Radio Communications in the United States

Radio in the United States was born at the intersection of social ideals and technical limitations. For individuals radio provided an infinite medium for communication, but to function as a system it necessitated cooperation and compromise. As such, the history of American radio has been characterized by the interaction of contradictory influences. Embroiled patent disputes played just as large a role as purely altruistic radio concerts in defining the technology’s developmental path. Radio propelled American modernity and consumerism all the while preserving the core cultural values of equality, freedom, and unity. In this way, the action of technical, institutional, and social pressures worked radio into a
functional mold that reflected American social expectations. Radio in turn redefined such expectations and the society that imposed them.

**Evolution of Radio Technology:**

Like most technological systems, radio resulted from incremental innovations made by individuals and institutions working in parallel and in competition with one another. Although the United States government and American corporations made pioneering contributions to the creation of a radio system, the technologies that made early radio possible were developed in large part outside of the United States.

The scientific foundations for radio were most firmly established during the nineteenth century by physicists and engineers hailing primarily from European nations. The existence of self-propagating electromagnetic waves as described by Scottish physicist James Clerk Maxwell’s equations made radio communication a theoretical possibility. In 1887, the experiments of German physicist Heinrich Hertz demonstrated the validity of Maxwell’s predictions.¹ Hertz constructed a spark-gap transmitter, a device that employs an electrical discharge to generate electromagnetic waves at high power across a wide range of frequencies, and successfully measured the frequency of the waves with a primitive dipole antenna receiver. However, Hertz did not appear to realize the implications of his wireless experiment. In fact, it was not a scientist but a young Italian entrepreneur, Guglielmo

Marconi, who recognized the market potential for Hertz’s wireless experiments and “fathered” wireless telegraphy.²

Marconi Wireless Telegraph Company of America, established in 1899, catered to the wireless needs of the United States Navy. American Marconi manufactured and sold wireless telegraphy equipment mostly for use in point-to-point ship communications where wired telegraphy and telephony were not feasible.³ Marconi produced the first commercially successful wireless telegraphy instruments; however, his contributions fall short of warranting the title “Father of Radio”. Technology beyond Marconi’s spark-gap transmitter-receiver pairs would be required in order to overcome the next great radio frontier: the wireless transmission of sound.

The development of wireless telephony was more central to the United States and witnessed greater involvement by American inventors and institutions than wireless telegraphy before it.⁴ The first investigations and inventions of wireless telephony followed shortly on the heels of Marconi’s radio empire. In 1901, Reginald Fessenden, a Canadian immigrant to the United States, patented a new type of radio receiver.⁵ Fessenden’s heterodyne receiver converted a radio frequency signal to an audio frequency signal. The heterodyne receiver accomplished this effect by “mixing”, electrically multiplying, the received radio frequency signal with a local

² Ibid.
⁴ Ibid. , 275
⁵ Ibid.
oscillator signal to produce a lower “beat frequency”. The extracted audio frequency signal, representing a Morse code sequence, could then be directly applied to a speaker and heard as a series of tones. While Fessenden’s heterodyne concept would ultimately form the basis for modern superheterodyne radio receivers, technical problems associated with the frequency drift of the local oscillator circuits available at the time as well as a lack of commercial interest in wireless telephony discouraged him from pursuing the idea further. Fessenden instead focused on his 1902 invention of the alternator, a rotary spark-gap transmitter capable of producing high-power continuous radio frequency signals. Fessenden’s heterodyne receiver and alternator provided solutions to some of the challenges posed by wireless telephony, and on Christmas Eve of 1906 Fessenden broadcasted the first radio program at Brant Rock, Massachusetts. However, still more technical issues remained to be tackled before wireless telephony could become a reality.

At a fundamental level, the task of transmitting and receiving audio over radio waves required an amplifying element by which a small input signal could control a larger output signal. In 1906, Lee DeForest patented such an amplifier for precisely this purpose. A Yale graduate, DeForest had previously profited in the radio business from his 1901 invention of the responder, a rather ineffective electrolytic radio detector, but had been ousted from his wireless company after a

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6 Ibid., 276
7 Long, “Technological Change,” 744
8 Cowan, A Social History, 277
9 Scientific American Vol. 87, No. 7 (August 16, 1902), 102-103
lawsuit over his improper use of a similar detector technology patented by Fessenden.\textsuperscript{10} DeForest’s triode, which DeForest himself called the audion, was based on the diode effect discovered earlier by British engineer John A. Fleming and was capable of amplifying small electrical signals.\textsuperscript{11} The audion enabled electrical voice signals to modulate radio frequency carrier signals. The modulated carrier signal would have to be demodulated at the receiver end in order to extract the audio signal. Demodulation could be accomplished by Fessenden’s heterodyne scheme with audions providing a stable local oscillator signal. The vacuum tube technology on which both Fleming’s diode and DeForest’s triode were based would remain central to radio electronics until the advent of transistors midway through the twentieth century.

For his invention of the audion, DeForest is credited in part with the development of AM radio. Amplitude modulation (AM) is mathematically defined by the multiplication of a carrier signal with an audio signal. At sufficiently high carrier frequencies, the audio signal forms an “envelope” that bounds the amplitude of the radio signal to be transmitted. Upon reception, the radio signal is passed through an AM demodulator circuit such as an envelope detector from which the original audio is retrieved. Although Fessenden’s Christmas Eve transmission of 1906 was in effect a form of amplitude modulation, the means by which the signal was modulated, specifically the direct loading of the transmitter power supply with a carbon microphone, constituted an inefficient and power limiting method that would be

\textsuperscript{10} Cowan, \textit{A Social History}, 277
\textsuperscript{11} Ibid.
made unnecessary by the introduction of the audion. Audion based transmitters and receivers demonstrated greatly improved quality and range of AM radio transmissions. Between the second and fifth decades of the century, the so-called “Golden Age of Radio”, AM existed as the primary transmission scheme. Yet issues of interference and noise inherent in AM radio motivated the development of alternative schemes.

One American inventor in particular played a key role in the development of an alternative and now dominant radio communication scheme, frequency modulation (FM) radio. Edwin H. Armstrong, a professor of electrical engineering at Columbia University and Major in the U.S. Army, made such prolific contributions to the advancement of radio that he was awarded the following critical acclaim by the journal *Science* upon his receipt of the Edison Medal in 1943:

> “Probably no one man has contributed as many fundamental radio inventions which so closely touch on our everyday life as Major Armstrong.”

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12 Ibid.


14 “Award of the Edison Medal to Dr. Armstrong,” *Science*, New Series, Vol. 97, No. 2505 (Jan. 1, 1943), 12
Armstrong began experimenting with DeForest’s audion while still an undergraduate at Columbia University, and by 1914 he had already patented a transformative new design.\textsuperscript{15} Armstrong’s regenerative circuit introduced a tunable feedback loop to the audion amplifier. The effect of this addition was to greatly enhance the sensitivity and selectivity of AM radio receivers. In addition, by tweaking the loop gain, the circuit could be made to oscillate at very high frequencies. In 1918, Armstrong invented yet another pivotal radio circuit: the superheterodyne receiver.\textsuperscript{16} The superheterodyne receiver applied Fessenden’s heterodyning principle to shift incoming high frequency radio signals to a lower intermediate frequency where they could be more conveniently processed.

![Block diagram of superheterodyne receiver](image)

The Armstrong oscillator and superheterodyne receiver opened up the possibility of shortwave, wide-band radio. This previously unexplored very-high frequency domain was suited for Armstrong’s FM scheme, which required greater channel width than AM radio. By encoding information in the frequency rather than the

\textsuperscript{15} Ibid.

\textsuperscript{16} Ibid.
amplitude of radio signals, FM could transmit higher fidelity audio more efficiently and with less noise than AM.\textsuperscript{17} Armstrong began testing his FM system from atop the Empire State Building in 1933,\textsuperscript{18} and a decade later all major broadcast companies had applied to the Federal Communications Commission for FM licenses.\textsuperscript{19} By 1980, FM had surpassed AM radio in terms of audience size.\textsuperscript{20}

\textbf{Government Regulation:}

During the early years of radio communication in the United States, the usable electromagnetic spectrum was viewed as a publicly shared domain.\textsuperscript{21} Broadcasting was inherently similar to recreational hunting and fishing in that both space on the air and wildlife were treated as natural resources owned by none and available to all. Additionally, the content of radio broadcasts, as in other forms of communication, was protected by free speech; individuals could broadcast without fear of censorship. In this way, early radio regulation in the United States incubated in a unique socio-political climate defined by First Amendment rights, individualism, and capitalism. The result was radio policy that, unlike the pattern of spectrum

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\textsuperscript{17} Slotten, ““Rainbow in the Sky”,” 690
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\textsuperscript{19} “Award of the Edison Medal,” \textit{Science}, 12
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\textsuperscript{20} Slotten, ““Rainbow in the Sky”,” 687
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nationalization seen abroad, was largely laissez-faire and primarily focused on protecting public interests.\textsuperscript{22}

Historians point to the April 1912 sinking of the *RMS Titanic* as the great impetus for government regulation of radio in the United States.\textsuperscript{23} In the hours following the vessel’s initial distress transmissions, radio chaos ensued as many operators began transmitting simultaneously. Confusion from overlapping transmissions resulted in the spread of false and conflicting information about the fate of those onboard. The incident demonstrated the need to establish order amongst competing users of the radio spectrum and spurred prompt legislative action. The Radio Licensing Act of 1912 created a federal regulatory presence on the air.\textsuperscript{24} Radio operators who wished to transmit were required to take a Department of Commerce issued licensing exam. In addition to a formal registration process, the Act also established bandwidth allocation, which partitioned the usable spectrum into portions specified for use by military, industry, and amateur operators.\textsuperscript{25} Licensees had to restrict the spectral content of their transmissions to lie within the bounds of their assigned position on the spectrum. Public response to the Act was generally positive. Amateur radio operators were among those dissatisfied with the Act, arguing that their assigned region of the spectrum placed technological

\textsuperscript{22} Ibid.

\textsuperscript{23} Cowan, *A Social History*, 279

\textsuperscript{24} Ibid.

\textsuperscript{25} Ibid., 280
limitations on their freedom of speech, but their concerns about allocation were largely ignored at the time.

The Radio Act of 1927 greatly expanded government regulatory powers beyond the specifications of the Act of 1912.\textsuperscript{26} In effect, its passing marks the beginning of active broadcasting regulation by federal agencies. The Act sought to deal with renewed congestion of the airwaves by enforcing frequency boundaries defined previously by the Act of 1912. However, the motive for regulatory action was not simply public safety as it had been in 1912\textsuperscript{27} but rather the greater public interest.\textsuperscript{28} Specifically, demand for space on the electromagnetic spectrum was growing faster than the supply. It appeared that seemingly insurmountable technical boundaries had placed an upper limit on the usable spectrum.\textsuperscript{29} Interestingly, some researchers have argued that institutional rather than technical constraints were more to blame for the apparent scarcity of bandwidth that prompted the Act of 1927.\textsuperscript{30} The contention is that allocation created a perceived deficiency that would not have occurred had bandwidth been established as a marketable commodity. This somewhat startling theory appears reasonable when viewing side-by-side a 1941 excerpt from the Harvard Law Review and a statement made by radio pioneer Edwin H. Armstrong upon his receipt of the Franklin Medal, also in 1941:

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\item\textsuperscript{26} Ibid., 288
\item\textsuperscript{27} Aitken, “Allocating the Spectrum,” 691
\item\textsuperscript{28} Cowan, \textit{A Social History}, 288
\item\textsuperscript{29} Aitken, “Allocating the Spectrum,” 686
\item\textsuperscript{30} Ibid., 687
\end{enumerate}
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“The inherent limitation in frequency has made [regulation] necessary.”\(^{31}\)

“A ‘place on the air’ hitherto denied them now becomes available for our educational and denominational institutions... forecasts reexamination of past legislative acts to determine their applicability to and bearing on our freedom of expression.”\(^{32}\)

The Radio Act of 1927 also created the Federal Radio Commission (FRC), which would later become the Federal Communications Commission (FCC).\(^{33}\) The new government agency was granted powers that enabled it to enforce proper use of the airwaves. Although it could not directly regulate what was transmitted, the FRC could control who had the right to transmit through the issuing and denial of licenses.\(^{34}\) In many instances, the exercise of this regulatory power by the FRC placed it at the center of legal conflict over the interpretation and extent of First Amendment rights. In Trinity Methodist Church v. Federal Radio Commission (1932), the applicant, whose previous broadcasts had consisted of slanderous statements and blackmail, was denied the renewal of his radio license on grounds that his transmissions were not in the public interest and were an inappropriate use


\(^{33}\) Cowan, *A Social History*, 288

\(^{34}\) Aitken, “Allocating the Spectrum,” 689
of a limited public resource.\textsuperscript{35} The issue of free speech also arose in the context of obscenity. In 1937, an NBC broadcast program featuring actress Mae West was deemed so indecent that the FCC threatened to revoke the licenses of any stations that broadcasted the program.\textsuperscript{36} Here, the FCC exercised its power by acting on more conservative views of the public interest.

\textbf{Radio and Society:}

Like the automobile before it, the radio was destined to make its way into the American mass market and, through advertising, drive the postwar trend towards a consumer society. Waves traveling near the speed of light, bearing news, music, or other intelligence brought the country closer together in much the same way that railroads had in the previous century. This was especially the case in isolated rural areas, where modernization and technology ownership had lagged behind.\textsuperscript{37} Radio was popularized in considerably less time than wired communications.\textsuperscript{38} In rural areas, incorporation of radio into the household had exceeded 50\% by the year 1940, compared to the telephone at roughly half that number.\textsuperscript{39} In fact, radio had surpassed not only the telephone but also electricity and the automobile in terms of

\textsuperscript{35} Trinity Methodist Church v. FRC, 62 F.(2d) 850 (1932)

\textsuperscript{36} “Radio Regulation and Freedom,” Harvard Law Review, 1222

\textsuperscript{37} Steve Craig, ““The More They Listen, the More They Buy”: Radio and the Modernizing of Rural America”, 1930-1939," Agricultural History Vol. 80, No. 1 (Winter, 2006), 4

\textsuperscript{38} James G. Harbord, “Radio,” The North American Review Vol. 231, No. 6 (Jun., 1931), 532

\textsuperscript{39} Craig, ““The More They Listen””, 4
usage rates on farms. The quick adoption of radio in rural areas mirrored the
general appreciation of radio’s potential for unifying the nation.⁴⁰ James Harbord,
Chairman of the Board at Radio Corporation of America in 1931, had the following
to say of radio’s cultural significance:

⁴⁰ Ibid., 3
For Long Distance Concerts
Super-Heterodyne; New Advanced Model "C"

Front View
Wave-length Range 160 to 850 Meters, Dimensions 40"x8"x7¾".

Simplicity—Only two variable dials for all waves 160 to 850 meters
Efficiency—Uniform maximum amplification over entire range
Tubes—Uses either UV-201A, 201, 199, WD-11, WD-12, etc.
Design—3 transformer radio amplifiers, 2 audio, 2 detectors, 1 osc.
Selectivity—The only receiver that works through local broadcasters
Range—2000 miles using Radio Corp. loop, more with antenna.

The Super-Heterodyne is the most efficient method of radio frequency amplification known.
The Super-Heterodyne is the only receiver in New York that receives long distance radiophone through local broadcasters.
The Super-Heterodyne is used extensively by commercial radio companies for long distance ship to shore traffic.

May we send you full particulars?

Write for Complete 1924 Catalog A

Experimenters Information Service
Designers of the Highest Class Radio Apparatus in the World
531 West 46th Street, New York City
“[Broadcast programs] have tended to reestablish the American home as a place where the family remains for its amusement...I know of no business that reflects more than radio the tempo of modern life.”

Even before the era of radio broadcasting had begun, ideas for consumer radio were being tossed around. In 1916, engineer David Sarnoff, made his famous pitch to the manager of American Marconi in which he described his “Radio Music Box”, a radio that would become a standard appliance of the modern household. Sarnoff imagined a system that would give consumers access to music, news, and even ball scores. It would be four years before the first radio broadcasts of the kind Sarnoff described would be made. On November 2nd 1920, the Westinghouse owned KDKA station made a famous broadcast relaying the news of Warren G. Harding’s defeat of James M. Cox. The broadcast caused a wave of consumer interest in Westinghouse’s radios, proving the effectiveness of Sarnoff’s plan. However, by 1925, the profitability of radio sets had diminished greatly, and the broadcasting industry was in need of a new market strategy. The answer was found in advertising. Initially, radio advertising was not seen as being economically viable, in part because newspaper and other forms of media held the lion’s share of advertising. Listeners often complained of advertisements, which they believed did

41 Harbord, “Radio,” 533
42 Long, “Technological Change,” 746
43 Cowan, A Social History, 285
44 Long, “Technological Change,” 747
not belong on the air. In 1922, the AT&T run WEAF station implemented sponsor announcements, short advertisements, in order to generate revenue.\textsuperscript{45} The success of this strategy led to its adoption as the industry standard by 1925.\textsuperscript{46} The future of radio broadcasting would be made possible by American consumer culture, and likewise, broadcasting would help to integrate consumerism into American culture.

Beginning in the Depression era, radio showed itself to be a media authority with great public influence. The largely one-way nature of broadcasting, which tied many listeners to a central hub of information and entertainment, had the potential to provide centrality to a geographically and socially diverse nation. This utility of radio as a tool for forging unity proved essential during critical national endeavors. Franklin D. Roosevelt’s “fireside chats” as President of the United States soothed an American society dealing with war and economic downturn and demonstrated the ability of radio to foster social unity by connecting people and leaders. However, in other instances, radio was applied to the opposite effect, inciting discord rather than harmony. The infamous \textit{War of the Worlds} broadcast was one such example. The program, narrated by actor Orson Welles the day before Halloween 1938, mimicked H. G Wells’ science fiction drama in which Martians invaded Earth.\textsuperscript{47} Despite hints and blatant disclaimers revealing the program to be a hoax, the broadcast unintentionally induced genuine fear of invasion in listeners, a few of whom

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\begin{itemize}
\item \textsuperscript{45} Ibid.
\item \textsuperscript{46} Ibid., 748
\end{itemize}
panicked at the fake reports of alien attack. Such iconic radio events as the *War of the Worlds* incident and Roosevelt’s fireside chats highlighted the position of public trust and authority that radio had come to acquire in the decade since the first broadcast programs garnered popularity. Through its reach, instantaneity, and personal touch, radio became a reliable form of communication and also a source of much desired connectivity.

Radio rose to prominence as a communications technology in the United States through several very trying periods in the nation’s history; consequentially, it became structured around both the protection of guarded individual liberties and the desire for social unity. As technical constraints manifested themselves in regulatory policy, the very foundation of the nation’s dearest beliefs was forced into reevaluation. The gift of connectivity through radio mandated a society that was willing to accept restrictions on its ideology so as to preserve it. Moreover, the willingness to make such compromises in policy and industry painted the portrait of a country that was prepared to adjust to an increasingly modern world. Thus, the success of radio in the United States exemplified not only the country’s technical readiness but also the resilience of its people and institutions when faced with change.