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OLIVER ELLSWORTH BUCKLEY

1887—1959

A Biographical Memoir by

MERVIN J. KELLY

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O. E. Buckley

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BY MERVIN J. KELLY

BUCKLEY was an industrial research pioneer. He was among the first ten scientists trained to the doctoral level who became members of the research organization of the Bell System. He entered the research branch of the Western Electric Company—the forerunner of Bell Telephone Laboratories—in New York City in 1914, immediately after completion of his doctoral work in physics at Cornell.

Except for a short period of military service (1917-1918), he served continuously in the Bell System research organization—first with Western Electric Company and after 1925 with Bell Telephone Laboratories—until his retirement in 1952. During these thirty-eight years he made many outstanding individual and leadership contributions to communications science and technology. Quite early in his career he was given research and engineering leadership responsibilities that expanded in scope with time. In his later years he served as president (1940-1950) and as chairman of the board (1951-1952) of these great Laboratories, the largest integrated industrial research organization in our country.

His leadership and later executive responsibilities did not preclude his participation in and influence on the research and development programs. He maintained a high level of knowledge of and enthusiasm for scientific and technical work throughout his career and, in addition to his exerting a stimulating influence on those participating in the work, he made many personal contributions of importance.

BOYHOOD AND EARLY ENVIRONMENT

Ancestors and early environment provide the principal ingredients that determine the qualities of a man. Buckley was fortunate in both his ancestors and his early environment. He was born in Sloan, Iowa, on August 8, 1887. Sloan is a small town in the northwestern part of the state, about twenty miles south of Sioux City. With its population of 600, it had the character of a local center for the surrounding agricultural community. Buckley's parents were pioneers in this community.

His father, William Doubleday Buckley, was born on a farm at Unadilla Center, New York. His parents were Oliver Ellsworth Buckley and Juliaette Douglas Buckley. Buckley's grandfather was none too successful in wringing a livelihood for his large family from the infertile hilltop farm which came to him from his father, Billy Buckley. Billy, with his wife, Mary Turner, had emigrated from Connecticut to New York State in the early days of the republic.

Buckley's paternal grandmother, Juliaette Douglas, was the daughter of Judge Douglas of Franklin, New York.

His grandfather Buckley discovered his natural bent late in life when he became a successful "book agent," distributing first a Bible dictionary and later Appleton's Encyclopedia. He was thus able to acquire a good house in the village of Unadilla and to send Buckley's father, William, and his younger brother to an academy and then to Cornell University for two years. Buckley's father then took up the study of law in a private office and eventually emigrated to Sioux City, Iowa, where he opened a law office of his own. Practice was slow in building up, so he turned to school teaching as an additional occupation. He soon moved to Sloan, Iowa. While he was superintendent of the public school there he met Sarah Jeffrey, destined to be his wife.

Sarah Jeffrey Buckley was the daughter of James and Georgina Nairn Jeffrey, who emigrated from Coldingham, Berwickshire, Scotland, after their marriage. Buckley's maternal grandfather was a wagonmaker and after emigrating to America set up a wagonmaking shop in Kirkwood, Illinois, where Buckley's mother, Sarah Jeffrey, was born. James Jeffrey later moved on west and took up a farm in the unbroken prairie near Sloan, Iowa. At that time Sarah Jeffrey was thirteen. She started teaching school at sixteen and continued until her marriage at the age of eighteen to William Doubleday Buckley. She was a most remarkable woman in many ways and was greatly admired by her son Oliver. To perpetuate her memory he wrote a booklet about her, entitled "Story of a Mother."

Buckley was the second child and the only boy in a family of four. The fact that Buckley and his three sisters—Margaret Shull and Dorothy Buckley of Ann Arbor, Michigan, and Juliet Mills of Bala-Cynwyd, Pennsylvania—were all members of Phi Beta Kappa is evidence of a scholarly interest that made the family outstanding in this little community.

William Buckley's law practice in Sloan grew and he soon gave up his school teaching. With combined activities in law, real estate, insurance, and banking, and with the aid of his wife, who doubled as housewife and secretary, he provided a good livelihood for his family. At the same time, he managed to save no less than half his earnings then and through the rest of his life. This thriftiness and sound financial management of his affairs also characterized Oliver Buckley throughout his life. Judged by the standards of the community, Buckley's father was well-to-do in a village where no one could be regarded as wealthy.

The Buckley family placed education at the top level of importance, and schoolwork took precedence over all other interests. A good supply of books on home shelves made up for the lack of a public library, and family discussions of public affairs and philosophical problems, which Buckley's father led with great zest, aroused in young Oliver interests that never died. It was a family harmonious to a rare degree. Neither bickering nor physical chastisement played any significant part in the lives of the Buckley children.

To William Buckley's leadership in the community was largely due the credit for better schools and a higher cultural level than in neighboring villages. He was a leader too in the development and support of athletic sports in the village, even though he was frail from his early youth. He lived only sixty-three years and died of kidney disease.

Buckley's mother, nine years younger than his father, lived seventy-nine very active years. Undaunted by the handicaps of a limited formal education and extreme impairment of hearing, she was throughout her life active in civic affairs and was admired and loved by a wide circle of friends.

Oliver Buckley was a skinny, bookish lad, lacking in athletic skill or prowess. Nevertheless, according to him, he "got a lot of fun out of skating and swimming, and was sufficiently gregarious to organize a boys' club and to lead it on camping expeditions." Obedience and an overpowering sense of duty were outstanding characteristics of this lad. Responsibilities for the care of horses and cows and tasks around the house and garden were assumed willingly and without compulsion. He took pride in these responsibilities. He enjoyed life and was generally regarded as a good and reliable boy.

From this account of Buckley's ancestors and his early environment, it is evident that the early statement that he was fortunate in them is amply justified. His largely Scottish ancestry and the wholesome environment—home and community—of his childhood combined in providing the foundation for a life devoted to the society in which he lived and to which he made large contribution, to the enjoyment of a wonderfully wholesome family life, and to the molding of an array of admirable personal characteristics. Chief among these was a spirit of cooperation at all times and in all things; next came an overpowering sense of duty and responsibility, and then a broad interest in the physical world and in the world of men and women. The bases for these admirable attributes were an intellect both keenly analytical and creative and an unsurpassed integrity.

As the story of Buckley's education, professional activities, public service, and home life is told, ample evidence will unfold to support these characteristics of Buckley, the man.

EDUCATION

His formal elementary and secondary education was obtained in the public schools of Sloan. In speaking of his high school subjects, he said that mathematics was a joy, that physics, the only available science, was exciting, but that Latin had the attraction of a puzzle and required his greatest effort. He graduated from high school at sixteen. The curriculum had not met the requirements for college entrance and he needed another year of Latin. It was arranged that he take a part-time graduate year in which he read Virgil. In this year he also took a course in mechanical drawing from the American School of Correspondence.

Buckley was an omnivorous reader. In his father's library was a five-volume set of books on electricity and its applications. He perused these volumes diligently in his high school years. During his senior year a telephone exchange was installed in Sloan. Buckley obtained employment as the "maintenance man" for the exchange and carried out the responsibilities faithfully until he departed for college about two years later. He found this an experimental or laboratory supplement to his reading in the volumes on electricity.

Going to college was taken as a matter of course in the Buckley family. Upon completion of his postgraduate high school year, he entered Grinnell College, in which his older sister had enrolled a year earlier, and which was outstanding among midwestern colleges of that day in its high educational standards. Mathematics and physics continued to be the subjects of his major interest.

Buckley was provided with an allowance of $400 per year for tuition and living expenses. During his first two years he supplemented his allowance through operating a laundry agency, collecting and delivering laundry for faculty and students. During his last two years he acted as an assistant in the physics laboratory, where he earned full tuition. This had an educational value of much greater importance.

Buckley was graduated from Grinnell in 1909. While he had a splendid opportunity to enter a banking and mercantile career with his father, his love of science and its applications and his desire for independence in building his life's work led to his proposing to his father that he enter Massachusetts Institute of Technology to study electrical engineering. His father, with his typical Scottish conservatism, proposed that Oliver should first earn his living for a year. Fortunately for Buckley's chance to follow his career interest without interruption, he was offered an instructorship in physics at Grinnell which he accepted without hesitation. He then spent a most constructive year in teaching a first course in physics and in advanced study and reading on his own in physics.

He obtained a teaching assistantship in physics at Cornell University for the following year at the modest salary of $400 a year and tuition. From the time of his graduation at Grinnell, Buckley was completely on his own financially. His father easily could and willingly would have supplemented the meager compensation at Cornell, but Oliver's desire for making his own way and his Scottish sense of economy led to most frugal living in his first two years at Cornell. In his entire life he never went into debt, and he always rigorously budgeted his expenditures, maintaining them at a level well below his current income.

He matriculated at Cornell in the fall of 1910 as a candidate for a Ph.D. in physics, devoting part of his time to teaching. Advancement to the grade of instructor in the last two years of his residence eased his financial situation substantially.

Professor Edward L. Nichols and Professor Ernest Merritt provided Oliver's main inspiration. The atmosphere of the graduate school in physics was most informal. From the beginning Buckley was pretty much on his own. He was permitted to initiate a thesis project in his first year. Two successive projects of his own choosing came to naught; he then began experimental studies of the Hall and Nernst effects in silicon, studies suggested by Professor Merritt. A clever experimental program led to new knowledge that was embodied in his thesis. However, there was then so little basic and analytical understanding of matter in the solid state that its importance was limited.

Buckley, always overmodest and self-critical, judging his thesis and allied studies in the light of present-day solid state knowledge and research techniques, said in his later years that this work was unimportant and did him little credit. It must be remembered that in 1910 graduate study in physics in our country was in its infancy. There were only a few universities where work leading to a Ph.D. in physics was available. If one applied Buckley's critical judgment to the papers then published in the *Physical Review,* a large fraction of them would be similarly judged.

He entered on his teaching assignments with enthusiasm and had much joy and satisfaction in them. His characteristic willingness to assume responsibility led to the senior professors' placing a larger burden of teaching on his shoulders than was normal for the graduate student. So much did he enjoy it that, when he left Cornell for industrial research, he planned to return eventually to teaching. His love for and outstanding success in industrial research and engineering, however, made this his lifelong career.

Buckley fulfilled the requirements for the Ph.D. in physics at Cornell in June of 1914 and was awarded his doctorate at that convocation. Some months previously Dr. Frank B. Jewett of the Bell System had visited Cornell and in interviews with Buckley told him of the character of the problems of the Bell System laboratories. By their very nature—the intermingling of science and engineering, the fulfillment of the service needs of the consumer, the necessary penetration of economics into the decisions on what goals to pursue in the laboratory, and the final assessment of the worth of a development in terms of its economic and service values—they at once had a tremendous appeal for Buckley.

He had known little or nothing of the infant industrial laboratories of our country. The view of the activities of Bell System laboratories and the purpose of them that Jewett presented to Buckley on his Cornell trip made this one of Jewett's most constructive missions for the Bell System. For, unknowingly, he raised the interest of the young man, who one day would succceed him as president of the yet unborn Bell Telephone Laboratories, to such a high pitch that Buckley at once decided this was the work for him. As the terminal days for Cornell approached, he applied to Dr. Jewett for a place in the Bell System laboratories and was promptly employed. He was assigned to the research section of the Engineering Department of the Western Electric Company at 463 West Street, New York City.

Thus as the period of Buckley's formal education closed, the doors opened for him to begin his career. While throughout his formal education Buckley was a good student, always more than fulfilling every requirement and ever manifesting that high sense of responsibility and integrity so characteristic of him, he was not a brilliant student. Even so, his thesis professor, Ernest Merritt, said, "If I am not mistaken, he will go a long ways." And how right he was, for during Buckley's professional career he became one of the outstanding industrial research leaders of his generation, made large and significant personal scientific and engineering contributions in the earlier years, and closed his career as the head of the world's largest integrated industrial research laboratory.

PROFESSIONAL CAREER

On July 14, 1914, armed with his newly acquired Ph.D., Buckley started his career in the Engineering Department of the Western Electric Company, working directly for Dr. Harold D. Arnold, the director of research. At that time the Bell System was in the pioneering years of its application of the new high-vacuum, electronic, and atomic physics to the broadening, improvement, extension of distance, and lowering of cost of telephone service.

His work in the first few years was directed mainly to the development of new high-vacuum thermionic devices suited to wire- and radio-telephone systems. He early found the universally used Gaede rotary molecular pump inadequate in speed, capacity, and degree of vacuum for the exacting task of "pumping" these new thermionic miracle devices. He invented and developed into useful form a mercury-vapor diffusion pump that met the requirements of speed, capacity, and degree of vacuum. It was later learned that Dr. Irving Langmuir of the General Electric Company's research laboratory had independently made an almost identical invention. The diffusion pump of Buckley and Langmuir was the forerunner of a large family of mercury and, later, oil diffusion pumps that are in universal use today in the laboratory and in the manufacturing plant.

The need for continuously measuring the degree of vacuum, as exhaust progressed, led Buckley to invent and develop the ionization manometer. It measures the degree of vacuum by collecting on a third electrode of a vacuum tube the positive ions formed by the collision of a constant current of electrons from a thermionic source with the atoms of the gas as they travel to a positive collector. With a positive ion formed at each collision of an electron with a gas molecule, the number of positive ions formed will be directly proportionate to the gas pressure. The relation is linear for all pressures less one ten-thousandth millimeter of mercury. This manometer is today the best means for the measurement of pressure in extremely high vacua.

In October 1914 Buckley was wed to Clara Louise Lane of Webster City, Iowa, whom he had met at Grinnell. Their first child, a girl, was born in 1916. But more of Buckley's family life later, in the section dealing with his home life and public service.

In the early spring of 1917, while in the midst of these exciting researches, Buckley was assigned to another more urgent area of investigation—that of developing means to detect and locate German submarines by "picking up" under water the acoustic noises radiated from the submarine and transmitted through the water. These noises were largely from engines and propellers. Western Electric, in cooperation with the Submarine Signal Company and the General Electric Company, established a field laboratory at Nahant, Massachusetts. It worked for and in close cooperation with the Navy. Buckley was assigned to duty at this laboratory. There he worked in close cooperation with Langmuir, Coolidge, and Dushman of the General Electric Laboratory. Buckley enjoyed the association with these distinguished members of the General Electric Laboratory and found the problems of submarine detection most challenging. His work at Nahant was soon terminated, since with the declaration of war Buckley was called to active service in the Army and was designated to be sent overseas.

He went into uniform as a first lieutenant but, since overseas plans in which he was to be involved had not yet matured, he was lent to the Navy by the Army to continue his work at Nahant. With the maturing of these plans, Buckley set sail for France in September 1917. He was assigned to the Research and Inspection Division of the Signal Corps and was placed in charge of the research section. He was promoted to the rank of major even before he had established his laboratory in Paris.

Quarters for a laboratory were located in an old mansion on Boulevard Montparnasse. In this romantic location in the Latin Quarter of Paris Buckley had his headquarters for the duration of his service in France. The war was of too short duration after the entrance of the United States to permit the establishment of well-organized effort. Even so, the research group under Buckley proved of great value as a liaison between the fighting forces and development effort back home.

Through visits to the scenes of battle and discussions with the operating Signal Corps forces, the needs of the forces were translated into development projects by the research group, and several worth-while systems developments for communications between the battlefront and command headquarters back of the line and between planes and ground were planned and sent to the Signal Corps headquarters at home for initiation by industrial companies. Also, the group was of great service to the fighting forces in adapting existing communications gear to the special needs of the fighting forces.

In the early fall of 1918 Buckley was sent to Washington on a temporary assignment to straighten out things that were taking too long to clear by cable, telegraph communication, and correspondence. While he was in the midst of this task, the war came to an end. Buckley did not return to France, but remained in service at a Washington desk until December 7, 1918, when he received his discharge from the Army. During this period he wrote a report on the accomplishments of his research section and a set of recommendations for future developments.

He soon returned to the Western Electric Engineering Department. He found many changes had taken place at the laboratory while he was away. The Engineering Department had grown markedly. The cessation of war work, to which the laboratory had given almost its total effort, had caused temporary confusion. The electronic developments that he had directed had advanced far beyond the point where he had left them. The author of this biography, who had come to Western Electric from the University of Chicago at the end of 1917, was now directing this work.

Buckley had seen for himself while in France the inadequate capacity of the submarine cables for telegraph communications between headquarters at home and our forces overseas. He therefore suggested that he undertake a study of the art of submarine cable telegraphy to determine whether the message capacity of a cable could be increased at a cost that would be economically attractive. He was permitted to undertake this, even though the Bell System had no direct interest in transoceanic telegraph services. It was undertaken in the national interest, through a type of decision that this author has seen repeated many times by the Bell System in his more than forty years in its service.

Buckley's study revealed a promising lead for a major advance in the art of submarine cable telegraphy where relatively little advance had been made for several decades. He envisioned a magnetic material wrapped about the central conductor of the cable. This would increase the cable's inductance and would place capacity and inductance more in balance, thereby also increasing the strength of the received telegraph signals and consequently the limiting speed of transmission.

Gustav Elmen of the Western Electric Engineering Department had recently invented a new iron-nickel alloy which, when properly heat-treated, developed an initial magnetic permeability higher than previously known magnetic materials. It provided the ideal material to serve as the continuous magnetic loading. By wrapping a thin ribbon of it around the central conductor of the cable and then giving it an appropriate heat treatment, it was possible to increase adequately the inductance of the cable. A cable so constructed had some four times the traffic capacity of the cables of the previous art.

To reduce this development to practice called for extensive research, numerous inventions, and solutions to a host of problems in manufacturing engineering and in means to operate such a cable. Buckley had complete charge of the research, development, and engineering aspects of the project and made many of the original contributions. Tests of a 100-mile experimental loop in Bermuda waters confirmed the laboratory result of a fourfold capacity increase. Manufacturing costs were also most favorable—only a small percent greater than that of cable made by the older art. The success demonstrated by this test led rapidly to the installation of commercial cables of this type on both sides of the world. The New York-Azores cable of the Western Union Telegraph Company was the first installed. In all, more than 17,000 miles of this cable have been installed and are in use.

The research, development, and design of the cable, technical aid in its manufacture, and technical supervision of the laying of the experimental loop in Bermuda and of the first commercial installations progressed successively through the first six years of Buckley's return to the Laboratories after his military experience. As will be told later, the scope of Buckley's activities was progressively increased beyond that of the submarine cable project beginning in the latter years of this period.

As the submarine telegraph cable project neared its successful completion, Buckley initiated studies of a transatlantic submarine cable for telephony. With the background of the telegraph cable development, Buckley devised a cable structure capable of transmitting only one telephone channel. Power amplifiers were required at each terminal to compensate for the attenuation of the almost 2,000 miles between the east and west coasts of the Atlantic. Trial lengths of this cable were constructed and given deep-sea tests off the northern west coast of Ireland. These tests were successful and indicated that a single-channel telephone cable of this type was technically feasible. However, its costs were so high that the project was abandoned.

With the suspension of the transatlantic project, Buckley initiated the development of a multichannel submarine telephone cable for much shorter distances than the transatlantic project. He found that a cable of economic size based on the technologies developed in his previous cable projects could provide as many as six telephone channels for distances of a hundred miles or so when terminal amplifiers were employed. This development was first applied in a cable to Cuba with terminals at Havana and Key West, which was manufactured and installed in 1930. It represented a very great advance in the submarine telephone cable art. It was made possible by Buckley's combining the submarine cable structure art that he had created with the multichannel carrier transmission art then employed in many of the land circuits of the Bell System.

After the successful completion of the multichannel submarine telephone cable for a limited distance, Buckley again turned his attention to the transatlantic problem. If transatlantic telephony through cables were to be economically possible, it was essential that a pair of cables carry more than one conversation, a development that Buckley had earlier attempted. Multichannel techniques must be employed. To realize multichannel broadband transmission over transatlantic distances, it would be necessary to insert amplifiers at appropriate distances along the cable to restore the strength of the telephone signals as they were attenuated with distance.

More specifically, vacuum-tube amplifiers must be integrated into the cable at equally spaced points, some fifty miles apart, along its entire length. Since the cable must lie on the bottom of the ocean, a housing to enclose each of the amplifier units must be an integral part of the cable sheathing and, like it, be hermetically sealed. No water vapor could be permitted to diffuse into the amplifier or into the conductor region of the cable. With the cable and amplifiers at the bottom of the ocean, at depths reaching six to eight miles, the pressure to which their structures would be subjected made the hermetic-sealing problem most difficult.

If such a complex and technically difficult system could be made operational, only the first hurdle of the development would be crossed. To provide continuous, uninterrupted service at a cost level that would make the cable commercial, there must also be very few failures over at least a twenty-year period. In the event of a failure in midocean, a cable ship would have to lift the cable at that point and make the necessary repairs. In winter, this might well remove the cable from service for two or so months and be a costly operation. Therefore, a trouble-free system for a period of twenty years was envisioned. This required that every component—vacuum tubes, condensers, inductances, transformers—and all interconnections have nonfailure lives of at least twenty years. No such components existed!

However, if transoceanic telephone service of the required quality and reliability and with no traffic-capacity limitations were to be realized, the submarine cable then provided the unique answer. Radio-telephone, which was then employed, had severe limitations in the possible number of channels, in the quality of transmission, and in the reliability of the transmission path, due to atmospheric changes. This was the vision Buckley had and the analysis that he made in the early 1930s.

A development to realize these goals was initiated under Buckley's immediate direction. Before its completion, however, he was progressively placed in higher levels of research administration and thus removed from direct participation. His keen interest continued, however, and even in the later years, when he was president of Bell Telephone Laboratories, the transoceanic submarine cable project received his attention almost daily.

The magnitude of the task, its tremendous scope, the necessity for establishing that the designs of each and every item meet not only functional requirements but also the twenty-year no-failure requirement, and the interruption occasioned by the Laboratories' almost complete participation in developments for the Second World War combined in making 1956 the date of the first commercial cable installation from this country to England. It provided, initially, thirty-six telephone channels. Since then a second commercial cable has been laid to the European continent and another to Hawaii. Several cables have been installed for military purposes. A third cable to Europe is planned, as well as a transpacific cable to Japan.

These submarine cable projects—telegraph and telephone—were the final projects of Buckley's initiation, direct participation, and immediate leadership.

The recent experiments in the employment of satellites as active broadband telephone repeaters may well bring an alternate means for conquering oceanic limitations to worldwide communications. The technical successs of a satellite communication system seems assured, although it is still too early to know its costs. Should they prove to be competitive with the costs of submarine cable systems, an additional means of worldwide voice communications will be made available. Should this come to pass, it will in no way dim the brilliance of Buckley's contributions.

His performance in these submarine cable projects, extending over some three decades, demonstrates the high order of his creativity, the quality of his leadership, and the soundness of his judgments. The rare combination of scientist and engineer that he was is clearly demonstrated in his submarine cable activities.

As was stated earlier, during the course of Buckley's work on cables, his fields of research and his responsibilities were progressively widened. He was first placed in charge of all of the research on magnetic materials, on microphone carbon, and on relay contacts, and was given the title of assistant director of research. In 1930 wire-transmission research was added to his responsibilities. Under his direction Maurice E. Strieby developed the coaxial-cable transmission systems in which hundreds of telephone channels are provided by a single coaxial cable. Until the advent of microwave repeater radio telephone systems in the late 1940s, these coaxial cable systems were universally employed for long-distance telephone service.

EXECUTIVE RESPONSIBILITIES

In 1933, through the death of Harold D. Arnold, Bell Telephone Laboratories suffered the tragic loss of its director of research. Buckley, with the evidence of his competence as a researcher in his own right and of his inspiring leadership of the work of other scientists, was the obvious successor; he was immediately appointed to this post.

At that time the functions of the Research Department comprised research in the fundamental and applied sciences that provided the broad base of communications technology and the development of telephone instruments and electronic devices. While he was assistant director of research, Buckley had the leadership of about one third of the programs of the Laboratories. As broad and varied as these programs were, it was still possible for Buckley to make significant scientific contributions to many of them in addition to his leadership and supervisory activities. The almost tripling of the area of science and technology under Buckley's cognizance that was involved in his assuming the new post of director made it impossible for him to participate in and contribute to programs in the way that he had done throughout the almost twenty years of his career in the Laboratories. Even so, his high level of scientific interest and his inspiring counsel made their imprint on all of the Laboratories' research programs.

In the administration of the Research Department, Buckley exhibited those qualities of judgment, common sense, and economy that had been increasingly evident in him from his early childhood. It was not surprising, therefore, that, when Edwin Colpitts retired in 1936 under the Bell System age rule, Buckley was appointed executive vice president of the Laboratories to succeed Colpitts.

The executive vice president, reporting to President Frank B. Jewett, was responsible for the management of all the operations and the over-all organization of the Laboratories. The research and development of the Bell System and the design of all equipments employed in the Bell System were the responsibilities of the Bell Telephone Laboratories. At that time there were 2,000 scientists and engineers in the Laboratories, with a supporting staff of 2,500. This vast broadening of Buckley's responsibilities removed him still farther from contact with research—and the area which he loved and to which he had made significant contributions throughout the previous twenty-two years of his service.

The principal home of Bell Telephone Laboratories was in a large, multistoried building at 463 West Street in New York City. With the change in the pattern of work in the Laboratories, this nonfunctional housing became an increasing handicap in obtaining most effective laboratory work. It was decided in the mid-thirties to initiate a gradual exodus from the city. A large tract of land was obtained at Murray Hill, New Jersey, some twenty miles from New York City. Under Buckley's leadership and with his active participation plans were developed in the period from 1936 to 1938 for the first unit at this suburban location. It was decided that research and advanced development activities were to be the first to occupy the suburban laboratory.

In cooperation with architects, an intensive program was initiated to determine the functional building requirements for laboratory space and then to prepare designs to meet these requirements. The construction according to these plans of a unit adequate to house some 1,500 was begun in early 1938 and the building was occupied some two years later. This was the first laboratory structure designed to meet the unique functional requirements of research. Many of its features have become standard for a very large fraction of the industrial laboratories built in the last twenty years. Since the completion of the first unit, Bell Laboratories has built new housing for some 7,000 additional people. Most of the functional features resulting from the structural design studies that Buckley initiated and led will be found in the new housing.

In 1940, with the possibility that the United States would be drawn into the world conflict, the Government initiated programs to increase the country's military strength. At that time America was ill prepared for war. Dr. Jewett, who was then president of the National Academy of Sciences, was appointed by President Roosevelt to membership on the five-man directorate of the recently formed National Defense Research Committee. The obligations of these two posts and that of the president and chief executive officer of Bell Telephone Laboratories were an impossible burden for any one man. With the Bell System's dedication to national service, Mr. Walter Gifford, then president of the Bell System, had the post of chairman of the Board of Directors of Bell Telephone Laboratories created and placed Dr. Jewett in this position. Buckley succeeded him as president and chief executive officer. This was in October 1940. This arrangement made the major portion of Dr. Jewett's time available for national service while still giving the Laboratories the benefits of his advice and judgment.

Buckley became president of the Laboratories in the year preceding the country's entrance into the Second World War. The demands placed on the Laboratories for research and development for the military made it necessary to progressively decrease the Laboratories' work for the Bell System in order to make manpower available for the rapidly increasing volume of military work. After the entrance into the war, the work for the military grew at an increasingly rapid rate. Within less than a year Bell System work had decreased to a level that was less than twenty percent of the normal level and sufficed only to maintain current Bell System service.

The manpower released from Bell System work, while very large, was inadequate to man the increasingly enormous number of military research and development programs that became the Laboratories' responsibility. Therefore, beginning early in 1941, manpower at the Laboratories was increased as rapidly as men of the required professional and technical aid skills could be recruited. The total number in the Laboratories grew from 4,600 at the beginning of 1941 to some 8,000 at the close of the war, plus about 1,000 workers who were obtained through contracts with other companies. In all, the Laboratories engaged in over 1,200 military projects with a tremendous range of diversification. In the field of radar alone the systems developed by the Laboratories exceeded those of all other industries of the country combined.

The cost of the military effort of the Laboratories during the war period was almost $200 million.

The position of Bell Laboratories in the war effort was unique among industrial laboratories in two important respects. The functions of the Laboratories in the Bell System encompassed the gamut in research and development from basic scientific research to engineering for final manufacture and use, with particular attention to systems engineering, an art little understood at that time outside of the Laboratories. Also, it has always been nothing less than the religion of the Laboratories to develop systems and equipment best to serve rather than best to sell in a competitive market at the sacrifice of quality and performance. These factors, which are just as important in military as in telephone systems, were recognized by the military establishment. There were other features that contributed to the Laboratories' leading position. It was not only the largest industrial laboratory in the country but also one of the most mature. The maturity of its scientists and engineers made it possible to take on the tremendous load and absorb a significant percentage of new people without sacrifice in the quality of work. The high importance attached to fundamental research and to scientific publication had given the Laboratories close association with academic scientists and had won their respect. This made the Laboratories outstandingly effective in its relations with the Office of Scientific Research and Development.

The Laboratories' military projects generated a vast volume of new weapons systems that saw extensive and dramatic service. The Western Electric Company alone manufactured in dollar volume exceeding two billions military equipments developed by the Laboratories. Other companies manufactured to Laboratories' design in dollar volume in excess of $1 billion. In all, the contributions of Bell Telephone Laboratories to the war effort can be truly said to have definitely hastened victory and to have played a significant part in minimizing our nation's total manpower losses.

The programs of the Laboratories became so numerous and varied that Buckley's personal contribution was of necessity largely restricted to that of an administrator. He performed administrative duties with dedication and tirelessly employed his energies in molding and recasting the Laboratories' organization for continually varying work patterns. However, while he carried out these duties with distinction and integrity, and to the limit of his energies, administration was not an area of activity in which he found enjoyment. He was too far removed from the scientific and technical problems to obtain the joy and satisfaction that had been his in his earlier years of work, when the focus of his attention was primarily on science and technology. Buckley often said that the happiest and most satisfying years of his professional work were those before he was made director of research. The increasing percentage of his time devoted to administrative problems after he became director of research deprived him of personal contact with the intimate realities of science and technology in which he was so proficient, gave so much of himself, and in return obtained so much satisfaction and enjoyment.

In recognition of his large contribution to the war effort, he was awarded the Medal for Merit and given a presidential citation in 1946.

At the close of the war the Laboratories rapidly took up the threads of peacetime activities in scientific research and developments for the Bell System. However, from this time on the Laboratories' attention could not be entirely directed, as it had been before the war, to those communication needs of society for which the Bell System was responsible. The state of world affairs necessitated the Government's maintaining the country's military leadership. For this an extensive program of research and development directed to warfare and weaponry was essential. With the many contributions that the Laboratories had made during the war period and the experience that had been gained, an obligation to the country and its well-being led the Laboratories to continue its effort for the military departments. After much consideration by the executives of the Bell System, Buckley and his immediate associates, it was decided that the Laboratories should plan and be willing to accept military research and development responsibilities to an extent not to exceed 20 percent of its work for the Bell System. It was recognized, of course, that, should an emergency develop, the Laboratories would immediately be available for what was required, as it had been during the Second World War.

The complete cessation of development for the Bell System during the war years enlarged the opportunity for fruitful work and major advances in all sectors of communications technology. With his usual vision, Buckley appreciated these opportunities and worked with zest in forming development teams of adequate size and strength to make available, at the earliest possible time, facilities stemming from the large reservoir of uncommitted science and technology that had accumulated during the years of inactivity in communication systems development.

One of the most significant and important of these was the microwave broadband radio relay system, which made possible the transmission of large bundles of telephone traffic with the centimeter radio wave acting as the carrier and the national distribution of television programs. Thus, in relatively few years after the close of the war, a new facility for long-distance telephone and television transmission was developed and placed in service.

The fundamental research programs of the Laboratories were also rapidly expanded at the close of the war. In a few years the rewards from these expanded programs became evident. The most striking and internationally significant of them was the invention of the transistor. This invention resulted from the establishment of an extensive and organized effort in solid state physics research shortly after the close of the war.

In many of these programs Buckley played a larger role than that of the administrator. Because of his love for science and technology, he spent more time than he could really spare from his administrative duties in contact with the more exciting and novel of the Laboratories' new ventures in science and technology. The laboratories devoted to solid state physics research and the microwave radio relay development were among the areas where Buckley could frequently be found in intimate discussions with those working in the programs.

The policy of limiting the Laboratories' participation in military development to a level not greater than 20 percent of the Bell System programs proved most difficult in application. The pressures from the military departments for the Laboratories' effort were so great that a program at least as large as the Bell System programs would have been required to satisfy the requests. Buckley gave much personal attention to the selection of programs from among the many offered and rigorously held to the 20 percent-maximum policy. The basis of selection that he established was for the Laboratories to accept only those obligations for which it was uniquely indicated. If there were others who could perform a development as well, it was declined, even though its performance could have been of some value in the Bell System's work. The largest and probably most important task that the Laboratories assumed was for the development of an antiaircraft guided missile system for the Army. This missile was characterized by the Laboratories as the "Nike." This development, with its beginnings in 1946, continues to this day. The resulting Nike missile family has provided the guided missile protection of the nation for its cities and military establishments.

In 1949 President Truman requested the Bell System to assume the responsibility for the development, design, and management of the manufacturing phases of the nation's atomic weapons program under the general direction of the Atomic Energy Commission. To discharge this responsibility, the Sandia Corporation was formed as a subsidiary of the Western Electric Company. Its headquarters and principal activities were at the Sandia Base of the military near Albuquerque, New Mexico. The Laboratories shared the responsibility for its operation with the Western Electric Company, the division of responsibility being the same as that of the Western Electric and Bell Telephone Laboratories in their Bell System activities. This placed on the Laboratories a large responsibility that was not included in the 20 percent of military effort. For the development and design of atomic weapons the Laboratories undertook the building of an organization equivalent in pattern and competence to that of the Bell Telephone Laboratories itself. To accomplish this, much of Buckley's and his immediate associates' attention was required, and many of the Laboratories' most competent development leaders were placed in appropriate positions in the Sandia Corporation. Mr. Donald A. Quarles, a vice president of the Laboratories, served for a period as president of the Sandia Corporation.

With the onset of conflict in Korea, Buckley was again called to the service of his country, this time in a civilian capacity. In April 1951 he accepted an appointment by President Truman as the chairman of a Science Advisory Committee reporting to the President and as science adviser to Charles E. Wilson, the head of the Office of Defense Mobilization. As these positions required almost his full time, Buckley relinquished his position as president and chief executive officer of Bell Telephone Laboratories and became chairman of its Board of Directors. He was succeeded as president by the author of this biography. Buckley remained in this post until his retirement from the Laboratories in August 1952 at the time of his sixty-fifth birthday.

At this time the Laboratories established the Oliver E. Buckley Solid State Physics Prize of the American Physical Society. Under the terms of this award, a prize of $1,000 will be given every year, for a period of twenty-five years, to a person who has been adjudged to have made a most important contribution to the advancement of knowledge in solid state physics within the five years immediately preceding the award.

Thus closed Buckley's thirty-eight years of service to the Bell System, performed during a period of tremendous technical progress and growth in size of the System. He had made large contributions, both personal and in direction, to the technical advances in telephony through the application of new scientific knowledge. One measure of his personal contributions is the forty-three patents issued to him and some thirty papers that he wrote.

HOME LIFE AND PUBLIC SERVICE

As was mentioned above, Buckley was wed to Clara Louise Lane in 1914, his first year with the Bell System. The Buckleys promptly established their home in East Orange, New Jersey, in rented quarters. Shortly after Buckley's return from military service in 1919 he and his wife purchased their first home in Maplewood, New Jersey—a modest and comfortable residence. But it was not of their own planning, so in a little more than a decade they decided to build a new home, also in Maplewood. Buckley, in his usual thoroughgoing and meticulous way, planned every detail of the lovely home and garden, which were a fitting expression of the combined tastes of the Buckleys.

In the early 1940s the Buckleys began to spend summer vacations at Southwest Harbor, Maine. A few years later they purchased a pleasant cottage in Southwest Harbor. Buckley lived throughout the remaining years of his life in the Maplewood and Southwest Harbor homes.

There were four Buckley children: three girls—Katherine, Barbara, and Juliet—and one son—William. Their childhood was spent in the splendid environment of these homes and of Maplewood. All of them graduated from the South Orange-Maplewood High School and received college education. All are married and are leading happy and constructive lives. There are eleven Buckley grandchildren.

While Buckley throughout his professional career gave dedicated and time consuming service to the Laboratories, he did not neglect his responsibilities as a citizen. At the local and national levels he gave generously of his time in a variety of public services. Outstanding among them were: member of the Board of Education of South Orange-Maplewood from 1938 to 1950, serving as president in the last two years; member of the Board of the Engineering Foundation through the same period and chairman in three of the years; member of the National Inventors Council from 1945 until his death; member of the General Advisory Committee of the Atomic Energy Commission from 1948 to 1954; trustee of the Thomas Alva Edison Foundation from 1951 until his death; trustee of the Jackson Memorial Laboratory from 1949 until his death; member, from 1947, of the Board of the National Multiple Sclerosis Society and chairman from 1953 to 1956. He served as a member of many advisory committees to the Government throughout the years of his service in the Laboratories. He received many honors and distinctions and was a member of many national professional societies. The principal honors and society memberships are listed below.

Even with his burden of administrative responsibilities throughout most of his professional career, he made many significant inventions. Alone or in association with others he was awarded forty-three patents. These are also listed below.

Buckley also found time for the preparation of many significant papers and talks. At all times he wrote the papers and prepared the talks that he gave. His principal publications are included in the Bibliography.

Late in 1951, while he was still performing his Washington tasks for the President, his health began to fail. When he could no longer meet the high standards of performance common to him throughout life, he resigned as chairman of the President's Advisory Committee but continued most of his less exacting public service activities for some years.

The decline in health was later found to have been occasioned by the onset of Parkinson's disease. Since it progressed slowly, Buckley had many years of a continuously more restricted but generally happy life. While he experienced a progressive decrease in strength and difficulty in walking, his mind remained unaffected and of the high quality of his earlier years. The disease finally brought his death on the fourteenth of December, 1959.

Thus the life of one of the nation's outstanding industrial research pioneers came to a close. His was a good life, dedicated to the service of his country, his fellow man, and the corporation where he spent almost all of his professional life.

As a friend, an associate for more than thirty years, and an admirer of Buckley, I was pleased by the Academy's request that I be his biographer.

HONORS AND PROFESSIONAL SOCIETIES

Medal for Merit, 1946
Doctor of Science, Grinnell College, 1936
Doctor of Engineering, Case Institute of Technology, 1948
Doctor of Science, Columbia University, 1948
Phi Beta Kappa
Sigma Xi
Phi Kappa Phi
National Academy of Sciences, Member, 1937
  Council, 1950 to 1953
American Philosophical Society, Member
  Council, 1948 to 1951
  Finance Committee, 1944 to 1954
American Academy of Arts and Sciences, Fellow
New York Academy of Sciences, Member
American Physical Society, Fellow
  Policy Committee, American Institute of Physics, 1942 to 1946
  Finance Committee, American Institute of Physics, 1949 to 1956
American Institute of Electrical Engineers, Fellow
  Vice President, 1946 to 1948
Acoustical Society of America, Fellow
American Association for the Advancement of Science, Fellow
Franklin Institute, Member

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1948

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1949

Frank Baldwin Jewett (1879–1949). American Philosophical Society Yearbook, pp. 317–20.

1950

Some Observations on Industrial Research. Journal of Patent Office Society, 32: No. 5; Bell Telephone Magazine, 29 (Spring):13–24.

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Number	Subject	Patent Issued
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1,301,644	Directive Sending System	Apr. 22, 1919
1,307,999	Method of and Apparatus for Exhausting to Low Pressures	June 24, 1919
1,371,734	Apparatus for Exhausting to Low Pressures	Mar. 15, 1921
1,372,798	Method and Apparatus for Measuring Gas Pressures	Mar. 29, 1921
1,433,258	Method of and Means for Exhausting to Low Pressures	Oct. 24, 1922
1,434,851	Vacuum Pump	Nov. 7, 1922
1,434,869	Electric Regulator	Nov. 7, 1922
1,486,863	Continuously Loaded Signaling Conductor	Mar. 18, 1924
1,536,764	Signaling System	May 5, 1925
1,551,797	Artificial Line	Sept. 1, 1925
1,567,316	Means for Reducing Interference	Dec. 29, 1925
1,586,874	Long Submarine Telegraph Cable for Operation at High Speed	June 1, 1926
1,586,875	Continuously Loaded Submarine Cable	June 1, 1926
1,586,876	Power Limiting Method and Apparatus	June 1, 1926
1,586,877	Electromagnetic Device	June 1, 1926
1,586,961	Submarine-Cable Telegraphy	June 1, 1926
1,586,962	Induction Apparatus	June 1, 1926
1,613,927	Translating Device	Jan. 11, 1927
1,624,470	Signaling Conductor System and Method of Operation	Apr. 12, 1927
1,647,267	Loaded Submarine Cable Telegraph System	Nov. 1, 1927
1,649,016	Control Apparatus for Electric Discharge Devices	Nov. 15, 1927
1,662,956	Telegraph Conductor	Mar. 20, 1928

Number	Subject	Patent Issued
1,666,680	Dynamometer	Apr. 17, 1928
1,668,888	Signaling System	May 8, 1928
1,681,515	Submarine Cable	Aug. 21, 1928
1,689,324	Manufacture of Continuously Loaded Electrical Conductors	Oct. 30, 1928
1,695,038	Magnetic Alloy	Dec. 11, 1928
1,696,265	Acoustic Device	Dec. 25, 1928
1,752,413	Signaling Cable	Apr. 1, 1930
1,756,341	Electrical Conductor	Apr. 29, 1930
1,762,956	Signaling Conductor	June 10, 1930
1,778,751	Control of Electrical Variation	Oct. 21, 1930
1,809,828	Telephone Transmission	June 16, 1931
1,880,764	Submarine Signaling Cable	Oct. 4, 1932
1,896,767	Signaling System	Feb. 7, 1933
1,903,975	Submarine Signaling Cable	Apr. 18, 1933
1,924,106	Submarine Cable Loading Coil	Aug. 29, 1933
1,957,487	Multicore Cable with Thermoplastic Insulation	May 8, 1934
1,982,784	Submarine Cable	Dec. 4, 1934
2,020,297	Submarine Cable Transmission	Nov. 12, 1935
2,043,346	Submarine Cable Loading Coil	June 9, 1936
2,415,808	Detection of Large Magnetic Bodies	Feb. 18, 1947