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Carl Dreher

E. H. Armstrong: the Hero as Inventor

The radio in every home reflects the genius of an American little known outside his profession, who expended himself in titanic battles over his legal and financial rights.

THE death of E. H. Armstrong in January 1954 ended the outstanding technological career of our time—one that brought into being devices so intricate that only a small group of specialists can understand them, yet so simplified in practice that they function in nearly every American home. It was a life replete with all the things ordinary human beings long for—and also a life from which most of us would recoil if we were given even a brief preview of what it entailed. *Fortune* said in 1948 that Armstrong could qualify as "the greatest American inventor since Edison and the most important of all radio inventors, including Marconi." Yet perhaps five Americans in a hundred know who Edwin Howard Armstrong was.

As far as a life can be, Armstrong's was planned —and it was he who did the planning. When he was fifteen he informed his parents that he intended to be an inventor. In the classical tradition he did his first work in a garret, though a very comfortable garret in the spacious Armstrong home in Yonkers, overlooking the Hudson. (His father was the American representative of the Oxford University Press.) By the time he was a junior at college he actually *was* an inventor and an extremely important one, though it took time for the fact to be recognized.

What he had invented was the regenerative circuit, known also as the feedback circuit, the oscillating audion, and the ultra-audion—the multiplicity of names reflects its importance—a milestone in technological history and the prize in patent litigation which lasted nineteen years, cost millions in lawyers' fees and lost time, and scarred Armstrong to the end of his life.

Apparently Armstrong's father started him on his career when he returned from a European business trip with a copy of *The Boy's Book of Invention.* Faraday and Nikola Tesla became young Howard's idols. But he began too at this early date to show some of the pugnacity he exhibited in later years when his inventions were at stake. If anyone disturbed his equipment he was furious. Sometimes he would stay in the garret, which was also his bedroom, for two or three days at a time.

When he was eighteen Howard Armstrong went to Columbia University for his electrical engineering degree. It is recorded that he drove a motorcycle between Yonkers and Morningside Heights at alarming speeds, and this was not the first time he had shown daredevil tendencies. He would climb trees, the cliffs of the Palisades on the New Jersey side of the Hudson, and—what was especially nerve-wracking to the neighbors—a high radio mast which he had erected in the back yard of the Yonkers home. There was something more to this than youthful exuberance, for he kept on doing it as he grew up. He liked to take physical risks—all kinds of risks—and if he felt fear it was to a lesser extent than most men.

BOY WONDER

IN 1909 the electrical engineering course at Columbia was only four years, but the teachers were top men like Arendt, Mason, Morecroft, and Michael I. Pupin, the Serbian goatherd who had arrived in the United States in 1874 at the age of fifteen, with a red Turkish fez on his head and five cents in his pocket, and had become professor of electromechanics and a redoubtable inventor. He remained picturesque. "The rotor of a synchronous motor," he would say in his lectures, "is lousy with harmonics." In later years Pupin, swelling with pride, would always refer to Armstrong as "my former pupil."

Except in radio, however, Armstrong was far from brilliant. Morecroft, after Armstrong became prominent, recalled that he had little interest in the characteristics of alternating current machinery and did "rather poorly" in many of his courses. Moreover, he was a nuisance; he

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spent most of his time in the laboratory setting up intricate radio circuits. At one point he was so much under foot that Professor Arendt told Professor Mason to "get Armstrong and his stuff out of the laboratory."

He received his degree in 1913. By that time he had impressed the department sufficiently with his zeal in research to be kept on as an assistant at $50 a month, correcting papers and doing other routine work. This was the only regular job Armstrong ever had and he did not have it long. He was to come back to Columbia eventually, as professor of electrical engineering, in which capacity he received no salary and did little teaching. For the moment, however, Morecroft felt Armstrong should work six days a week for his fifty a month, and finally he was fired. Armstrong went back to Yonkers, put up a 110-foot mast in the back yard, and continued to experiment.

THE feedback invention was the culmination of a series of discoveries by Armstrong's predecessors. Back in 1883 Edison, experimenting with the electric lamp, found that when a metal plate was introduced into the bulb a current would flow between the plate and the glowing filament, always in one direction. Edison had other worries and did nothing with the discovery; it came twenty years too early. In 1904 there was a need for a detector of wireless waves and a British electrical engineer, John Ambrose Fleming, made a two-element vacuum tube employing the Edison effect.

In 1906 Lee de Forest, then thirty-three and the only one of the great pioneers of radio still living today, introduced a third element into the Fleming valve and really started something. This element, a zigzag wire called the grid, controlled the current flowing between the filament and plate and added amplification to the detecting action. De Forest, a Yale Ph.D., may not have had a completely clear picture of what was happening inside his "audion," as he called it, but no one disputes that he first put the grid into the vacuum tube and thereby opened the door to modern radio—and to Armstrong.

In 1912 and 1913 reports were circulating that some lad up at Columbia had a receiver hundreds or thousands of times more sensitive than the conventional de Forest audion, so that he could receive signals at unheard-of distances. Armstrong demonstrated the device, which he concealed in a black box, to a number of engineers and commercial radio people—among them David Sarnoff, the twenty-two-year-old chief radio inspector of the Marconi Wireless Telegraph Company of America. Later Armstrong disclosed his engineering principles in a classical paper delivered before the Institute of Radio Engineers modestly entitled, "Some Recent Developments in the Audion Receiver."

What Armstrong had discovered was the technique of taking a portion of the current from the plate of a vacuum tube and feeding it back to the grid, where it would again go through the process of amplification and again make available a surplus of current to be put through the same process over and over again. If the feedback was increased beyond a critical point, the tube would become a generator of oscillations. Engineers could envision large vacuum tubes which would take the place of the arcs and sparks and rotating machinery currently in use. The regenerating and oscillating audion was one of those protean devices which revolutionize whole industries. Not only had it been created by a man barely old enough to vote, but he had done it with such superb engineering skill and thoroughness that the most resourceful, experienced engineers could add little or nothing.

Fitting the invention into the existing scheme of things, however, was a more complex matter. The way of the innovator is hard, and innovators make it hard for one another. There is no more ruthless competition than that between inventors, and the claims of an independent individualist like Armstrong had to be assessed on the strength of his patent position, which could be decided only by the tedious and unpredictable action of the courts.

Around 1915, Armstrong was a good buy. He was practically penniless. He would have sold all his rights for $10,000 and a research job at an equally modest salary. It was just as well for Armstrong that there were no takers, for within a few years, by granting licenses under his patents, he was receiving $7,000 to $8,000 a year in royalties. He could have lived very well had it not been for legal expenses. But five years later, he was in debt $40,000 to his lawyers.

SECOND BULL'S-EYE

ARMSTRONG'S closest friends were the founders and early directors of the Radio Club of America, which is not so much a club as an engineering society. In World War I a large proportion of the members were in the armed services. Armstrong was commissioned a captain in the Signal Corps, sent overseas, and given the job of intercepting German front-line

radio communications. It was impossible to pick them up intelligibly at the American listening posts with the vacuum tubes and receiving equipment then available. Armstrong solved the problem by devising a new type of receiver, the superheterodyne, so superior in selectivity, sensitivity, and ease of operation that by the late twenties it had superseded all other types of receivers and still holds unchallenged leadership.

The French made Armstrong a Chevalier of the Legion of Honor for the superheterodyne and the AEF promoted him to the grade of major. Characteristically, he came home from the war without giving notice of his arrival, appearing suddenly on the steps of the Yonkers house, his head swathed in bandages, crying, "I'm perfectly all right, perfectly all right."

The bandages were necessitated by a skin infection which soon cleared up but disposed of the remainder of Armstrong's hair, which had started falling while he was still in college. He had little vanity, though his high domed forehead, quizzical gaze, long upper lip, and firm mouth might have been accounted handsome in their way. When *Time,* in later years, referred to him as the "bald, monolithic professor of electrical engineering at Columbia University" the description was as accurate as it was merciless.

When he returned from France the Radio Club threw a big dinner for him. Every prominent radio man who was in New York or could get there was present. The only absentees were a few opponents in litigation. Armstrong had a hard, packed life but it contained some glorious moments and this was one of them.

Within the next two years his financial situation improved. He had licensed twenty concerns under his regenerative patents; he now sold what remained of these patents, together with the superheterodyne, to the Westinghouse Company. His total receipts from this sale came to $435,000, which in the early twenties constituted a substantial estate. Even so, it was only a fraction of the intrinsic value and Armstrong sold very reluctantly. An important consideration was his indebtedness to his lawyers and the continuing cost of litigation; once he had sold, the further defense of the patents devolved on Westinghouse.

MR. SARNOFF'S SECRETARY

As Armstrong was the technical genius of radio's second phase, David Sarnoff was and remains its administrative genius. Inevitably their lives were intertwined. In 1922 Sarnoff, the ex-messenger boy and wireless operator —one of the most expert who ever tapped a key—was, at thirty-one, vice president and general manager of the Radio Corporation of America. Sarnoff and Armstrong were almost exactly of an age; Armstrong was the elder by two months.

Sarnoff's secretary was a tall girl from Merrimac, Massachusetts, named Esther Marion MacInnis. One didn't get to be Mr. Sarnoff's secretary by looks and charm alone: Miss MacInnis was also intelligent. Armstrong was in Sarnoff's office a good deal, discussing patents and the like, and he was no more immune than other young men. His manner of courting her was in the spirit of the Scott Fitzgerald era. Armstrong had returned from a European vacation with a Hispano-Suiza, in which he took her for a ride on the Long Island Motor Parkway, a private toll road financed by W. K. Vanderbilt which in one respect was the precursor of modern turnpikes —it had no grade crossings. The road was forty-five miles long and an able driver would make it in forty-five minutes or less. According to Miss MacInnis at one moment on this ride the speedometer read 100 mph.

Another incident in the courtship reflected Armstrong's continuing impulse to risk his neck. Early in 1923 the Radio Corporation of America was erecting its first broadcasting stations in New York City, on West Forty-second Street, opposite Bryant Park. The building, which bore the name of the Aeolian pianola company, was over twenty stories high, and there were two one-hundred-foot towers on the roof to support the antennas. Each tower was surmounted by a crossarm on which a man could walk; in the middle, about fifteen feet higher, there was a ball of strap iron symbolizing, somewhat feebly, the world. Armstrong liked to come up to the station and climb all the way to the ball of the north tower, but Sarnoff had written him a sharp letter telling him to stop. By way of retort, Armstrong appeared at the formal reception which marked the opening of the station and (while Sarnoff was officiating as impresario in the studios on the sixth floor) went up to the roof, climbed the north tower, and stood on the ball 350 feet above Forty-third Street while a photographer took flashlight pictures from the crossarm. According to some eyewitnesses, Armstrong did a handstand on the ball. He had not had a drop to drink.

Armstrong sent a set of prints to Miss MacInnis and Mr. Sarnoff, and the next time Armstrong came to Aeolian Hall the engineer-in-charge had the painful duty of informing the inventor of

the regenerative circuit and the superheterodyne that he was *persona non grata.*

In a few months, however, Sarnoff forgave him. Nobody, except perhaps Dr. de Forest, could stay mad at Armstrong very long. Nobody wanted to and besides, it wasn't safe; with a man who turned the industry upside down at least once a decade, it was well to be on speaking terms.

Miss MacInnis also remained on speaking terms with Armstrong; she married him on December 1, 1923. While the bride-to-be waited in Merrimac, the bridegroom started out from New York in the Hispano-Suiza, paced by his friend George E. Burghard in a DeLage. A few miles out of New York the DeLage broke down. Armstrong and Burghard took the carburetor apart four times. At 2:00 A.M. they were on the outskirts of New Haven and further progress became impossible.

It was a cold, drizzly night. The two eminent technicians in their $15,000 vehicles did not have a tow rope between them. Armstrong drove into New Haven, obtained a rope, and towed Burghard into Hartford, where they arrived at 6:00 A.M. The DeLage had to be towed to the Bosch plant in Springfield for a new magneto. The next day, in Worcester, the battery fell out. Eventually Armstrong and Burghard reached Merrimac, the marriage was solemnized, and the couple fled south in the Hispano-Suiza.

HOW TO INVENT

THE Armstrong story is not merely a story of inventions, but of invention itself. Americans, even more than other peoples, live by invention—"We live by obsolescence," as Sarnoff puts it—yet most of us haven't the faintest idea of how the thing is done.

In Armstrong's case, one factor was humility. He was always ready to learn from others. He would patiently question the most uninspired engineer to elicit what little the man knew; in return, with equal patience, he would give as much of his own understanding as the other could absorb. In technical debate, when he felt credit for what he had done was being taken from him, he could be harsh and even cruel; the way in which he tore de Forest apart at meetings of the Institute of Radio Engineers is still vivid in the memories of those who witnessed it, forty years ago. But that was in the heat of battle and de Forest was equally harsh toward Armstrong; worse, he was patronizing.

Armstrong's second great characteristic was skepticism. He believed with Professor Arendt that "it isn't all in the books." He never tired of quoting—or quoting his version of—the Josh Billings saying, "It is better not to know so much than to know so many things that ain't so." When he started on a project he went over everything that had been done before to make sure it *was* so. Educated in mathematics, Armstrong distrusted mathematical formulations; he had seen how often, through erroneous assumptions, they made things seem impossible which were actually possible. He invented by observation, instrumentation, hunches, intuition, and reasoning. And he passed over nothing. "Listen, look, and measure" is one colleague's summing up of his technique.

And then, he *thought.* He thought long and hard. Most of us, most of the time, do not think in this way; we live in a fog of self-induced reverie. Armstrong could not have been entirely devoid of this aimless, restful activity, but his mental processes were abnormally purposive. Watching him with a radio circuit spread out on a laboratory table, or just talking with him, you felt the intensity, the preoccupation, the dogged resolution, the overevaluation—for who can do good work unless he is convinced it is more important than it actually is?

Not all of Armstrong's inventions were successful. One was a total failure and another, the super-regenerative circuit (1922), did not bear out the high hopes of its inception. Its selectivity was poor, and the superheterodyne drove it out; the most important effect of super-regeneration was to make Armstrong rich. When first revealed, its performance was spectacular, its weaknesses less apparent. RCA bought the patent for $200,000 and 60,000 shares of RCA stock, and later Armstrong received another 30,000 shares for helping, among other engineering services, to adapt the superhet for mass production. He thus became, and for years remained, the largest stockholder in the Radio Corporation of America.

THE bitter legal controversies of technology are not occasioned by mere greed or vainglory. Such factors play a part, but there are also honest differences as to who did what. Nobody invents by himself. Every inventor stands on the shoulders of his predecessors, and they stand on the shoulders of earlier investigators, and so on back through history.

Every inventor is also dependent on his contemporaries. An art progresses through the

efforts, in each generation, of a few major originators, perhaps some hundreds of second-rate originators, and thousands on thousands of run-of-the-mill engineers and technicians who do the common labor. In the realm of ideas the ratio is about the same. For every good idea, there are a hundred bad ones; for every new idea, a hundred old ones. The mistakes and failures are necessary to clear the ground.

Then, as Pupin said, inventions are always partly luck. There comes a time when an invention becomes possible, and at that stage there are usually more than one pair of hands reaching for it. It is not necessarily the most scholarly or most deserving investigator who grasps it first.

THE PATENT WARS

THE patent system attempts to reconcile the conflicting claims which arise out of all this confusion. In a patent conflict the parties—sometimes there are more than two—may all have ethically valid positions. They all made the invention and they may have made it in substantially the same way and at about the same time. Yet, by reason of some slight priority, or verbal dexterity in the description of what is claimed, or purely legal technicalities, one inventor may be doomed to deprivation while another reaps the reward both in fame and money. It is no wonder that at times the in-fighting gets dirty.

Not one of Armstrong's inventions was entirely his own in the sense that his authorship was never challenged. Eventually he lost the regenerative circuit in a heartbreaking decision in which the engineering profession lined up almost solidly behind him but the Supreme Court ruled that de Forest was the legal inventor. The superheterodyne patent was successfully challenged in the United States by Lucien Levy, a French inventor, although the French gave Armstrong a patent and none to Levy. Frequency modulation Armstrong never claimed as entirely his own; as he said, the idea had been kicking around for years, but nobody did anything with it except to prove, by beautiful mathematical analysis, that it was no good.

Alfred McCormack, a brawny, sapient Wall Street lawyer who became Armstrong's attorney in 1928, remarked that Armstrong's inventions were accepted by acclamation rather than by litigation. The acclamation came to him not because he was the only one who had the ideas nor because he was the only one who could make them work—but because he was one of the precious few who had ideas, made them work, demonstrated with pellucid clarity how they worked, knew what was the next thing to do, and went ahead and did it.

The regenerative litigation began in 1915 with patent "interferences" between Armstrong, Irving Langmuir of the General Electric Company, a German named Meissner, and de Forest. An "interference" is the Patent Office proceeding for determining priority among claimants who have all made the same invention. Armstrong beat out Langmuir by six months, Meissner by two. From 1922 to 1934 de Forest and Armstrong alternated as the legal inventors. The case went up to the Supreme Court not once, but twice. The animosities it aroused bordered at times on physical violence, and of verbal violence there was no end.

De Forest tells in his autobiography how Pupin, whom he had regarded as a "kindly friend," burst into a hall at the Bureau of Standards in Washington where de Forest was giving a demonstration of the oscillating tube, bellowing, "What right have you to have that there? That thing is not yours! That belongs to Armstrong!" And when de Forest read a paper on the audion and its evolution at the Franklin Institute in Philadelphia in 1920, Armstrong himself was ordered by the chairman to sit down when he declared that he himself was the inventor of the feedback circuit, and that all de Forest had invented was the audion.

In 1928 the Supreme Court, without reviewing the evidence, decided for de Forest on points of law. Armstrong was severely shaken. After a few days he got in touch with an engineer-friend and asked him to review the voluminous printed record and tell him who was the inventor—he or de Forest. A week later his friend informed Armstrong, over the telephone, that he was indeed the inventor from a technological standpoint, but that it might prove impossible ever to sustain his claim in a court of law. He then urged Armstrong to try to forget the experience, bitter as it was.

"You still have the mind with which you invented the damn thing," he said. "If anything, it's better than it was. You can make other inventions just as important." There was a pause, then Armstrong's voice came over the line in a tone of quiet despair. "There'll never be another oscillating audion," he said.

Others gave Armstrong the same advice. "We all know you invented the regenerative circuit," Burghard told him. "All the engineers know it. What do you care what the courts say?" But

Armstrong insisted on re-opening the case. In the meantime the Radio Corporation had created its patent pool and possessed rights under both the Armstrong and de Forest patents. RCA had no further interest in defending Armstrong—rather the contrary—and withdrew its support. Armstrong spent about $200,000 of his own money carrying the case up to the Supreme Court once more.

This time the court reviewed the evidence but made deductions from it which dumfounded radio engineers. Pupin and other savants protested in the newspapers and technical journals, pointing out the gross errors in the opinion written by Justice Cardozo. Nevertheless the decision, although somewhat altered in its final form, stood in favor of de Forest. Armstrong returned to the Institute of Radio Engineers its Medal of Honor, which had been awarded to him in 1917 for the invention.

But the directors voted unanimously to re-award the medal to Armstrong, and in 1941 the Franklin Institute awarded its medal to Armstrong for his inventions, including the regenerative circuit. In 1942 the American Institute of Electrical Engineers awarded the Edison Medal to Armstrong for the invention of the superheterodyne, the FM system, and the regenerative circuit. De Forest was awarded the Edison Medal in 1946 for the invention of the audion.

Schiller, being asked by some fool which was the greater poet, he or Goethe, replied complacently, "You can thank God for both of us." American technology and industry, and indeed the whole world, can thank God for both Armstrong and de Forest, but in the eyes of engineers Armstrong invented the oscillating audion. And Armstrong was right: there never was another invention of such far-reaching economic and industrial importance, and of such sheer technological beauty, in his lifetime. There was to be FM, but it was not the same.

LIFE WITH HOWARD

IN 1948 Mrs. Armstrong confided to a reporter that while it had been wonderful to live all those years with a genius—she did not use the term but Howard *was* a genius—it had not always been easy. He worked at all hours. Sometimes he would go to bed early, sleep for a while, then get up and work. Some one who liked and admired him complained that he could talk of nothing but radio. Professor Alan Hazeltine, another prominent radio inventor and an admirer of Armstrong's, tells how he waited, starving, until after nine at Armstrong's apartment where he had been invited to dine, because Armstrong, completely absorbed in the matter under discussion, forgot to take his guests in to dinner.

But that was only one side of him. For every story of how Armstrong didn't mix, there is another of how he did—and was a warmhearted and easy success at it. He would have enjoyed more of life if he could have invented a machine for stretching time. He played a good game of tennis until he was past sixty and gave it up only when trouble with his shoulder made it impossible for him to serve overhand. He liked to get off once in a while to a night club, have a drink and a hamburger and watch people. In middle life he loved the circus and musical comedies.

A light drinker, he liked drinking and dilated in spirit with a few ounces of whisky. Mrs. Armstrong says some of their happiest hours came when he would review the day's work with her, over old-fashioneds. They had fewer guests in the later years, but if Howard became something of a recluse it was only because he attempted to do too much for one human being.

His manner of operating an office must have appalled his wife. Howard had Professor Pupin's old office at Columbia but did not use it much. His principal office was in their twelve-room, five-bath apartment in River House, overlooking the East River. A secretary would come down three or four times a week to take dictation. In another room, cluttered up with radio equipment and packing cases and wires running in every direction, Thomas J. Styles, an old friend of Howard's who had been a banker, took care of accounts, payments, taxes, and the like.

In the library Howard sat on an old lounge chair, surrounded by telephones, a Duncan Phyfe sofa, and three tea tables on which he piled the most important correspondence and documents. Eight more tea tables and some chairs formed a kind of outer orbit. He would pile the day's mail on the floor, open it himself, and go through it. He would never write if he could telephone, and he made no distinction between local and long-distance calls.

He was scrupulously, almost morbidly, honest. It is even harder for a man to be a hero to his lawyer than to his valet, but McCormack speaks of Armstrong's "terrific integrity" and says he never overstated a scientific point, even when accuracy would confuse the courts and possibly result in the loss of the case. He loathed the

pseudo-scientific pap which is fed to judges in patent cases and never concocted any of it himself. "He was capable of kidding himself in other matters like the rest of us," says McCormack, "but never in science."

Armstrong might be bullheaded or at times naïve, but it was impossible to imagine him performing a mean-spirited act. His friend C. R. Runyan, Jr., who lived near the Armstrongs in Yonkers and knew him from boyhood, describes him as "the damndest, most generous man you ever saw." On a picnic or camping expedition he was always the one who carried the heaviest box, saw that everyone else was comfortable, and did most of the work.

Under a protective crust of reticence, he was extremely sentimental. He kept the Hispano-Suiza in storage and always intended to recondition it. When the Aeolian Hall towers were torn down he bought the strap iron ball from the wreckers. In 1930 he bought for $100 an old shed at Babylon, Long Island, which had housed the first American Marconi marine station in 1902. He presented the shack to the RCA station at Rocky Point to be set up and preserved.

FM: THE TITANS CLASH

IF FM is not exactly a revolution that failed, it is one that has not been as successful as it deserves to be. In FM Armstrong conquered nature, but the obstacles raised by men were too much for him. FM was unlike any of his earlier inventions. It involved not only the creation of a new form of radio communication but an effort to divert a complex industry with a large capital investment into a new channel.

The original motive for developing FM was to eliminate natural static, the bane of radio communication. Every inventive radio engineer had tried to lick it and it had licked them all. Apparently nothing could be done. A distinguished mathematical physicist had said, "Static like the poor, will always be with us." But Armstrong was a man who never gave up. The elimination of static was to be his monument.

Modulation is variation in some form that makes possible the transmission of information. In radio, the orthodox method of modulation was to vary the power or amplitude while keeping the frequency constant—AM, amplitude modulation. There was no way of shutting out static with this technique, for static is itself a form of amplitude modulation, present on every frequency. Armstrong's solution was to turn the technique upside down; he kept the power constant and varied the frequency—FM, frequency modulation. The type of electro-magnetic wave thus produced is not found in nature. As Armstrong worked it out, it largely eliminated man-made as well as natural (lightning) static, thus giving radio a silent background: you could actually hear the proverbial pin drop. But it made many existing transmitters and receivers obsolescent.

While, as Sarnoff said, we live by obsolescence, it is the task of the financial administrators to balance obsolescence—which involves loss of capital—against the gains from new devices which can reasonably be expected to replace the capital destroyed. Thus the seeds of conflict are sown between the independent engineer and the corporate administrator—in terms of the outstanding personalities in this case: Armstrong versus Sarnoff.

The Sarnoff-Armstrong alliance was one of the most productive in the history of radio. That they were able to work together for over twenty years is a tribute to the good sense and adaptability of both. They were not only collaborators but friends. After Sarnoff was married in 1917 Armstrong came to the Sarnoffs' house in Mount Vernon so regularly, in the morning before going to work, that the Sarnoff children called him "the coffee man," because Armstrong, declining breakfast, would always say, "All I want is a cup of coffee." Even after the real break had begun, in 1935, Armstrong appeared at the annual meeting of RCA and, when Sarnoff was under the usual fire of dissatisfied stockholders, rose impulsively to his defense.

"I didn't come here to make a speech," said Armstrong. "I didn't come here to get into a row. I have been a stockholder since 1915, since the days of the old Marconi Company. I have seen the inside of radio from the beginning to the end. I want to say that the man who pulled this Company through during the difficult times of the General Electric, Westinghouse, RCA mixup with the government was its President, Mr. David Sarnoff. [Applause] I think you would have been wiped out if it hadn't been for him. I know what I am talking about. I tell you, I wouldn't have his job for $500,000 a year. I don't agree with everything, for I have a row on with him now. I am going to fight it through to the last ditch. I just wanted to tell you what you owe to Mr. Sarnoff."

Sarnoff wrote Armstrong the next day: "Doubtless I have made many mistakes in my life but I am glad to say they have not been in the quality

of the friends I selected for reposing my faith." While he still pays tribute to Armstrong, however, Sarnoff says that he grew difficult to deal with. "And you know," he adds, "he liked to fight." This is a half truth, and it is also half true of Sarnoff. Neither went out of his way to fight; men of their caliber have too much regard for efficiency to engage in useless brawls. But neither are they backward in asserting their rights. Once they are in combat, such men fight with zest.

THE basic patent on Armstrong's system of frequency modulation was granted in 1933. The system was further developed and the IRE paper, which traditionally follows the culmination of a major radio research project, was delivered in New York City on November 6, 1935. Up to that time the system had required nearly ten years of experimentation and, according to one estimate, some 50,000 measurements. Armstrong worked on it like a man possessed, seven days a week, holidays included; some years he took only Christmas off.

Late in 1933 Armstrong demonstrated the equipment for Sarnoff and was invited to move it to the Empire State Tower, where it was field-tested for evaluation by RCA and NBC engineers from June 1934 on. The Armstrong and RCA groups did not see eye to eye and in October 1935 RCA informed Armstrong that it needed the Empire State space for its television research project, which had been carried on concurrently. In no pleasant mood, Armstrong moved out his gear, sold a hefty block of RCA stock, and in January 1936 applied to the Federal Communications Commission for a construction permit for an experimental station of his own, to be located on the Palisades at Alpine, opposite his old home in Yonkers. The FCC, after some boggling, granted him the permit; by the summer of 1938 he had a four-hundred-foot tower of his own to climb.

When Armstrong got into a real hassle you had to be for or against him; the middle ground quickly became untenable. The industry was split wide open. General Electric, Westinghouse, Zenith, and Stromberg-Carlson lined up with Armstrong and became his licensees. RCA, Philco, Crosley, Emerson, and other large producers manufactured FM receivers without benefit of Armstrong licenses. Armstrong and his partisans contended that these receivers were strictly *ersatz*. The non-licensees retorted that a large part of the improvement in quality was just a matter of high-fidelity reproduction which could be achieved just as well on AM as on FM. The engineering controversies were loud, involved, and bitter.

Amid the sound and the fury, this much was clear: Armstrong had rescued FM from oblivion and he was responsible, singlehandedly, for inducing—some would say forcing—the industry to recognize its advantages. He could and did reproduce sound with a fidelity and freedom from disturbance previously unknown. The strength of his patent position was something else again: it was possible that the systems not licensed under his patents were legally in the clear. The only claims he had were for the improvement he had actually effected, to the extent that this proved to be profitable—and, in the last analysis, to such amounts as he could compel the industry to shell out if the matter were carried to the courts.

In 1940 Sarnoff held out the hand of compromise. He offered a million dollars for a license under the Armstrong FM patents. The license was to be non-royalty paying: a million dollars in a lump sum, and that was that. And indeed it was. Late in 1954, after Armstrong's death, the suit was settled for "approximately $1,000,000."

Sarnoff, it has been said, likes to collect royalties, not to pay them. Naturally. He was largely responsible for the creation of the RCA patent pool which, however onerous it may have been to some, brought order out of chaos and enabled radio to go about its business instead of engaging in endless, destructive litigation. But Armstrong refused the offer. He already had royalty-paying licensees; and he was determined to keep control, this time, in his own hands.

THIS was a new Armstrong. A lifelong Republican, a revolutionist only in technology, in politics he was one of the most conservative of men. But in this instance Armstrong was bucking the economic and political system which places the interest of the financier before that of the inventor. Armstrong was trying to act like one of those eighteenth- or nineteenth-century industrialist-inventors who, before big business was dreamed of, started their own industries in an atmosphere of total freedom—freedom from either governmental interference or the network of existing financial and corporate interests.

First Armstrong had to hack his way through the electronic jungle. This he did with his old-time brilliance; only a man who felt and sensed and lived circuits could have brought FM into the realm of practicality at all. Then he came up against the thick wall of AM plant and vested interests—which includes, of course, not only

property interests but habit, inertia, and all kinds of psychological factors resisting change. He was making some headway against that when the government forbade the manufacture of TV and FM broadcast equipment during the war period.

TV was not yet commercialized, but FM was, and the four-year standstill hurt. Immediately after the war the FCC (on technical advice which Armstrong called "legerdemain" and "engineering skulduggery") uprooted FM from the 40-52 megacycle band and shifted it to 88-108 megacycles, just above the low TV band. With 500,000 FM receivers already in use, the forced move was damaging. Then TV reached the commercial stage and rocked FM back on its heels.

Armstrong spent more than a million of his own money on the construction and operation of the Alpine station and for twenty years most of his own time went into FM. He had envisioned thousands of FM transmitters on somewhat the same basis as local newspapers, so that every community, small as well as large, could formulate and express its views on the radio instead of relying on the nation-wide networks for entertainment and indoctrination. He did not submit gracefully to the relegation of FM to what he called "an auxiliary and uncompensated service" which merely duplicated the AM programs of the chains.

In July 1948 he brought suit against RCA and NBC in the United States District Court in Wilmington, Delaware, asserting in effect that the defendant companies had conspired to discourage FM, had attempted to persuade the FCC to allocate to it an inadequate number of usable radio frequencies, and had illegally obstructed an application of Armstrong's in the Patent Office. In 1953 and January 1954 he filed additional suits against numerous manufacturers of television and radio receivers.

TWILIGHT

IN 1950 Armstrong was sixty years old. Measured by deeds, he had lived much longer. He did, in fact, look ten years older than he was.

Invention, and scientific investigation in general, is as tough a way of life as can well be imagined. Mental and emotional breakdown is one of its occupational hazards. Lawrence S. Kubie, the psychiatrist, writing in the *American Scientist* for January 1954, reminds young scientists that for every successful piece of research there are hundreds which prove only that something is *not* so. "A scientist may dig with skill, courage, energy, and intelligence just a few feet from a rich vein . . . but always unsuccessfully." Or he may be brilliantly successful, as Armstrong was, and still the fate of which Kubie warns may overtake him.

By the summer of 1953, the suits against RCA and NBC had dragged on for five years. The pretrial testimony ran into volumes. Armstrong was spending most of his time on this litigation. During the war years and after, he had been engaged in classified radar work, and toward the end, an apparatus used to pick up impulses reflected from the moon was built under his direction. He was dangerously overtaxed.

Mrs. Armstrong tried to persuade him to taper off. Beyond a certain point devotion to a cause, however admirable, enters the realm of pathology. Mrs. Armstrong felt that Howard had reached that point. Howard, however, was not convinced.

On Sunday morning, January 31, 1954, forty-one years to the day from the legal date of invention of the regenerative circuit, Armstrong telephoned Burghard at about nine o'clock. Burghard's wife had been ill and Armstrong called to inquire about her condition. Burghard was leaving the house and the conversation was brief. It made no particular impression on Burghard; Armstrong sounded perfectly normal. During the day there were three servants at the Armstrong apartment; they left shortly after preparing his lunch. Mrs. Armstrong was in Connecticut. After about one o'clock he was alone.

Sometime during the evening or night of January 31, Armstrong wrote a love letter to his wife, in pencil on two sheets of yellow paper. Then he put on his hat, overcoat, and gloves and jumped out of the thirteenth-story window. He fell to the third-floor terrace. No one heard him. The man who had done more than any other to increase the clamor of the world departed from it without a sound.

What words, what prayers, what music could have availed him more? Perhaps if there were a special liturgy for the inventor, it could say that he creates the future out of the ideas left by the dead and the dying, including himself. Then, except by specialists, his name is forgotten. Armstrong's is the common fate; even now, only engineers and his friends remember him. But the forces of the past and the future worked in him, and if one measure of a life is this capacity to bridge time, the span of his life was high and long.

Armstrong lay dead on the terrace. The sun rose a few minutes after seven. At ten o'clock they found him.