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JAMES BROWN FISK

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A Biographical Memoir by

WILLIAM H. DOHERTY

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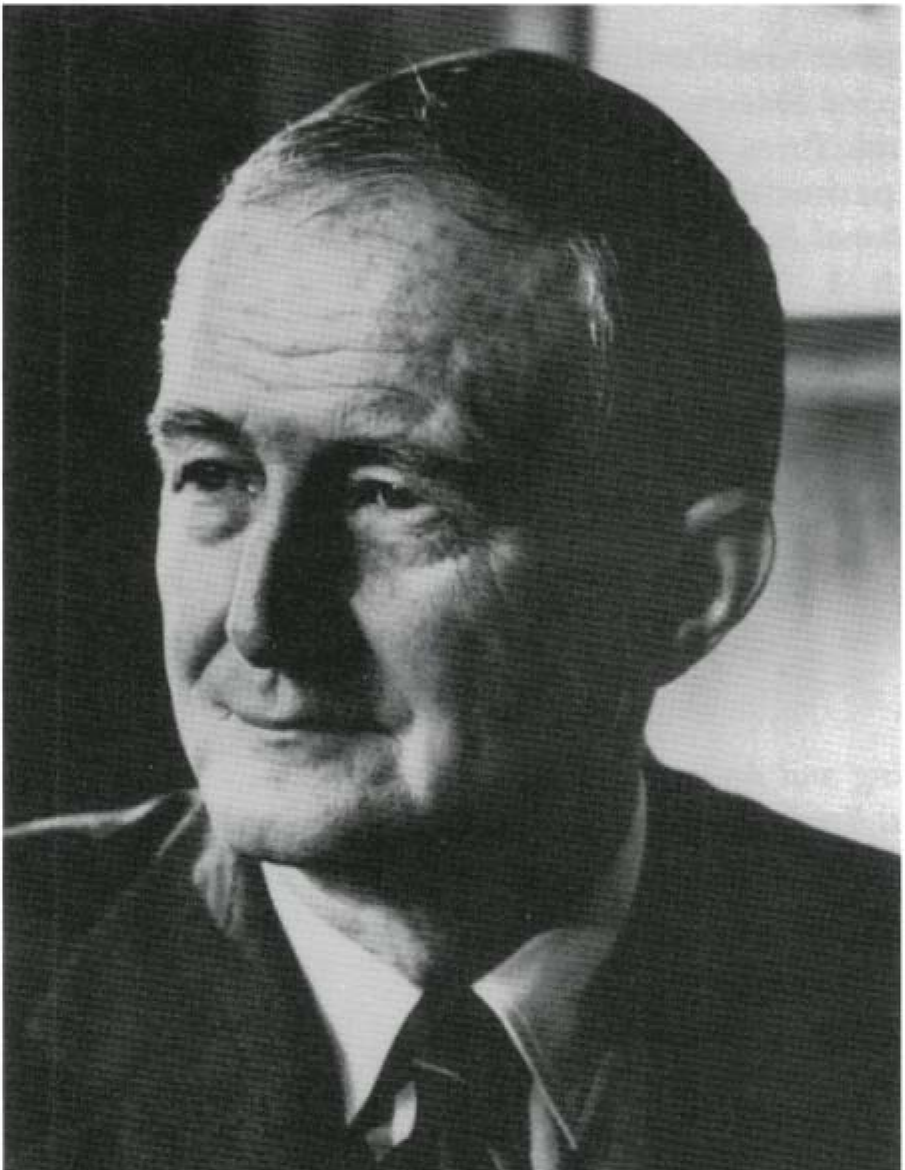

J. B. Fisk

JAMES BROWN FISK

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BY WILLIAM H. DOHERTY

EARLY IN 1876, the hundredth year after the signing of the Declaration of Independence, Alexander Graham Bell invented the telephone in Boston. He exhibited it a few months afterward at the Centennial Exposition in Philadelphia.

Ninety years later James Fisk, president of Bell Laboratories, looking ahead to the telephone's hundredth anniversary, suggested to me, a longtime associate, that a historical volume ought to be planned as a record of the development of telephone science over that period.

Several colleagues and I, going through the "Boston Files" of the earliest years, made an interesting discovery. The first trained scientist hired by the infant Bell company (late in 1885), Hammond V. Hayes, reminded us in many ways of our own Fisk. Hayes and Fisk came from old New England families. Both had studied at Harvard and the Massachusetts Institute of Technology. Both had earned doctorates in physics. But the resemblance ran much deeper, into their innermost personalities, their attitudes, their approaches, and their ways of operating: kindred spirits, aristocratic gentlemen both, born two generations apart.

The thousand-page volume produced in late 1975,[1] the eve of the telephone's centennial, covered the first fifty years (up to 1925, the year Bell Laboratories was incorporated). Fisk does not appear in that volume. He was not with us until 1939. But this memoir is about him, and its preparation has repeatedly recalled the approaches taken by Hammond Hayes in facing up to critical problems—human as well as technical—as the telephone art progressed from its primitive forms. Hayes had quickly seen that the scientific roots of telephony must extend into deeper soil than could be cultivated with the primitive tools of the early electricians and telegraph wiremen, scorned by Lord Rayleigh as "so-called practical men whose minds do not rise easily above ohms and volts."

The invention of the telephone had stirred up an intellectual ferment in the world of engineering and physics concerning electric waves and oscillations. Hayes, while facing a host of practical and "earthy" problems, sensed the need for a cadre of keen, academically trained minds. His first discovery was John Stone Stone, recruited from Johns Hopkins in 1890 through the recommendations of the renowned physicist Rowland, then on the Hopkins faculty. Following Stone came Campbell from MIT (with additional training at Harvard, Paris, Vienna, and Göttingen); Colpitts from Harvard; Pickard from Harvard and MIT; and Jewett from Chicago, brought over from the MIT faculty. These were the bright lights of the earliest days; their contributions, inspired by Hayes, demonstrated convincingly the importance of fundamental knowledge. Thus the pattern was established long before there was a corporate Bell Laboratories with Frank B. Jewett as its president (1925). And to Jewett's successors, of

[1] *A History of Engineering and Science in the Bell System: The Early Years (1875–1925)* (Murray Hill, N.J.: Bell Telephone Laboratories, 1975). Six additional volumes have completed the series.

whom James Fisk was the third, there has been no higher priority than to engage and stimulate the best intellects.

There had been no scientists in the immediate Fisk family. James, his sister Rebekah (Becky), and younger brother George were born in West Warwick, Rhode Island, to the southwest of Providence. Their parents, Henry James and Bertha (Brown) Fisk, natives of Providence, had been charmed by the Far West during a wedding trip. They subsequently took the children to Tacoma, and later to Long Beach, for their primary schooling. The elder Fisk was a sales manager in the canning industry; and when the mother—a beautiful lady and talented violinist—died as the children were nearing high school age, he contemplated going to Alaska for better business opportunities. At this point the maternal grandparents, the George Tilden Browns of Providence, urged that the children be placed in their care for their high school years. Judge Brown had retired as presiding justice of the Superior Court of Rhode Island. Becky writes that his whole life thereafter was devoted to his three grandchildren and their education. "They spoiled us and at the same time were very strict. . . . He would quiz us in the evenings after study time. . . . Gramp's greatest delight was seeing good grades on our report cards. Jim's were always the best and required the least effort." The boys were sent far across town to Providence Technical High School in preference to nearby public or private schools.

James entered the Massachusetts Institute of Technology in 1927, when he was barely seventeen years old. It was in January of that year that telephone service had been established across the Atlantic. For the first time it was possible to place a telephone call to London or Paris. It was not done by cable; the cable was nearly thirty years in the future. The medium was high-power, long-wave radio, the wave being transmitted from tall towers at Rocky Point, Long Island.

Two of the key people involved, Mervin J. Kelly and Ralph Bown—Kelly in the fabrication of powerful radio tubes, Bown in the painstaking study of wave propagation over the great circle route—would one day be Fisk's mentors at Bell Laboratories. They were physicist-engineers, and he would succeed both of them.

But even more glamorous, in May of that year, was another conquest of the Atlantic, the solo flight of Charles Lindbergh from New York to Paris. On his return the young aviator was acclaimed in many parades. One of these—which I witnessed, and Fisk was probably there—was from Boston through Cambridge along Massachusetts Avenue, passing MIT, which already had a vigorous program in aeronautical engineering, boasting an advanced design of wind tunnel. This was the field that appealed most to Fisk, and he pursued it enthusiastically, graduating with high marks in 1931.

The senior album of the MIT class of 1931 depicts Fisk as very active in extracurricular affairs, from smokers, proms, and field days through ROTC and varsity athletics (track and cross-country). A member of Kappa Sigma fraternity (as his brother George was to be, following him by three years), Fisk made Tau Beta Pi and was secretary of his class for five years following graduation. "Jim had a quiet dignity," writes a classmate, "that brought him many assignments, always discharged in a friendly manner and displaying uncommon ability."

As an aeronautical engineering student, Fisk came to know and work with Charles Stark Draper, a Stanford and MIT alumnus, a graduate student and faculty member specializing in aircraft instrumentation. In their work in the engine laboratory Draper became impressed with Fisk's astuteness and depth and urged him to become more involved in pure physics; in a postgraduate year as a research assistant in aeronautics Fisk did develop a strong interest in atomic physics, which led to a Redfield Proctor Travelling Fellowship for study in England. Redfield Proctor, MIT '02, former governor of Vermont, and long-time member of the MIT Corporation, had established these fellowships in the interest of promoting international student exchange.

Fisk's grant was for the year 1932–33 at Cambridge, with residence at Trinity College. This was a time of great excitement in British physics. It was in 1932 that Chadwick discovered the elusive neutron. And with the reputation of the Cavendish Laboratory for Experimental Physics—where Sir J. J. Thomson in 1897 and "discovered" the electron (that is, measured the charge-to-mass ratio *e/m*)—and of its director, Sir Ernest Rutherford, hailed as "the greatest experimentalist since Faraday," who had in 1910–11 established the minuteness of the atomic nucleus—there could not have been a more felicitous assignment for a lively and personable young American. Fisk appears to have relished it. He requested, and was granted, an extension of the fellowship into a second year. Among the friends made in England during that period, besides Rutherford (who died in 1937), I remember John Cockroft, who was lecturing in physics. Sir John remained in close touch with Fisk for many years.

After completing his second year (1934), during which he published two Royal Society papers (one with a coauthor) relating to the conversion coefficients of gamma rays, Fisk returned to the States to work at MIT for his Ph.D., which he received in 1935. The subject of his dissertation was "The Scattering of Electrons from Molecules," a topic suggested by Professor Philip Morse, who took a constant interest in the study.

Quantum theory had already accounted for most of the phenomena observed in experimental studies of the "collision cross-section" of atomic gases when bombarded by beams of electrons. In Fisk's thesis the theory was extended to the case of diatomic molecules, and the results compared with experimental observations on H_2, N_2, and O_2. The results were in reasonable accord, considering the rough assumptions that had to be made concerning the molecular potential fields; the most noticeable departures were attributable to inelastic collisions due to the low energy of excitation in H_2.

Following an additional year at MIT as a teaching fellow in physics, Fisk received an appointment as a junior fellow at Harvard. The Society of Fellows had been established through a gift from President Lowell. It included a small group of young men and women of exceptional ability, originality, and resourcefulness who were given residence, plus a stipend, with no specific requirements as to what they should study or teach. It was a happy and challenging situation for Fisk. Only twenty-six years old, he enjoyed living in Lowell House, one of the first three "colleges" newly built under Harvard's House Plan, down by the river, with the added privilege of dining informally once a week with the senior fellows. To add to the enjoyment of his first year, 1936 was the tricentennial year of Harvard's founding, a colorful year climaxed by ceremonies in September attended by many noted scholars and Nobel prize winners (including Eddington) from foreign countries. The University of Cambridge (the mother of Harvard) sent representatives from Fisk's Trinity College, from Kings, and from Emmanuel (John Harvard had been an Emmanuel man).

A hundred years before, at the bicentennial, Emerson had written:

> . . . Cambridge at any time is full of ghosts; but on that day the anointed eye saw the crowd of spirits that mingled with the procession in the vacant spaces, year by year, as the classes proceeded; and then the far longer train of ghosts that followed the company, of the men that wore before us the

college honors and the laurels of the State—the long, winding train reaching back into eternity.

Thus Fisk became, in spirit, a Harvard man as well as an MIT man and a University of Cambridge man. As we came to know him a few years later, he was all of these—quietly, unostentatiously, but always generously.

A friend from MIT days, Ivan A. Getting, had become a Harvard junior fellow a year earlier. As an MIT freshman, Getting had had Fisk as his ROTC platoon commander. When Fisk, as a graduate student, had switched his interest to theoretical physics, which was Getting's field, the two had worked out problems together. Getting had then, after graduation, been awarded a Rhodes scholarship and studied physics at Oxford, receiving his Dr. Phil. in 1935.

Fisk brought with him to Harvard some of the designs for Van de Graaff electrostatic generators as evolved at MIT, and he and Getting proceeded to build an improved and compact machine for accelerating protons and deuterons up to 500,000 volts. The generator was not entirely completed when Fisk left the Society of Fellows two years later, and Getting continued its construction with the aid of a graduate student. There were two *Physical Review* papers coauthored by Fisk on features of the generator and its use in the physical laboratory.

Fisk's departure in June 1938 coincided with the termination of his celibate life. Shortly after his return from England in 1934 he had met Cynthia Hoar, a Concord (Massachusetts) girl whose family, like his, had a long New England background. They had met at Saint-Sauveur, P.Q., on a weekend of skiing, a sport relished by both; and their mutual interests, to be shared for nearly forty-seven years, included music. Cynthia was a pianist, and after Concord Academy she had attended the New England Conservatory and had studied for a year in Germany. Jim, Cynthia tells me, was a clarinetist (since high school days), and a good one. In later years at Bell Laboratories, characteristically, he never allowed us to suspect this endowment. Hammond Hayes had been like that: self-effacing, not seeking the limelight; a scholar talented in more ways than anyone knew.

Following a June wedding and a trip to Europe, Fisk and his bride moved to Chapel Hill, where he had accepted an associate professorship in physics at the University of North Carolina. He had presented a paper there at a National Academy of Sciences meeting in May on disintegration of nuclei by high-energy radiation—a topic of much piquancy, coming on the eve of disclosures from Europe on nuclear fission and the possibility of chain reactions. But after one academic year, the long arm of Mervin J. Kelly, director of research at Bell Laboratories, reached out and brought Fisk into the department Kelly had recently headed, now run by J. R. "Ray" Wilson, director of electronics research. Kelly, urgently seeking to build up the staff in modern physics, had heard about Fisk from William Shockley, who had joined Bell Laboratories after collaborating with Fisk at MIT in 1935–36.

Wilson, an alumnus of Reed College, Cal Tech, and Columbia, was a superb administrator. For all the shabbiness of their headquarters—a former biscuit factory in downtown New York—his and Kelly's men had produced some remarkable electron tubes. Their devices ranged from the world's tiniest (for the first electronic hearing aids) to a 250-kilowatt water-cooled monster—the world's largest triode, seven feet high—for super-power broadcasting. They had also furnished high-power tubes to J. R. Dunning at Columbia University for his first cyclotron.

Fisk's first supervisor was physicist J. B. Johnson, soft-spoken and gentlemanly, developer of the first practical cathode-ray oscilloscope tube, and famous for his analysis of electron noise in vacuum tubes and his identification of the *Wärmeeffekt* in electrical conductors, which became known as Johnson noise.

But the emphasis in Wilson's laboratory in the mid-thirties had been shifting toward the high radio frequencies, partly in support of new communications ideas and partly as our awareness of Churchill's "gathering storm" in Europe suggested new uses of radio that could be of military importance. One of these, the detection and tracking of ships and airplanes by means of pulsed radio beams—not yet called radar—was already being pushed in Army and Navy laboratories in the United States and Britain. In 1938 a program sponsored by AT&T, but at government request, was begun in secret in the radio laboratory of Bell Labs at Whippany, New Jersey.

William C. Tinus and I were put in charge of this work, and we immediately jumped to the 600–700 megahertz range, three to four times the frequency employed anywhere else, in order to achieve narrower radio beams for better angular precision and resolving power. We were encouraged by the work of Wilson's very clever physicist-engineers on high-frequency tubes and by the expertise in microwaves being developed for forward-looking Bell purposes by radio research engineers at our Holmdel laboratory under Harald T. Friis.

This is where Fisk came in. There was a crucial need for more transmitted power to increase range. At 700 MHz we could not get more than a kilowatt from any existing tube, even on a "pulsed" basis. We were being pressed by the Navy to go to even higher frequencies for still narrower beams, and by the Signal Corps to undertake a project called "bombing through overcast" that would require scanning the terrain or ocean from the air with the narrowest possible beam.

On October 6, 1940, Wilson and Fisk, accompanied by Kelly, were at our Whippany laboratory to witness tests on a new invention brought over in secrecy from England, the multi-cavity magnetron.[2] We had been alerted, and my colleague Russell Newhouse, coinventor of the first radio altimeter, was prepared with a test setup that included a powerful electro-magnet. He had built this to test an experimental 3,000-MHz (10-cm) oscillator devised by another of Wilson's ingenious tube men, A. L. Samuel.

The results with the British magnetron were astonishing. An outwardly simple device, it delivered bursts of 10-cm power roughly estimated at 10 kilowatts.

The radar picture changed overnight, and Fisk was commissioned immediately by Wilson and Kelly to set up a group to hand-produce 10-cm magnetrons as quickly as possible for use in planning new radars; to find out how to "scale" the magnetron to the 40-cm range so that it could be used immediately to beef up the radars already designed and being built in Western Electric factories for use on battleships, cruisers, and destroyers; and to solve the many fabrication problems associated with a device so radically new and not yet completely understood.

Within two months of the demonstration, but with Pearl Harbor still a year away, sample magnetrons had been made. As the months passed, under great pressure from the radar

[2] The body of the magnetron was a copper block—the anode—having a central hole with a cylindrical (indirectly heated) cathode located axially, plus six or eight surrounding holes connected to the central hole by narrow slots. The holes (plus slots) being essentially quarter-wave resonators, the iterative structure would support a wave traveling circumferentially, provided it could be reinforced by a circumferential movement of electrons at the right speed. This was accomplished by employing a strong transverse magnetic field so that the electrons emitted from the cylindrical cathode, instead of moving radially toward the anode, would be forced to follow a spiral path. The circumferential component of this motion (modified by its interaction with the fields at the successive slots) was then the source of microwave power.

development engineers and the hard-driving Kelly, Fisk's team proceeded with magnetron designs for manufacture, at the same time advancing in theoretical understanding of the intricate electron dynamics. Of the many inventions related to magnetron development, four resulted in patents issued to Fisk himself. His two physicist coworkers from the outset, with others soon added, were Paul Hartman from Cornell and Homer Hagstrum from Minnesota. A paper authored by all three was published after the war (1946) to cover the practical as well as theoretical aspects of the work, not only in Wilson's department but in many other contributing groups.

Wilson's laboratory, with splendid shop facilities and highly imaginative physicist-engineers already active in the new electronic art of "bunched" beams and resonant cavities, was a propitious environment. With the long wartime working day, six days a week (stretched out to twelve hours for train-and-ferry commuters from northern New Jersey), there was another fortunate ingredient—an esprit and dedication, along with the seriousness. Emanating from Wilson himself, and augmented by a prankishness going down the line—in which Fisk was often the ringleader and provocateur—this spirit was contagious and made everyone, including wiremen, mechanics, and clerks, an enthusiastic partner. Looking back on that period many years later, when vacuum tube research had moved from downtown New York to more sanitized and university-like quarters in New Jersey, Fisk reminisced in a speech to old veterans that "the sweet bakeshop aroma that hung over from the old biscuit factory may have inspired us to pump better vacuums," and suggested that "our instincts to be inventive may have been sharpened by the man-eating flies that shuttled between our place and the stables of New York's mounted police a half block away."

Encouraging to Fisk and his colleagues were reports from the armed forces on successful engagements—land, sea, and air—in which radars powered by their magnetrons had been decisive.[3]

Soon after the magnetron project was started, the National Defense Research Committee (NDRC)[4] established the MIT Radiation Laboratory, with the aim of mobilizing the nation's universities for defense. As Kelly's emissary in promoting collaboration between Bell Laboratories engineers and the staff there under Lee DuBridge, I found one of DuBridge's group leaders on gunfire-control radar to be Fisk's old MIT-Harvard friend, Ivan Getting; while his other MIT friend and mentor, Stark Draper, was inventing a lead-computing gunsight for naval machine guns, for which we at Bell Labs were designing an antiaircraft radar.

This fruitful collaboration included magnetron development, and as the war continued and it became possible to build magnetrons for even shorter wavelengths (3 cm and 1.25 cm), specialists from both the MIT and Columbia Radiation Laboratories joined forces with Fisk's group and made contributions of great value. These advances included very large improvements in power output and in frequency stability (the absence of unwanted modes of oscillation), plus the feature of tunability, technically difficult but quite valuable in an operational radar system.

Radar was a decisive element in the prosecution of World War II, and the British-invented magnetron, developed for

[3] The Navy Bureau of Ships, which had cognizance of shipborne search radar, including torpedo-directing radar for submarines, was especially diligent in reporting on submarine-based radar (the 10-cm SJ, followed by the 3-cm SS). One report cited a nighttime engagement in the Pacific in which fourteen torpedoes, in conjunction with the Navy's torpedo data computer, were used to sink seven ships in a Japanese convoy in the space of a few minutes.

[4] Serving with Vannevar Bush, chairman of NDRC, was Frank B. Jewett, president of the National Academy of Sciences and soon to retire as president of Bell Laboratories.

quantity production by Fisk and his colleagues, was its crucial component. The enemy had nothing comparable. The Presidential Certificate of Merit, recognizing Fisk's vigorous leadership, came in 1946. Even before this, with the war ending and still in charge of the magnetron group under Wilson, Fisk had been given a parallel assignment under Harvey Fletcher, director of physical research. One of the stars in Fletcher's department was C. J. Davisson, Nobel prize winner (1937) for his demonstration of the duality of electrons and waves. The contributions of Fletcher's men to achievements in Wilson's area, including magnetic structures for magnetrons, had been notable. It was Kelly's view, with Fletcher's retirement only a few years away, that Fisk could bring new strength to an area that was close to Kelly's heart—the fundamental properties of materials and the physics of the solid state.

As assistant director under Fletcher, Fisk organized a solid state physics group that only two years later was to come up with the epochal invention of the transistor—another Nobel achievement. He also set up a research activity in electron dynamics to provide a continuing background in fundamental theory for the more developmental type of work on microwave tubes that was increasingly engaging Wilson.

The war's end had allowed Bell people, emerging from some of their all-out military commitments, to think again about their own business. Many things urgently needed doing. To Ralph Bown, a Cornellian with a long background in radiophysics and wave propagation who had succeeded Kelly as director of research, there was one area especially where the time was ripe and the technology ready: the plunge ahead on a nationwide system of microwaves, beamed from tower to tower, with a capacity for thousands of telephone channels, plus network television.

Thus the postwar Bell Laboratories was an exciting place. So, too, was the Fisk household in Madison, New Jersey, which included three lively young boys and a grand piano—a Steinway, the gift of Cynthia's Massachusetts parents. Accordingly, we who had been close to Fisk and observed the increasing responsibilities given to him by Kelly and Bown were surprised to learn late in 1946 that he was leaving us to become a professor of physics at Harvard. We knew the academic life had always appealed, and that the blandishments of the Harvard physics faculty could be persuasive. At first we suspected that a bit of nostalgia for the Cambridge-Concord environment was also involved, but this was not the motivation. Fisk was simply not ready to commit himself to a career inevitably leading to the management of research, or research and development, rather than the personal involvement as a scientist that had brought him such satisfaction.

The move to Harvard was delayed for a year to enable Fisk to respond to an urgent request from the newly formed Atomic Energy Commission to be its first director of research. In this capacity he was influential in emphasizing the role that should be assigned to basic research, as distinguished from reactor development, and introduced several programs to include such fundamental work in the AEC's plans (later he was to serve for six years, 1952 to 1958, as a member of AEC's General Advisory Committee).

After spending much of 1947 in Washington, with residence in Alexandria, Fisk was able to take on his Harvard commitment and to live with his family in historic, white-steepled Concord, the home of Emerson and Hawthorne, and the locale of Thoreau's Walden Pond—"a gem of the first water which Concord wears in her coronet"—where Cynthia had gone swimming as a girl.

The Harvard appointment was to the Gordon McKay Professorship in Applied Physics, along with which Fisk was given an honorary A.M. and, in 1949, made a senior fellow in the Society of Fellows. The university catalog listed his courses as Elements of Mechanics (classical mechanics, for undergraduates and graduates) and Electron Physics, a reading and research course for graduate students.

Fisk's students gave high ratings to his lectures, but they also appreciated his mischievous dry wit, already so well known to his Bell friends. On occasion he would invite a student to accompany him to a Red Sox ballgame at Fenway Park, winding up the day with a round of his favorite cigars, Corona Belvederes.

In a neighboring office was Edward M. Purcell, also teaching physics and another veteran of strenuous war years. Two years earlier he had observed the phenomenon of nuclear magnetic resonance (NMR), for which he and F. Bloch of Stanford would receive the 1952 Nobel Prize in physics. Purcell writes concerning Fisk that it was "a joy to be able to talk with him about anything from freshman physics to high technology, and to draw from that deep reservoir of humane wisdom. . . . How great was Harvard's loss when Jim left we have of course no way of measuring. I often thought he might have become, and would have made, a great president of the university."

But Fisk did leave, after one year, despite his love for academe; this time the challenge presented by Kelly and Bown was irresistible. Fletcher was retiring in the summer of 1949, and Bown confided to Friis and me: "We're getting Jim back; and our idea is that he would eventually move into my job. I presume this would be agreeable to both of you." It was, with no reservations. An old friend was rejoining us.

In telephony there is a subtlety in the end product. The end product is human communication, not hardware. This subtlety seems to offer a glamour of an intellectual sort to intrigue an inquisitive mind. Thus a keen physicist quickly catches on to the fundamentals of telephony's dominant technologies, transmission and switching.[5] These are the fields requiring the greatest amount of organized engineering manpower, yet continuously sensitive and responsive to new ideas.

This was what Fisk came into in mid-1949 at our new headquarters at Murray Hill, New Jersey. His direct responsibility was for research in the physical sciences. But his broader assignment, as Bown's and Kelly's heir apparent, was to encourage communications researchers like Friis and me, in trying to envision the telephone system of the future, to look even farther beyond the horizon.

There are near horizons and far horizons. In the early nineteen-fifties we were looking ahead to the circular waveguide, using millimeter waves and providing a quarter of a million voice channels, as the long-distance medium of the future, at least over land routes. About 1955 John Pierce, an electron dynamicist of extraordinary imagination who, like Fisk, had worked under Wilson, made the audacious proposal that we communicate across oceans by means of microwave beams directed at orbiting satellites. And from over an even more distant horizon there beckoned optical fiber transmission—though with little hope, until the nineteen-seventies, for any but short distances. To all of these approaches, Fisk—advancing to vice president for research in 1954 and executive vice president in 1955—gave enthusiastic support and encouragement.

[5] The term *transmission*, understood as the faithful transport of large bundles of voices over long or short distances, speaks for itself. The term *switching*, with its suggestion of the railroad yard, unfortunately conveys no notion of the fascinating complexity and intellectual challenge of this field. The French term *commutation* is scarcely better. The Germans at least employ *wählen*—to choose—for the dialing process. A German engineer could easily fashion a word—perhaps *Selbstwahlvermittlung*—to indicate what telephone switching really is: the prompt implementation of personally designated choices. Today, the choice is of one destination in a hundred million, handled in seconds.

In the equally important area of telephone switching, it had seemed to Kelly that the ultimate would be attained when the hundreds of millions of electromechanical contacts of the newest switching system, known as crossbar, could give way to electronic crosspoints. This, Kelly thought, would be a crowning achievement of solid state physics. It was not to come out that way. From over another horizon came the concept of "stored program control"—the idea of employing vast memories, with instant access thereto, whereby a great variety of new optional services, changeable on demand, could be provided to the telephone subscriber with no need for physical changes in the central office. This was the huge development program known as ESS (electronic switching systems); it was implemented in the 1960s and 1970s in thousands of central offices, using crosspoints that were still electromechanical, though miniaturized and highly refined. The ideal solid-state crosspoint, because of very severe requirements, did not appear until the 1980s.

In a mission-oriented laboratory of thousands of trained scientists and engineers, many of them with decades of experience, the prime requirement of a top executive is not inventiveness but leadership, a leadership that will bring out the best through inspiration and encouragement. It was for this job that Kelly wanted Fisk, and it proved to be Fisk's special genius. A problem he tackled early—and "head-on" (his favorite adverb)—was to develop a much-needed understanding amongst professional personnel of the company's policy on merit and rewards. At Kelly's behest Fisk and Frank Leamer, seasoned director of personnel under two administrations, formulated a statement of salary policy, including a graphic merit scale, that was available to any technical staff member for discussion with his superiors. The document was so clear, straightforward, and unequivocal that it evoked wide commendation in the personnel management world and was copied in many organizations.

Fisk was also strong on environment, the need for an atmosphere that encourages each scientist and engineer to use his talents to the utmost. "It takes an environment of stimulating associates, some of them patient, some impatient, some who sparkle brilliantly and some quietly persistent; individuals painstakingly selected over the years to insure mutual respect and establish a balance in their integrated skills." This statement was made in a 1966 address at the Southern Research Institute in Birmingham. And on a different point, moments later:

> Scientific advance comes, in large part, from interchange of knowledge with the world outside, with the academic world and with scientists and engineers of attainment and stature who are hammering at problems related to one's own. It is impossible to retain gifted men unless they are given freedom to discuss their work with others of renown in the scientific community, and the pass-key to that community is one's own prestige, attained through publication of results. Accordingly, it is short-sighted policy to delay or restrict publication beyond the very minimum required for patent applications, or discourage in other ways the driving urge of good scientists to be known and respected in their professional circles.

No predecessor or contemporary in Bell Laboratories—or perhaps anywhere—held these views more strongly than James Fisk, or was more unswerving in their implementation. They were the views Hammond Hayes held sixty years before: that the research support for a science-based industry must have the best people obtainable, must have its goals (in broad terms) clearly understood, and must provide an environment that will motivate and inspire toward their achievement. A part of this last was the recognition that there are some scientists who will do their best work when not constrained by rigid rules. A part of it was the deliberate bridging of departmental barriers, to promote collaboration between the disciplines (example: the solar battery, invented by a physicist, a chemist, and an engineer). Fisk was eloquent on this: "To achieve this necessary interaction it is not enough to rely on thermal diffusion, so to speak, across the interfaces. It must be worked at; it must be cultivated."

This concern was evident in his almost daily appearances in one department or another and his genuine friendliness toward people down the line, which continued after he assumed the presidency, succeeding Kelly, in 1959. In 1964, as plans were being made to add new "branch laboratories" located at Western Electric manufacturing plants—several of these having been highly successful—Fisk was gravely concerned lest this "decentralization" might be carried too far. He enjoined his colleagues to preserve at all costs, as he expressed it at our annual executive conference at Seaview that autumn, "the blessings of unity and compactness and close personal contact that have made it so easy for us to pull together and act as one Bell Laboratories."

Unsparing of himself in the interest of his government, in mid-1958 Fisk accepted an appointment by President Eisenhower to head a delegation of scientists to go to Geneva to lay the technical groundwork for a nuclear test ban treaty with the Soviets. It was something new in international negotiations for scientists to find themselves in such a role, knowing that the final decisions would be in the hands of the diplomats. Fisk earned high praise for the rare combination of skill, firmness, and tact with which he dealt with the Russians and their Moscow-dictated intransigence. The principal issue was the problem of verification, wherein it was necessary to agree on an adequate number of test stations to monitor noncompliance. In a second conference in late 1959, where Fisk and his partners presented indisputable evidence that far more test stations would be required than the Soviets would agree to, the delegates came virtually to a dead end. "It is quite impossible," wrote Frank Press,[6] then a professor

[6] Frank Press, "Scientific Aspects of the Nuclear Test Ban," *Engineering and Science* (December 1960):26–36.

at Cal Tech and a member of the delegation, "to feel secure with a treaty that allows too few inspections."

During the fourteen years of his presidency, while he continued to serve the government in many ways, as well as the cause of higher education, Fisk guided the Laboratories through some major developments. Perhaps most spectacular among these was the satellite program, beginning with the passive reflecting balloon *Echo* launched in August 1960 in collaboration with NASA and its Jet Propulsion Laboratory. And in the closing minutes of 1961, even as the big balloon made its 6,232nd orbit around the earth and sailed on into 1962, an advanced type of electronically equipped satellite, *Telstar,* complete with receiver, transmitter, and solar batteries, was receiving ground tests at Bell Laboratories for testing in space. It was still too early in the space vehicle art for geo-stationary orbits at 22,300 miles; and there were some worries about such an orbit, including the concern about the time delay (a half-second on each round trip), which could cause two fast talkers to become entrapped in their own rudeness. "If we cannot in the near future increase the velocity of light," quipped Fisk, "can we with some subtle attachment, not seen by the impatient user, soothe his impetuosity for those few minutes till he finishes his call. . . . so that communication by satellite may be smooth and uninterrupted not only for the chivalrous and gently bred, but for the rest of us as well?"

Intercontinental telephony by satellite, as is well known, passed from the hands of the Bell System to the Communications Satellite Corporation, organized by the government, and overseas telephone traffic has been shared between Comsat's facilities and AT&T's deep-sea telephone cables. The first of these (with thirty-six voice channels) had gone into service in 1956, using oceanbottom amplifiers ("repeaters" in telephone engineering jargon) every forty miles. Under Fisk's leadership the capacity of these systems, using transistors, increased to 800 channels, with a new 4,000-channel system envisaged before he retired.

The Fisk home in those years was a rambling farmhouse in New Vernon, New Jersey, with five acres for indulgence in a hobby Jim called "farming in miniature." One could drop by on a Saturday and find him riding jauntily over the furrows or adjusting a newly sharpened sickle bar on his tractor, but ready for a plunge with a guest in the Fisk pool, followed with a round of cigars. The Fisks loved the countryside, and Cynthia, having taught piano, conducted children's concerts for eleven years in nearby Morristown. One of the delights for the Bell Labs executive group known as the "cabinet" was a social hour and buffet at sunset time, after which some two dozen of us, plus wives, having participated in the Fisk largesse, could sometimes prevail upon Cynthia for a brief musicale. Many engineers are music lovers; I think telephone engineers especially, perhaps because through the science of sounds we know what music is "made of."

Fisk chose to retire from the presidency in 1973 at age sixty-two, remaining as board chairman for another year. His successor as president, Princetonian William O. Baker, a renowned physical chemist, Priestley medalist, and Perkin medalist, had joined Bell Laboratories in 1939, the same year as Fisk. Baker's contributions to the sciences of physical materials assured that the intricate bondings of atoms and molecules being elucidated by physicists in collaboration with chemists and metallurgists would bring into practical use new materials of scarcely hoped-for properties of benefit to communications and to industry at large.

In 1975 a signal honor and lasting tribute was paid to Fisk by the establishment of the James B. Fisk Merit Scholarship. Presented annually to outstanding boys and girls who are children of employees, the scholarship recognizes academic excellence, high character, and leadership, qualities Fisk respected and encouraged.

Fisk's retirement years saw continued advances under Baker and his successor, Ian M. Ross, English-born, from the University of Cambridge. Most dramatic were the microminiaturizing of complex circuitry (the new era of "chips") and the breakthroughs in optical fibers, which with lasers and other devices in the new art of "photonics" are providing a new long-distance communication medium of extraordinary capacity.

Less spectacular, but likewise affording Fisk much satisfaction, was the continued emphasis by Baker and Ross on a program Fisk had initiated, the application of computer-based systems to the complex operating problems of the telephone companies, with huge savings in manpower and expense.

Before the recently enacted divestiture, Harvard Dean Harvey Brooks wrote that "The Bell System represents the best example of a highly integrated technical structure in a high-technology industry and is widely regarded as the most successful and innovative technical organization in the world."[7] Although the System is now broken up, Ross is determined that the scientific quality and the innovativeness that his predecessors sponsored—as recognized in two more Nobel awards under the Baker and Ross regimes—shall remain undiminished.

The Fisks, while retaining their New Jersey home after retirement, were able to spend more time at Keene Valley in their beloved Adirondacks. To them the Adirondacks were what New Hampshire was to poet Robert Frost: not a place on the map but a region of the mind. And each year there was a trip to Europe to see friends, visit the universities, and

[7] Harvey Brooks, "Knowledge and Action: The Dilemma of Science in the 70's," *Daedalus* (Spring 1973):125–43.

talk with representatives of companies on whose boards Jim served.

I last saw Jim Fisk in New York at the Harvard Club—to both of us, at our age, a place of refuge in a perilous city. We had lunched with some Japanese guests who had been gracious to us in Tokyo. In parting we talked about another get-together to discuss some speculations of Harvard's late Percy Bridgman on the Second Law. But this was not to happen. After visiting Spain in the spring of 1981, Jim and Cynthia were vacationing in August in the Adirondacks when he suffered, unexpectedly, an aneurysm in the abdominal aorta that he was not able to survive. His death on August 10, in neighboring Elizabethtown, came three weeks before his seventy-first birthday.

Faithful colleague Frank Leamer, hurrying over to Keene Valley from Saranac Lake for the services at the Congregational church, paid a warm tribute shared by all Bell people. Speaking of Jim Fisk as not only a distinguished scientist but a great humanitarian in his quiet, unassuming, and modest way, he recalled that Jim was also "a great nature lover and outdoor man. We often shared experiences in the wilderness and seldom-trod areas. He used to bushwhack to the mountain tops instead of following the beaten path."

A resolution of the Corporation of MIT, of which Fisk had been a member for twenty-two years and had become a life member, spoke of him as "a princely human being of uncommon modesty," who was "as much at home in the university as he was in the corporate boardroom, laboratory and the high offices of government." The resolution also lauded his personal generosity and strong support in major capital drives and his leadership in the selection of three successive Institute presidents.

Following the passing of her husband, Cynthia Fisk moved from New Jersey to Boxborough, Massachusetts, a few miles from her native Concord, purchasing a villa-type house on a hilltop with gardens and play-space for grandchildren. She continues with her piano in a local chamber music group. Living in this area she is able to see two of her sons often—Samuel, out of Brown and the Columbia Business School, with overseas experience in the Peace Corps, and now in psychological counseling, with an office in Cambridge; and Charles, a graduate of Harvard and of the Yale School of Music, a concert pianist and teacher of piano, music theory, and the history of music at Wellesley. Son Zachary, from Harvard and the University of California, is farther away, a distinguished young physicist at Los Alamos.

All of the Fisk family know that to Jim's associates he was not only a leader but a warm friend, a blithe spirit moving amongst us, giving added life to a dynamic profession; personifying the spirit of noblesse oblige; one of the noblemen of our time.

THIS MEMOIR, written from a retirement haunt in the deep South, has benefited from notes graciously furnished by Cynthia Fisk, up in New England; by Dr. Fisk's sister Becky, Mrs. William Wilkinson, in Laguna Hills, California; and from the aid of an indefatigable lady at Bell Laboratories, Ruth Stumm, faithful researcher and transcriber.

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