

Kim cell
703-855-5561

202/667-7821

"premise"
calls of UHF
into 7 tel
500 1/4 am

- ~~premise~~
- premise mention ATT stability
- new tech / new reasons
- intro competition - night, FCC
- SCC + T leadership
- MFJ etc

96

~~outside about Wiley~~

* Article about Wiley

- Competition expanding telephones, independents vital & growing
- Fish (?) sees need for capital, need to acquire major independents, compete in all markets nationally. A man, a plan, a system, ...
- Enter NY banks, Vail: A man, a plan, a system
- Vail strategy: One system...
- Finance & management
- Regulation, states, DoJ, Congress; the "scam" (?)
- WW I, the monopoly

Chapter 1

*Chapter 1 tells the story of the **creation** of the electronic communications industries from 1900 to the early 1930s - the formation of the AT&T monopoly to eliminate telephone competition, and the birth of broadcasting in a competitive flurry that quickly settled into a monopoly of three radio broadcast networks.*

Theodore Vail and the Creation of the Bell System

As the Twentieth Century began, the telephone industry had revenues of only \$XX million¹. The telegraph was still [by far?] the largest electrical communications business, with XXX miles of lines and \$XXX million in revenue. But both the telegraph and telephone were dwarfed by the railroad industry with XXX miles of track and revenues of \$XXX million. But telephone service was on its way to becoming a reality in American homes and businesses instead of a novelty.

Alexander Graham Bell's telephone patents that had once given the Bell Company² a monopoly on telephone service had expired in 1894.^{3,4} By 1900, entrepreneurs and business groups had started hundreds of new "independent" telephone companies, providing service in the smaller towns Bell had ignored and competing head-to-head with Bell in larger towns and cities where Bell's high prices had kept penetration low.⁵ New manufacturing companies developed and sold improved telephones and switching equipment. By 1900, the number of telephones had quadrupled to over a million, and the independent companies were adding many more telephone customers each year than Bell.⁶

While it was growing rapidly, the telephone "industry" was anything but what we would today characterize as an industry. The Bell Company itself was a relatively small Boston-based company that manufactured telephones and leased them to affiliated regional operating companies owned by local investors.⁷ [had it been profitable?] [Brief

¹ AT&T revenue in 1900 was \$41 million: Walker Report page 56. table 1885-1935. Need\$ for independents.

² Is this the correct name? it changed names several times. We should pick a representative name (like "the Bell Company") to use prior to 1900 when it becomes AT&T. maybe we should list the prominent colloquial names - Bell, American company, ... See FCC 1939 Section 1.

³ Dates?

⁴ They expired in 1893 or 1894.

⁵ I want as often as possible to put sentences in the active voice. People did things, things didn't just "happen". So maybe we can rewrite this sentence, or maybe it is one of those that is better the way it is.

⁶ Quantify this. Some sources (FCC seem to say 40% ±) some say almost equal. Look in Mueller or some other book for table with my calculations showing how % accelerated.

⁷ Is this true as of 1900?? Bell had some minority investments; maybe this could be a footnote.

description of Board, management, Boston culture, ...]

[Brief paragraph on regional operating companies, ownership, financial ties to Bell, own finance, management,]

[Brief paragraph on standards, Western Electric, toll, long distance.]

[Brief paragraph on independents, finance, suppliers, farmers, company-ops, ...]

The Boston businessmen who controlled Bell's patents refused to license the patents to other potential telephone manufacturers and wisely built the early telephone business on the basis of an end-to-end service combining telephones with wires and switchboards to connect its customers.⁸ When the Bell patents expired in 1894⁹, other companies were free to manufacture telephones, but Bell refused to allow its customers to use them on its network and refused to sell Bell-manufactured telephones to competitors. Because of this policy, Bell's competitors had to build their own networks of wires and switchboards, and many large and small companies did just that, either stringing their own wires alongside Bell's wires to compete in the larger towns or going into towns and rural areas not served by Bell.¹⁰

Bell had tried various ways of dealing with competition in the years leading up to 1900. Reflecting the company's origins as a patent licensing business,¹¹ they filed numerous patent infringement suits that imposed heavy costs on many small independent phone companies and equipment manufacturers and put some out of business altogether.¹² But Bell's chief tools for either competing with its rivals, or preferably putting them out of business, were economic – undercutting rivals on price or expanding into new markets to foreclose entry by a competitor.¹³ But both of these tactics were costly, the one reducing revenues and profits, and the other requiring significant capital expenditures. By 1900, Bell was losing the battle with the independents big time¹⁴

There was more innovation and growth in independents because in some ways they had better access to capital, but small amounts of capital for small company needs. Bell was woefully undercapitalized to compete with them. It was set up at that time as a national entity that raised its capital for its entire industry in Massachusetts.

Massachusetts governor vetoed bill to allow Bell to raise capital. Massachusetts law prohibited majority ownership of operating companies. Bell needed reliable sources

⁸ "wisely" from their point of view. It could be argued that the country would have been better off if they had been required to license the patents to others to encourage technical and entrepreneurial growth as happened after the patents expired. But it could be counter-argued that this could have fragmented the telephone service industry into incompatible patterns.

⁹ It was actually 1893-94 for a series of patents.

¹⁰ Put a note here, or later, about mutual companies serving small towns and farms.

¹¹ Bell licensed manufacturers, leased phones to regional affiliates.

¹² Ref?

¹³ Same tools rivals used to enter the market.

¹⁴ Data

of accelerating capital needs and needed organization.

Bell needed much more capital to keep from losing its predominant position in the American telephone business.

Massachusetts state restrictions on raising capital, control of operating companies¹⁵ Consideration of move to NY as early as 1896¹⁶ fewer restrictions, larger amounts of capital.

Decision and announcement consolidate incorporation in NY¹⁷. Change from a Boston based company to a New York City based company with better access to the much larger and more open New York capital markets. This recognition of the company's capital needs and reorganization to remain the predominant national telephone company marked the beginning of the telephone business as a true industry.¹⁸

As it happened, John Hudson¹⁹, the president of AT&T who led the company through the first years of competition, died in 1900²⁰, and the job was offered to Theodore Vail²¹. Vail had turned 65²² in 1900. He knew AT&T well, having been the first General Manager of the Bell Company from 1878 to 1885^{23, 24}.

1901 Vail memo re capital needs to Crane

==+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

=====

Very shortly after that,²⁵ AT&T turns to New York syndicates for funding. They had a new syndicate led by JP Morgan and Morgan gains 2 – 3 seats on the

¹⁵ Stehman 40-41,59-63

¹⁶ Garnet 106. based on memos by EJ Hall

¹⁷ The Bell system reorganized itself Dec. 31, 1899 with AT&T as the parent company and ... details...

¹⁸ Can we add some weight to this statement? Do we want to put this flag here or on Vail's arrival?

¹⁹ Could introduce Hudson earlier, let him lead the fight against competition.

²⁰ Garnet, p 91

²¹

²² ??

²³ Garnet 31

²⁴ Vail apparently worked in NYC july-dec 1878 and then moved to Boston. Paine 146 & preceding.

²⁵ Insert date

AT&T board, former management is replaced and Vail is brought in to be CEO in 1905.

1. Theodore Vail

The telephone business in the first 20 years is mostly about Theodore Vail, who became CEO of AT&T in ___ and structured the Bell system. Vail was a systematizer. He believed in tight organization – every engineer had the same training materials and equipment everywhere across the country. [Other examples of tight organization would be useful] Decisions to expand were done in light of consistency. [What does this sentence mean?] Theodore Vail created the Bell system and made it a bureaucracy run by bureaucrats and enabled the company to deliver good service very well and become a very powerful entity. [How did his reorganization allow AT&T to become powerful? One doesn't necessarily flow from the other] AT&T basically provided better telephone service. They used that position to get the government to grant it preferential powers [such as?], which lead to the consolidation of their monopoly. So the telephone business is for the first 20 years substantially T. Vail.

Vail built AT&T into the Bell system, turning the company into a national organization that was centrally managed. He was able to buy and build equipment with large economies of scale and build uniform practices, pay schedules and rates on a national basis. Vail also created the regulatory framework,²⁶ first in the states and then nationally and ultimately at the FCC. This was a really successful intellectual scam. When encouraging and arguing for a regulatory scheme in a state, Vail insisted that the telephone business was inherently a monopoly business. It was naturally a monopoly and as such it had to be regulated because competition really wasn't feasible in the phone business and you had to have regulation to serve the public interest. That line he began articulating in the annual reports of AT&T in about '07 / '08. In the 20s, while Vail is building AT&T on this monopoly framework, the independent phone companies became more forceful, and Vail began arguing that the monopoly of the phone company was a good thing for society. Because of the good things that AT&T did and could do because of its monopoly, Vail asserted, regulation was needed to protect AT&T from competition. But those two ideas are fundamentally incompatible. A natural monopoly is an industry where competition isn't feasible. If you're a natural monopoly, why do you need protection from competitors?²⁷ Nonetheless, this idea continued until the 70s when the Nixon Administration's Office of Telecommunications Policy worked to undermine that rationale.

²⁶ Did he also coin public interest, convenience, and necessity?

²⁷ Bruce Owen's recollection was different -- Tom doesn't remember exactly, but it had to do with the time Vail said something.

Vail's mantra – one system, one policy, universal service – was aimed at the switchboard problem. When Vail coined the term "universal service," he meant that everyone should be on the same system, a nice word for monopoly. The phrase eventually came to mean that everyone in the country should have a telephone.²⁸ Vail thought that there should be one monopoly phone company because he believed that was the best way to develop a robust phone system in US.

And then after WWI, Vail's successor Gifford consolidates the natural monopoly structure that Vail had promulgated and makes some peace with the independents.

B. Radio Broadcast

0. Wireless

Impressed by Marconi's wireless coverage of the Kingstown Regatta, the *New York Herald* invited him to report on the America's Cup Race in October 1899. Erik Barnouw, *A Tower in Babel*, Oxford University Press, New York, 1966 at 13. Marconi and the directors of the Marconi's Wireless Telegraph Company, Ltd. decided to use this event as an opportunity to take advantage of business possibilities in the United States and planned to form an American subsidiary. Id.

Radio as we know it – as broadcasting – didn't happen until 1920. There was a lot of innovation in wireless and a lot of excitement about it – first wireless telegraphy and then wireless voice. But wireless voice was thought of as wireless telephony. For unexplained reasons no one really thought of wireless voice – radio – as a broadcast medium. Everybody saw it as a way to provide telephone service without wires. The thought of radio as a conduit for information and entertainment really just came out of the blue in 1920 and took off in a big, big way across the country starting in 1921.

There are three characters in the radio broadcasting story: H.P. Davis, Bill Paley, and Herbert Hoover. By the latter part of 1920s or 1930s, it had pretty much consolidated into a national system of radio stations and 3 radio networks. This was the predominant structure of radio and played an important role in creating a new thread in American mass culture. It also brought in a new dimension in advertising, which then carried over to the regulatory structure of T.V. broadcasting and became the primary industry structure for radio and television broadcasting news and entertainment pretty much as a monopoly through 1970s and then as a predominant factor into the 80s and 90s. But these

²⁸ This happened around time of 34 Communications Act.

three individuals' contributions formed an industry structure that carried over for a very long time. Collectively, the stories of these three individuals explain the creation and consolidation of the radio broadcasting business.

1. H.P. Davis

H.P. Davis at Westinghouse simultaneously developed radio broadcasting and the consumer electronics business.

Davis's contribution began in 1920 with Frank Conrad's experiments with voice transmission by wireless. Conrad worked at Westinghouse in Pittsburgh as an engineer originally on transmitters, but later on other assignments as demand for transmitters declined. Captivated by wireless, however, he created an amateur radio station - 8MK - at home, where he experimented with different ways of voice transmission. He solicited reports from people as to when they heard his station, how clear it was and how strong it was. Since he didn't want to talk all the time, he started playing phonograph records, he had his sons play piano, and had various people come by to talk. People sent him postcards, not only about the signal quality, but also asking for certain records to be replayed. At that time, there was no business of building radio receivers so the people who heard Conrad's transmissions were largely amateur tinkerers like Conrad who built their own receiver. Many were American boys who for some reason had an interest in radio. Increasingly, Conrad received cards solely about the content of his programs and unrelated to the technical aspects.

Sometime in 1920, H.P. Davis sees an ad in one of the Pittsburgh newspapers that the Horne department store is selling radio receivers²⁹ for people who want to listen to Conrad's radio transmissions. At that moment, H.P. realizes that, since Westinghouse builds radio equipment, it could sell radio receivers and it could sell more of them if it had a regular broadcast of entertainment and news material. So, he decided that Westinghouse should set up a station that has more power than what Frank Conrad has, which would create an audience of people to buy its receivers. So H.P. gets Conrad and other people at Westinghouse to build a more powerful transmitter on top of the Westinghouse plant in Pittsburgh and applies to the government for a license, which it grants. Until Westinghouse's application, no one had applied for a license for this purpose so the government came up with a way to give this license, and Westinghouse's station became KDKA.

This moment sparked the creation of the radio broadcasting industry which later became the television broadcast industry and the consumer electronic industry. The radio broadcast industry needed interesting radio

²⁹ Who built those radios?

broadcasts to encourage people to buy their technology.

H.P. gets Westinghouse to build this radio station and start a program of news and entertainment and starts selling radio receivers. So H.P. starts the station, he presumably starts building radios, and he builds a number of other stations around the country, from the midwest to northeast. Those were the first radio broadcast stations and most of those stations still exist today. WHPH in Boston and WABC in NY. In any event he starts a number of radio stations and starts making radio receivers. At this point, RCA comes into play because Westinghouse is part owner of RCA and has patents which came to be called the radio trust. Davis fairly quickly agreed to make RCA the sales arm for selling radios to the public. An agreement emerges that GE would manufacture 60% of radios sold and Westinghouse would manufacture 40%.³⁰

KPKA made its first transmission on election night in November, 1930. A few weeks later it began its regular radio broadcast, and radio as we know it emerges. Amazingly, no one had thought of this before. Though Fessenden transmitted a Christmas program, and someone on the West Coast was producing regular transmissions, they weren't thinking about making this a commercial proposition. It was either a publicity stunt (Fessenden) or personal hobby (West coast guy), not an attempt to stimulate radio sales to the general public.

H.P. largely disappears until 1926 when NBC is formed as a national broadcasting company, a network owned by RCA, and H.P. becomes NBC's chairman of the board.³¹ NBC crystallized the formation of a national network – a network provided for by AT&T.

2. Bill Paley

In the development of the networks, the characters are Owen Young at GE, Robert Sarnoff at RCA, and Bill Paley at CBS. The primary actor is Bill Paley. The three stories here – radio, the development of the networks (not sure who the actors are there), and the development of advertising on the networks as we know it (Bill Paley) – carries us up to the early '30s, when the '34 Telecom Act which consolidates the structure of the radio broadcast business.

After NBC is created, Paley picked up on the network idea and started CBS. Unlike NBC, which was owned by RCA, a company that manufactured radios, Paley's CBS did not create radios. NBC was justified partially on the grounds that it helped sell RCA radios and partially on the AT&T model of selling

⁹ Did Westinghouse sell radio receivers under its own brand for a while? Did it think it was its right to build them, exempt from the patent pool agreement?

³¹ How much of a role did he have in the creation of NBC? Was creation of the network his idea?

sponsorships.³² Paley had to make radio broadcasting a revenue producing business apart from the promotional value of selling radios and jumped into selling sponsorships and advertising. Because he was differently motivated from folks at NBC, he moved more aggressively to sell more direct advertising along the lines of what we know it today rather than the more stately sponsorships that NBC had been using. The different motivations are that NBC was expected to do more high class information and entertainment that would reflect well on parent companies and was heavily subsidized by parent companies so it wasn't under same pressure to create a stand alone business unit. So Paley led the way for the development of direct advertising. Maybe even created the model of sustaining programs. Paley sought out performers and program ideas that were more appealing to a large audience.

He built CBS in cooperation with the advertising agencies and major advertisers. He was much more aggressive than Sarnoff at NBC about allowing more and more overt commercialism in advertising.

A big part of Paley's success was that he treated radio as a commercial undertaking.³³ Whereas Sarnoff at NBC held to the view that radio needed to be uplifting and bring culture to the masses, Paley succeeded in making radio broadcasting and in particular network radio broadcasting a viable stand alone profitable undertaking based on advertising. He did that counter to the snobby elite view that this medium of the public airwaves should not be crass commercial purposes. Paley and what he was doing at that time did not mesh with the anglo-protestant perception of what responsible business men did.

Paley brought to the business the idea that you could build a commercially successful broadcast business as opposed to a broadcast business subsidized by the sale of radio receivers. RCA could justify running radio stations at a loss because they'd sell more radios. Paley wasn't in the business of selling radios so he needed to build his network to be economically viable and to do that he was more willing to accept more overt kinds of advertising. In the beginning it was sponsorships, then they started to do product placements - like the klondike ice cream singers. Then advertising crept in. The AT&T sponsorship model at WEAJ may have played a role in this but the important thing about Paley was that he built a third network by developing ways that sponsors and later advertisers could promote their products and brand name. Because of his different motivations than Sarnoff, he was always more aggressive than Sarnoff in organizing his programs so that commercial sponsors could get more and more value out of them and therefore pay more money to him. Over time this model grew into ad agencies developing programs directly in cooperation with

³² Did CBS own any stations? Tom thinks it was Westinghouse and GE that owned stations, not RCA.

³³ Paley's father ran a cigar company - he came from commercial business background.

the advertisers. Paley and CBS were always at forefront.

Paley built the economic model of the broadcast business as a stand alone successful industry with ads as the fundamental revenue source. This broadcasting model was copied 100% by television and still today most of the networks are advertiser supported.

3. Herbert Hoover

Herbert Hoover is one of the most important guys in the history of early broadcasting because he provided the regulatory mechanism, which is in large part why there are three television networks.

The radio act of 1912 said that the Secretary of Commerce must grant a license to whoever wants one. In the 1920s, both the transmission and reception technology was such that it was hard to distinguish between particular frequencies and, as the number of stations grew, there was more and more interference. Hoover at the Commerce Department believed in the cooperation of government and industry. He developed a procedure for granting licenses to broadcast stations subject to certain restrictions. I.e., a station might be able to broadcast with only certain watts of power or only on particular days or times. By working with the applicants for licenses and particular licensees, Commerce was largely able to accommodate anyone who wanted a broadcast station. There was interference, however, particularly at night. So Commerce added more frequencies which required at least new stations to adopt more precise frequency control transmitters. Adding stations with more frequencies required people to buy radios capable of tuning to particular frequencies without much interference, but the people with older radios still encountered interference. Hoover and the industry for the most part sorted that out. Radio grew v rapidly and the public interest grew –radio was an increasingly noticed phenomenon on national landscape.

Then in 192___, McDonald, the president of Zenith, moved his transmitter to a frequency that had been reserved for Canadian broadcast, saying that the government didn't have the authority to restrict it. Commerce sued Zenith, and ultimately the U.S. Supreme Court ruled that Commerce didn't have authority to refuse the company a license.

Long before the suit, Hoover had been asking for Congressional authority for the regulatory apparatus and procedures that he had created, but Congress was never able to get its act together,³⁴ either because it didn't think it was

³⁴ There is some speculation that, frustrated with Congress, Hoover encouraged Zenith to bring suit because he wanted a test case to show that he didn't have the authority to

urgent or didn't know what to do.

After the Supreme Court handed down its Zenith decision, people felt entitled to do whatever they wanted and began shifting into other frequencies. Hoover's system quickly devolved into a big mess and a previously annoying problem quickly became unmanageable.

Finally Congress got it together and created the Radio Act of 1926 which was passed in 1927. The Act provided that there would be a commission for one year to regulate and issue licenses, after which the authority would revert to commerce dept. The commission, however, was extended for several years and in 1929 was made permanent so that licensing was done by the Radio commission. The policies and procedures that Fed Radio Commission had adopted, however, were essentially those that Commerce had evolved under Hoover.

The litigation and legislation of this period illustrates that Hoover and most people believed that radio spectrum should not be owned by corporations but by government. There's a lot of reference to the public interest and regulating radio on behalf of public interest.³⁵

The Hoover story is a story of government regulation of air waves, cooperation with industry and emergence of a sound regulatory scheme under which industry grew and prospered.

One of the key elements of the Hoover policy was that to accommodate all these would-be broadcasters, they adopted a pattern of having high-powered transmitters located in certain areas and medium power located in other areas, low in other areas.

The table of allocation sets forth where stations may be located and at what power, which pretty much evolved from the stations that were already operating in the early days. The table also reflected Congress's desire that radio frequencies be equitably assigned throughout country.

Under the table, only a fraction of towns could receive 4 or more stations and that's important because when the networks were set up they naturally ran their lines where they could get the most audience. Because the LD rates that AT&T charged were expensive, the networks went to where they could get the

stimulate congress to enact a statute that explicitly governed government regulation of broadcasters.

³⁵ Where did "public interest convenience necessity" come from and when was it first applied to radio?

most people.

The first network would go to the most powerful set of stations. The second one would go to the second most powerful, using less powerful stations to fill in their audience. The third network had a different problem – it could go to the biggest cities, but finding other markets where people could hear three stations gets more important. The fifth network had a big problem because it has to run long distance cable to lots of different towns which is expensive and impracticable.

The result is that the first two stations evolve quickly, owned by NBC, followed by a third network, CBS, owned by Bill Paley. The assignment of stations and their power around the country was done in a way that was a balance of political pressures and commercial interests to reach the most people. What that produced was a scheme so that everybody could get at least one station. But from a commercial network economics point of view it was economically viable really only to have 3 radio networks. That policy / philosophy of balancing political interests and making sure everyone has radio access and the commercial theory to have more stations for more people was carried into TV with the result that there were 3 network T.V. stations.

Hoover created the scheme adopted by the FCC and perpetuated by FRC that allows commercial broadcasting to grow but constrains it to 3 networks. This gave the 3 networks a lot of economic, political and cultural power that they used in an oligopolistic way which we choose to call a monopoly.

WWI – patents, etc. – how did these come into play and why are they important to our story?

Movies – how did these come into play and why are they important to our story?

Quotes from *Bodies, Ideas, And Dynamics: Historical Perspectives On Systems Thinking In Engineering* by David A. Mindell, emphasis added by CTW for use in book.

Edison and electric power

Echoing the pattern of the railroads, electric power grew up on a similar model, though more consciously planned as systems. **Thomas Edison is hailed as a genius inventor for creating the light bulb, and indeed the light bulb has become a symbol for invention. But Edison's electric light succeeded because he designed not only light bulbs, but also a system that included generators and transmission lines.** When developing his system in the late 1870s, Edison explicitly compared it to the competitor he intended to replace: gas lighting. Edison designed light fixtures to resemble gaslights. An economic analysis of the cost basis of electric versus gas lighting led him to concentrate on a high-resistance filament, which required less current and hence smaller transmission lines than the lower resistance model his rivals were pursuing. **Edison described his invention in the physiological sense, as connected elements with current flowing between them. It was, in his words, "a system based on different inventions or discoveries, some of which have been made years before the others."** ¹⁴ Edison also organized invention in the philosophical sense, initiating many of the features of a modern industrial R&D laboratory, especially an organization devoted to a "systematic" attack on technical problems. During design, Edison clearly understood how the components of his electric lighting system interacted with each other. He was less clear, however, on the dynamics of the system, or how those relationships affected each other during operations.¹⁵ Indeed, Edison's early systems had stability problems, which his engineers solved with cut and try methods, not according to any overall model of their dynamics. For example, when the generators at the Pearl Street Station began to oscillate, the only solution was to replace them with newer ones, not to detune the system to avoid the resonance.¹⁶ **This approach worked well when the systems were simple, and even up to moderate size, and up through the 1920s, engineers conceptualized electric power systems in the physiological sense, as sets of interconnected elements like generators, motors, traction loads, or transmission lines, each of which could be designed and analyzed independently and then combined. As local networks,**

engineers could treat them as hierarchical and centrally controlled, with all power emanating from a central station. [Chap 2?]

¹⁴ Edison to Butler, February 1879, quoted in Paul Israel, 1998. *Edison: A Life of Invention* (New York: Wiley), 189.

¹⁵ Hughes, *Networks of Power*, 31.

¹⁶ Nathan Cohen, "Recollections of the Evolution of Realtime Control Applications to Electric Power Systems," *Automatica* 20 (2, 1984), 145-62.

In the 1920s, local or regional power networks connected into national "grids" or "superpower" systems. Hughes has pointed out the importance of "load factor," as electric power systems expanded to equalize their average and peak demand.¹⁸ No longer could individual systems be considered only as the power emanating from the station in the center of town. Now a system might incorporate a varied residential and industrial loads, coal-fired plant, and a hydroelectric station miles away – and connect to similar networks over a long transmission and tie lines. These new networks began to exhibit behaviors that could only be understood by looking at the system as a whole.¹⁹ Stability problems with large, interregional electric power networks drove engineers to study the characteristics of large-scale power networks as complete entities, and to conceptualize them as systems in the dynamic sense.

This new approach was exemplified by a young electrical engineering professor at MIT, Vannevar Bush, who sought to bring a variety of systems under a single quantitative model. In his 1929 book, *Operational Circuit Analysis* Bush applied Heaviside's operational calculus to model systems of varying types. Bush noted that across fields in engineering like hydraulics,

¹⁷ Ronald Kline, *Steinmetz: Engineer and Socialist* (Baltimore: Johns Hopkins University Press, 1992). Hughes, *American Genesis*, 161-175. While Steinmetz had the vision, G.E.'s research laboratory was headed by Ellis R. Whitney, a chemist, and focused primarily on physical chemical problems related to electric lighting.

¹⁸ Hughes, *Networks of Power*, 218-21.

¹⁹ See Committee on Power Transmission and Distribution, "Annual Report," *Trans. A.I.E.E.* 46 (June, 1927). For a general review of the subject of power system stability, see C.L. Fortescue, "Transmission Stability: Analytical Discussion of Some Factors Entering into the Problem," *Trans. A.I.E.E.* 26 (February, 1927), 984-994 and discussion 994-1003. Frederick Terman, "The Characteristics and Stability of Transmission Systems" (Sc.D. diss., MIT, 1924). Vannevar Bush, "Power System Transients," *AIEE Trans.* 44 (1925), 229-30. C. L. Fortescue, discussion of Bush and Booth, "Power System Transients," *Trans. AIEE* 44 (February, 1925), 97-103. This discussion, from six commentators, provides a good overview of the state of the stability problem in 1925.

In the other new large technical system of the early twentieth century, the telephone network, engineers used the language of systems more explicitly than in electric power. AT&T chief Theodore Vail's famous motto "One policy, one system, universal service," captured the

company's totalizing view, though its network was composed of vast numbers of small, interconnected units. Within AT&T, engineers referred to their national network as "the System," and beginning in the 1920s the company had job titles for "System Engineers" and a "Systems Development" department. Yet these were not systems engineers in the modern sense; they did not have an abstract view of the system, nor did they manage a variety of subsystems. Rather, system engineers at AT&T concentrated on the concrete manifestations of the networks: the equipment layouts, power systems, and wiring diagrams for local substations.²³ The system was physiological, a thing, emanating from central switching stations.

²⁰ Vannevar Bush *Operational Circuit Analysis* (New York: J. Wiley & Sons Inc.: 1929), 1-2. John Carson, *Electric Circuit Theory and the Operational Calculus* (New York: McGraw-Hill: 1926).

²¹ For more detail, see David Mindell, *Between Human and Machine: Feedback, Control, and Computing Before Cybernetics* (Baltimore: Johns Hopkins: 2002), Chapter 5.

²² Bernard Carlson, "Academic Entrepreneurship and Engineering Education," and Alex Soojunk-Kim Pang, "Edward Bowles and radio engineering at MIT, 1920-1940," *Hist. Stud. Phys. Bio. Sciences* 20 (no. 2, 1999), 313- 337. Christian Lecuyer, "The making of a science based technological university: Karl Compton, James Killian, and the Reform of MIT, 1930-1957," *Historical Studies in the Physical Sciences* 23 (1), 1992, 153-80. Larry Owens, "MIT and the Federal 'Angel:' Academic R&D and Federal-Private Cooperation Before World War II," *Isis* 81

As Bell Labs founder Frank Jewett told the National Academy of Sciences in 1935, **"We are prone to think and, what is worse, to act in terms of telegraphy, telephony, radio broadcasting, telephotography, or television, as though they were things apart. When they are merely variant parts of a common applied science. One and all, they depend for the functioning and utility on the transmission to a distance of some form of electrical energy whose proper manipulation makes possible substantially instantaneous transfer of intelligence."**²⁶

²⁶ Frank B. Jewett, "Electrical Communication, Past, Present, and Future," Speech to the National Academy of Sciences April, 1935, reprinted in *Bell Telephone Quarterly* 14 (July, 1935): 167-99.

for the \$7,500,000 advanced on one year notes, due January 10, 1902. Before January, 1902 arrived, when President Fish showed some reticence about accepting Coolidge's plans concerning this \$7,500,000, several interesting events occurred.

In March, 1901, there occurred an enigmatic correspondence in the President's File of the American Telephone and Telegraph Company which suggests that overtures were made to that company to add new names to its Directorate, coupled with a suggestion as to the probable influence which might be brought to bear upon the Gould-Western Union interests, affiliated with the Stillman-Rockefeller group, which had previously threatened the Bell domination. The letter, dated March 22, 1901, was addressed by the President of the Bell Company to W. M. Crane, and stated, in full: 303

I wish to acknowledge your favor of the 20th instant and to thank you for the information about Mr. Morgan's holdings in the W. U.

As we are not all of one mind here at present about this particular matter we have decided to allow it to stand over, and the directors will probably be the present board.

W. M. Crane later did become a director of the company (on March 18, 1903) but not until after the Baker-Morgan group had acquired a substantial stockholding in the American Company, as will subsequently appear.

F. P. Fish had assumed the presidency of the American Company in 1901, following the death of former President Hudson. 304
An envelope in the President's files, 305
containing a letter, had the following inscription:

T. N. Vail

Copy of his views on the general policy which should govern the Company etc., etc., as written to Gov. Crane about the time Mr. Fish became President. *

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- * 303. American Telephone and Telegraph Company, President's Private Letter Book No. 1, letter, Alexander Cochrane to W. Murray Crane, dated March 22, 1901.
304. Alexander Cochrane served as President for the nine-month interval between Hudson's death and Fish's election. (Cf. American Telephone and Telegraph Company, President's Letter Book No. 14, letter, John E. Hudson to Gus G. Coulter, dated September 17, 1900, and No. 15, letter, F. P. Fish to Hans Liebreich, dated July 2, 1901).
- * 305. American Telephone and Telegraph Company, President's File No. 18348, letter, T. N. Vail to W. M. Crane "about" July 1, 1901.

T. N. Vail had been identified with the company early in its career, but had resigned in 1885 because, as he stated in his letter of resignation: 306

My present position in the company is not such as I had hoped to attain and is also in some ways embarrassing and unpleasant.

The letter enclosed with Mr. Vail's letter to Crane broached the proposition that the American Company needed new and larger financial backing:

These views on the general policy which should govern the company, I recognize are, for the most part, plans which have been discussed and recognized by all who have devoted thought and attention to the business,-- all that is new arises from the new conditions.

* * * * *

The financial policy of the Company has been recognized as deficient from the time when the financial requirements of the company first covered extensive subscriptions to the stocks of the licensed companies, and the construction of extensive systems of lines.

The existing hand-to-mouth policy results wholly from a dread that the managers of the company had of acknowledging either to themselves or to the Public the full requirements of the business, and the responsibilities of the company for these requirements. The results have been unfavourable to the business. There has also followed a lot of surprises in the raising of new money which have affected the prices of our shares, sometimes favourably and sometimes unfavourably....

The knowledge that \$250,000,000 would be required in the natural development of our business in the next five years, coupled with the fact that it would be used in the necessary and legitimate extension of the business, and that it would all be revenue producing would not affect the shares of the company half so unfavourably as an unexpected issue of \$10,000,000 each year.

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INCREASE OF BUSINESS & FINANCIAL POLICIES.

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The worst of the opposition has come from the lack of facilities afforded by our companies,-- that is, either no service, or poor service. For this, circumstances beyond control are to a great extent responsible, as it was, in the early days, very difficult to provide money.

To meet these increasing demands, increasing amounts of money will be needed each year. A low estimate for the next five years would be \$200,000,000 -- every probability points to a larger sum.

These demands necessitate a broad financial policy covering a period of no less than five years....

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probability
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306. American Telephone and Telegraph Company, President's File No. 2304, letter, Theo. N. Vail to President Wm. H. Forbes, dated May 29, 1885.

The Company, having a tendency toward and desire for a monopoly, should be abundantly prepared to assume the obligations, and discharge the responsibilities of its position.

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ORGANIZATION OF OPPOSITION.

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With the growth of opposition, will come, in fact, has come, to a certain extent, connection, cooperation, consolidation or absorption with or by each other. Steps should be taken at once to anticipate and prevent any further work in that direction. Doubtless, different methods will be necessary in different sections, but generally, steps should be taken to control absolutely important central positions, to consolidate in the interests of our own company, sections which naturally gravitate to each other, either by an independent organization, representing toll or connecting lines wholly in our interests; or one with natural affiliations, working in harmony with our company, either with or without an understanding. In all these cases, care should be taken that a maximum of control be obtained by a minimum of concession.

Following these indications of at least strong suggestions to President Fish on the course he should pursue, the maturity date approached for the one year notes given by the Erie company for the \$7,500,000 advanced in January, 1901, by the Old Colony Trust Company "and its associates". On December 26, 1901, President Fish wrote to T. Jefferson Coolidge, Jr., Chairman of the Board of the Old Colony Trust Company, in which he stated, in part:

The suggestion that you and Mr. Winsor* have made, as to the terms under which the American Telephone and Telegraph Company is asked to put up \$7,500,000. of the \$9,000,000. due January 10, does not commend itself to us. We are under no obligation to intervene in the matter of meeting the notes, and cannot be expected to come into that situation except to an extent and in a way that is quite reasonable. Having made our arrangement with Mr. Winsor, we are, of course, committed to the reorganization on the proposed basis, and intend to co-operate as far as we may safely do so to bring about the desired result. The difference between you and Mr. Winsor on the one hand, and ourselves on the other, is, that what apparently seems to you a reasonable burden for us to assume, appears to us to be unreasonable.

(*Of Kidder, Peabody & Company)

Following this objection by Fish to the proposal that his company advance \$7,500,000. to repay the notes on which Old Colony and its associates had advanced

307. American Telephone and Telegraph Company, President's Private Letter Book No.1, letter, F. P. Fish to T. Jefferson Coolidge, Jr., dated December 26, 1901.

funds to the Erie company, there must have been an arrangement made which was satisfactory to Fish, for the notes were taken up promptly ³⁰⁸ under plans approved by the ₃₀₉ Bell company.

The precise reasons why President Fish of the American Company may have withdrawn his objection to advancing the \$7,500,000 are not indicated by the available records, but within sixty days plans had been completed whereby the American Company received \$7,675,000 from the sale of 50,000 shares of its treasury stock to George F. Baker and his associates, who included J. P. Morgan and Company and T. Jefferson Coolidge of the Old Colony Trust Company, to whom the above quoted letter was addressed.

Before continuing with this episode, in Chapter VI, a description will be given of the efforts of Messrs. Coolidge and Waterbury, through the Postal Telegraph system, to obtain control of the telephone and telegraph communications industry, in the following chapter.

Fisher?

308. Commercial and Financial Chronicle, Vol. 74, p. 98.
309. Ibid., Vol. 73, p. 1359.