chalk, hands. Here's what a computer looked like in 1823, the Difference Engine, invented by the famously brilliant, eccentric, and obnoxious Charles Babbage:



Here's Babbage, who said, "I wish to God these calculations had been executed by steam."

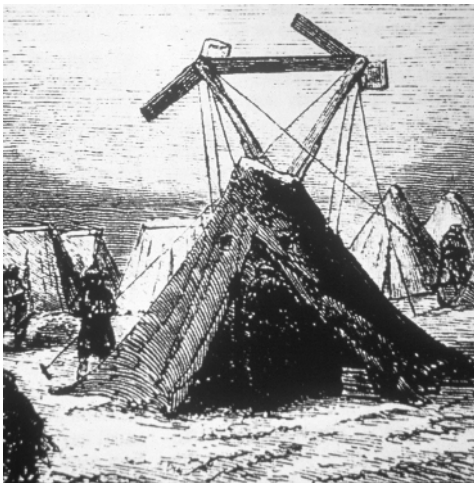
Here's Babbage's government sponsor, Prime Minister Robert Peel, who said, "What shall we do to get rid of Mr. Babbage and his calculating machine?"

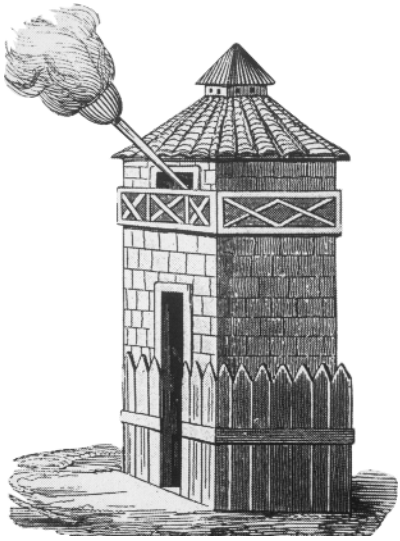
Babbage was stunningly smart, and even more stunningly insufferable. He lost his government funding, and the idea of automatic computing languished for many years. It was not used in financial markets or anywhere else in the nineteenth century. Babbage only built pieces of his machine; but when the Royal Museum in London put a whole one together from his designs a few years ago, it worked perfectly. The world could have been a very different place if Babbage had better manners. We'll pick up on him later.



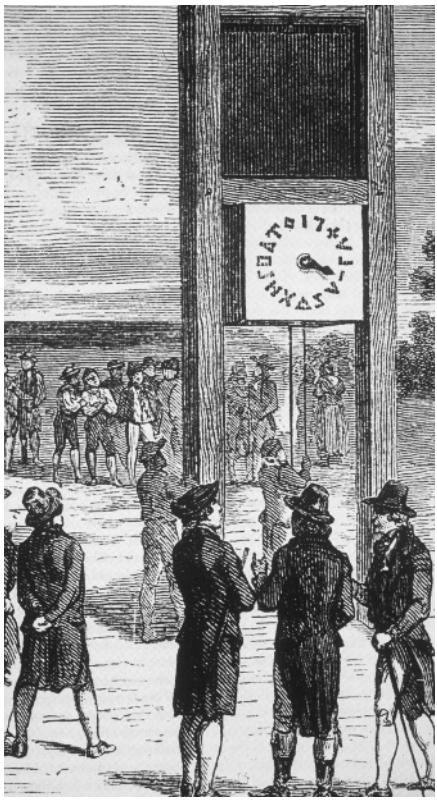
Now we have our happy traders signaling each other with their hands, dancing, and dressing up in bear suits. This is all very nice, but there's a problem: the traders and brokers have to actually be present in person to participate in the market. How is this problem solved? With a little more technology, namely telegraphy. The earliest telegraphs weren't the electric variety we think of at all. They were guys standing on hills waving flags, like the ones used at sea.

There were lots of problems with the flag system. For one, it was hard to see a little guy way up on a hill. In most places, people starting building big mechanical guys like this one, with large wooden arms, and put them up on the hill instead.





There were a few variations on this theme, such as the smoke-and-fire telegraph tower, which had a problem with burning down in mid message . . .

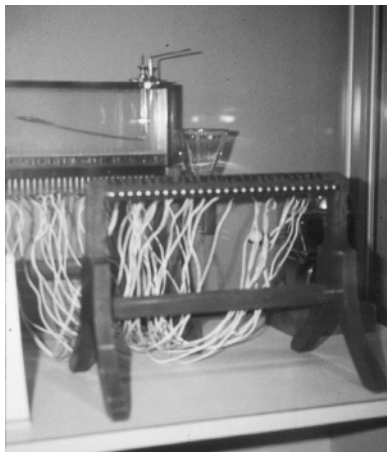


. . . and the decoder-ring-on-a-stick design, which is kind of nice.

These towers are why so many cities have a place called "Telegraph Hill." Around the world, the builders and first users of these early telegraph systems were the military, for obvious reasons. The second users were traders disseminating market information. The third users typically were con men perpetrating financial frauds on the traders by sending out false signals or front-running the real ones. Nobody really liked this business with the flags and the mechanical arms. There were too many problems with privacy, bad weather, and darkness. It took about half an hour for a price change to work its way from New York to Philadelphia. Everyone knew an electric telegraph would be a better way.

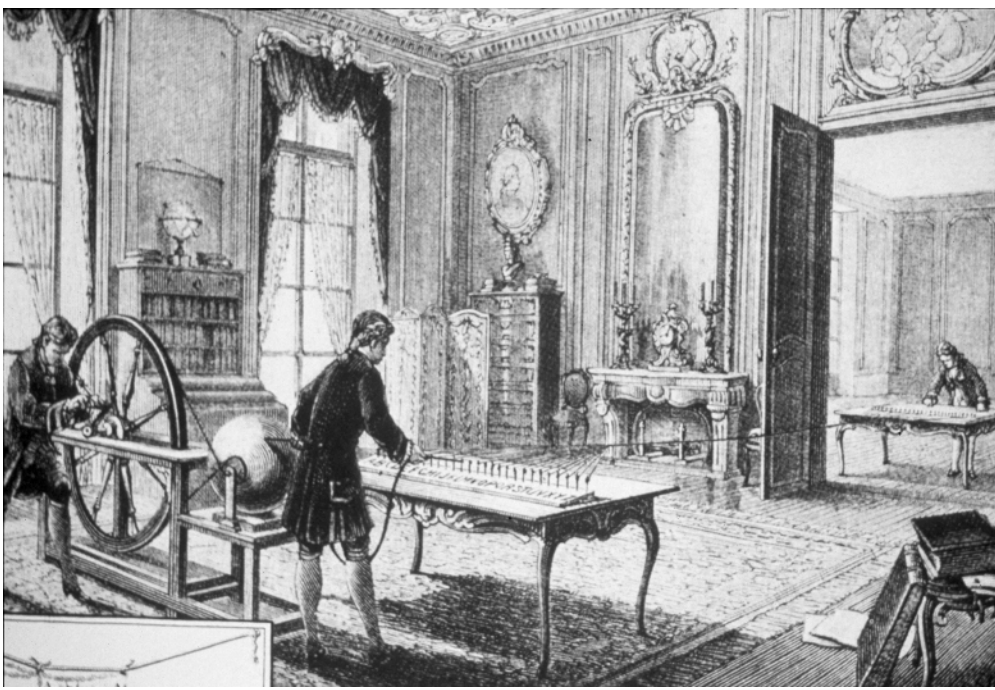
Here's another British multiwire device with a battery and a saltwater receiver.

Remember how in high school chemistry lab if you put wires from a battery into saltwater, one of them bubbled? It was the same deal here. There was a ball for each letter, and you looked to see where the bubbles showed up.

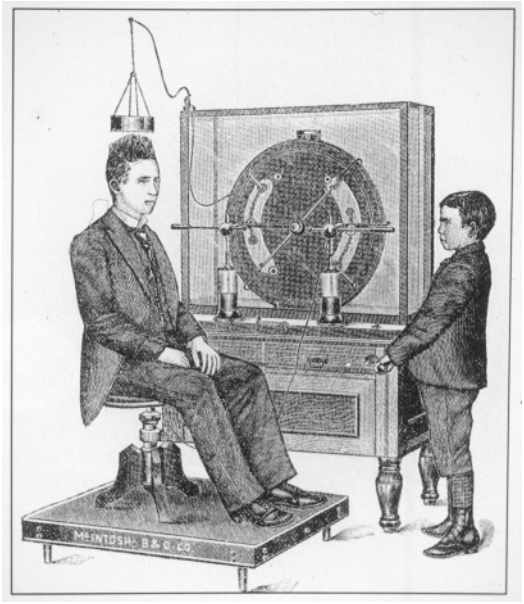


Here's one that tried to use tones for letters. It's the first singing telegraph and made signals like the keyboard at the end of *Close Encounters of the Third Kind*.

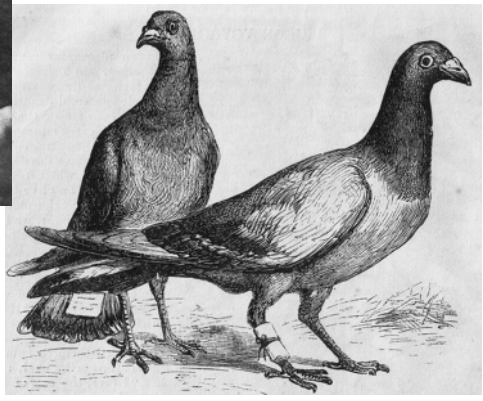
There were some really marvelous early attempts. Here's an electrostatic model, with a wire for each letter and number, and a range from the living room to the parlor, powered by some fur rolling over a piece of rubber—sort of the rub-a-balloon-on-your-head approach.



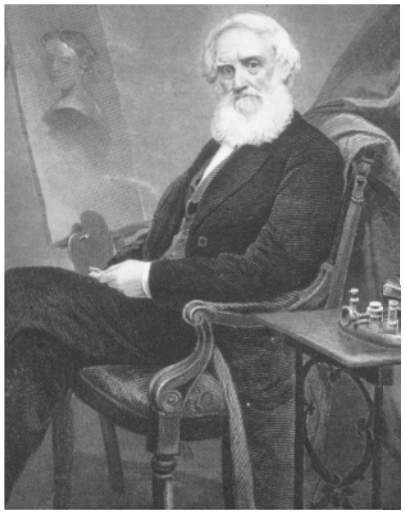
I have no idea how this one was supposed to work, but when they said "sell," you sold.



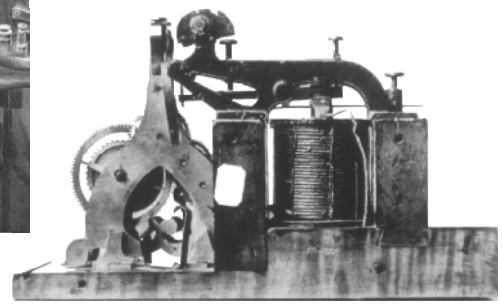
Julius Reuter and his son Herb decided to try another approach. They got into the messenger pigeon business.



Edward G. Robinson played Reuter in the 1941 classic film, *This Man Reuter.* The pigeons played themselves.



Finally, in 1837, Samuel Morse here got it right: a nice, simple, single wire and ground design.



This quickly caught on all over the world. Instantaneous Communication: The Wonder of the Age!

Notice here that "the electric fluid travels at the rate of 280,000 miles per second," or about one and a half times the speed of light. Maybe they knew something we don't.

You cannot underestimate the impact of telegraphy; it was truly the Internet of its era. For the first time in history, a message could be sent instantly over the horizon. An entire book could be filled with the stories of how all facets of human endeavor were transformed by telegraphy.[2]

THE WONDER of the AGE ! !

INSTANTANEOUS COMMUNICATION.

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THE GALVANIC AND ELECTRO-MAGNETIC

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ON THE

GT. WESTERN RAILWAY.

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"*This Exhibition, which has so much excited Public attention of late, is well worthy a visit from all who love to see the wonders of science.*"—MORNING POST.

The Electric Telegraph is unlimited in the nature and extent of its communications; by its extraordinary agency a person in London could converse with another at New York, or at any other place however distant, as easily and nearly as rapidly as if both parties were in the same room. Questions proposed by Visitors will be asked by means of this Apparatus, and answers thereto will instantaneously be returned by a person 20 Miles off, who will also, at their request, ring a bell or fire a cannon, in an incredibly short space of time, after the signal for his doing so has been given.

The Electric Fluid travels at the rate of 280,000 Miles per Second.

By its powerful agency Murderers have been apprehended, (as in the late case of Tawell,)—Thieves detected; and lastly, which is of no little importance, the timely assistance of Medical aid has been procured in cases which otherwise would have proved fatal.

The great national importance of this wonderful invention is so well known that any further allusion here to its merits would be superfluous.

N.B. Despatches sent to and fro with the most confiding secrecy. Messengers in constant attendance, so that communications received by Telegraph, would be forwarded, if required, to any part of London, Windsor, Eton, &c.

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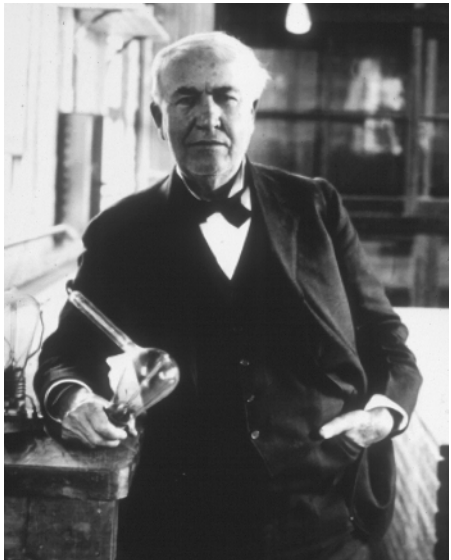
Traders picked up on telegraphy in a big way. Here we see a broker in New York with his nineteenth-century BlackBerry, a telegraph key, cradled in his arm.

In its day, telegraphy was seen as the same kind of overwhelming transformation that the Internet is today. Telegraphy was a big advance, but to participate in the market as things were happening, the participant had to know Morse code.

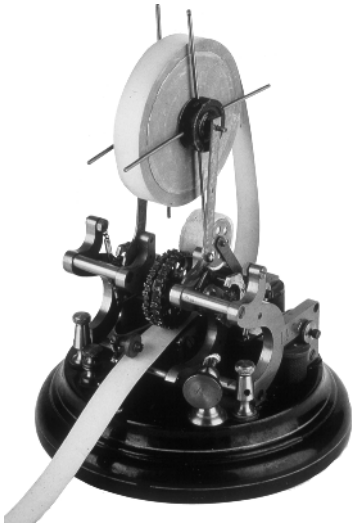
The technological revolution of the 1850s needed more technology to allow people to cope with the dramatic changes in the information landscape. This time the technological advance was the invention of the stock ticker in 1867 by Edward Callahan.

The first models were a little too delicate for boisterous NYSE crowds. So Tom Edison was hired to buff the thing up to Wall Street combat standards.

Edison just kept dropping the ticker out of a second-floor window and fixing it when it broke until it didn't break anymore. Finally, he ended up with



this design, deemed suitable for even the most *muy macho* NYSE traders.



These are seen in all sorts of museums, Wall Street offices, and the occasional sidewalk sale in Queens. If you want one in a hurry, they can be had at the Museum of Financial History, adjacent to the bronze bull.

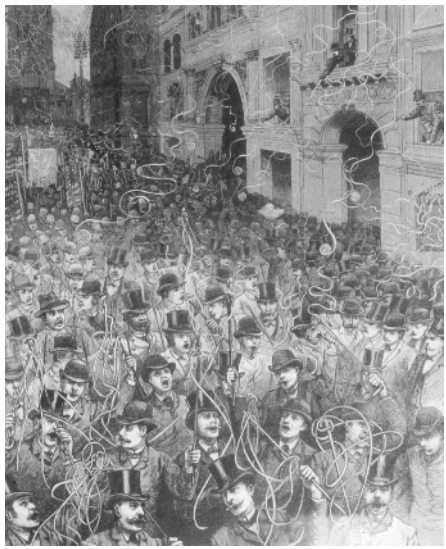
Ticker tape, like the roof, hand signals, and the telegraph, was a huge success, probably the most important technology in finance up to that time. People set up jumbo magnifying lens devices to project them onto walls. Back then, people traded faster than the machines could keep up with, so delay meters were installed on the floor. Delay indicators are still found on modern electronic feeds.

People saved tapes and studied them. You could say they were the first high-frequency market microstructure studies. Here's a fellow doing just that.

This looks like my office, but neater—a foreshock of the information explosion we have today.

On the floor, there were "human Quotrons" who used to pick up the most recent end of tape and follow it back in time to find the latest price quotes for specific stocks. This wasn't that long ago. Frank Baxter, former chairman at Jefferies and a recent U.S. ambassador to Uruguay, started out doing this.

All that ticker tape also made for nice parades. Here we see a group of specialists celebrating the one-millionth bagging of a buy-side trader.



Technological progress brought bigger, better, faster ticker machines. The ticker tape became the public symbol for the market.

Ticker tape became standard practice for blowout parades, like this one for General Douglas MacArthur after President Harry Truman fired him from commanding the U.S. armed forces in Korea in 1951.

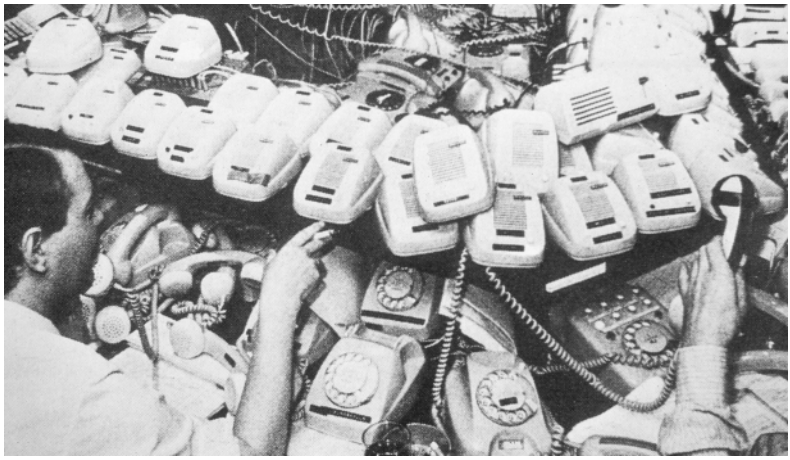
By the 1950s, the ticker and the exchange were so closely linked that the NYSE hired those noted market theorists, Kukla, Fran, and Ollie, to explain it to the public. I'm not making this up.

After more effort than I like to admit, I finally got a copy of what remains of the film. Believe me, this is the best part.

In one form or another, the ticker is still with us today—on the wall, or on the bottom of your TV screen.

Source: CNBC.

With the progress of technology, prodigious amounts of information can be quickly moved about. But all of this information moving around in a hurry can get pretty overwhelming. Telephones moved into exchanges alongside the ticker machines. This greatly expanded the capacity of the market to handle external order flow, and connected the exchanges to the public network. Some early adopters got carried away, as seen in the photo of a German trading room in the 1950s.

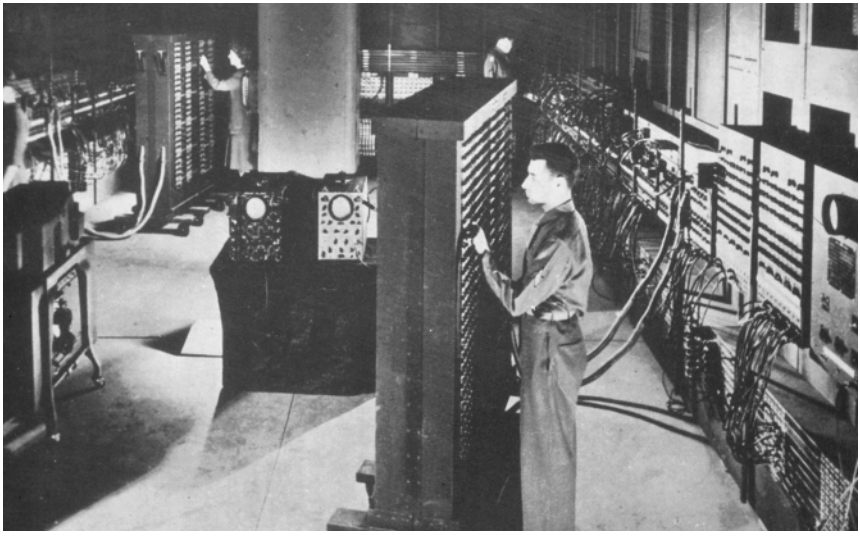


So far, the discussion has been about technologies for moving information around: hand signals, semaphores, telegraphy, stock tickers and telephones.

When we talk about using information, we're talking about computers. In the 1930s, if you said you had six computers in your office, this is what you meant—the NYSE computing department circa 1930:

"Computer" was a job, not a thing. If you said you had a supercomputer, this is what you meant.

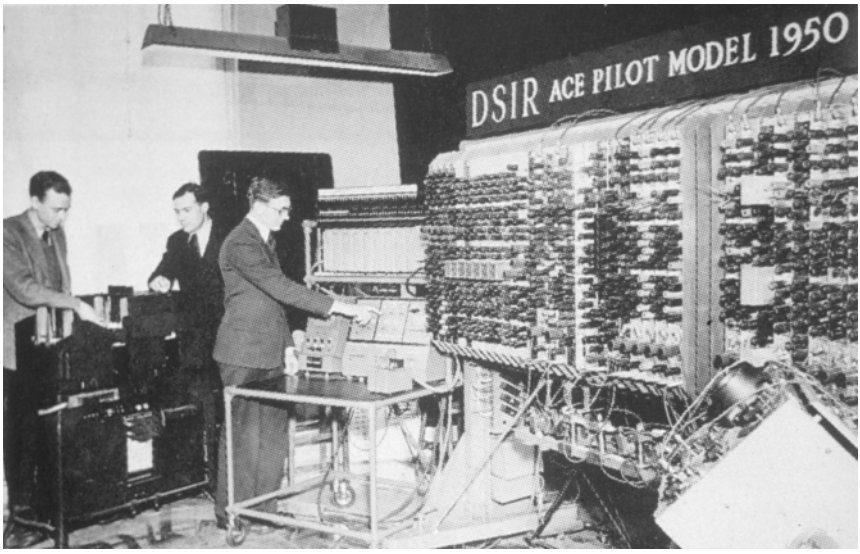
At about this time, the technological legacy of Charles Babbage stirred again at the Moore School of Engineering in Philadelphia. ENIAC (short for electronic numerical integrator and calculator), the first electronic computer, was developed in 1946 by J. Presper Eckert and John Mauchly.

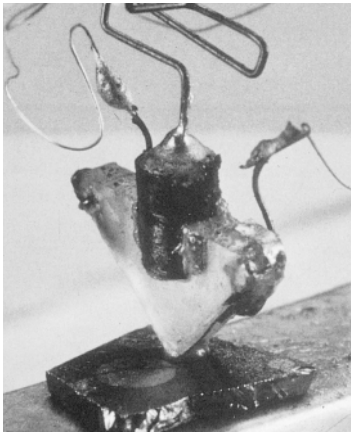


It weighed 30,000 pounds, had a 900-bit memory, ran at .017 MIPS (million instructions per second), and blew a tube every 45 minutes. It was programmed by someone moving these plugs and wires around. You may have seen Al Gore on TV down there in 1996 to celebrate the 50th anniversary. He pressed one of these buttons and parts the Moore

School haven't passed out to museums counted from 46 to 96. (There is no truth to the rumor that Al Gore invented ENIAC when he was minus two years old.)

Computers got a little better in the early 1950s (more memory and longer times between failures). But a battalion of nerds were still needed to get the things to do anything useful twice in a row.





This modest-looking little science project is what unleashed the torrent of computation we see all around us today.

It's the very first transistor, developed at Bell Labs in 1948 by Walter Brattain, William Shockley, and John Bardeen. They were awarded a Nobel Prize for it in 1956, around the time transistors started being manufactured in quantities large enough to show up in things like radios and, a few years later, computers.

Computers became much more manageable. One could fit in a room smaller than a barn. It might work for a whole week without breaking down. It had enough memory that a programmer didn't have to move

wires or think in binary to program it. And, most important, the salesperson had a picture to show that it came in the latest designer colors.

The NYSE had to have one. In 1966, they got it.

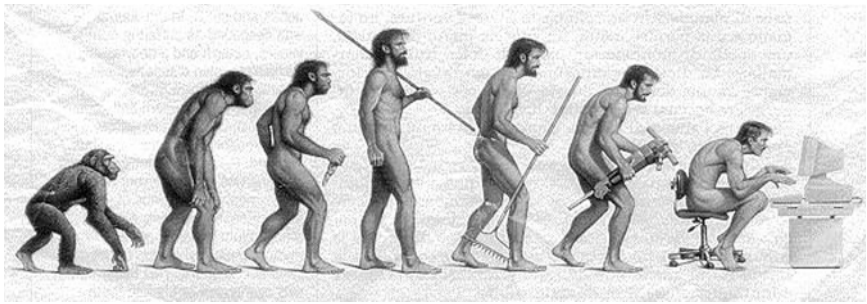
And there he is, the first nerd on Wall Street: Keith Funston, then president of the NYSE. Nerds were much snappier dressers then.

Computers keep getting better, faster, smaller, and cheaper. They're everywhere in trading. Traders can interact directly with algorithms using the NYSE handheld.

Computers have surpassed even telegraphy and ticker tape as a transformational market technology. The progress we've seen in computing technology that brought this about is really unprecedented. The rapid

technology trajectories forecast by the laws of Moore and Metcalfe continue unabated.*

Electronic markets started back when the Internet was a gleam in someone's eye at the Defense Advanced Research Projects Agency (DARPA). Now the future of electronic finance is profoundly intertwined with the World Wide Web, removing intermediaries in services ranging from trading to research. A lot of people think the three great technological ideas in history are fire, the wheel, and storing instructions as data. Based on the first 15 or so years of widespread use of the Internet, we might add the URL to the list.



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All this innovation is what has brought us to where we are today, wired markets in a wired world—a global financial system made of bits.[3] We have more Britney and Paris than we know what to do with, as well as some serious questions about how the investment business is going to cope with markets and market information in cyberspace.

Everything connects to everything else, if you want it to, and sometimes when you don't. Information goes wherever you want. There's more to this than just moving information around. Managing assets in a world of fragmented electronic markets requires enormous quantitative and technological expertise. Computer programs increasingly take over tasks from people, and allow people to amplify their abilities using machines. The "digerati" (a hybrid of *digital* and *literati*) would call this *artificial intelligence* (AI) and *intelligence amplification* (IA).

* Moore's Law is the well-known doubling of computational power every 18 months. Metcalfe's Law is the less well-known maxim that the utility of a network grows as the square of the number of users.

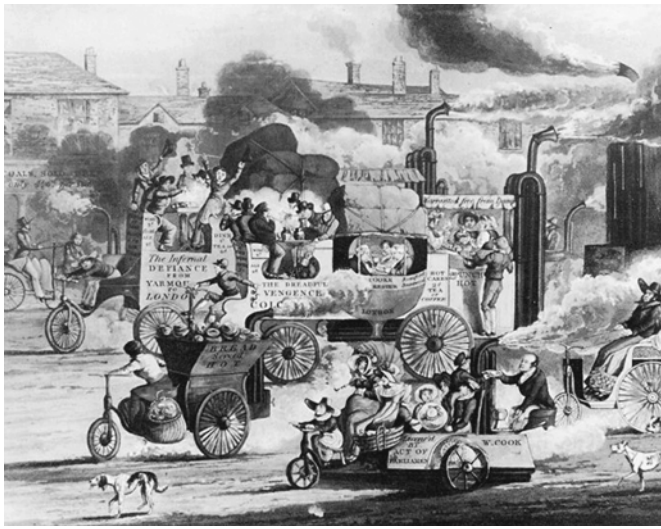
Ray Kurzweil, one of the great inventors of our age, built a reading machine for the blind in 1976 and then started a musical instrument company with help from one of his customers, Stevie Wonder. Kurzweil created the market for modern electronic keyboards, and has continued to innovate and articulate the growing capabilities of computing. The titles of his books trace an arc of future progress—*The Age of Intelligent Machines* (1992), *The Age of Spiritual Machines: When Computers Exceed Human Intelligence* (2000), and *The Singularity Is Near: When Humans Transcend Biology* (2005).

The technical literature on AI is utterly dwarfed by the sci-fi examples. From the evil HAL 9000 of *2001: A Space Odyssey* to the snappy patter between *Star Wars* droids R2D2 and C3PO, it's easy to miss the real thing. If you think AI is just cute, squeaky guys you find in the movies, ask World Chess Champion Garry Kasparov what he thinks. Deep Blue, the IBM computer, achieved one of the longtime goals of artificial intelligence in 1997 by defeating Kasparov. There are different opinions about whether Deep Blue is an AI program. Kasparov says yes:

> People in future generations would look back and say this was the moment when for the first time a machine was superior to all human beings in a purely intellectual field. . . .
>
> The match draws attention to very important questions that will confront us in many different areas in the not-so-distant future. Deep Blue shows us that machines can use very different strategies from those of the human brain and still produce intelligent behaviors.
>
> If you watch the machine play—and especially when you play against it—it is very difficult not to think of it as being intelligent. Man will have to accept that using the specific faculties of the human brain is not the only way to solve intellectual problems. . . .
>
> Often you get the feeling that the computer is trying to trick you, that it is "enjoying" the position, or even that it is laughing at you. Of course it is not, it is just processing billions of numbers. But its prodigious calculations translate into a behavior that is very hard to distinguish from the activities of a human chess master.[4]

Remarkably, the developers of Deep Blue disagree. It's not AI, it's just specialized search, say Deep Blue's makers. System architect Feng-Hsiung Hsu writes: "It is only a finely-crafted tool that exhibits *intelligent* behavior in a limited domain."[5] A key point here is that it is getting hard to distinguish between simple computation and intelligent behavior. When you can do enough simple computation, remarkable things can happen. MIT recently merged its Artificial Intelligence Laboratory and Computer Science Laboratory, reflecting this merger of ideas.

Along the path from hand signals to Deep Blue and the World Wide Web, we've seen some remarkable market applications of technology. This isn't going to stop. We've come a long way since the traders moved from under the buttonwood tree into the Tontine Coffee House, but we've really just moved indoors in our use of information technologies. There is so much written about information overload that we have an information overload information overload. But as we have seen, technological patterns repeat.



Living through a technology revolution isn't easy. We aren't exactly trapped in the cogs like Charlie Chaplin in *Modern Times*, or racing steam-powered Victorian dune buggies, but it often feels that way.

The good news is that one pattern we can expect again is that clever nerds on Wall Street (extending now into India and beyond) will find clever ways to get us off our current information cogs, and even more clever ways to put us on new ones.

Notes

1. Jargon watch: Brokers are the "sell side," while investors are the "buy side." What they buy is execution services. This includes selling securities as well as buying them. "Bagging" refers to any economic screwing of the customer. Specialists were the central traders on the NYSE, and could easily use any number of shady tactics to their advantage at the expense of the customer (e.g., selling out their inventory to a customer while holding a large sell order at a better price in their pocket). Specialists and market makers have been essentially replaced by computers, first by the fast hedge funds exploiting new "maker and taker" markets. In 2008, the NYSE retired the "specialist" term itself, replacing it with "designated market maker."
2. An excellent book comparing the development of the telegraph with the modern Internet is *The Victorian Internet* by Tom Standage (New York: Berkley Classics, 1999).
3. As is almost everything else. See *Blown to Bits: Your Life, Liberty and Happiness after the Digital Explosion* by Hal Abelson, Ken Leeden, and Harry Lewis (Boston: Addison-Wesley, 2008).
4. Garry Kasparov, "An Interview with Garry Kasparov," *IBM Research: Deep Blue*, www.research.ibm.com/deepblue/meet/html/d.1.6.shtml.
5. Feng-Hsiung Hsu, *Behind Deep Blue* (Princeton, NJ: Princeton University Press, 2004).