

Oppositional Uses of Technology and Corporate Competition

The Case of Radio Broadcasting

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Introduction

The study of technological competitiveness, especially in the United States in the twentieth century, usually focuses on competition within or between corporations, both large and small. Such studies also highlight the struggles between independent inventors and established industries. But as we consider how competition serves to stimulate or retard technological change, we also need to examine an area many corporations have sought to eliminate or suppress—the oppositional, often renegade applications of their devices or systems by subcultures of American tinkerers. This requires that we take a more bottom-up approach to competition.

This chapter focuses on the oppositional uses of audio technology, specifically radio and the hi-fi phonograph, and the key role these applications play in identifying underdeveloped or completely neglected areas of commercial development.¹ These appropriations of audio technology were pioneered by two often overlapping groups—the youth subculture and the engineering, tinkering subculture—in a way that often linked technical rebellion with cultural rebellion. This rebellion, which has been most recently dramatized by the controversies surrounding computer hackers, stems from a host of intersecting attitudes, which include a resistance to or rejection of technical hierarchies that seem too authoritarian and arbitrary, an antipathy toward corporations and corporate applications of technologies, and a sense of technical contempt or one-upmanship vis-à-vis devices made available to a mass market. Yet this corporate antipathy is often mixed with a need and desire to succeed in the corporate world, so these oppositional uses of technology are often the site of major cultural contradictions surrounding the corporate ethos in the United States.

This chapter considers three examples: the amateur wireless operators,² or “hams,” who pioneered in radio broadcasting at the very earliest stages of the commercial exploitation of radio in the United States; the hi-fi enthusiasts of the late 1940s and early 1950s,³ who challenged the corporate complacency surrounding phonograph equipment; and FM programmers of the late 1960s and early 1970s, who used this previously neglected technology to develop new broadcasting formats and to cultivate new audiences.⁴

What all these technical subcultures had in common was that their use of audio technology deviated significantly from the expectations of the originators and producers of these inventions, and from the business interests that took them over. The degree of conscious defiance animating members of these groups varied, however. While a subgroup of the hams challenged the government’s automatic appropriation of portions of the electromagnetic spectrum for military uses, and the hi-fi enthusiasts repudiated what they saw as technological complacency in the phonograph industry, the underground FM programmers attacked the entire political and cultural establishment as they saw it. These technologies allowed for—even invited—oppositional, antiestablishment uses primarily by white middle-class men and boys, who were expected, and eventually compelled, to integrate into institutional bureaucracies, yet who yearned to postpone such integration. Their use of these technologies allowed them to rebel. But it also provided them with critical technical expertise that would subsequently become valuable in the job market.

In all of these cases—wireless, hi-fi, and FM—men with their own technical and social agendas appropriated still underdeveloped audio technology and pushed it to new levels of performance and new realms of application. Their oppositional activities exposed areas of corporate and technological myopia. The corporations managing these technologies had to respond to the innovations of these hobbyists, and did so by co-opting and taming outlaw practices to create huge new businesses.

A Brief History of the Radio Amateurs

On a Sunday in 1907, the *New York Times Magazine* featured as its lead story an article starring Walter J. Willenborg, a previously unknown wireless experimenter and a student at Stevens Institute of Technology in Hoboken, New Jersey.⁵ A large oval portrait of Willenborg in the center of the page was surrounded by photographs of his homebuilt wireless station, which included transmitting and receiving equipment. The reporter described in excited detail all the messages he was privy to by listening in to “the ether” on Willenborg’s headphones. Willenborg made such good copy that he was also featured in a 1908 issue of *St. Nicholas*, “An Illustrated Magazine for Young Folks.”⁶

Willenborg was one of the young men the press chose to represent the burgeoning number of nameless amateur operators in the country. Since 1899, when Guglielmo Marconi (1874–1937) had first introduced his wireless telegraph to the United States during the America’s Cup races, the prospect of sending telegraph messages through “the air” without wires had generated enormous excitement in newspapers, magazines, and the technical press. This excitement helped spark a new

fad, and from 1906 onward, thousands of primarily white, middle-class boys and men began to construct their own wireless stations in their bedrooms, attics, or garages. Although they were to be found throughout the country, these amateur operators were most prevalent in urban areas, especially those with seaports. They hoped to listen in on messages sent by the navy, commercial ships, and shore stations, as well as to send Morse code messages back and forth to each other. They earned no money as operators, and had no particular corporate or professional affiliation. For them, wireless was a hobby, one that required technical knowledge and skill. The technical fraternity these amateurs formed was exclusive. Working-class boys with neither the time nor the money to tinker with wireless could not participate as easily. Neither could girls or young women, for whom technical tinkering was considered a distinctly inappropriate pastime and technical mastery a distinctly unacceptable goal.

The amateurs' ingenuity in converting a motley assortment of electrical and metal castoffs into working radio sets was quite impressive. With performance analogous to that of an expensive receiver now made available to them in the form of the inexpensive crystal detectors that had been introduced in 1906, the amateurs were prepared to improvise the rest of the set. Before 1908, they lacked this option, for very few companies sold equipment appropriate for home use. As the boom continued, however, children's books, wireless manuals, magazines, and even the Boy Scout manual offered diagrams and advice on radio construction.

In the hands of amateurs like Willenborg, all sorts of technical recycling took place. Discarded photography plates wrapped with foil served as condensers; cylindrical Quaker Oats containers wrapped with wires became tuning coils. One amateur recalled that he improvised a loudspeaker by rolling a newspaper into a tapered cone. Another inventor's apparatus was constructed ingeniously out of old cans, umbrella ribs, discarded bottles, and various other articles. The one component that was too complicated for most amateurs to duplicate, and too expensive to buy, was the head-phone set. Consequently, telephones began to vanish from public booths across America as the amateurs took them for their own stations.

By 1910, amateurs surpassed the U.S. Navy (the major governmental user of wireless) and the private wireless companies in numbers and, often, in the quality of the apparatus they owned. In 1911, *Electrical World* reported:

The number of wireless plants erected purely for amusement and without even the intention of serious experimenting is very large. One can scarcely go through a village without seeing evidence of this kind of activity, and around any of our large cities meddlesome antennae can be counted by the score.⁷

The *New York Times* estimated in 1912 that America had several hundred thousand active amateur operators.⁸ Even after passage of the Radio Act of 1912, which sought to regulate and stifle amateur activity in the air, the number of enthusiasts continued to grow. Between 1915 and 1916, the Commerce Department licensed 8489 amateur stations, compared to fewer than 200 commercial shore stations. Estimates placed the number of unlicensed receiving stations at 150,000.

One characteristic seemed especially prevalent among these amateurs: their disdain for authority and their delight in using this new technology to flout it. While

most amateurs used their equipment to gossip, trade technical information, share football or baseball scores, or compare homework, some were considerably more mischievous. The increased presence of amateurs on the airwaves, at a time when tuning was crude and interference was common, led to a struggle for control of the ether. This struggle especially pitted the more defiant amateurs against the U.S. Navy. Pretending to be military officials or commercial operators, they would dispatch naval vessels on all sorts of fabricated missions. Navy operators would receive emergency messages about a ship that was sinking off the coast. After hours of futile searching, the navy would hear the truth: the “foundering” ship had just arrived safely in port. For some, this was simple pranksterism, the sort of delinquency that is irresistible when the target is distant and detection virtually impossible. But other amateurs had a more thoroughgoing critique of what they saw as an arbitrary usurpation of the airwaves by the state, and expressed their indignation by sending obscene messages to naval stations, and arguing extensively with naval operators over ownership of the ether. Military officials complained bitterly to Congress about what they regarded as etheric outlaws, and the more politically conscious amateurs responded by sending their own representatives to Washington to testify against military domination of the spectrum. The navy was hardly helped in this skirmish by the often romanticized portrayals of wireless operators in the popular press.

Increasingly, magazines, newspapers, and popular fiction celebrated the wireless dabbling of these young men. Fictitious Tom Swift, boy inventor, used radio to rescue people in distress, and by the 1920s there was an entire series of adventure books called *The Radio Boys*. Stories like the ones written about Willenborg captured the many attractions that wireless experimentation might hold for a young man. On a practical level, a successful wireless dabbler could make extra money from his pastime. He would have technical knowledge and skills few others possessed. He learned a code and he became an explorer. Through wireless, he entered an invisible, mysterious realm, somewhere above and beyond everyday life, where the rules for behavior couldn't be enforced—in fact, were not yet even established. He could participate in contests of strength, power, and territory, by interfering with or interrupting other stations' messages, and win them without any risk or physical danger. In this realm, by mastering a new technology while letting his antisocial inclinations run loose, he could be, simultaneously, a boy and a man, a child and an adult.

A revolutionary social phenomenon was emerging. A large radio audience, whose attitude and involvement were unlike those of other, traditionally passive audiences, was taking shape. This was an active, committed, and participatory audience. Out of the camaraderies of the amateurs emerged more formal fraternities, the wireless clubs, which were organized all over America. One of the largest, formed in 1914 by the inventor Hiram Percy Maxim (1896–1936), was the American Radio Relay League (ARRL), which organized a national amateur network of stations across the country through which amateurs could relay messages to and for each other. Thus, by the mid-teens there existed in the United States a grass-roots, coast-to-coast communications network, and an incipient radio audience. When ARRL was formed, *Popular Mechanics* proclaimed “the beginning of a new epoch in the interchange of information and the transmission of messages.”⁹ The way these amateurs used the invention, trying to reach as many people and to be as inclusive as possible was the

opposite of the more closed, exclusive policies of the private companies and the navy. Through their activities, the amateurs raised the question: “Why restrict this invention to a few select corporate and military senders and receivers when so many everyday people could benefit from and enjoy this device?”

Amateur activity increased dramatically during the second decade of the century, and some of the more powerful stations transmitted voice and music. As early as 1909, the radio inventor Lee De Forest (1873–1961) had begun using more sophisticated transmitting equipment to broadcast music and the human voice, and the amateurs’ crystal detectors were capable of receiving such broadcasts. By 1914, De Forest was broadcasting voice and music fairly regularly from his station in Highbridge, New York, and other amateurs with similarly powerful equipment followed suit. By contrast, the wireless companies and the military stuck to sending the Morse code, and ignored this new use of radio. Amateur stations were temporarily shut down during World War I, but when they returned to the air in 1919, the amateurs with access to transmitting tubes began broadcasting voice and music on a more regular basis. Other amateurs listened in, and got their families and friends hooked on the hobby. It is important to emphasize that this way of using radio was completely at odds with how Marconi, the device’s inventor, had envisioned its applications. He had seen radio as helping the military, shipping firms, and the press expedite the transmission of coded messages between specific senders and receivers. The broadcasting of voice and music was simply not part of his agenda: this was an innovation of the amateurs.

By 1920, there were 15 times as many amateur stations in America as all other types of stations combined. Yet the executives of the Radio Corporation of America (RCA), which was formed in 1919 to buy out the British-owned Marconi Company of America and to consolidate the U.S. radio industry, regarded its main business as the transmission of long-distance Morse code messages. By late 1920, however, with the amateurs leading a huge radio boom in the United States, RCA had to redefine its mission. The amateurs and their converts had constructed the beginnings of a broadcasting network and audience. They had embedded radio in a set of practices and meanings vastly different from those dominating the offices at RCA. Consequently, the radio trust had to reorient its manufacturing priorities, its corporate strategies, and, indeed, its entire way of thinking about the technology under its control.

By the 1930s, it was the major corporations, not the amateurs, who dominated America’s airwaves. But a robust subculture of hams continued to transmit and to listen, especially with shortwave, and to tinker. One device they began tinkering with was the phonograph. By the early 1950s, this tinkering would revolutionize the recording industry in the United States.

Audiophilia

“A new neurosis has been discovered,” *Time* sarcastically exclaimed in January of 1957, “audiophilia, or the excessive passion for hi-fi sound and equipment.”¹⁰ Sufferers were usually “middle-aged, male and intelligent, drawn largely from profes-

sions requiring highly conscientious performance.”¹⁰ Six years earlier, *The New Yorker* had described the hi-fi craze as the fastest growing hobby in America.¹¹ As early as 1952, the sales of hi-fi equipment to audiophiles had climbed to \$70 million a year,¹² and sales figures were still soaring. And this was before corporations began to manufacture and market sets for the general, nontinkering public. By the mid-1950s, the phonograph industry, which had, according to a September 1957 article in *Business Week*, “once looked down on hi-fi fans as mere fanatics,”¹³ was scrambling in to meet the new demand.

The hi-fi craze of the late 1940s and 1950s had been started by tinkerers dissatisfied with the sound quality available in commercially manufactured phonographs. They thus began assembling their own “rigs” out of separate components, paying special attention to and customizing the wiring that connected the parts into a whole. The proper matching and balancing of components was critical to success. The goal was to reproduce in one’s living room the way classical music sounded in a concert hall. The most sensitive human ear can hear sounds ranging from 20 to 20,000 cycles per second (cps). Most old 78 rpm records could only play up to 7500 cps, and AM radio could reach a maximum of 10,000 but usually broadcast at 5000 cps. Audiophiles wanted to push beyond these restrictive ranges, which cut off the highs as well as the lows of most music.

This quest for fidelity gained impetus from several key developments during and just after World War II. The wartime shortage of shellac, the principal ingredient of records at that time, prompted research into other materials. The result was the introduction in 1946 of the vastly superior Vinylite. Columbia records used the material to introduce its new, 33 $\frac{1}{3}$ rpm long-playing (LP) record in the spring of 1948. Using considerably finer grooves than the 78 rpm, the LP provided three to four times the playing time with considerably reduced surface noise, and with additional range and clarity. The LP could record up to 12,000 cps, twice the range of the shellac 78 record. In addition, the shift to magnetic tape in the late 1940s dramatically enriched the quality of recording. Yet most existing phonographs failed to do justice to the new LPs.

During the war, many service personnel and civilians were trained in the fundamentals of electronics in order to participate in the manufacture, installation, and operation of radar and other communication equipment. Those stationed in Europe, especially in England, became acquainted with the striking superiority of sound engineering abroad, and the significantly higher quality of music reproduction and phonograph equipment. After the war, when these men and women resumed civilian life, some brought imported audio components home, while others bought surplus amplifiers and other kinds of electronic gear from the government. Small electronics companies also began to improve amplifiers, speakers, and other components. Armed with their recent training, soldering irons, miles of wire, and a host of experimental circuit designs, these people formed the initial core of the hi-fi enthusiasts who sparked the skyrocketing component parts trade of the late 1940s and early 1950s. The custom-built sets they assembled often provided twice the fidelity of reproduction that one could get from the most expensive commercial system, and for one-half to one-third the price. Magazines from *Popular Mechanics* to *The Saturday Review*

began to run regular features on hi-fi construction, musical developments, and the intense technical debates that raged among hobbyists. In 1951, a new quarterly called *High-Fidelity* began publication, and in one year its circulation leapt from zero to 20,000.¹⁴

The hobby's rate of growth was breathtaking, producing enormous sales for the small companies willing to cater to audiophiles by selling high-quality components. By 1953, approximately one million Americans had invested in custom-built sets. Firms such as Fisher Radio Corporation and Altec-Lansing reported that sales had increased by twenty times between 1947 and 1952.¹⁵ The quality of sound on these sets often produced instant converts: once someone heard a record on a custom-built hi-fi, the listener had to have a set of his or her own. For those incapable of building their own sets, small firms such as Electronic Workshop would install a customized set. One repeatedly noted characteristic of audiophiles was that they were never satisfied; they were constantly striving for greater fidelity, and spent endless hours and hundreds of dollars a year trying to approximate perfection. They were also completely disdainful of corporate America's audio offerings.

Another characteristic many of these enthusiasts shared was a deep aversion to the other new electronic invention sweeping the United States, the television. Their devotion to musical authenticity, and their antipathy to the passive, physically idle consumption of popular culture, made many of these audiophiles the first dedicated listeners to FM radio. The quest for fidelity, in other words, was not only a technical quest driving the improvements in hi-fi equipment and then in FM transmitting and receiving, but also a cultural and political quest for an alternative medium marked by fidelity to musical creativity and cultural authenticity. The quest for fidelity meant the reduction of noise, not just from static, but also from the hucksterism of America's consumer culture. This mindset, which was adopted and reshaped by the next generation of rebellious young people, helped spawn a new group of audio outlaws, the underground FM programmers of the late 1960s and 1970s.

FM: The Industry Outcast

From the earliest beginnings of its technical, business, and regulatory history, FM was an industry outcast, an antiestablishment technology marginalized by vested corporate interests. Invented by Edwin Howard Armstrong (1890–1954) in the early 1930s, FM was immediately perceived by David Sarnoff (1891–1971), the head of RCA, as a major threat to the already established AM industry. Sarnoff reacted by doing all he could to try to thwart the invention. He blocked financial support for experimentation, and he worked from behind the scenes at the Federal Communications Commission (FCC) to block allocation of spectrum for FM use. It is not surprising, then, that FM's renaissance would be pioneered by those very much outside of—even at odds with—the media culture those corporations had created.

Despite efforts to suppress his invention, Armstrong had by the early 1940s developed a small FM network in the Northeast, and a small group of fans had acquired FM receivers. The FCC's decision in 1945 to reallocate FM's slot on the spectrum made those sets obsolete, and with FM's prospects seeming so uncertain, the

number of stations actually declined in the early 1950s.¹⁶ Beginning in 1958, however, FM began to experience a resurgence. The number of stations began to increase, and so did the audience. The AM spectrum had become so crowded, especially in major cities, that by the late 1950s there were few or no slots left. The only way to start a new station was to use FM. Hi-fi enthusiasts began to tinker with FM, and others bought the newly available sets, especially imported ones. Between 1960 and 1966, the annual sales of FM radio receivers increased more than fivefold, and by 1967 over one-third of all radio sets sold were equipped with FM reception.¹⁷ In 1960, there were approximately 6.5 million households with FM; by 1966, that number had soared to 40 million.¹⁸

These early listeners to FM stations were usually more educated than the average American, and tended to have “high culture” tastes, preferring FM’s music, intellectual fare, and lack of commercialism to the usual AM programming. The households that accounted for the bulk of FM listening were also the ones that watched the least amount of TV and, in fact, listened to FM rather than watching TV during the prime time evening hours.¹⁹ FM audiences were concentrated in major metropolitan areas like New York, Chicago, Los Angeles, Washington, and Boston, and in the 1950s and early 1960s urban FM stations catered to their listeners’ devotion to classical music. By the mid-1960s, however, 61 percent of FM stations played “middle of the road” music, which ranged from Frank Sinatra and Mantovani to Dave Brubeck.²⁰

The immediate catalyst for the FM explosion in the late 1960s came from the FCC. Since the late 1940s, most of the FM outlets owned by AM stations had simply broadcast exactly the same programming as its AM parent. But by the early 1960s, FCC Commissioners Robert E. Lee and Kenneth Cox argued that frequencies had become so scarce that in the face of increasing demand, duplication was “a luxury we can’t afford.”²¹ In May 1964, the FCC issued its nonduplication ruling, which was to take effect in January 1967. In cities with populations of more than 100,000, radio stations with both AM and FM could not duplicate more than 50 percent of their programming on both bands simultaneously. This ruling helped promote much more enterprising exploitation of the medium: between 1964 and 1967, 500 new commercial FM stations and 60 educational stations took to the air.

A handful of figures suffice to convey the magnitude of the FM revolution. In 1964, total net FM revenues were \$19.7 million. Ten years later, that figure had increased thirteenfold to \$248.2 million.²² In 1962, according to the FCC, there were 983 commercial FM stations on the air;²³ in 1972, their number stood at 2328.²⁴ Four years later, there were nearly 3700 FM stations on the air.²⁵ By 1972, in cities such as Chicago and Boston, it was estimated that 95 percent of households had FM sets.²⁶ A few years later, that figure held for much of the country.²⁷

While technical refinements, overcrowding in the AM band, and regulatory changes were obviously critical factors in the FM explosion, it was also the emergence of a profoundly anticommercial, anticorporate ethos in the 1960s that caused FM to flower. This ethos was marked especially by a contempt for what had come to be called “mass culture”: a disdain for the “vast wasteland” of television and for the formulaic, overly commercialized offerings of radio. It also represented a scorn, first on the part of older intellectuals and, later, on the part of the counterculture, for the

predictability and mindlessness of mainstream popular music. The rise of 1960s youth culture especially transformed FM's content and appeal. Bound together by rock and folk music, contemptuous of the commercialization that seemed to infuse and debase every aspect of American culture, and hostile to bourgeois values and the profit motive, members of that loose yet cohesive group known as the "counter-culture" were revolutionizing almost every aspect of American culture, from its popular music to its language and clothing.

Particularly hateful to these young people was what they saw as the lockstep conformity of American life that made everything from work to popular music joyless, unspontaneous, and false. They wanted something different: they wanted their lives to be less programmed, less predictable. The music these young people were listening to, which was not broadcast on AM, gave expression to their critique of mainstream culture. At this time, AM radio was characterized by incessant commercials, songs lasting no longer than three minutes, and repeated promotional jingles. It is no surprise then that when some of these young people, primarily men, worked their way into FM radio stations, they deliberately used their positions to challenge every aspect of what people heard and how they heard it on the airwaves. That challenge led to the proliferation of "underground" or "progressive" rock stations around the country.

Some of the earliest of these stations, which went on the air between 1967 and 1969, were KMPX in San Francisco, KPCC in Pasadena, KMET in Los Angeles, WOR and WNEW in New York, and WBCN in Boston. The rebellious young people staffing these underground stations differed somewhat from the amateurs and hi-fi audiophiles. They were less interested in technical tinkering, in getting inside the "black box" of FM, than they were in using the invention for cultural tinkering, to defy the establishment. When they started their own FM stations, they threw all the conventional industry rules and responses out the window. They eliminated advertising jingles, the repeated announcing of call letters, and the loud, insistent, firecracker delivery of AM disc jockeys. They repudiated conventional market research that sought to identify the "lowest common denominator" and thus reinforced the predictable repetition of the Top 40 AM songs. College stations around the country, not surprisingly, pioneered and embraced the underground format.

Instead of being required to select songs only from a tight "play list" determined by a programming manager, disc jockeys on progressive rock stations were given wide latitude to play what they wanted. They also sought and responded to listener requests. They avoided most Top 40 music and the playing of singles. Instead, a low-key, at times somnolent male voice talked to the audience in what was called a laid-back and intimate fashion in between long segments of music that included album cuts of rock, blues, folk, jazz, international, and even, on occasion, classical music. Progressive FM stations especially delighted in playing the longer cuts of a song, some of them running as long as 12 or 20 minutes, for an audience that could hear such music nowhere else on the spectrum. In 1969, *Broadcasting* labeled underground radio "the first really new programming idea in 10 years."²⁸

The majority of listeners to these stations were educated, affluent young men, and they were extremely loyal to such stations. Like their predecessors the hi-fi en-

thusiasts, these men were dedicated to a musical cult of authenticity that emphasized the essential interconnections between composing, mastery of an instrument, and performance. The music they championed was usually complex, the lyrics metaphorical, political, or both, and spotlighted male virtuosos, especially on guitar or drums. Thus, while underground FM represented an explicate rejection of establishment notions of masculinity, it was also a deeply masculine enterprise focused on male performers, DJs, and listeners, all grappling with the crises surrounding traditional gender roles in the late 1960s and early 1970s. Progressive rock stations also specialized in information on the antiwar movement and general countercultural activities, rejecting the overly competitive and often destructive masculinity promoted in corporate and military circles.

Although underground radio represented only a tiny portion of FM stations, its impact on programming formats and content was enormous, precisely because it was so fresh, new, and compelling to listeners. In the 1970s, following this proliferation of stations and upheavals in program formats, the owners of FM stations saw an opportunity to make a profit. By October 1974, FM accounted for one-third of all radio listening, but only 14 percent of all radio revenues. One reason that so much experimentation had been possible with FM was precisely that advertisers exerted very little influence over the medium. Prejudiced by the notion that FM listening was the province of "eggheads and hi-fi buffs," advertisers had eschewed FM until the early 1970s. But both advertisers and owners of FM stations recognized that in spite of considerable alienation, American youth nonetheless constituted a big market, and as a result more and more stations converted to some type of rock format.

To appeal to the younger market, the ABC-FM network developed a hybrid format with the predictability of the AM format as far as music was concerned, but the underground style of announcing. In 1971, CBS-FM followed suit, co-opting some of the stylistic innovations of the underground while purging it of left-wing politics and too much musical heterogeneity. Such initiatives by the networks exploited some of FM's iconoclasm in order to turn the anticorporate ethos to the industry's advantage.

In 1974, *Broadcasting* featured an article that noted that many progressive stations were adopting tighter playlists and starting to rely on market research.²⁹ Albums out of the mainstream, once the mainstay of early FM, were now no longer given a chance at many stations. The playlist was agreed upon by committee or determined by the program manager, as it had been in AM during the early 1960s. Accompanying this trend toward homogenization was the adoption by different stations of a very particular, tightly circumscribed format: oldies, soft rock, album-oriented rock, or country and western, with very little, if any, overlap. By the late 1970s, the assembly line techniques that the early FM outlaws had deplored were now informing much of FM programming. As *Advertising Age* noted in May 1978, "The day of the disc jockey who controls his individual program is quickly becoming a dinosaur."³⁰ As had been the case with the amateur operators and the hi-fi audiophiles, the defiance of early FM enthusiasts invigorated an entrenched and complacent industry; but this defiance was quickly domesticated in the quest for massive audiences and profits.

Conclusion

The tinkering of these audio outlaws set the stage for radio broadcasting in the 1920s, revolutionized the phonograph and recording industries in the 1950s, and pioneered the use of a whole new frequency band, FM, in the late 1960s and early 1970s. All three groups of enthusiasts were outsiders who regarded the corporate uses of audio technology as unimaginative, technically backward, and culturally stunted. Each group, in its own way, challenged how the profit motive had circumscribed the exploitation of and access to audio technology. The ham operators still constitute a robust subgroup that exchanges messages around the world, proudly circumventing more established communications systems, while the more defiant technical outlaws have adopted the computer as their vehicle for fraternal rebellion.

Oppositional reactions against the dominant culture by technological enthusiasts have burst forward at various moments during our history. They represent serious, often passionately held views about what culture should be, and questions about the extent to which the demands of the marketplace should shape cultural practices and products. They also represent the vision of subcultural groups of men with often utopian ideas about how machines can promote a sense of community and reproduce cultural excellence. But one of capitalism's greatest strengths is its ability to incorporate the voices and styles of the opposition into a larger framework, and to adapt such opposition to its own ends.

Historians of business and technology need to consider more fully this process of opposition, co-optation, and taming, a process that incorporates certain oppositional applications of technology while simultaneously marginalizing the more iconoclastic elements of opposition that spawned the new applications in the first place. The cultural benefits are, of course, that mainstream culture does change, is enriched, and does, at moments of technological uncertainty and cultural upheaval, provide brief periods when diversity can really flower. But in times of more complete and entrenched corporate control over technology, and increased barriers to entry, can such competition from the bottom up still emerge and provoke new competitiveness in American engineering? That is certainly one of the major questions we face today.

Notes

1. The best general histories of broadcasting in the United States are Christopher Sterling and John M. Kittross, *Stay Tuned: A Concise History of American Broadcasting* (Belmont, Calif.: Wadsworth, 1990), and Erik Barnouw, *A History of Broadcasting in the United States*, 3 vols. (London/New York: Oxford Univ. Press, 1966, 1968, 1970).
2. The most detailed information on the early amateur operators can be found in Susan J. Douglas, *Inventing American Broadcasting, 1899–1922* (Baltimore, Md.: Johns Hopkins Univ. Press, 1987). The recollections of amateur operators can be found at the Columbia Oral History Library in New York City.
3. General histories of the phonograph include Oliver Read and Walter Welch, *From Tin Foil to Stereo: Evolution of the Phonograph* (Indianapolis, Ind.: Sams, 1976), and Roland Gelatt, *The Fabulous Phonograph, 1877–1977* (New York: Macmillan, 1977). Contem-

- porary accounts of the hi-fi craze exist in various issues of *Business Week*, *The Saturday Review*, *Time*, and *Newsweek* in the early 1950s.
4. The best accounts of the underground FM movement are in issues of *Broadcasting*. See also Jim Ladd, *Radio Waves: Life and Revolution on the FM Dial* (New York: St. Martin's Press, 1991).
 5. "New Wonders With Wireless—And By a Boy!" *New York Times*, November 3, 1907, pt. 5, p. 1.
 6. Charles Barnard, "A Young Expert in Wireless Telegraphy," *St. Nicholas*, 35, April 1, 1908, pp. 530–32.
 7. *Electrical World*, 57, no. 13, 1911, p. 760.
 8. *New York Times*, March 29, 1912, p. 12.
 9. Cited in Clinton De Soto, *Two Hundred Meters and Down: The Story of Amateur Radio* (West Hartford, CT: American Radio Relay League, 1936), p. 40.
 10. "Audiophilia," *Time*, January 14, 1957, p. 44.
 11. *The New Yorker*, November 24, 1951, p. 31.
 12. "High Fidelity: Next Year a \$300,000,000 Industry," *Newsweek*, December 21, 1953, p. 64.
 13. "Everybody Gets in Hi-Fi Chorus," *Business Week*, September 21, 1957, p. 62.
 14. "Cashing in on Finicky Ears," *Business Week*, March 22, 1952, p. 54.
 15. Op. cit., p. 66.
 16. Lawrence Lessing, *Man of High Fidelity* (New York: Bantam Books, 1969), p. 212; Sterling and Kittross, op. cit., p. 323.
 17. *Media/Scope*, May 1967, p. 12.
 18. *Ibid.*
 19. *Broadcasting*, April 12, 1965, pp. 36–37.
 20. *Media/Scope*, May 1967, p. 12.
 21. *Broadcasting*, March 29, 1965, p. 88.
 22. *Broadcasting*, September 13, 1976, p. 50.
 23. *Newsweek*, May 22, 1972, p. 57 and Sterling and Kittross, p. 379.
 24. *Ibid.*
 25. *Ibid.*
 26. *Broadcasting*, September 24, 1973, p. 31.
 27. Sterling and Kittross, op. cit., p. 465.
 28. *Broadcasting*, August 11, 1969, p. 46B.
 29. "FM Rockers Are Taming Their Free Formats," *Broadcasting*, November 25, 1974, pp. 47–49.
 30. *Advertising Age*, May 29, 1978, p. R1, R26.