Teacher Background

Inquiry Description

This inquiry leads students through a study of mass communications by studying the history of radio and broadcasting. Today's students have grown up with access to information for many purposes by wireless technologies, but broadcasting in the 20th century represents the first time that large groups of people great distances apart could receive information instantaneously. This inquiry encourages students to think like historians about the way they and earlier generations use and used wireless technology. The questions of innovation, use, and regulation invite students into the intellectual space that historians occupy. By investigating the questions of who decides what to create, broadcast, and receive, students will need to think about the questions of how technological change affects access to information, how peoples use their technologies, and how governments regulate what changes in broadcast and electronic technology enable people to send and receive information.

Students will learn about the technical, political, social, and economic problems of broadcasting and its innovations, and track the intended and unintended consequences of broadcast technology through the 20th century, from wireless telegraphy radio to television. As part of their learning about broadcasting, students should practice articulating and writing various positions on the historical events and supporting these claims with evidence. The final performance task asks them to synthesize what they have learned and consider how key figures from the past and present would evaluate broadcasting in the 20th century.

This inquiry requires prerequisite knowledge of historical events and ideas, so teachers will want their students to have already studied the 20th century periods of the world wars, interwar prosperity and depression, and the Cold War to ensure that they have an understanding of ideas promulgated in that era. For instance, they should especially understand that the United States was exceptional among the world's nations in regulating a largely private, for-profit, commercial, broadcast system that was unique in a world of government-controlled broadcasting. Since the 1980s other countries have relaxed government controls over broadcasting but governments everywhere continue to maintain final control over what information is transmitted by this mass medium.

A guiding principle of the IEEE REACH program is that students must learn the fallacy of technological determinism – the belief that technology determines the direction of society. As with all technological developments, those associated with broadcast radio did not evolve linearly. Rather, early innovators used available technologies in a variety of ways, resulting in dead ends and missed opportunities, as well as less frequent "strokes of genius." An example of this reality is the development of the Audion triode and its eventual successor, the superheterodyne. The following background material sheds light on this technological development and the people who exploited it to innovate the field of broadcasting.

NOTE: Teachers are encouraged to modify and adapt the inquiry unit to meet the needs and interests of their students as well as themselves.

Content Background

Historians' and social scientists' efforts to interpret the effects of 20th century broadcasting on society have produced results as complex as the activity itself. Practically from the moment broadcasting began, its meaning was debated, by scientists, engineers, business people, editors, entrepreneurs, investors, enthusiasts, military leaders, and politicians. The variety of voices indicates the social nature of the innovation, from the scientist's laboratory to the consumer's home.

The classic interpretation of broadcasting's impact interprets it as an informational and educational benefit to most societies, offering a virtual, paternalistic community for isolated households and useful news and enjoyable entertainment to the public. More recent critics observe that as a novel, government-regulated or –owned mass medium it does not enjoy the traditional freedom of the press and that it largely represents a joint effort between the national governments and corporate capitalists to preserve the political economic status quo in the interests of those in positions of power.

In addition to these debates about the impact of broadcasting, there are disagreements about the people most associated with the development of broadcasting technology. Supporting Question 2 in this Inquiry Unit looks at two competing personalities – David Sarnoff and Edwin H. Armstrong. While Sarnoff may deserve the credit for supporting the development of broadcast technology through marketing, Armstrong may have been one of the very few people to understand the ways to improve the technology and make it appropriate for broader distribution.

Edwin Howard Armstrong grew up privileged in many ways—by gender, race, class, and genius—and he put his advantages to productive use as an engineer and inventor of technologies that made radio broadcasting available to people around the world. Armstrong was born in 1890 on the west side of Manhattan, New York City, the oldest of three children, to prosperous parents devoted to the Presbyterian Church where they had met. In 1903, his father, an editor for the Oxford University Press, returned from a trip to England with a copy of *Boys' Book of Inventions [1899 edition]* for his only son. This was followed by *Stories of Inventors* a year later. After devouring the profusely illustrated stories of the people who created powered flight, x-rays, and wireless telegraphy, Howard declared that he intended to be an inventor, too—in wireless. There were just as many unknowns in what came to be known as radio as in aviation and x-rays, and Guglielmo Marconi's successes in transmitting wireless showed that one needed neither a lot of money nor a college education to be successful.

Within a couple of years, Howard had joined the small but growing ranks of amateur wireless experimenters. As Marconi had transmitted electromagnetic signals from the top floor of his parents' house outside Bologna, Italy, Armstrong also set up his laboratory on the top floor of 1034 Warburton. By tuning in other amateurs, or "hams," transmitting the dots and dashes of Morse code, he became friends with other boys interested in the novel technology. Howard recruited his younger sister Edith, or "Cricket" to help build and wire a 125-foot (38-meter) pole for his antenna, which required hoisting himself or her up the pole. A neighbor who appreciated

Howard's knowledge of wireless provided him with an expensive Audion vacuum tube in 1908, the first in his group of hams. The Audion with its three electrodes inside permitted reception of an amplified signal, but its inventor, Lee de Forest, like many of his contemporaries, didn't understand this important innovation – he thought his Audion triode was simply a more sensitive diode.

For the next several years, Armstrong focused completely on the operation of de Forest's Audion as a detector of electromagnetic radio waves. The Audion was like an old-fashioned incandescent light bulb, only with two additional metal components inside that enabled it to detect the electromagnetic signals that wireless telegraph stations transmitted via Morse code. No one, including its inventor, Lee de Forest, understood why or how the device worked, but Howard was determined to answer at least the second of those questions through careful study but especially through even more careful experimentation. In this respect he resembled not only Marconi, but Thomas Edison, as engineers. All focused less on the mathematically based theories that explained the physics of their inventions than on the manipulation of electricity to make them operate in the first place.

Armstrong's "Wireless Receiving System" – U.S. Patent 1,113,149 was granted 6 October 1914 for his regenerative circuit for positively feeding back and amplifying a weak radio signal with a single vacuum tube. At the time, vacuum tubes were handmade and very expensive, and Armstrong's design enabled amateur radio enthusiasts—the hackers and makers of their time—and then manufacturers in the broadcast boom of the 1920s to build cheap radio receivers. Armstrong first explained what he believed was a discovery, not an invention, in a three-page article for *Electrical World* soon after he received his patent.

Armstrong was not alone in inventing these circuits. History is full of examples of simultaneous invention or discovery by inventors, engineers, and scientists searching for solutions to a popular problem of their time. The patent systems designed to encourage creative solutions by rewarding one inventor with a potential financial return, however, give no credit to others judged to be too late in conceiving of or applying for a patent. In the case of the regenerative circuit, Alexander Meissner invented its equivalent in Germany for applying positive feedback to an oscillating vacuum tube in 1913; Irving Langmuir and Lee de Forest did so in the U.S. Howard, however, understood how it could be used in a world of wireless radio reception. He synthesized three ideas to create his superheterodyne circuit for selectively amplifying a very high frequency radio signal out of a noisy electromagnetic environment, receiving a patent for a "Method of Receiving High-Frequency Oscillations" – U.S. Patent 1,342,885 on 8 June 1920. He then began considering the possibilities of "super regeneration" after a lawyer fighting his claim to the regeneration patent made a technical error. While setting up an electronic circuit to demonstrate the error, Armstrong stumbled on super regenerative output. He explained his new circuit at a meeting of the IRE in June 1922, and was granted a patent for a "Signaling System" – U.S. Patent 1,424,065 on 25 July 1922.

Westinghouse bought Armstrong's regenerative and superheterodyne patents for $335,000 in October 1920; it would pay him another $200,000 if he won priority over the other three regenerative claimants. AT&T bought de Forest's regenerative patent rights, since his patent hadn't issued during the interference process, for $250,000. Negotiations led to the "pooling" of

these and other patents essential to radio and electronic technologies in the Radio Corporation of America (RCA). RCA ultimately took de Forest's side in the patent litigation because if it was upheld, RCA would have ten additional years in which to license it to radio manufacturers.

In June 1920, RCA bought Armstrong's super regeneration patent for $200,000 and 60,000 shares of RCA common stock; at about $3.50 per share, that amounted to another $210,000, well over a year before anyone anticipated the broadcasting boom that would drive the price much higher. When speculators began pumping the stock in March 1928, it was worth $94.50 per share; before the stock market crash of October 1929, it peaked in September at $505 per share.

Armstrong's first application for a patent on frequency, not amplitude, modulation, along with three others represented his wideband FM radio system. The Patent Office granted all four — "Radio Broadcasting and Receiving" – U.S. Patent 1,941,067; "Radiosignaling" – U.S. Patent 1,941,068; and "Radiosignaling" – U.S. Patent 1,941,069 — on the day after Christmas 1933.

Content, Practices, and Literacies

In addressing the compelling question "In what ways did broadcasting change history?" students will need to weigh conflicting evidence from each of the four periods addressed in the unit.

Deeply investigating the debates over broadcasting's impact on history would involve more time than most high school classes can offer to the topic. Nonetheless, the question of the impact of broadcasting allows students to wrestle with the complexities of broadcasting as a mass medium in ways similar to those of historians. The question implies that the outcomes were complicated and that an assessment of broadcasting's influence depends on the way in which one measures it. The first supporting question leads students to understand the scientific and technological origins of broadcasting so that they can evaluate the extent to which the science had a long-term effect on the way that people, companies, and governments used broadcasting. The next supporting question raises the question of the role of the individual—in this case, the so-called "great man"—in shaping his or her world. The third question examines the interaction between the technology and the utility of broadcasting, including the first stages and the beginnings of regulation. Both periods help students understand the complexity of revolutionary reforms and their impact on the people. The final supporting question brings students back to the big question of historical impact of broadcasting including the rise of television.

By investigating the featured sources, students will be able to construct multiple, complex claims about broadcasting's influence. We have provided Formative Performance Tasks for each Supporting Question that allow students to analyze the Featured Documents and develop creative responses to each question. Teachers are encouraged to use these tasks or create their own formative assessments reflecting the specific needs of their students. Either way, students will engage with documentary history using the inquiry methods of real historians and developing the skills that will develop their cognitive capacity to deal with the final Summative Performance Task. These skills include Gathering, Using, and Interpreting Evidence; Chronological Reasoning and Causation; and Comparison and Contextualization.

Staging the Question

"In what ways did broadcasting change history?" asks students to deal with the unpredictable pathways of innovation and their intersections with societies. To help warm students up for the inquiry, it will be important to have them start thinking about the concept of innovation and the messiness that accompanies major changes in technology or any other human activity.

One way to do this is to have students compare how they learned to use smartphones with the way that their parents or grandparents learned to use radios, televisions, or personal computers. If the teacher has time, this article from 1908 (https://web.archive.org/web/20200108045206/http://earlyradiohistory.us/1908chld.htm.) on how a child learned to use a telephone may help students understand that innovation in media and other technologies is not new.

Teachers may want to work with students on making distinctions between a series of terms, including "science," "research," "invention," "engineering," "entrepreneur," and "innovation." The teacher should guide students toward the notion that innovations are sometimes characterized by radical change that fundamentally transforms a political, economic, or social paradigm. At this point, the teacher should ask students, "Why do some people currently refer to smartphones as a *revolutionary innovation*?"

From these initial understandings, the teacher should then show the images of radios and televisions, making note of the dates and asking students to consider how people used the devices pictured. The teacher should move the students toward the compelling question by asking them, "Is broadcasting changing the world?" The goal of this activity is not for them to come to a definitive answer—the goal is for students to recognize their hesitation and the fact that the answer is not clear. *If* there is an answer, it must certainly be a complicated one, and it might depend on when the question is asked. It is essential that the teacher names this tentative or hesitant point for students so they can recognize it again when they return to it throughout the inquiry.

At this point, teachers might want to show similar image sets from other historic revolutions that further engage their students. Alternatively, or additionally, they might want to lead a more general conversation with students about what might make a revolution successful.

It is important to note that making direct comparisons between technological innovations and social/economic/political change is challenging, so teachers should be wary of oversimplifications or anachronistic connections. Technology does not change by itself; people change technology by creating, buying, using, and regulating it. Few people bother to predict the long-term outcomes of their work or efforts to change something in the short term, and when they do consider these long-term outcomes, they are more often wrong than right. Additionally, students generally know little about the process of innovation, so it is important for the teacher to provide enough background knowledge so students can examine the images and thoughtfully engage in the discussion.

The goals of this exercise are two-fold. First, it helps students recognize that the history of innovations in this case study have important implications for the world in which they live.

Second, it helps students understand that the broadcasting revolution has lasted more than a century and that the goals of broadcasters and listeners changed over time, with varying effects. Often students see these kinds of events as overnight successes. We hope that, by examining the broadcasting revolution from its inception as a scientific curiosity, students will come to expect the unexpected during revolutions, understand that few people are skilled at predicting the future, and that radical technological change is rarely as straightforward as we would like to believe.

Supporting Question 1

To answer the supporting question "How do you turn equations into a technology?" students will need to understand the problems that led to the broadcasting revolution. By answering this supporting question, students should be able to use their response throughout the rest of the inquiry to judge broadcasting's impact. The accompanying formative performance task calls on students to create a slide presentation demonstrating the international nature of innovation. Within this task, students analyze six featured sources to discover examples of the problems people in western civilization faced in the period preceding the broadcasting revolution.

Featured Source A is a webpage for the IEEE Milestone honoring James Maxwell's conceptual and mathematical unification of electric and magnetic behavior as "fields." In using this source, teachers should think about the ways they could draw out the meaning that may not be readily apparent to students. A teacher might begin with a sequence of questions:

Who was Maxwell?
What did he do?
How do we know?
Why is it worth remembering?
Did Maxwell think about the technological, economic, or political implications of his discovery?

Featured Source B is from an exhibit booklet on the two 19th century experimental and theoretical scientists who established the foundations for the field of electrical engineering and much else. It will help students broaden their understanding of James Clerk Maxwell's work in the contexts of his scientific predecessor, Michael Faraday; life in 19th-century Great Britain; and the implications of the theory of electromagnetic fields.

Featured Source C offers a glimpse into how scientists presented their research in the late 19th century. In his landmark article, Maxwell writes simply and clearly about the basic problem that he is trying to resolve. By skimming the physical details of the phenomena (polarization, inductance, etc.) and the equations, young and lay readers can understand the main point of his effort to understand, that is to know, a fundamental aspect of the laws of physics.

Featured Source D is from a well edited online encyclopedia of primary source articles and other texts, largely on American radio with influences from Europe. The many examples given of people experimenting on, investing in, using, and promoting their versions of wireless telegraphy and early broadcast technologies should indicate to the teacher and students that the history of the broadcast revolution involves many more people than the scientists, engineers, inventors, and entrepreneurs that are the focus of popular culture and documentaries. This timeline identifies some of the people who theorized, experimented on, researched, or

demonstrated parts of the science and technologies that contributed to the commercialization of wireless telegraphy and broadcasting. It should indicate to students that the developments in the years before the broadcast revolution were uncertain and often undirected. When directed, the researchers are sometimes focused on unexpected goals

Featured Source E are images of electromagnetic spectrum allocation charts for the United States and South Africa. Governments decide how to use this natural resource first posed by Maxwell as an "aether" over 150 years ago. Each innovation that involves the use of an electromagnetic motor or electromagnetic radiation either requires some frequencies in the electromagnetic spectrum for operation, or threatens to interfere with the use of the spectrum. By viewing the spectrum charts and the links to their primary source webpages, students can see for themselves the many current uses of wireless technology. Each use—broadcasting, cellular telephony, microwave ovens, radar, the "internet of things"—supports an industry or military or intelligence department that lobbies to preserve or expand its allocation of spectrum. Because of developments in processing dynamic assignments of spectrum allocations based on immediate use, static charts like these are beginning to disappear.

Featured Source F is a REACH-produced video outlining the chronology of early radio technology. REACH professor, Alex Magoun, guides students through the earliest technological developments and the people who used them in an entertaining 8-minute presentation. This video helps link Supporting Questions 1 and 2.

Additional Resources
In addition, teachers may want students to consider some of these other sources to further their understanding of the problems faced by the people involved in the broadcasting revolution.

Heinrich Hertz, *Electric Waves being Researches on the Propagation of Electric Action with Finite Velocity through Space*, D. E. Jones, translator, 1893. The English translation of Hertz's collected researches on electromagnetic waves, with a preface and introduction that puts his work in historical perspective reaching back to Isaac Newton.
Guglielmo Marconi, Nobel Lecture: "*Wireless Telegraphic Communication*," 1909. Marconi's explanation of how he turned Hertzian waves into a wireless communications technology, in competition with cable telegraphy and uniquely for ship-to-shore and ship-to-ship communications.
Lee De Forest, "The Audion: A New Receiver for Wireless Telegraphy," *Proceedings of the AIEE,* 1906. Lee De Forest's lengthy report to his fellow engineers in New York City on his invention or discovery of electronic amplification of Hertzian waves in a vacuum tube, although he doesn't understand why. For a useful and short critique, see Professor Michael Pupin's discussion in the following issue of Proceedings.
Robert A. Millikan, "Radios Past and Future," *Journal of the Society of Motion Picture Engineers,* 1931. All revolutionary technologies become enmeshed in patent disputes. This article reviews the questions of patent priority and invention, over AT&T's improvement of De Forest's Audion. In 1912 engineer Harold Arnold realized that the Audion essentially needed a stronger vacuum to make it practical for the telephone company's purposes, and he and AT&T's lawyers did not believe that was a patentable invention. Nineteen years later, in 1931, the U.S. Supreme Court agreed.

Radio Station KDKA Historical Marker. Explains KDKA's role in the birth of sports broadcasting. "First Radio Commercial Hit Airwaves 90 Years Ago," NPR, 2012. AT&T controlled the nation's telephone network and

Supporting Question 2

For the second supporting question, students build on their understanding of the broadcasting revolution by analyzing how individuals shaped or tried to shape its direction in the early stages of the era. To help students "think analytically and systematically about how past interactions of people, cultures, and the environment" affected mass media over time and cultures, we use the examples of David Sarnoff and Edwin H. Armstrong. The development of the revolution's first stages helps them understand the complexity of revolutionary reforms and their impact, or lack thereof, on the world's peoples. Students should evaluate whether one person can make a difference and if so, whether that person accomplished his or her vision. They can look back at the political, social, and economic problems to corroborate whether or not early successes addressed and remedied the prerevolutionary issues. The formative performance task for this supporting question requires students to create a TIME Person of the Century magazine cover supporting the contributions of either Sarnoff or Armstrong. This task can be the starting place for the claims that students will write to respond to the compelling question.

Featured Source A is excerpted from the Dictionary of American Biography entry for Armstrong by his biographer, Lawrence Lessing. Teachers can explore with students what factors in his life, and in the times in which he lived, make Armstrong a historic figure.

Featured Source B is from an online biography of David Sarnoff, where Part I covers his early life and contributions to the innovation of broadcast radio, and Part II covers his contributions to the innovation of broadcast television. Teachers can explore with students what factors in his life, and in the times in which he lived, make Sarnoff a historic figure.

Featured Source C is Mike Katzdorn's large website of original documents and artifacts originally from Armstrong's assistant, Harry Houck. Students are asked to consider the roles Armstrong played over his lifetime in the broadcasting industry: that of inventor, entrepreneur, or both.

Featured Source D is from a scholarly paper highlights one of David Sarnoff's early efforts to promote radio as a broadcast medium. However correct his predictions would prove to be, he could not persuade his bosses to innovate radio before consumers forced a response in 1922. Students can discuss how Sarnoff's experiences in the previous decade might have affected his ability to persuade his RCA colleagues and superiors to invest in innovations like television in the 1930s.

Featured Source E is from Jack Ryder's book for electrical and radio engineers about the superheterodyne radio circuit, one of Armstrong's inventions, will help students understand the impact of the technology by making clear its advantages and the rapidity of its adoption by radio manufacturers. The number of editions between 1934 and 1942, and the number of printings of the latest edition suggest the continuing improvements to the circuit and its popularity.]

Additional Resources
In addition, teachers may want students to consider some of these other sources to further their understanding of the people involved in the broadcasting revolution.

The Wikipedia entry on David Sarnoff and the Talk tab suggest some of the controversies surrounding Sarnoff and his business career. They could be used to discuss the role of documentation and judgment in interpreting people's actions and motivations in the past. Alexander B. Magoun, "Why Was Sarnoff Allowed to Sell Stalin Television?" offers a view of relations between the United States and the Soviet Union before the Cold War through Sarnoff and RCA's history. RCA also licensed its electronic television camera and other TV patents to western European and Japanese companies in the 1930s before the war, just as Thomas Edison, IBM, and Ford Motor Company had done before. (6.2.12.C.4.a Analyze government responses to the Great Depression and their consequences, including the growth of fascist, socialist, and communist movements and the effects on capitalist economic theory and practice; 6.2.12.C.3.b Analyze interrelationships among the Industrial Revolution, nationalism, competition for global markets, imperialism, and natural resources.)

Primary Sources: Publications

WorldRadioHistory.com, a not-for-profit gift to the world from David Gleason, who had a successful career in radio, offers an enormous range of primary source magazines and books on "Early Radio"—pre-1950—and the technology, business, and content that went into radio and television broadcasting.

FM Magazine, 1940-1954: First publication dedicated to promoting FM broadcasting, from November 1940's first issue, followed by the *Journal of Frequency Modulation*'s first issue in February 1946, after World War II.

Armstrong articles

Regeneration – Lee de Forest, who had invented the three-electrode vacuum tube at the heart of Armstrong's circuit, never understood its operation or the operation of Armstrong's radio frequency circuit (see Comments after Armstrong's lecture in March 1915). He and assistants had been experimenting with his tube, however, and filed his own patent application for the same circuit, claiming that he and an assistant had conceived, or thought, of it before Armstrong. The Patent Office put his application "in interference" with Armstrong's patent (and two other inventors), and twenty years passed in an incredibly complex series of cases before the U.S. Supreme Court ruled in favor of de Forest's priority of invention. Armstrong's professional and

amateur peers in the Institute of Radio Engineers and the Radio Club of America refused to accept the legal decision and continued to honor him for his technical brilliance and creativity.

Superheterodyne – While engineers agreed that it greatly improved radio reception, only the Radio Corporation of America installed it in radio sets in the 1920s. A superheterodyne circuit was more complicated than alternatives, requiring more knobs for users to adjust, and also cost more to install in receivers. In the early 1930s, however, the increase in the number of stations from 30 (1922) to 605 (1935), and changes in vacuum tubes and manufacturing techniques made the "superhet" circuit practically standard in radios. As John D. Ryder, author of the leading textbook on the circuit, wrote in 1934, "everything is the superheterodyne" and remained that way until digitization of broadcasting in the 2010s.

Super regeneration – That fall, after he received the patent, *Popular Radio* published a photo of Armstrong demonstrating his new radio reception circuit to the Radio Club of America at Columbia University, touting him as the inventor of "three definite contributions to radio," superregeneration following regeneration and the superheterodyne.

Ironically or not, the *Popular Radio* editor placed an article by Armstrong's rival, Lee de Forest, immediately after the photo, about using vacuum tubes to generate musical sounds. Despite the fact that the circuit used only two vacuum tubes to amplify high frequency radio signals to audible levels, it was not selective, which was a problem as more radio stations crowded the AM radio frequencies, or bandwidth.

Super regeneration had two consequential effects, however. RCA's payment enabled Armstrong to pursue the problem on research to develop more selectivity, research that resulted in wideband frequency modulation; and the U.S. air forces used it for the widely spaced signals in the Identification Friend or Foe radios used to distinguish between its planes and the enemy's.

Court decisions and congressional hearing

Armstrong et al. v. de Forest Radio Telephone & Telegraph Company, District Court, Southern District of New York, 17 May 1921, Judge Julius Mayer's decision in favor of the plaintiff, Armstrong, on the regeneration patent: *Federal Reporter*, Vol. 279 (1922), p. 445-454.

293 U.S. 1 55 S.Ct. 928 79 L.Ed. 163 Radio Corporation of America et al. v. Radio Engineering Laboratories, No. 619. Argued May 2, 3, 1934. Decided May 21, 1934. As Modified on Denial of Rehearing Oct. 8, 1934. Justice Cardozo's opinion for the majority ruling in favor of de Forest over Armstrong.

Armstrong v. Levy, Court of Appeals of the District of Columbia, No. 2,085, decided 3 December 1928, 378 O. G. 736; 58 App. D.C. 293; 29 F. (2d) 953. Decision overturning Armstrong's superheterodyne patent in favor or French inventor Lucien Lévy.

Progress of FM radio. Hearings before the Committee on Interstate and Foreign Commerce, Eighteieth Congress, second session, March 30, April 23, May 12, 13, 21, 1948. (Washington,

D.C.: 1948). Twelve hundred pages of testimony, including Armstrong's, reviewing the history of efforts to commercialize frequency modulation radio up to the hearings.

Miscellaneous primary sources

Armstrong website with photos, by years: users.erols.com/oldradio/year.htm; or by document collection highlights: users.erols.com/oldradio/highligh.htm. A useful site of primary source photos and documents scanned in low resolution, from the papers of Armstrong's assistant and colleague, Harry Houck. These were recovered from Houck's collection by a private collector.

Armstrong climbing WJZ tower, 1923
WJZ 1922-1925 page, theradiohistorian.org/wjzgallery/wjzgallery.html.

Secondary Sources

Paper by Prof. Sungook Hong, "A History of the Regeneration Circuit: From Invention to Patent Litigation" puts Armstrong's regeneration circuit in technical perspective: lots of people were trying to improve the qualities and potential of de Forest's Audion in 1912-1913.

D. G. Tucker, "The History of Positive Feedback: The Oscillating Audion, the Regenerative Receiver, and other applications up to around 1923," *The Radio and Electronic Engineer*, Vol. 42, No. 2, February 1972, p. 69-80, also puts Armstrong's oscillation/regeneration circuit, and, very briefly, the superregeneration circuit, in technical and historical perspective.

Alan Douglas, "Who Invented the Superheterodyne?" from *Proceedings of the Radio Club of America*, Vol. 64, no. 3 (November 1990). A thorough review of how Armstrong and French engineer Lucien Lévy both invented the superhet circuit.

Rupert Maclaurin, *Invention and Innovation in the Radio industry* (1949) provides a broad but detailed and documented analysis of the roles of inventors and individual and corporate innovators in developing wireless technology, from Marconi's first telegraphy system to RCA's monochrome (black and white) television system in 1941. He provides useful business analyses of Armstrong's and RCA's decisions: e.g., p. 184-190 for FM.

Gary L. Frost, *Early FM Radio: Incremental Technology in Twentieth-Century America* (2006) provides the best examination of what Armstrong was trying to do with frequency modulation and why RCA opposed FM because he documents his sources, particularly Armstrong's archival papers, unlike previous writers.

John Schneider, "The Beginnings of FM Radio Broadcasting," *The Radio Historian* (2018). Article that draws on sources sympathetic to Armstrong's efforts to commercialize FM broadcasting; should be read in conjunction with Maclaurin's chapter on FM and particularly Frost's last chapter, "FM Pioneers, RCA, and the Reshaping of Wideband FM Radio, 1935-1940." Schneider's use of contemporary magazines is unique for describing the growth of FM radio stations and their owners' commitment to the technology.

Don Erickson, *Armstrong's Fight for FM Broadcasting: One Man vs. Big Business and Bureaucracy* (1973). The title's use of "fight" and subtitle's setting of the scene indicate the author's perspective. He provides extensive quotes from Armstrong and other participants in the various government hearings on FM from 1930s and 1940s.

Jessica Francis, "A Case Study of Edwin Howard Armstrong's Public Relations Campaign for FM," Thesis (Rochester Institute of Technology: 2012). A useful review and analysis of Armstrong's coordinated program to put himself and his radio system before the U.S. public most favorably between 1940 and 1954.

EHA's community of radio amateurs, the Radio Club of America, seen through his and their collaboration on the first trans-Atlantic transmission and reception of shortwave radio messages in 1921: internetwork.com/radio/n1bcg/.

Ham Radio History provides a series of documented chapters of the development of amateur radio, which gives a technical, political, and commercial context to Armstrong's development and demonstration of his radio circuits. It also includes a glossary of ham radio terms and abbreviations: w2pa.net/HRH/.

Supporting Question 3

This supporting question encourages students to grapple with the material and cultural effects of the broadcasting revolution. After engineers and designers simplified broadcast receivers and made them aesthetically attractive by placing them in decorated wooden cabinets in the 1920s, receivers became steadily smaller, cheaper, and simpler into the 1960s. David Sarnoff and RCA led the innovative addition of video to radio receivers with the introduction of television in 1939, and color TV in 1954. In the U.S., sales of radios and then televisions contributed to the development of a public that consumed entertainment as a commodity in the form of soap operas, sitcoms, crime shows, westerns, and super heroes. Radios and televisions were devices for capturing ears and eyeballs for advertisers, and NBC's profits offset RCA's losses on radio sales. Rather than only examining a simple narrative of technological and other forms of progress, students should also consider the range of motivations behind innovations. The Formative Performance Task requires students to closely read and interpret advertisements and period magazines to identify a rationale for consumerism, along with two supporting details.

Featured Source A is a webpage is devoted to radio commercials from the 1920s through the 1950s. The brief recordings, often less than a minute, are "air checks"—made by listeners at home. The author, who has collected the recordings since the 1970s, briefly describes their commercial contexts on individual pages. Most date from the late 1930s onward, when home recording equipment was more widely available. They are not necessarily from the specific years given, which are the first that a corporation began sponsoring a program. Students will likely find these both interesting and amusing. Teachers might use them to spark discussions comparing the monetization of broadcast technologies then and now.

Featured Source B is a digitized collection of magazine and newspaper advertisements (1922-1957) is a subset of Duke University's J. Walter Thompson Company Competitive Advertisements Collection. You can select "Radio" or "Television" subject categories, or search those terms for more results. Searching for "TV" or "RCA" also generates additional ads.

Featured Source C is an archived section of an encyclopedic website that includes "articles and extracts about early radio and related technologies, concentrating on the United States in the period from 1897 to 1927.

Featured Source D is a video produced by the IEEE REACH team to describe the functions and uses of early radio receivers. It features engineer Alan Klase of the New Jersey Antique Radio Club, who explains the effects that radio had on U.S. society and culture in the 1920s. Klase then demonstrates the challenges of tuning in a station on a restored 1925 Atwater Kent Model 20C radio receiver. This video helps to contextualize the other evidence connected with this Supporting Question and provides a firsthand experience with the operation of early radios.

Featured Source E is a REACH-designed Classroom Activity. In this activity, students will write, perform, and record their own original radio programs. Teachers may use this activity to spark discussion about the differences between video and radio productions and their popular consumption. Were radio programs, like the Lone Ranger, essentially different from their modern video counterparts or were the differences restricted to the technology itself?

Supporting Question 4

Having examined the innovations, individuals, and material effects of the broadcasting revolution, students will be asked to assess whether or not broadcasting had social, economic, or political effects within and across the nations of the world. They will analyze primary documents, audio and video recordings, and broadcast transcripts that offer provocative examples of the power of broadcast media. This question's Formative Performance Task requires students to utilize primary and secondary sources in support of an original claim about the impact of broadcasting on a particular country.

Featured Source A is a recording of Orson Welles' infamous radio broadcast, The War of the Worlds. Students will likely find it humorous that so many listeners were convinced that the story was real – that NJ had been invaded by space aliens. This source might give teachers an opportunity to discuss the immense impact of media on the popular mindset. Students might be reminded of the many recent examples of media information – regardless of its veracity – steering the actions of large segments of the population.

Featured Source B is an online collection of presidential speeches. Transcripts date back to George Washington with recordings added for modern presidents, beginning with Warren G. Harding. In conjunction with some in-class historical context, this source might be very effective for analyzing the government uses of broadcast technology and their impact on America and the world.

Featured Source C is a recording of Joseph Goebbels' 1943 speech, "Nation, Rise Up, and Let the Storm Break Loose," delivered at the Berlin Sports Palace. Although the entire speech is in German, students will quickly understand the impact of the Nazi government's use of broadcast technology on the people of Germany by listening to the fervor in Goebbel's words and the reactions of the live audience.

Featured Source D is excerpted from the transcript of Goebbel's speech in Source C. Used together, teachers might help students to better understand the ways by which ideas of propaganda are amplified – literally and figuratively – through the use of broadcast technology. Students may be surprised at the crowd's enthusiastic acceptance of what they may have imagined to be "fringe" ideas. Teachers should note that, much like modern partisan rallies, the Sports Palace had been populated by hand-picked supporters of the Nazi regime. Students should discuss the impact of this information on their understanding of the crowd's reaction, as well as the impact of a broadcast of this sort on other, possibly less fervent, citizens of Germany at that time.

Featured Source E is excerpted from the R.T.L.M. transcripts of Radio Rwanda – a state-run broadcast network – in 1993 and 1994. According to the source website, "[R.T.L.M] Free Radio and Television of the Thousand Hills, was probably the most successful hate radio station in the history of the world." Teachers might use this source in conjunction with Sources C & D to support arguments about the impact of government-sponsored propaganda delivered widely using broadcast technology.

The broadcasters used a chatty, informal format that mixed long monologues with popular, bigoted songs and interviews with members of the Hutu-controlled government, which legitimized their commentaries. They lied about previous massacres of Tutsi by Hutu in Rwanda's history, exaggerated Tutsi violence against Hutus, and employed the same coded language as a "Hutu Power" nationalist newspaper had used for several years. They labelled Tutsi Inyenzi, or cockroaches, and told listeners to "work," to kill, with their "tools," weapons, in cooperation with the army and their neighbors at roadblocks. The unexplained airplane crash that killed Rwanda's president on 6 April 1994 was the pretext for launching the purge of Tutsi from their country. When confronted afterwards with what they had done in interviews or at the International Criminal Tribunal for Rwanda, Hutu participants alternately denied that the genocide had occurred or asserted that the Tutsi deserved extermination.

Students should look in the excerpt for references to roadblocks, Inyenzi, and "work." If there is time and access to mapping software, they might locate the places mentioned in the broadcast. Teachers can use this source in conjunction with Sources C & D to discuss the political uses of broadcasting and support arguments about the impact of broadcast propaganda. It also provides an opportunity to coordinate this supporting question with the genocide unit in English/language classes, as many school districts use readings about the Rwanda slaughter.

Summative Performance Task

In this task, students construct an extended, evidence-based argument responding to the prompt "In what ways did 20th century broadcasting change history?" At this point in the students'

inquiry, they have examined the problems of prerevolutionary innovation, the role of the great individual in a revolution, and the effects of the broadcasting revolution. Students should be expected to demonstrate the breadth of their understandings and their abilities to use evidence from multiple sources to support their specific claims. As students work through the Summative Performance Task, they are demonstrating the social studies skills of Gathering, Using, and Interpreting Evidence, as well as those of Comparison and Contextualization.

Before the Summative Performance Task, it may be helpful for students to review the sources provided and utilize the Evidence to Argument Chart for support as they build their arguments with claims and evidence. (See Evidence Chart below.)

Students' arguments likely will vary but could include any of the following:

- The broadcasting revolution was successful because it gave many people opportunities to inform themselves and sometimes act progressively, even as it anesthetized others to violations of human rights.
- The broadcasting revolution was unsuccessful because it contributed to mass societies of passive consumers and voters.
- The broadcasting revolution was successful in changing attitudes about civil rights in the United States. Although the revolution addressed some of the prerevolutionary problems of communication and information, the successes came at a very high price.

It is possible for students to find support for any of these arguments in the sources provided and through their analysis of the sources.

It is important to note that students' arguments may take a variety of forms. In some cases, teachers may have them complete a detailed outline that includes claims with evidentiary support, and in other cases, teachers may want them to write a paper that formalizes their argument. Their decision to do either may be predicated on whether they plan to do the Summative Performance Extension Task.

Extension

In this task, students will construct an imaginary dialogue between historical and modern figures around the compelling question of whether the broadcasting revolution was successful. At this point in the students' inquiry, they have examined the problems of prerevolutionary innovation, the role of the great individual in a revolution, and the effects of the broadcasting revolution. This extension offers students the opportunity to use evidence from all of these lessons to make and support competing claims and interpretations.

Once students have selected their historical figures, they should articulate what they think that person's perspective on the question might be. It might also be helpful for students to construct a three-column chart of all the evidence from the various historical sources they have encountered that could be used to support a view of the revolution's success or lack thereof. Additionally, it would be important for students to conduct background research on the selected historical figures to avoid overly speculative dialogue. Perspective-taking exercises will always be subject to anachronistic interpretations; however, by foregrounding the exercise with evidenced-based

argumentation, the extension is offered in the hopes that students might engage more authentically with the inquiry.

It might also be helpful for students to offer a menu of choices for the historical figures. Examples might include

- Scientists and engineers: James Clerk Maxwell, Guglielmo Marconi, Lee De Forest, Edwin Armstrong
- Broadcast industry figures: David Sarnoff, William Paley, Walter Cronkite

Twitter might serve nicely as a medium for these conversations for three reasons. First, by asking students to use a modern discourse, it can lead to higher engagement and allow the cognitive load for this task to rest primarily on the historical thinking, setting students up for more complex and mature forms of communication throughout the year. Second, by asking them to translate historical discourse into a modern form of communication, they gain a greater ownership and fluency with the content itself. Finally, Twitter's 140-character limit demands efficiency in students' communication, ensuring a focus on the fundamentals of articulating claims and supporting them with evidence.

Teachers might ask students to create actual Twitter accounts with fake names. Alternatively, students could construct a script of an imaginary conversation. Of course, if the Twitter aspect of the assignment unnecessarily complicates things for students (or teachers), any form of scripted conversation could accomplish the same historical and literacy goals for this assignment.

This inquiry includes a sample handout (see below) that could be used by students for this task. Teachers can adapt it to fit the conventions of their class and school, particularly around length and medium of submission.

Evidence Chart

Initial Claim	
What is your opening claim about the success of the broadcasting revolution? This claim should appear in the opening section of your argument. Make sure to cite your sources.	

Evidence	
What evidence do you have from the sources you investigated to support your initial claim? Make sure to cite your sources.	

Additional Claims	
What are some additional claims you can make that extend your initial one? Make sure to cite your sources.	

Additional Evidence	
What additional evidence do you have from the sources you investigated that support your additional claims? Make sure to cite your source.	

Double Check	
What ideas from the sources contradict your claims? Have you forgotten anything? Make sure to cite your sources.	

Pulling it Together	
What is your overall understanding of the compelling question? This should be included in your conclusion. Cite your sources.	

Handout for Summative Extension (Optional)

Over the past few classes, you have sought to answer the question "Did broadcasting change societies during the 20th century?" At this point, you have examined the problems of innovation, the role of the individual in implementing the broadcasting revolution, and the effects that the governments and businesses running broadcast technologies had on various publics. For your final assignment, you will seek to demonstrate the understandings, knowledge, and skills you have developed throughout the inquiry. You are expected to use evidence from these lessons, as well as any additional evidence you find, to make and support *competing* claims about the broadcasting revolution.

Task:

Construct an imagined Twitter conversation among three historical figures: a wireless scientist or engineer, someone from the broadcasting industry, and an intelligent 10th grader living today. The topic of the conversation is "Did broadcasting change societies during the 20th century?"

Below is a list of options for the figures in your dialogue. You are welcome to propose alternatives in each category:

Scientist or engineer:

- James Clerk Maxwell, Heinrich Hertz, Lee De Forest, Edwin Armstrong, H. P. Arnold, Frank Conrad, Vladimir Zworykin, Philo Farnsworth.

Broadcasting figure:

- David Sarnoff, William Paley, Walter Cronkite

Intelligent 10th Grader:

- Yourself, someone in the class you admire and respect, how you imagine your teacher as a 10th grader

Guidelines:

- Each participant in the conversation should make a clear claim about the success of the broadcasting revolution; there should be disagreement among the claims.
- Each participant should cite specific evidence from the historical sources analyzed in the inquiry. You could find support for any of these arguments or additional arguments in the sources provided and through carefully reading and analyzing the sources.

Taking Informed Action

Taking informed action can manifest itself in a variety of forms and in a range of venues: Students may express action through discussions, debates, surveys, video productions, and the like; these actions may take place in the classroom, in the school, in the local community, across the state, and around the world.

The three activities described in this inquiry represent a logic that asks students to (1) *understand* the issues evident from the inquiry in a larger and current context, (2) *assess* the relevance and

impact of the issues, and (3) *act* in ways that allow students to demonstrate agency in a real-world context.

For this inquiry, students draw on their conceptual understanding of the term "revolution" to think about the nature of contemporary revolutions. Clearly, there are many modern-day examples of political revolutions they could investigate, but they should also consider other types of revolutions, including economic, social, or even technological revolutions. In this way, students will be able to transfer their knowledge around the French Revolution to other contexts, evaluating the ways in which revolutions can be similar or different and ultimately successful or not.

To *understand* the situation, students could identify a current unfinished revolution, focusing on a group of people who are currently trying to revolutionize some element or aspect of contemporary society. They might select a political revolution (e.g., Syria), but students might also choose a social, economic, or technological revolution. Students should read about the effort and assess the extent to which this group has been successful and the challenges they currently face. Additionally, students should take a stand on the revolution, taking into account their personal reactions and support of the revolutionary effort. In doing so, they may also consider the overuse of the term "revolution" and the extent to which the effort is, in fact, revolutionary. Lastly, students could write an editorial for the school or local newspaper. Within the editorial, students might discuss their positions on the efforts of those engaged in revolution and the extent to which those efforts are currently successful.