CONNECTING A CONTINENT:

AT&T and the Broadcast Networks

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This is a second update of the original work dated October, 2013. The most important changes include:

1) The strengthening and expanding of a good deal of factual information, including further research and follow-up on comments and suggestions offered by readers of the original work. Thank you for your input!

2) The rebuilding of drawings and the addition of illustrations and URLs to offer deeper understanding.

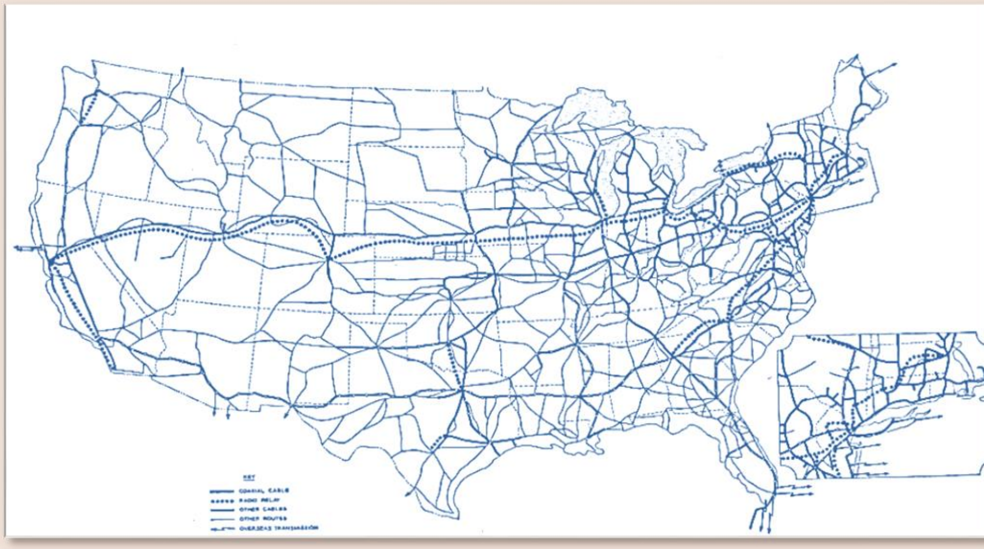
3) The transfer of deep technical detail to the last chapter where it becomes a technical addendum. (This should make the story easier to follow and should make it easier for those not interested in such detail…while offering deep technical detail for those who *are*.)

4) The original URLs pointed to an older website. These hot buttons have been repointed as of April 2021.

5) The document has been reformatted and may be easier to read.

To supplement the material referenced throughout, we're fortunate to keep turning up fresh information online. New web sites appear almost daily containing scans of the trade magazines, literature and correspondence involving the subject under scrutiny (one of the most useful is *WorldRadioHistory.Com*).

Hopefully the changes will be useful!



"Everything that once was wireless is now wired. Everything that once was wired is now wireless." *- Rodney E. Nilk*

About four years ago, inspired by a piece by James O'Neal in *Radio World Magazine* I came to realize that, while many of us grew up in a broadcast industry created in part by AT&T, there's been no easy access to the full detail of AT&T's contributions. Furthermore, those with first-hand experience in an earlier analog world were retiring and the heritage of experience with AT&T methodology was being lost. This is unfortunate, since AT&T's pioneering helped form the practical electrical world in which we operate today.

It's also true that there's a body of curious folks who wish to know more about these bedrock principles and learn about a company that was such a force in early commercial broadcasting. This work is the first step in satisfying that curiosity. We'll drill down into early telecomm history (before there was an AT&T) and we'll learn how "The Telephone Company" was born, matured and made its bones in radio and radio-network transmission.

In its first half-century of service, the American Telephone and Telegraph Company developed connectivity-by-wire to every home and business in the country…and then used that wiring to expand the reach of the radio networks that rode the copper to national coverage. These achievements helped lead to the homogenization of America, when regional boundaries fell and the nation began to experience common community. That common community evolved because citizens could now talk with one another beyond the back fence.

This e-book is a multi-media presentation of honest business effort and anti-competitive practice, vision and pragmatism, technical innovation and practical reality. We fight the temptation to view this history in the light of today's knowledge, and we attempt to define developments in the context of their time. We end around 1945 when wirelines were about to be overtaken by microwave radio and "The Coaxial Cable."

e-Outline

In **Chapter One** we follow communications from the "state of the art" of 3000 BC to the patent pool of 1919, reviewing early technical and business developments that moved us to the world of speech-over-wire. Next: "Wired Radio" pre-dated broadcasting by almost a half-century; we'll look at those early efforts and learn how the telephone became the nexus for early telemarketing and political messaging. And we'll learn how a new "AT&T" was founded out of the explosive expansion of the telephone industry…launched with the goal of *connecting the continent*.

In **Chapter Two** the story turns to "Wireless" and to how AT&T developed the wired/wireless interface that led to radiotelephony and "Broadcasting." We examine the milestones that were stepping-stones to today's mass media, and peer inside AT&T at the company's *culture,* as the telco approached the new medium of "Radio."

Chapter Three concerns AT&T's "broadcasting experiment." Here are outlined the advances in network expansion and long-distance radio-program transmission. Chapter Three ends with AT&T's move out of radio broadcasting and back to its core business.

In **Chapter Four** we track the evolution of the radio networks, including little-known detail on the networks' activity on the Pacific Coast.

Chapter Five discusses the alternatives to AT&T available at the time. Long Lines transmission was expensive and broadcasters sought other options. We'll learn how Short-Wave was used for simulcasting and for inter-continental audio links.

Chapter Six takes an *operational* look at how AT&T and the radio networks handled multi-channel radio traffic on the national system. We also learn how AT&T transmission standards evolved (explaining the evolution of the famous "VU meter.")

Chapter Seven is for the technically interested; its deep detail takes us into the wire offices and development labs where the electrical aspects of long-distance transmission were refined and implemented. We witness AT&T's 'perfection' of wire performance while Long Lines searched for an amplifying system that would make transcontinental telephony a practical service. And we rubberneck as AT&T developed "high-fidelity" multi-channel audio transmission through the use of "Carrier."

e-Foreword:

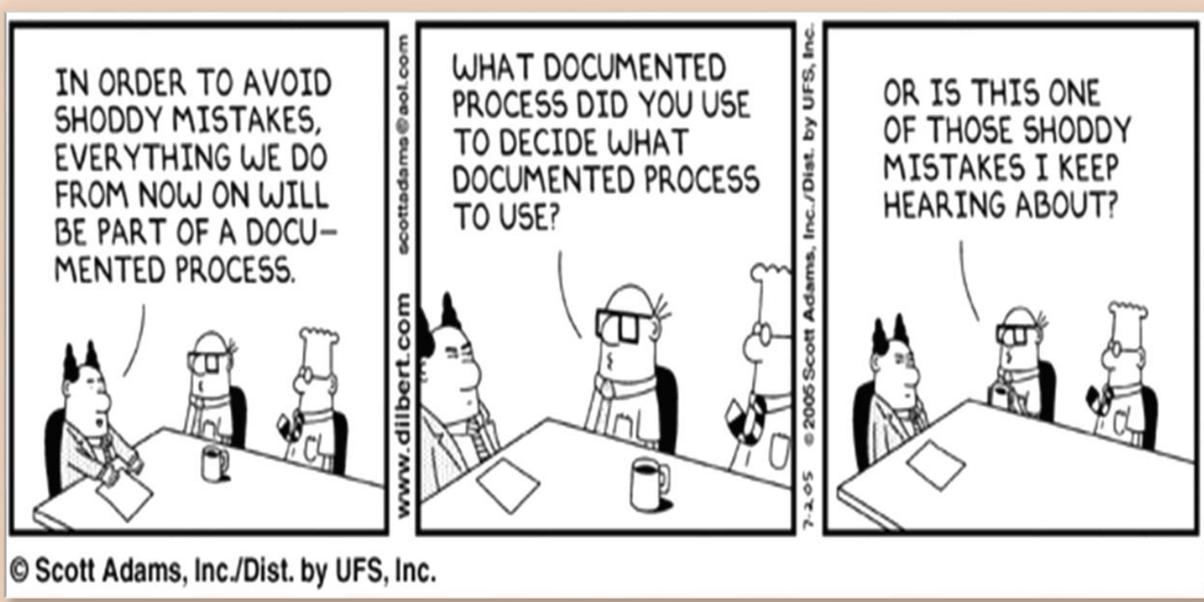
AT&T went through several distinct development phases, after a business reformation in the early 1900s led to a re-commitment to core operating principles. That first decade was when it all began to come together. As the company grew its service obligations, the Regional Bell Operating Companies ("RBOCs") were established as the first- and last-mile service legs (aka: "network-to-customer nodes"). **'End-to-End Service'** would become the watchword.

Through it all, AT&T worked to defend its monopoly status, to ensure deployment risks were mitigated. After all, the company was leading a field in which the stakes were incredible and the fighting was at best described as "distasteful." It wasn't until the acquisition opportunities of the Depression years that AT&T became "Too Big to Fail."

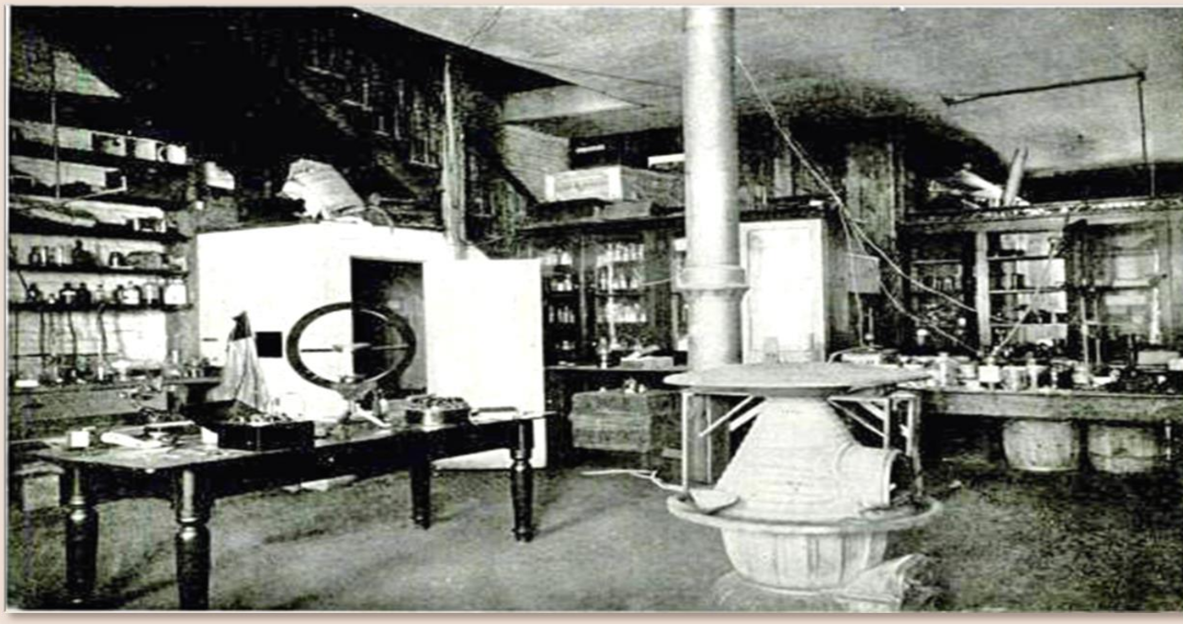
This history looks at two intertwined aspects of AT&T:

I. AT&T as a telephone-technology company

AT&T took a singular approach to technology: First, the research teams theorized, designed and tested improvements in the labs, and only then was field implementation authorized. This was a marked departure from the Edison-centric methodology of "try this; then try that, until we hit on something." At AT&T, formal operating procedures were published and fine-tuned after extensive experience in the wire offices, and then documented as ***Operating Practices***.



The first labs: AT&T's early technology research was centered in Boston:



Bell Laboratory: Boston, 1880s From the Bell Labs Record

AT&T "wrote the book" on electrical practice for audio transmission during the wire-line development period from 1890 forward. Much of that basic knowledge base is still applicable a century later. That's another reason this history is relevant.

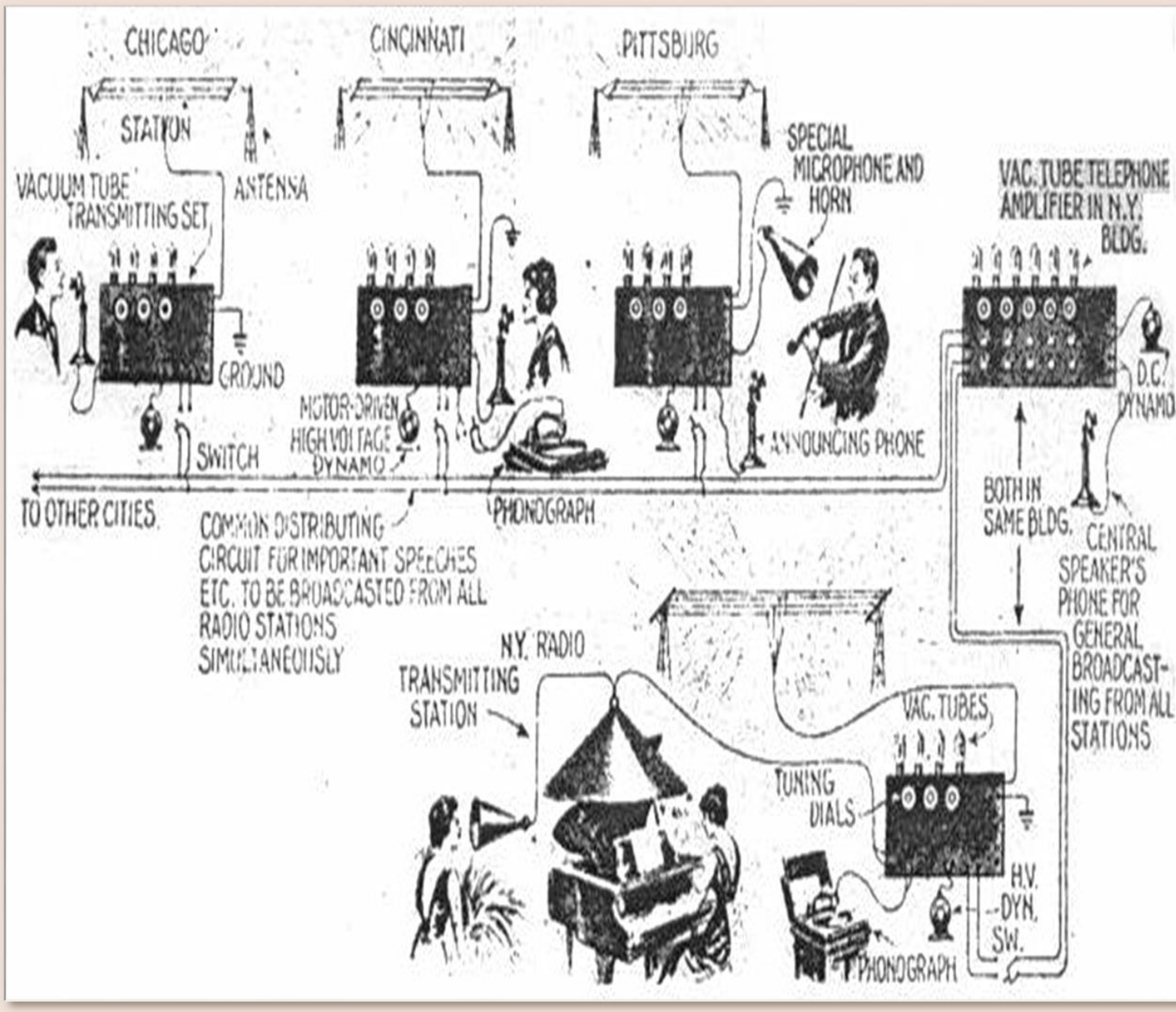
II. AT&T as a "Broadcaster"

AT&T introduced *commercial* broadcasting while building the long-distance network backbone. They weren't first off the mark in radio but their agreements with other communications giants gave them, as we'll see in chapter Three, a presumed right to the exclusive use of airwaves for commercial broadcasting.

Here's where these two identities merge: It was obvious from the onset of broadcasting in the United States that radio's political and commercial success would be measured by audience reach. The ideal goal of course would be for *each* station to touch *every listener* in the country. But it was clear that, given the physics of the assigned Medium-Wave (or Long-Wave) radio bands, no single radio signal could do this; the country was too big. Multi-station collectivity would be needed. This "station-grouping" idea was driven by a clear business fact: costs were reduced when programming expenses could be shared with other stations. At the time, the only practical solution was *station-to-station connectivity by wire*. And the only wire system capable of doing the job was owned by AT&T.

AT&T was at first the 'dog in the manger' regarding such inter-station connectivity. Then, when it suited its purposes, became a full-fledged player in building out the radio networks for others.

The early attempts at program networking were ground-breaking, yet seem almost naive when viewed through today's fiber-optic periscope.



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Throughout this living work you'll find references, illustrations and hot-links. Citations will follow each quotation rather than lurking in the rear of the document. Mistakes in the non-quoted copy are purely mine and your comments, corrections and updates are welcome.

We hope it makes interesting reading!

CHAPTER ONE

"Well-informed people know it is impossible to transmit the voice over wires. Even if it were (possible), it would be of no practical value." – *The Boston Post, 1865*

"Wide-area networks" go back a long way: 3,000 years for homing pigeons; 800 years for Genghis Khan's version of the Pony Express. 2000 years ago "long-distance" communications meant signal fires; then it was carrier pigeons and, in the Olympic Period, marathon runners. Visual (semaphore) relays were used along coastlines a thousand years ago. Simple messages took a few hours to travel from country to country; additional weeks and months *within* those countries.

In the 1700s a crude semaphore network with basic signaling protocols was established across Europe and parts of America. "Code books" were used; not for security but so that entire sentences could be transmitted by a few code words. The estimated speed of these links was about fifteen characters per minute. "The non-electric telegraph was invented by Claude Chappe in 1794. This system was visual and used semaphore, a flag-based alphabet, and depended on a line of sight for communication." *About.com*

Messengers and sight-line signaling gave way to electrical communications in the mid-1800s. First was a communications development that required *third-party intervention* (the telegraph); then we advanced to telephone technology that permitted human-to-human conversation *without* intervention. Gradually a vision arose: If we could talk 'one-to-one,' why could not a single communicator reach a *mass audience*? This might be possible using a communications *network*.

Sociologists view a *network* "in terms of the integration of people, of culture, of the world. Well before radio networks discourses of progress, integration and modernity were linked to telegraph, telephone, railroad and electricity networks. Radio networks extended this logic of interconnection leading to modern progress, and those who were judged to be outside of the radio nation were considered primitive and lacking." *Alexander Russo*: "Points on the Dial"

Telegraphy: A "Disruptive Technology"

The first workable telegraphs did not evolve from a Eureka" moment on Sam Morse's workbench. "In 1830, an American, Joseph Henry (1797-1878), demonstrated the potential of Brit William Sturgeon's device…by sending an electronic current over one mile of wire to activate an electromagnet which caused a bell to strike." *About.com* (Sturgeon had invented the electromagnet in about 1825.)

"Another…electromagnetic telegraph design was created by German diplomat Pavel Schilling in 1832. He set it up in his apartment in St Petersburg and demonstrated the long-distance transmission of signals by positioning two telegraphs of his invention in two different rooms of his apartment. Schilling was the first to put into practice the idea of a binary system of signal transmissions. *Wikipedia* (underlining added)

In the 1830s the British team of Cooke and Wheatstone developed the "Needle Telegraph." It was a strange, 'Ouija Board' -type device in which the receiver pointer moved to the display of a letter that had been selected at the transmitter end. One imagines how cumbersome this must have been, but it was the best they had, and it transcended visual signaling. The needle telegraph was immediately obscured by the electrical telegraph, but for its time it was the state of the art. (Cooke and Wheatstone themselves went on to adapt prior technology in developing an improved electro-magnetic version of the needle telegraph.)

In the mid-1830s (date depends on historian cited) Samuel Morse advanced Joseph Henry's work to design the electromechanical signaling device he named the "Recording Tele-graph." (He was working with a man named Alfred Vail (cousin to the Vail who would later become President of AT&T). In 1838 Morse and Vail developed a "standard code" for the on-again/off-again nature of his signaling. The "Morse Code" was, in essence, the first digital algorithm.

After some years of testing, Morse received a grant from Congress to install a test telegraph wire between Washington and Baltimore. On May 24, 1844, Morse sent a message from Washington to Vail in Baltimore: "What hath God wrought!" The first commercial telegraph circuit came up between Washington and New York in 1846. Long-distance communication by wire was born.

An interesting parallel in today's world is the *texting* explosion and its own sociological impact. In writer Kurt Andersen's heyday (in a story written about 1848), the protagonist says "He watched the agent tap away in Morse's code, musing: "when telegraphic keys were common appliances, as the Wall Street promoters insisted they would someday become…installed in every house and shop from Maine to Texas…*might this funny new telegraphic style become the ordinary way of writing…and even speech? Every document and conversation pared and crushed and minimized?"* WOW!

Three scrappy enterprises competed in legitimate telecommunications development. They were the **Bell Company**, **Western Electric** and **Western Union** (nee: "The New York and Mississippi Valley Printing Company"). These companies would integrate, separate, battle, marry, divorce, re-marry…each playing an important role in communications technologies.

Western Union

A few years after the telegraph went into operation a group of entrepreneurs pooled resources to form the Western Union Telegraph Company. The components of the company included 'Outside Plant' (poles and wire-laying), 'Research and Development' and 'Sales/Marketing.' "Telegraphy became big business as it replaced messengers, the Pony Express, clipper ships and every other slow-paced means of communicating. The fact that service was limited to Western Union offices…seemed hardly a problem. After all, communicating over long distances instantly was otherwise impossible. Yet as the telegraph was perfected, man's thoughts turned to *speech over a wire*." *Tom Farley's Telephone History series* (italics added)

The first baby step in transmitting that *'speech over a wire'* was taken in 1876, when Alexander Graham Bell announced the "speaking telephone." (And now we're getting ahead of our story.)

By the mid-1800s, Western Union was scrambling to cross the continent with telegraph wires. Congress passed the Pacific Telegraph Act in 1860 (President Lincoln wanted to establish commercial communications with California and Oregon to keep them in the Union). Western Union opened the first transcontinental telegraph line in 1861. It was a big deal. Railroad rights-of-way were used for telegraphy where possible (construction was easier on the roadbed, access for maintenance was simplified…and the railroads availed themselves of the wire for their own communications).

In the boxing ring: "Round One"

In the decade 1851-1861, the number of telegraph stations in the U.S. skyrocketed from 51 to 2,250. Western Union now faced off against **American Telegraph** and **United States Telegraph** in the fight over who would be the biggest bully in the sandbox. When Western Union bought out the other two in 1856, it became the largest monopoly in the country. (It wasn't the *only* monopoly: on the news-gathering side the Associated Press had hundreds of affiliates and a choke-hold on news distribution.)

As for Western Union, it certainly didn't hurt matters that the company had friends in the post-Civil War administration. The government deeded to Western Union some 15,000 miles of circuits that had been built for war operations. By the mid-1870s, Western Union telegraphy reached every population center in the country.

Western Electric

The telegraphy business needed a strong player in the design and manufacturing arena. Enter Elisha Gray, an Electrical Engineer and college Physics professor with an interest in long-distance communications. (Gray in fact had developed his own version of the telephone and narrowly lost out to A.G. Bell in the patent application…see below). Gray was looking for shop support and came across a fellow named Enos Barton; himself in the employ of Western Union as a new-product evaluator and quality control specialist. Barton saw the potential of Gray's work and he and Gray married their interests in 1869. A third partner in this new company was Anson Stager, a former Union General and Western Union telegraph operator. His ties to Western Union opened the door to investment by that monopoly. With Western Union's cash in hand, the partners opened their doors in Chicago in 1872 as **The Western Electric Company**, and they became the principal supplier to Western Union.

Bell Telephone: 'Can you hear me now?'

1876 was a watershed year in communications. The real money was being placed on the development of a "multiplex telegraph" (though multiplex telegraphy wouldn't see a commercial rollout until 1913). Several inventions purporting to enable multiple telegraph messages on the same line were on exhibit in "The White City" Exposition in Philadelphia; if you spent a few hours at that 1876 Exposition, you marveled at the progress of Mankind. You could see the new invention being credited to Alexander Graham Bell (and only reluctantly displayed by him) that sent *speech* over a wire. (Bell's primary exhibit featured a "*harmonic" approach to multiple telegraphy*. His idea was to create audible signals, each of a different "sound," for multiple "tuned receivers" to decode.)

Now some controversy (always good in a story): We know that the telephone patent came down to a last-minute race to the Patent Office between Bell and Elisha Gray. I wasn't aware of the purported Machiavellian machinations behind the applications until reader/historian David Dintenfass offered this: "Recent research suggests that it was Gray—and not Bell—who invented the liquid transmitter of 1876. See *Shulman, Seth, The Telephone Gambit: Chasing Alexander Graham Bell's Secret, Norton, 2008.*

Shulman makes a convincing argument that Bell stole a key aspect of his design…the liquid transmitter…from Elisha Gray. Shulman did a lot of research before reluctantly concluding that *Bell may have been shown Gray's invention by a patent examiner in February 1876*…at which time Bell modified his own patent application to include such a liquid transmitter. Bell's lab records also show that, prior to that visit to the Patent Office in February, he had done no work on such a liquid device. Shulman points out that Bell's lab notes record his return from Washington on March 7th 1876…"whereupon work began immediately on a liquid transducer."

(Technical readers will know that the 'liquid transducer' was a form of "variable resistance." Whether Bell and Gray came up with the idea *independently*…or Bell brought Gray's idea home…variable resistance was the breakthrough.)

To Bell's credit, once he had the idea in his lab he immediately made it work (as related in the famous "Watson call" of March 10, 1876). Why no outcry from Gray? Gray's attention was on the multiple telegraph.

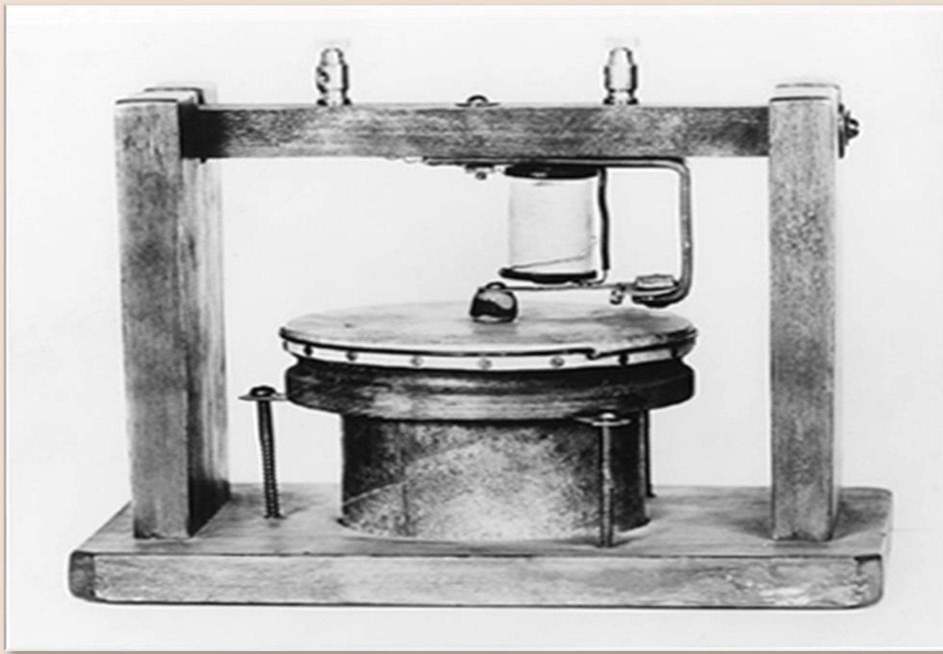
Further review snips on the 'controversy' are found here.

A 22-minute NPR story on the inventor-allegations can be heard via this hotlink.

No matter; Bell's name will forever be 'connected' to the telephone patent. But that honor might also have gone to Germany's Philipp Reis…who built and demonstrated a "telephone" in 1863. Reis's invention created the modulation through a vibrating element's intermittent contact that interrupted a current flow.

Sound-Sidebars: 1) Sound archivists have recently discovered a recording of Alexander Graham Bell's voice, recorded in 1885. *Smithsonian Collection*

2) Here's a great story about how Bell developed his "voice-over-wire." We invoke a century-old recording of Thomas Edison, himself a good friend of Bell's. Edison's reputation as a credit-hog is refreshingly absent. Edison speaks into the horn.



A “Tele-phone”

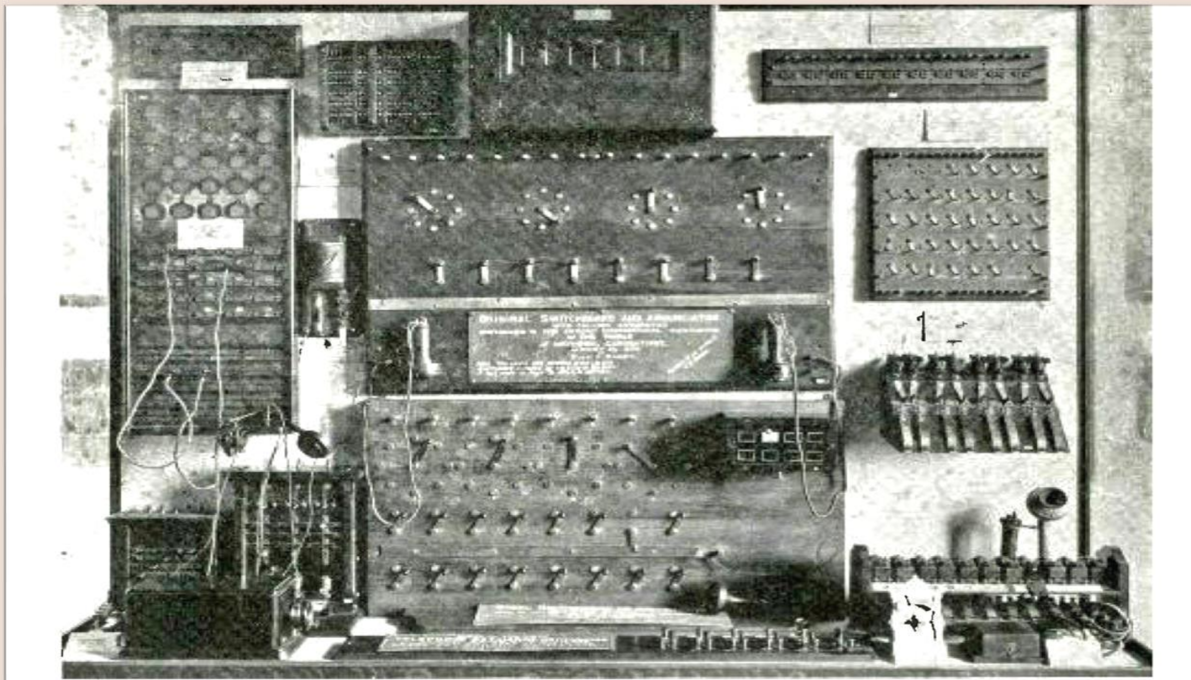
“Hello Central”

“Station-to-station” technology quickly developed to the point that instruments could be connected to each other, and the focus turned to building out the needed wire paths into an interconnected “network” so that any instrument could be *switched* to any other. The logical approach was to treat all telephone instruments as compatible devices hard-wired into a “star” system. The star system lent itself nicely to a core “server” that was really a cross-connecting switch (nee: manual switchboard), central to the telephone serving area. Thus were developed “wire offices” (“exchanges”)…the hub of the “star”…that terminated all subscriber lines and provided the switching to connect any telephone to any other.

In this early telephone world, the distance from the core of the star to any outlying instrument (hence ‘the wire office serving area’) was limited by the efficiency of the device and the loss in the connecting lines. It was typical to expect about a 20 mile useful range; this limitation drove the architecture of local telephony for years to come.

Following the success of the Philadelphia Exposition, A.G. Bell and partners Tom Sanders and Gardiner Hubbard (a wily entrepreneur who became Bell’s Father-in-law) formed the Bell Patent Association and continued to file and perfect their applications.

The partners opened "The Bell Telephone Company" on July 9, 1877 and offered licenses to any company willing to play by their rules (and pay a license fee). The New England Telephone Company emerged, offering a novel plan under which subscribers *leased* rather than owned their instruments. The first "telephone exchange" was brought on line in New Haven, Connecticut in 1878.



Early telephone switchboards: upper center, one installed at Meriden in 1878; at its left, one of the "universal" boards made by the Western Electric Manufacturing Company. This board used the "jack knife" switch.

Once the genie was out of the bottle, the clamor arose for connectivity *between communities* (anything outside the reach of the local wire office was considered 'long-distance.') There were also <u>standards</u> issues to be enforced: the requirement that all telephones be able to work with all other phones and with the networks connecting them. At times during the "Wild, Wild West" of free-for-all telephony, these seemed insurmountable obstacles. But, as with any disruptive technology, the evolution was too big to be contained and problems were resolved. The demand detonated; the number of telephones (and wire offices) increased exponentially. Hundreds of "telephone companies" went into business.

The growth of the New England model and the need for Bell to control his invention resulted in formation of the National Bell Telephone Company in 1879 and, with it, the International Bell Telephone Company (the latter would fight patent battles in Europe).

Western Union Hubris

New England's success notwithstanding, after Bell secured the telephone patent, his firm found itself with a great idea but without the cash to pull it off. Anecdotally, we're told Gardiner Hubbard visited Western Union, proposing a sale of the telephone patent for about $100,000. Western Union meanwhile had been buying patent rights from several independent telephone companies, to form "The American Speaking Telephone Company" in 1878. Armed with a small collection of patent rights and flushed with its own success in telegraphy, Western Union rejected the Bell offer and instead bulled ahead with its own telephony plans, confident in its deep pockets and its national dominance in telegraphy.

In the Boxing Ring: "Round Two"

Bell immediately filed suit against Western Union for patent infringement. The companies settled out of court in 1879; they agreed henceforth not to compete with each other. Western Union dropped out of the telephone business, agreeing to stick to telegraphy and messaging. Bell handed its telegraph business to Western Union and agreed not to use the telegraph for general, news or business messaging. Bell purchased existing Western Union telephone assets and added a cash payment. Most importantly, Western Union recognized Bell's patents.

These dealings could only happen at a time when there were no rules for business beyond those that benefitted business concentration. In spite of the acrimonious nature of the patent-infringement settlement, Bell and Western Union again married (and divorced) a few years later.

Reader/historian Dave Hochfelder provided this recent feedback: "The story that Western Union rejected the Hubbard offer is apocryphal. I have found no evidence of it in Bell's papers, his father in law Gardiner Hubbard's papers, WU president William Orton's papers, or official WU records. I have material on this in my book (*The Telegraph in America, 1832-1920*)." My comment: This book is a good read!

Strangely, A.G. Bell himself seems to have lost interest in the telephone development cycle around this time. Shulman in his book postulates that Bell "felt guilty" about stealing the patent idea from Gray. One is left to speculate if Bell was actually a victim in all this, bowing to the pressure of Hubbard and Sanders to make it to market, and was persuaded to compromise his own rigid principles to get the telephone invention approved by the Patent Office. Much has been written about the ongoing patent fights; they endured seemingly forever since the stakes were so high. The Bell companies prevailed in nearly every case.

Early operating standards

Since "Universal Service" was a core driver in Bell's business model it was critical to set and enforce technical and operating standards. Large-scale manufacturing was needed so all the devices worked the same way. There was only one obvious manufacturer for Bell: Western Electric. General Stager and businessman visionary Theodore Vail put a deal together in 1881 and Western Electric became the provider of telephone equipment to the Bell Company.

(The tale is enriched by a footnote: while Western Electric was sole provider to Bell, it still provided equipment to the *competition*, until Bell bought Western Electric.)

Meanwhile, Western Union was facing a "Robber-Baron-era" battle of its own. Financier Jay Gould decided to wrest control of Western Union from fellow Robber-Baron William Vanderbilt. Gould announced formation of "The American Union Telegraph Company." It was a *paper competitor*…meant to dilute the value of Western Union stock.

As basic telephone patents were expiring, American Bell moved to secure its hold on the business. The company encouraged development of telephone instruments by all and so balanced its goal of complete control of the business with the pragmatic recognition that, in the developers' world, independent operators also had good ideas.

"Long Lines"

Now Theodore Vail shared a vision: He would collate the various Bell companies into a nation-wide telephone network providing "end-to-end" service, with the various Bell nodes in the network serving as the "first-and-last-mile" between network and customer. Thus, **"Long Lines"** was created. In a business reorganization to begin developing Long Lines, the National Bell Telephone Company became The American Bell Telephone Company in 1885.

A junior division of the new company called **The American Telephone and Telegraph Company** was also formed in 1885; its purpose to develop "long-distance" communications. The initial Charter: *"Connect one or more points in each and every city, town or place in the State of New York with one or more points in every other city, town or place in said State and in each and every other of the United States, Canada and Mexico; and each and every of said cities, towns and places…with each and every other city, town or place in said states and countries, and also by cable and other appropriate means with the rest of the known world."* *AT&T Files*

In 1890 American Bell published the prediction that ultimately "*the lines used in the daytime for business affairs will at night carry music, lectures, and various oral entertainments to all the cities…of the East*." *ibid* (underlining added)

Mention of "the East" reflected a population-centric mindset and recognized the reality of the cost of serving the sparsely-populated West. The concept of 'thin-route' communications was a long-term concern for investors; it reflected a mandate of franchising authority: Any company granted a license for high-density, high-revenue markets would also have to provide (more-expensive) *rural* connectivity.

Wiring the nation for long-distance telephony was an incredibly ambitious project. The first long-distance telephone circuit was turned up between New York and Philadelphia in 1886 and was an instant success. By 1892 the lines were extended to Chicago.

In building out these (unamplified) circuits, developers had to contend with single-wire plant (installed for telegraphy but increasingly unsuitable for voice). Bell knew the practical approach to lower-noise transmission was *balanced* wire-pairs; installation of *paired* circuits began in 1890 and network conversion to balanced circuits took more than 10 years. AT&T was fortunate to have the cash and resources for such upgrades.

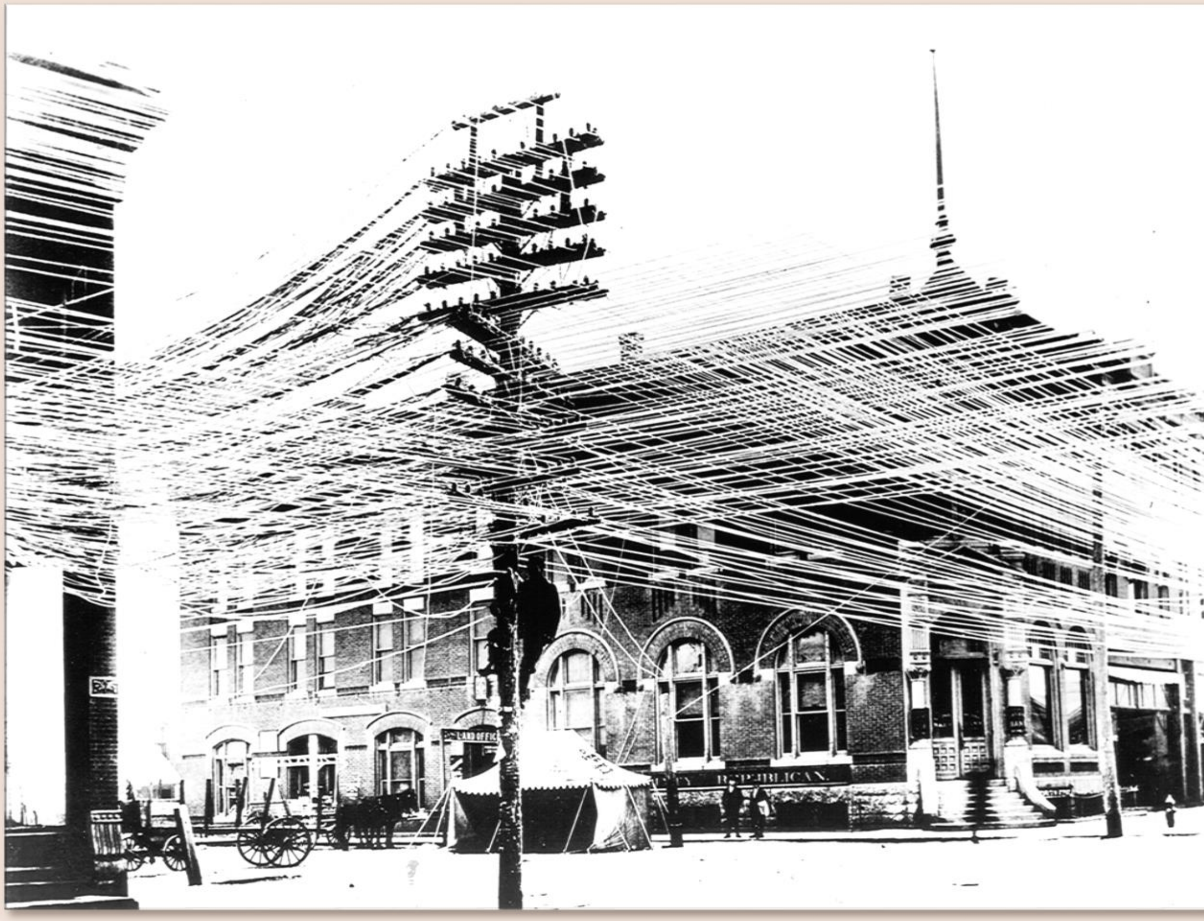
Two years after kick-starting his long-distance plan, Vail left the company, just as various telephone patents were expiring and the predictable telephone wars were heating up. Vail's vision had given American Bell a formidable leg-up in the long-distance business. He would return to guide AT&T through its developmental years.

On the last day of the 19th Century, American Bell folded itself into its subsidiary and became **The American Telephone and Telegraph Company.** Its business purpose was to provide *end-to-end* long-distance voice connectivity.

It was an enormous undertaking. "Long-distance" transport was to be addressed by network engineers and in 1911 local-service responsibility was assigned to far-flung regional groups to be known thereafter as the Bell Operating Companies.

And what a mess they found in those first- and last-mile systems! Service had been added line by line upon demand, and no master plan existed since no one could have anticipated the demand for telephones. Subscribers demanded better call performance. Most early *service* problems were found to be in the caller's equipment. (Exacerbating this situation was the lack of standards at some inter-connecting telephone companies.)

Engineers now focused on reducing electrical interference in the lines. The cause of some of the interference and the reason for maintenance headaches was apparent:



Source unknown

One solution to this mess was to get rid of overhead lines where possible. Multi-pair underground cables were deployed between New York and Philadelphia in 1906, and buried cable was soon being placed in most cities. Cleaning up these overhead quagmires was a long and cost-intensive process…with little potential for new revenue.

New uses for the wires

While Bell is rewiring and the promotions people are lining up their new image campaigns, we step back for a moment to the 1870s, to see what entrepreneurs were doing with the telephone wire beyond point-to-point calls. Futurists had begun to articulate a world of "mass communications" enabled by this connectivity. It began with new uses for the wire. From 1876 comes a report that symphonic music went down telegraph lines for the entertainment of telegraph operators along the line.

Thomas White notes: "At the 1881 Paris International Electrical Exhibition, Clément Ader demonstrated the transmission of music from local theaters using telephone lines. Ader's use of dual lines also introduced the phenomenon of stereo listening -- at the time referred to as 'Binauriclar Auduition.'" (Say that aloud.)

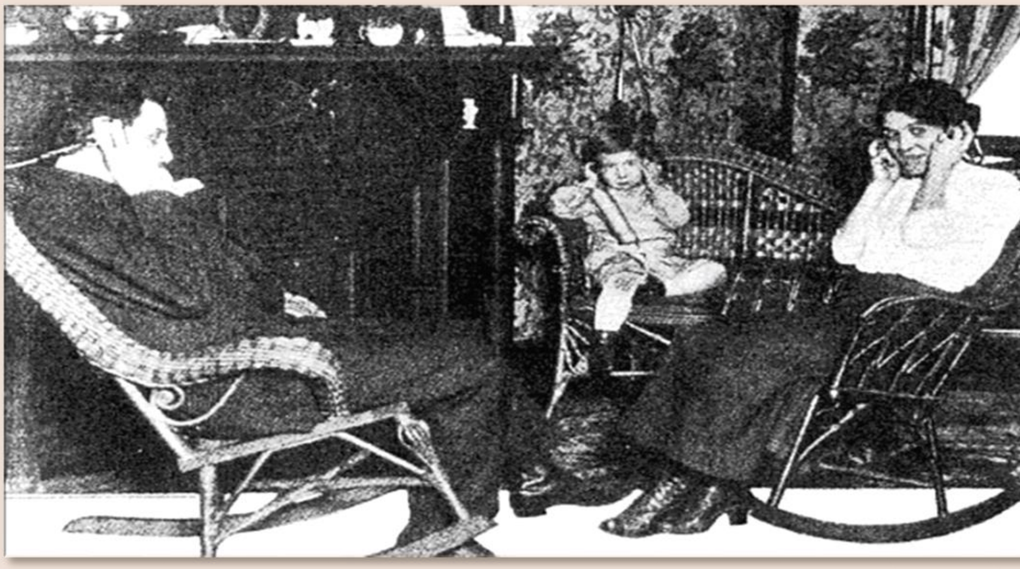
This 1881 demonstration came to be called "*The Paris Experiment*." Some time ago the BBC, in a program entitled "The Hearing Aid," reports on the Paris experiment.

"Wired Radio"

In 1893 Telefono Hirmondo, arguably the most successful telephone-based service in the world, came on the 'air' broadcasting news, weather, readings, lectures and other entertainment to some 6,000 telephone subscribers in Budapest. Reach was limited to a practical distance from the serving wire offices. Telefono Hirmondo was the most successful of the (pre-wireless) "broadcasting" attempts.

Telefono Hirmondo--Note the mouthpiece microphone!

In 1895 a telephone-based system opened in London. Queen Victoria was a listener. It was expensive and it soon disappeared. A Detroit company announced "The Tellevent" in 1907 as a news offering with music and live performances. It may never have launched. Holland reportedly had the largest wired system; some 170,000 subscribers were registered.



Because the marketing area was limited by the need to be close to a telephone exchange, wired entertainment didn't catch on in the United States. The most legitimate of the American launches was that of the New Jersey Herald Telephone Company…meant to be a model for a national system. It gained decent press and some 5,000 subscribers, but lasted only a couple of years. Demos in other areas received enthusiastic reception but not enough funding to launch.

FIRST BROADCASTERS USED PHONE

WHO were the earliest broadcasters? Ten years before the first radio programs were put on the air, a group in Chicago., Ill., regularly delivered musical programs and news bulletins over the telephone lines of many subscribers. The rare old photograph reproduced below shows these pioneers broadcasting from their studio. Each singer is holding a microphone, while other individual microphones are attached to the instruments. To listen to the music, a subscriber had merely to sit beside the telephone and hold the receiver to his ear. If he received a 'phone call while listening, the musical program was automatically disconnected.

First broadcasters used microphones attached to their musical instruments

Around 1907 one Thaddeus Cahill tried delivering organ music via telephone wires; his short-lived service was dubbed "Telharmony." It transmitted keyboard output and not the acoustic output of musical instruments. (A bit ahead of his time.)

Thomas H. White reports on "the *Tel-musici* of Wilmington, Delaware, a pay-per-play phonograph offering, where…home and commercial subscribers rang a central office to request tunes played back over their phone lines." He notes: "A short notice in the September 21, 1912 *Electrical Review and Western Electrician*…announced that a recorded music service had been inaugurated by The New York Magnaphone and Music Company…the January, 1913 *The World's Work*…emphasized the possibilities of telephone-distributed news and entertainment, declaring that "There is a talking ticker now, a machine that will entertain and instruct you for twelve hours on a stretch with the gist of the day's political speeches, baseball scores, election returns, and any other news that seems important." But this apparently was another case where the technology once again fell short of commercial success" *Thomas H. White* *http://earlyradiohistory.us/index.html* All these ideas preceded the vacuum tube!

"Wired Radio Inc." appeared around 1925, based on a patent filed in 1911 by George Squier and used 'carrier-current over power lines.' The company (AT&T was an investor) test-marketed a service in New York and Cleveland in the early 30's, and in 1935 launched commercially in Cleveland as "Muzak." After a year in Cleveland the company was moved to New York City and Wired Radio Inc. was folded into Muzak.

GROCERY STORES GET MUSIC IN "WIRED-RADIO" PROGRAMS

HOUSEWIVES in New York City are now buying their groceries to the strains of concert orchestras, as the result of a recently inaugurated "wired-radio" service being offered to hotels, restaurants, and shops. Special musical programs, reproduced from high-grade recordings in a central studio, are transmitted by direct telephone lines to loudspeakers installed in fifty stores of a large grocery chain. Between musical numbers, a studio announcer calls the customers' attention to new food items, daily specials, and exceptional values being offered. If the main office of the grocery chain decides to reduce the price of a given item, the information is announced over the store loudspeakers and the change becomes effective at once. General "wired-radio" programs, without special announcements, are supplied to restaurants and hotels in the metropolitan district by four studios, each of which is equipped with dual phonograph turntables and operates twenty-four hours a day.

An announcer reading a sales message as part of a "wired-radio" program supplied to a large chain of stores. Note new-type microphone used

At right, a turntable and control panel for reproducing specially recorded music carried to subscribers by wires

This screen-type receiver for hotel use conceals twin speakers, for both high and low frequencies

The October 1926 *Radio News* magazine related the description of entertainment delivery by RF carriers over telephone and power lines. Receivers plugged into electrical light sockets could grab the signal from the electric mains. The system was to be capable of three simultaneous program transmissions via three separate RF carriers. It never caught on. In 1932 a new form of RF-carrier service was applied with some success in Britain, Belgium, Switzerland and Holland. It was marketed against radio as: "no interference, no noise." Any radio plugged into a wall outlet picked up the signal.

In 1936 *Radio News* suggested "wired radio was catching on in restaurants hotels and nightclubs." Program offerings included wired music, ticker news and tele-facsimile. "Foretell" (flash sports news) was the chief program offering, with music used as fill material. A "Ticker News" offering was described as an 'audible newspaper.' In the evening it was probably 'all music, all the time.'

Radio News adds: "A novel part of the wired music services is that the *timing* of (musical) selections is almost identical to that of average metropolitan restaurant entertainment. For example, after a few selections there is a period of silence. This program gap simulates the intervals in the (restaurant) when the players leave the bandstand for a smoke." *Excerpts from Radio News: January 1936*   The article goes on to declare that similar setups were established in Boston and Philadelphia, Baltimore and Chicago. Muzak would embrace this "scheduled silence."

Hotel Guests DIAL for Radio Programs

This radio room, containing greatest all-wave receiving and program distributing system in world, is in Waldorf-Astoria Hotel. Panel at extreme right holds receiving equipment.

Each room has a modern loud-speaker with dials permitting a choice of six foreign or local programs. Some rooms have the dialing system shown at right, which offers a much greater variety of programs. Equipment cost nearly a million dollars.

HOMESICK foreign guests at New York City's Waldorf-Astoria hotel can now listen to radio programs from their own country, or perhaps even from their home town. At their service is the greatest all-wave radio receiver in the world—a set which can bring to each of the 2,200 suites of rooms programs from any one of the powerful broadcasting stations in the world. These programs are oftentimes heard with the same volume and clarity as are local stations.

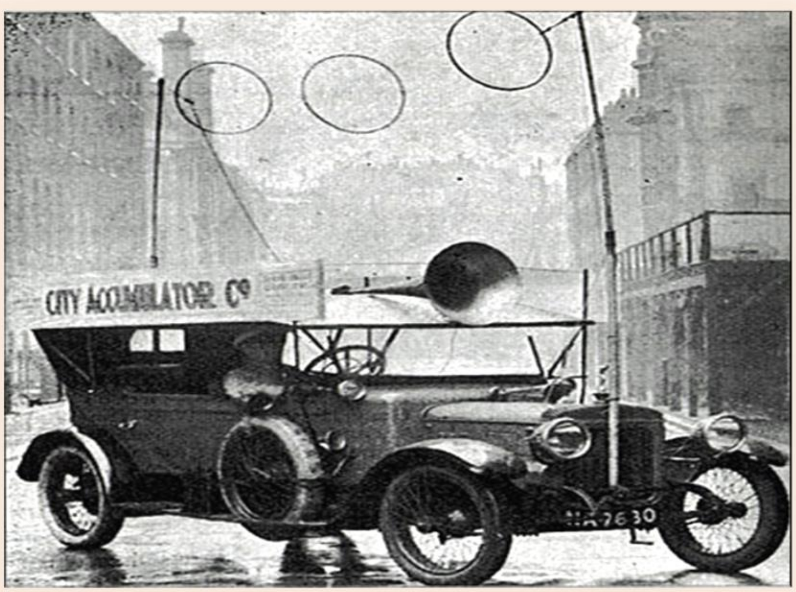
Some rooms have a unique dialing system, which permits guests to select any station they desire from a printed daily list of world-wide broadcasts, or even hear their favorite phonograph records. In other rooms there are controls on the modernistic loudspeaker, which give to guests a choice of six broadcasts. Amplifiers build up the strength of weak signals more than a hundred billion times.

A few years later in Britain, "Rediffusion," (a "wireless relay exchange") gave wired subscribers a way to listen to radio without buying an expensive receiver. BBC's broadcast signals were captured by centrally-located receivers and relayed over self-constructed or British Post Office telephone lines. In its best years Rediffusion claimed a quarter-million subscribers. While well-financed and elaborate, it was one of those services that was made obsolete when the over-the-air broadcast service expanded to provide good coverage to most of England, and the price of over-the-air listening dropped to less than the cost of the wired service.

Early marketing of the telephone universe

In the early 1900s savvy marketers began to target telephone-equipped homes for the purpose of direct marketing. A trade-magazine article reported that a Fairmont, Minnesota store found telephone soliciting much more effective than "sending clerks or errand boys" to inform potential clients about store specials. An electric power company advised its offices to call potential customers at home, noting that, regarding the time of calling, "it is suggested that between 8 and 9 PM is preferable, owing to the fact that the head of the house is generally in at that time and a sufficient length of time has elapsed after the evening meal so he would be in a receptive mood."

The telephone was also used for 'get-out-the-vote' calls. Recorded political speeches were played down the phone to prospective voters. Political recordings were also played on truck-mounted loudspeakers cruising the streets; in vaudeville halls, political parlors, churches, schools and shops.



Sidebar for those who love historical political detail: Reader/historian Todd Kosovich tells us: "1908 was the first election that used recordings of presidential candidates. Wilson would have been dubbed a great communicator if broadcasting were operational in 1912. He had a straightforward way of explaining things without condescending, without long words. His voice is beautiful, warm and resonant. But in 1916, no one was willing to expend the cost to produce recordings.

In 1920 and 1924, *National Forum Records* tried to revive the recording series, but they were failures. The campaigns were expected to pay for the service and the Democratic Party had little money to spare. So we have plenty of recordings of Harding and Coolidge, but precious few of Cox and Davis." (Here's one such political recording, purportedly of President McKinley in 1901).

And a further word from Kosovich: "I am 99 % certain that the recording of McKinley is not McKinley. I have that and the companion recording with Williams Jennings Bryan…it's the same guy with the same crowd noise….When McKinley was assassinated, a number of spurious recordings of McKinley popped up from minor labels. I know of only one recording of McKinley that is genuine. The presidential candidates that made recordings as part of a series made them in 1908, 1912 and 1920. I am not aware of presidential candidates using sound trucks before 1908." These efforts assumed folks were interested in political words; the truth may be they were attracted by the *novelty* of the offering.

GETTING THE GAME PLAY BY PLAY
A crowd gathering around a loud speaker stand in Park Row, New York City. The input of the loud speaker was supplied from a radio receiving set located on the truck. On the upper left-hand corner of the truck may be seen a small loop antenna for receiving

Back to AT&T for 'board-room brawls'

While AT&T engineers were busy with the networks, around 1905 financial titans were wrestling for control of the promising telephone company. Financier J.P. Morgan had the biggest club; his acumen, resources and connections brought him control of the newly-named company. Management was re-aligned.

Morgan made some smart hires. The man he wanted to lead the company in a new direction was the same Theodore Vail who had taken the company into the long-distance business. Vail immediately modified the company's charter--the new watchword was QUALITY. Quality would be a benchmark of AT&T's reputation.

AT&T announced the slogan: "**One Policy, One System, Universal Service**."

AT&T now kept busy a battery of white-lipped attorneys. The company refused to sell *connecting equipment* to those independent telephone companies who had not signed licensing agreements. AT&T also stipulated that only *licensed* independent telephone companies could connect with the AT&T long-distance network.

To expand its control, the company then tried to acquire the Postal Telegraph Company but couldn't strike a deal. Western Union, meanwhile, had been hemorrhaging from competition in the telegraph business and was an easier target. A merger between the former enemies was inked in 1909. It could only happen in Big Business.

AT&T's immovable position about connectivity requirements and its demonstrated desire to acquire its competitors led to government investigation into AT&T's "predatory practices." Alarmed by what it had seen, in 1910 the Federal Government, by means of the Mann-Elkins Act vested certain interstate telephone toll-rate authority in the Interstate Commerce Commission. Out of this oversight came a government antitrust suit that led to the "Kingsbury Commitment" of 1913, under which AT&T agreed to allow independent telephone companies to connect to its network. (AT&T also had to stop bullying or buying other telephone companies…and in 1914 had to shed its recent interest in Western Union.)

A 2600-mile telephone call: the challenge

Two factors defined the value of the long-distance network. First, each circuit pair was initially capable of just one voice path. It took the development of the "Phantom" circuit before a metric known as "Pair-Gain" would be recognized (with the Phantom, for every two wire pairs a third circuit could be realized). "Pair-Gain" progress is discussed in detail in chapter Seven.

Second, the end-to-end telephone network had practical mileage limits defined by the physical properties of the wires and their environment. Bell engineers had worked out ways to squeeze additional miles from their (passive) circuitry. But without a way to amplify the voice signal, a practical distance-limit was soon reached.

Nevertheless, in 1909 AT&T announced *it would have transcontinental telephony working by the opening of the Panama Canal Exposition in 1915*. This public challenge to Engineering came from AT&T's Chief Engineer John Carty, himself one of Vail's earliest hires. The lights in the offices burned all day and all night.

AT&T was also concerned that advancement in European technologies might push them out of total control of the business. Vail and Carty agreed to put the company's prestige on the line with the 1909 announcement. Engineers had five years to deliver.

Long Lines immediately lit up its internal development teams. Not to give away the ending (we'll reach that in another chapter)…the coast-to-coast line was ready in 1914, six months before the opening of the Panama Exposition. AT&T used the time to perfect its circuits.

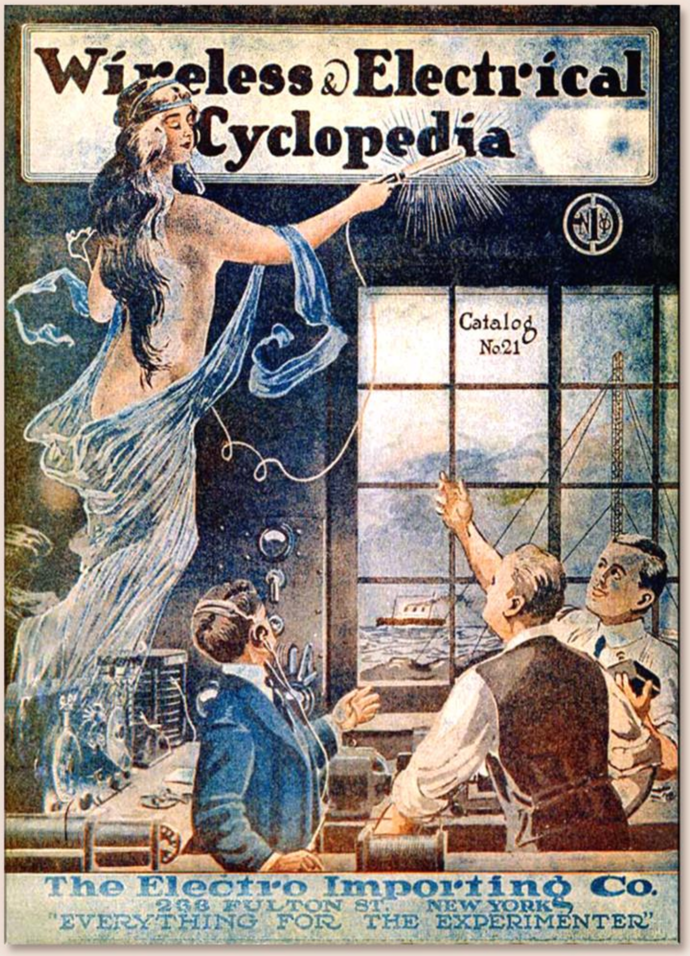
Telecommunications in the Great War

America's entry into World War One tipped a lot of priorities upside down and led to AT&T's serious interest in wireless. Wartime experience uncovered the potential for counter-offensive inherent in wireless communication: on the battlefield enemy signals could be intercepted, and direction-finding techniques could locate the positions of enemy transmitters.

In August 1914, the German Army used vital wireless intercepts to defeat the Russian 2nd Army in the Battle of Tannenberg. And it was detection of wireless traffic that alerted the British navy to the movements of the German fleet and precipitated the Battle of Jutland in May 1916.

Once the U.S. entered World War One, the U.S. Navy was all over wireless. Huge government contracts awaited businesses that advanced the development of these potentially-decisive tools of war. Naval officials saw the military implications of direction-finding and for communications among ships. Of the armed services the Navy was the entity that saw the real potential in all this. In 1916 the U.S. Government ordered all amateurs and experimenters to shut down for the duration; (a very few established stations were given limited test authorization). Amateurs and experimenters went into their garages and basements and kept tinkering.

The Army then announced it wanted radio for its aircraft. AT&T and Western Electric jumped onto the runway. "Aircraft-to-Ground" voice transmission was demonstrated in 1917. Shortly thereafter, planes could communicate with each other (via telegraphy!) What a thrill that must have been for the plane crew.



By now it was obvious that wireless communications was a playing field with no goalposts. The players were well-endowed companies with the belief there was money to be made and influence to be acquired. But these large companies were separated by disparate interests. It took a mini-crisis: British Marconi's grab for the Alexanderson Alternator, to get them to consider working together. The United States Government got behind the idea of a group of companies forming a patent pool, to react to the potential of British wireless domination. Out of these machinations came "The RCA."

The Patent-pool backstory

After the war, Westinghouse and General Electric had remained bitter rivals; both were looking for new work. Since GE had the Alexanderson Alternator and was a leader in vacuum-tube development, Westinghouse went after any other uncommitted vital patents and absorbed the International Radio Telephone Company ("IRTC"), a part of the work of Audrey Fessenden (who was credited with doing the spadework for the Alternator). Westinghouse gathered valuable Armstrong-Pupin patents into its portfolio. (It turned out that, for its part, IRTC had no useful assets other than potential landing rights for international communications.)

General Electric was in the best position to respond to the threat of British hegemony demonstrated by its bid for the Alternator. In spite of all odds, GE successfully negotiated a deal with the British to sell their interest in American Marconi.

Meanwhile Secretary of the Navy Josephus Daniels made one more run for Navy control of wireless but he encountered resistance among Congressmen who didn't want the government running business. Instead, Congress suggested Daniels support the government's plan to create a new patent-pool arrangement among American industry.

And so the *Radio Corporation of America* (RCA) was formed in 1919. GE invested in RCA and included its newly-acquired American Marconi interests. Marconi was merged into RCA and its shareholders received RCA stock. In the first of the patent-swaps, a 1919 cross-licensing agreement between GE and RCA gave GE a marketing arm and gave RCA access to GE's assets. Antitrust lawyers lay awake at night.

On a busy day in 1920 AT&T and General Electric signed a cross-licensing agreement that was immediately expanded to include RCA itself, Western Electric and other major stakeholders. AT&T brought to the table its rights in the vacuum tube. RCA was re-confirmed as the exclusive wholesale merchandiser for the group.

Eugene Lyons adds: "Wired telegraphy and telephony were reserved to 'The Telephone Group' (AT&T). "Space" communications remained the dominion of RCA and its partners ('The Radio Group'). The Radio Group was given exclusive rights to produce and sell "devices for the reception of news music and entertainment…overlooked at the time was <u>the rights in devices and stations for transmitting such programs.</u>

<u>"…it was destined to provoke one of the great industrial conflicts of that generation…between the telephone and electric interests for primacy in the broadcasting field."</u> *From 'David Sarnoff' by Eugene Lyons*

How Westinghouse joined the group is another interesting story element. RCA had long been developing the international market. "RCA Communications" was operating in 1920 and the first direct overseas radio circuits were opened in March (this was Long-Wave traffic using the Alexanderson Alternator).

In 1921 Westinghouse's International Radio Telephone Company (IRTC) went overseas to try to build out its own global wireless system…only to discover that RCA Communications had already tied up the major international companies. Westinghouse, embarrassed, next went to the U. S. Government on the advice of a patent lawyer, where they discovered some 140 *non-exclusive* patents gathered during the war that hadn't been tied up by RCA. The IRTC immediately entered into a non-exclusive patent-licensing arrangement with the Government.

Westinghouse continued to look for other opportunities. They attempted to build a ship-to-shore radio market; that failed. It looked like Westinghouse might have to join The RCA while its patents had some value. Had it not for that fellow in Pittsburgh, Westinghouse might have then focused its entire effort on the success of RCA.

As it was, Westinghouse joined the pool, dividing receiver-manufacturing rights 60/40 with GE. (When Westinghouse joined, RCA took over management of the new Westinghouse station WJZ, but that story remains to be told.) Significantly, *AT&T was assigned by the others to something called "**Toll Broadcasting**."*

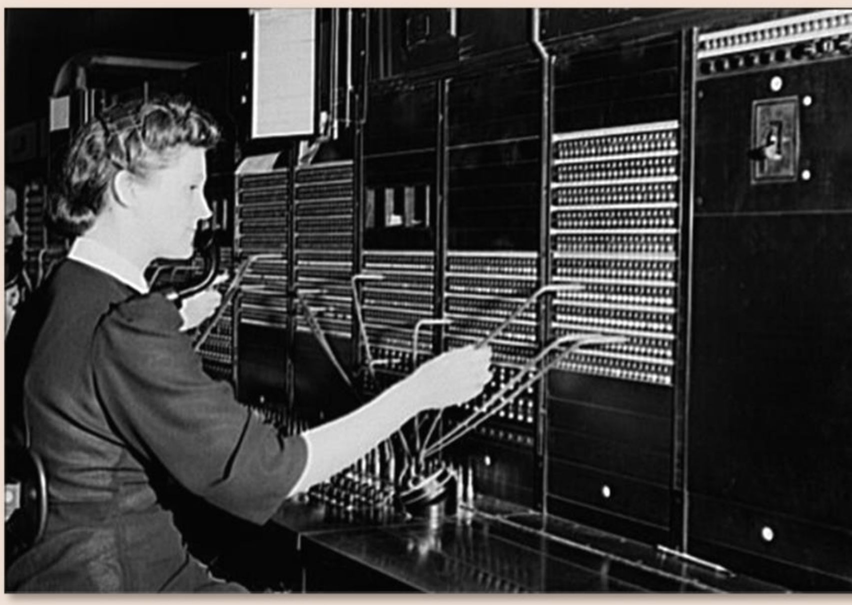
When the Westinghouse deal was signed few apparently saw far into the future, but the value of the Toll Broadcasting element would explode and the deal was soon beset by litigation and threats of legislative interference. "Shortly thereafter there emerged a dispute as to *who could build and operate the stations for the new radio broadcasting business*. The Radio Group of RCA claimed primacy. AT&T, in reaction to its interpretation of the agreement, sold its stock in RCA and declared war. The agreement wasn't proving to be definitive and its interpretation would be the subject of a protracted battle. *ibid* (italics added)

Perhaps the language in the 1920 Agreement could have been more definitive but that would have reflected a prescience unavailable to most…for example, one of the arrangements gave to GE, *for the purpose of 'non-commercial' radio operation,* AT&T's purported control over what became "broadcasting." Another poorly-written bullet point was that Westinghouse and AT&T "were to fully share patents for radio."

It was a lovely space for litigation.

End-to-end calling

By 1920 AT&T's telephone network was ubiquitous, but it was cumbersome to place a telephone call. "For many years, all long-distance calls began with connection to an operator sitting at a toll (long-distance) switchboard. Until the 1920s, that operator wrote down the calling information provided by the customer. The first operator then passed the information to another operator, who looked up the route that the call should take, and then built up the circuit one link at a time by connecting to operators at switchboards along the route. A typical long-distance call took seven minutes to set up. Once operators established a circuit, it was dedicated to that conversation until the end of the call." *AT&T History of Network Switching*



Because we won't be talking much about operator-assisted calls, we take the liberty of jumping forward a few decades, to point you to this snip from a CBS "Suspense" broadcast called "The Hitchhiker." It's a bit over the top, but it illustrates how you placed a long-distance call.

And that's about enough background. We know who the players were, we know what was driving AT&T and we have some understanding of how the company operated. Our next chapter takes us to wireless and radiotelephony.

Throughout this e-book, Twenty-First Century hindsight makes it almost embarrassing to see the struggles to develop what now seems old-fashioned. But it was a grand experience in its time! Let's move on.

CHAPTER TWO

AT&T and "The Wireless"

In AT&T's universe there existed under-served areas impractical to reach with the wired network. Connectivity could only be provided by leap-frogging through the ether. AT&T's interest in marrying wire to wireless had been awakened by developments in the new medium, by the potential applications revealed during World War One and by the public safety interests that had mandated wireless capability on ocean-going vessels. Initially, their interest was not in "wireless" per se but rather in technology that would marry wireless with the telephone network. It's instructive to see how the success of this marriage would lead to AT&T's involvement in "broadcasting."   AT&T matchmakers had to be impressed with wireless developments:

In 1885 Thomas Edison had demonstrated a "wireless" telegraphy link that worked by *induction* (moving trains passing through railway stations changed the flux in a loop surrounding the tracks for the short time the train was moving through the station). As usual he filed for a patent. Marconi…just in case…bought that patent in 1903.

The Marconi Company flourished in business communications and in connecting ships at sea via telegraphy. By 1900 most ocean-going vessels had a 'radio shack.' In 1901 the American Navy gave up visual signaling and carrier-pigeon, and several of the Hawaiian Islands adopted wireless for inter-island connection. By 1903 trans-water telegraphic messages were commonplace (the Russo-Japanese War was reported by radio-telegraph news dispatches). In 1904 the U.S. Weather Bureau adopted wireless telegraphy to disseminate weather information.

Reader Bob Dildine's comment is appropriate: "Mark, you say 'By 1903 trans-ocean telegraphic messages were commonplace.' I thought that 1903 was about the time that Marconi finally succeeded in sending 'S' across the Atlantic (although as you mention, it's questionable whether that was a real 'S' or just static)." My response to Bob: The text is corrected to read *"**trans-water**"* since 'Trans-Ocean' could imply continent-to-continent.

Many thought wireless was 'the greatest of all electrical mysteries.' Machinery Magazine tried to explain it all in 1899, concluding a lengthy article on the subject: "From the foregoing…there is nothing mysterious about the operation of wireless telegraphy; it simply consists in using, for a sending instrument, a device that is capable of emitting electrical radiations and for the receiving instrument a device acted upon by these radiations.

"The possibilities of wireless telegraphy have been greatly exaggerated by the sensational press. It has been asserted that it would supersede the present methods and that before long messages would be transmitted across the Atlantic and that many other impossible things would be done. As a matter of fact, however…any receiving instrument placed within the range of the transmitter can receive the signals; hence there could be no privacy."
Machinery Magazine, November 1899. (underlining added)

Privacy, eh? Maskelyne hacks Marconi

The comments of Machinery Magazine notwithstanding, Guglielmo Marconi lent the status of his reputation to the belief that wireless messaging *was* secure. He naively believed that sharp tuning would keep messages from being 'overheard' by those with wide-band receivers. The Emperor was disrobed in 1903.

Marconi and J.A. Fleming had scheduled a long-distance wireless demonstration in London. That demo was interrupted by an engineer named Nevil Maskelyne. Maskelyne interrupted the proceedings with a nearby transmitter, easily overpowering Marconi's distant signal and inserted messages in Marconi's demo, accusing the Italian of misleading the public about security.

Marconi was privately furious at the hacking of his demonstration but refused to respond to newly-minted doubters regarding wireless security. It seems Senatore Marconi had a blind spot. Still, wireless *was* magic! Mary Bellis explained: "In 1910 Marconi opened regular American-European radiotelegraph service. (Anecdotally) several months later the…radio service… enabled an escaped British murderer to be apprehended on the high seas. In 1912, the first transpacific radiotelegraph service linked San Francisco with Hawaii." *The Invention of Radio, Mary Bellis*

Facts are funny things. A document like this, proposing factual information, is always susceptible to correction and interpretation by others who have done deeper research. Bob Dildine again, on Mary Bellis's transpacific telegraph date: "Mary mentioned that 'In 1912, the first transpacific radiotelegraph service linked San Francisco with Hawaii.' Marconi built the wireless station at Bolinas, California (transmit site) and Marshall, California (receive site), both just north of San Francisco in 1913 and started California to Hawaii service in 1914 with two 200 kW rotary spark transmitters.

I'm part of a small team of volunteers, the Maritime Radio Historic Society, restoring and operating RCA's old KPH station on that site. There's a lot of information on the site's history dating all the way back to Marconi at our web site, www.radiomarine.org.

The spark-gap transmitter and the coherer receiver operated at very slow speed and required manual intervention (one had to continually reset the detector). It took the development of the continuous-wave (CW) generator by Alexanderson and Fessenden, followed by the subsequent implementation of high-power high-vacuum tubes, to provide practical signals at ever-decreasing wavelengths. It would take "linear" detectors to 'decode' the signals.

Of tube developments, AT&T's Lloyd Espenschied recalls: "(In) about 1914 (*1915?)*…we began to experiment with the high-vacuum tube as an oscillator and a transmitter for *carrier-current* work---High-frequency transmission on <u>wire</u>. To explore that situation, one of our new recruits, Raymond Heising, was put to work to see what could be done with the vacuum tube as a transmitter, a receiver, and (in building) selective circuits for high-frequency transmission over wires. This was the beginning of our Carrier work. The scene then shifted, beginning in 1915, to experiment in *radio telephony* using the high-vacuum tube as a power tube device for transmitting (over the air), as well of course as other vacuum tubes for receiving." *Espenschied: IEEE interview* (By 1922 the Alternators had been replaced by tubes.)

Technology's next goal was to cross the Atlantic with the human voice. In 1915 "Radio-phone" tests began off Long Island, with (arguably) the world's first high-power vacuum-tube transmitter. The test frequency was about 60 kilocycles. "It was from (the famed Naval station) NAA (in Arlington Virginia) that the human voice first leaped the Atlantic. Early that morning of October 22, 1915, a group of Naval officers were told that they might hasten to Arlington and from there talk to other Americans in the Eiffel Tower, with the bustle and roar of a thousand guns only a few miles away from Paris, and the Tower itself used as a target now and then in the daytime. They talked (in Arlington), and were heard in France, (in the Canal Zone) as well as Pearl Harbor in the Hawaiian Islands." *"NAA" by Donald Wilhelm*

It was a milestone one-way "call." And if you want some cocktail party trivia, the words first memorialized in that transatlantic connection were "Hello Shreeve!" So that you appear cutting-edge in your conversation, you'll offer that "Shreeve" was H.E. Shreeve, a young Bell company engineer given the dubious task of hanging out at the top of the Eiffel Tower, dodging artillery and waiting for the signal from NAA.

A good deal of thinking was going on regarding potential new "Short-Wave" operations ("Short-Wave" was what we now know as High Frequency or HF.) AT&T engineers had been experimenting to determine the effectiveness of these new bands…until those experiments were ended by AT&T Chief Engineer John J. Carty, who called them "undignified." Carty's directive: conduct your research in the <u>long waves</u>.

RCA thought otherwise and was converting its Rocky Point Long Island plant to "Short-Wave" (circa 100 to 50 meters) but AT&T was a huge RCA customer and, for its 1915 transatlantic experiment, RCA allowed AT&T to place a 60-kilocycle rig at the station.

With the absorption of American Marconi's interest in 1919, we noted that RCA Communications took a commanding lead in international messaging. Early on they focused on building out their fabulous East Coast stations.

Thin-route communications

During and after World War One Western Electric began the design and manufacture of wireless radiotelephone equipment, and initial products included a low-power duplex voice transmission system. (Such manufacturing was another step in AT&T's vertical integration in the market.)

Long Lines engineers meanwhile addressed the problems inherent in connecting a non-linear wireless world with the existing wire network, to enable service to markets where wire circuits were impractical. From these efforts a marvelous body of development followed (including applications from the science of psychoacoustics). This work is detailed in the technical appendix of chapter Seven.

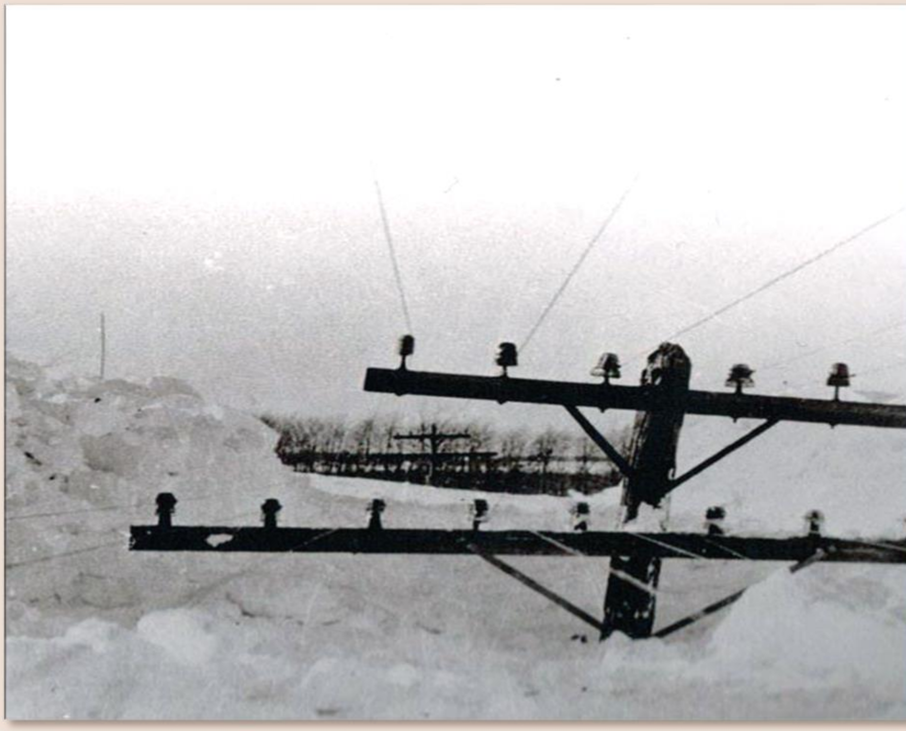
"…the first use of radio telephony for public service…was a radio link which went into service July 16, 1920, between the town of Avalon on Catalina Island in the Pacific Ocean, 30 miles away from the California mainland…and a land station at Long Beach where junction was made with the wires of the Bell System. The transmitters had an output of about 100 watts, and two-way communication was obtained by using two frequencies—638 kc from California to Catalina and 750 kc in the opposite direction. A cable to carry the traffic from the island to the shore (owing to conditions growing out of the war) could not be manufactured as soon as required. Radio was therefore turned to because it could be made available promptly."
Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning

This radio link lasted three years and spawned many other short- and long-hop telephone-radio links around the world. Notable for a permanent long-distance telephony link was the voice connection between Seattle and Juneau Alaska.

On a grander scale, another transatlantic experiment was set for the late evening of January 14, 1923. Specially-equalized phone lines connected AT&T's NY headquarters with the Rocky Point transmitter. AT&T historians record the following conversation, as the terminal was being readied for the Trans-Atlantic test: "AT&T's Vice-President Carty…had remarked…after giving some final instructions: 'Now I'll get a little nap.'

"'What!' said the astonished Publicity Manager. 'Aren't you nervous? Can you really sleep?' 'There's nothing to worry about,' was the answer. 'The tests are what I expected. There was sleet on the wires (back when) we opened the first transcontinental line, but I slept, on that very sofa, for 30 minutes. You see, I knew that line was being watched by *telephone men*.'" *Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning* (italics added)

A job for Carty's ***telephone men***:

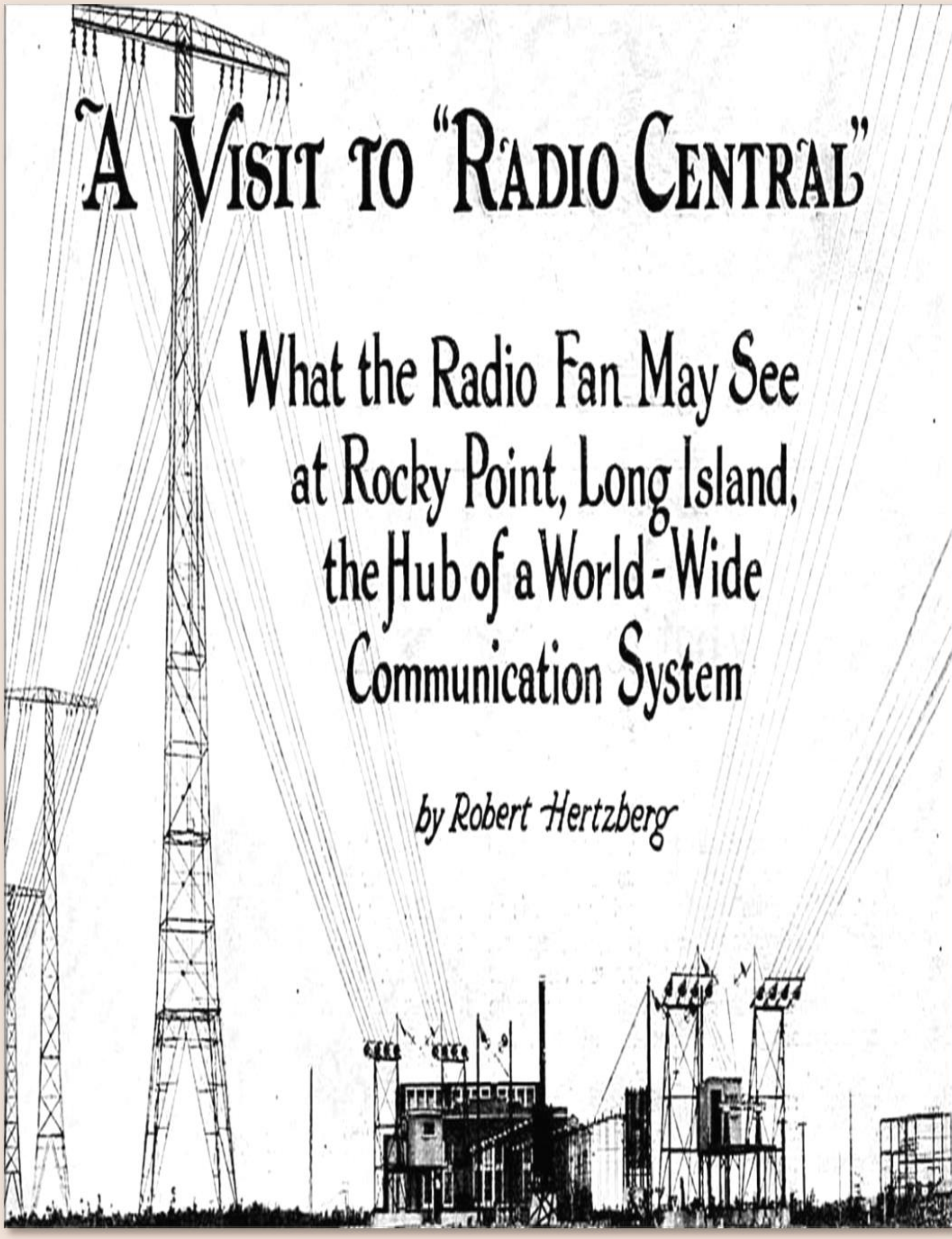


"Neither rain nor sleet nor snow" *Communications magazine*

In 1927 a New York to London full-time connection was opened, using RCA's duplex Short-Wave. Naysayers predicted Short-Wave conditions would make extended conversation impractical, but the first call stayed up for four hours. Carty's Long-Wave strictures were forgotten. Here's a recording of that call.

Two years later service was established between the United States and Paris (the circuits landed by shortwave in London and the audio was transported the rest of the way via landline). With its flair for telling moments, AT&T included the afore-mentioned Shreeve in the call. Full-time radio-telephony to Hawaii was turned up in 1931 and Tokyo's connection made in 1934. America was now in voice contact with the world…and the world had grown a little smaller.

Speaking of speaking long distances, the final (terrestrial) 'milestone' occurred on April 25th, 1935. It was the first 'around-the-world' telephone call, from one office at AT&T New York, around the world, to another office. The route was primarily Short-Wave links, remarkably clear of noise. AT&T President Walter Gifford seems to have a sense of humor. *Courtesy Art Shifrin*



RCA Journal

From the onset of 'wireless' some at AT&T had been observing a specific application of radiotelephony: "broadcasting" to mass audiences. The concept might prove impractical but it was worth tracking, they thought. Prior to the U.S. Government's ban on radio during World War One, the records suggest the following developments:

>In 1897 a workable wireless telegraph “broadcasting” transmitter was demonstrated at the University of Arkansas; it became station 5YM. In the fall of 1898, Notre Dame professor Jerome Green sent telegraphic wireless messages a distance of about a mile, from Notre Dame to St. Mary's College. Other claims notwithstanding, this purportedly was the first transmission of any significant distance in North America.

>In 1900 University of Wisconsin professors and students begin experimenting with radio transmission using spark transmitters. Their apparatus was assigned the call letters 9XM; that station became the famous WHA. By 1915, 9XM was broadcasting daily reports for farmers by code…transmitting to grain elevators. Code-savvy receiver operators transcribed the information for posting to the elevator’s bulletin boards. (It’s another example of one communication medium being enhanced by a second…in this case wireless information becoming the printed word.) 9XM also transmitted music to Great Lakes shipboard operators, asking them to report what was heard. Their tests with naval vessels in the Great Lakes led the government to exempt 9XM from the overall wireless ban imposed during the war.

>‘Tuning’ the receiver of the early 1900s, one typically heard nothing but the sound of spark gap and arc-generator Morse code…different speeds, different intensity. Crude ciphers now protected confidential messages. Then in 1900 Canadian-American physicist Reginald Aubrey Fessenden purportedly spoke some words into a telephone transmitter: "One, two, three, four, is it snowing where you are Mr. Thiessen? If it is, would you telegraph back to me?" Mr. Thiessen, one mile away, rsponded.

Reginald Fessenden at his “computer” with oral ‘thinking aid’ *Source unknown*

>A few history books say that on Dec. 12, 1901, G. Marconi claimed to have heard the letter "S" transmitted by Morse code across the Atlantic. Fact-checkers have since concluded that this reception was probably not possible and that Marconi may have heard static caused by lightning.

>In 1902 a fellow many consider the real “Father of Radio,” Nathan Stubblefield, lit up a wireless telephony link from shore to a boat on the Potomac River.

>Here’s an interesting if anecdotal addendum to the timeline: David Kaye reports that “Francis McCarty, a teenager, first transmitted voice across San Francisco in 1902.” Look to John Schneider’s great site for more on this.

>Supposedly the first broadcast of voice intended for *general reception* was heard on Christmas Eve 1906. According to legend, that same Aubrey Fessenden transmitted voice programs from Brant Rock Massachusetts including a speech, an invitation to report on reception, and a phonograph recording. A second broadcast reportedly occurred New Year's Eve.

The claims are anecdotal. Author James O’Neal writes: “This is in reference to the Fessenden 1906 "Christmas Eve" broadcast. I've spent many hundreds of hours over the past seven years in trying to get to the bottom of this story and can truthfully say that, based on all of the documentation I've examined, it has to fall strictly into the myth category. Other than Fessenden's 1932 ‘deathbed’ letter, everything points totally away from it having ever happened. (Sterling and Halper drew this conclusion too, as did a couple of other researchers back in the 1956 timeframe [50th anniversary of the supposed ‘broadcast'].) I would respectfully ask that you consider reporting what is documentable in this area--that Fessenden did do what can be considered to be the world's first broadcast in 1906, but this was a demo of radiotelephony that took place on Friday Dec. 21 instead of Monday Dec. 24. A big pile of records supports this.”

>In the October 1922 edition of *Radio News*, Charles Gilbert, a spokesman for the De Forest Radiotelephone and Telegraph Company, recalled: "The first actual application of the De Forest radio phone in reporting a news event was no doubt the reporting of the yacht races on the Great Lakes in the summer of 1907; Gramophone music was furnished between the spoken bulletins.”

>Around 1909 Lee Deforest established an experimental voice station, 2XG in the Bronx. Harriet Blatch, de Forest's mother-in-law, spoke in favor of women's suffrage; de Forest claimed this was the first ‘propaganda broadcast.’

>We can reliably trace the beginnings of *scheduled* radio broadcasting in this country to April 1909, when Charles Herrold began to transmit voice programming from San Jose California. Had Herrold stayed on the air regularly his would, without a doubt, have been credited as the first broadcasting station in this country. His interim operation used experimental call letters FN, 6XE, 6XF and SJN. (The station later became KQW and in 1949, KCBS 740.)

Reader Rob Spencer adds this: "You gave Charles Herrold…short shrift. You rightly cite his early experimental station as the first to have scheduled broadcasts, but his firsts did not end there. He also had the first *sponsored* broadcasts, among other things. You can get chapter and verse at http://www.charlesherrold.org. "

Herrold's station. *No picture credit available*

The experimenting continued:

>What would become WGI in Medford Massachusetts began life as 1XE in 1917, formalizing voice experiments that began in 1916. 1XE is a legitimate contender for pioneer status ahead of KDKA. There were other such contenders, including the Detroit News station 8MK.

>From Todd Kosovich: "On November 7, 1916, the first (*telegraphic*) election broadcast took place with the New York Times joining De Forest Radio Laboratory station 2XG broadcasting election reports for approximately six hours . Coverage ended about midnight, announcing that New York's Charles Evans Hughes had defeated incumbent President Woodrow Wilson. Of course, that was incorrect. The whole nation was waiting for California…which went for Wilson on Friday. (The New York Times also ran an extra proclaiming Hughes the winner.)"

>By this time others (notably in Minnesota, Kansas and Texas) had been making news with their own (telegraphic) information services. Then on January 1, 1918 President Wilson's historic address to Congress explaining his "Fourteen Points for a Just Peace" was disseminated throughout the world by Morse code wireless, in just a few hours. (This was not a true "broadcast" in the sense that the information was sent through a lot of relays.)

>Station 6XD came up from Los Angeles in April 1920, beating KNX (nee 6ADZ) which came on the air in September 1920. (6XD became KOG in 1922.)

>XWA in Montreal was broadcasting in May 1920 and claims to have operated "the first scheduled broadcast in North America" (it became the famed CFCF).

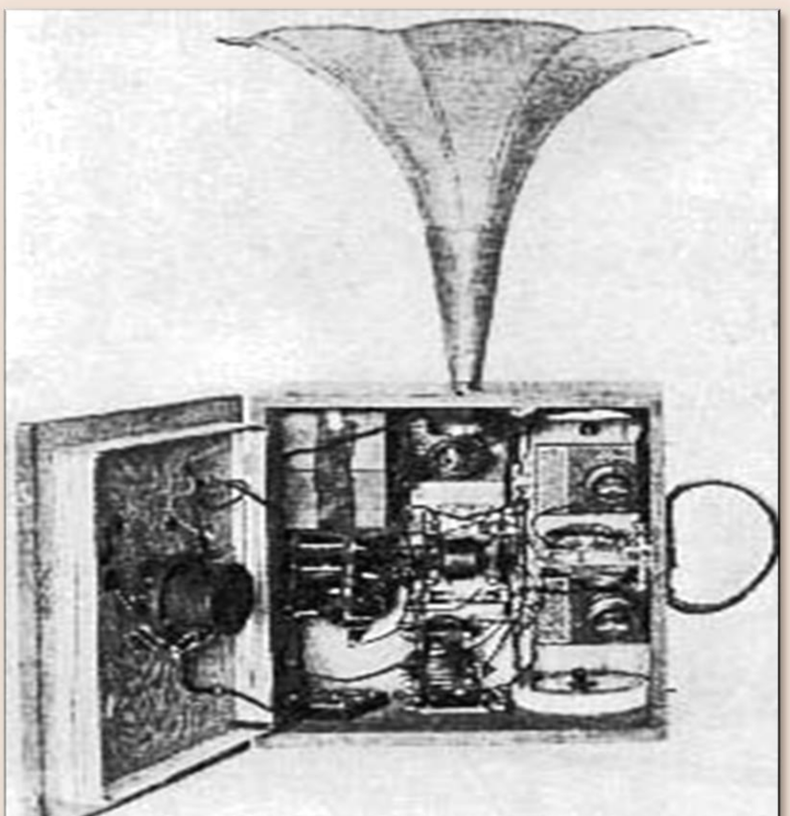
Broadcasting history seems fixated however on November 1920 when KDKA broadcast election results. The Pittsburgh station had been testing as 8XK and 8ZZ and in 1920 received the KDKA call letters. And so, the November 1920 "first" broadcast…on a transmitter may have signed on as 8ZZ. A backstory we all know is that Doctor Frank Conrad, who had been instrumental in communications development during the war, had been broadcasting from his home with experimental licenses; one of them 8XK.

Westinghouse management apparently heard his broadcasts. They also heard that competitors' radio set sales were going through the roof. They asked Conrad to have a sending station ready to go on the air at Westinghouse in time for the 1920 elections. *Conrad had 34 days.* Concerned about the fruits of a rush job, he configured his own station 8XM as a "hot standby" transmitter.

Chicken and egg: the transmitting station needs a receiving station

KDKA and other early stations had been put on the air to sell receiving sets. In turn, to make broadcasting stations successful, the receiver universe had to be populated. Risk-takers properly understood these parallel realities. In the event, the first broadcasting stations set off an astounding crush of set manufacturers striving to get to a market clamoring for the "radio sets."

The receiving end of a broadcasting system didn't even have a name when it all began; in 1916 Sarnoff had called the *concept* a "Radio Music Box." In 1920 the National Bureau of Standards waxed poetic about just one of the many new reception devices, 'The Portaphone "…which device opens up many new possibilities. For instance, at 8:30 o'clock each evening a central station might send out dance music from its transmitting apparatus and those who cared to dance could set up their Portaphones on a table, turn on the current and have the music furnished sufficiently loud to fill a small room. Or in the morning a summary of the day's news might be sent out to be received by a Portaphone and digested by a family at breakfast, in which all could participate, whether Paterfamilias had the paper or not…



Portaphone *Radio News August 1920*

"So far the only application of the Portaphone has been purely experimental…but it presents interesting possibilities for more general and utilitarian applications. A similar device with a larger coil has been built there…which develops sufficient power in connection with a transmission source to reproduce music loud enough to fill a very large room suitable for dancing." *Technical News Bulletin of the Bureau of Standards* The word 'radio' is nowhere mentioned.

Meanwhile "The RCA" was preparing for mass construction and distribution of "radio sets" under its 1920 agreement.

The earliest (pre-superheterodyne) receivers were not easy to tune and their circuitry tended to "howl" during tuning. We point you now to an entertaining video describing the mass destruction of these early sets. Make of it what you will…

Several radio museums around the country have dedicated space to display the hundreds (thousands?) of radio sets built in those first decades of radio. One of the finest is the Pavek in Minneapolis www.pavekmuseum.org

Lack of regulation

From the 1900s onward, wireless development in this country was a case of "let's see what happens." The American government stood by…while at the same time encouraging private enterprise to build up the infrastructure (at its own risk of course). A form of government control *was* instituted around 1910 and, while some of those laws framed actual legislation, the 1910 regulations had no teeth since they were obsolete before they were printed.

It's beyond the scope of our story to rehash the well-known history of wireless (and broadcast) regulation, de-regulation, anarchy on the airwaves and the government's feeble attempts to get its hands around an issue few at the time understood. It should be pointed out however, that radio broadcasting development cast aside the usual business architecture (the common belief you had to develop *standards* before manufacturers invested in equipment design). In this case the genie let out of the bottle was simply too overwhelming to stuff back in, and it's easy to understand why radio exploded the way it did in this country and others.

Two factors hindered radio's early progress in many *developing* countries: most citizens could not afford receivers…and there wasn't always an adequate power grid nor the mechanical resources necessary to support high-power transmission. In developed countries however, radio's explosion took place at exactly the right time…the Roaring Twenties. Citizens were ready for this new form of entertainment media.

AT&T and radio

Within AT&T in the early 1920s there were evolving ideas about "broadcasting." The culture of the company influenced the dialogue of course; some thought radio would defocus the company. Entering a new business was a complicated procedure typical to large corporations. It required careful step-by-step analysis…followed by analysis and more analysis and market evaluation and creation of risk/reward scenarios and analysis.

By early 1921 some at AT&T were willing to stake their reputations on a "go" decision to enter broadcasting, but the company had a lot of large fish in the frying pan. Long Lines was dealing with an exploding demand for long-distance telephone circuits. Additional transcontinental lines were needed, as were submarine cables. Research was headed in seventeen different directions. Wags thought 'it was difficult enough keeping ahead of traffic projections for the *telephone* network. And now some Ivory Tower mercenaries wanted to add broadcasting to the mission!'

The need for a broadcasting decision surfaced in another AT&T division when engineers reported that the broadcasting spectrum was becoming hopelessly crowded. This implied that the "radio" idea was wildly popular…*and* that AT&T was running out of time.

One fundamental conviction at the corporate level was that if the company stepped into radio, the end game had to be in keeping with AT&T's policy of *serving the entire country*. That meant by definition any foray into the field would include stations from coast-to-coast. Here AT&T had a singular asset: its developing wire network. The company also believed its public-service obligations mandated any such activity as *responsible exercise* of its *exclusive license* over several of broadcasting's components. Finally: the company's primal need to control any business in which it participated.

As to the leveraging of at least the local component of its wire network, the train had already left the station. Local Bell Operating Companies ("RBOCs") were even now providing connections for local studio-to-transmitter service…and for "**NEMO**s."

NEMO: Anecdotally**:** "**N**ot **E**manating from **M**aster **O**perations" (or: "**M**ain **O**ffice")

According to some, NEMO is not an acronym at all. Historian Michael Shoshani (who has a superb site on the NBC chimes we'll tell you about later), has 'chimed' in with this: "I'm of the opinion that "Not Emanating" is probably accurate, although an early 1940s book I have on radio-directing by NBC's Albert Crews asserts that "nemo" (he used all lower-case letters) didn't stand for anything. Most likely the term continued in network use from the 1920s, but its meaning did not."

NEMOs originated outside the studios; today we call them "remotes" (they were known then as "Remote Control"). Prior to the invention of short-hop radio links, the only way to connect a remote broadcast site to a radio studio was via telephone line. By the early 1920s the telcos had developed a protocol for the provisioning of these services. In metropolitan areas Bell companies placed special 'low-cross-talk' cable from the "Toll Board" (switch center) into the radio stations. Upon receipt of a "Remote Control" order, the phone company extended a "lateral" from the intended remote location back to its wire office, and then cross-patched this "lateral" to the already-established loop to the station.

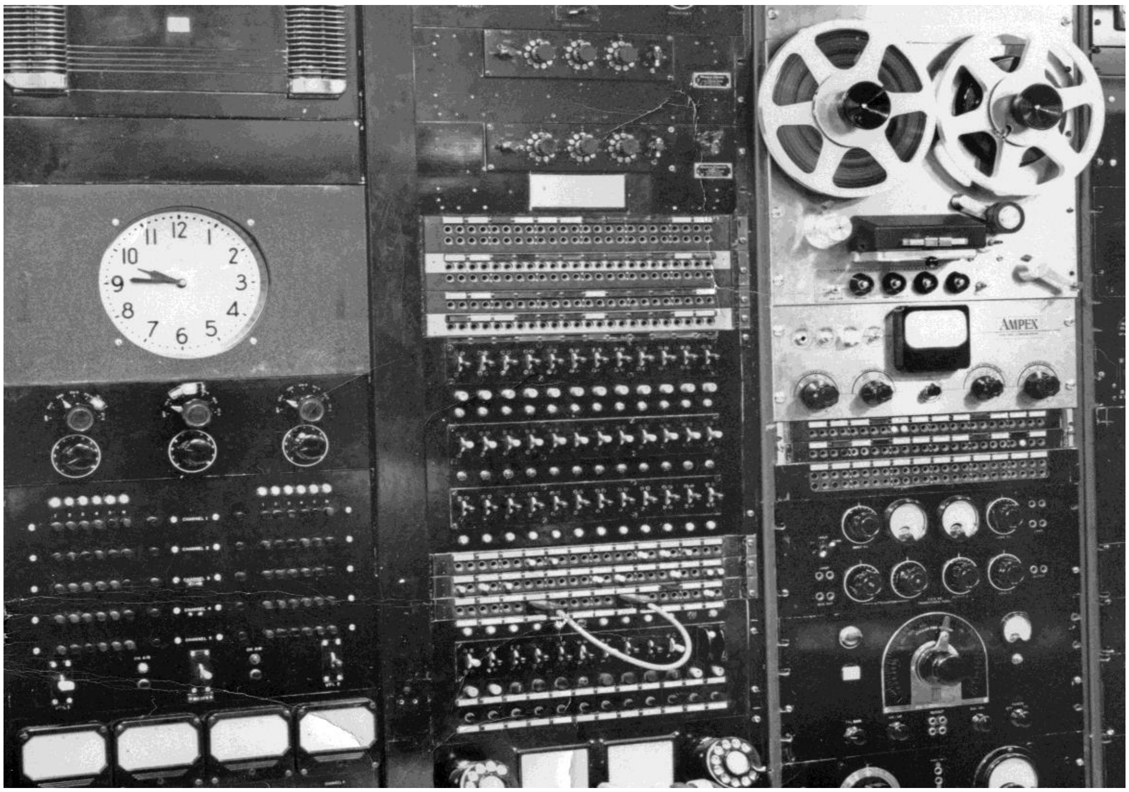
A "NEMO Service" could include one or more 'Program' lines, as well as an 'Order Wire' circuit for talk-up or a path for telegraphic communications (with telegraphy, to cue the remote site, Master Control sent the famous "K"--"go-ahead"--to the remote engineer). Sometimes a "ring-down" line was added to the service. (Not to get ahead of our story but, once the big networks began doing a lot of remotes, "NEMO Preview booths" (separate control rooms with good monitors) were assigned to audition, adjust and monitor levels and watch the network's remotes in a "broadcast quality" environment.)

NEMO circuit line-up

To test the Remote Control loop end-to-end after the connections were up, the installer cranked a magneto at the remote site, causing a ring-down drop to appear at the station's board. The radio station engineer who answered was asked to test the circuit. That worthy would first zap the line, placing 110 volts from each side to ground. The installer then shorted the pair at the remote location and the station engineer observed line resistance (hopefully this was done after the 110 volts was removed). Next: a noise test…performed by the station engineer with headphones! If all was 'quiet,' the line was accepted and 'red-tagged' at the Toll Board against inadvertent 'man'-handling (there were no women in the switch centers).

The first "NEMO Equalizers" were designed to flatten the frequency response of the line by reducing low frequencies only; then amplifying the result. A version known as an "active equalizer" *amplified the high-end only* (active boost, shelving at around 4000 cps). Stan Adams reports that "the first commercial equalizer for the broadcast or commercial media was the Western Electric 1-A. It consisted of several resistive step switches and capacitor and inductor, in addition it had a switch that would either put in the 5 or 8 kc position."

Here's a (1960s) look at part of WCCO's Master Control. In the middle rack are, from top to bottom, the passive equalizers we described, remote-assignment keys, telco ring-down trunks. Don't be surprised to learn that remote-loop/passive-equalizer systems endured into the late 60s.



KDKA pioneered in RBOC-supported "Remote Control;" its 1921 firsts included the first church broadcast (Jan 2), first prize fight (April 11), first broadcast from a theater stage (May 9), the Davis Cup matches and a baseball game (August). How did they do it under the noses of AT&T? One reason: great relations with Pittsburgh's Bell subsidiary.

The RBOCs may have been responsive to requests for NEMO service because of the local competition. The August 1923 issue of *Radio News* reported for example that broadcasts by famed star Bertha Brainerd were sent from her New York theater *via Western Union facilities* to WJZ/WJY. KDKA itself used Western Union when it could find no other path. None were happy with these circuits.

Unfortunately, even Western Union's modernized plant was encumbered by its design; it was built for telegraphy, not wide-band audio. The disabilities eventually eliminated Western Union as a potential player in the broadcast-service arena (though RCA's Radio Group had to use Western Union circuits for its own startup network.)

Corralling the 'can-do" spirits

In AT&T's view it was one thing for the local telephone companies to be cooperative, but their provisioning had to reflect company policy. A spotlight in Pittsburgh illuminated the issue: Shortly after KDKA took to the air a request was sent to AT&T:

"We require the connection of a transmitter and speech amplifier connected to a telephone circuit. At the station's end we require connection from the telephone wire to the input circuit of a second speech amplifier or to the input circuit of our radio transmitter.

"We have found it desirable to connect *around* the distributing frame at telephone centrals rather than to go through the switchboard equipment. The telephone company will want to know what current and voltage will be applied to their standard telephone circuits…We should be able to get along in all cases without exceeding 100 volts on the telephone circuit. The current should not exceed 100 milliamps." *Bell Telephone Company files Oct, 1921.*

The Pittsburgh phone guys went to work…but the memo was also sent upstairs. AT&T approved the request but made it clear to KDKA that under its licensing authority this response was not de rigeur. It intended to *"observe further developments with respect to the company's public-service obligations*." *AT&T files*

Internally, the question was: if AT&T's obligations *didn't* mandate universal service, was the company undermining its own position by providing ad-hoc service? This question could be put another way: *Was* AT&T required to provide connectivity to *everyone*…or could it apply strict access rules to protect its network? ("Strict access" might have been construed as picking and choosing customers…a practice that would get the company into trouble.)

AT&T's Walter Gifford looked back at these questions twenty years later: "Nobody knew…where radio was really headed. Everything about broadcasting was uncertain. For my own part I expected that since it was a form of telephony…we were sure to be involved in broadcasting somehow. Our first vague idea, as broadcasting appeared, was that perhaps people would expect to be able to pick up a telephone and call some radio station, so that they could give radio talks. It was impossible for a while even to guess what our service duty would be." *Telephone-The First Hundred Years, John Brooks; Harper, Row, 1975.*

That definition of "service duty" remained elusive. A 1921 inter-office memo on the subject concluded: "Radio-telephone broadcasting bids fair to become such an important matter in the communication world as to warrant a careful consideration of its possibilities from a business standpoint and a redetermination of what interest we may have in the field…the only feasible way of obtaining returns is considered to be through the sale of apparatus. This has led to the conclusion, inasmuch as this company is not interested in the sale of apparatus *outside the Bell System*, that (therefore) we are not interested in broadcasting."

The argument concludes: "The exploitation of apparatus sales will be dependent, however, upon some news and amusement broadcasting service; *and it would be well worth while…to underwrite such service in one way or another*…(after all) it seems reasonable to expect that we will be called upon for wire connections to these broadcasting stations. If we, ourselves, do not broadcast, we have to face such policy complications as the wire end of the service may involve, as well as the uncertainty of what effect such service may have upon our own service. The fact that radio *supplements* wire service could in no way better be demonstrated continually to the public than by having this broadcasting conducted as part of the Bell System." *Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning* (italics added)

The engineers added their own vision: "The technical possibilities of broadcasting from the Bell standpoint may be best indicated by picturing the setup for some national event…we can imagine the President or other official speaking in Washington with or without the use of local loud speakers, and that his voice is then carried out over a network of wires… …extending to all the important centers of the country. If each point on this network can be reached by two or more routes, the possibility of interruption to telephone service would be small.

"At the offices along the selected route connections are established through one-way repeaters to other circuits, to loud speakers and radio stations, without interfering at all with the main circuit. In each city and larger town there are halls equipped with loud speaking apparatus at which the people in the neighborhood are gathered and which are properly connected directly or indirectly to the backbone routes. To properly do the above will require that we have available along all of our important routes one or more circuits which are constructed and maintained so as to give a somewhat better grade of transmission, and a…higher degree of reliability." *ibid*

The engineers' language spoke to their concern for <u>quality</u>. The fidelity requirements of radio meant the quality bar had to be lifted and held high. After all, in their experience with public-address across the nation, the interfacing with the phone lines was the easy part. Getting good audio all the way to the public-address site was the real chore. If AT&T were to formally participate in broadcasting, engineers served notice they'd insist on applying the same quality standards to such a service.

A final reason for getting into radio was that AT&T believed *only AT&T-licensed* stations had the right to engage in "Toll Broadcasting." This they felt was a privilege granted them under the patent pool Licensing Agreement. Others clearly wanted to get into the action.   *AT&T should therefore exercise that exclusivity promptly…or lose it*. (After all their Western Electric division was already in the game in full uniform, designing and selling radio-transmission equipment.)

Having heard all the arguments and understanding the opportunity, executives were finally ready to make the move. AT&T would commit to an <u>experiment</u> to determine whether "Toll Broadcasting" was feasible and, more importantly, whether it met the company's operating culture and responsibilities. Read on.

CHAPTER THREE

By 1907 Western Electric had combined its Boston and Chicago research offices in New York. In addition to its work chasing a non-mechanical telephone repeater and improving transmission cable, in 1911 the department was handed the responsibility of supporting the newly-formed Regional Bell Operating Companies. The work of Western Electric Research stood behind the company's design and development and was in large part responsible for Western Electric's superb reputation as a manufacturer.

Bell Laboratories

In 1925 AT&T took several significant steps. Western Electric was sold into a new company, the *International* Telephone and Telegraph Company ("ITT"). **Graybar Electric** was formed…named for Elisha **Gray** and Enos **Bar**ton. These moves allowed Western Electric to better focus on its own priorities while AT&T (through ITT) could operate in the global telephony scene. Finally, the Engineering Research division of Western Electric became **Bell Laboratories** and began its storied career, honing the cutting edge in all forms of technology.

The Bell Labs story has been well told. One of its earliest challenges was motion-picture sound. Then: television by wire…while also implementing world-wide telephone service…while also developing dial-up "TWX" (teletypewriter exchange) service…while working on undersea cables and massaging the electron. And memorializing its work in the Bell Labs Journals for the world to share. What a great time to be working there!

AT&T and Broadcasting

AT&T's move into "Toll Broadcasting" seemed logical, given the company's interests and assets. In its simplest form, "Toll Broadcasting" was the selling of radio air time. The "Toll" concept harmonized with the company's model for long-distance rate charges, and it's tempting to think it might have been AT&T attorneys who proposed the notion during the negotiations for cross-licensing in 1920. We know "Toll Broadcasting" was placed under the aegis of AT&T by the other partners in The RCA…clearly they did not understood the impact of that assignment at the time.

Over the next few years AT&T would try to define "Toll Broadcasting" as '*a franchise under which AT&T would collect "license fees" for any station operating with radiotelephony technology*.' Another interpretation: "*any* station operating at a profit." These attempts at hegemony drew litigation and government involvement. In the beginning however, "Toll" was to be 'the sale of radio time to a third party.'

In 1921 AT&T proposed an "experiment to test a Toll Broadcasting service…through the experience of the people." It fell to AT&T's Walter Gifford to announce the long-awaited decision. Gifford was a financial star rising through the ranks who would soon be President of AT&T. Kenneth Bixby in his review of Gifford said that, while he was an orthodox conservative, thus fitting the AT&T mold, there were also 'elements of daring' in his make-up. With those character attributes but with the risking of AT&T's reputation, the broadcasting move must have caused Gifford to lie awake at night.

Gifford's 1921 announcement: "A field in which the radio telephone has possibilities is in the furnishing of broadcasting service, a one-way service which consists in sending out by radio telephone from a central station news, music, speeches, and the like which, under favorable atmospheric conditions may be received by all who have receiving stations within the area served, and who care to listen. The number of wave-lengths available for this radio telephone service is limited, but we are preparing to furnish this broadcasting service to such an extent as may meet the commercial demands of the public, subject to that limitation."

Gifford used the occasion to share AT&T's related vision of a national network of stations: "This service would enable advertisers, industrial institutions of all kinds, and even individuals if they desire, to send forth information and advertising matter audibly to thousands. A first consideration is that the material broadcasted (sic) be desirable to the receiver so that the demand for service will be stimulated. Our *present* plans do not contemplate our providing talent for entertainment ....we propose (instead) to be responsible for the quality of the service as far as the broadcasting is concerned." *Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning* (italics/underlining added)

WBAY: the first station in the AT&T experiment

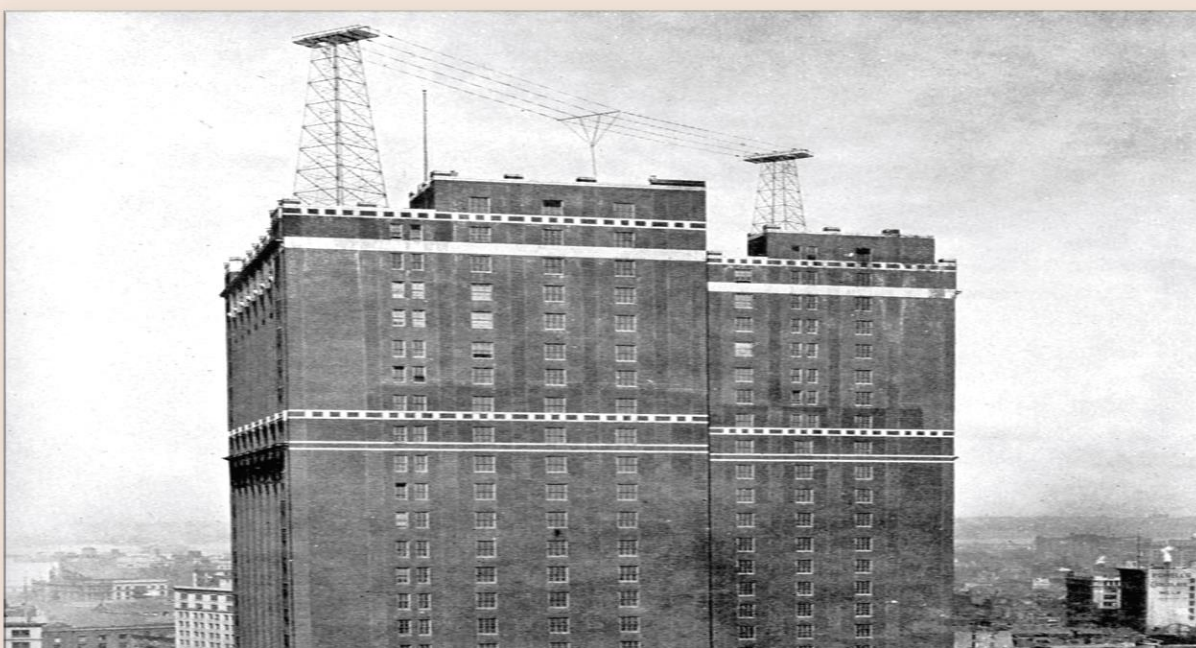
A February 1922 communique announced the establishment of radio station WBAY, New York City, on 360 meters. Walter Gifford again: "It is expected that the work will be started at once and that the station will be ready to begin operations in less than two months' time. This wireless broadcasting station will be unique in many respects…equipped with the latest developments of the Bell System, including the use of electrical filters and new methods, whereby, as the business grows…several wave-lengths can be sent simultaneously from the same point, so that… receiving stations may listen to any one of the several services." (This was certainly prescient.)

Gifford continued, with foresight: "It will be unique in another respect, because (WBAY) will be the first radio station…which will…handle the distribution of news, music or other program on a commercial basis for such people as contract for this service.

The American Telephone and Telegraph Company will provide no program of its own, but provide the channels through which anyone with whom it makes a contract can send out their own programs. Just as the company leases its long distance wire facilities for the use of newspapers, banks and other concerns, so it will lease its radio telephone facilities and will not provide the matter which is sent out from this station." *ibid* (underlining added)

Hugo Gernsback's *Science and Invention Magazine* shaped Gifford's announcement in its own language: "…if there appears a real field for such service…it will be followed as circumstances warrant by similar service from stations erected at important centers thruout (sic) the United States...As these additional stations are erected, they can be connected by the toll and long distance wires of the Bell System, so that from any central point the same news, music or other program can be sent out simultaneously… by wire and wireless with the greatest possible economy and without interference." *Science & Invention, 4/22, courtesy Thomas H White* David Sarnoff was taking notes.

AT&T's Long Lines Division built the new station at the Walker Street headquarters. Engineers carried with them the mantra of quality service; a de facto Long Lines principle. Now those engineers would be learning a new craft. On an August night in 1922, WBAY came up on 360 meters. Because of the airwave congestion, WBAY had to time-share 360m with others; its total *weekly* time-share allotment was *7½ hours*!



WBAY antenna: Long Lines Building, Walker Street, New York *Bell Telephone Record*

It was soon discovered that, in addition to the limited hours, the roof-top antenna was sized wrong for 360 meters and was oriented wrong for New York City (but they're not about to twist the building). WBAY was coming up short; especially when compared with competitor WJZ. Besides…360 meters was a lousy wavelength.

Why 360 meters?

At the outset all "entertainment" stations were assigned the 360-meter wavelength. Government and "weather stations" were on 485 meters. But in a governance model still true today, many of the radio regulatory powers of the Department of Commerce relied on the consent of the governed. WBAY lawyers went to Commerce, fighting for a better frequency. (So did everyone else.) Herbert Hoover, in search of sanity, called several "Radio Conferences" in the mid-1920s to seek the input of the affected. The broadcasters at these conferences told Hoover that new wavelengths were in fact badly needed. Consequently, in 1922 the 400-meter band was opened for "high-power" broadcasting (500 to 1000 watts) followed by a larger band; 300 to 545 meters. The medium-power stations (up to 500 watts) would be assigned to 220-300 meters and the low-power "locals" would stay on 360 meters. This was the first of many changes mandated by government oversight always three steps behind developments.

WEAF saves the day (and the evening hours)

WBAY may have been the first "official" station in AT&T's broadcasting experiment but the company had quietly dabbled in radiophone transmission back in 1919 when Western Electric was authorized experimental station 2XB and set out to build it with the help of Westinghouse. Several months prior to WBAY's inaugural, 2XB was upgraded and licensed for 360 meters as WEAF. ("The original call, taken from an alphabetical list, was to be WDAM but that was considered too profane.
www.angelfire.com/nj2/piratejim/nycamhistory.html

Western Electric's station was to be an experimental facility but WEAF's signal blew away both WBAY and WJZ. It was probably a short conversation at AT&T Headquarters: 'Take over WEAF and switch WBAY's programming to that transmitter.' WEAF replaced WBAY and WBAY disappeared on August 16, 1922. WEAF was initially licensed at 500 watts on 360 meters as a "Toll Broadcaster." Within a year the station had moved to 400 meters; then 405 meters and then 492 meters (610 kc).

WEAF moved to fill its newly-expanded air time, and it was quickly apparent that this time would not be completely filled by paying third parties. WEAF had offered "Toll time" for sale across the broadcast day…in long-form blocks. The reaction was underwhelming. Then someone thought about dividing air-time into smaller segments.

The first such 'segment' aired on WEAF on August 28, 1922. The client was the Queensboro Corporation, selling real-estate development. AT&T's revenue for five days of that announcement: $50 for air time…*plus a "long-distance access fee!"* This time: a positive response that's noted in the radio history books.

Sidebar: Other radio stations may actually have sold advertising before WEAF. The afore-mentioned Telefono Hirmondo sold short mentions in its wired service in 1893. In May 1920, an amateur radio broadcaster leased out his operation in exchange for $35 per week for twice-weekly broadcasts. There were others, and Secretary of Commerce Herbert Hoover was displeased: "It is inconceivable that we should allow so great a possibility for service to be drowned in advertising chatter" he said.

No one was paying attention to him, but competitors were crying "foul" because of AT&Ts publicly-stated position that only *its* facilities could legitimately offer 'programming-for-hire.' To update his own troops, in 1923 A. H. Griswold, assistant vice-president in charge of radio matters, said to a Bell System radio conference: "We have been very careful,…not to state to the public in any way...the idea that the Bell System desires to monopolize broadcasting, but the fact remains that it's a *telephone* job, that we are the *telephone people*, and…we can do it *better* than anyone else...in one form or another, we have *got* to do the job." *Telephone-The First Hundred Years, John Brooks; Harper, Row, 1975* (italics added)

Because of public and political sensitivity to advertising on the new medium, advertising was to be "institutional"- there was no "selling" but merely courtesy announcements identifying sponsors of programs. Prices could not be mentioned after 5pm, and sponsor mention was to be minimized (they got around this by naming musical groups after the sponsor…so every time the band was mentioned in music programs, the sponsor got his plug). Those 'rules' didn't last long.

The Early New York City Radio Dial

AT&T was not alone, nor was it first in New York. Independent operators, radio-set manufacturers and other players in the patent-pool were not sitting by. Westinghouse was focused on KDKA and WBZ in Boston while building WJZ in New York (licensed in 1921 as New York's first). Through its cross-licensing agreement, RCA and Westinghouse operated WJZ as a joint effort until 1923, when Westinghouse bowed out of New York City and turned WJZ over to RCA. RCA launched WJY as a temporary outlet to broadcast the Dempsey-Charpentier fight and followed with station WDY in December 1921 (WDY lasted three months). (WJZ/WDY was arguably the first--short-lived--"duopoly.")

WOR too was assigned 360 meters in February 1922; then it too moved to the longer waves. (WDT, built as a service to marine operations, snuffed it in 1923 and WJY passed on in 1926.)

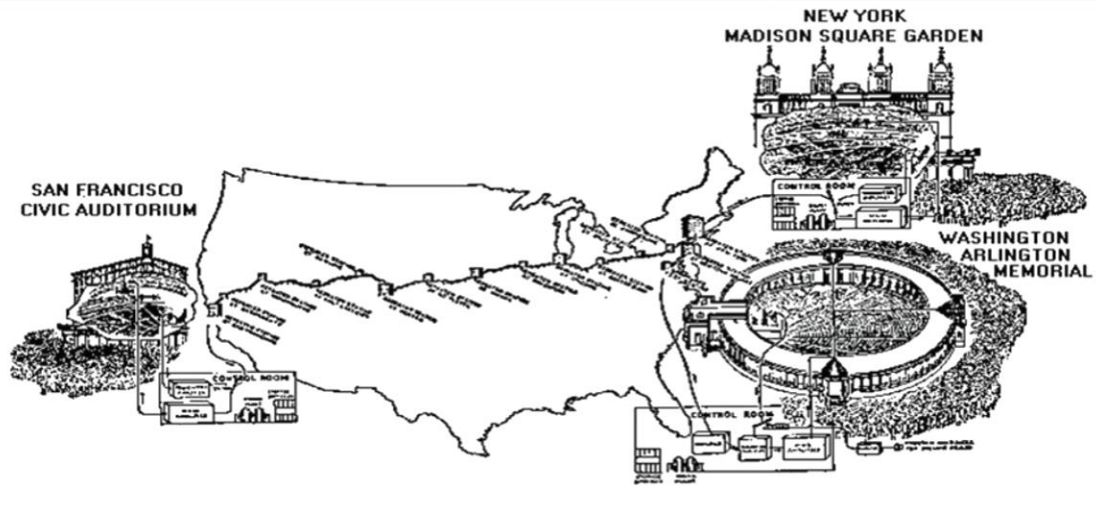
WEAF would feel its way through a business becoming daily more competitive. WJZ was the identifiable archenemy and their competition set the table for similar battles throughout radio's long history. Both stations claimed legitimate broadcasting "firsts" and both advanced the state of the art. Stories abound of the rivalry between them; as two examples: when WEAF claimed exclusivity on paid commercial broadcasting, WJZ aired commercials *free of charge* and the WJZ journalists derided the "hacks" on WEAF who "were doing news for money." (This rivalry continued well beyond the time when both stations were operated by NBC.)

Queensboro aside, WEAF's people, cushioning the lukewarm response to advertising efforts, advised the faint-hearted at AT&T to 'keep the faith' and to remember the larger picture: "Our experience has shown that there is a real demand for broadcasting for hire…there is also a large demand…on the part of *national* advertisers. The best and most economical way to conduct such national broadcasting is to render the program at some convenient city, such as New York, *and to simultaneously distribute the program by wire to broadcasting stations in a number of different cities*."
Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning.

The meat and potatoes of AT&T's "broadcasting *research*" project was of course a "National Toll Network." While WEAF was finding the competition tough going in New York, the wire network faced little opposition in funding and designing program-transport facilities. And in 1921 the transmission folks reached for the West Coast. Long Lines stitched together a 3800 mile program circuit, stretching across the country from the Tomb of the Unknown Soldier in Arlington, VA to crowds gathered in large cities where AT&T interfaced phone lines with Public-Address systems.

From San Francisco, 3,000 miles away, came…reports that the voice of the President… reached those in the audience so distinctly that they held their breath in unconscious expectation that he himself might step forward into plain sight."
Unaccredited newspaper story

(Keep in mind that this entire lash up relied heavily on telephone circuits and did not deliver what would come to be known as "network quality.")



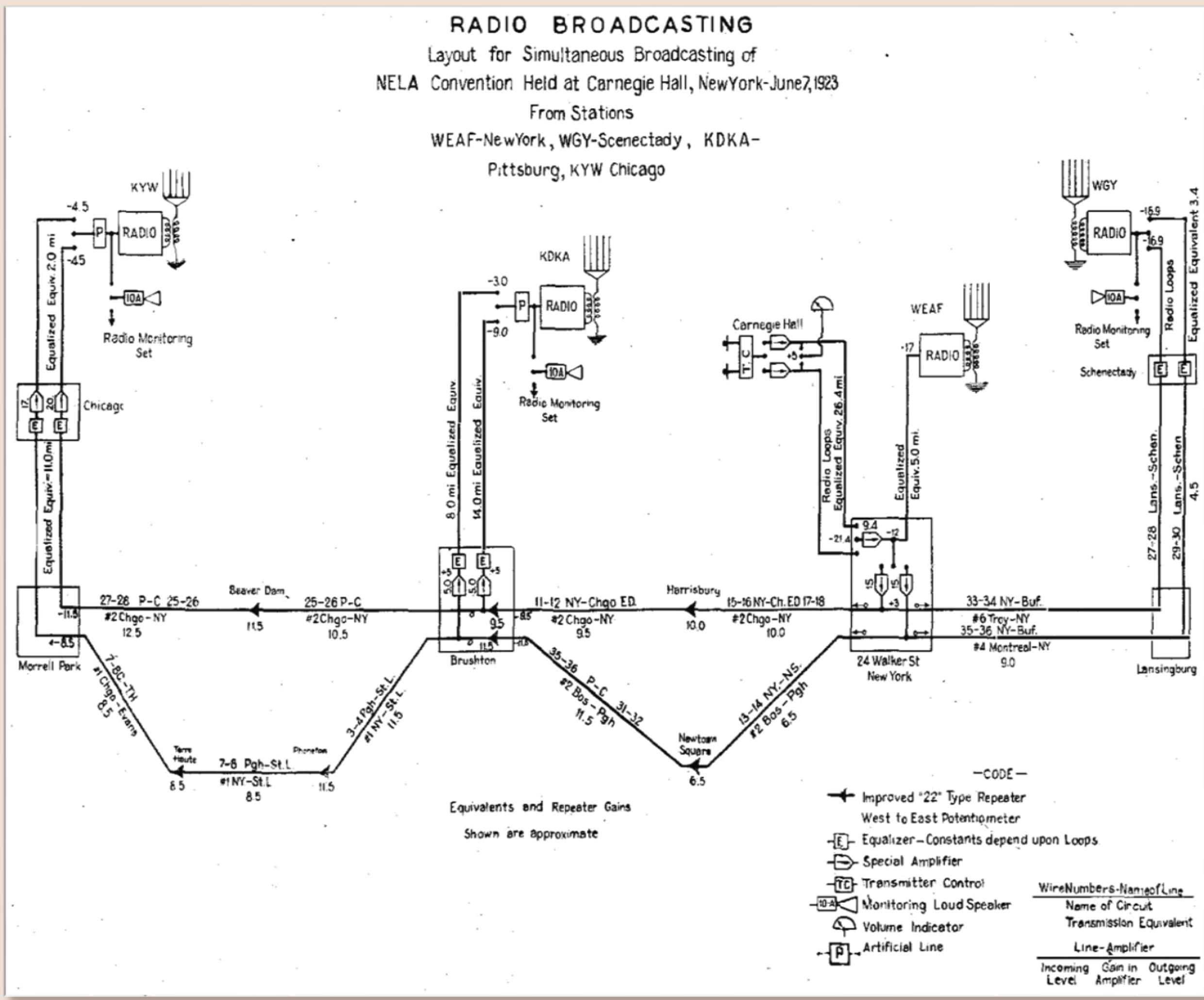
Telephone circuits and vacuum-tube amplifiers carried President Harding's Armistice Day address, in 1921, from the Tomb of the Unknown Soldier at Arlington to crowds in Washington, New York, and San Francisco. This contemporary diagram shows the course of the circuits.

On January 4, 1923 the headline read: "*American Telephone and Telegraph (connects) First Station in Boston— Two Plants Send Same Program at One Time During Tryout*
New York—An experiment in Radiophone broadcasting, the first of its kind ever attempted, has resulted successfully—so successfully, in fact, that the world's greatest telephone corporation is about to launch the establishment of a chain of Radio test laboratories and Radio toll stations that will extend from the Atlantic to the Pacific coasts, both north and south in two lines…This experiment, preparations for which covered several months, was that of simultaneously broadcasting from a New York station on a 400-meter wave-length and Boston station WNAC on the 360-meter wave length. The results are declared by experts to have been flawless."
Unaccredited newspaper story

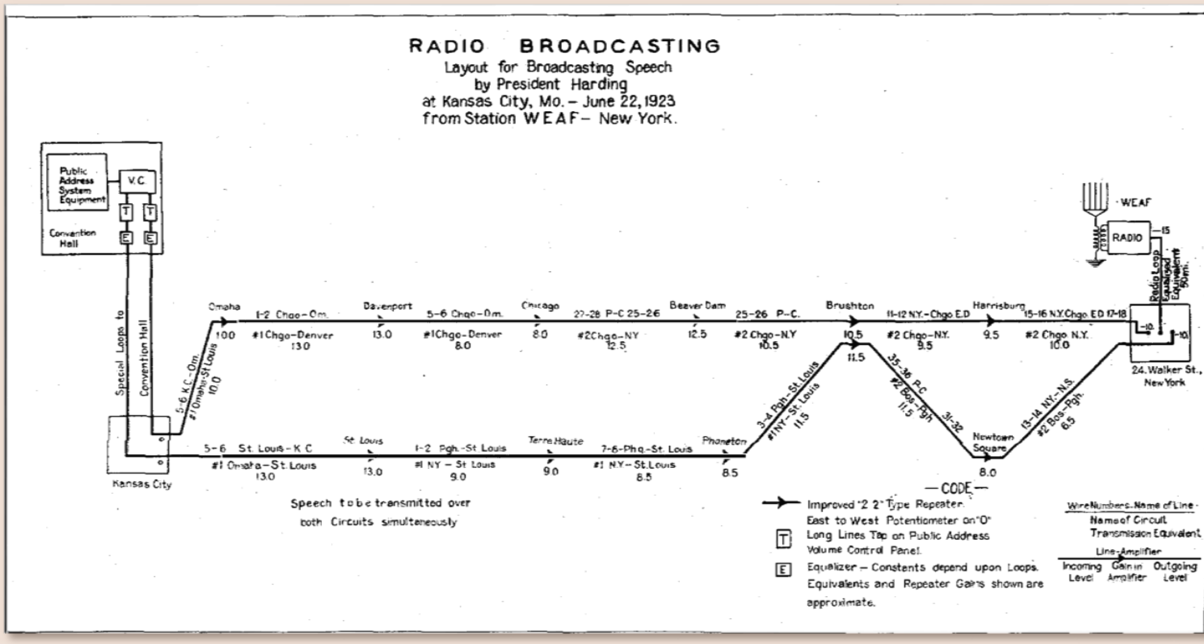
The "WEAF-WNAC broadcast" was a five-minute saxophone solo. To set up that five minutes, Long Lines had to proceed as follows: "From a technical standpoint, the control of a broadcasting station 300 miles from New York by means of telephone lines is a most delicate problem. Four circuits were used to make it happen. The first was the 'regular' circuit, which carried the program. The second was an 'emergency' circuit, which could be plugged in should the regular one fail through storm or other inter-ference. The third was a 'local' circuit, used in Boston…The fourth was the 'order' circuit, by which the telephone and radio engineers in New York and Boston kept in touch with each other. (One wonders: were these circuits route-diverse?)

WCAP Washington D.C. had come on the air in April, 1923 and would be part of the early WEAF Network. The call letters were said to stand for the "**C**hesapeake **A**nd **P**otomac Telephone Company". (Those call letters had been assigned to The Central Radio Service of Decatur IL. It's not known whether AT&T bought the call letters from Central Radio.) WCAP built its own solid reputation in Washington and was instrumental in many AT&T network and propagation tests. It began life time-sharing with The Radio Group's WRC and in 1926, with the formation of NBC, disappeared in favor of WRC.

On June 7, 1923 the first "Chain Broadcast" was fed from Carnegie Hall in New York to WEAF, KDKA Pittsburgh, KYW Chicago and WGY Schenectady. Reaction was outstanding. (The folks at WMAF Round Hill Massachusetts were listening in that night…they wanted to be part of that sort of action.) Below: Part of the layout.



Then on June 21, 1923 came the first live broadcast of President Harding, from St. Louis to WEAF New York. (The diagram below may have been for a similar broadcast the next day, from Kansas City):



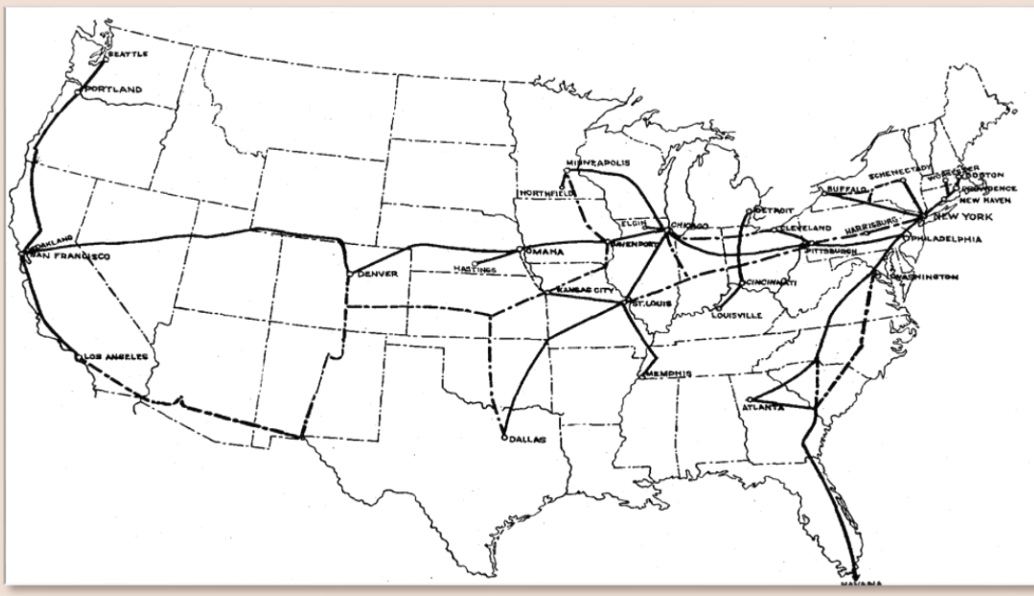
Harding's folks were so excited they immediately scheduled another broadcast for July 31st, connecting a planned podium in San Francisco with local KPO (now KNBR), WOAW Omaha, WMAQ Chicago, WMAF Round Hill Massachusetts, WEAF New York and WCAP Washington. AT&T engineers scrambled; Harding died before the broadcast.

On October 10-13, 1923 a limited-duty circuit between WEAF and WGY was established for the World Series broadcasts of 1923. The Yankees beat the Giants in six games. Long Lines operators across the country heard the direct play-by-play, thanks to informal non-official re-routing of the transmission to Schenectady. *(Some records also suggest a linkup between WJZ and WGY for 1922's games.)*

New President Calvin Coolidge sent a message to Congress December 6, 1923. Coverage was a cooperative venture among the stations of the newly-minted WEAF Network (WEAF, WCAP and WJAR) and Southwestern Bell Telephone Company, which added KSD St Louis, WDAF Kansas City and WFAA Dallas.

The Republican nominating convention assembled in Cleveland on June 10, 1924. Long Lines was poised to pull off another first. Among those 'assembled' were listeners to WLAG, WBAP, WGN, WEAF, WCAP, WBAP, WGN, WLS, WMAQ, WJAR, KDKA, KFKX, WSB, WRC, WOC, WDAF, WHK, KSD (some were fed via telephone-grade circuits).

Two weeks later broadcasting got more than it bargained for with the Democratic Convention in New York's Madison Square Garden. It took 103 ballots to agree on John W. Davis and it was the longest-running convention in political history when it mercifully ended on July 9th. During many of the ballot roll-calls, listeners heard the stentorian tones of the whip from Alabama declaring his state's votes for "*OSCAR---W---UNderwood*."

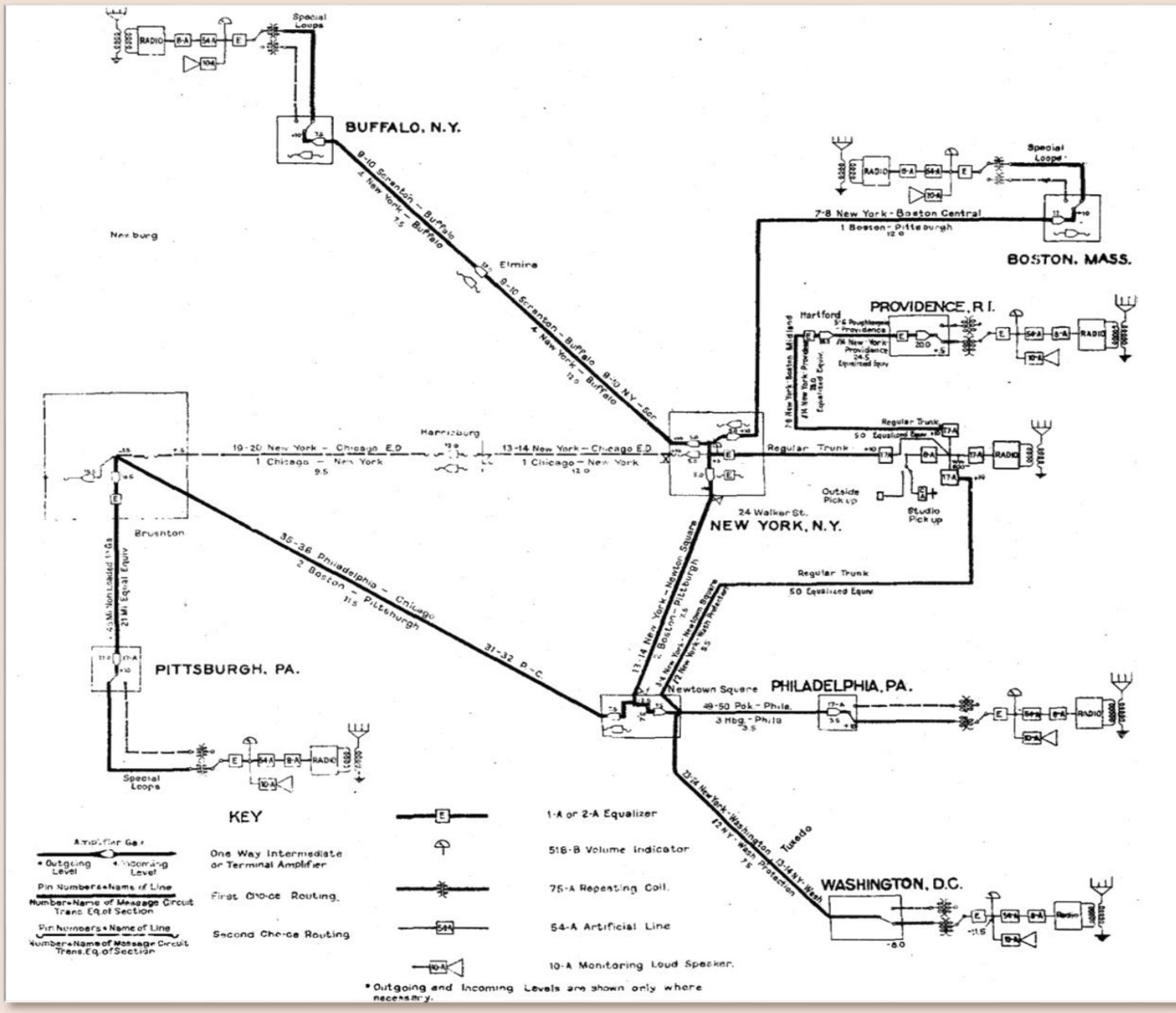


Democratic Convention "chain" 1924   *Communications Magazine*

15 stations in 12 cities carried the 1924 Democratic Convention: KDKA, KGO, KSD, WBZ, WCAP, WDAF, WEAF, WGR, WGY, WJAR, WJZ, WLS, WMAQ, WRC, WSB.

The numbers and stations covering the conventions will vary depending on which radio history you read. What was clear at the outset however is that politicians immediately tumbled to a medium that could carry a voice to millions of people, and it wasn't long before convention events were 'staged for radio.'

Then on September 12, 1924: The U.S. Army conducted the first of two "National Defense Day" broadcasts, using AT&T Long Lines to connect stations from coast-to-coast. A recording of that broadcast has survived; the emcee is heard calling the roll of stations and talking with repeater personnel. It was a two-way network; an enormous undertaking. 39,000 miles of telephony-grade and 11,000 miles of telegraph lines were used. Here's an edited recording of that broadcast, with [the station roll-call.](#)



Part of the "National Defense Test Day" circuitry *Communications Magazine*

The Army was ecstatic and immediately ordered another national hookup for July 1925. AT&T swallowed its objections in patriotic fervor (and because it was good public relations). Not incidentally, AT&T took the occasion of these major broadcast requests to invest in upgrades that served the network in the long-term. (Presumably they wrote off the improvements as the cost of performing this "Public Service.")

On Election Eve 1924, 27 stations broadcast Coolidge's final campaign address, with Denver, Seattle, Portland, Los Angeles, Oakland, and San Francisco added to the line. "If America's radio listeners hailed nationwide broadcasting as a wonderful experience, the Long Lines men best knew what made it so."

Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning

Coolidge was part of yet another original broadcast. His inauguration to a full term took place on March 4, 1925. A 21-station hookup of radio stations was augmented by installations of public-address systems directly connected to the network. These ad-hoc achievements were living lessons for AT&T personnel. Meticulous performance records were kept on these 'sustaining innovations' and each experience made the next a bit better. When WEAF called for its *full-time* "Toll Network," AT&T Long Lines was ready.

The WEAF Network

The announced goal for the WEAF Toll Network was 16 to 20 stations along the route of the wire network. Quality was the AT&T watchword, so 'target candidates' were selected for their coverage, stability, signal and market penetration. (Perhaps not coincidentally, almost all of these stations used Western Electric equipment.) Further definition brought the early target list to 21, including: WNAC Boston, WJAR Providence, WGR Buffalo, WFI Philadelphia, WDAR and WCAP Washington, WCAE Pittsburgh, WJAX and WTAM Cleveland, WCX and WWJ Detroit, WLW and WSAI Cincinnati, WGN Chicago, WOC Davenport, KSD St. Louis, WCCO (nee WLAG) Minneapolis, WHB and WDAF Kansas City and WFAA and WBAP Dallas. Most if not all these stations qualified for operation in the 400-meter band. Thus did AT&T hope to monetize its "Exclusive License" to use the airwaves for hire.

Not all the targets were excited about the idea of joining a commercial network. Many believed that broadcasting was meant for "good will" and felt that commercials, even if indirect, were a violation of the trust assumed by the grant of their licenses. Despite their initial objections, a few unwashed were led to the bath. WCCO Minneapolis, WOC Davenport, WWJ Detroit, WSAI & WLW Cincinnati, WEAR Buffalo and WOO Philadelphia finally agreed to join the proposed group.

With affiliates-in-hand (on paper), the next step was to establish station connectivity beyond WCAP. Following the WEAF-WNAC test, WMAF's interests were recognized and test programming began in July 1923 between WEAF and WMAF. The WMAF arrangement was a 'summer-only' trial (a short-lived deal between radio pals). For AT&T to fully test the concept of Chain Broadcasting, at least one other *full-time* station was needed. It turned to be WJAR, Providence, Rhode Island. Rhode Island was an unlikely hotbed of early radio development. "In June of 1922, Shepard's Department Store launched WEAN, the first radio station in Rhode Island. Just three months later WJAR was on the air, followed shortly by WPRO.

These stations were looking for programming, and a chance to join AT&T must have been alluring. WJAR joined the network on October 14, 1923.
Taken in part from "The Rhode Island Radio Hall of Fame"

Colors on the map

The 1923 WEAF-WJAR-WCAP connectivity formed the first full-time radio network. WEEI, WGR and WCAE were soon added. These six became the "Expanded WEAF Network." This is where the fabled network-coloring scheme began, for AT&T Long Lines engineers did indeed use a red pencil to describe the first network routing on their route maps. That red pencil would describe the "NBC Red" network three years hence.

Long Lines engineers were now reminded of the company's plans for hookups of more stations in more cities. Engineers pushed back, reminding their bosses that such full-time connectivity might seriously affect the network's ability to handle its core business: peak telephone traffic. An internal memo: "Every individual broadcasting undertaking was a special problem to the long-distance operating unit, *for its facilities has been designed and built for telephone purposes only.* The conception of a network for regular service was thus a separate challenge to provide the necessary circuits *without impairing the organization's ability to meet the public need for long-distance service*." *Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning*

The primary consideration in establishing a national network was, therefore, circuit availability. This concern is again noted in a September, 1923 warning by the Long Lines Director who thought there might be occasions involving the question of "…priority in use of Long Lines (telephone) circuits as an adjunct to radio broadcasting. "Last night…we had a specific case, in which the circuits normally used for connection between WEAF and WCAP in Washington were unavailable on account of induction…in this specific case, an available circuit as an emergency proposition meant cutting into the New York-Havana circuit group." *ibid*

The execs were listening, but the engineers must have seen the handwriting on the colored map. The build-out was done slowly, deliberately, and with AT&T quality and reliability. From what we can see from the records, AT&T wasn't above pushing hard to make radio-networking happen…but they appeared to have a healthy respect for engineering's realities.

Network modifications for program transmission

Building out network connectivity was costly. The circuits used for the early WEAF Network were taken from facilities that had been engineered for the transmission of speech only. The technical detail of chapter Seven outlines the problems in adapting the existing wire network for wider-bandwidth radio programming.

RCA Tries to Build a Network

It was interesting to note how David Sarnoff claimed to see things in the early 1920s. In light of AT&T's vision for a group of connected stations across the country, Sarnoff said he believed that a multiplicity of stations was not a good thing for the public. He went on to share his belief that eventually the entire country could be served by a small group of "Super-Power" stations…not supported by advertising, he said, but rather by revenue-distribution from the sale of receivers.

He also argued for outright endowment of a public service by philanthropic organizations. He was either totally sold on cloning the BBC…or he saw how the wind was blowing and was positioning himself publicly for what he saw as the coming battle with AT&T.

Thomas White sums up the situation: "Although the proposed umbrella broadcasting company was not organized at this time, The Radio Group members (GE, Westinghouse, RCA) did increase cooperative efforts. The original plan was for the Group's stations, starting with…WJZ in New York, to expand coverage by increasing transmitter outputs to "superpower" status of 50,000 watts…although the higher powers did help…regional coverage, even 50,000 watts wasn't powerful enough to achieve the goal of covering the entire nation with signals…one way to economize was to emulate AT&T by connecting the stations together to simulcast programs. Thus was born the idea of an "NBC."

"WJZ would be the key station; WBZ, WGY and WRC and perhaps a Pittsburgh and Chicago station were expected to be on the line at various times. But transmission quality (would suffer if Western Union's telegraph lines had to be used)…Poor sound quality was sometimes accompanied by annoying hums." *Thomas H. White* *http://earlyradiohistory.us/index.html*

Frustrated by the denial of AT&T network access, the Radio Group threatened litigation, with government intervention invoked if needed. The issue RCA articulated was whether AT&T had gone too far in denying competitors network access. AT&T construed the original Licensing Agreement as conferring to itself and its associated stations the sole rights to "Toll Broadcasting" including network connectivity.

John Brooks picks up the story: "Up to early 1922, it was AT&T's policy to refuse the use of Bell telephone wires…to radio stations not owned by Bell. There was a relaxation of this hard-line policy in April, 1922, when AT&T informed its operating companies that it now seemed desirable…to be liberal in the matter of leasing private lines to broadcasters (*on a local basis*).

"However, the stations owned by AT&T's chief competitors in broadcasting—Radio Corporation, General Electric and Westinghouse—were specifically excluded from the new…policy, under AT&T's interpretation of the 1920 agreement." *Telephone-The First Hundred Years, John Brooks; Harper, Row, 1975.* (italics added)

AT&T also thought its license for Toll Broadcasting meant that even those stations already licensed had to pay *an additional license fee to broadcast* (shades of iBiquity). Many new stations paid this license fee and AT&T's licensing rights generally went unchallenged…until WHN came on in New York and refused to ante.

AT&T took the station to court; public outcry was unexpected and immediate. Those who knew about such matters yelled "MONOPOLY!" Secretary of Commerce Herbert Hoover said it would be "unfortunate" if broadcasting were controlled by a monopoly. The WHN case settled out of court, but so great was the reaction that AT&T decided not to pursue further remedies.

While the WHN settlement might have reinforced the idea that a radio station needed an AT&T license to broadcast commercials, within a few months AT&T took pains to clear up what it called a 'misspoken claim' that radio stations couldn't operate *for profit* without at AT&T license. The distinction may have been lost.

Meanwhile, an increasing number of industry-watchers were telling anyone who would listen that direct commercial announcements by radio was a disservice to the medium and the public. This attracted Congress and the Federal Trade Commission (FTC).

The Feds came to the conclusion that a monopoly might indeed be at work here…but the administration was seriously business-friendly and hesitated to get involved. At the same time RCA, while privately furious about AT&T's interpretation of its licensing authority, softened its public position since it too might be construed as fighting for a monopolistic position. Arbitration and 'discussion' was long and bitter.

The 1925 negotiations

Seeing no apparent change in AT&T's litigative posture, the FTC re-opened the 1920 Cross-Licensing Agreement. However…*both* sides wanted the government to stay out. It seemed prīmā faciē that AT&T and The Radio Group had specific concerns that might be mutually satisfied by reasonable discussion, in a true "big business" manner.

The Issues:

> The Radio Group believed the 1920 Licensing Agreement included access to AT&T's lines.

> The Radio Group wanted to get its hands on WEAF and the other well-developed stations under AT&T's control. Their position on WEAF was that the station could be better utilized 'in the public interest' than had been demonstrated by AT&T's operation. (This again stemming from the snarkiness between WEAF and WJZ.)

> AT&T wanted the right to manufacture tubes for its own business (usage was estimated at between one and two million tubes annually, in the Bell System alone).

> AT&T wanted to build radio receivers.

Internally, AT&T's overriding interest was in protecting its traditional areas of operations as well as its futuristic technical developments…including sound and film advances and television, games in which Bell Labs was now playing.

The threat of government interference in the broadcasting matter was probably not formidable, given its dismal track record in broadcast regulation. (Historians will recall that due to a Circuit Court override of Hoover's Commerce Department authority, the "Chaos of 1926" created near-anarchy on the radio dial.)

Pundits didn't see the Federal Trade Commission as having the chops or the understanding to referee this fight. And the Federal Radio Commission was in gestation. The Radio Group and AT&T called for arbitration; the arbitrator flunked.

So both sides sat down in a smoke-filled room and hammered out a historic agreement. The meetings were intense, difficult…and brief. In a matter of days a five-year conflict was ended.

Sale of AT&T Broadcast Interests

When the smoke cleared, WEAF (and AT&T's interests in WCAP) were sold to The Radio Group for a million dollars. AT&T agreed to exit broadcasting and to provide universal access to its network system (through its own interfaces of course).

AT&T also surrendered the right to exact a license fee for commercial broadcasting; even for stations using Western Electric gear.

With The Radio Group, Long Lines now had a huge customer for its program-transmission business (a single-channel transmission contract was valued at a million dollars per year).

Furthermore, Western Electric could now manufacture tubes and AT&T could manufacture radio sets for its own purposes (though it rarely exercised this privilege). The tube deal gave Western Electric the legs it needed to remain a strong force in building station and network equipment and in sharing the leadership in tube manufacturing. Not a bad place to end up for either side.

AT&T President Gifford explained in the Annual Report for 1926: 'The Company undertook to develop radio broadcasting in order to ascertain how it could be made most useful in the business…The further the experiment was carried, the more evident it became that the objective of a broadcasting station was quite different from that of a telephone system.'

"(This)…meant that AT&T --under pressure, to be sure --had given up another dream of monopoly, and that entertainment stars would no longer enliven the scene at 195 Broadway." *Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926; Banning*

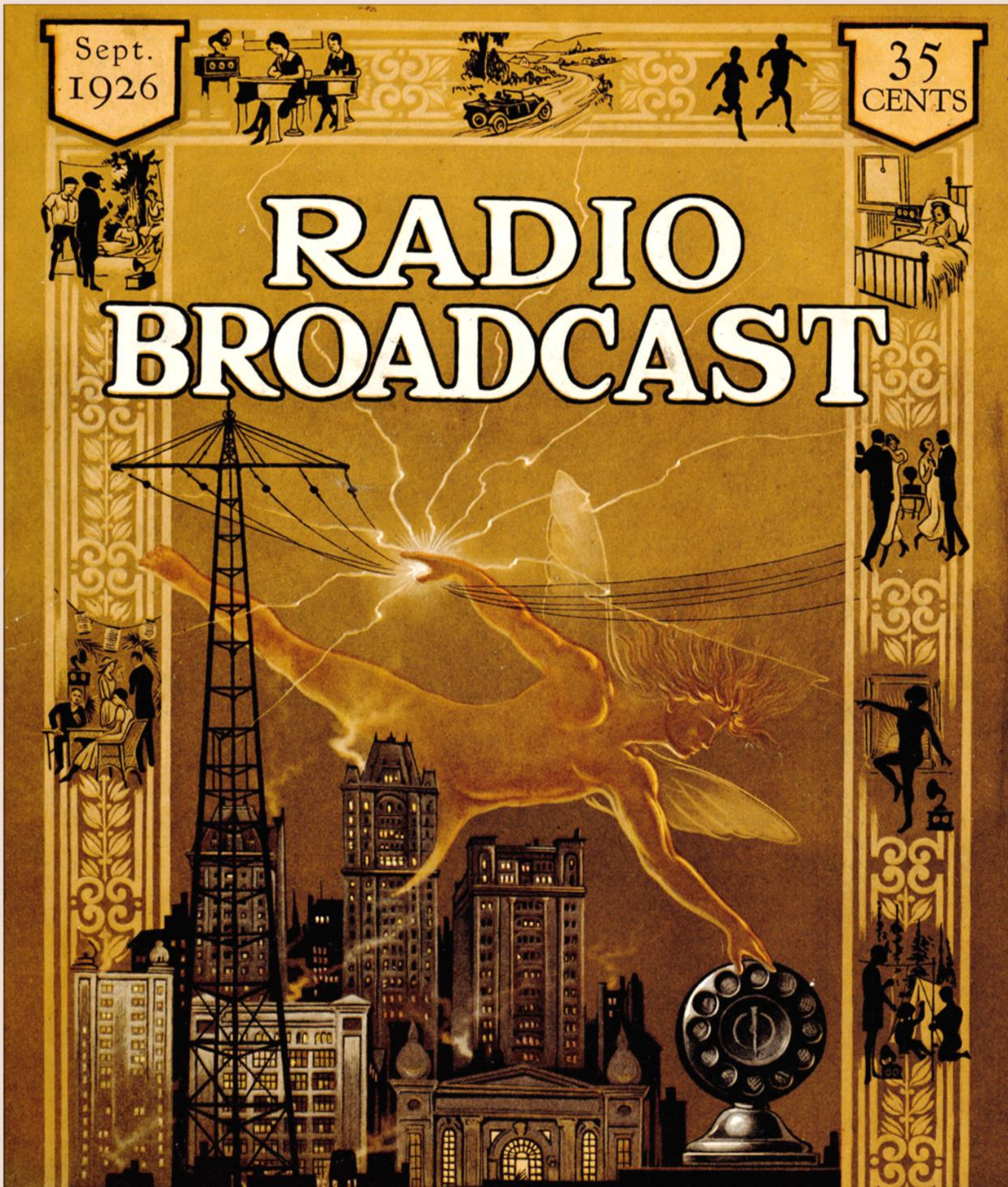
"…the selling of WEAF was the beginning of the end of AT&T's venture in broadcasting *even though it later attempted to set up its own network." The Broadcast Century, Hilliard and Keith* (italics added) We've been unsuccessful in chasing down this reported 'new-network' move by AT&T; it may have never happened.

It had been hard work for AT&T in those years of "testing" the response to radio broadcasting. Along the way, WEAF had come of age. And by the way, the WEAF story never really ended. 'WEAF' is still on the air; several call-letter changes later, it's WFAN-Sports Radio. Through its commercials, WFAN has become the top-billing sports station in the world.

Not a lot of stations were successful in the 20s. Of the several hundred on the air when WEAF came to life, only about two-thirds survived. Some prospered by commitment to local community. Some survived by sharing a network. Some folded. Radio was never an easy business to be in, in spite of its apparent "glamour."

Thus ended the "WEAF Experiment." Thus began large-scale network radio in America.

Closing the chapter on AT&T's broadcasting "experiment, it's appropriate to include the iconic *Radio Broadcast* cover…memorializing the magic, the power and the progress of the new 'mass medium.'



CHAPTER FOUR

In this chapter we focus on how the networks came of age. (Again, the deeper technical detail of the buildouts is relegated to chapter Seven.)

AT&T may have given up its radio outlets but its Long Lines division was positioned as the gateway to national radio coverage. By now Sarnoff's vision of a few "super-stations" was shown to be impractical. With the "WEAF Experiment" AT&T had met some of its stated goals: 1) to determine the public's taste for 'Toll Broadcasting;' 2) to evaluate the practicality of upgrading the telephone network for program transmission; and 3) to control the market for its core businesses. They scored two out of three.

WEAF's creative staff and support cadre turned in their AT&T access cards and moved with WEAF to The Radio Group, continuing to empower a station that in so many ways had made such an indelible mark on the business. The Radio Group, including GE and Westinghouse, lost no time in renaming and expanding the WEAF Network, and in November 1926 announced the "National Broadcasting Company." Of this development, RCA's Sarnoff was fond of saying: "When life hands you a lemon, make lemonade." The AT&T settlement altered that dictum to: "When life hands you a lemon…buy the other guy's lemonade stand."

Lofty goals

At first David Sarnoff did not seem to want to continue what WEAF had been doing; his own vision of a "WEAF Network" was purportedly far more noble. He said he wanted to build a non-commercial national group, operating in the public interest (patterning the concept after the BBC). But not long after he acquired WEAF he changed direction…perhaps the million-dollar WEAF price tag and the income expectations of the Radio Group's Board helped clarify his vision.

NBC's inaugural broadcast for the "Red" network took place on November 15, 1926. Sadly, no recordings of that broadcast are known to have survived. In addition to the existing WEAF network outlets, that inaugural broadcast extended as far west as Kansas City and was heard on new affiliates including WJZ (New York), WEEI (Boston) WLIT (Philadelphia), WRC (Washington), WDAF (Kansas City), WWJ (Detroit) and WCSH (Portland ME).

Announcing the

National Broadcasting Company, Inc.

National radio broadcasting with better programs permanently assured by this important action of the *Radio Corporation of America* in the interest of the listening public

THE RADIO CORPORATION OF AMERICA is the largest distributor of radio receiving sets in the world. It handles the entire output in this field of the Westinghouse and General Electric factories.

It does not say this boastfully. It does not say it with apology. It says it for the purpose of making clear the fact that it is more largely interested, more selfishly interested, if you please, in the best possible broadcasting in the United States than anyone else.

Radio for 26,000,000 Homes

The market for receiving sets in the future will be determined largely by the quantity and quality of the programs broadcast.

We say quantity because they must be diversified enough so that some of them will appeal to all possible listeners.

We say quality because each program must be the best of its kind. If that ideal were to be reached, no home in the United States could afford to be without a radio receiving set.

Today the best available statistics indicate that 5,000,000 homes are equipped, and 21,000,000 homes remain to be supplied.

Radio receiving sets of the best reproductive quality should be made available for all, and we hope to make them cheap enough so that all may buy.

The day has gone by when the radio receiving set is a plaything. It must now be an instrument of service.

WEAF Purchased for $1,000,000

The Radio Corporation of America, therefore, is interested, just as the public is, in having the most adequate programs broadcast. It is interested, as the public is, in having them comprehensive and free from discrimination.

Any use of radio transmission which causes the public to feel that the quality of the programs is not the highest, that the use of radio is not the broadest and best use in the public interest, that it is used for political advantage or selfish power, will be detrimental to the public interest in radio, and therefore to the Radio Corporation of America.

To insure, therefore, the development of this great service, the Radio Corporation of America has purchased for one million dollars station WEAF from the American Telephone and Telegraph Company, that company having decided to retire from the broadcasting business.

The Radio Corporation of America will assume active control of that station on November 15.

National Broadcasting Company Organized

The Radio Corporation of America has decided to incorporate that station, which has achieved such a deservedly high reputation for the quality and character of its programs, under the name of the National Broadcasting Company, Inc.

The Purpose of the New Company

The purpose of that company will be to provide the best program available for broadcasting in the United States.

The National Broadcasting Company will not only broadcast these programs through station WEAF, but it will make them available to other broadcasting stations throughout the country so far as it may be practicable to do so, and they may desire to take them.

It is hoped that arrangements may be made so that every event of national importance may be broadcast widely throughout the United States.

No Monopoly of the Air

The Radio Corporation of America is not in any sense seeking a monopoly of the air. That would be a liability rather than an asset. It is seeking, however, to provide machinery which will insure a national distribution of national programs, and a wider distribution of programs of the highest quality.

If others will engage in this business the Radio Corporation of America will welcome their action, whether it be cooperative or competitive.

If other radio manufacturing companies, competitors of the Radio Corporation of America, wish to use the facilities of the National Broadcasting Company for the purpose of making known to the public their receiving sets, they may do so on the same terms as accorded to other clients.

The necessity of providing adequate broadcasting is apparent. The problem of finding the best means of doing it is yet experimental. The Radio Corporation of America is making this experiment in the interest of the art and the furtherance of the industry.

A Public Advisory Council

In order that the National Broadcasting Company may be advised as to the best type of program, that discrimination may be avoided, that the public may be assured that the broadcasting is being done in the fairest and best way, always allowing for human frailties and human performance, it has created an Advisory Council, composed of twelve members, to be chosen as representative of various shades of public opinion, which will from time to time give it the benefit of their judgment and suggestion. The members of this Council will be announced as soon as their acceptance shall have been obtained.

M. H. Aylesworth to be President

The President of the new National Broadcasting Company will be M. H. Aylesworth, for many years Managing Director of the National Electric Light Association. He will perform the executive and administrative duties of the corporation.

Mr. Aylesworth, while not hitherto identified with the radio industry or broadcasting, has had public experience as Chairman of the Colorado Public Utilities Commission, and, through his work with the association which represents the electrical industry, has a broad understanding of the technical problems which measure the pace of broadcasting.

One of his major responsibilities will be to see that the operations of the National Broadcasting Company reflect enlightened public opinion, which expresses itself so promptly the morning after any error of taste or judgment or departure from fair play.

We have no hesitation in recommending the National Broadcasting Company to the people of the United States.

It will need the help of all listeners. It will make mistakes. If the public will make known its views to the officials of the company from time to time, we are confident that the new broadcasting company will be an instrument of great public service.

RADIO CORPORATION OF AMERICA

By February 1928 several Pacific Coast stations were clearing NBC Red programming and by the end of 1928 the network was coast-to-coast on a regular schedule.

The original 'Radio Group' network (anchored by WJZ) quickly migrated to AT&T's facilities and the "Blue Network" formally opened its own microphones on January 1, 1927 with WJZ as the flagship. The Blue Network added its color to the AT&T map.

By the way: There's a small body of NBC history that suggests this 'two-color image' approach carried over into the record industry, when RCA differentiated its high-brow Red Seal recordings from the rest of their offerings. In 1927 the Red Network was purposed to provide 'commercially-sponsored popular entertainment' while the Blue would carry news, cultural programs and whatever else was discarded from Red.

The Upstart Columbia

A half-hearted talent search began at NBC but, for the moment at least, the entertainment resources inside the WEAF and WJZ staffs 'provided all that listeners should need; thank you very much.' That was fine for New York City, but performers of broader appeal were key to attracting a wider audience. Sarnoff took a meeting with an Artists' Rep named Arthur Judson who wanted to provide star-quality performers. Sarnoff suggested Judson form a talent group. Judson was barely out of the building when Sarnoff decided he'd build his own talent pool. He walked away from Judson, using Judson's ideas to form the NBC Artists' Bureau.

Judson believed he had a viable product, so in 1927 he formed a small radio network to make use of his entertainment cadre. It began as "United Independent Broadcasters." United came on the air in 1927 and became an immediate money-sink. While Judson had the artists lined up, the cost of AT&T transmission was killing him. He sought investors. The Columbia Phonograph company agreed to provide stop-gap funding…IF Judson would rename the network "The Columbia Phonographic Broadcasting System." (On AT&T maps Columbia became the "Purple Network.") Audio turned purple on September 18, 1927. There were 16 stations including "key" station WOR.

Columbia soon tired of the losses and sold out to the Levy brothers in Philadelphia…who brought on board a smooth young fellow named William S. Paley. (Paley's family was part owner of the Congress/La Palina Cigar Company. This outfit spun off a lot of cash and was pleased by its advertising on Judson's network. The cigar company became a major investor in Columbia.) "Columbia" collected 49 affiliates in 1928.

Thus began the storied lifelong competition between Robert Sarnoff and William Paley; it was good for the American listener since the networks became fierce combatants and sought through the years to outdo one another in broadcasting accomplishments.

Judson went back to being an Artists' Rep, opened a recording studio and a syndicated recorded-broadcast company. The Judson Studio pressings were done by Columbia.

Mutual

Though this is getting ahead of our timeline, it's a good place to mention the Fourth Network. In 1929, WOR, WLW and WLS created a cooperative called "The Quality Network." The idea was to place air-time buys on a selected group of stations and, eventually, to *feed* those stations the sponsored programs via network or transcription.

To improve the reach of the hot new "Lone Ranger" radio show, WXYZ Detroit was added. Because the raison d'etre for this group was to function as a cooperative enterprise, the name "Mutual" lent itself nicely to the branding.

While a group of high-power broadcast stations looked good on a map, Mutual discovered that there weren't many high-power signals that weren't already affiliated with NBC and CBS. Self-identified "wise folks" say that 'when you need to move a lot of rock and the rocks are too big to lift into the wheelbarrow, you instead fill the wheelbarrow with a lot more (smaller) rocks.' Many lower-power regional and local stations joined Mutual's lineup; it eventually had the largest network-affiliate base.

Affiliate stability

The first few years of network/affiliate development did not happen in a linear fashion.

In "*American Broadcasting,"* Schlichty and Topping note that: "Network facilities making possible the distribution of programs to all parts of the nation would not have been sufficient to attract sponsors to radio…unless, at the terminals of the network wires, there were transmitting stations capable of putting out a broadcast signal *on a regular basis* with a minimum of interference. Prior to 1926 these conditions did not obtain; the…task at local stations was not the development of programming, but the problem of *keeping the station on the air* on the same frequency.

"After 1926, station transmitters were fairly dependable, but stations' schedules remained irregular because of the necessity…of sharing wave-lengths. Station WMAQ, Chicago, for instance, interrupted its broadcasting four times each day to give other stations air time, as late as September 1928.

"In fact, the hours of operation among Chicago stations were such that in order to reach that city with (its) programs…*the Columbia Broadcasting System had to sign affiliation contracts with three stations,* and to cover it with two networks, *NBC needed five stations.*

"Thus, during the 1927-28 season, the advertiser could not have the broadcasters' assurance of a full, daily, stable program schedule. It was the activity of the Federal Radio Commission in 1927 and 1928 that eventually made it possible for broadcasters to give that assurance." *American Broadcasting, Lichty/Topping* (italics added)

During the "reassignment follies" of the late 1920s the Federal Radio Commission ("FRC") moved some stations three or four times within a couple of years; some frequency assignments lasting but months! Repeated wavelength realignment came about because of the need to discontinue time-sharing; because of the flood of new station and power-upgrade applications.

Changing a station's frequency was not a trivial exercise; antennas sometimes had to be completely rebuilt and sometimes transmitters replaced. Then there was the impact on a station's image when it had to play hide-and-seek across the dial. The FRC issued General Order 40 in 1928 in a crawl toward stability. General Order 40 established five "radio zones" and assigned a number of high-power stations to each (the zone assignment were based in part on the population distribution of the time).

Channels were now classified as "Clear," "Regional" and "Local" with maximum allowable power levels for each. Canada was recognized in the channel-sharing. General Order 40 would be effective until the 1941 NARBA frequency-reassignments were issued; the 1941 plan would remain in place until modified slightly by the Rio de Janeiro Regional Agreement in 1981.

Of special interest in 1928 was General Order 43, designed to separate high-power, same-network affiliates. This was in response to listener objections about network duplication (particularly in the Midwest). It mandated that ***'Clear-Channel' stations affiliated with a common network must be separated by at least 300 miles…***(except for one hour each evening; presumably near sunset). The FRC also encouraged *synchronous broadcasting* by permitting exceptions to rule 43 for synchronized operation.

Broadcast interests created delay after delay in the Rule's implementation…until General Order 43 was finally canceled and stations could go about their business. As in Hoover's Commerce days, *rules seemingly required the consent of the governed.*

Why affiliate, anyway?

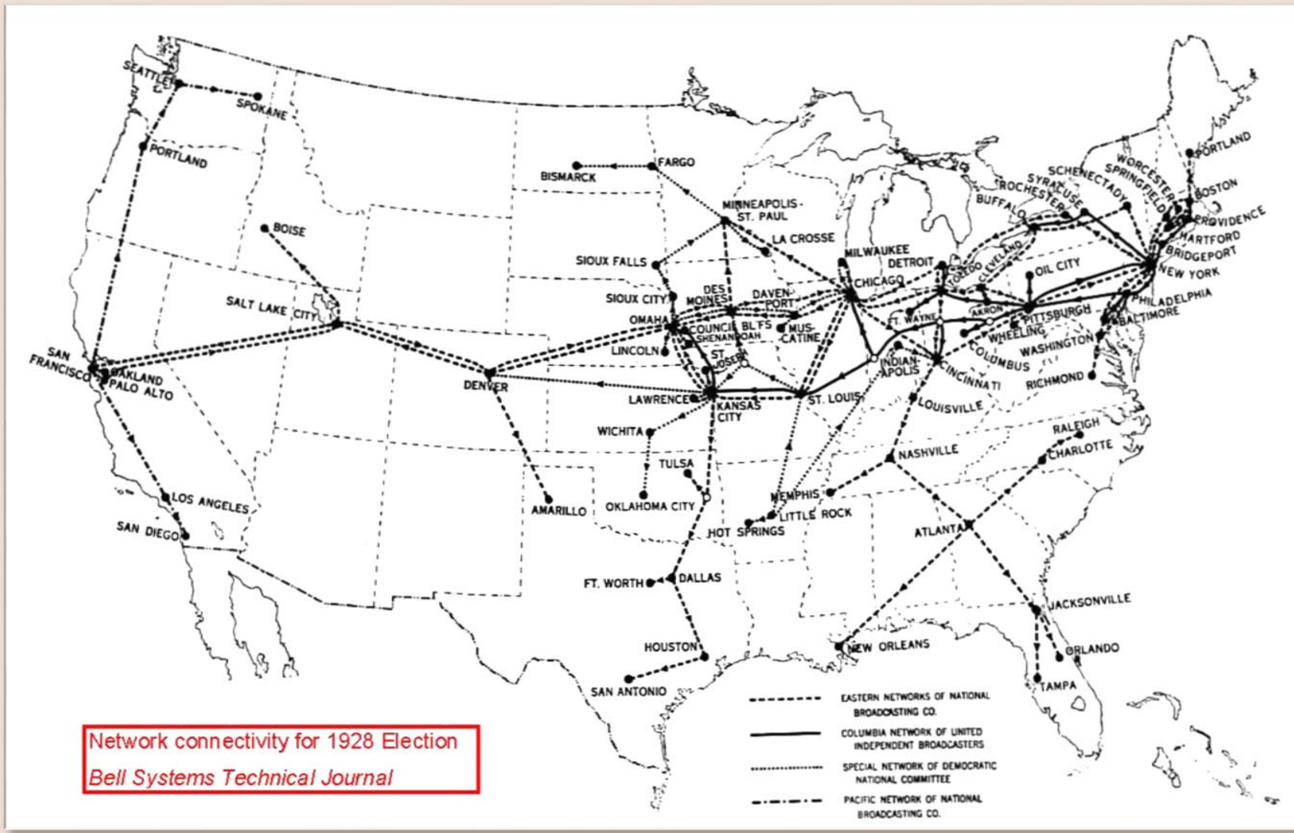
The impetus for network affiliation wasn't just to add big voices to a stations offerings. Broadcasters had developed a station-value model still in use: "reach-cost per listener." High-power stations had a huge economic advantage in these equations. Wide-area coverage allowed them to charge more for air-time…while delivering a larger market-area to mine for potential advertisers. Especially at the big stations, more revenue meant better programs; better programs meant more listeners; more listeners meant higher rates.

For smaller stations, airtime sales, whether in blocks or individual "announcements," weren't always enough to offset operating costs. The mathematics caught up with many. There were only so many minutes of broadcast time per hour. Most stations operated in markets that, driven by their local economies, imposed a practical limit on per-unit ad revenues. They had to strictly control costs.

National news reporting

One of the advantages to network connectivity was that it enabled simultaneous program-clearance across the country. News was an obvious candidate for this model but the networks would not launch serious news efforts for some time; they did not see the demand, and news-gathering was expensive.

However by 1928 NBC and CBS were going all-out for "specials" and that included election coverage. Here's one of the ad-hoc networks set up for these projects. (Parts of the network were telephone-hookup):



Network connectivity for 1928 Election
Bell Systems Technical Journal

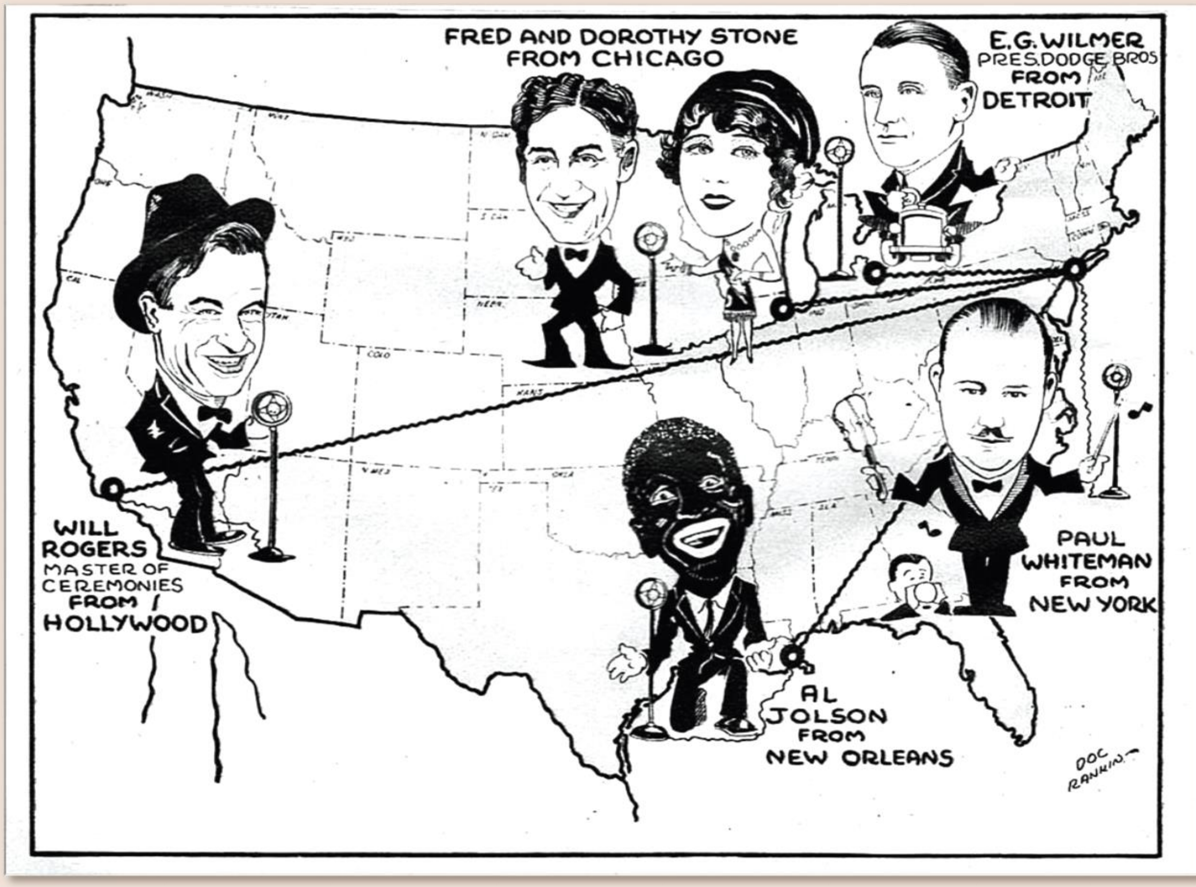
Note Columbia was still called "United Independent Broadcasters on this map. Note also the additional (private?) connectivity used by the Democratic National Committee as well as the "white areas" in the West and Southwest.

Challenging Long Lines

The three nets were still doing 'top-down' broadcasting and that meant everything was coming from New York. However, there was a lot of star power living on the West Coast and the networks wanted to tap that potential. If connectivity was the only impediment, money could be thrown at it. If it was a problem of coordinating far-apart presences into a smooth presentation, why not test the concept?

To do so, an experimental broadcast took place in early 1928. *Radio News* reported: "A national broadcast said to be one of the most ambitious ever attempted was aired the evening of January 4, 1928. Will Rogers in Hollywood, Fred and Dorothy Stone in Chicago, the president of Dodge in Detroit, Paul Whiteman in New York, and Al Jolson in New Orleans were all on the same hookup which reportedly cost $1000 per minute for three transcontinental telephone circuits.

"To bring these widely separated persons before the vast radio audience, estimated at more than 25 millions, approximately 12,000 miles of telephone lines were employed. Engineers of the National Broadcasting Company, in conjunction with the engineers of the Bell System, which supplied the lines, worked on the arrangement for several weeks." *Radio News, March 1928* Another 'first' for Long Lines.



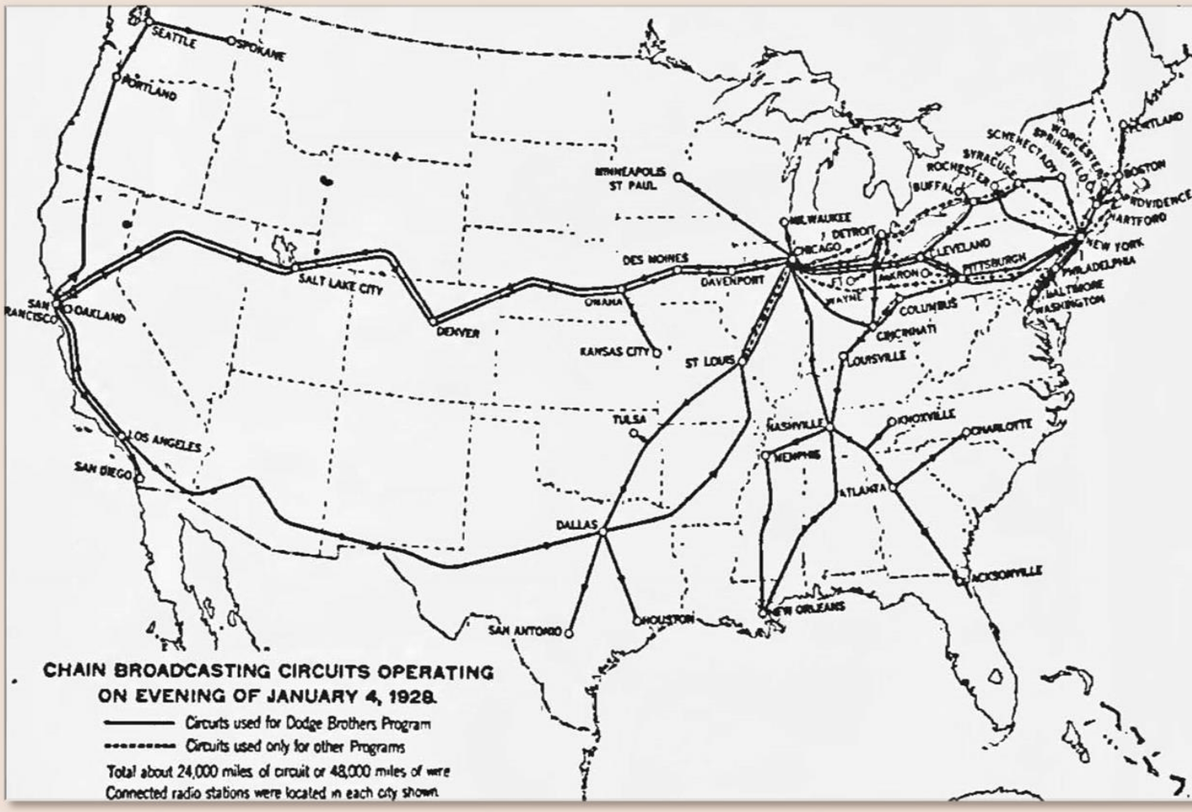
Radio News

As to affiliate count, *Radio World* reported that "NBC and CBS were neck and neck by the end of 1928. NBC was fighting the so-called 'elective-affiliation method' whereby a single station chose its affiliation depending on day-parts and program popularity. This practice had been started by WCCO, Minneapolis." *Radio World, December 1928*

A snapshot from the *Bell Systems Technical Journal* provides the following profile as of the end of 1928: Most networks were operating six hours per day. NBC Red had 41 stations fed through 10,500 circuit miles. NBC Blue totaled 12, served by 3,600 miles.

The AT&T map showed Purple CBS with 41 stations (8,450 route miles), the Green Network of 8 stations (3600 route-miles); the Orange (NBC Pacific) with 5 stations at the ends of 1700 California wire-miles, the Brown Network (Don Lee) of 3 stations; 450 miles. There was even a short-lived Gold Network on the West Coast as we'll see.

The White Network would be added as an NBC Short-Wave group. Good color choice for Short-Wave; a hard color to place on an AT&T wire-network map :-)

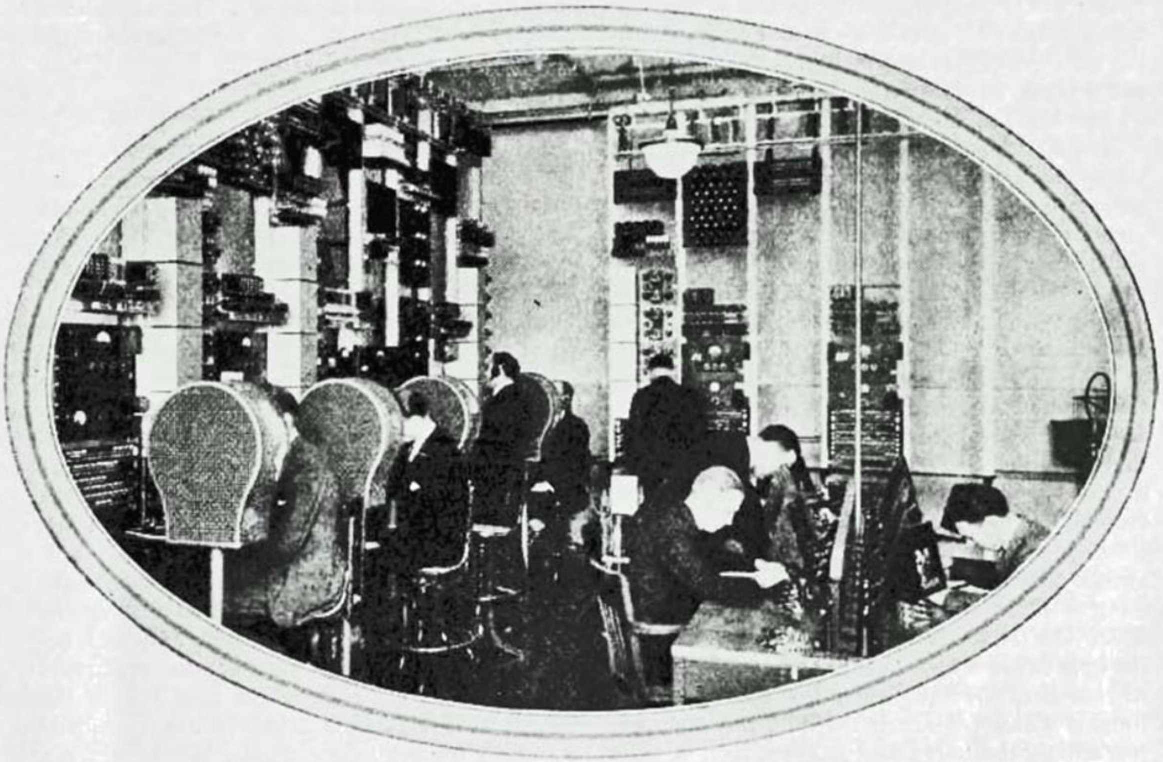


Bell Systems Technical Journal

How Chain Broadcasting Is Accomplished

By C. E. Dean

American Telephone and Telegraph Company



THE CHAIN BROADCASTING CONTROL ROOM IN CHICAGO

Similar control rooms are located in Boston, Cincinnati, Detroit, St. Louis, Atlanta, San Francisco, and New York, each in charge of a "transmission supervisor." Repeaters, oscillators, equalizers, transmission measuring devices, and other apparatus necessary in the exacting work of transmitting the programs are shown in the illustration. Cone loud speakers are mounted in the protecting frames at the left. During operation, one cone is connected to the Red network, another to the Blue, a third to the Purple; the fourth is a spare.

Network Broadcast-Channel Service Configuration

Usually provisioned for NEMOs, a typical long-haul broadcast transmission service included a minimum of three channels: a Primary, an Emergency, and an Order-Wire circuit for communications. Occasionally a fourth "monitor" circuit was added so the transmission tech could immediately patch the Primary to the Emergency circuit if he heard problems. A telegraphy circuit was optional.

In July 1938 *Radio News* pithily summarized the state of network broadcasting: "It's a huge business for AT&T Long Lines."

The Networks Wander West

West Coast-originated programming was necessary for the networks' image. "The first nationwide broadcast from the West Coast to the East had been the Rose Bowl Game from Pasadena on New Year's Day, 1927, with Graham McNamee at the microphone." *http://earlyradiohistory.us/index.html*

Until the late 1920s AT&T had no full-time program-quality circuits west of Denver. The only way to get broadcasts to the West Coast was via a telephone relay from Denver. This worked okay for news events but sounded pretty grotty on musical programs. On the Pacific side of the Rockies the audio was in good hands; Pacific Telephone and Telegraph Company was hip to program-transmission technology and provided almost 2000 miles of program circuitry (though at first *only* during non-peak-telephone hours).

NBC Pacific

From the outset NBC wanted a critical mass of coastal stations, so the network decided to leapfrog the mountains, building a West Coast subsidiary web. The "Orange" Network came alive in April 1927, from a San Francisco switching center/hub. It fed stations in San Francisco, Los Angeles, Seattle, Portland and Spokane. To air NBC shows in the West, programming material was sent by railroad to San Francisco, where East Coast programing was "re-created" a week later. By 1929 AT&T had bridged the Rockies with west-bound program circuits. Facilities were limited at first; NBC had to share a single circuit between Red and Blue programming.

NBC's San Francisco Switch Center *The Radio Historian*

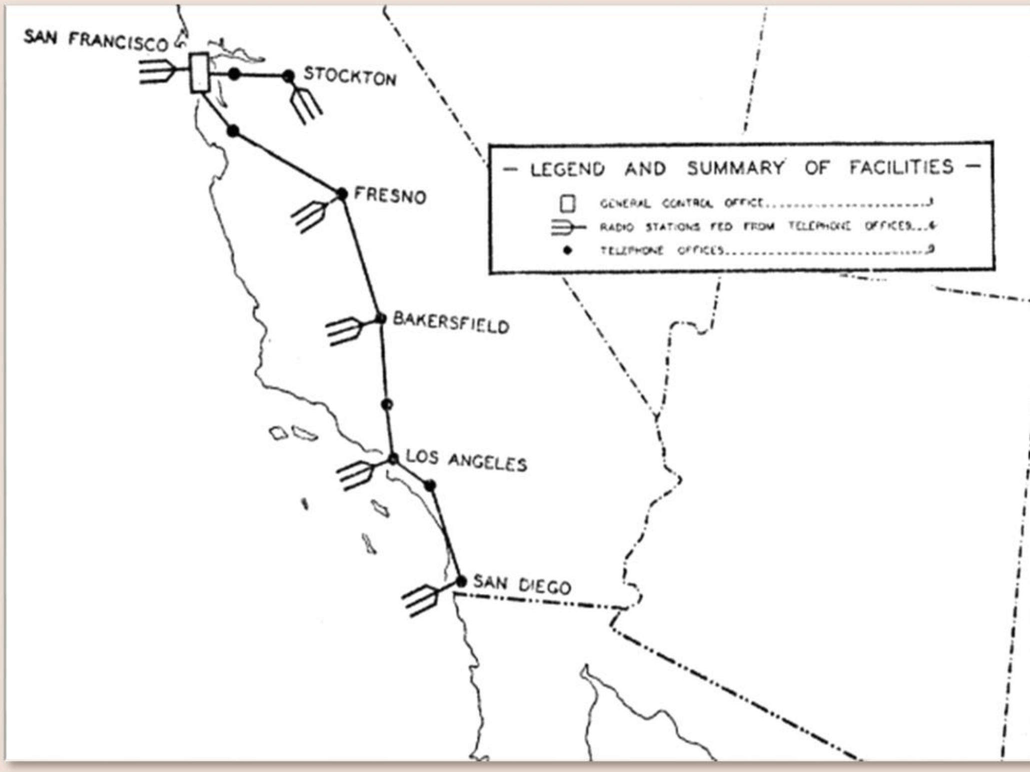
NBC wasn't finished with the West Coast; it reconfigured coverage in reaction to the population settlement and the availability of good stations. In late 1931 NBC purchased "The North Broadcasting System" and realigned the Orange Network into KGO, KFI, KGW, KOMO, KHQ…powerhouses all.

An 'informal' version of the Gold Network consisted of KPO, KECA, KEX, KJR, and KGA (more good-coverage stations). KTAR and KFSD were added as needed for program clearance. The original NBC Pacific Coast Network was then dissolved. In 1936 NBC launched a second West Coast network ("Pacific Red," the former Orange network). A station shuffle followed; "West Coast Blue" replaced the now-defunct Gold network that had been operated by one of the (several) "American Broadcasting Companies."

The new Blue circuit terminated in Los Angeles rather than San Francisco. This meant it was no longer necessary for Hollywood stars to travel to San Francisco to go live, or for the network to pay for a program loop from Los Angeles to San Francisco.

NBC West coast network center *Americanradiohistory.com*

Columbia initiated its own Pacific presence by contracting with auto dealer Don Lee; himself a broadcasting mogul with San Francisco and Los Angeles stations and a network that reached to Washington State. In July 1929 the Don Lee stations became "affiliates" of Columbia as the "Don Lee-Columbia Chain."



Southern segment of the Don Lee Network *Courtesy Bell Telephone Record, 1934*

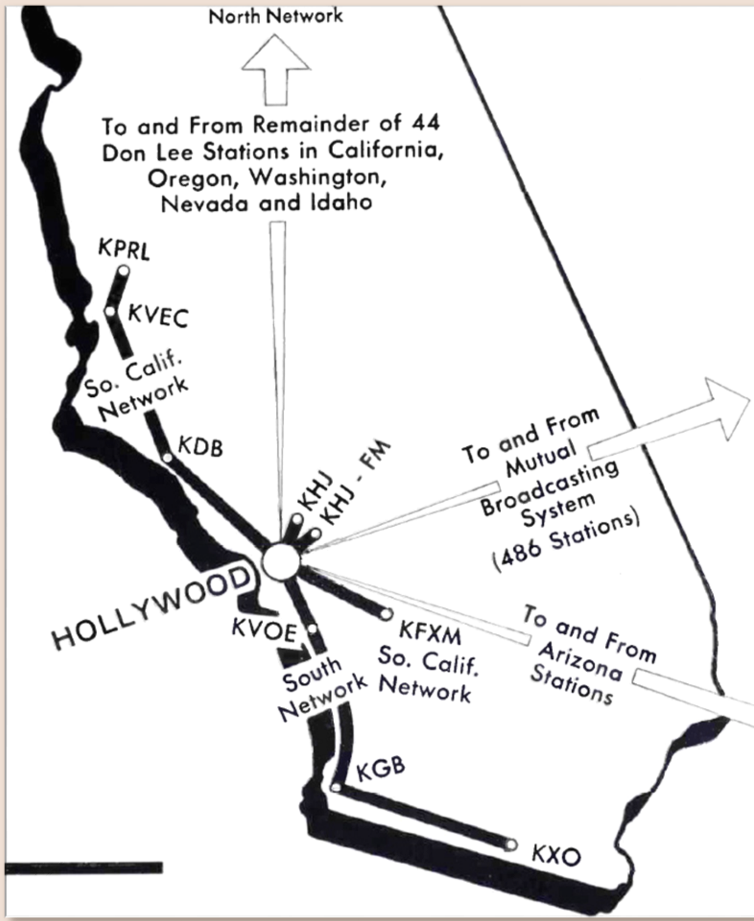
San Francisco's Lee-owned KFRC became Columbia's West Coast switching facility. In addition to its Pacific stations, Don Lee fed the CBS network to the East in the late hours, after New York studios were closed. (In spite of the reverse time-zone situation, several West Coast programs gained great popularity on the national network.)

The eventual demise of the Columbia-Don Lee agreement said a lot about the way Paley did business. In structuring the affiliation deal with Lee he had given himself an escape route; it would be easier to abrogate an *affiliation agreement* than to fracture a more closely-tied *sub-network arrangement*. Without notice to the Don Lee group, Paley purchased KNX in 1936, displacing Lee's KHJ as "Columbia-Los Angeles."

Since KNX and San Francisco's KSFO had a close relationship, Paley also obtained a right to purchase KSFO, planning to move to that station from Don Lee's KFRC. Paley couldn't buy KSFO so instead he grabbed KQW, bumping KSFO from Columbia. Loyalty apparently meant little; this was business.

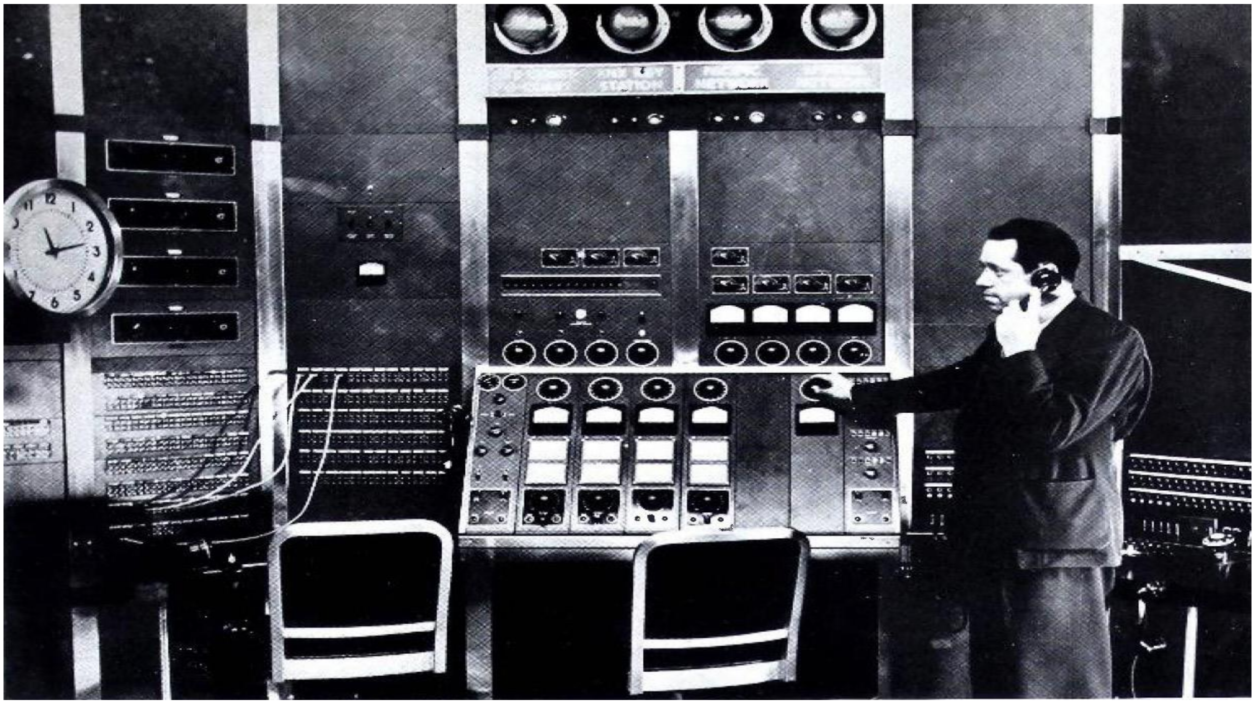
Don Lee was confounded. Long-time partners jumped ship and, tired of the East Coast way of doing business, formed their own "California Radio System." (It didn't last long.)

Meanwhile the new Mutual "Co-Op Network," opening in 1934 was looking for West Coast affiliates…at the same time Don Lee was seeking a new network affiliation. A long-lasting mutually-beneficial relationship began with the launch of the "Don Lee-Mutual Network" in late 1936. Mutual's national AT&T circuit terminated in Los Angeles rather than San Francisco, so Lee's KHJ again became a West Coast primary station!



Mutual-Don Lee network *Oscillator*

By the mid-30s the networks were building Hollywood hubs, and San Francisco's days as a switch center and program hub were numbered. The "NBC Hollywood Broadcast Studios" opened in 1936; two years later NBC built a completely new broadcast complex and moved its West Coast management team from San Francisco to Hollywood.
For its part, in 1938 CBS opened "Columbia Square" in Hollywood, based around KNX. The powerhouse station housed CBS's transplanted West Coast switching hub.



Presumed to be CBS Hollywood *Source unknown*

Mutual's own commitment to Hollywood was completed in 1949: "A new building has gone up in Hollywood…the new home for the West Coast operations of the Mutual and Don Lee Broadcasting Systems, one of the most complete installations of its kind ever to be erected." *Radio-TV News, 1949*

Reversible Circuits

By 1936 all networks were terminating in Los Angeles, further reducing San Francisco's importance. With national network lines in Los Angeles and with the investment there in programming, the major networks now sought to reduce the costs of hauling Hollywood-based shows back East onto the network. AT&T came up with a solution.

It was 'simply' a matter of reversing the direction of the amplifiers and repeaters on the national network channels…in several dozen repeater locations across the country…*all at the same time*.

Path-reversal was originally done by engineers flying patch cords; the switching coordinated with all hands listening to an Order-Wire circuit. Fifteen seconds were allowed for everyone to re-patch; this was usually during a network break.

The West-bound program path was now East-bound…and bad marks to the engineer who missed a switch or mis-patched, because he could take down the entire network or create a nice round-robin howl. With switching accuracy and reduced switch-time in mind, Long Lines now engineered a remote-controlled relay bank that operated via a phantom voltage imposed on the line *from the originating station* (this line-reverser was controllable from either direction).

(By the way it's likely that the technical characteristics of this fast-reversed path didn't exactly match those in the normal direction, due to the individual West-bound line conditioning (such as pre-emphasis) set up in the various repeater stations. Reversing worked best when engineers had several hours' notice to line up amplifiers and equalizers in the East-bound direction.)

Adding direction-reversal to the network meant that for the first time shows originating in Hollywood could routinely head east for national distribution ("East-bound" meant New York for CBS termination and Chicago for NBC further routing).

Interestingly, many Hollywood programs had to travel all the way around the horn to be heard locally on the LA affiliate. Shows went east on AT&T lines, were turned around in the East and re-fed to the network where they landed back in Hollywood. Listeners with good ears easily detected the difference between a locally-originated KNX program and one routed through this long network configuration.

This reversing facility was still in use in the 1950s; many of us recall hearing "NBC Monitor" taking that "pause to reverse our circuits" before switching to California.

The reversible circuit got a workout during World War Two, when Short-Wave reports from the Pacific Theater were directed east to the networks from Pacific Coast Short-Wave receivers. Since these reports were live (remember…no recording allowed) the news anchor gave a verbal cue and we'd all wait while the clicks on the line signaled path-reversal before the Pacific receiver was heard. Here's what it sounded like:

Now before we move on, here's a quick look at the BBC's early thoughts on program transmission.

Defining 'Marketing Reach'

The first radio stations had been built to stimulate receiver sales. Once the 'radio-set' market was saturated and air-time was being used for third-party commercials, 'radio markets' were fashioned following the newspaper model…the focus was on large population centers and, within, on high-income areas.

Network program-clearance decisions came to be defined by marketers who connected advertising, distribution and consumption capacity. Since advertising followed the local availability of a product, the "split-network" approach became commonplace. That could be a problem. In many cases, advertisers refused to pay for clearance in markets they didn't want, so the networks had to provide alternative 'fill' programming to those markets or clear the program on the unwanted stations, with no compensation. This led to friction between advertiser and networks (who pushed back because of production costs), and between networks and affiliates (who wanted dependable programming not at the whim of the current sponsor.) Since the money flowed from the advertisers, they often won these skirmishes.

There was also a concern on the advertisers' part about marketing a product where it wasn't welcome. (WCCO provided a network that fed Minnesota Twins baseball play-by-play to several states. As a WCCO control room engineer, I remember having to send a separate Hamm's Beer commercial to Minnesota's Iron Range stations…a commercial that didn't tout the Hamm's 'new *aluminum* can.')

So it was simplistic to think of the national radio networks as providing simultaneous country-wide coverage. Despite lip service that "national networks helped achieve cultural unity," this concept was a *goal,* more admirable in the selling than in the doing.

Network "quality" parity was an issue. The networks delivered 'full-quality' transmission (100 to 5,000 cps) to the stations in dense population centers; other areas (including the Deep South and sparsely-populated regions of the West) were served by program circuits of narrower-bandwidth (less ears to feed…so let's use cheaper phone lines).

Another contradiction surfaced. The major networks (except Mutual) sought to destroy small-market radio, calling it 'technically inferior' and citing the absence of network-quality programming as a reason to take these smaller stations off the air (thereby of course enhancing the power of the nets' big-signal affiliates). But when advertisers required full national coverage (think sports broadcasts), those small stations would suddenly be of value to fill in underserved areas.

It's hard to disagree with the comment: "Despite its image as uniform, consistent and singular, the (network) system was limited, unstable and hybrid."   *Points On the Dial, Alexander Russo*

Expansion Into Mexico

The saga of the super-power "Border Blasters" was a tale of reach, romance, sleazy marketing and the emergence of a new form of appealing music. That story has best been told in "*Border Radio*" (Gene Fowler and Bill Crawford, 1987). Trans-border program connectivity from American studios to Mexican super-power transmitters was an early issue solved, not by using telephone channels, but by recording the programs on ETs and carrying them across the bridge.

By 1939 CBS had received FCC permission to transport programming into Mexico *by land-lines*, to feed key Mexican stations. This coverage was in addition to the extensive Short-Wave system beamed to Central and South America (of which more in chapter Five). Language translation was inserted into the land-line service in Monterey and the Mexican Government's official telegraph service would link the Mexican outlets together. Mutual wanted to be in that Mexican mix as well but the necessary capital was not to hand. So Mutual contracted with the *Press Wireless Association* for transmission over the border, and FCC approval was granted in October 1941 to add audio modulation to the existing Press Wireless radio-telegraph facilities.

The Other "National" Networks

Besides NBC and CBS, some other "start-up" networks had begun appearing in the late 1920s. One of several networks labeled "ABC" was announced in 1929, with WMCA New York as the primary station. The initial line-up was to include stations as far west as St. Louis. It fell apart because of a lack of advertisers. (BTW: Jim Ramsburg relates a wonderful "ABC" story you'll find here at the end of chapter Six.) In 1933 Comedian Ed Wynn announced the Amalgamated Broadcasting System ("ABS"). He had great ideas and commitment from several stations, but the network was short-lived. There were other abortive network starts; all fell apart due to high transmission costs.

“Regional” Networks: Significant Players

Since the late 1920s geographically-related stations have grouped together to serve areas of common interests while realizing the economies of transmission cost-sharing. *Regional live-program* distribution (news and sports) was an arena in which the big nets couldn’t play. Some areas were served by more than one such network; some were full-time; others affiliated on an ad hoc basis. Nearly all were fed by a Primary or “Key Station,” responsible for show production and commercial continuity distributed to smaller affiliates for production by their own local staffs.

At larger Key Stations several different broadcasts might be fed simultaneously to different affiliates, so routing could be challenging. The solution was a version of the technology used by the big networks: “salvo switching.” The upcoming various sources and feeds were pre-assigned but not activated, on the “standby” bank of a switcher. At switch time: push one button and the entire new-feed combination went live.

Many affiliates came aboard these networks to gain access to professionally-delivered regional news and fast-decay information (commodities quotations and weather by region come to mind). A strong driver for *ad-hoc* regional networks was sports play-by-play. Early on, big stations found they could charge more for networking their sports coverage and, by marketing to a sports team’s entire franchise area, help stimulate game-ticket sales. Such sports networks still operate profitably today.

The wired regional nets were serviced by AT&T Long Lines. We also note there were many “unwired networks” collaborating on a ‘sales-only’ basis. (Unwired networks in fact accounted for a significant segment of advertising revenues.)

RadioCraft magazine summarized the regional network scene in 1935: "Although the NBC and CBS networks are the two important broadcasting networks in the USA, other networks are in existence; some of them affiliated with either the NBC or CBS networks on a part-time basis….Don Lee had 12 affiliates...A network of Wisconsin radio stations had 7 affiliates; it was associated with CBS. The Mason Dixon Radio Group consisted of 5 stations and had no other network affiliations. It served Southern states. The Michigan Radio Network totaled 8 stations and had no other network affiliations. NBC was heard over 5 stations in the New England Network. The Northern California Broadcasting System was just a couple of stations with no other network affiliations. 4 stations were part of the Southern Californian Network; no other network connections. A Southwest Network fed 11 stations; associated with CBS. The famed Yankee Network had 11 stations. Iowa Broadcasting Company included 3. Such was the state of Regional Networks as of December 1933.” *RadioCraft Feb 1935*

There's a terrific amount of detail on these unwired networks in most of the broadcast-trade "Annuals," available for example at *worldradiohistory.com*

The 1941 Radio Annual put regional network growth in rather circular fashion: "Steadily increasing growth of regional network billings indicates that national advertisers are directing their campaigns in high-spot markets. With the advent of purchasing the time actually wanted, tailor-made talent of…appeal to the specific area and aggressive marketing policies of the networks, the advertiser is provided with sales impetus in…areas where sales can be produced. As the majority of these networks are sufficiently flexible to provide coverage where and when the client wants it, it is believed that the trend in 1941 will be of greater application to selective markets as exemplified by regional networks." *Keyes Radio Annual, 1941*

Unwired-network salesmen (there were no 'sales*persons*') would present a "joint rate card" to the client, showing the cumulative coverage of all stations. Commercials could be aired on *all* regional-network stations…or only on a select group of stations chosen by the advertiser. For advertisers interested in customization and granularity, these "networks" provided a great solution. But unwired networks did have a logistical problem…simultaneously clearing programs.

The national networks themselves would create unwired-network sales plans. For example, in 1942 you could buy time on the Blue Network in a dozen configurations from "*Blue Basic*" to "*Blue Pacific Coast Group Overseas Services: (Honolulu/Manila/Cebu*)." Each of the unwired networks had its own group rate card, and savvy time-buyers mixed and matched markets of appeal, thus circumventing the cost of unneeded advertising on the entire national network.

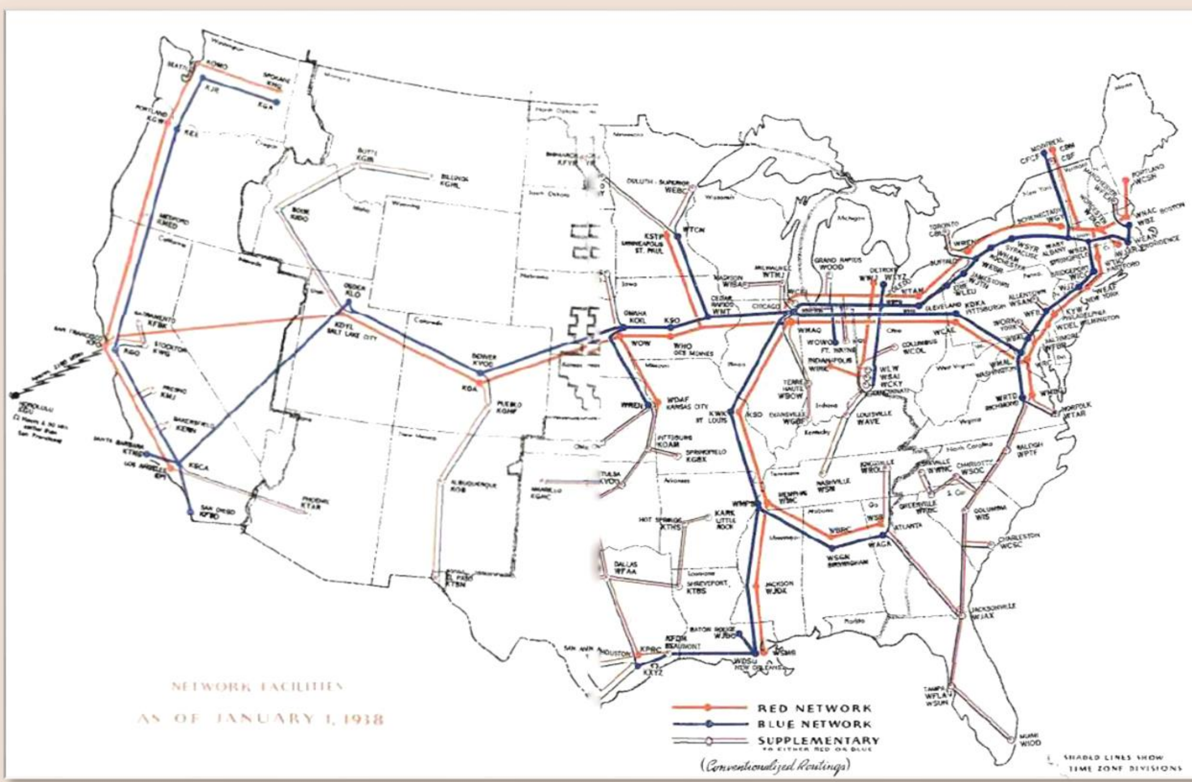
The saga of John Shepard and the *Yankee* and *Colonial Networks* is deserving of an entire journal…and indeed several have been written. Shepard was a maverick, a visionary, a salesman and a hard-headed but inconsistent businessman…yet he had the power of a group of significant stations behind him. He first appears in the timeline as the entrepreneur who brought WNAC to the ground-breaking network test with WEAF in 1923, and he understood the issues that would face the networks. From the way he played those networks, one might think he had been lurking in their board rooms. Shepard's dealings (first with CBS; then NBC and Mutual) caused a number of changes in Boston network affiliation…including an almost-move of WTIC from Hartford to Boston. His dream of a national sales network was derailed by the launch of Mutual in 1934. (Shepard's *Yankee Network* ultimately became a force in FM-Relay as we'll see in the next chapter.)

“Too Big to Fail?”

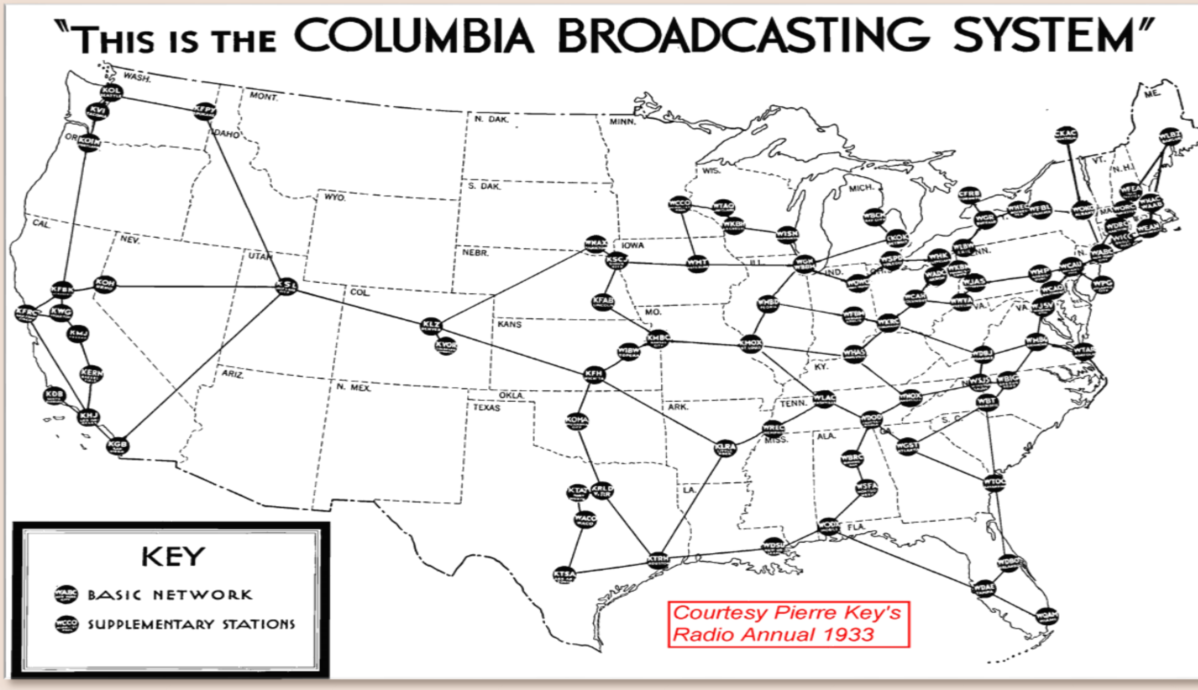
The interest in regional coverage was a talking point for those who stood against the “country-wide, one-size-fits-all” concept. As early as 1928 *Radio News* editorialized that “the days of Chain Broadcasting may be over.” They cited the problem with time zones and the disruption on western listener’s lives when a popular live program originated on East Coast time. The commentary suggested “too many programs of sectional interest were broadcast to *areas where there was no real interest.”* Their solution: *AT&T should split network service into regions.* Radio News, Feb 1928 (italics added)

But the big networks remained the main arteries and their total reach was unmatched.

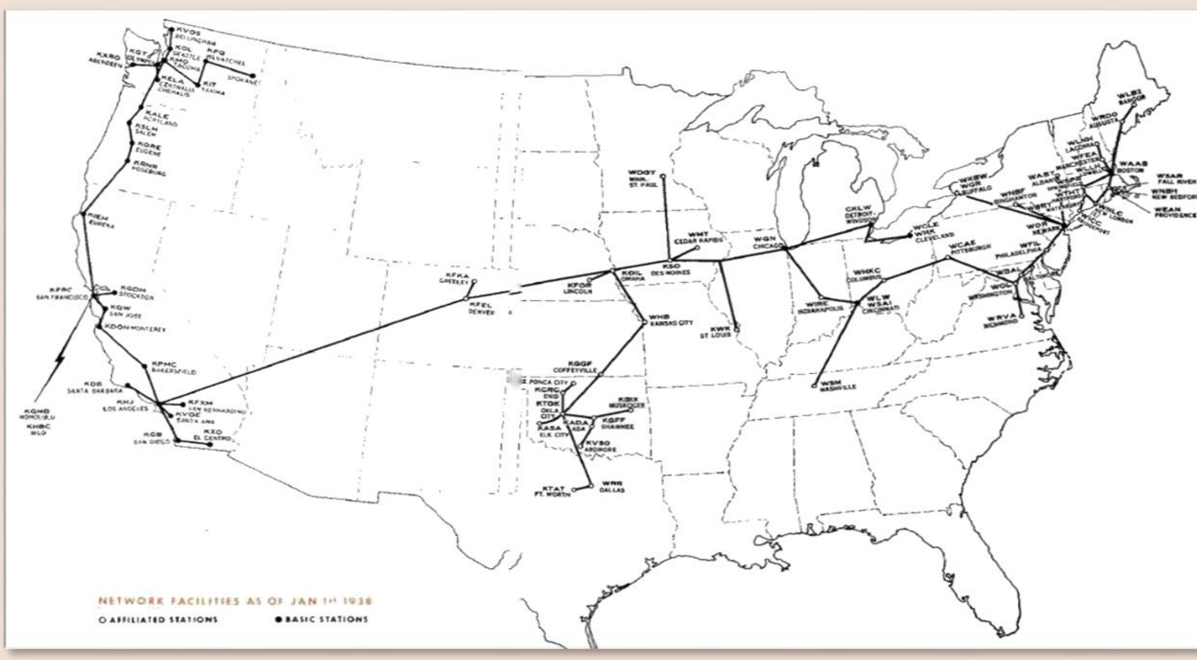
Here’s a poorly-fitting match of two maps from *Keyes Radio Annual* showing NBC’s coverage in 1938. It looks like a national network… but for some programs it was less impressive when affiliates in certain markets declined a program either because of appeal or because the show landed too late in the evening in their time zone.



NBC coverage map in 1938. Note the “Supplementary” network feeds.



CBS in 1933. Both networks relied on the bigger stations as their key outlets and granted them a degree of protection from would-be affiliates.



Composite Mutual map for 1938: *Courtesy KEYES Radio Annual 1938*

These network backbones represented an awesome investment. The AT&T Long Lines network service was well-run. Telephone Engineers made "getting the programs through" a primary objective. "Belt-and-Suspenders" protection ruled. Failures were rare and, unlike the culture in some of today's telephone companies, when someone screwed up, they admitted it, notified the customer, and moved on.

As an emerging reflection of the times, "service companies" such as radio-station-program networks were being challenged to prove their rates were fair. Some thought the monopoly status that created them might be a social good…if its rates were a fair reflection of the services provided.

In April 1942 the FCC announced an inquiry into AT&T's transmission rates and issued a Show Cause Order asking why rates should not be considered excessive. It cited annual revenues for AT&T's combined toll service rising from $20 million in 1938 to $27 million in 1941. An approximate 10% reduction was mandated via a new tariff, with smaller stations benefitting the most.

In many cases however, AT&T charges to distribute a national network remained prohibitive. That protected the status quo and impeded new-network-venture roll-out.

So we look next at *distribution alternatives*.

CHAPTER FIVE

Alternatives to the Long Lines Network

Some stations operating close to the bone found at least mythical salvation in the idea of sharing operating costs with affiliated outlets. But AT&T transmission costs were a stark reality. For this reason and because the reach of wire-lines wasn't ubiquitous, broadcasters searched for practical distribution alternatives (syndication by transcription if practical, or simulcast by radio-relay if it needed to be live). Of course, in areas not reached by wire (think for example International Broadcasting) the only practical solution was Short-Wave radio.

"Off-line" distribution

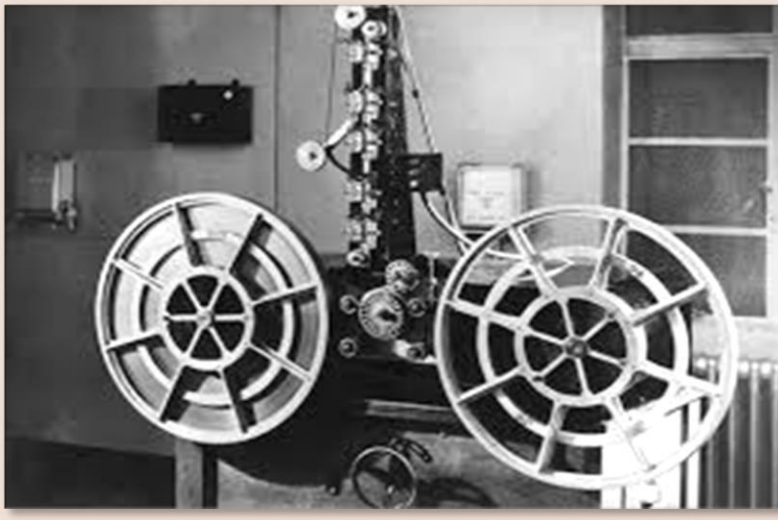
Non-real-time syndication was not a new idea; in their pre-network days of the 1920s, Amos and Andy distributed their Chicago show on 78 RPM discs. The standard for transcribed programs soon evolved into a 16-inch, 33-1/3 RPM disc (the "ET"). ET specifications were developed for the early "talking pictures" revolution: prior to sound on film technology, the ET would be synchronized with the film to give the movie its voice (the ET speed/size matched the duration of a reel of film).

With acetate-based discs, recording got a lot better in the mid-1930s. But the quality of playback from ETs wasn't consistent. The physics of disc velocity meant there was a gradual loss of highs as the stylus approached the disc center. While not a standard practice, playback of programs segmented by multiple discs *could* be finessed by recording every other disc "inside-out" so the change in highs wasn't as noticeable when one disc followed another.

Other transcription technologies tried for a time included wire recording; embossed film (the "Pallophotophone") http://en.wikipedia.org/wiki/Pallophotophone

The Philips-Miller recorder had been introduced earlier; it cut a variable-area track onto film stock. Neither of these "solutions fitted the needs of network operators or their competitors, the syndicators.

A working recorder (the Blattnerphone/Marconi-Stille) had gone into service at the BBC in the early 1930's but the machines were bulky and even dangerous. But before you dismiss the idea of a working tape recorder 15 years before Ampex, take a listen to the Marconi-Stille in the early 1930s.

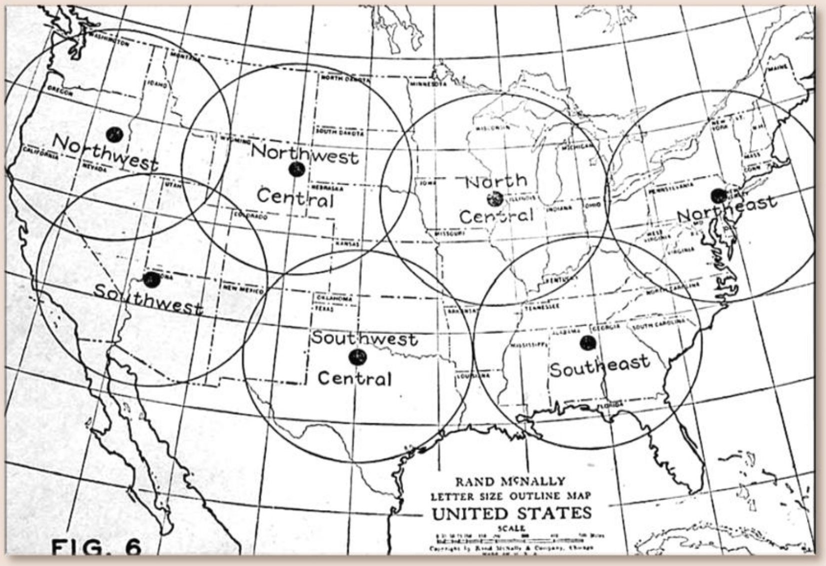


Marconi-Stille recorder at the BBC *Source unknown*

All of these "recording alternatives" to the disc were a decade or more older than the development of the tape recorder in the United States. The German Magnetophone was the basis for the Ampex work in the late 40s…though in fact AEG-Telefunken had demonstrated its technology to American countries in the late 1930s and were met with the American version of the Gallic Shrug and the truly American attitude of "it wasn't built here; we're not interested."

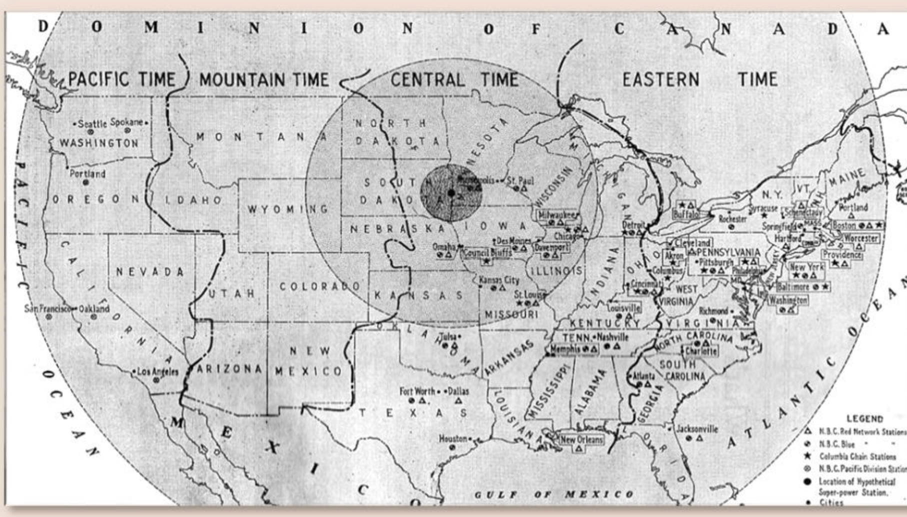
"Wireless" Alternatives to Network Distribution

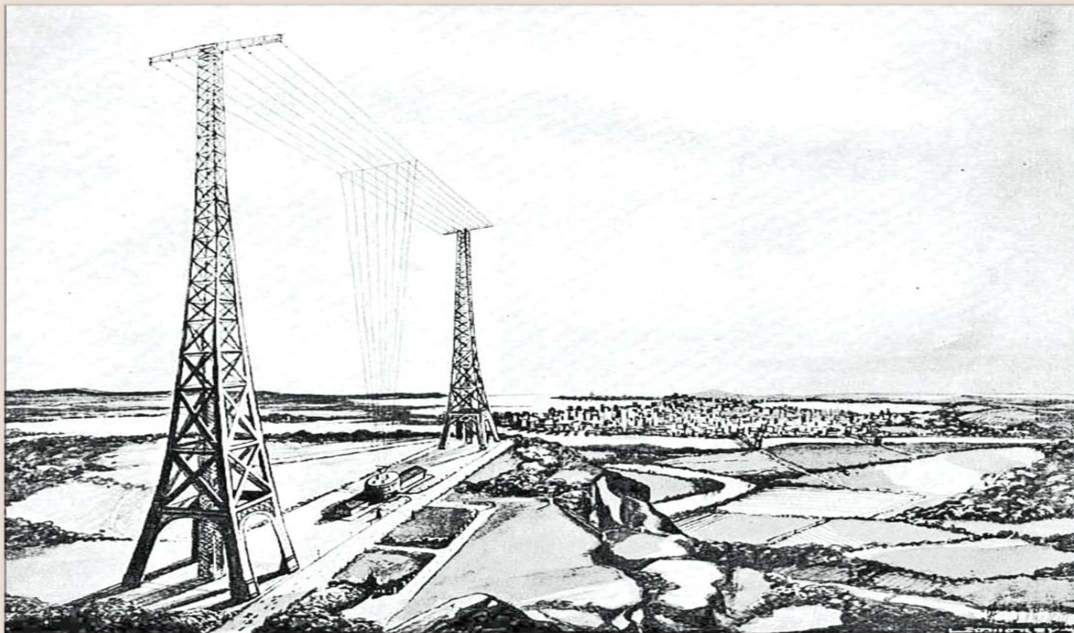
Radio News for April 1931 suggested that seven Long-Wave superpower stations could supply substantially complete national coverage. The article reports that 200 kc broadcasting experiments in the United States "have shown no fading inside of 300 to 350 miles." The story suggested seven stations of 100 to 1000 kilowatts could cover the country if located in Oregon, Wyoming, Illinois, Eastern Pennsylvania, Northern Alabama, Northern Texas and Northwest Arizona. The seven stations would operate on separate frequencies with about 70 kc protection. "Partial Synchronization" was contemplated. It was also envisioned that "a single 10 KC channel might be derived with complete synchronization." *Radio News, April 1931*



Long-Wave national coverage *ibid*

Long-Wave broadcasting was a good fit for smaller countries…but the U.S. was too big to do this without relays. Still, several Long-Wave transmission tests were conducted during this period. And of course someone had to propose a single "big-stick" solution. That idea was discussed in *Radio News*, Feb 1928. Proponents of 'the big stick" thought full national coverage might require oh, say, about a megawatt of RF, from a radiator on the Minnesota/South Dakota border.





A Super-Broadcasting Station of the Future?

To cover the whole country by direct waves, towering antennas 800 feet high, located in a central radiating position, would be fed by a 1,000-kilowatt transmitter operating on 1,500 meters, according to Lieut. Wenstrom's plan. This system would not rely on the sky wave with its effect in producing fading in distant receivers

Radio News

"Almost Long-Wave"

In 1944 Paul F. Godley, an industry consultant, informally proposed to the FCC that the frequencies 520, 530 and 540 kilocycles be added to the MW band and their operation limited to low-power (50 to 250 watt) stations. He conceded that true Long-Wave (200 to 400 kilocycles) wasn't practical in the United States and that it would be difficult to gather support for that band, with FM and Television now in the mix.

A fascinating idea for a synchronized radio network appeared in the February 16, 1929 *Radio World*. Two synchronized 50-kilowatt national-coverage Short-Wave signals were proposed; their "difference frequency" would generate a stable Medium-Wave carrier, modulated locally. Programming would ride on one of the Short-Wave carriers.

These proposals and others assumed that one national voice was sufficient; they completely misread the realities of the competitive broadcasting business.

AM Synchronization

As early as the late 1920's empirical trials were underway to determine the effectiveness of synchronizing AM stations.

Over the years few such attempts have been successful; the most notable was the WBZ-WBZA effort. If you want to know what they were thinking, click here.

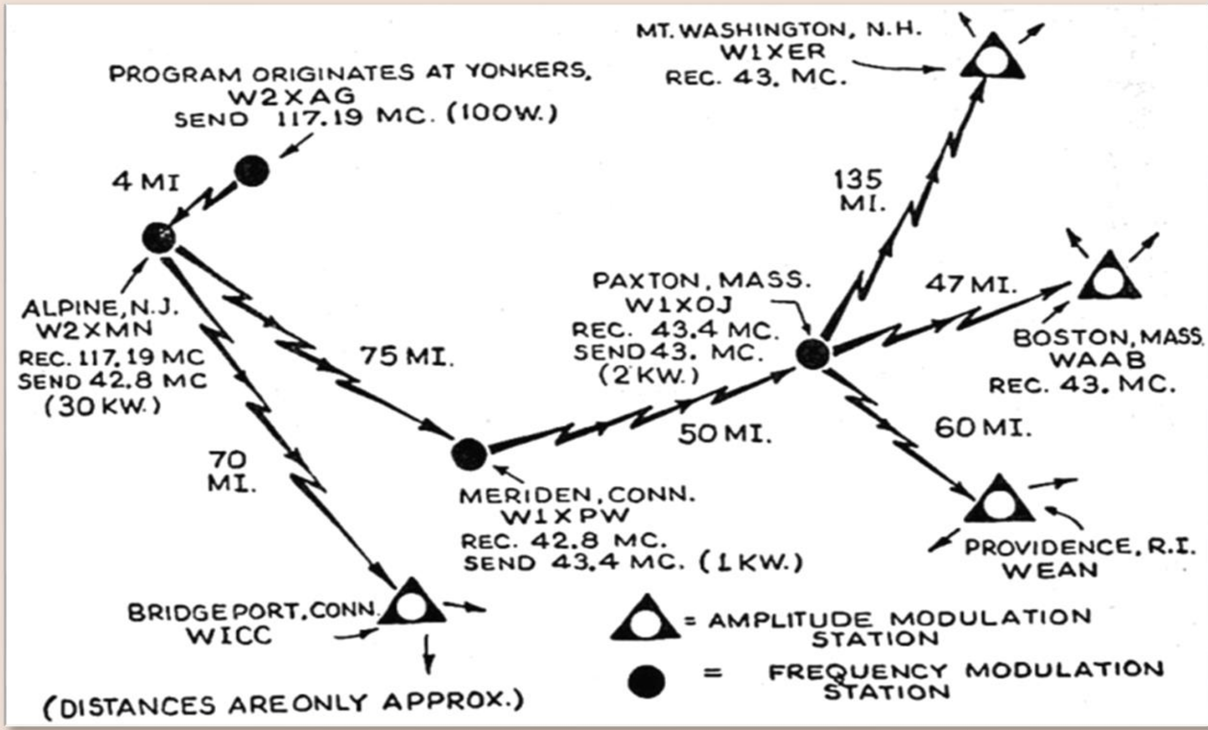
AM synchronization never caught on as an effective mass-market solution, though individual licenses have been effectively operated.

Station-to-Station Relays

By the 1940s, off-air redistribution included the use of FM relays. The best-known example was the Yankee Network. Here are snips from *FM Magazine*: "The Yankee Network…embarked on a program of experimentation with frequency modulation in the Spring of 1937…The completion of the new antenna at Yankee's 50,000-watt FM transmitter, W1XOJ, represents over two years of experimentation and FM broadcast operation. This station, located at Paxton, Mass…operates from the Boston studio through an FM radio link…When this project was planned, no 50-kw equipment had been built for the frequencies assigned to FM experimentation. Furthermore, no antenna system had been designed or constructed with radiating efficiency high enough to ensure the desired performance.

"It was estimated at the outset that a transmitter of 50-kw capacity located near Worcester, Massachusetts, using an antenna with a…power gain of five or more, would serve a residential and rural population to a distance of about 100 miles. Further, it was estimated that the large cities would receive sufficient field intensities to insure satisfactory (coverage) within 50 to 75 miles, depending on topographical conditions between the station and the area in question. "On January 15, 1941, the new antenna was put in operation and reports…show that the performance fulfills all expectations.

"With that breakthrough, tests were originated at Armstrong's W2XMN Alpine NJ and relayed…across New England via… Meriden Connecticut (W1XPW) and…W1XOJ."
FM Magazine," March 1941



FM Magazine March 1941

The November 1941 issue of *FM Magazine* noted: "The prospect of improved program service for New York's FM listeners came closer…with the announcement that The American Network, FM's first chain organization, will shortly file its application for a key outlet in New York City.

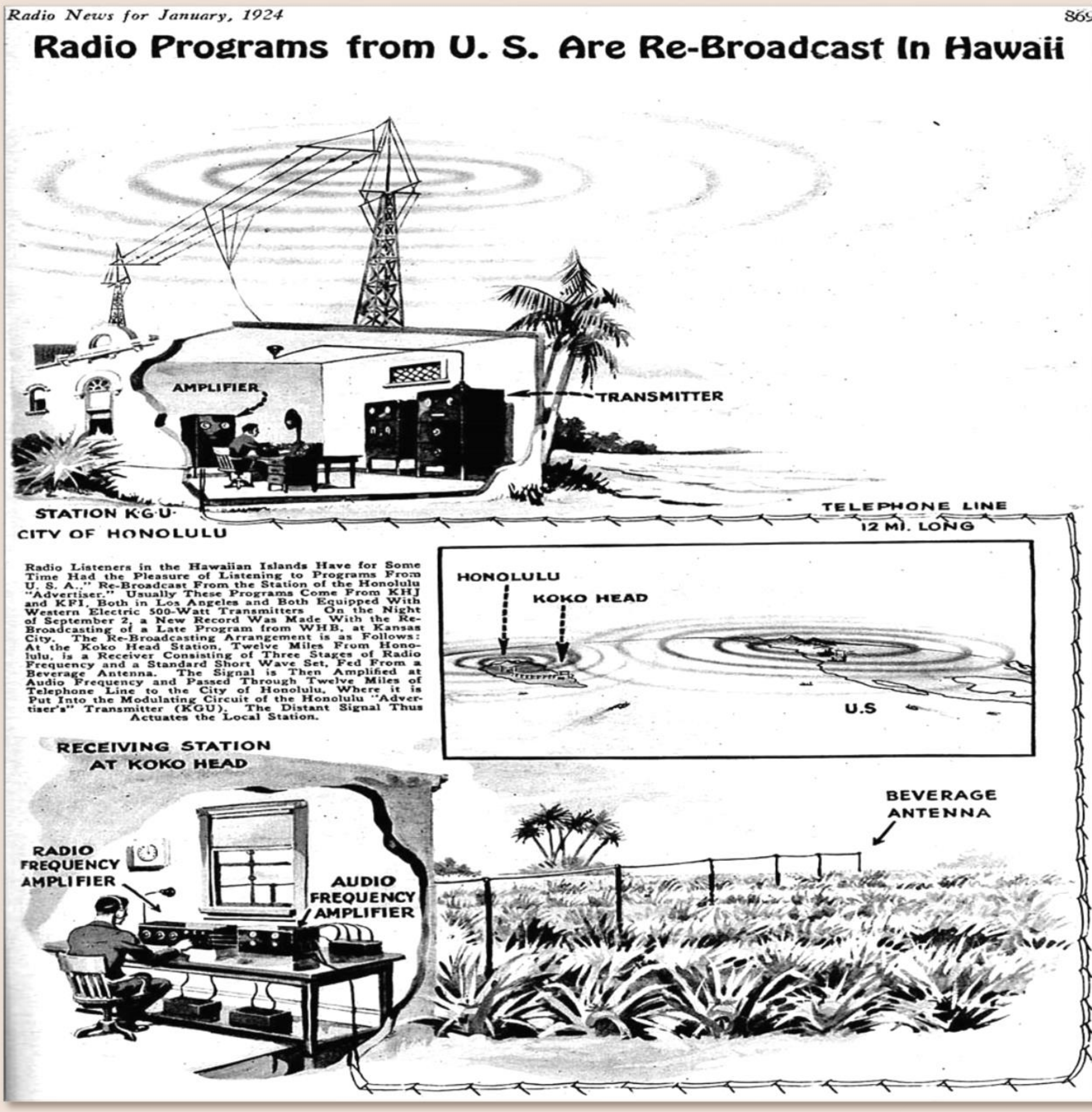
"The American Network plans the eventual establishment of a coast-to-coast web having outlets in more than 40 principal cities, with approximately 75% of the national population living within the proposed service areas. Already operating are two of the network's stations in New England, W43B and W39B, which have a combined coverage capable of reaching 93% of the population in those six states.

"As soon as W53PH. Philadelphia makes its debut as that city's first FM station, it will be another outlet of The American Network. Establishment of a New York station would provide a valuable link, giving continuous FM network coverage along the entire northeastern seaboard.

"Other stations of the chain already on the air…but not as yet linked up for program exchange, are W47NV Nashville, W55M Milwaukee, W45D Detroit, W51R Rochester, and W45CM Columbus. In addition, W41MM Mount Mitchell, NC, will be operating shortly." *Ibid*

Some AM stations built their own off-air links. Dr. George Brown remembers that WHA in Madison fed its satellite WLBL in Auburndale Wisconsin; WLBL used a Beverage antenna to receive solid copy from WHA.

Radio News published an illustrated story in 1924 describing KGO Honolulu's use of a Beverage antenna for relay of KFI and KHJ (even WHB).


Radio News for January, 1924 869

Radio Programs from U. S. Are Re-Broadcast In Hawaii

Radio Listeners in the Hawaiian Islands Have for Some Time Had the Pleasure of Listening to Programs From U. S. A.," Re-Broadcast From the Station of the Honolulu "Advertiser." Usually These Programs Come From KHJ and KFI, Both in Los Angeles and Both Equipped With Western Electric 500-Watt Transmitters On the Night of September 2, a New Record Was Made With the Re-Broadcasting of a Late Program from WHB, at Kansas City. The Re-Broadcasting Arrangement is as Follows: At the Koko Head Station, Twelve Miles From Honolulu, is a Receiver Consisting of Three Stages of Radio Frequency and a Standard Short Wave Set, Fed From a Beverage Antenna. The Signal is Then Amplified at Audio Frequency and Passed Through Twelve Miles of Telephone Line to the City of Honolulu, Where it is Put Into the Modulating Circuit of the Honolulu "Advertiser's" Transmitter (KGU). The Distant Signal Thus Actuates the Local Station.

The Short-Wave World

The usefulness of Short-Wave for *broadcasting* was not appreciated early in the 1920s, although as early as 1924 Short-Wave had been added to the *broadcast station* mix as a class of "experimental relay broadcasting." Short-Wave would become a great tool for overseas news links and as a distribution system to extend the networks to international markets, as we'll learn.

Thomas White has written the definitive work on early radio history in the United States. He says: "Another alternative to telephone lines briefly looked promising. Experimenters in the early 1920s, led by amateur radio operators looking for more spectrum space, and aided by the development of vacuum-tubes transmitters operating at much higher frequencies, came across the fact that low-powered Short-Wave signals traveled remarkable distances. Due to their ability to bridge wide gaps…Short-wave transmissions appeared to offer an inexpensive and flexible method for interconnecting widely scattered stations. Westinghouse…began investigating whether Short-Wave transmitters could link its broadcast stations into a national network." *Thomas H. White* http://earlyradiohistory.us/index.html

RCA's wireless division, RCA Communications, led the Short-Wave private-messaging opportunity. By 1920 RCA had established direct transoceanic telegraph circuits to London, Honolulu, Norway, Germany and France. Italy, Poland and South America were added. Holland, Brazil, French Indochina soon followed. RCA Communications would continue to play a commanding role in overseas communications.

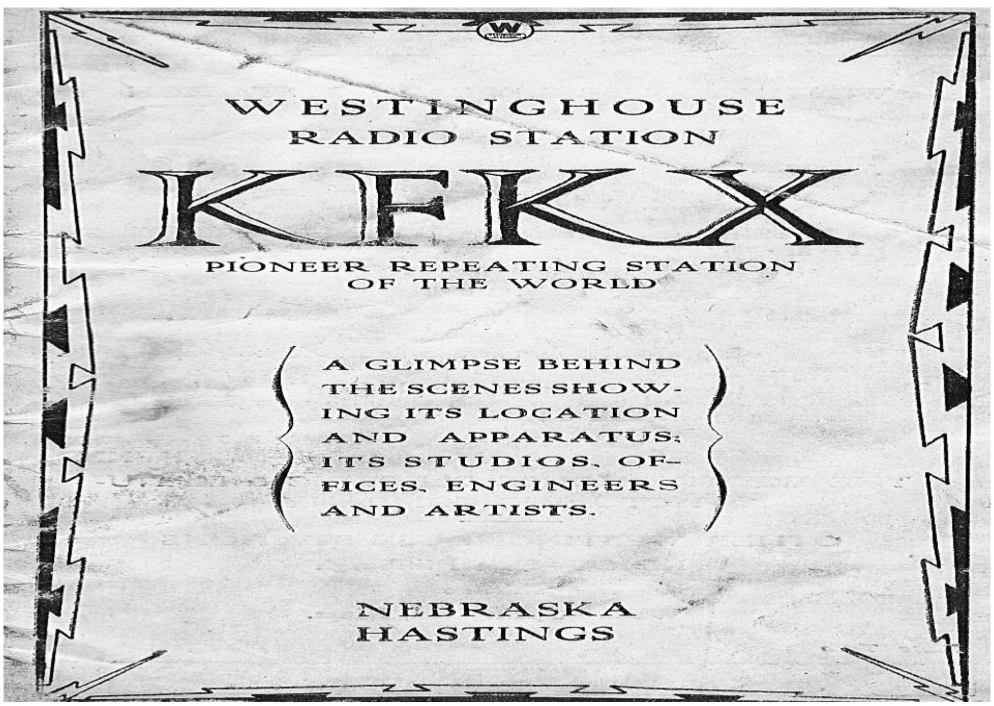
AT&T and IT&T built overseas shortwave trunks as well but their market was international telephone traffic.

Westinghouse may have been aced out of the international messaging business, but it never lost its interest in Short-Wave relay. In October 1922 the company scored a coup when they provided the first Trans-Atlantic radio "remote" from London to WOR in New York. This accomplishment presaged the heavy use of radio links from the European Continent in the warm-up to World War Two. By 1924 Westinghouse's KDKA was exchanging off-air traffic with British Vickers…probably on 100 meters.

A *Radio World* article explained how on March 7, 1924 a Westinghouse "radio-relay-landline" hybrid linked several stations on two continents for the gathering of MIT alumni in New York. WJZ was the originating station; feeding WGY by (Western Union?) telephone circuit and connecting WBZ in like manner.

Near Boston a 100-meter Short-Wave transmitter relayed the signal to KDKA Pittsburgh. KDKA forwarded on 98 meters to KFKX in Hastings Nebraska and station 2AC in Manchester England.   KFKX then uplinked a 108-meter signal to KGO in San Francisco.

"These messages definitely placed the stamp of success upon the experiment, for two stations over 7000 miles apart had incontrovertibly received and been able to rebroadcast the same program without the use of any material connection."   (This aside from reader Carl Mann: "Westinghouse shortwave relay in Nebraska KFKX was in little old Hastings, not Lincoln. (corrected above). It was indeed an early SW relay pioneer, opening in 1923. From what I could learn, it was billed as the world's first 're-broadcasting' station, though KFKX did originate some programming of their own. The station lasted four years. In 1927 the newly-formed FRC asked Westinghouse to shut down KFKX during their band-reassessment."



Note KFKX branded itself as a "Repeater Station."

In another experiment, a KDKA spokesman noted that the station was able to dramatically improve reception toward Cleveland from Pittsburgh, by simulcasting KDKA on 80-100 meters. They posited the country would benefit from *"two classes of broadcasting stations: stations national in scope (presumably Short-Wave) and those serving local markets."* Westinghouse felt the use of Short-Waves for domestic broadcasting could open up many new broadcast frequencies. *Taken from Radio World, March 1944 and from KDKA files.* (italics added)

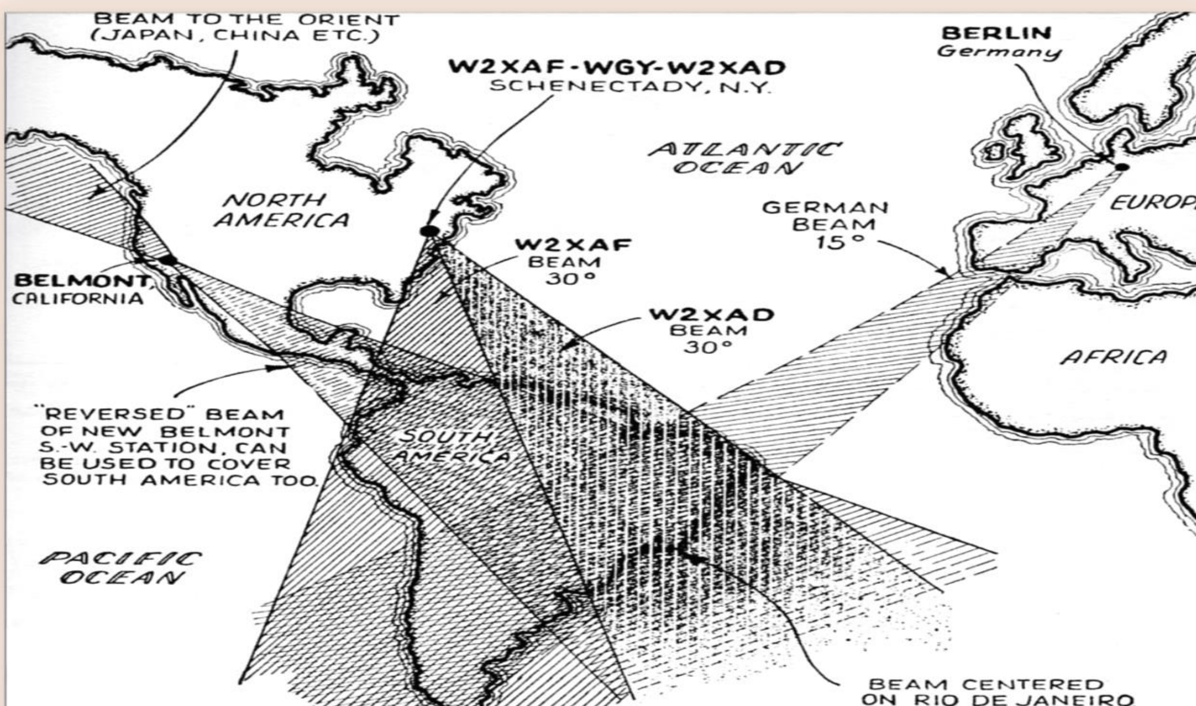
In 1928 WOR operated W2XAQ as a "Remote-Pick-Up" link for use on airplanes and ships. In the early 30's WOR brought up experimental broadcast stations W2XJL and W2XUP on 11 meters. These facilities took part in the experimental facsimile transmissions of the late 1930s.

By 1930 International Short-Wave was well-defined and pretty slick. Many countries implemented high-power Short-Wave as an instrument of national policy (many of them on the air into the 2000s).

Short-Wave suddenly seemed a big deal to many stations. Some built placeholders in case the frequencies around 100 meters ended up as a new "broadcast band." Stations operating Short-Wave in the early 1930s included KDKA, KFKX, KHJ, KMOX, KNX, WABC, WCFL, WGY, WHK, WJR, WJZ, WLW, WOR, WWL, WSM, KGO and others.

Network Programs Short-Wave

International "Broadcasting" usage now began in America in earnest as the major networks eyed the countries of the Southern Hemisphere as targets for expansion. (The totalitarian countries had long been putting great emphasis on Short-Wave broadcasting to Mexico and South America, where many lived in isolation and had few other sources of information. Here's a view of some of GE's (and Nauen Germany's) evolving coverage of South America:



The U.S. networks believed participation in South America's communications might mitigate the feelings of interventionism in President Roosevelt's "Good Neighbor" policy. As well as improving Pan-American understanding, Inter-American contact would be useful in enlisting support should the United States enter the European war. Besides…the networks saw South America as a natural market for re-purposing their programming…for profit of course.

In 1940, executives of the Columbia Broadcasting System quietly visited 18 Latin American countries and made arrangements for more than 60 Long-Wave and Short-Wave broadcast stations in those countries to become associated with the new CBS International Network, carrying regular day-by-day broadcasts of specially-built programs (CBS scored the publicity on this, but NBC was there several years earlier).

CBS had been transmitting Short-Wave since 1930. In 1932, Short-Wave station W2XE, formerly WCBX, came on the air and future designs included 250 kW stations WCBX and WCRC at Brentwood Long Island.

NBC was using stations W3X(A)L, W8XK, W2XAD and W1XK as relays to Central America, South America and Europe (a steerable antenna also directed about 120 KW toward Alaska). In 1942 NBC upgraded WRCA-WNBI to 50,000 Watts at Bound Brook New Jersey. (Bound Brook was also the site of the WJZ transmitting facilities. The patching system for the Short-Wave transmitters cleverly provided a way to use those facilities as a backup for WJZ.) And speaking of Medium-Wave, the call "WRCA" would for a short time in the future appear on the WEAF frequency.
Proceedings of the IEEE, March 1942

By the end of the 1930s there were 117 affiliates in the NBC South American Network; CBS had 76; and Crosley had 24. American broadcasters also used the Short-Wave signal as a backup at their domestic affiliates, in the event of network transmission interruptions.

Short-Wave Feeder Services

In the 1930s the only practical way to get decent audio from across the seas was to haul it via Short-Wave. In the U.S. the East Coast International facilities were well-matured (major West Coast landing-sites had yet to be developed). RCA Communications had redundant speech links to/from Europe operating in the 50 to 70 meter band. These relatively reliable circuits helped reinvent radio news as listeners eavesdropped on international developments from Europe, enabled by a new genre of radio journalists; CBS's Edward R. Murrow and NBC's Max Jordan principal among them.

The CBS World News Roundup

CBS and "Murrow's Boys" in Europe were in the right place at the correct time. Our story on AT&T is further unraveled here by our inability to resist imparting the story of the first CBS World News Roundup. That broadcast was triggered by unfolding events in Austria in March 1938.

The rivalry between the American networks was reflected by in the European Theater and during the Anschluss, NBC's Max Jordan made a solo end run. As things came to a head on March 12th, Jordan provided direct coverage from Vienna to NBC listeners. His was the only radio report to make it to America. Jordan got the scoop because he was the only one who could get Short-Wave transmission facilities.

When he heard the NBC broadcast in New York, CBS President William Paley immediately ordered a "World News Roundup" broadcast. "Get several reporters on air from different points in Europe, he said. <u>And do it tonight</u>!"

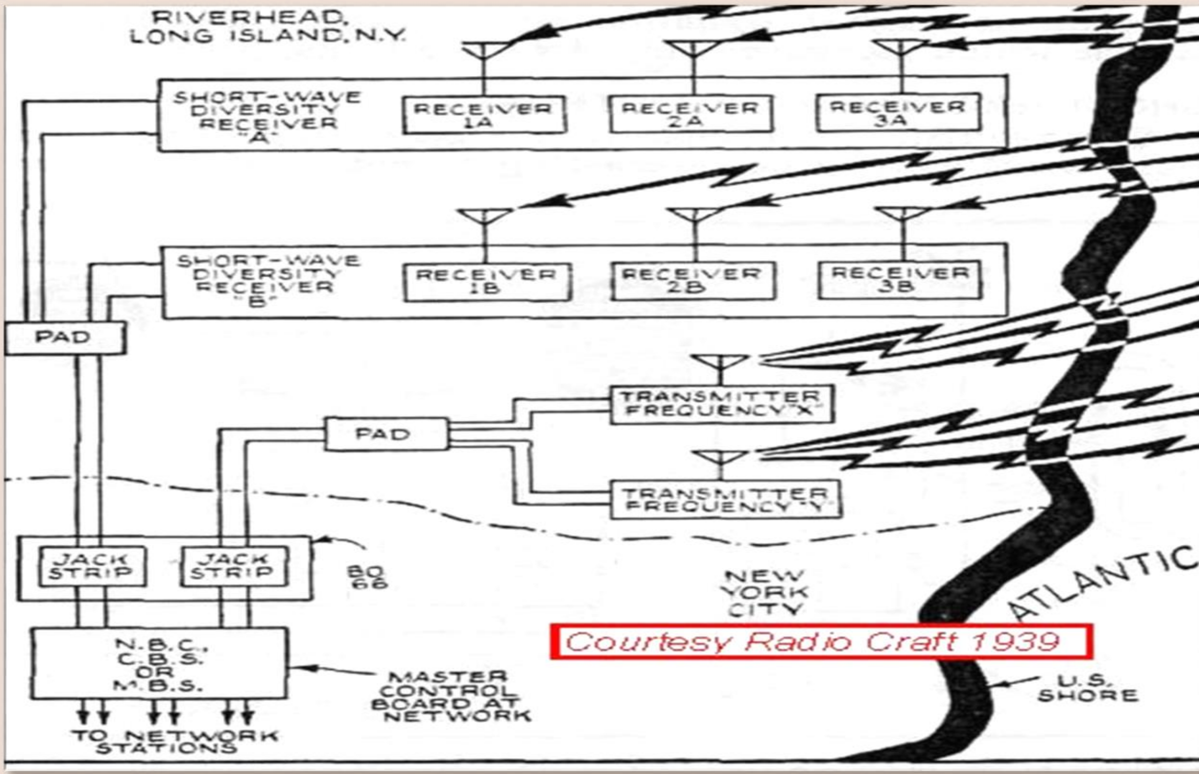
CBS's William L. Shirer picks up the tale: "About five o'clock my telephone rang in London. News Director Paul White was calling from New York. 'We want a European round-up tonight. One AM your time. We want Ed Murrow from Vienna, and American newspaper correspondents from Berlin, Paris, and Rome. Can you and Murrow do it?" I said yes. The truth is I didn't have the faintest idea how…in less than 8 hours, anyway.

"Murrow and I had newspaper friends, American correspondents, in every capital in Europe. Before long my telephones were buzzing in English, German, French, and Italian. Each city would have to come up on a separate shortwave circuit and since they couldn't hear each other they'd have to use the clock…. New York would switch its receivers to the different capitals at the time for each report. New York's brazen serenity, its confidence…encouraged me.

"My newspaper friends said they would broadcast…but only if their New York offices agreed. Not much time to inquire…more calls to New York to get permission from their newspapers. Rome was out, I told CBS New York, but our reporter in Rome was on the telephone at that moment… dictating his story to a stenographer in New York who would then dictate it back to me so I could read it from London.

"We made it! Our part went off all right, I think. Edgar Mowrer and Ed Murrow were especially good. New York said afterwards that it was a success. *Shirer memoirs*

Here's a redundancy diagram of the Short-Wave receive side:



RadioCraft included this story with the above picture: *"Behind the scenes of the Trans-Atlantic hook up:* Point to point communication was given one of its severest tests during the Czechoslovakian crisis (of 1938). In three weeks NBC delivered 110 international broadcasts, CBS made 98 foreign pickups, while Mutual, which made its coverage by playbacks of recorded foreign news broadcasts, contributed five European broadcasts – altogether a total of 213 completed and broadcast foreign programs" *RadioCraft, October 1939*

Live broadcasts via Short-Wave faced some very practical problems. Because recordings were not permitted except for reference, the feeds were subject to the vagaries of radio conditions at actual air time. And "air time" in one European country might not be exactly identical in another, since clocks weren't slaved to a universal standard. Newscasters on site relied on a reverse Short-Wave feed from America for their 'go-ahead' cues…and sometimes conditions were such that they couldn't hear New York. In that event they were directed to start their feed by the clock. Sometimes it worked, recalled CBS newsman Don Mozley.

And this is how it sounded when the field newsman couldn't hear the 'go-ahead.'

The "Voice Of America."

At the beginning of World War Two the United States was one of the few major countries without an official Short-Wave voice. The first "official messaging" came from Short-Wave station WRUL Boston (nee W1XAL). Designed primarily to counteract false propaganda; primarily from Europe, the WRUL series began in spring 1941, in 12 different languages.

When it came to the greater effort now facing the government at war, it fell to the Office of War Information (OWI) to figure out how to craft war-propaganda messaging and to transmit it using additional existing facilities (since there wasn't time to build new transmitters). OWI's efforts created "The Voice of America."

It was an ambitious undertaking. OWI built out studios and recording facilities to time-shift and repeat broadcasts for Short-Wave transmission. Their recording team was also tasked with recording broadcast network feeds and reproducing them without commercials. These commercial-free programs were then aired as time allowed (since after all the transmitters belonged to the networks) and they were duplicated on ETs for shipment to American Forces transmitters overseas.

At first VOA air time was purchased from commercial Short-Wave broadcasters but eventually the government leased 14 transmitters, reimbursing the owners for operating costs. This was no great hardship for many commercial Short-Wave broadcasters; they had been viewing the cost of operations as no longer worth the investment.

The government lease took effect on November 1st 1942 and included RCA's WRCA and WNBI at BoundBrook, GE's WGEO and WGEA, Westinghouse's WBOS, WorldWide's WRUW, CBS's WCBX and others. Once these transmitters were connected to the OWI complex in New York the OWI used them exclusively for wide-area broadcasting, relinquishing time they had been buying from the point-to-point transmitters of RCA Communications, AT&T and Press Wireless.

Communications to the Pacific

The Short-Wave stations in California are worthy of special note for their contribution to World War II. Prior to Pearl Harbor President Roosevelt enlisted a commitment from Wesley Dumm to build two new Short-Wave stations to serve the Pacific Rim. These would join GE's KGEI (on the air in 1939).

Dumm's stations came up as KWIX and the beloved KWID. (During the negotiations Dumm also proposed that as a quid pro quo the FCC authorize a Los Angeles MW station to be called KPFL and a Seattle outlet to be named KSEA.)

NBC and CBS also made a wartime commitment to built out at Dixon and Delano CA respectively. For deeper detail we refer you to John Schneider's excellent work: http://www.theradiohistorian.org/wcsw/wcsw.htm

Meanwhile in Ohio, Crosley had lost its MW Super-Power authority for *full-time* 500-kilowatt operation on WLW 700 but could operate 'experimentally' at 500 kilowatts after midnight, as W8X0. Stories abound of that signal getting into Nazi Germany; Hitler branding the service (which undoubtedly had a pro-government slant) as "The Cincinnati Liars." (Crosley had also proposed a further increase to 750 kilowatts to test new transmitter technology but all higher-power operations were denied. This denial had freed the W8X0 facility for use by the Office of War Information.)

In the post-war years the industry was talking about the government's interest in maintaining control of these Short-Wave facilities. Government spokesmen contended that in the future all international radio outlets would become voices of national policy among the prevailing countries and that the United States 'must keep in step.'

In the interim, most Short-Wave station leases were terminated and the transmitters returned to their owners. But by then broadcasters had lost interest in International Broadcasting and were happy to leave them to the government. The OWI vigorously expanded its plans (for 32 stations), so as a ''public service' NBC and CBS provided additional government programming under contract to VOA until 1948; then left Short-Wave broadcasting entirely.

Domestic Short-Wave "broadcasting" diminished under the universal acceptance of the American Medium-Wave band and the emergence of FM. Most stations turned in their Short-Wave licenses. That left but a handful of American-based *international* broadcasters and the mighty Voice of America.

All of this now leads us to examine how the networks used their distribution systems, and about AT&T's role as a benevolent traffic cop; keeping it moving while continuing the Long Lines march toward 'network perfection' and a ringing cash register.

CHAPTER SIX

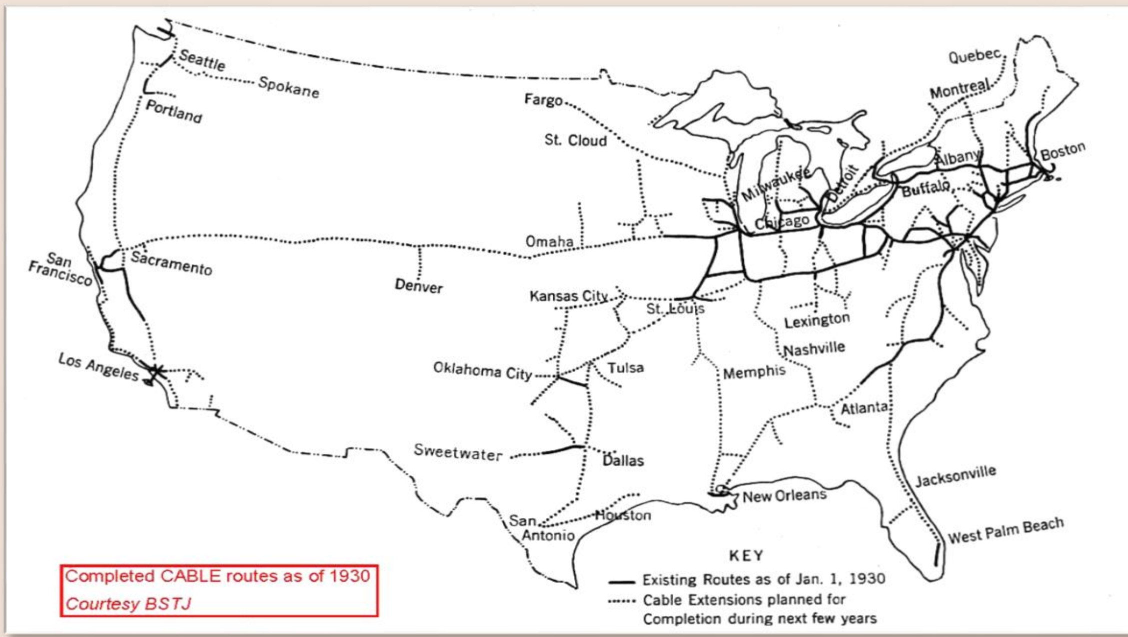
AT&T Operations Center *Western Electric "Oscillator"*

In this chapter we consider the tools, practices and methodology in use by the networks. *(NOTE: In response to requests, deep technical information has been relegated to a following chapter, as a technical appendix.)*

For a number of business and timeline reasons we chose to end the story of AT&T and the broadcast networks in the 1940s. To be sure, there were many significant developments over the decades following. There's a lot more history…but we need to end somewhere. By the late 40s they'd 'gone about as far as they could go' with analog audio on wire. The "pre-microwave" era of AT&T is thus in its own wrapper, leaving the follow-on story to be developed by others…including wideband transmission via microwave links, satellite distribution, digital satellite distribution and fiber optics.

In this chapter we visit the Long Lines "Toll Boards" and the Network Distribution Centers to see how they handled multiple radio channels to multiple destinations. We'll also look at the development of "The VU Meter."

By the mid 1930s all the network *east* of the Mississippi was in cable (both buried and elevated). Cable design reserved separated, heavier-gauge pairs for program transmission; these pairs were isolated from the message-traffic wire bundles. By 1942 the buried cable build-out was essentially complete and open-wire was relegated to use by customers along the rights-of-way. As to voice/program traffic, *Radio News* reported: "By 1938 there were 4 routes from the Mississippi to the West Coast:



The *Northern* route was Minneapolis-Fargo-Billings-Spokane-Seattle.

The *Central* trunk ran Omaha-Denver-Salt Lake City-San Francisco.

A "*Near-South*" path went: Oklahoma City-Amarillo-Albuquerque-Whitewater CA.

The "*Real-South*" line was routed Dallas-El Paso-Tucson-Yuma-Los Angeles.

North- and South-running trunks inter-connected these cities as needed.

Long Lines also divided the country into four <u>operational areas</u>:

Eastern (New York control)

Northern (Chicago control)

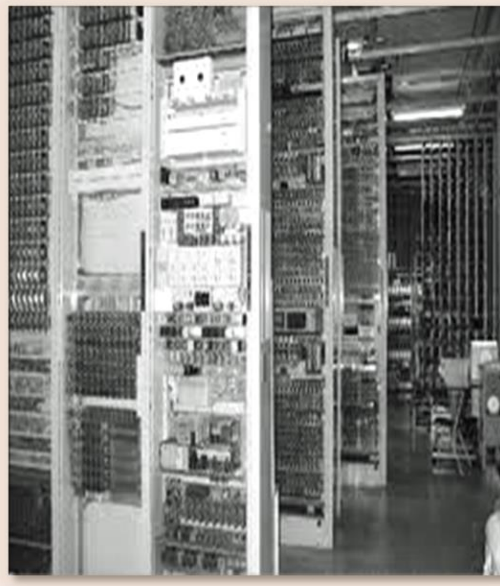
Southern (Cincinnati control)

Western (San Francisco control)."

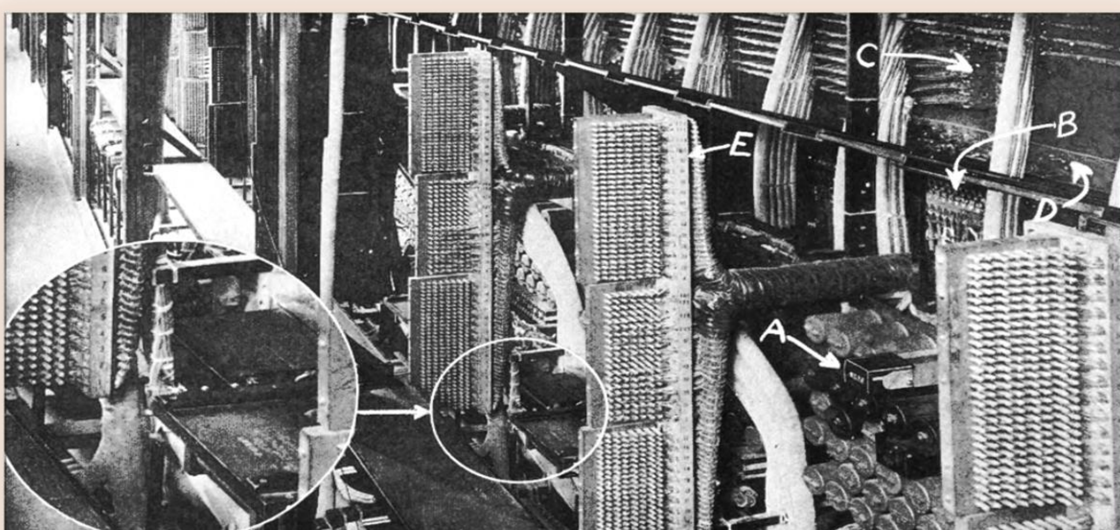
To keep the control centers talking to each other, "43,000 miles of Order Wires and telegraph circuits were dedicated to 'Command, Control and Coordination.' Each of the four centers is connected to every repeater station in its territory."
Bell Systems Tech Journal

Long Lines Program Circuitry

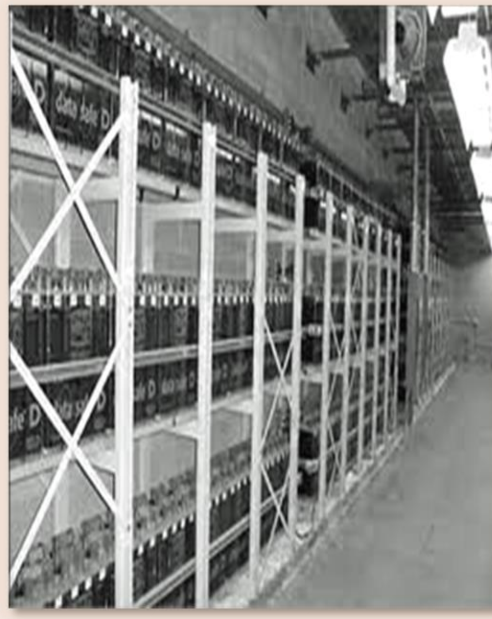
At Toll Boards across the country, new resources made it easier to handle transmission requirements. Rows of equipment racks stretched endlessly across each room:



All equipment was hard-wired to patch bays and "Christmas-tree" distribution frames.



Heat load was a recurring concern; the bigger offices had thousands of tubes in operation. Predictable wire-circuit performance depended on a uniform operating environment for the equipment. The wire offices themselves were physically protected against man-made and natural storms; partly underground or within reinforced buildings above ground and within reach of protected power. Hundreds of thousands of underground cable pairs were each terminated and conditioned. Huge battery rooms provided floating power.



Photos courtesy Cedar Knoll Telephone

Within the wire offices, "program-transmission" was a separated segment. The Toll Test Board was operated by technicians trained to know the difference between voice/message circuits and program audio. Specialized test gear was introduced.

The VU Meter: A New Tool for *Dynamic*-level Measurement

Most transmission specifications had been derived from static measurements, using steady-state tones as the test signals. But in the presence of varying radio program material these same 'acceptable' circuits could behave quite differently.

The long-distance channel was unforgiving of operating-level variations. A narrow window of acceptable volume levels had to be maintained across the network so that line noise didn't overcome the audio. At the same time, complex program audio with its associated peak energy meant special attention was needed to avoid 'overload distortion' from wide level-swings.

Peak-limiting devices (to protect program feeds from peak-excursion distortion) were not widely used at the time. Techs at the studios did their best to watch levels but live programing made it an ongoing challenge. So the game came down to finding a compromise "optimum transmission level" that would maximize noise performance and minimize distortion. To find that sweet spot you needed a realistic way to measure the complex program levels. The industry needed a responsive metering device.

In January 1938 engineers from the radio industry sat down with Bell Labs to resolve the ongoing issue of program-level definition and to define a *standard measurement methodology for program transmission.* A major agenda item was whether this meter should display complex peak energy or RMS values.

Substantive group-listening tests were conducted to determine the meter's ability to portray operating voltages in a complex waveform. In 1939 a new type of "Volume Unit" or "VU" meter replaced the old Transmission Unit "TU" meter and became the industry standard. The final design was not an accident.

(A tiny tad of tech-talk; sorry) The new meter was to employ a 'quasi-RMS' approach, as a compromise between peak and average level measurement. As to response time, the meter was to provide a less-than-critically-damped movement such that, with a 1,000 cps sine wave applied, the meter would read 99 percent in 0.3 seconds, with a 1-percent over-swing. This was a pragmatic compromise (interestingly these meters were in use into the 'modern' era when most were replaced by LEDs).

The meter was to be illuminated and driven by a full-wave rectifier. A series resistance of 3900 ohms was specified for a '0' dbm equivalent voltage to provide '0' VU" reference. The overall impedance of the new VU meter ended up at about 7500 ohms.

The meters read either in db ("A" Scale) or a corresponding voltage-percent ("B" Scale). The meter size and scale was expanded; they even specified a color for the meter wallpaper.

Designers also acknowledged that the VU meter added harmonic distortion. (In the past few decades, purists have recognized the distortions introduced by the meter, and have learned to buffer the meter.)

Then…finally…the Standard Reference Level was re-established. **"0" dbm** was firmly cemented as **"1 milliwatt in 600 ohms."** With the VU meter in place at networks, radio stations and wire offices, it was possible to establish and maintain better levels.

Some Long Lines offices came up with an ingenious trick in which a single shared VU meter was displayed via a projector/mirror so that the meter might be seen from wherever in the room the technician was adjusting levels.

The Weston Company, which had participated in the standards-setting, introduced the Weston "VU Meter." Here's the "B-Scale" type:

That left 'loudness measurement'… a Holy Grail of sorts that hasn't really been resolved to this day. Your author has seen a letter between a writer of NBC's "Fibber McGee and Molly Show" and its ad agency, in which the "music too loud" complaint is repeated. (Network engineers of course would affirm they were doing proper gain-riding by the meters available.) Audio ballistics as a perception tool was still an unknown science.

Extending Network Frequency Response

AT&T knew that "ideal" program channels could pass 20-20,000 cps. The pragmatists reminded the idealists however that such extended performance wasn't worth the extravagant alignment cost for network radio, since the weakest link was the AM radio broadcasting system and its receivers. So when transmission-circuit redesign was undertaken, some of the wire circuits were qualified to pass 50-8,000 cps +/- 1 db, with about 40 db dynamic range. 'Good enough' for AM radio!

However, *Radio Craft* wrote a story in 1934 predicting what might be expected in the future: "For special occasions, transmissions (over the telephone lines) are being made over a band of 15,000 cycles. And short-distance demonstrations have been given of cable transmission over a frequency band of 45,000 cycles."
"Third Dimension in Music," Radio Craft, May 1934

Multi-channel Audio Circuits

Pragmatic and cost constraints notwithstanding, by the 1940s Bell Labs was doing psychoacoustic work to determine acceptable frequency-response limits for human hearing, with an eye toward extending the response of the wire plant. (After all, FM broadcasting was about to become a reality.) While "AM" transmission didn't require much finesse, the FCC was also experimenting with double-wide "high-fidelity" AM stations in the 1500+ kc band. They were also promoting 'APEX.' Both formats would want wider-bandwidth network audio. (Both experiments were short-lived.)

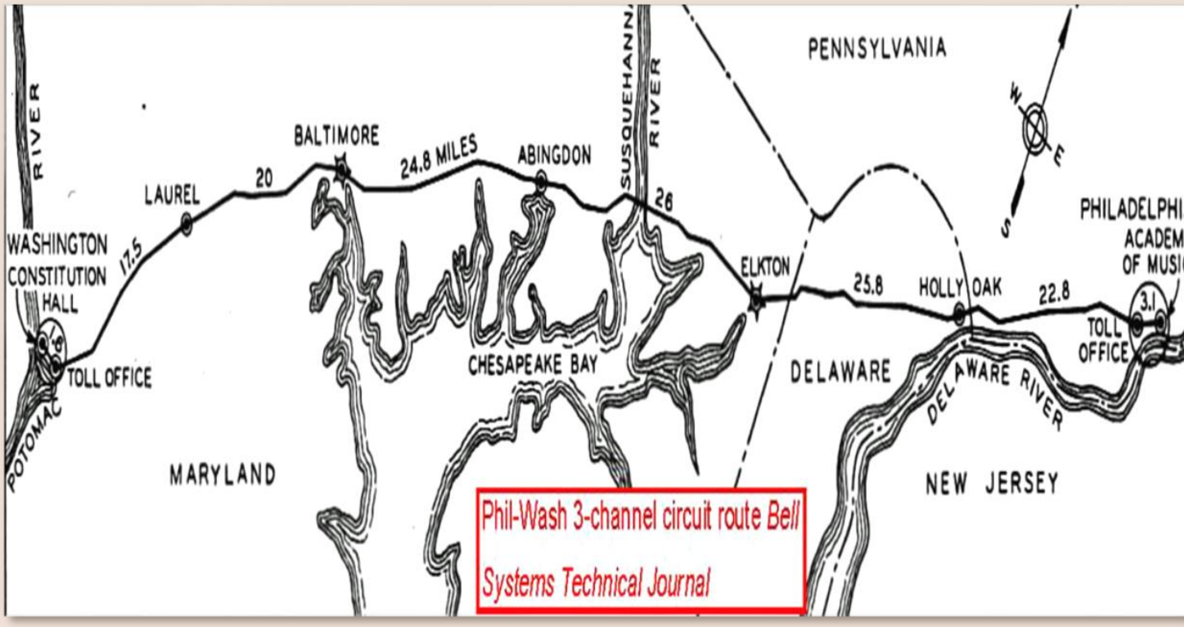
"**APEX** was an experimental radio broadcasting system introduced in the United States in 1934 that used high frequencies between roughly 25 and 42 megacycles and wideband AM modulation (as opposed to traditional AM broadcasting's narrowband modulation)…to achieve high fidelity sound with less static and distortion than Medium-Wave AM stations in the so-called Standard Broadcast Band. They were called "apex," "skyscraper" or "pinnacle" stations because of the height of the antennas used." *Wikipedia*

To address FM, APEX and other high-fidelity opportunities, in March 1941 AT&T announced wide availability of 8 kilocycle bandwidth and shortly thereafter offered 15 kilocycle bandwidth. A move to "wideband" channels was not a big deal for the *local* telephone companies; many of them had long provided such service on local studio-to-transmitter (STL) links. The ability to deliver reliable *national* wideband networks would depend on deployment of "Carrier" technology.

Leopold Stokowski, Bell Labs and the Grand Experiment

Famed conductor Leopold Stokowski was unhappy with the sound of his orchestra as transmitted over the NBC network. He interested Bell Labs in the problem and allowed them to use the Academy of Music in Philadelphia as a test bed to develop improved facilities. This would have been in the early 1930s. It was during this period that Bell Labs had produced the first "premium" disc recordings…including tests done in *binaural* sound. Here's a sample of one such recording. Close to 100 years old!

Stokowski was an audio experimenter and got behind a Bell Labs/Long Lines project to demonstrate multi-channel audio in "auditory perspective" (the word "stereo" was not in the lexicon of the time). In 1933 under his auspices **three** audio channels were sent via Carrier from Philadelphia to Washington for his music. Repeaters were placed about every 25 miles along the 150-mile path:



Unloaded cable pairs were selected and repeaters of the 'negative-feedback' type were used. Suppression of noise and interference was necessary on the cable pairs selected for the demonstration *as well as on adjacent pairs*. (As they fine-tuned the channels, they encountered and removed several interesting roadblocks. As a specific example, engineers found noise in some circuits being induced by pair-coupling in the Baltimore wire office. They dealt with it by the addition of chokes in the lines.)

The response of the derived audio channels from this Carrier system was to be 40 to 15,000 cps within a db or so, with 65 db useful signal-to-noise. In 1933!
From Bell Systems Technical Journal

The three channels were ready on April 27, 1933. The Philadelphia Orchestra was to play a "test concert" at the Philadelphia Academy of Music. The band was miked "Left-Center-Right" (a fourth "soloist" mike was mixed into the Center channel as needed). Three "playback" loudspeakers were placed in Constitution Hall in Washington, in positions complementary to Philadelphia's microphone placement.

At Constitution Hall, measurements were made well into the audience space, and final equalization helped the high-end audio reach into that space. The "Conductor" at the Washington end (Leopold Stokowski) was also given a bass boost/cut control, shelving at 500 cps. Finally…talk-back and a click-track were provided.

The Bell Labs' Harvey Fletcher was part of the experiment. The BBC again.

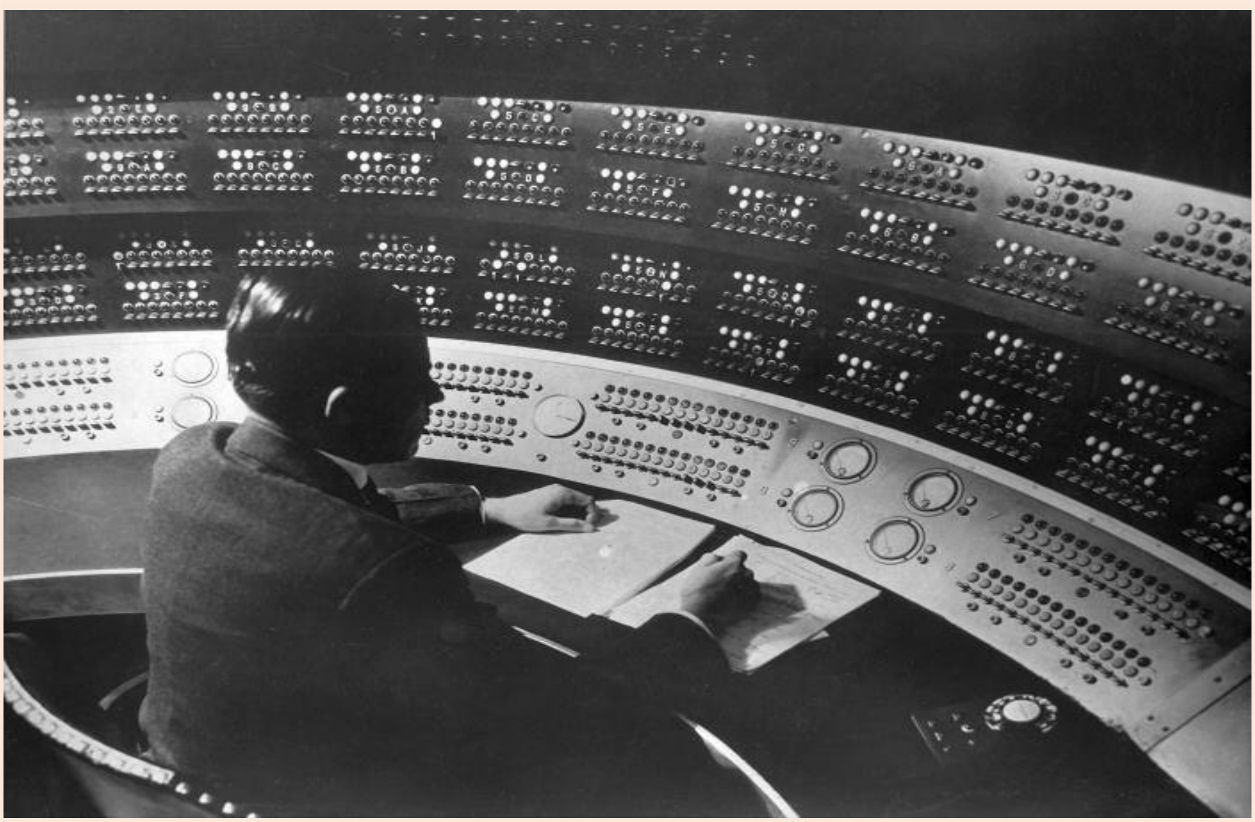
By all accounts, the demonstration went extremely well. What fun to have been there!

Just to put this achievement in perspective…we note Elisha Gray had done "something similar" in April 1877! His test was from Philadelphia to Lincoln Hall in Washington. But his was "music by telephone." Would love to know more about his expectations.

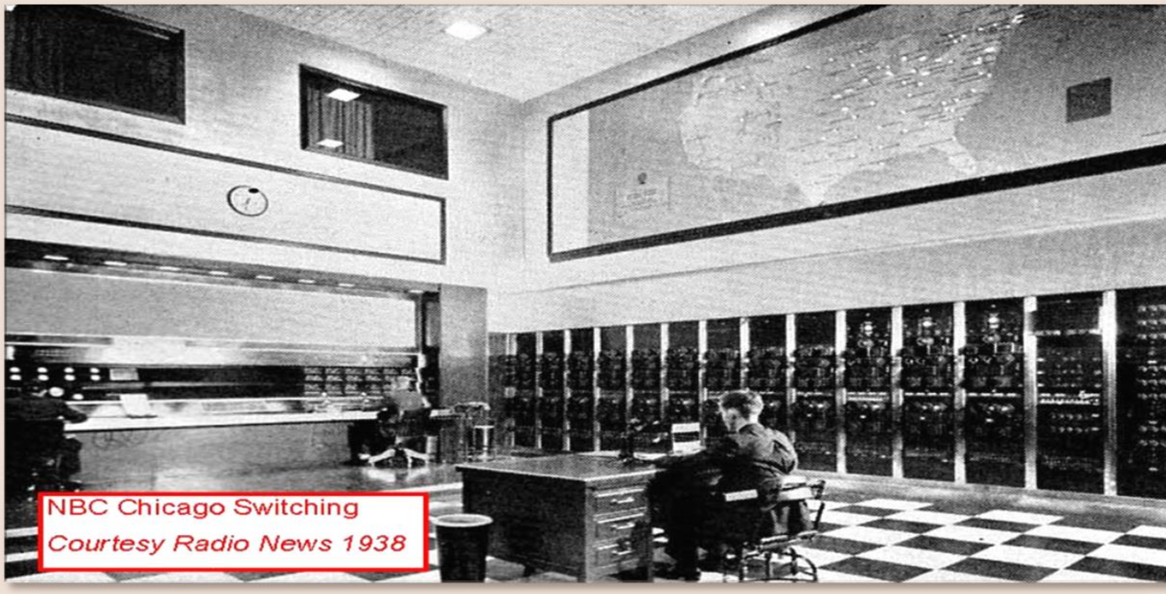
The Stokowski 1933 experiment demonstrated the great strides in audio quality that had been made over the years. It's worthy of note that, because Stokowski applied his artistic side to the practical world, the 1933 tests also revealed the awesome potential of *the intersection of technology and art!*

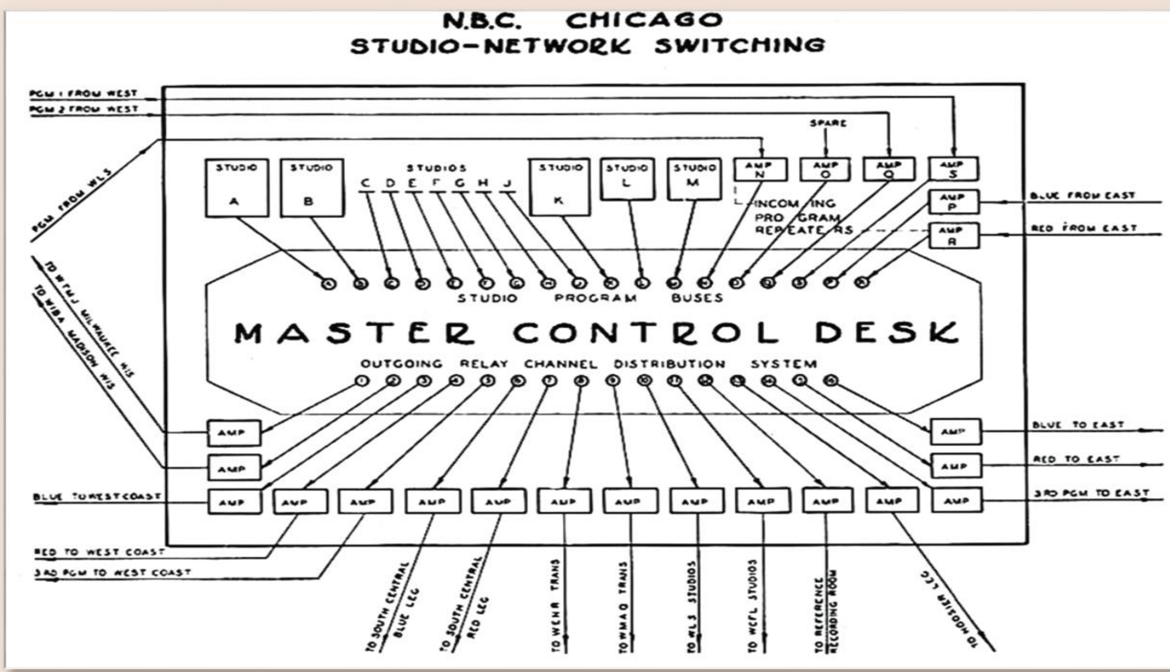
Switching at NBC

Network control rooms were full of routing switches, patch-bays, relays and meters, staffed by a bevy of tie-clad nail-biting engineers, armed with program-routing schedules and tasked with watching operating levels. Out of New York, NBC's Master Control routed two dozen studios to NBC Red, Blue, WJZ, WEAF and W3XAL and other Short-Wave transmitters, ad-hoc and regional networks along the Eastern seaboard as well as the Chicago distribution center. It could be a scheduler's nightmare.



Chicago's switching hub played a key role in NBC's distribution. The center was built when NBC acquired WENR, upgraded its transmitter facilities and added experimental Short-Wave Relay Station W9XF. "All NBC passed through Chicago; here was located NBC's main network center. 152 amplifiers. 3,160 jacks. 976 relays in the circuit."
Radio News, March 1928


NBC Chicago Switching
Courtesy Radio News 1938



You'll find an interesting close-up of the Chicago center through the eyes of an Engineer at: http://www.richsamuels.com/nbcmm/webster/webster.html

The "Chimes" as a Switching Cue

NBC's three-chime cue became arguably the most famous and recognizable aural identification in history. But did you know the chimes were originally used to give AT&T network engineers a cue for switching? Historian Michael Shoshani adds a further aside: "Even though NBC adopted a chime signal in 1929 to alert AT&T network engineers to the next switch/realignment, NBC also transmitted alerts to AT&T engineers *in Morse Code,* on parallel sets of lines, until 1933."

The *Radio Club of America* wrote: "Programs on the Red and Blue networks often ended at different times. NBC protocol was that the program finishing ***first*** relinquished control to the later-ending-program's announcer. That worthy would switch the first-vacated channel (whose show was over) to simulcast the show not yet ended. The 'last' announcer then sounded the chime for *both* networks and released the temporarily-piggybacked second network for its own follow-on programs." *Proceedings of the Radio Club of America, October 1930* In the network files we learned "It was felt that "the best coordination of thought and action is obtained by having the announcer do his own switching." *NBC Files*

The announcer habitually "rang" the (then-manual) chimes for national network cues. (Stations that operated regional and split networks used their own chimes for their own signaling.) Here's a clip of a network cue/WEAF station break (with the "Announcer's Delight" control panel seen at left): https://www.youtube.com/watch?v=96rA-QgXL58

Here's a sweet adaptation of the chimes, in a song titled "I Love You."

The "Rangertone" chime machine replaced the manual chimes in 1932. The chime machine permitted clock-controlled automatic cutoff of late programs, delivered a consistent chime-sound…and took the end-cue duties away from the studio announcer. If you wish to learn more about NBC Chimes history, we point you to the great web-site: http://www.nbcchimes.info/linkcred.php

Switching at CBS and Mutual

CBS did its switching from New York, with the exception of shows routed out of Hollywood. *We're searching for descriptions of CBS's and Mutual's switching and routing practices. If you're aware of such detail, we'd appreciate hearing about it!*

Switching at AT&T Long Lines

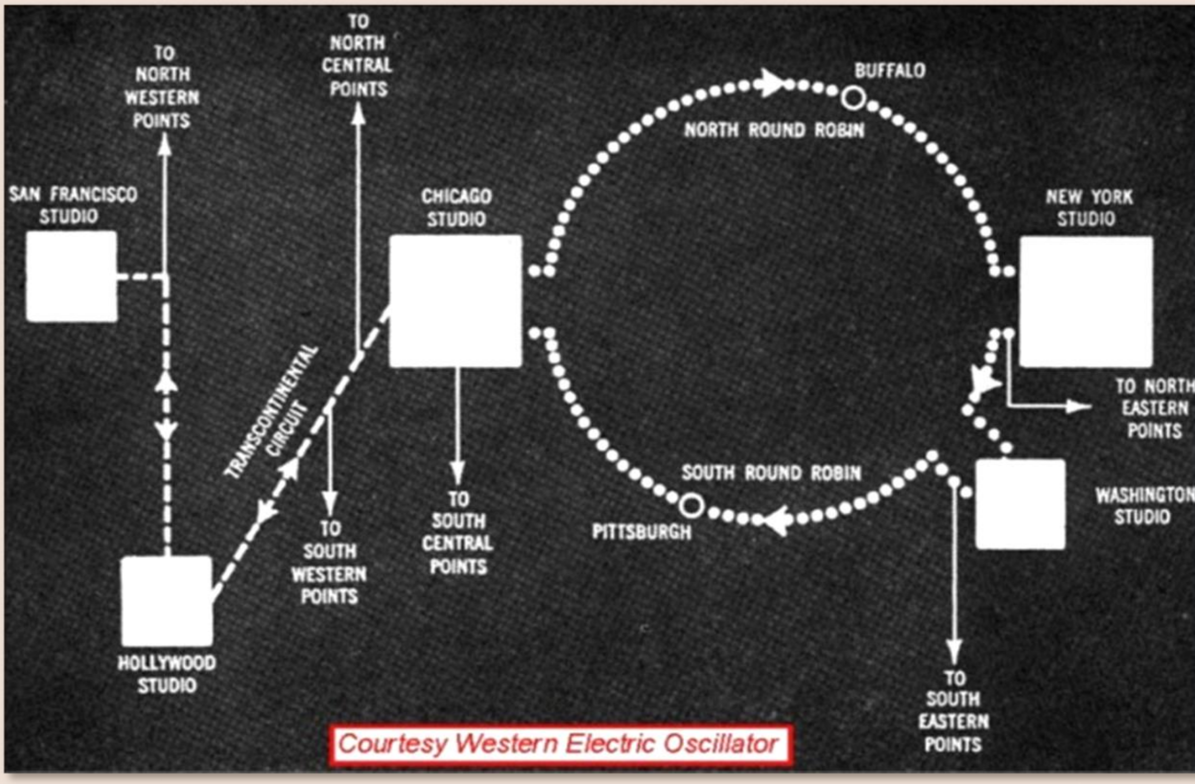
From the BSTJ: "Special operation and special switching and reversing equipment are required at many points along the network. Much of this equipment is under remote control. The greater portion of the switching is done at about 25 points throughout the country. More than 25,000 switching operations per month are performed at these 25 points. During the busy hours of any typical evening there may be something over *500 men on duty* (working with) the networks. At points where switching requirements are simple, the switching equipment consists merely of a few keys. At the larger points where the switching requirements are complex, the switching equipment consists of elaborate relay and control arrangements. These are so designed that it is possible to set up in advance the circuit combinations required for the ensuing program period without disturbing the programs in progress.

"The actual switching operation takes place at the instant the monitoring attendants signal the receipt of the last of selected cues, and not before then. This type of arrangement affords a maximum of protection against error, as it is possible to check the presetting for the next switch or make a last minute change if necessary any time before the switch has been made. Transmission is monitored continuously at strategic points about the networks. In order to facilitate the activities of this group many thousands of miles of intercommunicating telephone and telegraph circuits are provided full time for their use." *Bell Systems Technical Journal*

Typical AT&T network switch center (Washington) *ibid*

The Round-Robin

Boston Historian Donna Halper recalls that NBC fed its eastern stations in a "round robin" manner as far back as the late-30s. "This was a loop that went from NYC, perhaps to Boston, then through Cleveland, Chicago, St. Louis, etc., the South, Washington and back to NYC. Major points could break the loop and insert audio. It was "interesting" when the originating station didn't break the loop for enough time for audio to die out before closing it."

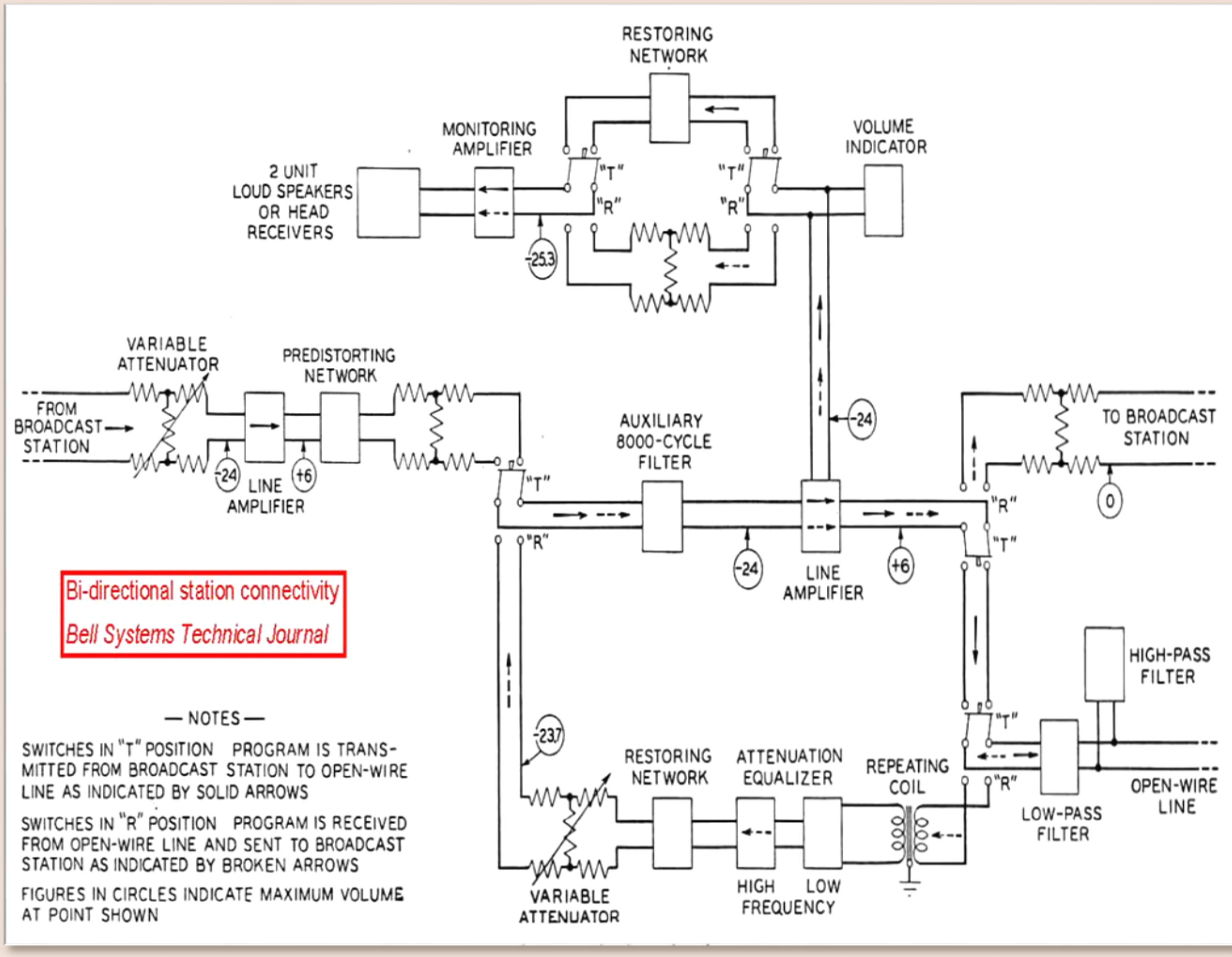


This arrangement employed a form of "Drop-and-Insert" topology. It was also the technique used by a group of "1-A" stations when operating "Clear-Channel Round Robins" with participation from talent at each station, being fed to all other stations. It took some savvy about "mix-minus" on the part of broadcasters…and they didn't always get it. ("Mix-minus" was an unusual way for radio guys to think back then.)

The "Standard" Affiliate Connectivity

By the 1940s mature, systematized network arrangements had survived the test of time. The uniformity of equipment and connectivity made it easy to cross-train personnel on the interfacing between the network and the local affiliate.

Here's a "standard" AT&T/affiliate interconnect. The equipment sets for this connectivity were dedicated for each station, but all were on patches, so fast equipment substitution was possible.



Time-zone feeds

From the very moment the networks pushed west across the Mississippi, those responsible for station clearances needed to consider how listener living patterns varied across four time zones. It wasn't brain surgery to recognize the most-valuable clearance time for evening shows was *in* the evening. But a show airing at 7PM Eastern would vibrate the airwaves at 4 in the afternoon in Fresno. Not terribly acceptable.

Not surprisingly, resolution of the "timely-coverage" issue was a matter of economics.

With the exception of live events (news, sports etc**) the networks in an ideal world would clear each broadcast at its optimum listening time (i.e. when that show could earn the highest revenues).

** As early as 1939, some stations on the West Coast (notably Seattle's KIRO) received network permission to delay World Series games for later consumption.

Further, researchers were aware that "8 PM in the West" might attract a different audience than "8 PM in the East." Finally, they knew certain programs had differing appeal at different times in different parts of the country. And this may be where the real power shifted to the advertising agencies. <u>They</u> would make the clearance decisions because they owned most of the programs. In those cases the networks assumed the passive role of *distributor*, providing only the (branded) transmission path. If a live show had to be "repeated for the West Coast," so be it.

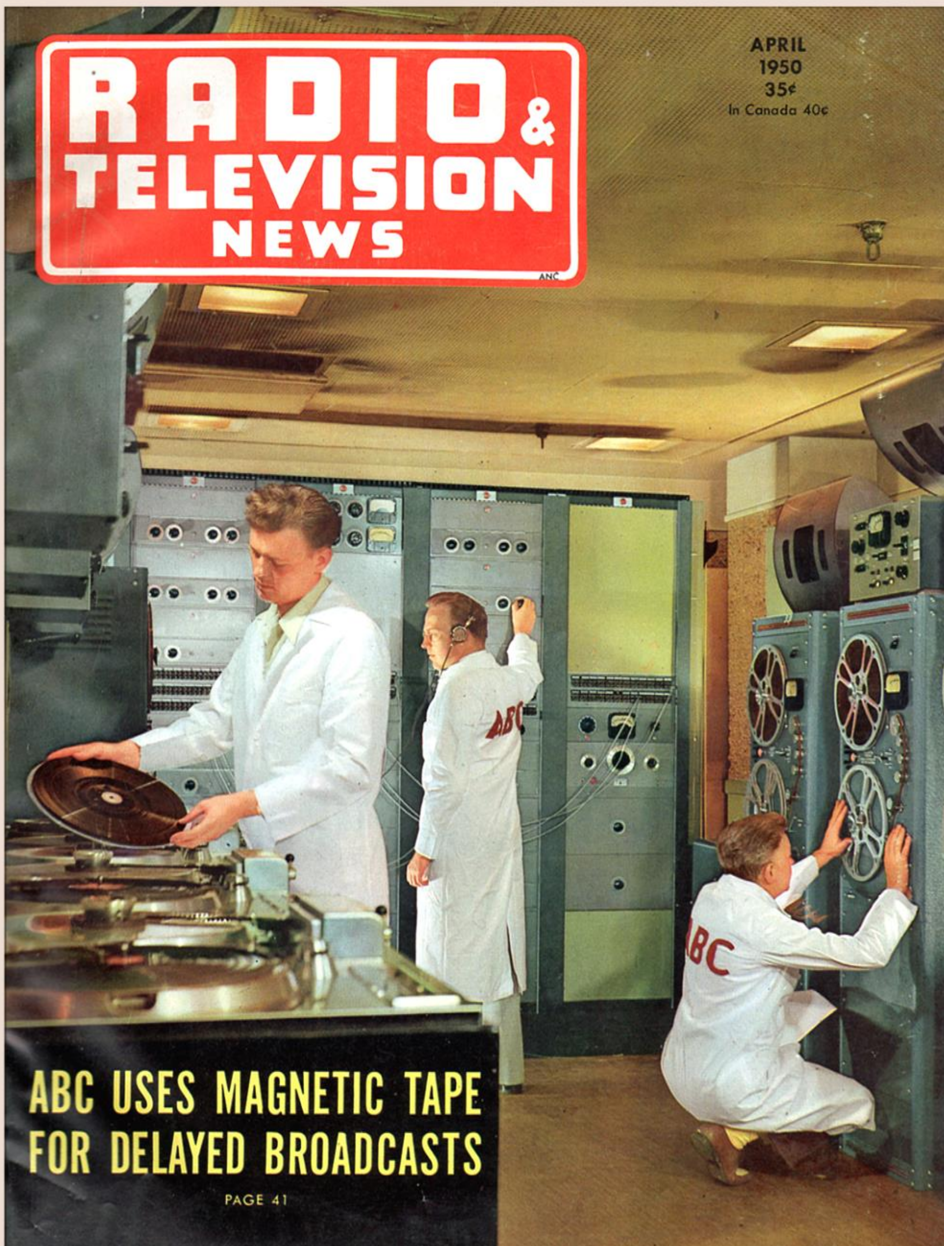
A backstory: The cost of *repeating a live program* wasn't significant at first. But once programs became popular and stars well-compensated, production costs became a serious economic deterrent to repetition. Today of course the task is handled by automated recording/playback technology, but remember: until the late 1940s there was a network ban on program recordings for replay.

The networks and the agencies duked this out and at the end of the day, certain valuable shows were repeated live (at significant cost) in order to clear them across the U.S. at times of highest audience appeal. In certain specific instances sponsors worked out arrangements in which *recordings of some shows* were used to provide '*simultaneous'* clearance across time zones (the East's live feed was recorded on the West Coast and the disc was spun up 3 hours later). And sometimes a network-program ET was sent to a non-network station, to add that market to the coverage.

On the West Coast the sponsors might not like the available stations on a given NBC network, so some shows were recorded from one NBC network to be played on the other. Again, it was usually the ad agency that made the choice. Never one to follow the pack, Mutual allowed ET-replay of selected shows beginning in the 1930s. Mutual (and probably ABC) went on to allow the use of ETs for *most* West Coast programming.

The 'network way' of doing things was upended when Bing Crosby began using the tape recorder to repeat his shows. Crosby had started show-repeats on ET, losing his sponsor in the bargain. Then the tape recorder brought the technology to the point where no one could say that recording a broadcast impaired its technical quality. Besides, Crosby could then enjoy the benefit of editing!

It had been a long journey to the Bing Crosby milestone and the networks were dragged along reluctantly. It was the imperative of scheduling program clearances around Daylight Savings Time that helped nudged them into accommodation of tape recording for time-zone program re-feeds. Here the goal was to keep clearances at the same hour across the year, whether or not a given region had switched into and out of DST. ABC was first with time-zone program feeds; comfortable with their experiences on the Bing Crosby show. ETs were used for this purpose for about two years before the tape recorder was considered trustworthy for the job.



Well, we're nearing the end of our AT&T story. When I review the incredible amount of information available to broadcast history fans, I feel privileged to have been able to lead you through this information. To the extent this material is at variance with more accurate work, the fault is mine alone. This revision includes new information and some corrections provided by readers. We welcome your input and ideas about a follow-on subject. One thought was the telephone company's work on submarine cables. Currently we're at work on a book with the working title: "***How Radio was Reinvented for World War Two***." Do you have other suggestions?

Deeper technical detail is provided in the next chapter, a technical appendix. Whether you bail now or after reading the next 30 pages…as an unrequested 'encore' we offer below a few anecdotal "snapshots" and notes of interest to be used in your next cocktail party conversation.

ENCORE 1: "ABC"

Jim Ramsburg did some fascinating research on when the "real" ABC finally came into being as a national network: "…when Edward Noble's American Broadcasting *System*, Inc., bought the Blue network from RCA in October, 1943…Noble had every intention of renaming his property "The American Broadcasting Company" and re-branding Blue's on-air identity as ABC. But there was a hitch in his plan because the name ABC was already registered to Detroit broadcaster George B. Storer, who had created his own American Broadcasting Company radio network in October, 1934.

"By coincidence, (or more probably not), the original ABC came into being just a few weeks in 1934 after another Detroit station owner, George Trendle of WXYZ, joined forces with WOR/New York, WGN/Chicago and WLW/Cincinnati to establish the Liberty Network which morphed into the Mutual Broadcasting System…Lack of programming and advertising doomed the original ABC within a year, but Storer kept the name. So, when Noble came calling the crafty broadcaster knew that he had a seller's market. For that matter, so did the owners of the defunct American (FM) Network, the newly formed and quickly failed Associated Broadcasting Company, the Arizona Broadcasting Company - and the list went on. Although Noble's corporate name was changed to The American Broadcasting Company in September, 1944, the chain's on-air identification had to remain "The Blue Network," until all claimants to "ABC" were satisfied or dismissed. But the determined Noble's negotiators worked through the tangle with checkbooks in hands and on June 15, 1945, his network's announcers were finally cleared to read the system cue, "This is ABC…The American Broadcasting Company." *From Jim Ramsburg's Gold Time Radio* http://www.jimramsburg.com/

To which I'd add the following trivia: The split-off network was ordered to cease its use of the NBC Chimes on December 1, 1943…though the network was still being identified as "The Blue Network." What's also of interest: in September 1942, under pressure from commie-phobes, the "Red" title was discontinued at the main network which became simply "NBC."

By the Bye: What shouldn't have been an original idea was fielded by ABC in 1967. The plan was to use the "quiet" portion of each hour to feed additional programming to additional affiliates. Out of that idea came the American Information / Entertainment / Contemporary / FM Radio Networks; all on the same channel. *(Back then that idea required FCC approval !)*

ENCORE 2: "HARDENING" STATIONS

In 1942, AT&T's opening of the more-secure cross-continental *cable* line prompted NBC to propose the establishment of an ad-hoc "Defense Network"…joining together literally all of the 880 stations on the air, for national defense emergency news during the war. Not much came of this. The proposal included the "hardening" of individual stations; particularly with respect to power supply. (The 'hardening' concept has been re-invented and applied to today's key broadcast stations.)

Intriguingly, in the 1942 proposal, NBC disclosed a new (consumer?) "RCA Alert Receiver" that worked on sub-audible tones from key AM stations.
Radio News, January 1942

ENCORE 3: "THE CUSTOMER-FRIENDLY ATTITUDE OF LONG LINES"

Reader Rick Melzig recounts what I too remember to be a typical story: "In the early part of the 1970s I was the contract chief engineer of a little 1 kw on 1230 in Manchester (near Hartford), CT. Along with a bunch of loops from nearby churches (which paid us to carry their services), we had a 5 KHz circuit from AT&T Hartford TVOC (TV Operating Center). It was used to patch in various sports feeds and as backup for our CBS radio network feed which came to us from the same place. During the college football season we carried Notre Dame football on Saturday afternoons. The Notre Dame contract required me to call AT&T to order the connection each game. So of course, one Friday afternoon at about five, I walked into the IBM office in Hartford (my day job) after having been at an account all day. One of our admin guys called out: "Rick, some guy from AT&T called for you". (Oh shoot, I forgot to call and order the patch.) "He said he didn't have an order for Notre Dame football this weekend, but just in case, he'll leave the patch up over the weekend, You can call him to tell him to bill you or not."" …(where are they now)…?

ENCORE 4: "HITLER AND THE RUNDFUNK"

(Anecdotal): The story is passed down that during World War Two the Germans operated some of their broadcasting studios on wheels; this mobility protecting them from bombing raids. Equalized lines were run along the Autobahns; every so often they were terminated at a pedestal, where a mobile studio could park for a few hours; do a broadcast and move on before Allied bombers could find them.

ENCORE 5: "WARTIME POWER-REDUCTION"

Did you know that in 1942 and for the duration of the war the FCC required all broadcast stations to reduce transmitter power output by 1 db (presumably extending tube life), while relaxing minimum-modulation and minimum required hours of operation? "There was one exception," according to reader Tim Hills: "WLW in Cincinnati was allowed to increase power to 600KW after Midnight, as W8X0. Running that much power into an 800' half-wave tower, the 700KHz signal was easily heard in England and on the Continent.

"England had cut back night time radio power to keep the Germans from using signals for targeting, so often the Brits were getting their news from the United States." The American power reduction was canceled on October 1, 1945, as would be a FCC Freeze on AM applications, created by the war-scarcity of transmitting equipment.

ENCORE 6: "NETWORK QUALITY IN THE TV AGE"

Reader Ralph Gould is a veteran of radio in Texas and the Southwest. He recalls: "Both NBC and CBS originally bought an 8kHz backbone from New York to Chicago, New York to Boston, and New York to DC until the late forties to early fifties. When TV started to get big, it was one of the first cost reductions at network radio. I remember having to check the line response from ABC to Dallas. The split was in Kansas City. By the time the feed got to Dallas it was -3 dB at 100 Hz and 5kHz. It was via microwave from Kansas City at that time (1974). A couple of times a year they would check equalization and tweak it. I assume they had some correction between microwave equipment. When I moved to Phoenix as a kid in 1958 I remember thinking that network radio sounded really funny on KTAR there. I had been a fan of Monitor in Boston and it sounded much better on WBZ. You see, Phoenix was fed from LA. If the program originated in LA it sounded pretty good. If from New York, pretty mediocre."

AND FINALLY…

A look to the future from the past, thanks to reader Luke Pacholski:
https://www.youtube.com/watch?v=XWwV4Hc-Nkc

CODA

For those of you who never knew the *sound* of radio over a long pair of wires, or wondered how it was done, this e-book has hopefully been of interest. **<u>I value the attribute of *CURIOSITY* and applaud you for making it through this history!</u>**

Most of us older folks are conversant with how network service changed once we entered the satellite age. (And by the way…*that* transition was by no means seamless.) By that point of course, Long Lines was trunking its audio, video and data via Carrier on wide-bandwidth radios or coax cable; breaking at demark points to feed individual stations and other customers "the last mile" via local copper. And fiber was on the horizon, thanks to an Atlanta engineer named Snelling.

There's an App For That

Today we're accustomed to breaking down knowledge barriers and solving problems in the time it takes to write or buy some good code, download clientware or order a plug-in card. This is because the world has become binary.

It tkaes a disproportionate amount of "processing power" to finesse the *analog* world. That "processing power" was the capability and the experience of the AT&T engineers and technicians who wrestled to understand and subdue each variable in their electrical world. There's a lot of that story in the following technical appendix.

The analog world was tough to conquer, but AT&T did a pretty good job of it. And they left a real "standards" legacy. The rack rows, the battery power, underground, inter-office ties, pair "conditioning" can all be found in some form in today's "wire" (fiber) offices. There was no 'dither' in the old phone world; you took everything you could get, noise and all.

It's a tribute to the AT&T model that they did it so well!

There's obviously more to these stories and we encourage you to add your own two bits' worth, or to refer our readers to other resources. At some point we anticipate publishing historical work that will take us down other, related paths. *Perhaps one of our readers will now carry our story into the IP era.* I'll be the first to but *that* e-book!

And if you have a further interest in these subjects please visit www.durenberger.com. It will certainly be worth your browsing time!

I want to recognize the engagement and support of Richard Hess, who provided invaluable assistance on the formatting and publishing of this work…and to the readers who submitted information that made the story more interesting and accurate. They embody the principle espoused by my dear late friend Jerry Miller, to whom this work is dedicated. Jerry's dictum: "LEARN---EARN---RETURN." LEARN your craft. EARN your living at it. RETURN to others what you've gained in experience and wisdom.

"**CONNECTING THE CONTINENT**" is my own effort at heeding Jerry's counsel.

We appreciate the fact that a hundred years ago AT&T had the resources to "write the book," developing electrical principles and applications that built the platform on which rides so much of our twenty-first-century communications system. While some of us may not fully understand the "new AT&T it's easy to suggest that within the technical ranks of the company resides the determination to promote and defend the reliable, quality service provided by the company's Grandparents and Uncles a century ago.

Methinks monopolies were not always a bad thing…

Respectfully submitted,

Mark Durenberger *Mark**4**-at-durenberger-dot-com*

Minneapolis, Minnesota, August 2014 and April 2021

For further information, go to durenberger-dot-com and/or the references below which supplement the URLs and references within this work:

"A History of Engineering and Science in the Bell System." Edited by F.M. Smits and published by AT&T Bell Laboratories.

"Invention and Innovation in the Radio Industry" by W.R. Maclaurin, MacMillan, 1949 (reprinted by Arno Press, 1971).

"The Telegraph in America, 1832-1920" by David Hochfelder (Johns Hopkins Studies in the History of Technology)

NBC Recordings at the Library of Congress: http://www.loc.gov/rr/record/recnbc.html

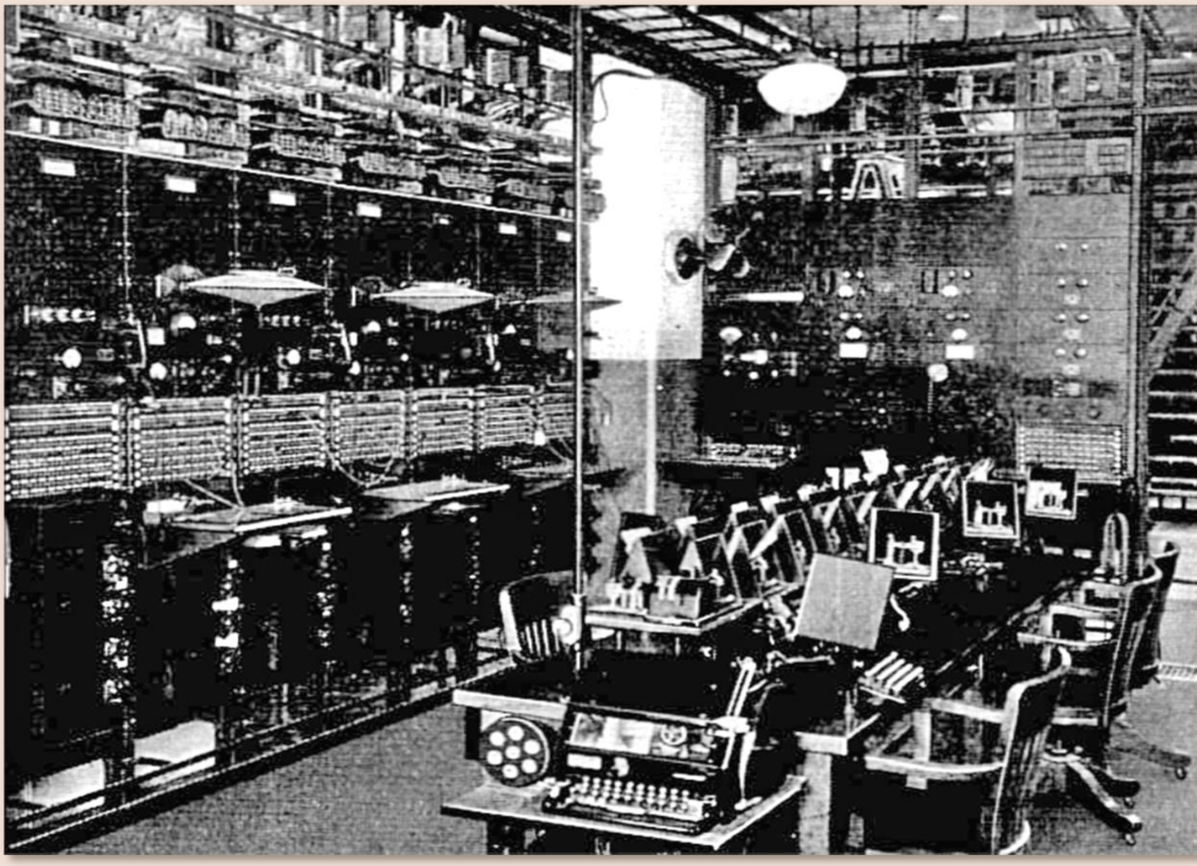
Thomas H. White series: http://earlyradiohistory.us/sec019.htm

Good general history: http://www.oldradio.com/archives/general/

Searchable information on the subjects of this book: http://mediahistoryproject.org/

Go to the bookshelf http://www.worldradiohistory.com/Bookshelf_Master_Page.htm and download *History of Radio to 1926* by Gleason Archer for the backstory and a lot of detail.

Chapter Seven: "A Technical Appendix" is next



An AT&T "Test Center"

CHAPTER SEVEN

Technical Appendix

AT&T Builds a Voice Network: A fair amount of technical evidence

This final section contains technical detail that might…if placed within the rest of the e-book…have distracted from the historical context of AT&T's growth and development. The information below is for those interested in the technical issues involved. Its presentation is grouped by subject and doesn't necessarily follow our original timeline.

As giant corporations go, the history of AT&T is one of the best-documented. The theory and practical expertise developed 100 years ago is in many cases still useful in the 21st Century. They did not throw 'the book' away once they wrote it; new chapters were simply added. The detail is of value to historians. We share a bit below.

Improving wire performance by "balancing"

While one AT&T development group worked to improve the telephone instrument, others were addressing the electrical problems of wire-equipment interfacing. Serious effort in this area is traced to about 1906.

Prior to the practical repeater you could move voice just so far on a pair of wires; the low audio output of telephone instruments encountered the noise on the wire path. The unbalanced single-wire Western Union system simply would not work for telephone-level audio.

High ground resistances dramatically increased loss; indeed, telegraphers had to use batteries approaching 200 volts to operate relays at any practical distances. Keying those paths with that kind of voltage created transients that radiated from the wire into adjacent lines. The unbalanced, single (iron) wire was great at generating impulse noise and was itself highly susceptible to such disturbances.

One of the more predictable noise problems resulted from the placement of wires along railroad rights-of-way. Inductive and capacitive reactance was upset as trains rolled by, and noise fields generated by the trains themselves were induced in the wire. There were many other electrical disturbances along the many hundreds of wire-miles.

Balanced transmission lines

The first significant improvement in noise-rejection was the two-wire audio transmission line. It was known that a *pair* of wires could be made to work with each other in such a manner *as to reject much of the eternal noise that had been coupled to the lines*. So that's where they headed.

The telephone wire pair looked like an AC transmission line whose impedance was a complex vector, consisting of distributed resistance, capacitance and inductance. These factors were changeable, quantifiable and could be managed in part by good engineering practice.

Two new terms came into the lexicon. "**Metallic-Circuit Noise**" is a voltage that appears *between two conductors* in a pair. (Metallic Circuit Noise is also known as "**differential noise**.") "**Longitudinal-Circuit Noise**" is a voltage that *exists equally on both wires* of a pair (we now call that "**common-mode noise**").

Longitudinal noise usually results from a wire *pair's* proximity to interfering sources, (where both wires are equally susceptible).

This interference includes inductive coupling from power lines, nearby parasitic leakages, perhaps capacitance between offending and affected lines.

Properly-twisted pairs, whether open-wire or in cabling, would expose common-mode voltages *equally* to both wires. It could then be cancelled at a termination transformer.

Open-wire paired lines were twisted by "Transposition." Wires would cross each other (each crossing creating a 90-degree phase shift), at distances such that several transpositions occurred per wavelength of audio. (High-voltage transmission lines still use this technique.)

There were two popular types of "Transpositioning" on open-wire lines:

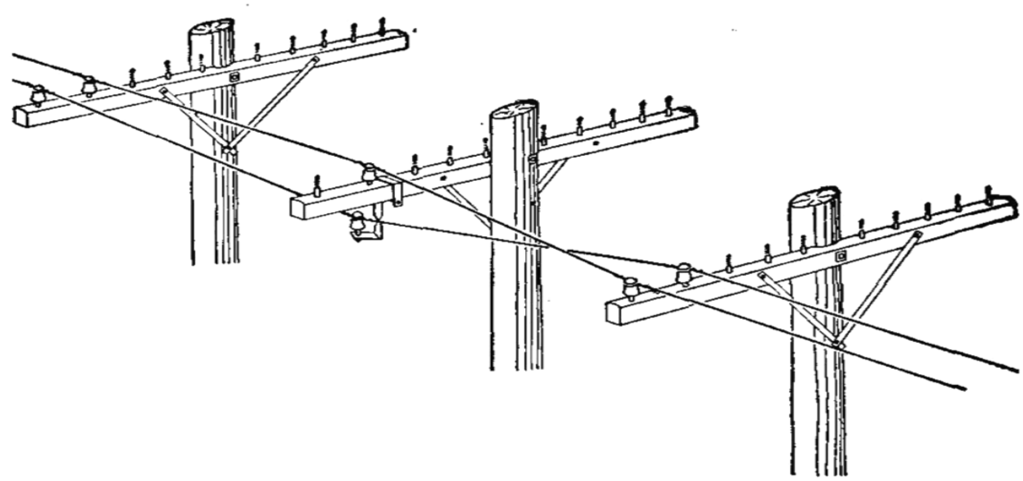


FIG. 34-12. DROP-BRACKET TRANSPOSITION

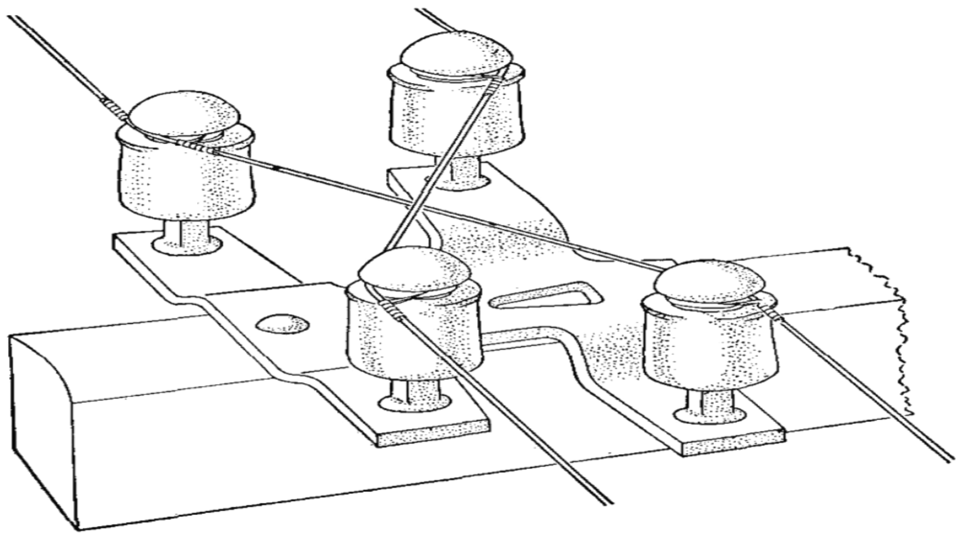


FIG. 34-11. POINT-TYPE TRANSPOSITION

Courtesy Bell Systems Technical Journal

AT&T began converting its outside plant to two-wire architecture around 1890 and as noted spent the next ten years in converting the entire network to balanced operation.

Balanced terminations

Good signal-to-noise performance required that each wire-pair's termination be conditioned to minimize the complex noise coupling. It was done with transformers and a look at design shows how Western Electric approached the problem. In the terminating transformer, Longitudinal-Circuit (common-mode) Noise transfer was reduced by the design of coils with *precisely-matched windings on both halves of the center-tap*. (A perfectly-wound (and balanced) transformer was tough to make; layered coil construction was easier. But…by their construction…layered coils were not precisely balanced: one winding had slightly more wire.)

If you're wondering…it occurred to engineers that grounding the center-tap on the transformer ought to cancel out common-mode noise. Unfortunately, unless the transformer was perfectly wound ($$$), the wire pairs were perfectly matched and the ground was really low-resistance, there would always be slight imbalance currents flowing.

Metallic Circuit Noise was reduced by the use of electrostatic shielding in the transformer. This shielding reduced inter-winding capacitance (leak-thru) between primary and secondary windings.

To make the job tougher, on the *equipment* side the transformer was usually connected to a circuit that was unbalanced against ground (amplifier input etc). The best transformer designs used electrostatic shielding on *both* primary and secondary windings. Noise currents flowed from the *shields* to ground.

Western Electric's ultimate transformer design was what we fondly call the "Repeat Coil." It was a pretty good device even at birth, and latter-day refinements endure as benchmarks for good transformer design. The repeat coil got its name because its primary function was to transfer energy from one circuit to another *without loss or added effects*. The best repeat coils minimized imbalances and noise transfer from the 'Loop' (wire) side to the 'Drop' (equipment) side. Most repeat coils also handled impedance-transformation; coils had ratios of from 0.6:1 to 2.5:1. Beyond providing good balancing, some repeat coils had to handle common-battery voltages and to minimize cross-talk when the circuits were combined in the "Phantom" arrangement described below. Transformer design was not a design job for the faint-hearted.

Engineers knew that low-end audio response was important for radio-program applications…and that for certain applications transformers had to have certain enduring characteristics at DC. Early transformers that did their job at DC and had good low-end response exhibited an unacceptable two to three db loss in the voice-band and thus weren't acceptable for telephony. Conversely, transformers that worked well in the voice-band exhibited poor frequency response at the lower audio frequencies and couldn't pass the original 20 cps ring-down voltage. (The 20 cps ring-down problem had earlier been solved by the design of "Composite Generator: it transmitted 135 cps as ring-down voltage.)

One compromise design was a coil that used toroidal cores wound with silicon-steel wire, in a coil that had a gap cut into it. One early version was Western Electric's "62-type." The coil was stable at DC and minimized magnetization; yet it was *fairly* good in the voice-band. Then the "93-type" coil was developed, with a powdered iron fill in that gap. This improved the low-end response without significant loss in the voice band. A further iteration was the "173-type" using a 'Permalloy' core.

(By the way: Forgive us for using the language of the day--"cycles-per-second/cps"--rather than "Hertz.")

Many other transformer improvements were introduced over the years, including the 119C, the 153A…and the venerable 111C. The matter of balancing transmission lines was perfected to the point that performance of a properly-installed twisted wire pair approached theoretical limits.

Loop length and the Loading Coil

Now attention turned to wire-length loss. The physics of the real world in which the wires existed meant that capacitance (and high-frequency loss) increased with wire length and, at some point, even the lower voice frequencies were lost in the noise. An early solution to this problem was Michael Pupin's "Loading Coil," invented in 1899 and further improved by Western Electric. Loading coils were, quite simply, series inductances added in the wire leg to minimize the shunt capacitance of the wire; reducing line reactance and approaching a pure resistance.

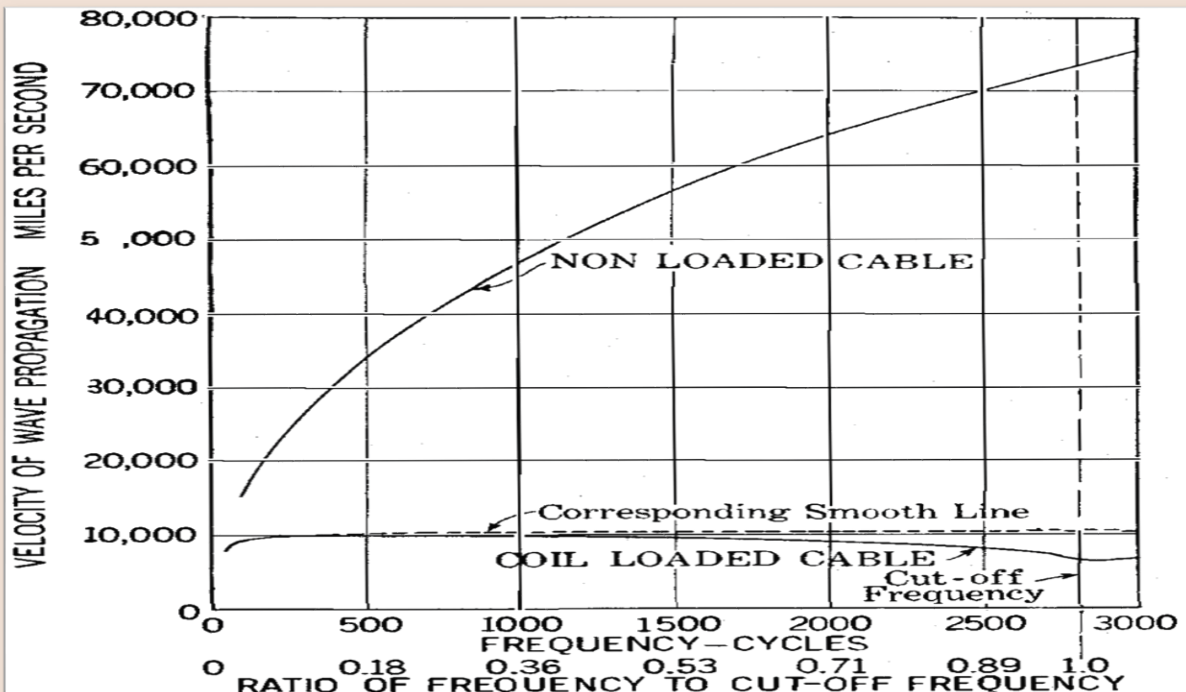
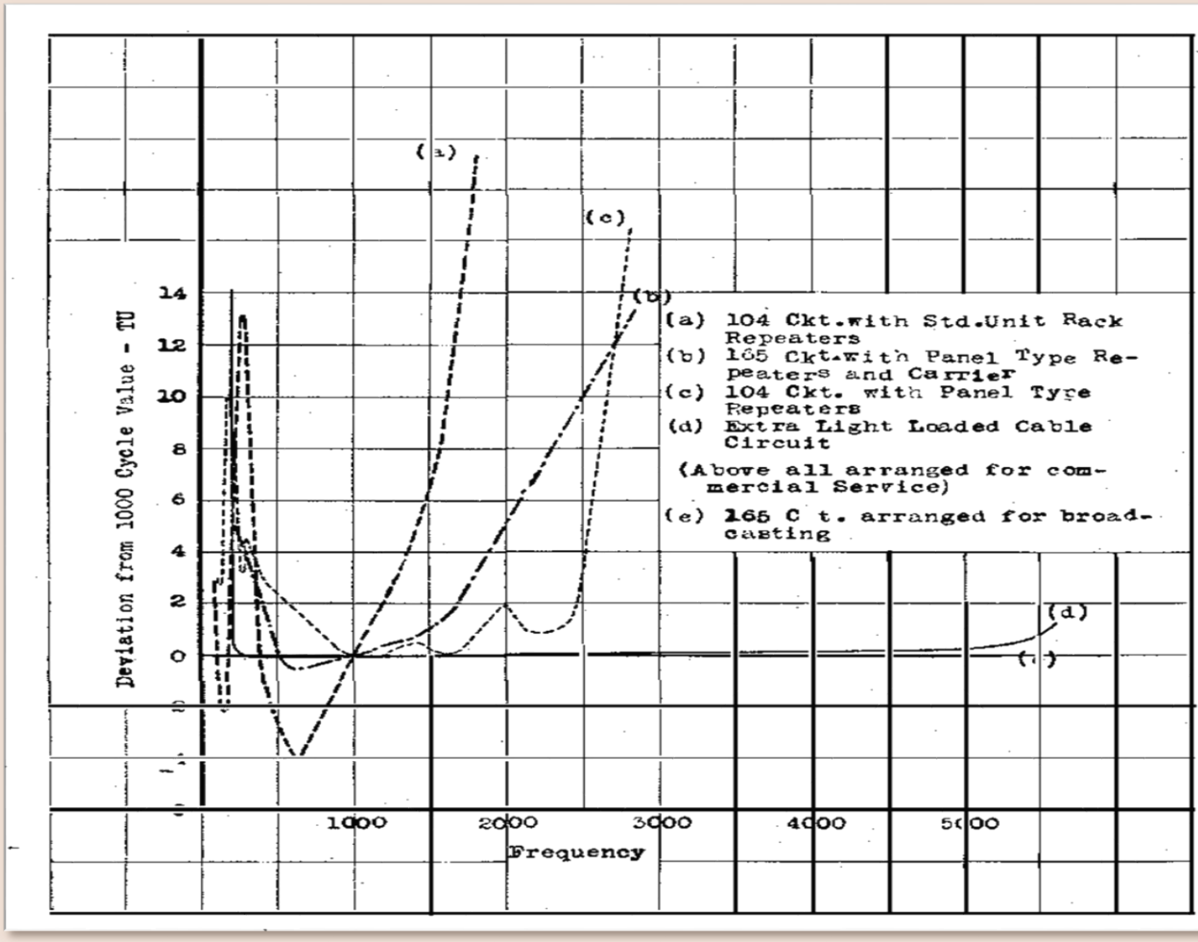


Figure 2—Velocity-frequency Characteristics of Loaded and Non-loaded No. 19 A. w. g. Cables of Figure 1

If you're really into performance characteristics, gaze upon the graph below…while noting the "TU" axis is *inverted* from the way we measure response deviation today:



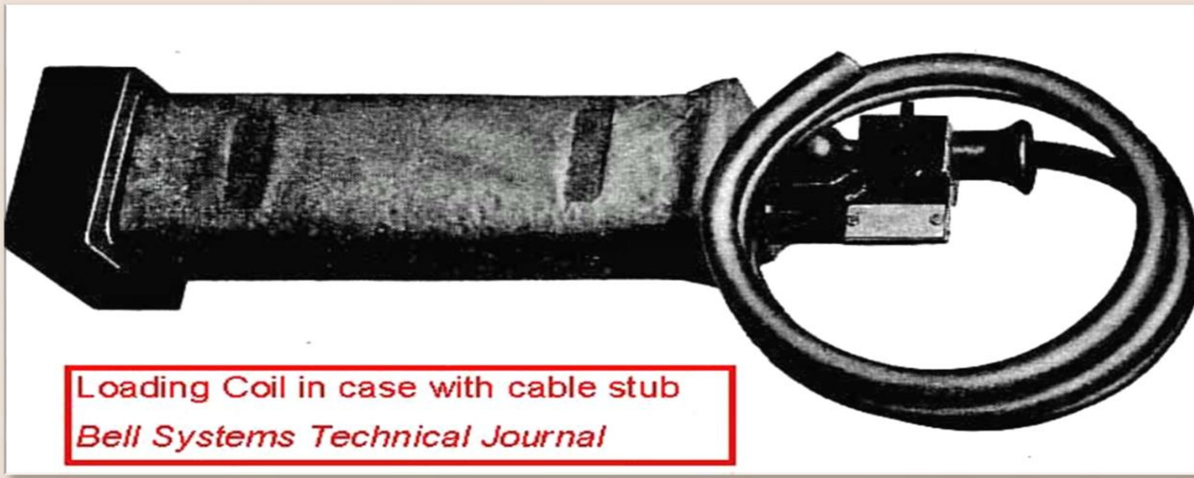
Communications magazine

Typical inductance of loading coils for early telephony was approximately 0.163 Henry; this produced a pass-band of around 2400 cps for a 'nominal' loop-length (of course different wire sizes and lengths dictated different loading). It was obvious that open-wire lines, by virtue of their lower native capacitance, required substantially less loading than did cable.

Loading of open-wire was usually done at the transposition locations. Loading of *cable* pairs usually happened at wire offices or splice-points in an underground system.

The loading coil was a big deal for AT&T. (And as anecdotes would have it, there were others who could have been credited with this development. One of AT&T's giants, Lloyd Espenschied, believed George Campbell should have been recognized as the real developer of the loading coil but that Pupin was first to promote an answer and AT&T was looking for an early answer, so it endorsed Pupin's solution.

For balanced circuits, loading coils were added to both legs and, to maintain balance, these loading coils were usually wound on a common core.


Loading Coil in case with cable stub
Bell Systems Technical Journal

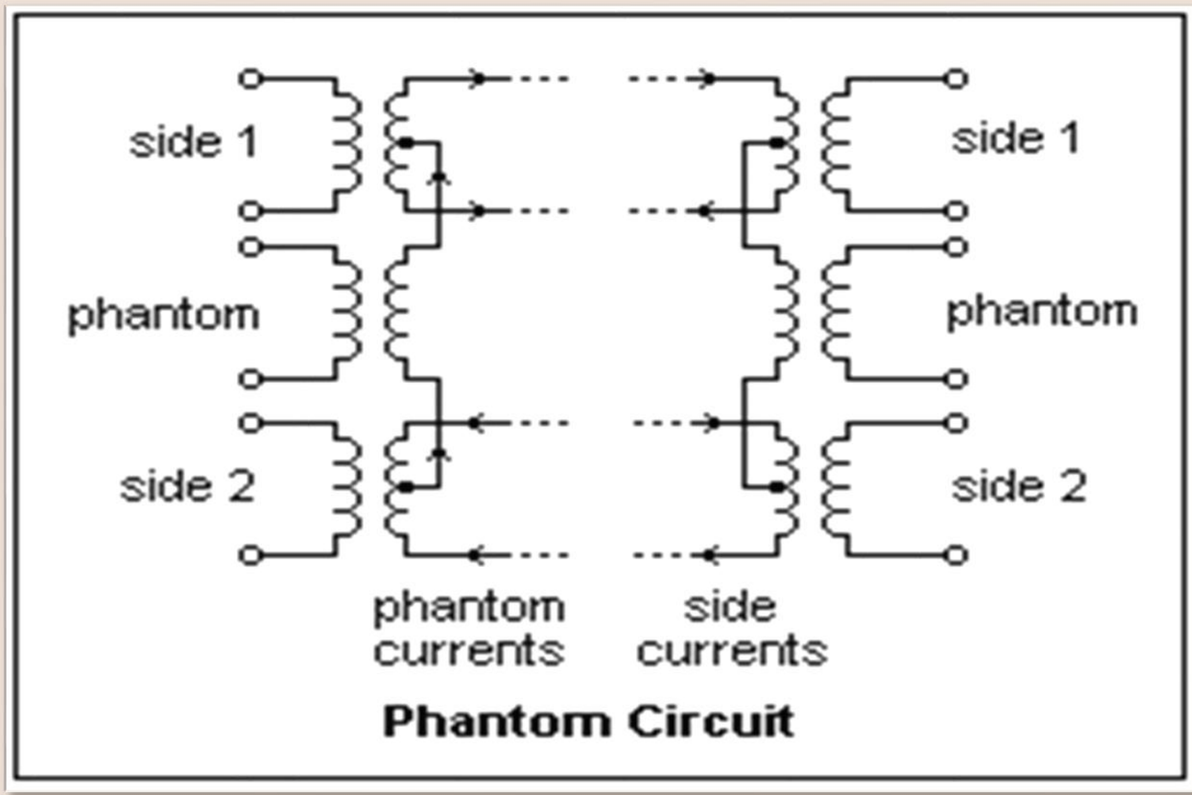
Loading Coil pass-band limitations

The loading coil and the self-impedance of the line together defined a fairly sharp cut-off frequency (and thus the pass-band of the channel.)   Practical loading coils delivered useful response for voice communications. But because loading produced a fairly sharp cut-off just beyond the voice-band, it had to be removed from circuits used for wide-band broadcast audio.

Another effect of line inductances along the channel such as loading coils and repeat coils wasn't really noticeable until radio programming passed through a long-distance channel. The cumulative effect of these inductors produced significant "Group Delay" in long-haul channels…what Fred Krock called "That Network Sound" ("*Radio World," August 17, 2005*.) Farther into this chapter we'll learn more about how AT&T dealt with Group Delay.

The Phantom

Once line-balancing had been "perfected" and loading effects were predictable, engineers took advantage of the state of their art to extract something for nothing. The "Phantom Circuit" was a "free" channel derived from the center-taps of repeat coils on the ends of two closely-matched pairs. Thus was derived an additional 50 percent capacity on the paths where such matched pairs were available. In the first chapter we introduced this concept as "Pair-Gain."



The two "main" circuits (strangely known as "side" circuits), together with the derived phantom were collectively labeled a "Phantom Group." The three circuits were in normal practice independent of each other, assuming line balance is good (line imbalances created cross-talk).

Loading of Phantom Groups was the next challenge. Phantom Group Loading required different topologies for the "side" pair in a phantom circuit. This was necessary because 'off-the-shelf' loading coils introduced unbalances into the phantom pair and negated their effectiveness.

Better-balanced loading coils were developed shortly after Western Electric's New York labs were opened and put into the field almost immediately.

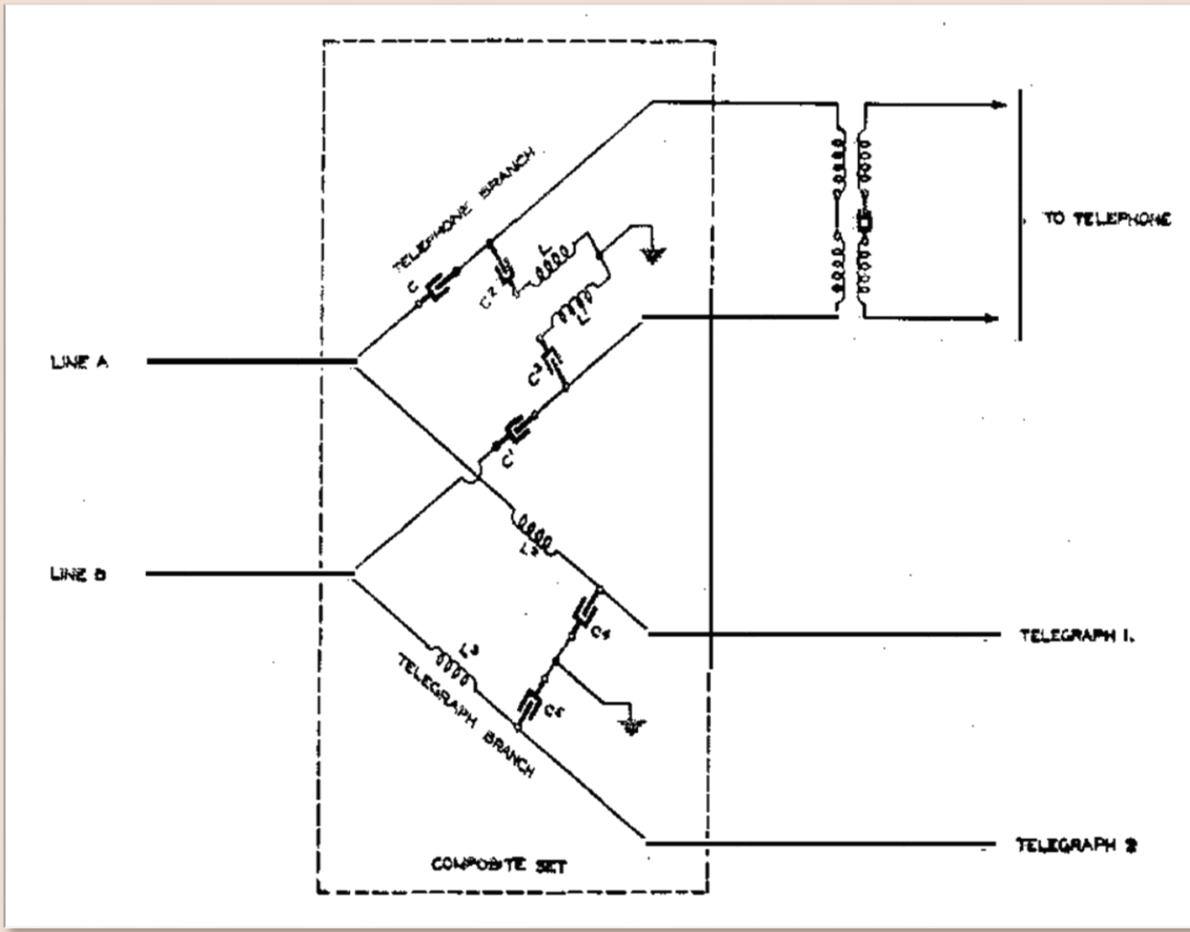
With appreciation, we also recall that these balancing and loading solutions were installed on varying open-wire and cable configurations, in a physical world in which environmental variations could be extreme.

The circuits had to work under all conditions in all environments. Period.

Composite Telephone-Telegraphy

"Pair Gain" of course had serious business value.

Western Electric's superbly-balanced repeat coils not only enabled the "Phantom" circuit but its application variations could also provide a concurrent path for telegraphy.
It was fine engineering; another "something-for-almost-nothing" solution that had been attempted as far back as the late 1880's, in balanced-wire thin-route communications where facilities were limited. Like any such finessing, there were problems to be worked out over the years. The practical solution was a "high-pass/low-pass" filter circuit called a "Composite Set" (not to be confused with "Composite Ringer").
Engineers in testing also discovered that *inertia* in the telegraph side of the circuit would decrease cross-talk, so a bit of hysteresis was stirred into the broth.



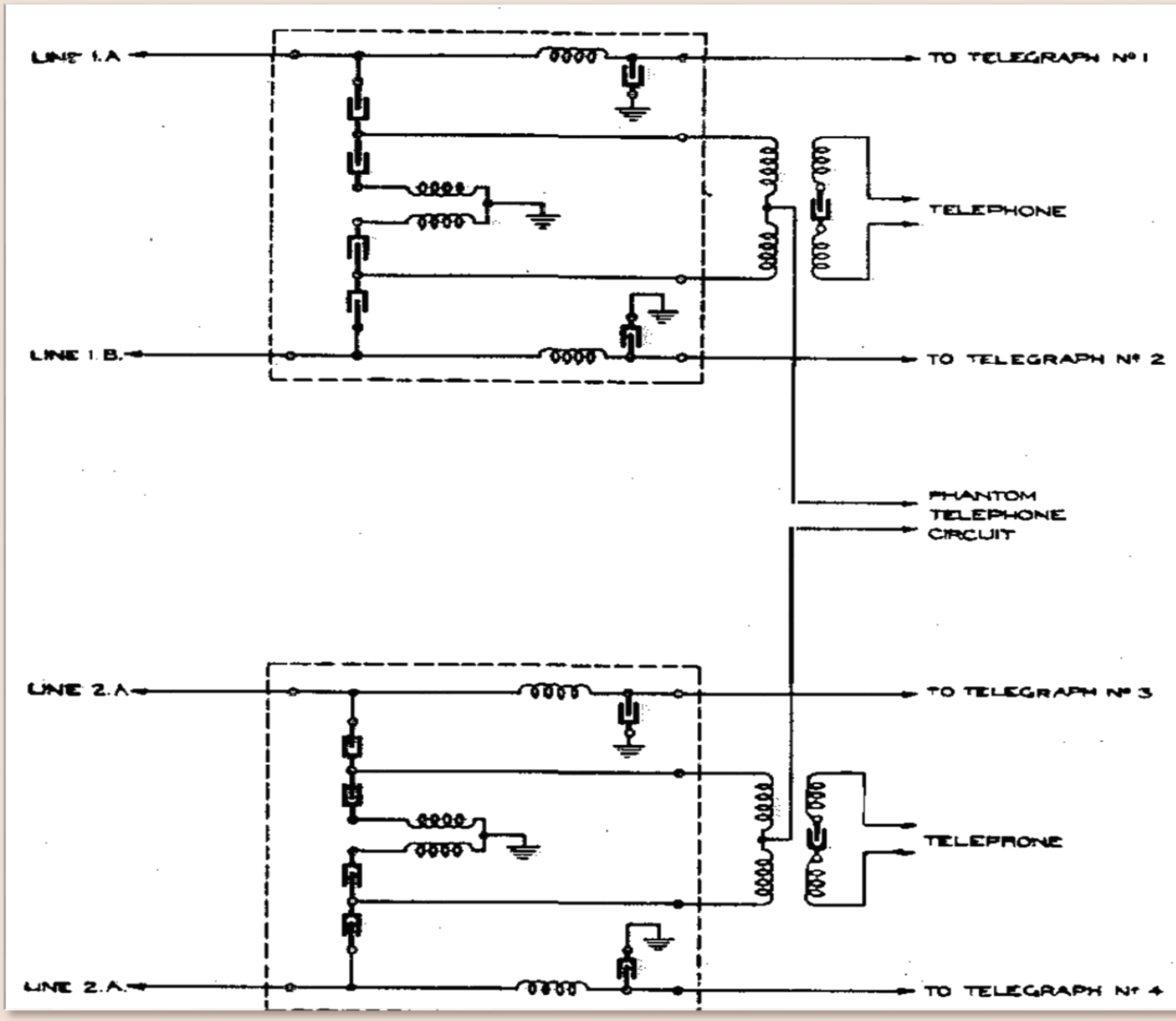
The Composite Set *Electrical Communication Magazine*

In composite applications, telegraph speed was limited to 60-90 words per minute…limited by cross-talk clicking and low-frequency interference into the telephone circuit, called "Morse Thump" by the engineers.

"Morse Flutter" or "Telegraph Flutter" was caused by the rapid change in telephone speech volume and quality that occurred when DC pulses caused momentary changes in coil impedance. This is where "inertia" helped. The "inertia" (beyond the normal circuit hysteresis) was probably done by current-limiting, and that may have limited word-speed at first,), until the more-stable coils discussed above were deployed.

Phantom Composite

It was a short step to incorporate the Composite Set into a phantom circuit (where the problems of course could multiply). But they made it work after a fashion:



"Phantomed" Composite Set *Electrical Communication Magazine*

One last example of "Pair-Gain:" By 1906 the Eastern half of the country had toll lines between every major city. Almost all the network was metallic but some thin-route rural services used power-line "Carrier-Current" for the "last-mile." Here, 'Carrier-Current' referred to the imposition of an RF signal on the power line serving the subscriber (see below). Even the earliest versions usually permitted multiple audios.

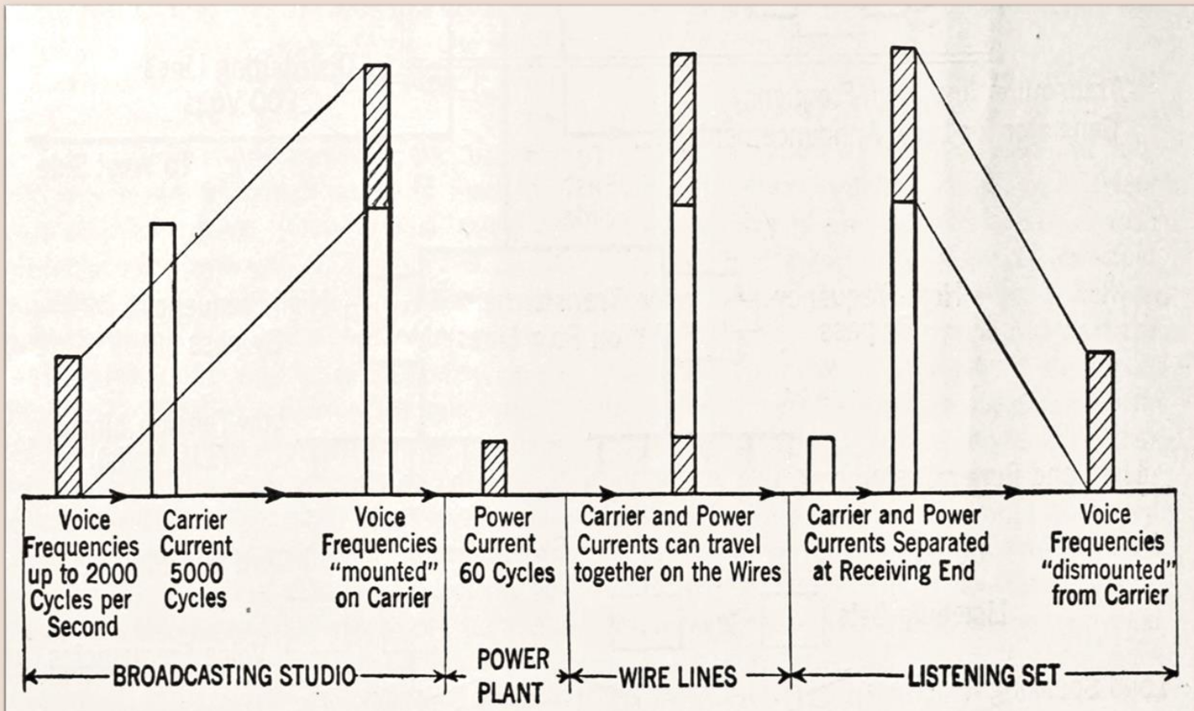


Fig. 2. How use of high and low frequencies allows wires to carry power and broadcasting at the same time

Early "Carrier-Current" design *Bell Labs Record*

Those of us who grew up with college radio in the 50s and 60s knew "Carrier-Current" as a more-or-less legal way to build campus radio stations, limited in coverage only by the architecture of the campus power distribution (large power transformers were great RF chokes).

Carrier-Current as used herein should not be confused with "Carrier" technology. The latter would become the conceptual transport for multi-channel service and would *really* amplify "Pair-Gain."

We'll have more on "Carrier" technology below.

Documentation

To enforce the Long Lines requirement for standardization in the networks AT&T published a set of technical and operating specifications that morphed into the iconic "***Bell Systems Operating Practice***" ("***BSOP***"). In 1922 the ***Bell Systems Technical Journal*** appeared, containing thoughtful and in-depth technical papers reflecting the cutting edge of the state of their art. Shortly after opening in 1925 Bell Laboratories published the ***Bell Labs Record***. Today these documents are available on-line---a treasure-trove of technical detail---written in the parlance of the day. As you've noticed, we're extracting a lot of information from these papers.

The State of the wire network

In the early 1900s almost all inter-city lines were open-wire pairs of "104" cable. "104" (104 mm) was equivalent to about #10-gauge wire. Western Electric then introduced a new "165" wire (closer to #8-gauge). The larger wire meant lower loss and higher strength…but its impedance changes created a problem with existing loading coils; particularly in bad weather. Here's a graph of how 165 line reacted to weather:

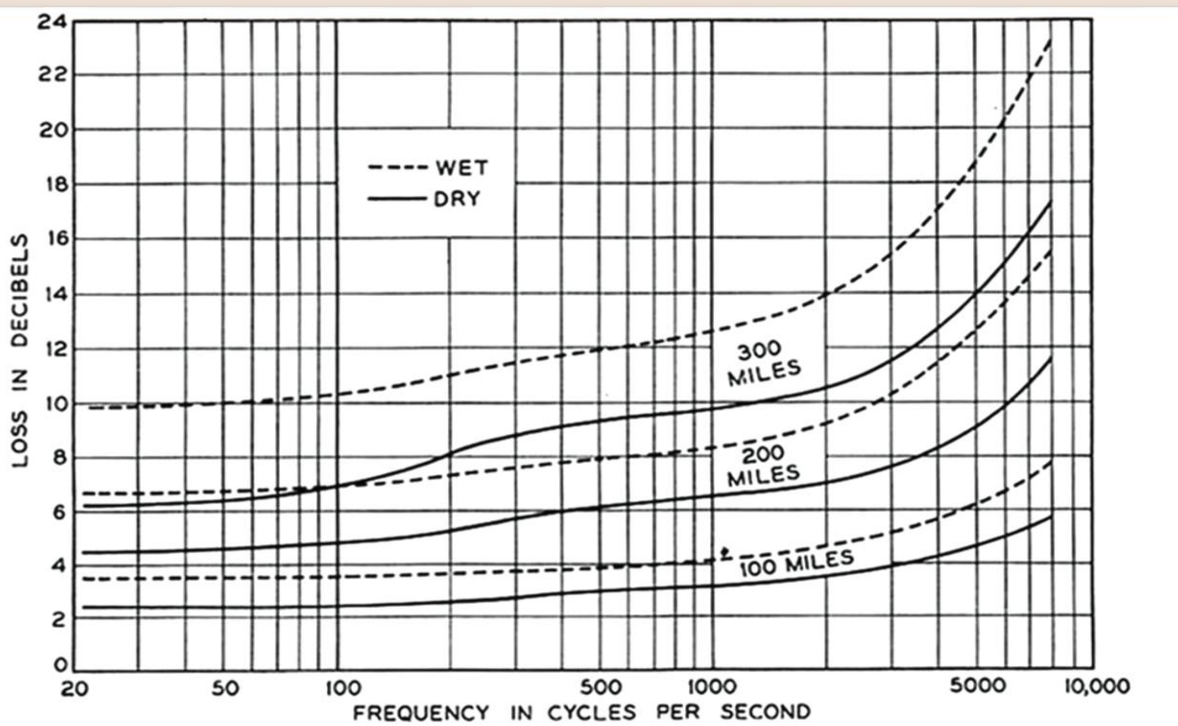


Fig. 2—Loss of 165-mil. 8-inch spaced pairs when inserted between 600-ohm resistances.

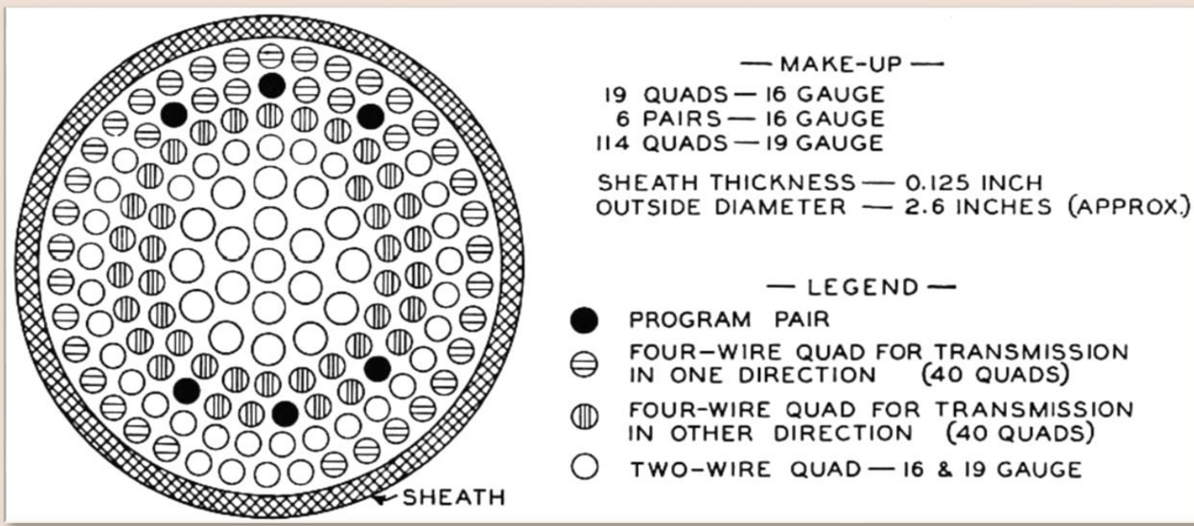
Bell Systems Technical Journal

Our story to this point

By 1910 the use of balanced circuits and the loading coil, together with better telephone sets, extended the range for telephony to hundreds of miles. Engineers were approaching the theoretical limit for long-distance un-amplified reach. While they waited for an amplifier, designers turned to developing better cable.

In the exchanges, engineers would soon be using “quad” entrance cables in which each set of two pairs was closely matched (shades of Cat-6!) Detailed work led to exacting specifications for pair arrangement and placement, twist, insulation and capacitance uniformity.

This is a later version of what the cable looked like:



Deployment of this new cable also meant that Phantom Group Loading was more successful because matched pairs were bundled together. While this made phantom-derivation more reliable, phantom circuits weren’t as important in *cable* applications; additional circuits simply used additional pairs. Phantoms thus remained most popular in open-wire applications.

Buried long-distance cable

In 1914 AT&T Long Lines deployed the first quad-cable in a buried Boston-to-Washington route, as well as a successful submarine cable in Chesapeake Bay: a cable of 17-pair, 13-gauge paper-insulated wire, installed with two loading coil sets. (The new cable with built-in loading was a product that Western Electric was testing at the time.) Cable was more physically secure and subject to less temperature variation than open-wire, but higher capacitance-per-foot meant more conditioning per unit length.

Further improvements in (passive) long-wire transmission

By 1910 Long Lines was operating more than 85,000 route-miles; primarily open-wire…still with no amplification. Encouraged by the results from larger-gauge open-wire and working to meet the challenge of transcontinental telephony, engineers now approached the entire wire plant, end-to-end and section by section. Attention first focused on New York-to-Denver.

"165" wire was installed between New York and Chicago in 1910 and during that installation, a better way of hanging wire was found. New (glass) insulators were developed and new wire hangers at the transpositions led to a reported 20-percent improvement in balance.

With 165 mm open-wire now in popular use, attention turned to fine-tuning the phantoms. Most of the initial balance problems were traced to poor (or absent) transpositioning of open-wire lines. (It seems 100-percent oversight of installation crews was necessary even then.)

When they finished, phantom cross-talk on the Denver line measured 28.5 db (TU); well within specified limits. This line segment was so good that it was specified as the test bed for the day a new "voice-repeating system" could be brought into the field for evaluation.

The Repeater

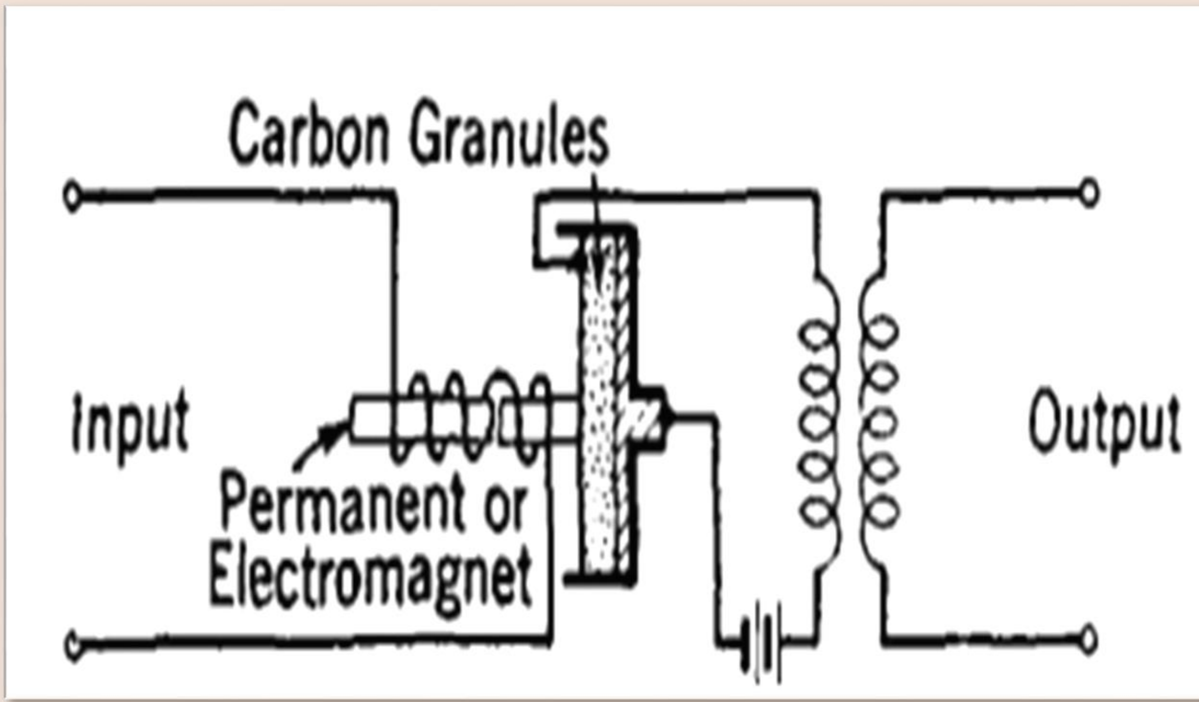
The voice repeater was an inevitable development. There was just too much need for it *not* to happen. However, it took the intellectual energy and experience of AT&T to bring it into the practical world.

Chief Engineer John J. Carty, who in 1909 had issued the challenge to be ready by 1915, had made some smart hires. He now turned the company's internal engineering focus to *science* research. One of his best additions was Physicist Frank Jewitt who had an inside track to the scientific community. Jewitt was considered a "star magnet" to the extent that very qualified scientists wanted to work with him. In turn, Jewitt's best hire was Harold Arnold, a guru in Western Electric's research department.

AT&T issued a "General Repeater Study" in April 1911. It was essentially a call for amplification technology and it brought inventors out of their basements. One of the 'inventions' under consideration for a few minutes was Thomas Edison's "Reciprocal Telephone Repeater." That turned out to be nothing but a method of switching a wire pair between "talk" and "listen," and not a form of uni-or bi-directional linear amplification. It also required gnarly DC control voltages against ground.

The British meanwhile put forward what they called "The Electrophone System." An outgrowth of their approach to wired music distribution, it was essentially a loudspeaker activated by the incoming voice signal, whose sound coupled to a diaphragm that generated the outbound signal. Terribly inefficient. A similar device of little value was essentially a telephone "earpiece" acoustically coupled to a telephone "mouthpiece."

In 1906 Western Electric brought out its own crude form of repeater (the "Shreeve"). The Shreeve consisted of a powerful stationary field and a movable coil. The Shreeve was terribly inefficient, it got hot, and it only worked for short periods. It required non-loaded open-wire lines and Shreeves could only be operated in limited tandem.



Concept of the Shreeve Repeater

Loop tests were set up in the laboratories and since the Shreeve was the only thing that worked as least in a limited way, it became part of an early "22-type" repeater scheme ("22-type" meant "two-wire, bi-directional"). The Shreeve in fact was part of the backup plan, in the event an inertia-less repeater wasn't developed by the deadline.

Mechanical repeaters had physical limitations that just couldn't be overcome. Moving toward a non-mechanical solution, the first *electronic* lab work was on mercury arcs. Mercury arcs worked after a fashion…but exhibited severe non-linearity…and it was difficult to get the arcs *started* in the first place. This one was put in the storage shed for possible later consideration.

As wire improvements were wrapped up and the 1915 deadline approached, engineers were preparing a back-up "**non-repeater**" plan…just in case. A non-amplified coast-to-coast voice system *would* work they said…but it would require replacing open-wire spans with **#5 wire**!

On the other hand, engineers had calculated that if they *could* find a voice-repeater performing to AT&T specifications, the 165 mm open-wire line would work fine.

In the labs the scientists went to work alongside the engineers. (One wonders if this was when the white lab-coat and pocket-protectors first appeared.)

In setting the goals for a trans-continental voice system, a set of specifications for the working environment (i.e. the real-world impedances and line resistances) was created. The design team would work against these physical limitations.

The high-vacuum-tube repeater

As if turning up the temperature, in 1912 a fellow named John Stone published a landmark paper on high-frequency radiotelephony. His technique was a departure from damped-wave transmission, replaced the technology with a *Continuous-Wave* approach. That required oscillation and amplification. So here was yet another imperative…to find a non-mechanical replacement for the Alexanderson "RF" Alternator.

AT&T was chasing a gaseous tube made in Germany called the "von Lieben tube" when Stone told them about a device developed by Lee de Forest. de Forest called it his "Audion." A demonstration was arranged and it was disappointing. The Audion worked fine at low signal levels but it crashed at higher levels (a blue haze appeared in the tube).

AT&T scientist Harold Arnold immediately knew what was wrong: the vacuum tube wasn't sufficiently evacuated (de Forest had thought too high a vacuum was detrimental). It was also noted the tantalum filament was puny when it came to electron emission; de Forest thought it was fine. In other words, de Forest had little idea how the thing worked.

Without explaining how they would improve the Audion, AT&T quietly bought de Forest's patent rights and those of others who had developed similar devices. Scientists then turned to making the Audion work properly, developed an improved version they called the "101 high-vacuum tube," and handed an early version of this tube to Western Electric for mass production. It was a watershed moment that reverberated across dozens of disciplines.

(**Anecdotally**, this tube may not have been the first to be made workable; that honor may belong to Irving Langmuir and GE. And the French and Germans were developing high-vacuum tubes along parallel lines.)

So I have to say….wait for it….

"New developments don't necessarily exist in a *vacuum*."

The high-vacuum tube was another Disruptive Technology. All sorts of applications awaited mass production, from PA to sound-on-film to disc recording to radio to television. Western Electric turned its full facilities to production. Once AT&T engineers had made the high-vacuum tube the heart of an amplifying system, they immediately applied it to long-haul telephony as a voice amplifier. 1915 was creeping closer; they were thankful for Western Electric's ability to turn out massive quantities of tubes under excellent quality control.

Practical repeaters

Development now moved to building a "mother board" around the tube that would optimize the gain of the tube while minimizing the effects of the telephone lines to which it was connected. This wasn't a serious issue with one-way circuits but, from the outset, the repeater would have to amplify *in both directions simultaneously*, so that a single two-wire circuit could carry a long-distance two-way conversation. For bi-directional amplification on two-wire lines, the "send" and "receive" circuits had to be isolated by a factor greater than the amplification of the repeater, or feedback and 'singing' would occur.

The practical two-wire repeater employed a form of Wheatstone bridge using a balancing network identical in impedance to the connected transmission line (today we know this as a "hybrid"…see the "Balancing Network" in the photos following). Engineers modeled the impedance of a telephone circuit in order to construct that "balancing line." Trouble was…every telephone line had different characteristics…that varied with environment. It didn't take long to design an *approximate* balancing line that would provide a modest amount of repeatable isolation. Aware of the difficulties in consistent field-adjustment, engineers came up with an "average" network of three reactances that could be switch-selected.

Amplifiers were adjustable from 3 to 30 db gain. The use of band-pass filters narrowed repeater response to the useful voice pass-band and that added to stability. Careful circuit design also meant the circuits could support phantom telegraphy.

Historians may be interested in this *Communications Magazine* rendering of an early repeater. It contained a form of balance network and bandpass filters and employed really slick transformer coupling…indicative of design sophistication at this early stage of development:

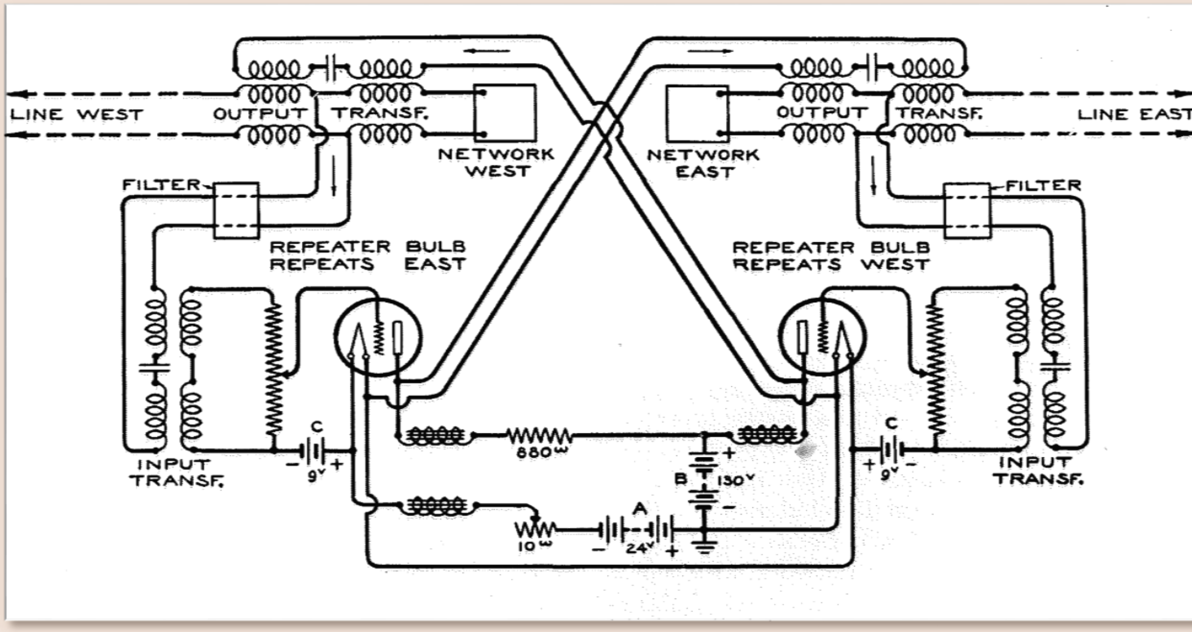


Photo courtesy AT&T files

The first test of the “high-vacuum” repeater prototype took place on October 18, 1913 in Philadelphia, on a New York to Baltimore circuit. It worked; the transcontinental telephone line would be a reality.

On January 25, 1915 Alexander Graham Bell sat before a telephone in New York; Thomas Watson, his assistant in 1876, waited in San Francisco. Bell: "I have been asked to say to you the words you understood over the telephone through the old instrument: 'Mr. Watson, come here, I want you.’ “ From across the continent, Watson responded: "It would take me a week to get there now!"

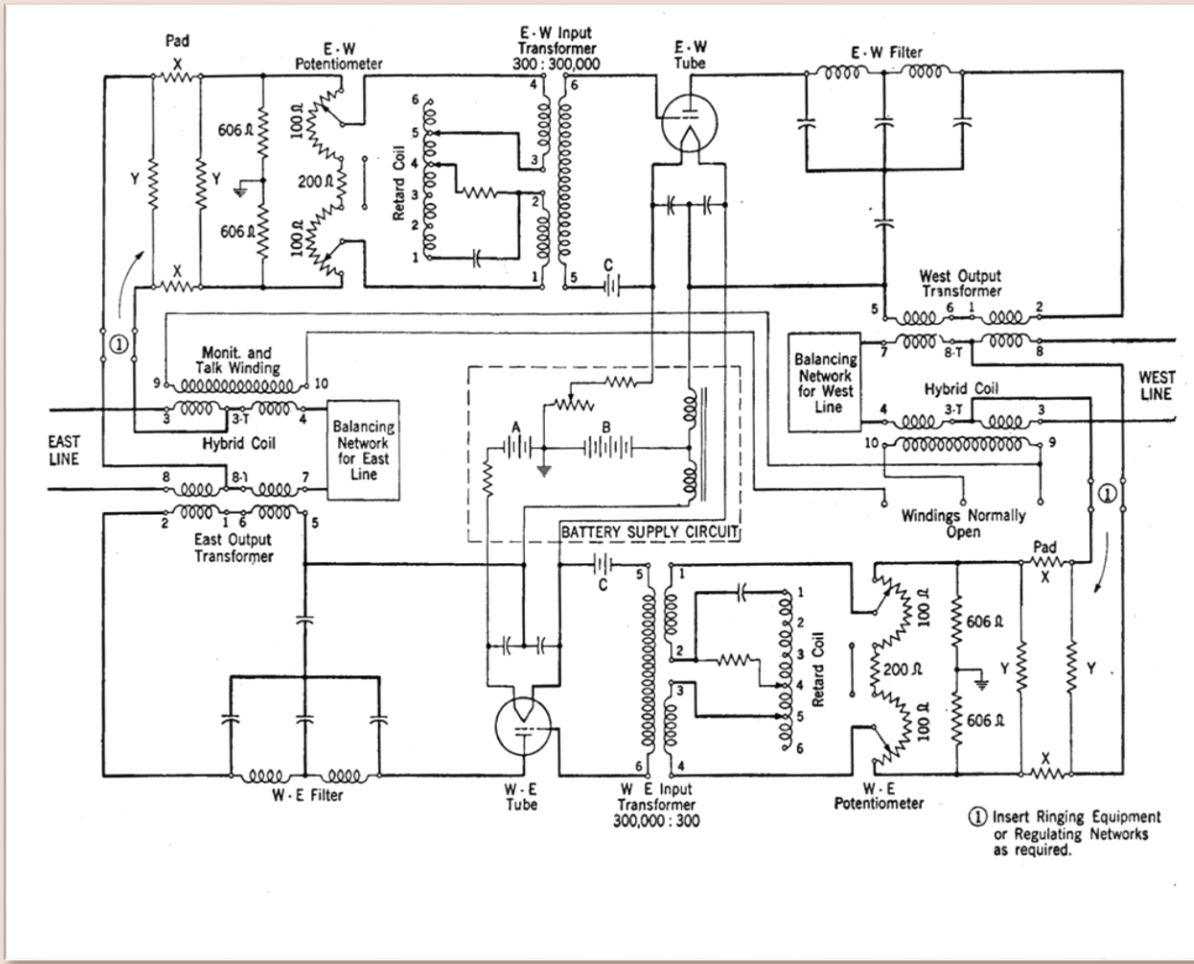
The first transcontinental telephone line was crude, but it worked. It was a single telephone circuit. But it was exactly what AT&T needed to legitimize its position in the telephony world.

The specs on the first, carefully-tweaked transcontinental telephone line:

Overall length:	3,359 miles
Total Bare-Line losses:	53 db (dry weather)
Equipment Insertion Loss:	7 db
Frequency response:	350 to 1250 cps *+/- 10 db*!
Total Repeater Gain:	40 db (6 repeaters)
Delay:	.067 seconds

The next step was to achieve simple, reliable transcontinental transmission on “ordinary” non-loaded 165 mm lines. World War One held up field development; then in 1919 a non-loaded circuit of vastly improved performance was successfully tested between New York and Chicago. From Chicago on west, circuits received the benefit of several improvements in terminating and balancing technology worked out in the labs during the war years.

The transcontinental wire paths would have 12 repeaters with an end-to-end loss of no more than a dozen db, using non-loaded pairs in a combination of cable and 165 mm open-wire plant. By 1920 such circuits were no longer ‘one-of-a-kind.’ Below is one of the more-mature versions of the repeater. Note the DC battery circuit.

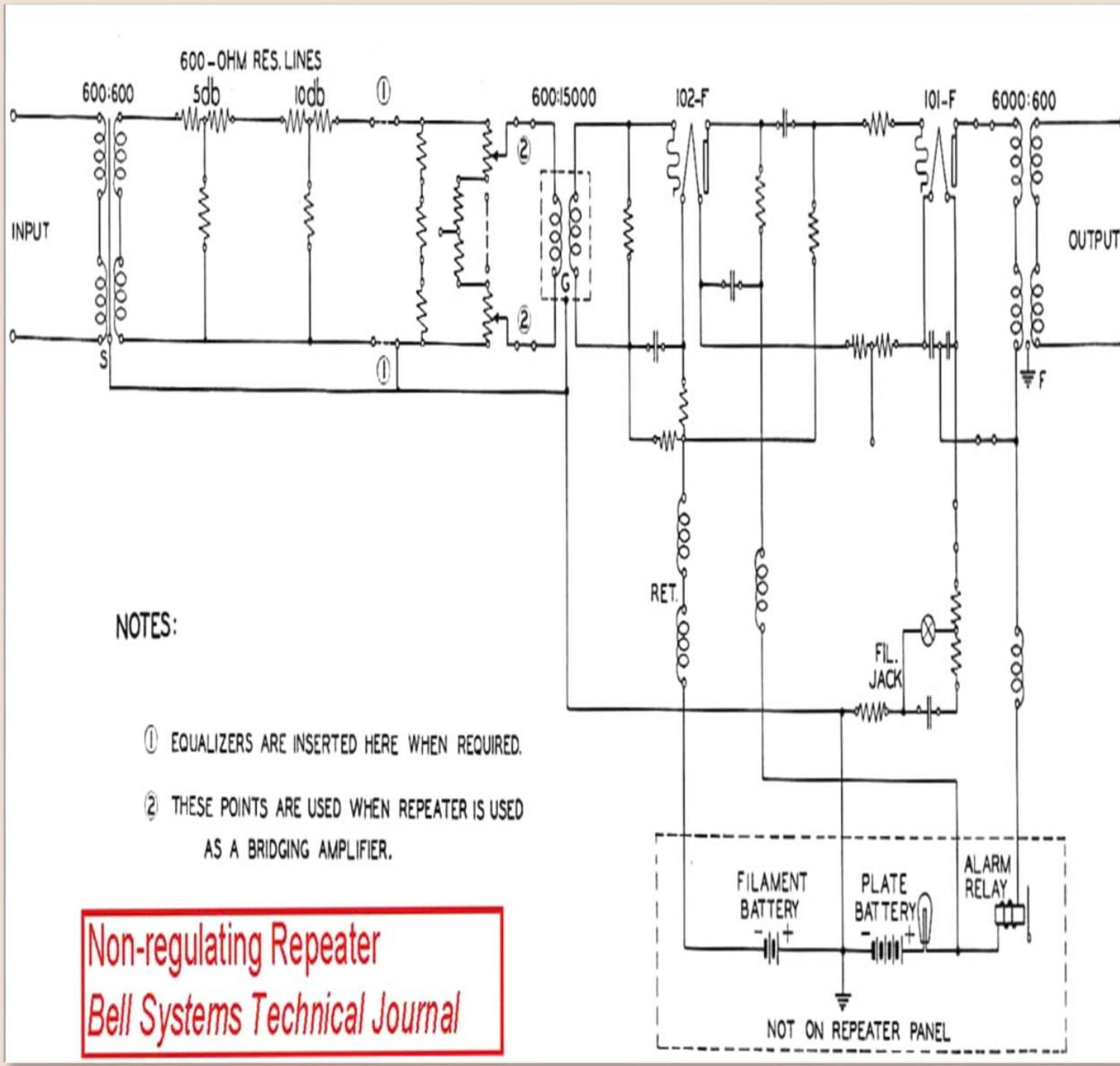


The "22-type" repeater (two-wire, two-direction) *Bell Systems Technical Journal*

By the early 1930s much of the outside plant was cable, east of the Mississippi. Now repeater regulation was added to compensate for tube changes and for cable-loss variations with temperature. (Over a temperature range of 55 F to 109 F…not uncommon in the West…as much as an 18db change at 100 cps was seen; at 1000 cps the delta reached 28 db!)

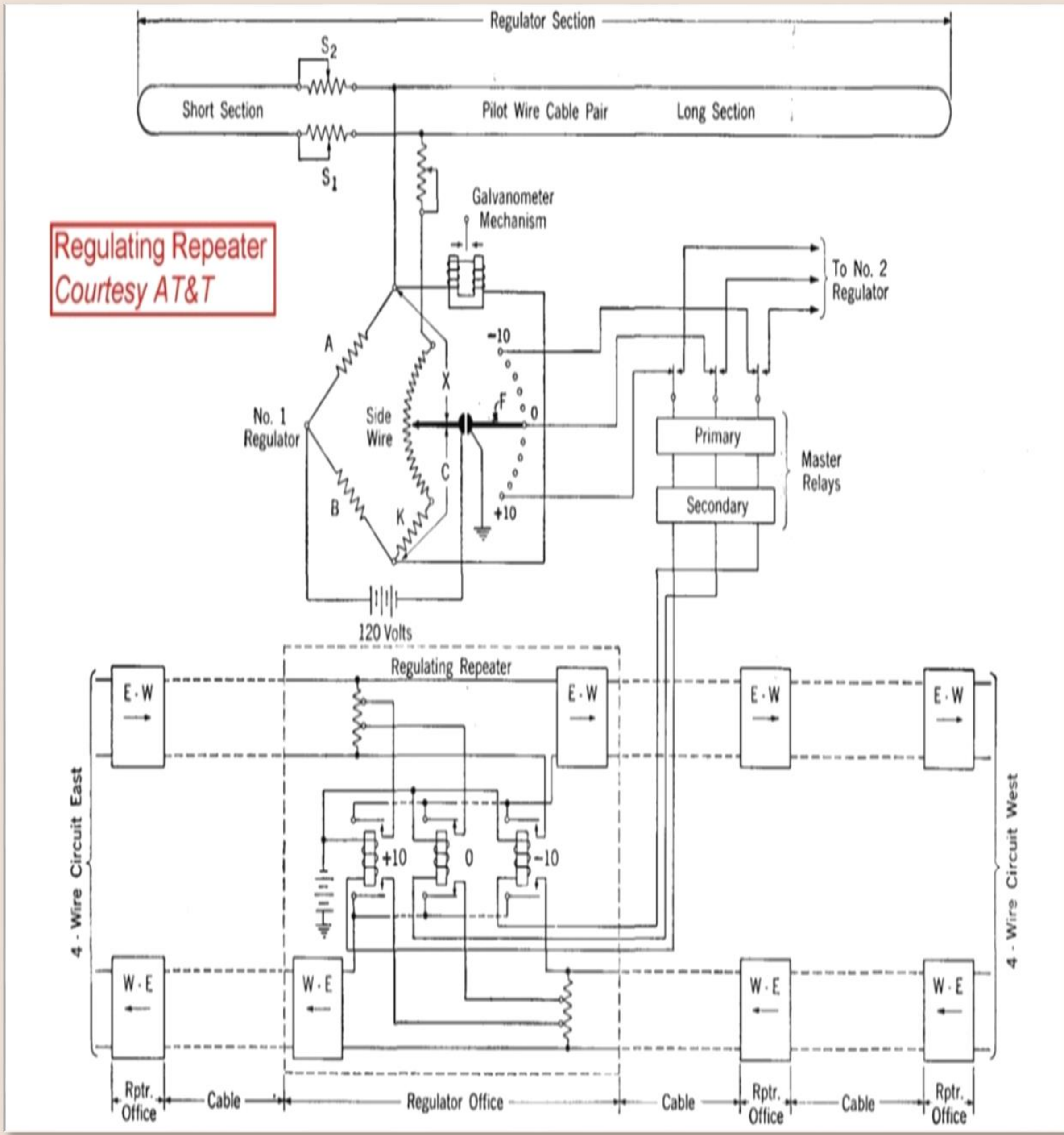
Since compensating for dynamic changes in every wire office across the country was a task beyond the capability of the operating staff, Long Lines deployed two classes of repeater: "*Regulated Stations*" and "*Non-Regulated Stations*."

The non-regulated repeaters (below) were fixed-gain, preset during line-up, and were accessible for adjustment. Here's a single-direction *non-regulated* system; there's not much to it (line equalization was outboard). Note that this arrangement could also be deployed as what we now call a "Distribution Amplifier."



Regulated repeaters were installed at key *unattended* repeater offices and/or in venues where the environment was apt to be changing routinely.

The Regulated Stations had remote-operated gain controls controlled by a master pilot-tone voltage, itself a derivation of path performance measurement. Slick for the time:



Regulating Repeater
Courtesy AT&T
Regulator Section
S2
S1
Short Section
Pilot Wire Cable Pair
Long Section
Galvanometer
Mechanism
To No. 2
Regulator
A
B
K
X
C
F
No. 1
Regulator
Side
Wire
-10
0
+10
Primary
Secondary
Master
Relays
120 Volts
Regulating Repeater
E-W
W-E
+10
0
-10
4 - Wire Circuit East
4 - Wire Circuit West
Rptr.
Office
Cable
Regulator Office

Wire standards

The long-distance cable universe was now a standardized 16-gauge twisted pair with a capacitance of 0.062 mfd/mile. For voice-messaging, these circuits were loaded with 22-mhy loading coils about every 3000 cable feet. With this conditioning, the loss per mile was about 0.25 db through the speech pass-band.

For best cross-talk specs the pairs dedicated to radio program service were carefully placed within the cable. *From the Bell Systems Technical Journal*

Standardizing network-performance specifications

By 1930 engineers were gaining a better handle on dynamic range. They had previously established a *maximum transmit level as +2 db over "0"* (though "0" was still TBD). Dynamic range was defined as the difference between that "0" and *the minimum satisfactory level at which cross-talk was heard*. That range was 27-30 db depending, I suppose, on the engineers' ears.

To maintain good noise performance it was standard practice for the operator in the network's distribution head-end to be in contact with brethren along the line. Operators monitored volume levels, and order-wire coordination obviated the potential *smash* that might occur down the line, if engineers at every repeater added a few db of gain…all at the same time. And remember they were still monitoring static transmit levels; the "VU Meter" was nearly a decade away.

Some of the more important early Long Lines specifications:

> Operating Level

Because of differing measurement methodologies, there had never been a standard reference level across the telephony universe. From the 1920s "Transmission Units" ("TU") had been used to describe operating levels. (A "TU" was based on log derivations and closely resembled a db. 40 TU was a power gain of 10,000.)

Reference and calibration levels had originally been *plant*-dependent; the same "reference" could range from a measured *one milliwatt in 600 ohms* to as much as *12.5 milliwatts in 600 ohms*.

Early on, an amplifier-driven direct-current milliammeter was the 'meter standard' and little attention was given to ballistics. Variations of this meter were tried; some peak-reading and some RMS. Some were lightly damped; others more heavily.

A "mid-scale" TU meter reading represented the 'standard' level and actual levels were calculated by observing *the position of the input attenuator that brought the meter to mid-scale*. This "reference level" was initially subjective; sometimes defined as being "10 db below the point at which *distortion was heard*." The ears as a tool once more. *Bell Systems Practices* (italics added)

> Noise Reference

The noise reference level was established as 90 db below 1 milliwatt of power in 600 ohms. (This baseline noise level supposedly matched the ideal 90 db-loss "cross-talk coupling" figure.) Actual noise was then measured as a number ABOVE this level. This measurement was called the "**dbrn**" ('**db** **r**eferenced to **n**inety'). So: -60 dbm in the audio world was "30 dbrn."

Extracted from the *dbrn* was the "***dbx***"(the cross-talk measurement above the reference). Another measurement figure in use was the "***cu***" or "crosstalk unit."

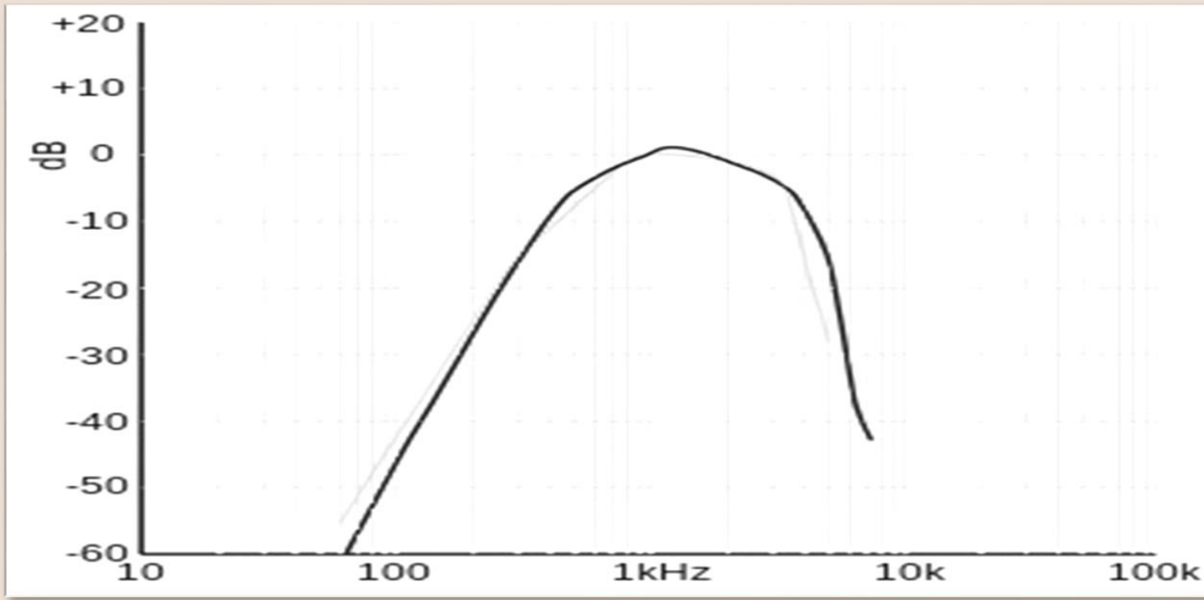
> Repeater gain concerns

Since phantom groups were in wide use on open-wire plant, the special hazard of cross-talk had to be monitored. Cross-talk could occur from the broadcast circuits TO the phantom being used for telephony…usually tolerable. ***But** cross-talk from the phantom to the program circuits could cause a private telephone conversation to find its way to a broadcast transmitter.* Bad karma.

Given the number of repeaters and other gain blocks in these circuits it was also possible that cross-talk could be induced by abnormal *tandem* gain settings. It was all a careful, coordinated dance. Long Lines engineers and operators became very proficient at following the orchestra.

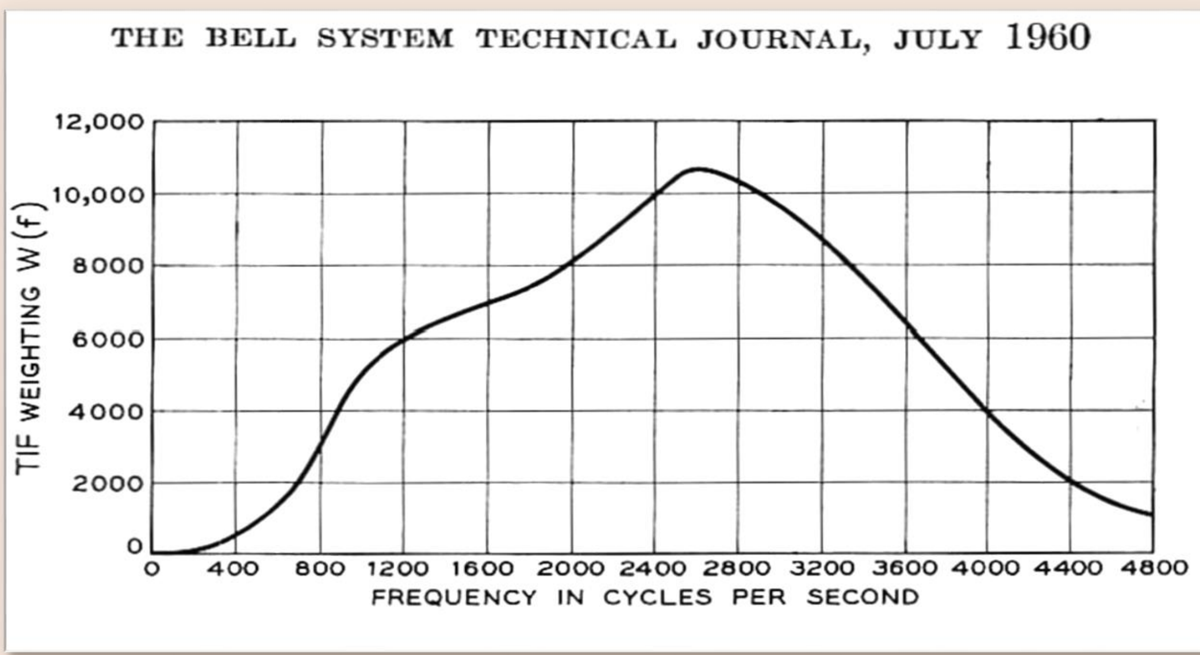
> Weighted measurements

It was impractical to measure realistic noise in a transmission medium without defining the band-pass of the audio channel. This was done electrically by adding a "weighting" network to the measuring device. The weighting network would pass only the frequency range of interest.



A form of "C" Message Weighting *Bell Systems Technical Journal*

Weighting was also a component of the "Telephone Interference Factor" ("TIF"), and a "TIF Meter" was developed to compare measured interference voltages in the speech band. The TIF meter recognized the harmonic content of interfering noise. As noted by the date on the graph, this measurement survived into the modern age.



> Group Delay

The arrangements used for practical circuit loading created some nasty frequency-dependent delay characteristics; typically, lows were delayed longer than high frequencies (due to the loading inductances). Initial compensation included adjusting the value of series capacitors so the circuit delay was lower at low frequencies.

The *Bell Journals* explained the physics: "The velocity of transmission through a loaded cable decreases as the frequency is increased toward the cutoff point of the loading. To neutralize this effect, delay-equalizing networks are inserted in the circuit. (These) retard the lower frequencies, thus equalizing the velocity of transmission through the combination of cable and networks for all frequencies in the band to be transmitted.

"With the greatest length of cable circuits which will be used in this country for program transmission, this amount of deviation per section is not sufficient to cause objectionable distortion. For a 50-mile section uncorrected, the delay at 8,000 cycles was 0.9 millisecond greater than at 1,000." *Bell Systems Technical Journals*

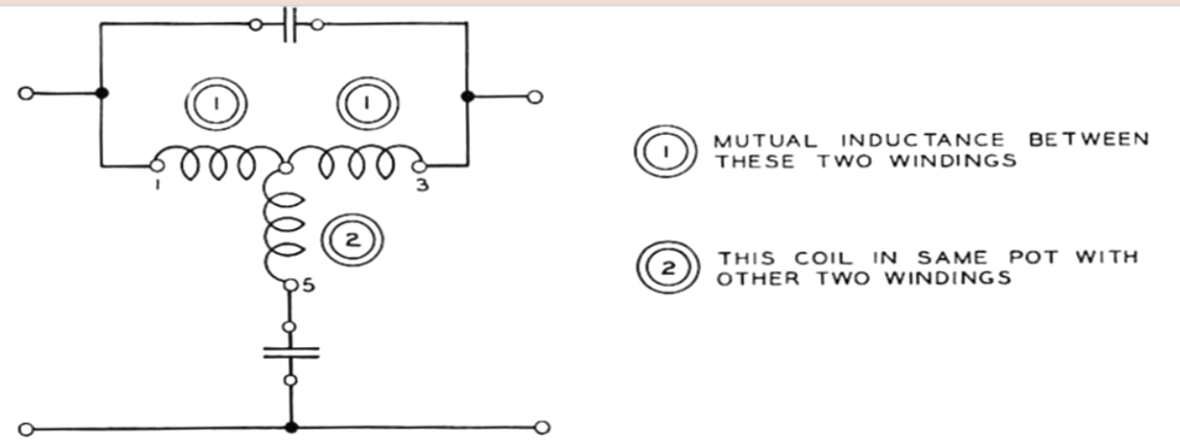


Fig. 20—Schematic circuit of section of delay equalizer. For a 50-mile equalizer, three kinds of sections are used which vary in the resonant frequency and in the sharpness of resonance. The first three sections are of one kind, the fourth is of another and the last seven are of the third kind.

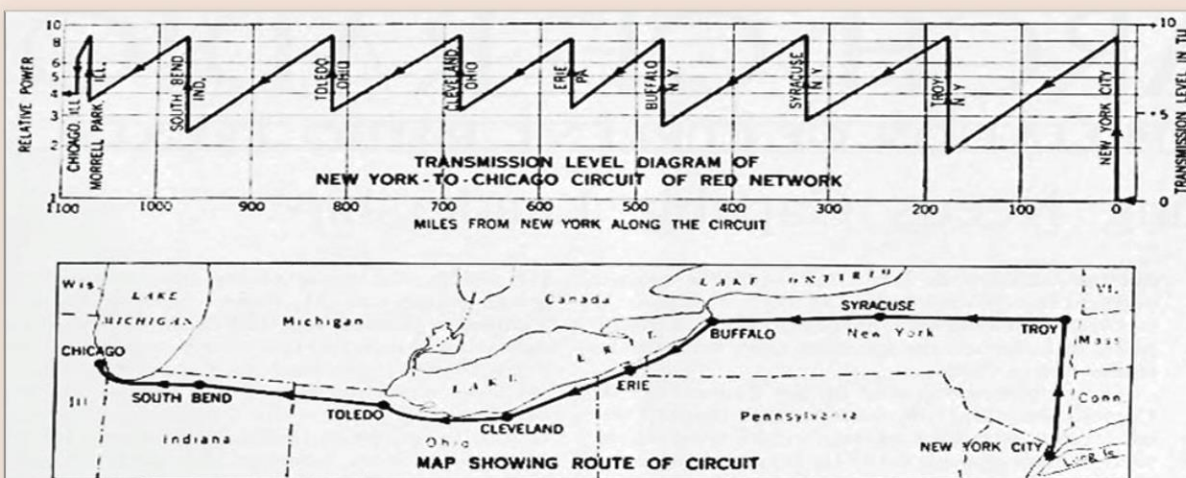
Total delay was soon held within "reasonable" limits: "With 40 amplifiers in tandem, the overall delay at 35 cycles is 75 milli-seconds greater than at 1,000 cycles, while there is no appreciable difference between the delay at 1,000 cycles and the delay at higher frequencies." *ibid*

The new "standard" 16-gauge cable had a pair capacitance of .062 mfd per mile. Since Group Delay could now be controlled, for radio-program use these cable pairs could be loaded with 22-millihenry inductance coils spaced 3,000 feet apart. (By comparison, telephony voice-grade circuits used loading coils spaced 6,000 feet apart, injecting path loss of about 0.25 db per mile).

Further fine-tuning: Pre-distortion

Long Lines had one more trick in its tool-kit. A form of pre-emphasis was inserted *ahead* of troublesome program channels. The pre-emphasis assumed there was sufficient headroom in the amplifiers following this high-end boost, and it was a good way to beat down long-haul noise. In the language of the day: "The means utilized to accomplish the pre-distorted transmission… includes the provision of a so-called pre-distorting network at the sending end of a program circuit, and a restoring network in each branch which supplies a broadcasting station. The…network introduces a large loss at low frequencies with a decrease in loss as the frequency is increased…the resultant effect is to raise the high-frequency transmission relative to the low-frequency transmission by the difference in loss between the 1,000-cycle loss of the pre-distorting network and its higher frequency loss." *ibid*

A *combination shelving amplifier/equalizer* became the standard at repeater stations across the country. End-to-end network response for program audio was a guaranteed 100 to 5000 cps (some measured 50-8,000 cps). With apologies for the quality, here is an early map and diagram of NBC network line loss and amplifier compensation showing repeater locations.



WHAT HAPPENS TO ENERGY IN WIRE CIRCUITS
How the voice-frequency currents are attenuated as they travel over long lengths of wire. Note the effect of amplification at the repeater points

A Transformative Technology

Behind all this was the *negative-feedback amplifier*, invented in 1927 by AT&T engineer Harold Black. It revolutionized the character and quality of sound transmission. Reader Tom Norman writes: "I got more than 500,000 results on Google by typing 'negative feedback amplifier inventor.' The articles tell the story better than I could, but it appears Black was riding a ferry across the Hudson when the idea came to him. He scratched it out and signed it. The negative feedback amplifier became vital to the development of AT&T's long lines; fundamental to amplifier design today."

Reader John Crabtree adds: "IMHO, Harold Black's invention of the negative-feedback amplifier was one of the great inventions to come out of Bell Labs in that era.

"His paper on 'Stabilized Feedback Amplifiers' in the BSTJ Jan 1934 was, in Black's own words, a companion paper to that published the previous year by Clark and Kendall titled 'Carrier in Cable.' Clearly the negative feedback amplifier was very important, if not essential, to the Carrier system."

"Carrier?" Carrier was a breakthrough in message capacity. We saw Carrier at work in Stokowski's "Grand Experiment." The Carrier concept originated in about 1915 when practically the entire outside plant was open-wire and pair response extended beyond 50 kilocycles.

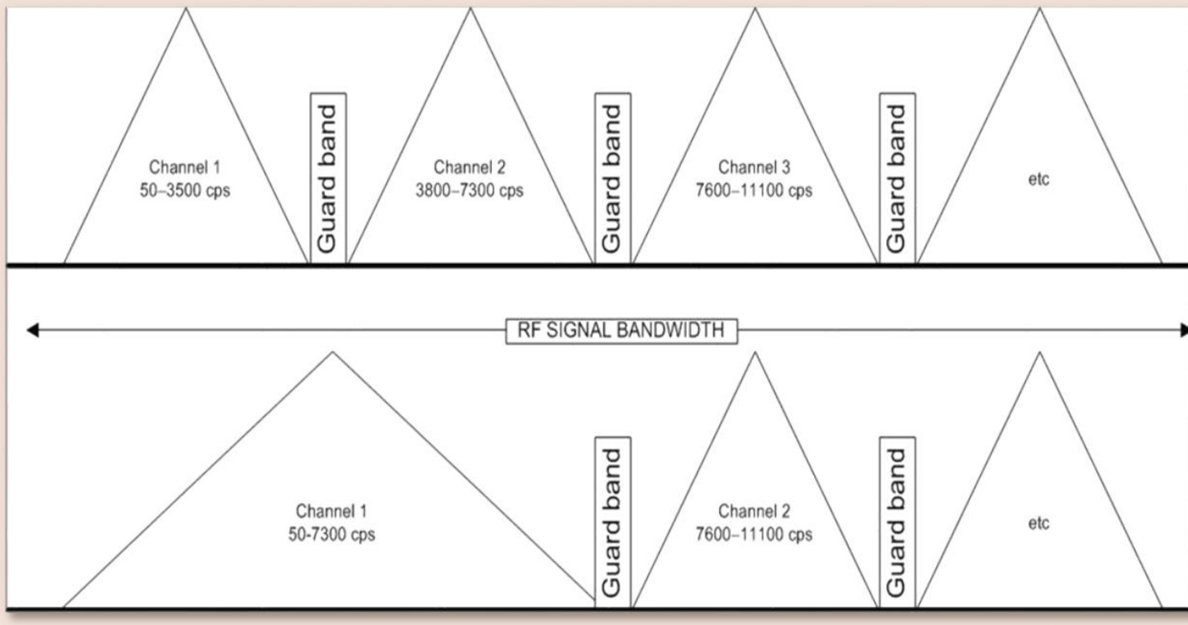
It was a fairly simple task to inject modulated RF signals at 5 kilocycle increments through that pass-band above audio. Single-sideband was used, in conjunction with the Type "C" weighting filter. Multiple audio channels were delivered on a single open-wire pair and this system saw its first commercial use in 1924.

Carrier: Bedrock of the future

A "Carrier" system was a group of combined RF signals, each carrying an audio channel. Together they formed a very wide signal placed on a wide-band telephone channel. This composite signal accommodated multiple channels, stacked "side-by-side" if you will, and kept apart by the use of filters specific to each channel. The beauty of this system was the flexibility.

If you wanted to carry three channels of telephone audio (3,500 cps high-end) you could use three RF signals on three frequencies, with 'guard bands' between channels. If you wanted to deliver wider audio response you could throw out some of those channels and transmit fewer (wider) signals.

Here is a ***conceptual*** *drawing…*this is not quite how it works but you'll get the idea. The upper group is carrying 3 (or more) 3500 cps-wide telephone channels; the configuration at the bottom swaps two of the telephone channels for one wider-band channel:



The RF that transported the audios was "**S**ingle-**S**ide-**B**and-**S**uppressed **C**arrier" (SSBSC) at a frequency well above the normal audio pass-band of the wire (centered at first, for example around 40 to 50 kilocycles). The Carrier system presented as a four-wire terminal. A cool feature was an imbedded control signal to reverse the channel direction as needed. Pre-emphasis was employed and "Modem" delay correction and equalization added. The "Drop" to a local customer was accomplished by band-filtering the chosen "sub" carrier and adding de-emphasis to the channel demodulator. A telegraph circuit could be imposed on the circuit paths. All of this in the analog domain!

A Carrier circuit required a two-way pair of wide-bandwidth transport channels. By the 1930s some wire lines had enough bandwidth to handle a Carrier that transported 4 telephone channels. By 1949 twelve-channel systems were operating. Demodulation and reconstruction was of the lower side-bands. The Carrier system was capable of 15,000 cps demodulated audio if some voice channels were removed and others "stacked." A critical component to the Carrier system's performance was the filter sections. Reader John Crabtree reminds us that Warren Mason did much of the early work on crystal filters (presumably used in the carrier systems). His paper on crystal filters (BSTJ, ca. 1934) was the reference for the next two decades.

Here's a block diagram to give you a sense of how later systems were constructed:

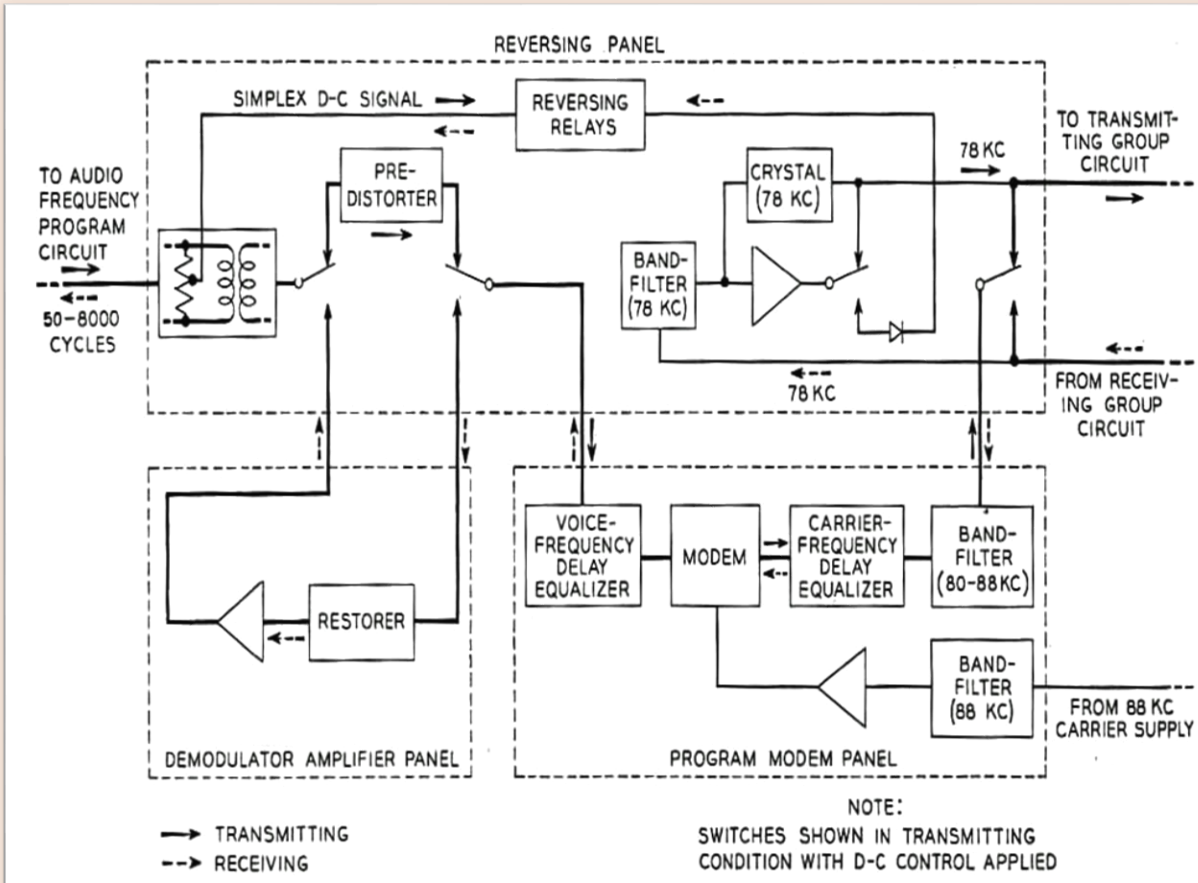


Fig. 2—Block schematic of carrier program terminal.

The Carrier was a break-through for message capacity ("Pair-Gain")

Before the digital age and its mux-ing, Carrier technology was about the last frontier. With the introduction of wideband coaxial and radio links, the capacity of Carriers was continually expanded.

The difficulty in filtering in the neighborhood of the SSBSC signal led engineers to adopt Vestigial Sideband modulation. This resulted in increased stability and audio response down to DC (though engineers felt 40 cps was a pragmatic high-pass cut-off). Carriers had to be synchronized because of the Vestigial modulation employed.

Since you’ve made it this far…how about some *serious* detail? If you can decipher this…it’s the actual circuit diagram for Stokowski’s Grand Experiment:

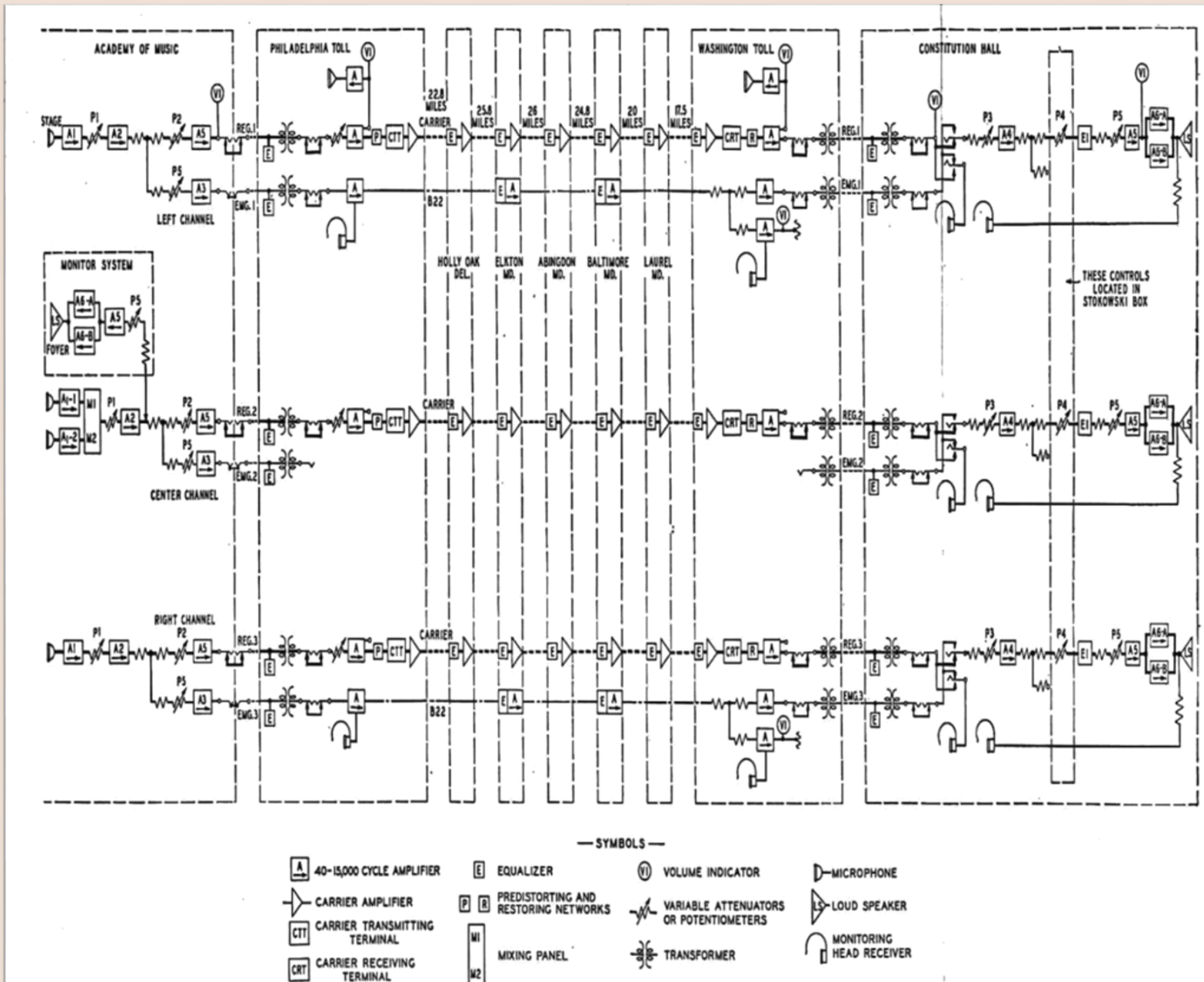


Fig. 10—Schematic diagram of circuit layout for 15-kc channel used for symphonic program demonstration.

Bell Systems Technical Journals

Here are some examples of how Long Lines communicated internally in the provisioning of its long-haul circuits…in *telco-speak*.

Remember the initial connectivity as the WEAF Network was rolled out? An early challenge was to establish connectivity from WEAF to test station WMAF in Round Hilll Massachusetts. To pull it off, engineers had to tame a mix of open-wire and cable.

AT&T records show: "Service to Station WMAF from (WEAF) 195 Broadway studio started July 1st, 1923; hours, 4:30-5:30 P.M., 7:30-10 P.M., daily except Sunday; Sunday, 7:20-10 P.M. Transmission nominally from 100 to 5,000 cycles but down 10 db at 5,000 cycles.

"Final equalization by resonant shunt at 2,000 cycles, giving a 1,000 cycle loss of 12 db. Resulting transmission within 3 db between 200 and 3,500 cycles, down 10 at 5,000 cycles, down 8 at 100 cycles." *Commercial Broadcast Pioneer: The WEAF Experiment 1922-1926*

When WJAR replaced WAMF the following was generated internally: "Service to WJAR starts Sunday, October 14th; repeat on Fridays and Sundays until further notice; requires transmission frequencies up to 5,000 cycles....in the meantime Outlet Company wants to broadcast World's Series baseball which starts October 10th. Transmission…will require equalization only up to 3,000 cycles but it seems desirable to equalize up to 5,000..." *ibid*

Within the Long Lines engineering group, the feasibility of connecting a larger group of stations for full-time service drew the following internal correspondence: "At the present time the circuits between New York and Providence and New York and Washington used for broadcasting purposes are non-loaded 165 (mm open-wire) circuits with a small amount of intermediate cable. The circuit to Providence is equipped with two intermediate amplifiers and equalizers…Extra-light-loaded H-44-25 #19 gauge cable conductors which are used for extra-light loaded four-wire circuits, if equipped with suitable repeaters or amplifiers, can be made to transmit the average program from WEAF with about the same degree of satisfaction to the listener as the present circuits.

"New York to Philadelphia: There are at present 6 quads of H-44-25 $19 gauge four-wire conductors between New York and Philadelphia. One of these quads could be released for use in broadcasting. Philadelphia to Washington. There are at present no extra-light loaded conductors between Philadelphia and Washington and it would be necessary to load existing spare #19 gauge non-loaded conductors in this section.

"New York to Providence: There is no H-44-25 loading between New York and Providence. There is, however, one spare non-loaded quad from New York to Providence which could be loaded and used for broadcasting. "A special amplifier or repeater…would be required at each of the repeater points along both of the cable routes. *Summary:* The cable distance between New York and Washington is 223 miles, and the distance between New York and Providence is 187 miles.

"The total distance over which additional loading would be required is 323 miles, since the 87-mile section between New York and Philadelphia is already loaded." *ibid*

Here's another internal communication regarding a fairly complicated 1924 broadcast. It's pretty detailed, but if you want to drill down into facilities assignment, the memo supplies a feel for the precision of Long Lines Engineering: *Long Lines Engineering Memo*: "January 31, 1924. This telegram concerns the Long Lines service in connection with broadcasting the AIEE program on February 5th, from the Philadelphia Metropolitan Opera House; Gimbel Brothers Station (WIP), Philadelphia; Station WEAF, New York; Station WGY, Schenectady; Station WCAP, Washington; Station KDKA, Pittsburgh; per SCS Order G-7606.

"For this service these telephone facilities will be required: Pairs 257 and 260 Cable C, Philadelphia to New York, with 4-Wire repeaters at Philadelphia, Princeton and New York. No. 2 Chicago-New York circuit between New York and Pittsburgh. No. 2 Boston-Pittsburgh circuit between Newtown Square and Pittsburgh. No. 3 Harrisburg-Philadelphia. circuit between Newtown Square and Philadelphia.

"Nos. 7 and 25 New York-Washington circuits…New York and Washington. Sides of 33-36 group, New York-Buffalo, New York to Lansingburg. Sides of 27-30 group, Troy-Elmira line, Lansingburg to Schenectady. For this service the following Morse facilities will be required: 0194 program co-ordinating circuits with Morse calls and drops as follows: New York (BY) radio station WEAF Philadelphia (KF) control room Philadelphia (RF) radio station WIP (not to be connected unless asked for later) Pittsburgh (RW) radio station KDKA Washington (CA) radio station WCAP Schenectady (GY) radio station WGY; the above circuit to be operated metallic Morse New York, Philadelphia, Harrisburg, Bedford, and Pittsburgh; leg Philadelphia to Washington and New York to Lansingburg half duplex. Single, Lansingburg to Schenectady.

"These telephone and Morse circuits shall be established for rehearsals on Sunday, February 3rd, 8:00 P.M.--11:00 P.M., E.T., and again on Monday, February 4th, 5 P.M.--9 P.M. E.T. On Tuesday, February 5th, the night of the demonstration, the circuits will be taken at 5:00 P.M., E.T., lined up and held until 'good night.' During the periods of rehearsals and demonstration, telephone repeater attendants required at repeater stations en route, and transmission man required at New York, Pittsburgh and Philadelphia. For this service provide a New York-Philadelphia order wire between Room 224, 24 Walker Street, N.Y., and the telephone repeater room at Philadelphia and control room of Philadelphia Opera House on dates of rehearsals and demonstration. For this purpose use any New York-Philadelphia circuit. (RSS)" *ibid*

Fortunately, much of that early system was still open-wire facility with its wider bandwidth and lower losses. As we've noted, until dedicated wide-band facilities were commonly available, engineers took telephone circuits out of service, disconnected them from their switchboards, and added conditioning. This work was accomplished during periods of low telephone demand. Sometimes, after testing for several hours, the pairs chosen delivered too much noise or cross-talk…and the work had to be re-started on different pairs…in the middle of the night.

Audio processing for radio-phone links

We spent some time earlier discussing how AT&T interfaced its wire network to the RF domain. To finesse the sometimes-undependable radio links, engineers went back to the labs and, not for the first time, psychoacoustics was invoked. Some new acronyms entered the language in the Bell Systems Technical Journals.

First: *VOGAD*. In operation 60 years before Star Wars appeared, VOGAD stood for "Voice Operated Gain-Adjusting Device." VOGAD used VARIO, a "Variable-Gain Amplifier." This was arguably the world's first gated, program-controlled AGC. It featured a "Gain Increaser," a "Gain-Increaser-Stabilizer" and finally a "Gain-Decreaser." (Those who developed the CBS Audimax with its "Gated Gain Stabilizer" may have found their initial recipes in the Bell Systems Technical Journals.)

In order that the voice-operated switch didn't lock up when channel noise overrode speech audio, CODAN was brought to the rescue. CODAN meant "Carrier Operated Device Anti-Noise." It was essentially a carrier detector: no signal; no audio. To keep CODAN honest in the presence of varying signal strength, a mechanical contrivance sensed both signal and noise levels and opened the circuit only when the signal was stronger than the (band-pass-filtered) noise. This lash-up also functioned as a carrier-sense gate. Next came Compandors; also ahead of their time. The companding system wasn't absolute in its action; instead its time constants were designed to approach syllabic rates and repetition. Compandors added 25 to 30 db to the S/N ratio.

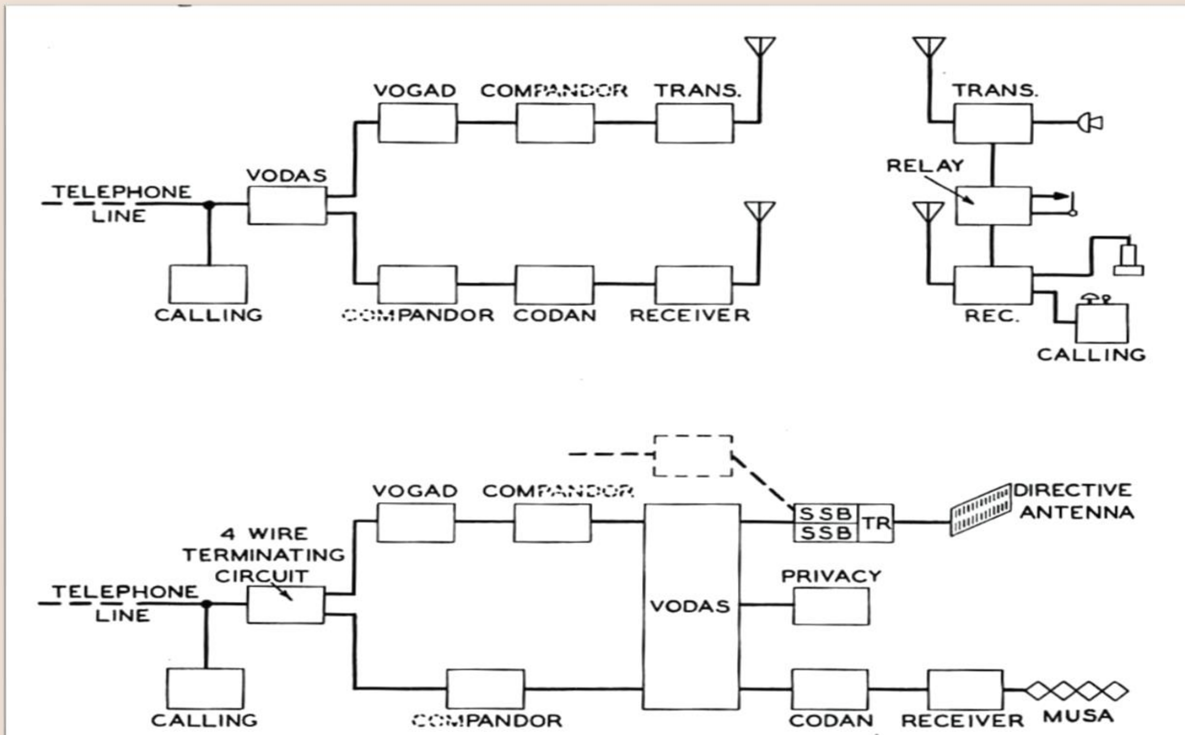


Fig. 5—Three arrangements of radio terminal apparatus are shown herein.

The ‘radio-to-telephone’ system *Bell Systems Technical Journal*

The final word (s)

Before we close this appendix and say ‘thanks for reading’ we offer a couple of final sidebars having to do with latter-day (analog) network alerting:

NBC debuted its “**Hot-Line**” network-alert sometime in the 1950s (date uncertain). From my recollection of the system, the alert signal may have been a low-frequency tone (60 hz?) sent on top of the network audio, to a receive system at the affiliates:

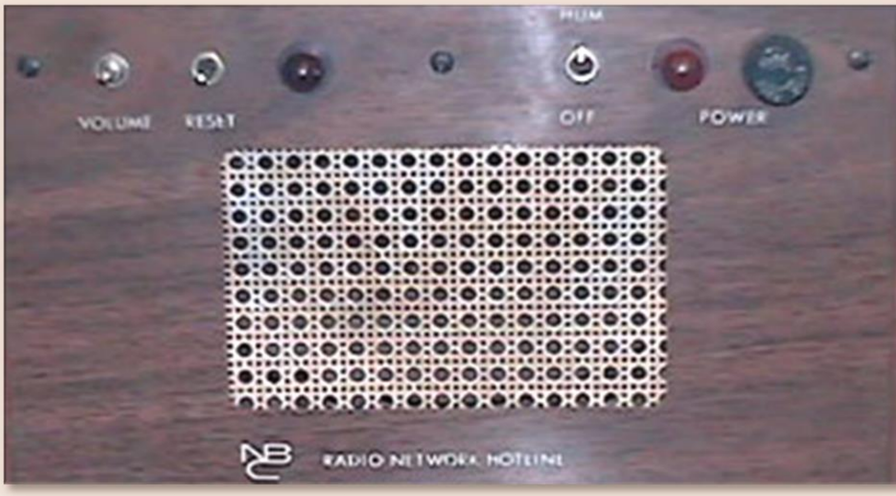


Photo courtesy dcrtv.com:

In a 1960 *Broadcasting Magazine* story, CBS announced a new system for alerting its own affiliates…christened "**Net-Alert**." The original system, deployed around 1961, used a series of two-frequency pulses of around 30 milliseconds that rode on the network audio.

CBS Labs carried out a good deal of subjective analysis on pulse-duration, since the pulse had to be reliable yet not audibly objectionable. Pulse level was to be 20 db below program level. The number of pulses sent determined the alert level and a stepper relay at the affiliate receivers could be heard stepping its way up as far as Alert # 9—"National Emergency."

I can recall being in the WCCO Control Room on some of the few occasions when the "non-routine" sequences were firing…you'd hear a relay snap; count the relay clicks and chirps and as the count got higher you'd go from "*what's happening*?" to "***Oh-Oh***."

The Net-Alert system was upgraded in 1978. Reader Hal Schardin adds:

"There was a NetALERT test record in the WCCO shop, which we used to align NetALERT receiver levels. I'll never forget the bird sound effect used in the CBS Mystery Theatre would false-trigger NetALERTs!

ABC's retired Engineering guru Bob Donnelly shared this on a public reflector: "In 1966, ABC Radio Network used a single 2030Hz signal ahead of news alerts, bulletins and other critical information of interest to its affiliates. A notch filter was inserted across the output of the channels feeding the AT&T network.

"In time for split-network service at ABC in 1968, a FSK duo-tone service was installed. A low pass filter was inserted above 4500 Hz to allow these two tones to be sent without interference from voice and music programming. Keep in mind the leased inter exchange carrier channel had a bandwidth of 50-5000 Hz. There was little slizzle on the network line feed. Many stations accessed the network with a 300-3.5 kHz voice grade line. The duo tone configuration had to work on both grades of service. So ABC Radio retained the 2930 Hz alert for sometime after the introduction of the FSK 'chirp' signal. Prior to moving to satellite and multiple channels, I removed the low pass filter and replaced it with two notch filters for the FSK 'pulses.' With some affiliates capable of receiving audio out to 8 kHz courtesy of AT&T's 'upgrade' to T-carrier program channel gear, this slight tweak in audio performance helped many East Coast stations and those connected from satellite point to point trunks in Chicago, LA and other west coast links.

"We also reduced the 'chirp' level to about 20 db below +8 operating level (memory might off on the exact drop) following our transition to satellite and PCM audio. Eventually, the chirp was dropped altogether and replaced by a more efficient and higher-capacity digital cue system. The system is still in service today and available to both ABC affiliates and to some extent to ABC's channel service customers. The warning was transmitted at 10 seconds prior to all ABC shows. It was generated from an oscillator operating at 400 Hz @ +8. I changed it to 440 Hz ("the key of A"). The time beep on the hour was turned off because many stations put the news in delay and the signal proved somewhat inconvenient. I didn't want it to go. But programming always wins out over sentimentality. That's why I love the CBS 'bong.' Awesome!" *Bob Donnelly, VP Engineering (retired)*

And there we are. The network operations controlled by many centers like the room above are now replaced by a single operator at a computer work-station riding herd on network fiber/satellite topology that's mostly self-healing. It's true that we do so much more with today's technology, but that observation doesn't detract from the fact that AT&T built and refined an analog transmission world in which the nation's communications were handled with professionalism, efficiency…and quality!

This e-book *formally* ended a chapter ago, so if you missed that farewell by jumping to this chapter, we hope you'll go back *to revisit our closing thoughts*.

Thank you again for your curiosity!

Mark Durenberger, August 2014, revised April 2021

Mark4 at durenberger-dot-com