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ALFRED LEE LOOMIS

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A Biographical Memoir by
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THE BEGINNING of this century marked a profound change in the manner in which science was pursued. Before that time, most scientists were independently wealthy gentlemen who could afford to devote their lives to the search for scientific truth. The following paradigms come to mind: Lord Cavendish, Charles Darwin, Count Rumford, and Lord Rayleigh. But after the turn of the century, university scientists found it possible to earn a living teaching students, while doing research "on the side." So the true amateur has almost disappeared—Alfred Loomis may well be remembered as the last of the great amateurs of science. He had distinguished careers as a lawyer, as an Army officer, and as an investment banker before he turned his full energies to the pursuit of scientific knowledge, first in the field of physics, and later as a biologist. By any measure that can be employed, he was one of the most influential physical scientists of this century. In support of that assessment, one can note: (1) his election to this Academy when he was 53 years old, (2) his honorary degrees from prestigious universities, (3) his crucial wartime role as director of all NDRC–OSRD radar research in World War II, and (4) his exceedingly close personal relationships with many of the leaders of American science and government in the mid-twentieth century.

With that brief introduction to the remarkable career of Alfred L. Loomis, we will now examine the man himself, to find, as one might expect, that he was indeed as extraordinary as his unique accomplishments would suggest.

He was born in New York City on November 4, 1887. His father was Dr. Henry Patterson Loomis, a well-known physician and professor of clinical medicine at New York and Cornell medical colleges. His grandfather, for whom he was named, was the great nineteenth century tuberculosis specialist whose work was commemorated in the naming of the Loomis Laboratory at Cornell Medical College, and the Loomis Sanatorium at Liberty, New York. His maternal uncle was also a physician, as well as the father of Alfred Loomis' favorite cousin, Henry L. Stimson, who was Secretary of State under Herbert Hoover, and Secretary of War throughout World War II.

From Alfred Loomis' educational background, one would correctly judge that he came from a prosperous, but not exceedingly wealthy family. He attended St. Matthew's Military Academy in Tarrytown, New York from the age of nine until he entered Andover at thirteen. His early interests were chess and magic; in both fields, he attained near professional status. He was a child prodigy in chess, and could play two simultaneous blindfold games. He was an expert card and coin manipulator, and he also possessed a collection of magic apparatus of the kind used by stage magicians. On one of the family summer trips to Europe, young Alfred spent most of his money on a large box filled to the brim with folded paper flowers, each of which would spring into shape when released from a confined hiding place. His unhappiest moment came when a customs inspector, noting the protective manner in which the box was being held, insisted that it be opened—over the strong protests of its owner. It took a whole afternoon to retrieve all the flowers.

The story of the paper flowers is included in this biographical memoir because it is the only story of Alfred's childhood I can remember hearing from him. (Since all his friends called him Alfred, and since the story of his life is for his friends in the Academy, I will refer to him most often as Alfred. Those who knew him less well called him Dr. Loomis.) In the thirty-five years during which I knew him rather intimately, I never heard him mention the game of chess, and his homes contained not a single visible chessboard or set. (When I checked this point recently with Mrs. Loomis, she wrote, "Alfred kept a small chess set in a drawer by his chair and would use it, on and off, to relax from other intellectual pursuits. He preferred solving chess problems or inventing new ones to playing games with other people.")

He loved all intellectual challenges and most particularly, mathematical puzzles. He made a serious attempt to learn the Japanese game of Go, so that he could share more fully in the life of his son Farney, who was one of the best Go players in the United States. But his chess background wasn't transferable to the quite different intricacies of Go, and he had to be content to collaborate with his son in their researches on the physiology of hydra. As he grew older, his manual dexterity lessened, but he still enjoyed showing his sleight of hand tricks to the children of his friends and to his grandchildren—but never to adults.

It was characteristic of Alfred that he lived in the present, and not in the past the way so many members of his generation do. On the very few occasions when he shared one of the many closed chapters of his life with me, I was enchanted by what he had to say about the captains of industry and the defenders of the America's Cup, who were many years ago his most intimate friends. He apparently felt it would sound as though he were bragging if he alluded to the great power he once wielded in the financial world when in the company of a university professor. In 1940, I casually asked him what he thought of Wendell Willkie, the Republican presidential candidate, and he said, "I guess I'll have to say I approve of him because I appointed him head of Commonwealth and Southern." Alfred was the major stockholder of that utility, so there was certainly an element of truth in his flip and very uncharacteristic remark. He was immediately and obviously embarrassed by what he had said, and it would be another twenty years before he made another reference to his financial career in my presence.

Alfred entered Yale in 1905, where he excelled in mathematics, but he was not interested enough in the formalities of science to enter Sheffield Scientific School. He took the standard gentlemen's courses in liberal arts, and without giving much thought to his career, felt he would probably engage in some kind of scientific work after he graduated. But one afternoon, a close friend came to him for advice on choosing a career. Alfred strongly urged him to go to law school, pointing out that a broad knowledge of the law was a wonderful springboard to a variety of careers; in addition to formal legal work, a lawyer was well prepared for careers in business, politics, or government administration. Alfred was so impressed by the arguments he marshaled for his friend that he enrolled in Harvard Law School. He never regretted that decision, because it gave him a breadth of vision that he applied to many fields.

In his senior year at Yale, he was secretary of his class, but he had the time and the financial resources to pursue his life-long hobby of "gadgeteering." His extracurricular activities involved technical matters such as the building of gliders, model airplanes, and radio-controlled automobiles. He was fascinated by artillery weapons, and we shall learn that the great store of information he accumulated in that field played a crucial role in changing the major focus in his life from business to the world of science. A glider he built and tested from the dunes near his summer home at East Hampton stayed in the air several minutes. It was obvious to his friends that he was distinguished by a wide-ranging mind and the ability to "learn all about" a completely new field in a remarkably short time through independent reading. That facet of his personality and intellect was the most immutable throughout his life—a life that would be characterized by periodic and major changes of interest.

Alfred's decision to become a lawyer was certainly influenced by his cousin, Henry Stimson, in whose firm of Winthrop and Stimson he was assured a law clerkship. But after his distinguished performance at Harvard Law School, where he was in the "top ten," helped edit the *Harvard Law Review,* and graduated cum laude in 1912, he would have been welcomed in any New York law firm. As one would guess from his later interests, he specialized in corporate law and its financial aspects.

By 1915, he was a member of the firm, and married to the former Ellen Farnsworth of Dedham, Massachusetts. They lived in Tuxedo Park and raised three fine sons, each of whom shared one or more of his father's major interests. Alfred's ideas on child rearing were unorthodox, but very successful. He thought that his sons should learn at an early age to manage all their own affairs, so he gave each of them a large sum of money at age fourteen, with no controls whatsoever. Each one planned his own education, and decided what hobbies to pursue, after much consultation with, but no veto power from, Alfred. The oldest son, Lee (Alfred Lee Loomis, Jr.), is a successful financier and famous deep sea sailor. The second son, the late Farney (William Farnsworth Loomis), was a physician and later Professor of Biochemistry at Brandeis University. He was a Himalayan climber, pilot, and as an OSS doctor, parachuted into China beyond Japanese lines in World War II. The third son is Henry, a radar officer in World War II who gave up a career in physics for one in public service administration. He was assistant to the President of MIT, later Director of the Voice of America, and is now President of the Corporation for Public Broadcasting.

Alfred's career as a young corporation lawyer was interrupted by World War I. When he joined the Army, his fellow officers were surprised to learn that he knew much more about modern field artillery than anyone they had ever met. He had made good use of the special communication channels available to Wall Street lawyers, and had accumulated a vast store of up-to-the-minute data on the latest ordnance equipment available to the warring European powers. His expertise in such matters led to his assignment to the Aberdeen Proving Grounds, and before long, he was put in charge of experimental research on exterior ballistics, with the rank of major. At Aberdeen, he was thrown into daily contact with some of the best physicists and astronomers of this country, and he and they benefited from each other's talents.

In those days, before photoelectric cells and radar sets came to the aid of exterior ballasticians, there was no convenient way to measure the velocity of shells fired from large guns. Alfred invented the Aberdeen Chronograph, which satisfied that need for many years after its invention. It is hard for someone like me, who came into a scene long after an ingenious device had been invented, and later supplanted, to appreciate what made that device so special. But the fact that Alfred singled out the Aberdeen Chronograph for mention in his entries in *Who's Who* and *American Men and Women of Science,* and mentioned it on a number of occasions in conversations with me, makes me believe that it must have been a remarkably successful and important invention.

Alfred set such high standards for his own performance that no other interpretation of the value of the Aberdeen Chronograph would be consistent with his pride in it.

One of the friends Alfred made at Aberdeen was R. W. Wood, who was considered by many to be the most brilliant American experimental physicist then alive. They had known each other casually from the circumstance that each of their families had summer homes at East Hampton, on Long Island. But at Aberdeen, they initiated a symbiotic relationship that lasted many years. Wood became, in effect, Alfred's private tutor, and Alfred responded by becoming Wood's scientific patron. The following paragraphs from Wood's biography, including some direct quotations from R. W. Wood, tell of this relationship better than anyone of the present era could.

It was a consequence of Wood's scientific zest and social strenuousness that fate brought him, about this time, the facilities of a great private laboratory backed by a great private fortune. He had met Alfred Loomis during the war at the Aberdeen Proving Grounds, and later they became neighbors on Long Island. Loomis was a multimillionaire New York banker whose lifelong hobby had been physics and chemistry. Loomis was an *amateur* in the original French sense of the word, for which there is no English equivalent. During the war, he had invented the "Loomis Chronograph" for measuring the velocity of shells. Their friendship, resulting in the equipment of a princely private laboratory at Tuxedo Park, was a grand thing for them both.

A happy collaboration began, which came to its full flower in 1924. Here is Wood's story of what happened.

"Loomis was visiting his aunts at East Hampton and called on me one afternoon, while I was at work with something or other in my barn laboratory. We had a long talk and swapped stories of what we had seen or heard of 'science in warfare.' Then we got onto the subject of postwar research, and after that he was in the habit of dropping in for a talk almost every afternoon, evidently finding the atmosphere of the old barn more interesting if less refreshing than that of the beach and the country club.

"One day he suggested that if I contemplated any research we might do together which required more money than the budget of the Physics

Department could supply, he would like to underwrite it. I told him about Langevin's experiments with supersonics* during the war and the killing of fish at the Toulon Arsenal. It offered a wide field for research in physics, chemistry, and biology, as Langevin had studied only the high-frequency waves as a means of submarine detection. Loomis was enthusiastic, and we made a trip to the research laboratory of General Electric to discuss it with Whitney and Hull.

"The resulting apparatus was built at Schenectady and installed at first in a large room in Loomis' garage at Tuxedo Park, New York, where we worked together, killing fish and mice, and trying to find out whether the waves destroyed tissue or acted on the nerves or what.

"As the scope of the work expanded we were pressed for room in the garage and Mr. Loomis purchased the Spencer Trask house, a huge stone mansion with a tower, like an English country house, perched on the summit of one of the foothills of the Ramapo Mountains in Tuxedo Park. This he transformed into a private laboratory deluxe, with rooms for guests or collaborators, a complete machine shop with mechanic and a dozen or more research rooms large and small. I moved my forty-foot spectrograph from East Hampton and installed it in the basement of the laboratory so that I could continue my spectroscopic work in a better environment . . ."

Loomis, who was anxious to meet some of the celebrated European physicists and visit their laboratories, asked Wood to go abroad with him. They made two trips together, one in the summer of 1926, the other in 1928. . . .†

After World War I, Alfred formed a lifelong business partnership with Landon K. Thorne, his sister Julia's husband. In the thirty-five years I was so personally close to Alfred, I met Landon Thorne on only two occasions. Alfred kept his business friends and his scientific friends quite separate. For a long time, he apparently reasoned that while his broad range of interests made both groups exceedingly interesting to him, the two disparate groups might not feel about

* At the present time, the word "supersonic" is reserved for the characterization of objects that move faster than the velocity of sound. The subject pioneered by Langevin, Loomis and Wood—sound waves with frequencies above the audible range—is now called "ultrasonics."

†William B. Seabrook, *Dr. Wood, Modern Wizard of the Laboratory* (New York: Harcourt, Brace and Company, 1941), pp. 213–17.

each other as he did about them. So Alfred had many business friends about whom I have heard in the greatest detail, but never met. As he grew older, Alfred's personal ties to the scientific world became the dominant ones, and I find that his last entry in *Who's Who in America* lists his occupation simply as "Physicist."

Alfred was proud of the fact that he and Landon Thorne were in many kinds of business deals, and in every one of them, they were equal partners. First of all, they had equal shares in the very profitable Bonbright and Co., the investment banking firm of which Landon was the president, and Alfred the vice-president. This firm was instrumental in putting together and financing many of the largest public utilities in the country.

The two partners also built a very innovative racing sloop of the J-class, which they hoped would win the right to race against Sir Thomas Lipton in one of his periodic attempts to capture the America's Cup from the New York Yacht Club. To cut down on wind resistance, the partners arranged to have most of the crew below decks at all times, working levers in the fashion of galley slaves, rather than hauling on wet lines on the deck. With the help of the MIT Naval Architecture Department, they did a thorough study of hull shapes, and there were several changes in the location of the mast—made of strongest and lightest aluminum alloy—during the test program. But in spite of all these efforts, *Whirlwind* wasn't a success. Perhaps the best indicator of Alfred Loomis' financial state at that time is that J-boats were then almost always built by "syndicates" of wealthy men such as the Vanderbilts. But in order to have complete control of their J-boat, Alfred and Landon paid for the whole project, 50–50 as always. After World War II, J-boats became too expensive even for syndicates of rich men, so the America's Cup races are now sailed in the smaller "12-meter" boats.

Another of Alfred and Landon's partnerships was the ownership of Hilton Head, an island off the coast of South Carolina. Hilton Head is now a famous resort area, with luxurious hotels and golf courses. But when Alfred and Landon owned it, it was completely rustic. They used it only for riding and hunting, and invited their friends to share the beauties of the place with them. They also owned a large oceangoing steam yacht, which they donated to the Navy at the start of World War II. I can count on the fingers of one hand the number of times I've seen Alfred's name in the public press—he believed that the ideal life was one of "prosperous anonymity." The first time I saw Alfred's name in print was when *Time* identified him as a "dollar-a-yacht man," one of several who had given their yachts to the Navy in return for a dollar. Recently, I've found in the library two old articles about Alfred. The first was a popular article on the unusual J-boat and its owners. The second was an article in the very first issue of *Fortune* concerning Wall Street firms, and telling of the great success of Bonbright and Co., its well-known president, Landon Thorne, and its shadowy and brilliant vice-president, Alfred Loomis, who kept in the background and planned their financial coups. According to the article, "Bonbright . . . rose in the twenties from near bankruptcy to a status as the leading U.S. investment-banking house specializing in public-utility securities."

Another joint endeavor was the Thorne-Loomis Foundation which sent ten boys at a time (2,000 in all) on six-week tours of industrial plants in special trucks, designed by Alfred.

When the *Fortune* article appeared, Alfred was leading a double life; his days were spent on Wall Street, but his evenings and weekends were devoted to his hilltop laboratory in the huge stone castle in Tuxedo Park. The laboratory was abandoned in November 1940, so those who worked in it could join the newly established MIT Radiation Laboratory which Alfred was instrumental in founding, and which reported directly to him, in his wartime role as head of the NDRC's Radar Division. I arrived at MIT at the same time, so I learned much about the Tuxedo Park laboratory from the young scientists and engineers who worked there throughout the year, and from the former laboratory manager, P. H. Miller. The following account of a laboratory I never visited is based on those recollections, and on stories I heard from older physicists who had been Alfred's guests during summers at Tuxedo, and finally on the countless reminiscences of Alfred and other members of his family.

Because of the strong influence of R. W. Wood, the laboratory concentrated at first on problems that interested him. As the quotations from his biography tell, the first major work was in ultrasonics. Loomis and Wood are still mentioned in the introductory chapters of textbooks on ultrasonics and sometimes referred to as the "fathers of ultrasonics." The field has grown enormously since they did their pioneering work, and it now has practical applications in industrial cleaning, emulsifying, and most recently in medical imaging, in place of X-rays when the required moving pictures would involve excessive radiation doses. Imaging ultrasonic scanners are now in common use to watch the motion of heart valves, to observe fetuses, and at the highest frequencies, they serve as high resolution microscopes.

A bound volume of the "Loomis Laboratory Publications" (1927–1937) includes reprints of sixty-six scientific papers, of which twenty-one were on ultrasonics; Alfred was a co-author of the first four, and of four later ones. The first is the classic 1927 paper by Wood and Loomis, some of whose results were described by R. W. Wood in the quotation above.

The laboratory was well equipped for work in Wood's specialty of optical spectroscopy. Ten papers in this field came from the laboratory, including one by Alfred and

George B. Kistiakowsky entitled "A Large Grating Spectrograph," which illustrates Alfred's talents as an innovative designer of precision mechanical devices. None of the spectroscopic papers bears Alfred's name; it wasn't in his nature to publish in a mature field. Although Alfred admired those who could do the involved spectroscopic analyses that came from his laboratory, he preferred to do the pioneering work in some new field. His admiration for the real professionals of this era is shown by the fact that he arranged a series of conferences in honor of visiting European physicists. Guests at the conferences were transported to Tuxedo Park in a private train, and entertained in lavish style at the laboratory. The *Journal of the Franklin Institute,* in the issue of April 1928, has a sixty-five page section entitled "Papers Read at a Conference in Honor of Professor (James) Franck, at the Loomis Laboratories, Tuxedo, New York, January 6, 1928." Included are papers by J. Franck, R. W. Wood, K. T. Compton, and several others.

I have no records of the other conferences, but Alfred once showed me the guest book from the laboratory. (It had just been returned to him by his son, Farney, when the latter had closed his "Loomis Laboratory" to join the Brandeis University faculty.) The book showed the names of most of the well-known American and European physicists of the period. On some occasions, a page with many famous names would be headed by the name of the man in whose honor the group had assembled. Most often such an honored guest was a visiting European physicist, for example, Einstein, Bohr, Heisenberg, or Franck.

Alfred's main interest at that time was in accurate timekeeping. The following quotation from R. W. Wood's biography will serve to introduce that subject:

> Wood's second trip abroad with Alfred Loomis was made in 1928. They called first on Sir Oliver Lodge, who presented each of them with an autographed copy of his latest book, *Evidence of Immortality*. . . .

One of the things Loomis hoped to obtain in England was an astronomical "Shortt clock," a new instrument for improving accuracy in measurement of time. It had a "free pendulum" swinging in a vacuum in an enormous glass cylinder—and was so expensive that only five of the big, endowed observatories yet possessed one. Says Wood:

"I took Loomis to Mr. Hoke-Jones, who made the clocks. His workshop was reached by climbing a dusty staircase, and there was little or no machinery in sight, but one of the wonderful clocks was standing in the corner, almost completed, which made the total production to date six. Mr. Loomis asked casually what the price of the clock was, and on being told that it was two hundred and forty pounds (about $1,200), said casually, 'That's very nice. I'll take three.' Mr. Jones leaned forward, as if he had not heard, and said, 'I beg your pardon?' 'I am ordering three,' replied Mr. Loomis. 'When can you have them finished? I'll write you a check in payment for the first clock now.'

Mr. Jones, who up to then had the expression of one who thinks he is conversing with a maniac, became apologetic. 'Oh, no,' he said, 'I couldn't think of having you do that, sir. Later on, when we make the delivery, will be quite time enough.' But Loomis handed him the check nevertheless."

Back in America, they learned that Professor James Franck, Nobel prize winner, was coming over in January to give lectures at various universities. Wood suggested to Loomis that he hold a congress of physicists in his Tuxedo Park laboratory in Franck's honor. Franck accepted and the meeting was held in the library, a room of cathedral-like proportions, with stained-glass windows. Franck gave his first lecture in America there. Wood, Loomis, and others made subsequent addresses. The visiting American physicists were conducted through the laboratory and shown the supersonic and other experiments. The congress in this palace of science proved such a success that it was repeated the following year.*

Alfred's interest in accurate timekeeping probably resulted from his seagoing background, and his fascination with the art and science of navigation. He installed the three Shortt clocks on separate brick piers that were isolated from the laboratory structure, and extended down to bedrock. He was surprised to find that the clocks beat for long times in exact synchronism, and thought at first that they were locked together by gravitational interactions between the pendula.

*Seabrook, p. 221.

But he found that the coupling was through the bedrock, so the clocks were then placed at the corners of an equilateral triangle, facing inward, and the coupling was broken.

The Bell Telephone Laboratories had recently been developing quartz crystal oscillators with low temperature coefficients, and they came to surpass the Shortt clocks for short-term accuracy, but not for periods greater than a day. Alfred had a private line installed to carry the Bell oscillator signals to his horological laboratory, and he designed an ingenious chronograph to compare the timekeeping abilities of the Shortt pendulum clocks with the quartz oscillators. Since the first of these types was sensitive to gravity but the second was not, Alfred used his chronograph to demonstrate the expected but previously undetected effect of the moon on pendulum clocks. The observational data were accumulated by Alfred, but the data analysis required the services of a battery of "computers"—women who operated desk top computing machines, and whose salaries were paid by Alfred. The results of the analysis were published by Ernest W. Brown and Dirk Brouwer in a paper immediately following Alfred's "The Precise Measurement of Time," in the *Monthly Notices of the Royal Astronomical Society,* March 1931.

Alfred published several papers on biology and physiology with E. Newton Harvey and Ronald V. Christie. I never heard him speak of the physiological work, but he was obviously proud of the microscope-centrifuge he developed with Harvey. This was a typical Loomis "gadget" of the kind he enjoyed building all his life. The device made it possible for a biologist to watch for the first time the deformation of cells under high "g-forces." As Harvey and Loomis said in the introduction to their first paper on the subject,

The previous procedure has been to centrifuge the cell in a capillary tube, remove it from the tube and observe it under a microscope to determine what happens. It would obviously be far better to observe the effect of centrifugal force while the force was acting . . . Our communication describes a practical means of attaining this end.*

In typical Loomis fashion, Alfred's name appears on only the first of thirteen papers on the microscope-centrifuge that are to be found in the collected reprints of the laboratory.

In the mid-thirties, Alfred turned his attention to the newly discovered brain waves. Berger had published his observations in the German literature, but American physiologists were unable to duplicate his results, and most of them apparently doubted the existence of the very low voltage signals that Berger described. From his contacts with industry, Alfred had available the best amplifiers, and he did his work inside "a screen cage," to eliminate interfering electrical noise. He had by this time retired from his Wall Street firm, and was devoting his full attention to his scientific work. For this reason, his name appears on all of the laboratory papers on brain waves, many of which were of great importance. His work erased any lingering doubts concerning the value of Berger's discovery; electroencephalograms are now used routinely in the diagnosis of epilepsy and many other diseases. In fact, one finds advertisements in magazines for "bio-feedback devices" that let the user observe his Berger "alpha waves," and learn to control them, "leading to greater creativity." (In kit form, $34.95.)

Alfred and his co-workers investigated many aspects of brain waves and did particularly important work with sleeping subjects that involved the abrupt changes in the character of the waves as the subject underwent "quantum jumps" in his "depth of sleep." It was then possible to tell precisely when a subject dropped from one of five states of sleep from which he could instantly be awakened by a small disturbing noise, into one in which he would fail to respond to the loudest

* E. Newton Harvey and Alfred L. Loomis, "A Microscope-Centrifuge," *Science*, 72(1930):42–44.

noises that Alfred's high fidelity amplifiers could produce. (Alfred was one of the first "hi-fi buffs"; his homes were always filled to overflowing with a changing parade of the latest and most advanced high fidelity sound reproducing equipment. Avery Fisher and Alfred were close personally, and on at least one occasion, Mr. Fisher improved his superb product line with an idea that Alfred had devised to make the fidelity even higher.)

The only formal scientific talk I ever heard Alfred give was at the weekly Physics Department Colloquium in Berkeley, in 1939. He described his important brain wave experiments on sleeping, hypnotized, and blind subjects. My brief description of this work derives from my memory of Alfred's talk, but if space permitted, I could expand greatly on those observations. Henry Loomis' first important exposure to science came in those experiments, and he shared his experience with me on more than one occasion. (One of the papers lists a sixteen-year-old subject with the initials H.L.)

In 1939, Alfred's scientific interests changed drastically. He became deeply involved in Ernest Lawrence's projects and he shifted the emphasis of his own laboratory from pure science to war-related technology, by starting the construction of a microwave radar system to detect airplanes. The Sperry Gyroscope Company had bought an interest in the klystron patents that were owned by the Varian brothers, who invented the klystron, and Stanford University, which had supported the development work. Sperry built a small klystron plant in San Carlos, near Stanford, and their first customer was Alfred Loomis, who appeared, checkbook in hand, as he had years before at the small plant making Shortt clocks. (I'll temporarily interrupt this story to tell of Alfred's concurrent involvement with Ernest Lawrence's Radiation Laboratory.)

I was not surprised to meet Alfred in Berkeley, on his first visit to the Radiation Laboratory, in 1939. Francis Jenkins of the Berkeley Physics Department had spent a summer at Tuxedo as Alfred's guest, and he had told me in wide-eyed amazement about the fantastic laboratory at Tuxedo Park, and about the mysterious millionaire-physicist who owned it. Everyone who had submitted an article to the *Physical Review* in the depression years had received a bill for page charges together with a note saying that in the event the author or his institution was unable to pay the charges, they would be paid by an "anonymous friend" of the American Physical Society. There was of course no way to break the veil of secrecy surrounding the "anonymous friend," but "Pan" Jenkins told me in confidence that he felt sure that Alfred Loomis was the Society's benefactor. (That was a correct surmise.) Pan told me that Alfred was a wonderful person, but he didn't like the other residents of Tuxedo Park. He thought they were too "snooty," and looked down on the scientists as barbarians who "didn't even dress for dinner." (The gentlemen in Tuxedo Park followed the aristocratic British tradition of dressing for dinner in what most people would call tuxedo's, but which were called dinner jackets in Tuxedo Park.)

The relationship that quickly developed between Alfred and Ernest Lawrence had all the earmarks of a "perfect marriage"; they were completely compatible in every sense of the word, and their backgrounds and talents complemented each other's almost exactly. Ernest was a country boy from South Dakota who was the first faculty member of a state university to win a Nobel Prize. He had developed an entirely new way of doing what came to be called "big science," and that development stemmed from his ebullient nature plus his scientific insight and his charisma; he was more the natural leader than any man I've met. These characteristics attracted Alfred to him, and Alfred in turn introduced Ernest to worlds he had never known before, and found equally fascinating. Anyone who was in their company from 1940 until Ernest died in 1958 would have thought that they were lifelong intimate friends with all manner of shared experiences going back to childhood.

I was impressed by the way Alfred would seek out the younger members of the laboratory to learn everything he could about us and what we were doing and planning to do in our next round of experiments. I had never before had any serious discussions of physics with anyone as old as Alfred, and I was pleased that he liked to visit with me after I had taught a freshman class and was sitting out my required "office hour"—waiting to talk with the students who seldom came by. We talked a lot about physics, and found we were simpatico. He taught me an important lesson that I have put to good use in my life; the only way a man can stay active as a scientist as he grows older is to keep his communication channels open to the youngest generation—the front line soldiers.

Although Alfred's real mission in coming to Berkeley was to help Ernest raise the funds to build the 184-inch cyclotron, he also used the time to learn everything he could about cyclotron engineering and nuclear physics. I remember one occasion when I mentioned in passing that because of the war in Europe, the price of copper had risen to almost twice that of aluminum, for a given volume. Since aluminum had only 60 percent more specific resistivity than copper, I suggested to Alfred that aluminum might now be the preferred metal for the magnet windings of the 184-inch cyclotron. It seemed obvious to me, from elementary scaling laws, that an aluminum coil would be larger but would cost less. I had completely forgotten the suggestion, when a few days later, Alfred showed me a long set of calculations based on several altered designs of the 184-inch cyclotron that proved my snap judgment wrong. I came to appreciate for the first time the difference between the world of business, where a 20 percent decrease in cost was a major triumph, and the world of science, where nothing seemed worth doing unless it promised an improvement of a factor of ten. I hadn't done the calculations concerning the cyclotron cost because they obviously didn't permit a "large" savings in cost. But Alfred considered it worth a day or two of his time to see if he could cut the cost of the magnet windings by $50,000.

Ernest once told me of spending some time with Alfred in New York, after the Rockefeller Foundation had allocated $2.5 million to build the 184-inch cyclotron. Earlier, Alfred had been instrumental in securing the virtually unanimous backing of the "scientific establishment" for the proposal, thus relieving the Rockefeller Foundation of any necessity for acting as a judge between factions competing for the largest funds ever given to any physics project. So after acting as a senior statesman in the worlds of science and philanthropy, Alfred was ready to help Ernest obtain the best possible bargains in the purchase of iron and copper for the giant cyclotron. Ernest recalled that after spending some time with the Guggenheims, during which a favorable price for copper was negotiated, Alfred said, "Well, now we have to go after the iron. I think Ed Stettinius is the right man." (Stettinius was then Chairman of U.S. Steel, and later Secretary of State.) Ernest was impressed when a call was put through and Alfred said, "Hello Ed, this is Alfred. I have someone with me I think you'd like to meet. When can we come over?" They were soon in Mr. Stettinius' office, and shortly after Ernest had given him a pitch on the great cyclotron, Ernest and Alfred were in the latter's apartment celebrating their success with a drink.

In early 1940, Alfred was back in Berkeley, and he told me that his next big project was to arrange for the funding of Enrico Fermi's embryonic plans to build a nuclear chain reactor. I hadn't given any thought to the problems involved in designing or building such a device, so everything Alfred told me was most interesting. But Alfred's involvement in reactors was cut short in the summer of 1940 by the dramatic appearance in Washington of the "Tizard Mission." The purpose of this group of visiting British scientists was to enlist the help of the United States in developing and building the new devices needed to meet the military requirements of a war that had become technologically oriented to a degree quite unappreciated by our military-industrial-scientific establishment. As an example, radar had been invented independently in the United States by the Navy and the Army, and in England by Robert Watson-Watt. The U.S. military departments treated the subject with such excessive secrecy that no "outsiders" learned of it. Since the outsiders were the real professionals in radio engineering, they were the ones who could have developed American radar into the useful military tool that the insiders didn't manage to achieve. (The dismal state of U.S. radar was demonstrated at Pearl Harbor, a year and a half after the Tizard Mission had revealed all the British successes to the U.S. armed forces.)

The world now knows that the operational success of the long wave British radar was the foundation on which the RAF triumphs of the Spitfire and Hurricane pilots were based. A second generation of VHF radar, in the 200-megahertz (1.5-meter) band, could be fitted into planes to turn them into night fighters and anti-submarine patrols. Everyone agreed that microwave radar in the 3,000-megahertz (10-cm) band would be vastly superior to the 1.5-meter equipment then available. But there appeared to be little chance that a powerful generator of such pulsed microwaves could be developed.

When Randall and Boot made their breakthrough with the cavity magnetron in Mark Oliphant's laboratory in Birmingham, it was suddenly clear that microwave radar was there for the asking, but Britain had no spare "bodies" who could be asked to do the development—everyone with applicable skills was working at breakneck speed on the immediate problems of a desperate war that could be lost any day by the starvation of the submarine-blockaded British people. So, in a great and successful gamble, Winston Churchill made the decision to share all of his country's technical secrets with the United States, in the hope that the potential gain would offset the loss in compromised security. Sir Henry Tizard was sent to Washington with a committee of experts, including such luminaries as Sir John Cockcroft, to brief their American counterparts on all aspects of the scientific war.

Alfred Loomis was included in the briefings not only because of his unique position in the scientific establishment, but because his laboratory had built one of the two microwave radar sets then existing in the United States. Both were based on the klystron tube recently invented by the Varian brothers at Stanford University, and both were "continuous wave Doppler radars" of the type now used by police departments to apprehend speeders. William Hansen, who designed the first of these microwave radar sets, attempted for the next few years to find a wartime niche for such a device, but without much success. Alfred immediately sensed the great superiority of the pulsed microwave radar devices that could be based on the new magnetron, so he dropped his work on the klystron-powered radar set, and devoted all his energies to pulsed microwaves for the next five years. But his klystron radar could detect planes, as he demonstrated to the "founding fathers" of the MIT Radiation Laboratory in the winter of 1940—in fact, it was the first working radar set that any of us had ever seen. But immediately after that demonstration, it was junked.

The Tizard Committee spent some time in Tuxedo Park as Alfred's guests, and on that occasion, Alfred brought a number of friends, including Ernest Lawrence, into the newly formed Microwave Committee of the fledgling National Defense Research Committee (NDRC) which had just been established by President Roosevelt on the advice of Vannevar Bush. Alfred was chairman of the Committee which took the responsibility for establishing the MIT Radiation Laboratory, one of the world's most successful scientific and engineering undertakings. Alfred made the arrangements with industry for equipping the laboratory with the necessary hardware to make several flyable night-fighter intercept radar sets, and Ernest Lawrence took the responsibility of staffing the laboratory, mostly with young nuclear physicists. (The Tizard Mission suggested this, because the British had found nuclear physicists to be more quickly adaptable to a radically new set of "ground rules" than were professional radio engineers.) Lawrence persuaded Lee DuBridge to become the director of the new laboratory, and that was a most fortunate choice. He also traveled all over the country, recruiting his former students and their colleagues from the cyclotron laboratories they had modeled after his own, and he didn't spare his own laboratory; Edwin McMillan, Winfield Salisbury and I all rushed off to Cambridge in November of 1940, and didn't return to Berkeley for five years.

But this is the story of Alfred Loomis, and not that of his friends, nor of the great laboratory he founded and guided so successfully with a loose rein. So I will single out from the many successes of the laboratory only two projects, one invented by Alfred, and the other invented by Lawrence Johnston and me, but in which Alfred played a key role. The first was Loran (for Long Range Navigation), which was of great importance during the war, and is still a major navigational aid in use all over the world. Loran is a pulsed, "hyperbolic system," and in its original form, made use of Alfred's great store of knowledge about accurate timekeeping. In fact, the Loran concept of a master station and two slave stations can be traced to the Shortt clocks, which had a master pendulum swinging in a vacuum chamber, and a heavy-duty pendulum "slaved" to it, oscillating in the air.

To obtain a navigational "fix" with Loran requires the measurement of the time difference in arrival of pulses from two pairs of transmitting stations. Each such time difference places the observer on a particular hyperbola. The observer's position is fixed by the intersection of two such hyperbolas, each derived from signals originating from a pair of long wave transmitting stations. It is common for a Loran fix to derive from only three transmitters, with the middle one serving as a member of two different transmitter pairs. All of the wartime Loran stations operated at the same radio frequency, and different pairs of transmissions were distinguished by characteristic repetition rates for their pulses. The techniques for separating the signals and for measuring their differences in arrival time were "state of the art" at that time, but the problem of synchronizing the transmissions to within a microsecond, at points hundreds of miles apart, was a new one in radio engineering. Alfred proposed the following solution: the central station was to be the master station, and its transmissions were timed from a quartz crystal. The other stations also used quartz crystals, but in addition, monitored the arrival times of the pulses from the master station. When the operators noted that the arrival time of the master pulses was drifting from its correct value, relative to the transmitting time at that particular "slave station," the phase of the slave's quartz crystal oscillator was changed to bring the two stations back into proper synchronization. This procedure was able to bridge over periods when the signals at one station "faded out," and it was also what made Loran a practical system during World War II, rather than an interesting idea that would have to await the invention of cesium beam clocks, which were introduced in the 1950's.

The second project of interest in this biographical sketch is Ground Controlled Appraoch (GCA), the "radar talk-down system for landing planes in bad weather." The basic idea behind GCA came to me one day in the summer of 1941 as I watched the first microwave fire control radar track an airplane, automatically, from the roof of MIT. It occurred to me that if a radar set could track a plane accurately enough in range, azimuth and elevation to shoot it down, it could use that same information to give landing instructions to a friendly plane caught up in bad weather.

Starting from that simple concept, my associates and I, with strong backing from Alfred, showed that the technique would work if the radar set gave angular information that was as reliable as the optical information we used in our tests. We had to wait several months for the radar set to become available for landing tests, but in one early demonstration, the radar did track several planes successfully as they executed their approach and landing. But in the scheduled radar tests, the equipment was found to be quite unable to track planes near the ground; it would suddenly break away from the line of sight to the plane, and point instead down at the image of the plane, reflected in the surface of the ground.

At the conclusion of this disastrous set of tests, Alfred invited me to have dinner with him in his suite at the Ritz-Carlton in Boston and he did an amazing job in restoring my morale, which was at its lowest ever. He said, "We both know that GCA is the only way planes will be blind-landed in this war, so we have to find some way to make it work. I don't want you to go home tonight until we're satisfied that you've come up with a design that will do the job." We both contributed ideas to the system that eventually worked, and that involved a complete departure from all previous antenna configurations. I'm sure that had it not been for Alfred's actions that night, there would have been no effective blind landing system in World War II, and many lives would have been lost unnecessarily. I would have immersed myself in the other interesting projects that concerned me, and would soon have forgotten my disappointment and my embarrassment.

Alfred played another interesting role in GCA by ordering ten preproduction models of the embryonic device we had invented at the Ritz-Carlton from a small radio company on the West Coast. He did this for two reasons: in the first place, the laboratory had failed badly in transferring its first airborne radar set to industry for production. The industrial engineers predictably developed a bad case of NIH (Not Invented Here), and promptly decided that everything had to be re-engineered. The final product came out so late and was so heavy that it never saw any action. Because of that experience, Alfred and Rowan Gaither (later the first president of the Ford Foundation) set up the "Transition Office," whose job was to avoid the problems mentioned above. Rowan became head of the Transition Office, and GCA was selected as the first test case of the new technique. Its basic idea was that a company would be selected to produce a new radar set before the original ideas had been worked out in any detail. The chief engineer of the designated company, plus a few of his assistants, would come to the laboratory and participate in the design and testing of the new device, as members of an MIT-company team. In this way, when they returned to their factory to produce the device, everything in it would be "our ideas" and "our design." The Transition Office was a spectacular success, and in the process, Rowan Gaither became extraordinarily close, personally, both to Alfred and me.

The second reason that Alfred ordered the ten preproduction sets, using NDRC-OSRD funds, was that the Army and Navy as well as the RAF had all said, independently, that their pilots would "never obey landing instructions from someone sitting in comfort on the ground," and that they would continue pressing for something like the ILS (Instrument Landing System) that is now in general use throughout the world. Alfred was confident that as soon as the three services saw GCA work, they would immediately accept it, and want working models to test, "yesterday."

After some very successful tests at Washington National Airport, in which high service officials watched pilots land "under the hood," when those pilots had never even heard of the system until after they were in the air, there was a rush to order several hundred GCA sets. When the three services learned that NDRC had ten sets almost built, they called a meeting at the Pentagon to allocate them for tests in this country and in England. Alfred was invited, and he asked me to sit in. Neither of us said a word as the admirals, generals, and air marshalls engaged in a horse-trading session that ended up with all ten sets allocated to the services, and none to MIT or to the NDRC. The meeting was about to break up when Alfred said quietly, "Gentlemen, there seems to be some misapprehension concerning the ownership of these radar sets; it is my understanding that they belong to NDRC, and I am here to represent that organization." His training as a lawyer was immediately apparent, and after he had shown in his gentle manner that he held all the cards, an allocation that was satisfactory to all concerned was quickly worked out. And NDRC even ended up with one of its own GCA sets!

At the end of the war, Ernest Lawrence was asked for his evaluation of Alfred's contribution to radar, and he had this to say:

> He had the vision and courage to lead his committee as no other man could have led it. He used his wealth very effectively in the way of entertaining the right people and making things easy to accomplish. His prestige and persuasiveness helped break the patent jams that held up radar development. He exercised his tact and diplomacy to overcome all obstacles. He's that kind of man. I've never seen him lose his temper or heard him raise his voice. He steers a mathematically straight course and succeeds in

having his own way by force, logic and by being right. I am perfectly sure that if Alfred Loomis had not existed, radar development would have been retarded greatly, at an enormous cost in American lives.*

Alfred's other important role during the war is so little known that its only mention in print is in a brief obituary notice I wrote for *Physics Today.* Many authors have commented on the remarkable lack of administrative roadblocks experienced by the Army's Manhattan District, the builders of the atomic bombs. In my opinion, this smooth sailing was due in large part to the mutual trust and respect that Secretary of War Stimson and Alfred had. Alfred was in effect Stimson's minister without portfolio to the scientific leadership of the Manhattan District—his old friends Ernest Lawrence, Arthur Compton, Enrico Fermi, and Robert Oppenheimer. Alfred maintained a hotel room in Washington throughout the war, which his friends used when they couldn't find other accommodations, and one of the reasons for this was so that he could be available to talk with the Secretary on short notice. Alfred was also a member of a small committee set up by the Secretary to advise him concerning the V-1 and V-2 weapons being developed by the Germans, and just coming to the attention of military intelligence. At the committee's suggestion, the V-1 menace was largely blunted by a combination of the SCR-584 developed in Alfred's laboratory, an advanced computer developed by the Bell Telephone Laboratory, the proximity fuses developed by Merle Tuve and his associates working under NDRC sponsorship, and the Army's anti-aircraft guns. The V-2 rockets could not be defended against, and the committee recommended the only course of action possible, and the one that was followed—capture of the firing sites.

Toward the end of the war, Alfred was able to relax for the first time in five years, and he concurrently made an

* "Amateur of the Sciences," *Fortune,* 33(March 1946):132–35.

important change in his personal life. He and Ellen were divorced, and he married Manette Seeldrayers Hobart. They had an extraordinarily happy time together during the final thirty-two years of Alfred's life. His lifestyle underwent a dramatic change from one of multiple homes staffed by many servants to a very simple one, in which he and Manette cooked dinner every evening in East Hampton, side by side in the kitchen. Alfred designed a special rolling cart that brought the food to one end of the table, where he and Manette sat opposite each other, and served themselves from the cart. If there were guests, the plates were passed down each side of the table to them, from the cart. This new style of servantless elegance was written up in a magazine devoted to "good living."

Alfred's principal scientific interests changed at this time from the physical to the biological. As an example, I've mentioned his contributions to research on hydra. In that period, one of the bathrooms in his Park Avenue apartment was filled with petri dishes containing hydra. Alfred spent hours each day examining the hydra under a microscope, and comparing his observations with those of his son, Farney. He and Farney organized small meetings to which they invited specialists in subjects about which they wished to learn more. As in the old Loomis Laboratory days, the invitations included first class round trip transportation, plus luxurious living at the resort hotels where the meetings were held.

Alfred enjoyed introducing his scientific friends to the pleasures that are normally known only to the very wealthy. For many years, he and Manette visited California each spring, and invited several couples from Ernest Lawrence's laboratory to be their guests at the Del Monte Lodge at Pebble Beach, and to play golf at the Cypress Point Golf Club. In later years, the Loomises spent their winters in Jamaica, where their friends were invited, a week at a time, to share with their hosts the sun, the beach, and good food and good conversation. As often happens with men as they grow older, Alfred's circle of closest friends shrank to those he called "my other sons." I was fortunate to be included, along with John S. Foster, Jr., Walter O. Roberts, Ronald Christie, and Julius A. Stratton. Had Ernest Lawrence and Rowan Gaither outlived Alfred, they would have continued to visit the Loomises each winter in Jamaica, as members of the "other sons."

I can think of no better way to end this biographical memoir than by quoting the last paragraph of my *Physics Today* obituary:

> For those of us who were fortunate to know him well, he will be remembered as a warm and wise friend, always interested in learning new things. I was his guest for three days in May of this year, and what he most wanted to learn from me concerned programming tricks for the Hewlett-Packard model 65 hand-held computer that was his constant companion. I think it most fitting that my last visual memories of this renaissance man, whose life encompassed and contributed much to the electronic age, should have him operating a hand-held electronic computer containing tens of thousands of transistors.*

*Luis W. Alvarez, "Alfred L. Loomis" (obituary), *Physics Today,* 28(11):84–87.

HONORS AND DISTINCTIONS

HONORARY DEGREES

D.Sc., Wesleyan University, 1932
M.Sc., Yale University, 1933
LL.D., University of California, 1941

AWARDS AND MEDALS

Wetherhill Medal of Franklin Institute, 1934
Medal for Merit, 1948
His Majesty's Medal for Service in the Cause of Freedom, 1948

BOARDS OF TRUSTEES

Massachusetts Institute of Technology (Life Member)
Carnegie Institution of Washington
Rand Corporation
Research Corporation
New York Hospital

SCIENTIFIC SOCIETIES

National Academy of Sciences
American Philosophical Society
American Physical Society
American Chemical Society
American Association for the Advancement of Science
American Astronomical Society
Audio Engineering Society
Institute of Electrical and Electronic Engineers
Royal Astronomical Society

ADMINISTRATIVE POSTS

Chief, National Defense Research Committee, Division 14 (Radar)
Director, Loomis Laboratories
President, Loomis Institute for Scientific Research
Vice President, Bonbright and Company

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1933

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