Early FM Radio

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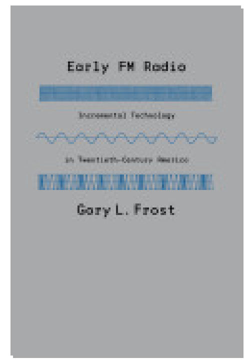

Published by Johns Hopkins University Press

Frost, L..
Early FM Radio: Incremental Technology in Twentieth-Century America.
Baltimore: Johns Hopkins University Press, 2010.
Project MUSE., https://muse.jhu.edu/.

Conclusion

> By a process of evolution, [frequency modulation] may well supersede most of our existing system of radio before ten years or less.
>
> *American broadcast engineer, 1940*

> What's wrong with American FM?
>
> Popular Electronics, *1962*

This book has situated the history of FM between two complementary questions: Was frequency-modulation radio socially constructed? Or was it determined by natural law? The answer to both questions is yes, but the social origins of the technology exerted far more influence than did nature. Nature constrained what was technologically possible, ruling out narrowband FM, for example, by refusing to cooperate with those who counted on that method to solve the problem of spectrum congestion. But closing off one path still left a virtual infinity of other paths from which to choose. In other words, the "black-boxed" version of FM that we hear today was not the only possible result, or even the most likely or optimal outcome. In 1940 the FCC mandated a set of specifications to which FM broadcasters and transmitter and receiver manufacturers had to conform—namely, a 200-kilocycle channel width, a 150-kilocycle frequency swing, and a 15-kilocycle audio bandwidth. FM radio in America and many other countries is still based on these specifications. But no *technical* reason has ever existed to prevent the commission from diverging from that standard, choosing, for example a 100-kilocycle channel, a 50-kilocycle swing, and a 10-kilocycle audio bandwidth. The FM we hear today essentially matches the system that Armstrong and other FM pioneers had standardized by 1939 only because the FCC accepted their judgment in 1940.

The years of continuously shifting social factors, ranging from the organizational to the personal, strongly shaped the technology of FM radio. The amateur radio community played a key role in the long-term development of FM systems by educating a generation of boys about radio before World War I. Many adolescent hams grew up to become professional engineers, and nearly every professional engineer who did significant work with frequency modulation during the 1930s and 1940s entered the radio technology community as a youngster. Further, amateur radio clubs found and created forums for hams to hone their skills as public practitioners and engineers. The Radio Club of America sent Armstrong to the Hoover Radio Conferences that first met in 1922, and several members assisted him in exhibiting and promoting wideband FM in the 1930s. The amateur radio community also provided an alternative complimentary culture to the corporations that employed radio engineers. Radio clubs encouraged the free exchange of information, as opposed to companies, which placed a higher priority on the control of proprietary secrets. Thanks to those clubs, radio engineering was a relatively communal profession.

A number of changes in the context of radio during the twenties and thirties also shaped the present system of broadcast FM radio and helped determine when it appeared. None of these changes can be considered simply technological or social in the traditional overly narrow meanings of those words. The congestion of AM radio broadcasting triggered a conceptual move to the spectrum paradigm, which in turn shaped the debate about how radio in general should be regulated. Congestion and the new paradigm accounted as well for why engineers took another look at FM radiotelephony during the early 1920s, after twenty years of that technology's dormancy. Narrowband FM, for a brief time, signified for some people the best hope for curing congestion, but they soon discovered the futility of that idea. Nevertheless, for two reasons this disappointment marked one of the most valuable lessons in the history of FM: first, it taught that narrowband could never work; and, second, it inspired minded engineers at Westinghouse and RCAC to develop further the mathematical theory behind frequency modulation.

An even more significant accelerant to FM research originated entirely within the commercial context of radio. During the first half of the 1920s, engineers at General Electric, Westinghouse, and RCAC independently investigated frequency modulation, albeit while envisioning different purposes for the method. Although noncompetition contracts tied these companies together, the firms did not cooperate on FM research until they began to implement David Sarnoff's short-lived unification plan in 1928. By compelling GE and Westinghouse to share the results of their radio research with RCAC, unification effectively funneled almost everything that was known about FM to the latter organization, an intellectual windfall that spared RCAC engineers a great deal of spadework. Without unification, some sort of practical FM would have emerged from Westinghouse or RCAC (or perhaps another source), although any hypothetical system would have arrived perhaps decades after 1933, the year that Armstrong was issued his wideband patents. In retrospect, the union of Westinghouse and RCA research benefited Armstrong more than anyone.

If Armstrong was a great engineer, it was not because he was a genius, unless one considers his remarkably dogged ability to frame and reframe sometimes unworkable theories. For all the errors he committed while developing wideband FM—his theoretical misconception of balanced amplifiers, for instance, and his assumption that frequency-modulation radio would have no effect on static noise—he ranks as a superb designer of radio hardware. The singularity of his technological achievements existed, though, within a social, economic, and cultural context in which the theory and practice of frequency-modulation radiotelephony was already familiar to, if not mastered by, scores of his colleagues. Traditionally depicted as an independent inventor who single-handedly invented wideband FM, Armstrong in fact stood on the shoulders of earlier researchers who had labored, often successfully, on many problems associated with FM. This is not to minimize his several crucial improvements to the art, such as a radically wider frequency swing and a balanced-amplifier detector that replaced the old slope detector. But his invention of wideband FM and his development of a broadcast service depended on both indirect and direct assistance, especially from RCA. All during the 1920s and early 1930s, he exploited his unique access, as a consultant, shareholder, and friend, to the work and material support of RCAC engineers, who themselves had recently acquired valuable knowledge from Westinghouse and GE. Moreover, Armstrong rarely reciprocated, typically keeping his work secret until his patents were securely in hand. And when it came time to sell FM to the FCC, it was FM pioneers who did so, another instance of how Armstrong relied on communities of practitioners to further his goals and continue to shape frequency-modulation technology.

This study also overturns the fifty-year-old conventional explanation for Armstrong's greatest disappointment during the 1930s: his failure to obtain RCA's backing for wideband FM. Why RCA squandered its chance to acquire the rights to wideband FM is attributable to a number of causes, but the company's desire to protect its investments in AM technology was not one of them, as amplitude-modulation radio broadcasting accounted for only a tiny proportion of RCA's overall capitalization and income. Rather, RCA's hitherto puzzling behavior occurred chiefly because FM was at first so theoretically abstruse. Because no one, including Armstrong, foresaw until the spring of 1934 what advantages (such as static noise suppression and high fidelity) wideband FM would ultimately offer, the tests he and RCA carried out that year were not designed to confirm, let alone quantify, those advantages. Instead, RCA evaluated FM only with respect to the primary claim of Armstrong's patents—namely, that the system extended the service range of short-wave communications. The testing strategy, which narrowly focused on only this feature, created a distorted picture of Armstrong's invention, and no credible consensus developed within RCA about what he had actually invented. It was an acute, though understandable, blunder for which Armstrong himself shoulders much of the blame, because he misunderstood wideband FM radio, too. Still, the company might have sponsored the Armstrong system had a half dozen or so of its managers caught the error in time. Instead, RCA's engineer-managers continued obliviously both to play down the technical potential of wideband FM and, later, to underestimate the persuasive power of the ever-growing community of FM pioneers. As a result, RCA let FM get away.

Despite Armstrong's inability to win over RCA, this book elevates him as an exceptional "heterogeneous engineer"—that is, an individual who played the "social" side of the technology he promoted as skillfully as he played the side that is traditionally seen as technical.[1] One can understand this role and Armstrong's relationship with both RCA and the FM pioneers in terms of "actor-network theory," as conceived by sociologists of technology approximately fifteen years ago. From the early 1920s until 1936 Armstrong was associated with the "pre-existing network" of the RCA organization at large. When he failed to obtain RCA's backing, he created a new "social-technological" network by recruiting—sociologists would say "enrolling"—FM pioneers to help further improve the technology and to sell FM to the public. In doing so, Armstrong became a "dedicated network builder."[2] His most valuable recruit, John Shepard III, was also an experienced "network" builder in two senses of the term when Armstrong met him. Shepard had, of course, created the first (temporary) radio network as an experiment in 1923, and afterward, even while leading the FM movement, he presided over an organization of regional AM broadcasters that he had cofounded. By late 1939 Shepard headed FM Broadcasters, Inc., the group he had almost single-handedly created for the purpose of lobbying the FCC on behalf of the Armstrong system. Thanks to a strategy largely of Shepard's design, the commission gave FM an "enthusiastic green light" only a few months later.[3]

The history of FM radio helps drive another stake into the heart of technological determinism, which in 1985 Wajcman and Mackenzie asserted was "the single most influential theory of the relationship between technology and society."[4] The belief that the evolution of technology operates according to its own internal logic, or that external factors minimally bear on that evolution, has waned in popularity during the past twenty years, especially among scholars who study the history and sociology of science and technology. But technological determinism is nowhere near its deserved death, due partly to writers who still neglect interrelated technological and social contexts in modern life. According to Thomas Misa, someone who commits the error of technological determinism often adopts the wrong "perspective" in how he or she approaches the object of study. "Those historians (and others) adopting a 'macro' perspective are the ones who allow technology a causal role in historical change. They deploy the Machine to make history." As a partial solution, obviously, one can adopt—as does this book—a sufficiently "micro" perspective in which the "causal role for the Machine is not present and is not possible."[5] But while assuming a micro perspective one should not also revert to old-fashioned internalism, which disconnects technology from society in other ways. A historian must at least take into account the exogenous factors that continually shape the hardware that emerges from the experiences of technological practitioners. And without denying that technology "impacts" society, we must keep in mind that society *always* acts on technology as well. Indeed, this book examines the origins of a specific technology during a period when that technology influenced society minimally, if at all.

Finally, this book contributes to a long-standing debate in the field of science, technology, and society studies about the role of nature in technological innovation. As with technological determinism, the argument that nature plays no part in the construction of technology is made far less vigorously today than a few years ago, but the idea survives in many corners of academia. The history of FM provides ample empirical evidence that nature imposes limitations on what technology can and cannot do. Walter Vincenti has pointed out that when Thomas Edison was developing his electric lighting system from 1877 to 1882, at least two simple "non-negotiable" technical constraints imposed by the "real world" constrained Edison and his staff: Ohm's law, for current, voltage, and resistance ($I = V \div R$); and Joule's law, for electrical power, resistance, and current ($P = R \times I^2$). Vincenti avoids making a simple essentialist argument by allowing that these formulas are "human artefacts, subject to modification or coercion over time." But he also asserts that "in the absence of anything demonstrably better, power engineers have to take them—in fact, they think of them—as tantamount to the real world itself."[6]

Of course, *thinking* of a statement as “tantamount to the real world” does not ensure that the statement *is* tantamount to—or even descriptive of—the real world. But the fact that no one has documented a violation of Ohm’s and Joule’s laws—despite powerful social, economic, and technological incentives for doing so—constitutes compelling evidence that we sometimes just cannot interpret our way around a natural law, whether that law is socially constructed or not. Indeed, the history of FM provides a far stronger and more interesting role for nature than does Ohm’s law: not only did FM inventors believe that they were constrained by the same *known* laws that governed Edison, but practical FM radio turned out to be constrained as well by *unknown* laws that researchers had to feel out for themselves. In three notable instances, those laws contradicted the previous expectations of researchers. First, narrowband FM advocates hoped that they could cure congestion on the AM broadcast band. Second, Armstrong believed, for a several years, that balanced amplifiers would reduce static noise. And, third, he was so certain that FM could not suppress static and that wider channels always brought greater noise levels that he memorialized his conviction in one of his famous wideband FM patents of 1933. In all three cases, testing demonstrated the original conceptions as wrong. No engineer, not even an Armstrong, Crosby, or Hansell, could bend frequency-modulation technology according to his ideology or other social values in contravention of the rules of the natural world.

Nearly seven decades have passed since the Federal Communications Commission established a commercial FM broadcast service, during which FM radio has continued to reflect the political, economic, and aesthetic values of society.[7] Today the FCC reserves a 4-megacycle portion of the FM broadcast band for nonprofit organizations, an artifact of Armstrong’s strategy to bring as many AM broadcasters into the FM camp as he could afford. During the 1930s, he assessed commercial broadcasters relatively modest fees for using his fifteen FM patents—$5,000 for a 50,000-watt transmitter, for example. But educators received an essentially free ride because Armstrong charged them only one dollar.[8] As more and more colleges and universities applied for FM station licenses during the 1940s, New Deal reformers, including most FCC commissioners at the time, increasingly saw the Armstrong system as “radio’s second chance” for education, since the FRC had withdrawn the great bulk of AM licenses for educational broadcasters in the 1920s and 1930s.[9] Over the long term, Armstrong’s strategy worked. Today hundreds of educational and other nonprofit organizations in America operate FM stations.

Wideband FM was the first high-fidelity mass medium, and the FCC has traditionally fostered further improvements in its quality. In 1961 the commission authorized FM stations to use a multiplexing technology in their transmitters that made possible stereophonic radio broadcasts.[10] Although multiplexing slightly degraded the signal-to-noise ratio, on balance most listeners accepted the trade-offs. At first the improvement appealed mainly to "hi-fi" buffs, many of whom played classical music exclusively to show off FM's wider audio frequency response and greater dynamic (loudness) range.

FM broadcasting spread erratically during the fifties. Ironically, it only puttered along in America, attracting more listeners in urban than in rural areas, but never really challenging its older rival until nearly forty years after Armstrong was issued his patents. Not until 1983 did American FM stations outnumber AM stations.[11] FM often found far more popularity abroad, especially in Europe and the USSR. As a Soviet broadcast engineer pointed out during the early 1960s, "You Americans had the technical ability to produce FM, but it takes us and the Europeans to show you how to use it." In 1961 only 912 American FM stations were licensed, a *decrease* of 10 percent from 1950, and a fraction of the number of AM stations. By contrast, European stations during the same period climbed from 4 in number to approximately 1,000. One reason was that European radio tended to be government operated, and therefore listeners had fewer alternative sources for programs on AM bands. But also, European listeners heard more variety on their FM receivers than did Americans. During the 1950s one of the most popular networks in Germany—FM or AM—was the American Armed Forces Radio Service, established during the post–World War II occupation, and which aired jazz, popular, and even rock-and-roll music.[12]

FM in America, however, became associated narrowly with a highbrow culture that some characterized as overly devoted to "educational radio" and classical music. "If the AM band has become the home of rock-and-roll," one American critic complained in 1962, "much of the FM band is nothing more than a classical juke box."[13] Woody Allen made a similar point fifteen years later in his 1977 film, *Annie Hall.* While attempting to impress his new girlfriend, the insecure protagonist, Alvy, realizes that he has resorted to pretentious jargon about modern photography. "Christ," he tells himself, "I sound like FM radio!"[14]

Making fun of FM's highbrow reputation worked in 1977, but not ten years later, for within that decade FM radio would undergo another transformation. As historians of postwar radio have explained, several historical events removed the taint of high culture from American FM. Most important, rock music of the 1960s and 1970s, much of which demanded audio fidelity beyond the technological limits of AM, found a home on the underpopulated FM band.[15] Eventually, many FM stations became commercially successful, but other problems now afflict the FM band. As the ownership of American media becomes increasingly concentrated and less diverse, listeners are served up more and more predictable and ever blander programming. National broadcasters have invested in technology that enables the production of generic programs in, say, Los Angeles, that are disguised as locally produced shows in dozens of distant cities.

No reason exists to assume that the present sorry state of the medium is permanent, but can we know FM's future? There is some truth in Howard Armstrong's declaration that "the best way to look into the future is to look at the past."[16] But the history of FM indicates that forecasting the future of technology can be, at the very least, tricky. In October 1940 the chief engineer of radio station WOR, John R. Poppele, predicted before a meeting of the Radio Club of America that, "stemming from such a rosy present, it seems inevitable that FM will have an illustrious career of steady growth. . . . By a process of evolution, it may well supersede most of our existing system of radio before ten years or less."[17] Later events soon proved Poppele dead wrong, and now, at the dawn of the twenty-first century, developments in communications technology becloud FM's future more than ever. Digital modulation could render both FM *and* AM broadcasting obsolete within a decade or two. Or perhaps the FCC's present policy of encouraging low-power FM will revive community broadcasting by fostering thousands of short-range, low-wattage transmitters.[18] Indeed, the difficulty of predicting the future of FM demonstrates the principal argument of this study—namely, that a technology is no more inevitable than the historical events that continually shape it.