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BANCROFT GHERARDI

1873—1941

A Biographical Memoir by

OLIVER E. BUCKLEY

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Biographical Memoir

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BANCROFT GHERARDI was a great engineer. There are many ways to define engineering as there are many kinds of engineers, including those who devise, design, construct and manage machinery, roads, bridges, buildings, etc. A broader and more basic definition of engineering is "the art of the economic application of science to the purpose of man." This was the definition used in describing Bancroft Gherardi as "an engineer par excellence" by his friend and admirer, Gano Dunn, on the occasion of the award of the Edison Medal for 1932.[1]

Gherardi was indeed one of the most eminent engineers of his time, by whatever definition of engineering one may choose. He was skilled in the technical aspects of his art, and able in management as well as in design and construction. As Mr. Dunn further noted, Gherardi's career demonstrated "genius in a sense of proportion, balance, and the fitness of things that leads to eminence in organization." But even the more mundane description of an engineer applies in a broad way to Gherardi, for his major interest throughout his long professional career was in the design, construction, and operation of what has become probably the greatest, most complex and most completely integrated machine of our time. Such is the system of communication of the American Telephone and Telegraph Company of which Bancroft Gherardi became Chief

[1] *Electrical Engineering*, LII, No. 2 (February, 1933), 126-129.

Engineer and in the structure of which Gherardi's contributions still endure. Some of those contributions and the way in which he rose to his high position will be described in what follows, but first let us review some preliminary events in the life of the subject of this memoir.

Bancroft Gherardi was born in San Francisco, April 6, 1873. His father was Commander (later Rear Admiral) Bancroft Gherardi, U.S.N., son of Donato Gherardi who, in the early 1820's, had come to the United States as a political refugee from Italy. Donato had secured employment as an instructor in Latin and Italian in the famous Round Hill school of George Bancroft, the historian, at Northampton, Massachusetts. Donato married the sister of Bancroft and later taught at the College of Louisiana at Jackson, Louisiana. It was there, in 1832, that the first Bancroft Gherardi, who was to become the father of our subject, was born. As a young naval officer, this first Bancroft Gherardi participated in numerous engagements in the Civil War and took an especially prominent part in the Battle of Mobile Bay. Even before that war, as Senior Watch Officer of *U.S.S. Niagara,* he had distinguished himself by his participation in the laying of the first transatlantic telegraph cable of 1858. For his share in this historic occasion the then Lieutenant Gherardi was awarded a gold medal by the Chamber of Commerce and Citizens of New York, thus presaging certain other great advances in communication in which a son, later to be born, would play a leading part.[2]

The Bancroft ancestors of the wife of Donato, grandmother of our subject, had settled in Worcester, Massachusetts, before the end of the eighteenth century. Donato's son, the first Bancroft Gherardi, married Anna Talbot Rockwell and to them were born two sons who later became men of note. Walter, the younger, followed in his father's footsteps and in due course became a Rear Admiral in the Navy with a long and distinguished record of service. The

[2] *The Telephone Review,* Special Triumph of Science Edition, January, 1915, p. 26.

elder son had other ambitions and wished to become an engineer.

Of the early formal education of our subject, whom I shall refer to frequently as BG, as did his intimates and colleagues, we have little information. When his father, the naval officer, moved from one Navy assignment, usually a shipyard, to another, the son was transferred from one school to another, never attending any one school more than two years in succession and never developing a strong sentimental tie to any one of them. The Navy was his school and from it grew his love of boating and, more importantly, his dominant sense of order, his respect for constituted authority, his overpowering conscientiousness. It is not unlikely that his oft repeated move from one location to another contributed to the development of another of his great assets, that of superb judgment of men.

BG's college education did not suffer from the shift of location of his earlier schooling. From the Brooklyn Polytechnic Institute he got his B.S. in 1891 and from Cornell University his M.E. in 1893 and M.M.E. in 1894. To both of those institutions he thereafter felt a strong bond, and for both he served as Trustee, for B.P.I. from 1917 to 1923, and for Cornell from 1928 to his death in 1941.

When BG completed his formal academic training at Cornell the country was emerging from a period of depression. Good jobs were not yet looking for men, men were looking for jobs. It was his ambition to be an engineer. He knew nothing about telephony nor did he recognize that it was an especially promising field, but it was the first door that opened to him. He recognized the opportunity and grasped it. In his own words, taken from his commencement address at Worcester Polytechnic Institute, June 2, 1936, "It was just a matter of luck, but to me a matter of great good fortune. Ever since I was a youngster I had known Lieutenant Bradley A. Fiske, now a Rear Admiral retired. He was the inventor of the first practical range finder. The manufacturer who made these range finders for him was the Western Electric Company whose principal business was manufacturing switchboards,

cables and telephones for the Bell Telephone System. So, hearing that I was looking for a job, Lieutenant Fiske gave me a letter of introduction to the New York manager of the Western Electric Company and this resulted in my getting a job as an engineering assistant with one of the operating companies making up the Bell System."

Like nearly all of the executives of the Bell System who rose to high positions, BG started at the bottom and made his advance by demonstrated merit and capacity for growth. Growth of responsibility in the Bell System has always been a double-barreled matter. While functional responsibilities are broadened and extended, the size and complexity of the physical plant increase so rapidly that in the course of a decade or so a radically new array of components is superposed upon, or altogether replaces, the old. Moreover, the evolution of the new mechanism is accompanied by problems in human relations among both the employees who man the machine and the subscribers who use it. This was so when BG started on his first telephone job in February, 1895, and it is so today.

BG's first assignment was as a cable tester for the Metropolitan Telephone and Telegraph Company of New York, later to become the New York Telephone Company. This work brought him up against some of the most critical telephone problems of the day. The first telephone lines were overhead wires, but the number of them required to serve the crowded and growing business district of New York was so great that this method of construction had to be abandoned in congested areas and wires had to be led through underground cables. This introduced new problems, both mechanical or structural, and electrical.

The first underground cable carried only 150 pairs of 19 gauge wires, a compromise between transmission efficiency and cost. Facing the necessity for more circuits, BG demonstrated that it would be sound economy to use less efficient cable with a greater number of pairs for the short lines running from the central offices

to the subscribers, and more efficient cables of larger gauge and fewer pairs for trunk lines between central offices. This was the beginning of a series of advances that led to the 2,100 pair cables now in use for local connections.

Transmission theory was little comprehended by the practical telephone man of that day though Oliver Heaviside had published his brilliant analysis of transmission of electric waves over wires some years before. By making measurements on various types of telephone cable, BG demonstrated that telephone transmission obeyed the same laws of attenuation as did the lower frequency telegraph currents. Simple as that may appear to the engineer of today, it was a great forward step in telephone engineering for the practical telephone man of BG's early years.

About 1896 the general use of lead-covered aerial cables was just beginning. The practice at that time was to suspend these cables by means of ordinary guy strands or other wires. Mr. Gherardi raised the question of whether this practice provided proper support for the cables and made an extended series of investigations of cables then in use, determining the sags and spans and then computing the stresses in the supporting wires. This showed that proper factors of safety did not exist, and he determined the characteristics of and the specifications for strands for the special purpose of suspending aerial cables of various sizes, as well as the proper engineering requirements to go with the guying of poles carrying such cables.

Another contribution of BG's early days and one that presaged a great interest of his later years was his recognition of the importance of establishing definite standards of transmission for various classes of telephone calls, such as local, suburban, and long distance. He directed the necessary experimental work to determine what the local and suburban standards should be.

These are only a few examples of BG's firsthand accomplishments in the five years before he took on heavy administrative duties.

At the beginning of that period there were 310,000 telephones in the Bell System and by 1900 there were 836,000.

In 1900 the newly formed New York Telephone Company established a Traffic Engineering Department and BG was placed in charge of it as Traffic Engineer. His rise as an executive was rapid and in the next year he was made Chief Engineer of the New York and New Jersey Telephone Company operating in Brooklyn and suburban New Jersey. He served in that capacity until 1906, when he was appointed Assistant Chief Engineer of both the rapidly expanding New York Telephone Company and the New York and New Jersey Telephone Company.

During this period of expansion of his executive responsibilities BG did not lose his interest and firsthand participation in solving technical problems. One outstanding problem was that of the layout of switchboards in large urban central offices. Up to 1900 it had been the standard practice to utilize a single line of switchboards, placing at the head the "B" positions for incoming calls from other central offices, and following these with the "A" positions for answering outgoing calls from local subscribers, and having one continuous line of multiple jacks. This arrangement necessitated, each time that additional "B" positions were needed, the conversion of "A" positions to "B" positions, changing the keyboards, removing the answering jacks, and making other changes in the position, and at the same time providing new "A" positions at the end of the board. BG conceived the idea of using two lines of boards, one for "A" sections and the other for "B" sections, so that one could grow independently of the other. He demonstrated that, taking everything into account, this would be most economical, and it was adopted as standard practice.

Another problem was that of handling suburban toll traffic around New York. While Traffic Engineer of the New York Telephone Company in 1900, BG had made the first general study of the proper methods of handling toll calls around New York City. This study showed the relative economy of the direct trunk method

and the toll board method of handling messages as it varied with both length of haul and volume of business. The report was adopted and used as a basis for a study which BG made subsequently to determine the number, size, and location of the toll boards.

Up to 1901 there were three common battery offices in Brooklyn and no plans for any additional offices. Under BG's immediate direction and supervision, a fundamental plan was prepared for Brooklyn in accordance with methods which he had an important part in devising, and he then prepared plans for the conversion of all the rest of the city, with eight central offices, to the new type of switchboard. This work included not only the switchboards themselves but new buildings as well.

In 1902, in association with Mr. John J. Carty, then Chief Engineer of the New York Telephone Company, BG undertook the engineering of the first commercial application of loading coils following the invention by Professor Michael I. Pupin of this revolutionary improvement in telephone transmission. The cable chosen for this first installation on a commercial scale extended from New York to Newark, and practically all of it was in the territory of the New York and New Jersey Telephone Company. BG personally, in association with Mr. Carty, worked out the engineering problems in connection with the application of loading to this job and participated in the solution of the many mechanical questions involved.

Up to 1903 it had been the practice in the design of telephone buildings to base their ultimate capacity upon the indications of the fundamental plan and to locate the equipment in these buildings usually going from the back to the front. BG conceived the idea that all the important elements of the equipment could go from the front to the back, and worked out the details of floor plans and of the arrangement of the equipment in the building. Thus it was made possible to design buildings capable of being extended to the rear at a later date, and having a much greater flexibility than ever before. This principle was promptly adopted and has since been generally used.

Perhaps most important to BG in the period from 1900 to 1906 was the development of a personal contact with that great dean of all telephone engineers, John J. Carty, the leader in telephone research and development. To win the respect and confidence of Mr. Carty was not easy. He put his trust only in the most capable, thorough, and dependable subordinates. His selection of BG as one of his right-hand men when, in 1907, the corporate structure of the Bell System was reorganized, was a step of far-reaching importance both in the advance of telephone technology and in the lives of many men.

The first seven years of the 1900's were thus years of great growth of telephone engineering and growth, too, of the man who is our subject. It was a period also of great growth of the Bell System. The number of telephones in the System increased from 836,000 to nearly 3,000,000 and it became possible to telephone, but not too well, halfway across the continent.

In 1907, a year of national financial crisis, the headquarters of the American Telephone and Telegraph Company, the parent company of the Bell System, were removed to New York, and Theodore N. Vail was recalled to the presidency. Mr. Vail was a most capable and powerful individual of remarkable foresight and imagination. He surrounded himself with able subordinates. He chose as head of his engineering department the no less imaginative John J. Carty of the New York Telephone Company, and with him the young Bancroft Gherardi as Equipment Engineer. At the same time Dr. Frank B. Jewett, Edwin H. Colpitts, and some others of the research group of the American Telephone and Telegraph Company were transferred to the Engineering Department of the Western Electric Company in New York. Jewett soon became Assistant Chief Engineer of the Western Electric Company. This made for a powerful research, development, and engineering team, binding closely together the design and manuufacturing functions of the Western Electric Company with the operating and field needs of the parent company and its subsidiaries and affiliates.

Great progress was made in the art of telephony, much of it un-

spectacular but important in building up a plant to provide high quality of performance and durability. One of the most important developments of this era of telephony was the beginning of the practice of placing long distance wires in underground cables, as had previously been done with local lines in large cities.

More spectacular developments were not long in coming. In 1909, on the occasion of a visit to San Francisco of Carty, Jewett, and Gherardi, by this time Engineer of Plant Development and Standardization, Carty brought up the question of means for extending the range of telephony to the West coast so that subscribers on the eastern seaboard could converse by wire with subscribers in San Francisco and Los Angeles. Gherardi and Jewett were sure it could be done, although the means for doing it were not known and it would take a few years and many new inventions. BG's estimate of about five years turned out to be very close to the time actually taken, and telephone service between New York and San Francisco was opened in January, 1915.

The accomplishment of transcontinental telephony required devices to boost the strength of telephone currents at intervals along the line and thus to compensate for attenuation or fading. Such devices are called repeaters, and the heart of the repeater was the amplifying vacuum tube. This was the beginning of electronics in the telephone system and the abolition of distance limitations in over-land telephony. There was ushered in a revolutionary advance in the arts of electrical communication.

When in 1914 war broke out in Europe, the telephone officials promptly took cognizance of the possibility of involvement of our own country. Telephone development was gradually slowed up by the diversion of research and engineering effort to the solution of military problems of communication. Mr. Carty, Dr. Jewett, and several others were given reserve commissions in the Signal Corps, and before the war came to an end nearly all technical development activities were being conducted in the interests of winning the war. The task was not made easier by the temporary seizure of the

telephone companies by the government, which placed them under the jurisdiction of the Post Office Department.

The decade from 1907 to 1917 was thus filled with great events in the history of the Bell System. It was marked not only by technical advances but also by recognition of engineering problems arising from the provision of adequate telephone service for the military and for a public with increased communication consciousness. During this period the number of telephones in the Bell System grew from 3,000,000 to 7,000,000.

In 1918 when Colonel (later Brigadier General) Carty went to France, BG was appointed Acting Chief Engineer of the American Telephone and Telegraph Company, and on June 18, 1919, not long after General Carty's return, BG was made Chief Engineer, succeeding General Carty and leaving him free to devote his time more fully to his development and research activities and to extracurricular activities of national importance, among them the formation of the National Research Council. BG's increased responsibility was followed in 1920 by his appointment as Vice President and Chief Engineer of the A. T. & T. Company, which position he held until his retirement eighteen years later.

As Vice President and Chief Engineer, BG was responsible for the headquarters staff functions in the area of the Operations and Engineering Department of which he was the head. In that position he exercised a profound influence on the course of telephone progress. His functions in this new position and the work of his department are best described in his own words:

"Well, my personal responsibilities of course are for the correct and proper administration of the department at all times, and seeing that the work is done in a satisfactory and helpful manner. The work of the department consists of advising and assisting the associate companies of the Bell System, including the Long Lines, with reference to engineering and operating problems. . . . The principal part of our work is the development of engineering methods, the methods of using Bell System standards, the devising

of operating schemes and methods, the analysis of operating results, and the making of comparisons between the results obtained in one place and another, and then as a result of all that work, the assisting and advising either in a general way, or specifically if specific advice is needed, as to the conditions thus developed." [3]

It is not possible to relate all of the major accomplishments of BG in this last eighteen-year period of his active telephone service, but there are certain items that seem to this author to deserve special mention; first, BG's leadership in the orderly and constructive development of engineering and operating organization and procedures of the subsidiary companies of the Bell System including the Long Lines Department of the A. T. & T. Company; second, and perhaps most important, his decisive promotion within the Bell System of dial or machine switching for interconnection of subscribers.

The first of these achievements was a natural outgrowth of Gherardi's work as Engineer of Plant Development and Standardization. He was a great proponent of standardization as a means toward efficient and economical plant construction and operation, but he recognized full well its limitation in relation to the introduction of the new products of research and development. Without imagination and far-seeing administration, standardization can become a curse instead of a blessing. This is outstandingly true in the art of telephony where all components must fit together for a common purpose.

The headquarters staff of the parent company of the Bell System exercises a difficult and delicate function. The parent company has a contract responsibility to provide to the licensee or operating companies full information on the practices and standards of operation, as well as advance information on new scientific developments that come out of the Laboratories and instructions on how to employ them. This must be done in a way to insure that all

[3] Testimony in Illinois Bell Rate Case, U. S. District Court, March, 1932.

parts of the system fit and work efficiently together, but not in a way to relieve the licensee companies of their independent operations and responsibilities in relation to regulatory commissions, to the public, and to the stockholders, whether the subsidiary company be wholly or only partly owned.

Fitting together applies not only to physical components but also to people, and one of the most important functions of the headquarters staff is to encourage the development and interchange of executive personnel in a way to insure the benefit of experience and growth to both the individuals and the companies. In all these aspects of headquarters staff activities BG was an outstanding leader.

The second item, that of machine switching or dial operation, is one which had been a subject of some differences of opinion among telephone engineers. There were unresolved questions as to public acceptance and successful use of the dial with the large number of digits required for metropolitan coverage. Could dial systems give the great variety of special services that the operators of manual switching were called on to give? Could not better and more economical service be given by machines operated by central office operators rather than by subscribers? Were the principles of the Strowger or step-by-step system, which had been employed by some independent companies, sound for use in the large urban localities serviced by the Bell System?

The Western Electric Company had developed a switching system called the panel type that promised better to meet the needs and standards of the Bell System for large cities. It used motor driven switches controlled indirectly by dial impulses instead of depending on the pulses themselves to control directly a selecting switch a step at a time. It embodied a flat array of terminals permitting economical access to a very large number of lines with relatively compact machinery. It achieved economy of equipment by converting the information received from the dial into an unconventional numerical system and made use of coding, decoding, and storage

of signals. It was an early example of the "mechanical brain." Progress was being made in the engineering and trial installation of the panel system for large city service when the First World War came along and temporarily slowed up this and many other undertakings. At the same time light was cast on another aspect of machine switching that theretofore had not been recognized as critical. This was the unavailability of women operators to supply all the switching requirements of the growing system. This problem was brought sharply to attention by the influenza epidemic which swept the country during the latter part of the First World War.

Perhaps one of the most far-reaching of BG's recommendations was that made in 1919 for adopting dial operated machine switching of the panel type, gradually to replace manual operation in all multiple office cities and the larger single office cities. This change could not be made all at once, even though there were situations in which it was urgent. In other situations, the new system was to take many years to prove itself. Also, the using public had to be educated in dialing the number of digits required for covering large urban communities. BG's recommendation was accepted and acted upon. To meet the needs of smaller less complicated single office situations, the step-by-step system of the Automatic Electric Company was adopted and manufactured to meet Bell System requirements, both by that company and the Western Electric Company, under a patent license arrangement that made the improvements introduced by either company available to the other.

Experience with both systems met with a gratifying degree of subscriber acceptance and, as the use of dial operation became more widespread, ways were found to do by machine many of the operations that had formerly necessitated manual assistance. As the use of the dial was extended over the years, the number of operators employed by the Bell System did not decline, as might be expected, but on the contrary increased. The growth of the System was so great that the reduction in local service operators owing to the gradual introduction of machine switching was more than offset by the need

for more long distance operators and auxiliary services. By the time of BG's retirement in 1938, 52 percent of the telephones of the Bell System were dial operated. Today (1955), 85 percent are dial and there are about twice as many operators employed as in 1919. With adoption of many improvements in the older switching systems and the introduction of a still better new system employing "crossbar" switches, the range of dial operation has greatly extended and nation-wide toll dialing with automatic accounting is well under way. The wisdom of BG's engineering recommendations has been amply demonstrated.

Among the other remarkable telephone developments in which BG participated as Vice President and Chief Engineer was the opening of commercial overseas radio telephony in January, 1927.

Another tremendously important development of Gherardi's time was the application of carrier telephony, or wired wireless, as it was sometimes called, to provide a multiplicity of circuits over a single pair of wires. This was first done over open wire circuits in 1918 and was later followed by the application of carrier to wires in cables and to coaxial conductors.

During the period of BG's service as Vice President and Chief Engineer the number of telephones in the Bell System increased from 7,700,000 to 15,700,000. Subsequently that number has grown to more than 45,000,000 at the time of this writing.

Indeed, every part of the physical telephone plant still is undergoing scientific study and improvement. This applies to telephone instruments, to structures for carrying telephone current, and to equipment for establishing connections. Standards of telephone transmission were raised and the quality of service was so smoothly improved that the public took it as a matter of course, scarcely being conscious of the change but always increasing its use of electrical communication.

In 1925 the Engineering Department of the Western Electric Company was incorporated in the newly formed Bell Telephone Laboratories, charged with the responsibility for research and devel-

opment for the System. General John J. Carty was Chairman of the Board of the new corporation, Dr. Frank B. Jewett was its President, and Bancroft Gherardi was a member of its Board of Directors. BG's interest in the Laboratories and its works was high and he was a strong supporter of fundamental research, as well as aggressive in the introduction of new developments. With General Carty thus leading the research and development activities of the System, with Jewett in direct charge of the work in the Laboratories, and Gherardi directing the work of introducing new instrumentalities in the field, the users of telephones and those who invested their savings in financing improvements and in extension of the service of the Bell System had the benefit of a team that could hardly be surpassed in technical leadership. The spirit of this group has been carried on by their successors, who foresee even greater advances in electrical communication than have yet been realized.

In addition to his Bell System functions, BG's activities in technical societies and in cooperation with related industries were notable. In the American Institute of Electrical Engineers he became an Associate in 1895, a Fellow in 1912, Vice President 1908-1910, President 1927-1928, and member at various times of many committees. He served on the Board of Trustees of the United Engineering Trustees and the Engineering Library Board, and on committees of the National Research Council.

He was a member of the Joint General Committee of the Bell Telephone System and the National Electric Light Association, a member of the Joint General Committee of the Bell Telephone System and the American Railway Association, Chairman of the American Committee on Inductive Coordination, and a Director of the Cuban American Telephone and Telegraph Company. He was one of the original members of the Board of Directors of the American Standards Association when it was formed in 1929, and he served as a member until 1934 and as its president for two terms, 1931 and 1932.

He was Commodore of the Bay Head Yacht Club in Bay Head,

New Jersey, where he made his home for many years prior to his residence in Short Hills, New Jersey. Throughout his later years he continued his summer residence in Bay Head and his active interest in sailing. He was also an active member of the Cornell Club of New York.

He was a vestryman of Christ Church of Short Hills.

In the course of his career he received many honors, including the Edison Medal for 1932, the Fourth Order of the Rising Sun from Japan, and the degree of Doctor of Engineering from Brooklyn Polytechnic Institute and from Worcester Polytechnic Institute. While in college he was elected to Sigma Xi. He was elected a member of the National Academy of Sciences in 1933.

Bancroft Gherardi's qualities of orderliness, straightforwardness, and prompt decisiveness, coupled with his high integrity and sense of duty, won the respect of all associated with him. He had an unerring ability to recognize the weak spots in any proposal presented to him or in any person with whom he dealt. He did not easily tolerate in his subordinates or associates any lack of the clear thinking or prompt decisiveness which he valued so highly. Some there were who considered him overcritical and even dictatorial, but others close to him found beneath a somewhat austere exterior a warm, good-natured friend with a lively sense of humor and deep-seated human kindness.

An outstanding characteristic of Bancroft Gherardi was his technical insight. Quick to get to the bottom of technical problems within his cognizance, and decisive as he was in matters of opinion, he was ever ready to admit a mistake in situations where his opinion was proved to be wrong.

On June 15, 1898, at Paterson, New Jersey, Bancroft Gherardi was married to Mary Hornblower Butler, daughter of Henry Varnum Butler, a manufacturer of that city. There were no children from this union but Mr. and Mrs. Gherardi cherished as their own the children of BG's brother, Rear Admiral Walter R. Gherardi. Three of these children survive: Walter Gherardi of Oyster Bay,

Long Island, Harry Taylor Gherardi of New York and Mrs. Nevill (Christopher) Robinson of Ottawa, Ontario.

Bancroft Gherardi retired under the age rule of the Bell System on April 30, 1938, after 43 years of active service for the Company. His years of retirement were few and he died on August 14, 1941, at French River, Ontario. Many of those who knew him best and worked most closely with him are now (1955) gone, but the mark of his accomplishments endures in the art of telephony to which he contributed greatly and into the fabric of which were woven the life threads of his being.

The author is indebted to Mrs. Gherardi for her cooperation in the compilation of this memoir.

KEY TO ABBREVIATIONS

A.I.E.E.J. = American Institute of Electrical Engineers Journal
A.I.E.E. Trans. = American Institute of Electrical Engineers Transactions
A. T. T. Co. = American Telephone and Telegraph Company
Bell Syst. Tech. J. = Bell System Technical Journal
Bell. Tel. Quart. = Bell Telephone Quarterly
Elec. Comm. = Electrical Communications
Elec. Eng. = Electrical Engineering
Elec. World = Electrical World
J. Elec. = Journal of Electricity
N.E.L.A. Proc. = National Electric Lamp Association Proceedings
N. A. Rev. = North American Review
Tel. Engr. = Telephone Engineer
Tel. Rev. = Telephone Review
Univ. State N.Y. = University of the State of New York

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1,311,808—granted July 29, 1919, filed Dec. 5, 1918.
Means and method for avoiding interference. Grounding arrangements for submarine cables, etc.

1,336,558—granted April 30, 1920, filed Nov. 26, 1918.
Anti-abrasion cable support. For suspending cable from messenger wire.

1,396,930—granted Nov. 15, 1921, filed Dec. 27, 1917.
System for the equalization of transmission lines. Equalizes telephone subscriber loops for d.c. and voice frequencies.