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ALEXANDER GRAHAM BELL

1847–1922

BY

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Alexander Graham Bell

FROM A PHOTOGRAPH TAKEN IN 1876, THE YEAR IN WHICH
THE TELEPHONE WAS PATENTED

It was the intention that this Biographical Memoir would be written jointly by the present author and the late Dr. Bancroft Gherardi. The scope of the memoir and plan of work were laid out in cooperation with him, but Dr. Gherardi's untimely death prevented the proposed collaboration in writing the text.

The author expresses his appreciation also of the help of members of the Bell family, particularly Dr. Gilbert Grosvenor, and of Mr. R. T. Barrett and Mr. A. M. Dowling of the American Telephone & Telegraph Company staff. The courtesy of these gentlemen has included, in addition to other help, making available to the author historic documents relating to the life of Alexander Graham Bell in the files of the National Geographic Society and in the Historical Museum of the American Telephone and Telegraph Company.

ALEXANDER GRAHAM BELL

1847–1922

BY HAROLD S. OSBORNE

Alexander Graham Bell—teacher, scientist, inventor, gentleman—was one whose life was devoted to the benefit of mankind with unusual success. Known throughout the world as the inventor of the telephone, he made also other inventions and scientific discoveries of first importance, greatly advanced the methods and practices for teaching the deaf and came to be admired and loved throughout the world for his accuracy of thought and expression, his rigid code of honor, punctilious courtesy, and unfailing generosity in helping others.

The invention of the telephone by Alexander Graham Bell was not an accident. It came as a logical result of years of intense application to the problem, guided by an intimate knowledge of speech obtained through his devotion to the problem of teaching the deaf to talk and backed by two generations of distinguished activity in the field of speech.

Bell's grandfather, Alexander Bell (born at St. Andrews, Scotland, 1790, died at London, 1865) achieved distinction for his treatment of impediments of speech, also as a teacher of diction and author of books on the principles of correct speech and as a public reader of Shakespeare's plays. Young Alexander Graham Bell, at the age of 13, spent a year in London with his grandfather. He was already interested in speech through his father's prominence in this field, and this visit stimulated him to serious studies. Bell afterwards spoke of this year as the turning point of his life.

Bell's father, Alexander Melville Bell (born in Edinburgh, Scotland, 1819, died at Washington, 1905), was for a time professional assistant to Alexander Bell, then he became lecturer on elocution in the University of Edinburgh. He developed "Visible Speech," a series of symbols indicating the anatomical positions which the speaking organs take in uttering different sounds. This won him great distinction and, with improvements made by Alexander Graham Bell, is still a basis for teaching the deaf to talk. On the death of his father in 1865, Melville Bell

moved to London, to take over his professional practice. He also became lecturer on elocution at University College and achieved distinction as a scientist, author and lecturer on both sides of the Atlantic.

In 1844 he married Miss Eliza Grace Symonds, daughter of a surgeon of the Royal Navy, a talented musician.

Alexander Graham Bell, the second of three sons of Melville Bell, was born March 3, 1847, in Edinburgh. From his mother, he inherited musical talent and a keen musical ear. He took lessons on the piano at an early age and for some time intended to become a professional musician.

His father's devotion to the scientific study of speech had an early impact on the boy. "From my earliest childhood," said Alexander Graham Bell, "my attention was specially directed to the subject of acoustics, and specially to the subject of speech, and I was urged by my father to study everything relating to these subjects, as they would have an important bearing upon what was to be my professional work. He also encouraged me to experiment, and offered a prize to his sons for the successful construction of a speaking machine. I made a machine of this kind, as a boy, and was able to make it articulate a few words." This early illustrates his energy, his ambition, and his inventive ingenuity.

Always an individualist, Bell decided at the age of 16 to break away from home and teach. His first position was pupil-teacher in Weston House Academy, a boys' school at Elgin, Scotland. After a year here he returned to the University of Edinburgh for a course in classical studies and then returned to the Academy a year later as teacher of elocution and music. His scientific curiosity, a prominent characteristic throughout his life, is illustrated by his studies, made at this early age, of the resonance pitches of vowels. Placing his mouth in position for the utterance of various vowel sounds, he was able to develop two distinct resonance pitches for each vowel, tapping with a finger a pencil placed on the throat or on the cheek. The young man transmitted a lengthy account of his researches to his father and through him to Alexander John Ellis, President of the London Philological Society. Through Ellis, Bell learned that

similar experiments had long before been made by Helmholtz with the aid of electromagnetically controlled tuning forks. Unable to repeat Helmholtz' experiments at the time because of insufficient electrical knowledge, he determined to study electricity, including its principal application, telegraphy, for he felt it was his duty as a student of speech to study Helmholtz' researches and repeat his experiments.

In 1868, Alexander Graham Bell took over his father's professional engagements in London while Melville Bell gave lectures in America. Entering into the opportunities of this life in London with characteristic energy and enthusiasm, he was launched on a career of feverish activity with a heavy program of teaching, lecturing, studying and experimenting.

At about this time, tragedy struck the Bell household. In 1867, Bell's younger brother had died of tuberculosis. In 1870 his older brother died of the same cause. The health of Alexander Graham Bell himself became seriously impaired under the strain of his active career. Melville Bell acted swiftly to save his only remaining son. He gave up his professional career in London and in the summer of 1870 moved to the "bracing climate" of America. He settled in Brantford, Ontario, for what was intended to be a two-year trial period.

In the new environment, Alexander Graham Bell's health rapidly improved, so much so that in 1871 his father suggested that he be invited to Boston to fill a request for lectures on visible speech to teachers of the deaf. The invitation was given and accepted.

The success of these lectures, which began in April, 1871, led to a succession of engagements and to the rapid establishment of Bell in Boston as a leader in the field of teaching the deaf to speak. Shortly after taking up this work, Bell was entrusted with the entire education of Mr. Thomas Sanders' five-year-old son George, who was born deaf, and a year or two later, Mr. Gardiner G. Hubbard of Boston brought to Bell his sixteen-year-old daughter, Mabel, deaf since early childhood, for instruction in speech. These associations were destined to have a profound influence on Bell's life.

While in Brantford (August, 1870-March 1871) and later in Boston, Alexander Graham Bell continued his studies of Helmholtz' electrical experiments. Working with electrical circuits controlled by tuning forks led Bell to consider the invention of the harmonic telegraph, that is, a telegraph system making possible a number of simultaneous transmissions over the same wire by the use of different frequencies of interruption of the electric current. The idea was not novel with him, for the harmonic telegraph had for some time lured inventors with the promise of rich reward. Bell believed that his experiments gave him the clue to important improvements in this system and by 1873 he was working hard on this invention.

At that time all experiments on the harmonic telegraph were made with interrupted electrical current, e.g., with circuits in which electrical impulses were produced by alternately opening and closing the circuit. The interrupted current, acting upon a mechanically resonant receiving device, such as a reed, properly tuned, would cause it to vibrate. When the effort was made, however, to achieve harmonic telegraphy by operating simultaneously over the same circuit a number of devices of this sort using different frequencies, inventors, including Bell, found great and unexpected difficulties.

During this period, Bell's intense experimental activities were by no means confined to the harmonic telegraph. His profession was teaching the deaf to speak. His imagination was fired with the idea that if deaf children could "see" speech as it is spoken they might be taught more easily to articulate. With this in mind he worked with the manometric capsule of Koenig, a device which produces a band of light with an outline pattern corresponding to the sound pattern spoken into it; and with the phonautograph, which scratches a pattern on smoked glass conforming with the pattern of the sound spoken before it. His idea was to prepare standard patterns of the various sounds with the phonautograph and have the deaf children enunciate into the manometric capsule until they could produce light patterns identical with the standards. He built a number of phonautographs of his own. For one he used an actual human ear provided by Dr. Clarence J. Blake, a distinguished aurist

of Boston whom he had consulted in the matter. While these experiments failed in their direct aim they later were given credit by Bell for suggesting to his mind the great conception of a speaking telephone with a single vibrating membrane.

Other inventors had worked on the problem of transmitting speech electrically but had found no way to do it. Bourseul in 1854, had proposed it, but offered no solution of the problem. About 1861 Philip Reis (in Germany) had produced a device in which, by very rapid interruptions of the current in a circuit, an iron rod surrounded by a coil of wire at the receiving end was made to vibrate and thus a musical tone was produced. Reis called his device a telephone. It was, of course, not a telephone in the present sense of the word, as the interrupted current was far too crude a medium for the transmission of speech.

By the summer of 1874, Bell had achieved the conception that "It would be possible to transmit sounds of any sort if we could only occasion a variation in the intensity of your current exactly like that occurring in the density of the air while a given sound is made." It also occurred to Bell that this variation of the current could be caused by the movement of a single steel reed in a magnetic field if some way could be found to move it in the same way as the air is moved by the action of the voice. Speaking later of his phonautograph constructed from the human ear, he said, "I was much struck by the disproportion in weight between the membrane and the bones that were moved by it; and it occurred to me that if such a thin and delicate membrane could move bones that were, relatively to it, very massive indeed, why should not a larger and stouter membrane be able to move a piece of steel in the manner I desired? At once the conception of a membrane speaking telephone became complete in my mind." At the moment, however, Bell did not know how to reduce this conception to practice. While he knew that the motion of iron in a magnetic field would produce magneto-electric currents, he had the idea that "magneto-electric currents, generated by the action of the voice alone" would be too feeble to produce audible effects from a receiving telephone.

In this critical time in Bell's thinking about his great invention occurred the famous meeting between Bell and Joseph Henry. On March 2, 1875, Bell had occasion to visit Washington in connection with his harmonic telegraph patents. Bell had a letter of introduction to Professor Henry, who was then nearly 80, Secretary of the Smithsonian Institution and dean of American scientists. Bell described his experiments on the harmonic telegraph to an attentive ear. One experiment so aroused Henry's interest that Bell brought his apparatus to the Institution the next day and Henry spent much time experimenting with it. A few days later, Bell wrote to his parents, "I felt so much encouraged by his interest that I determined to ask his advice about the apparatus I have designed for the transmission of the human voice by telegraph. I explained the idea and said, 'What would you advise me to do—Publish it and let others work it out—or attempt to solve the problem myself?'

"He said he thought it was 'the germ of a great invention'—and advised me to work at it myself instead of publishing.

"I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to overcome the difficulties. His laconic answer was—*'Get it.'*

"I cannot tell you how much these two words have encouraged me. . . . Such a chimerical idea as telegraphing *vocal sounds* would indeed to most minds seem scarcely feasible enough to spend time in working over.

"I believe, however, that it is feasible, and that I have got the cue to the solution of the problem."

In spite of this encouragement, for several months the idea of the telephone was pushed into the back of Bell's mind. During the hours that could be snatched from his professional work he was working on his invention of the harmonic telegraph which his financial backers, Gardiner G. Hubbard and Thomas Sanders, were anxious to have completed at the earliest possible date. On June 2, while he was engaged in this work with his assistant, Thomas A. Watson, one of the transmitting reeds became out of adjustment so that when plucked it did

not interrupt the circuit but merely vibrated before its associated electromagnet without opening the contacts. Bell's musical ear and trained observation caused him to note at once the different quality of the sound produced by the vibration of the corresponding reed at the receiving end. He immediately investigated the cause of this change. He was surprised and delighted to find that without interruption of the circuit the inductive effect of the vibrating reed at the sending end produced enough current to cause the receiving end to vibrate audibly. "These experiments," he said, "at once removed the doubt that had been in my mind since the summer of 1874, that magneto-electric currents generated by the vibration of an armature in front of an electro-magnet would be too feeble to produce audible effects . . ." Immediately he felt that he had the key to the fulfillment of his long cherished dream of the electrical speaking telephone. Before the night was over he had made sketches for the first models and asked Watson to build them without delay.

The following months were difficult for Bell. His inventive interest was centered on his hopes for realizing the electrical transmission of speech, hopes which were aroused to a high pitch. But his time was fully committed elsewhere. Hubbard and Sanders had financially backed his invention of the harmonic telegraph, and he felt obligated to press forward with that project. Nevertheless he found time, by great exertion and excessively long hours, to work on his new idea. The first models did not prove satisfactory and successive modifications were made. At last, early in July, while Bell and Watson were testing a new pair of models, Watson rushed upstairs in great excitement to tell Bell that "He could hear my voice quite plainly, and could almost make out what I said." This was enough to convince Bell that he was on the right track.

The pressure of this program proved too much for Bell's health, and in August he was obliged to return to his father's home in Brantford to recuperate. While there he began writing his patent specifications covering his conception of the undulatory current. Here also he continued his telegraph experiments, especially on means of quenching sparks at contacts. For this

purpose he devised a variable water resistance to bridge the contact points. It was this work that suggested the first form of variable resistance transmitter, later used when the first complete sentence was transmitted electrically.

On his return to Boston, Bell's time was largely taken up with the organization and conduct of a normal class for the instruction of teachers of the deaf and with lectures at the Boston University. Now engaged to Hubbard's daughter, he was reluctant to call on his backers for further financial assistance and felt that he should insure adequate support from his teaching before resuming his electrical experiments. He wrote Mabel Hubbard at this period that he would be glad when his plans for the normal class were completed, "for my mind will then be free to bend all its energies upon telegraphy." With his normal class well under way, Bell's time was taken up with the completion of his telephone patent applications and visits to his attorneys in Washington. After his patent was allowed, March 3, 1876 (issued on March 7, 1876), Bell returned to Boston and a few days later, March 10, 1876, transmitted the first sentence ever sent over wires electrically, using the liquid transmitter suggested by his telegraph experiments.

The fertility of Bell's genius is illustrated by the breadth and scope of the first two patents relating to the telephone. They cover the broad conception of the undulatory rather than the interrupted current as applied both to harmonic telegraphy and to the speaking telephone. They cover the production of the undulatory current both by magnetic induction (vibrating iron before a magnet on which a coil of wire has been placed) and by varying a resistance (as is done in the modern transmitter). They cover telephones with a non-magnetic diaphragm to which a piece of iron has been attached, as in Bell's original models, and with iron or steel diaphragms which Bell quickly found to be more effective.

In 1883 a journalist wrote, "The issuance of Bell's patent on March 7, 1876, attracted little or no attention in the telegraphic world. The inventor was practically unknown in electrical circles, and his invention was looked upon, if indeed any notice at all was taken of it, as utterly valueless."

A lively interest in Bell's invention, however, quickly arose in scientific circles. It was stimulated by the successful demonstration of the telephone at the International Centennial Exposition at Philadelphia, to a committee of judges including Sir William Thomson, Joseph Henry and other prominent scientific men. As a result of this demonstration on June 25, 1876, Bell was given a Certificate of Award. Sir William Thomson wrote later of the telephone, "This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of invention which has devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound."

The telephone was described and demonstrated before the American Academy of Arts and Sciences in Boston on May 10, 1876. Demonstrations followed in rapid succession in Boston later on in May, at Brantford in August, between Boston and Cambridge in November. On November 26, Bell talked from Boston with Watson who was in Salem 16 miles away, "the greatest success yet achieved," Bell wrote Mabel Hubbard. On December 3, there was a similar demonstration between Boston and North Conway, New Hampshire, a distance of 143 miles. Other demonstrations and lectures followed.

After the issuance of his second telephone patent, in January, 1877, Bell spent a few months on lectures, demonstrations and experiments. He married Mabel Hubbard July 11 and with her left in August for an extended trip to England to interest English capital in the new invention. On March 5, 1878, he wrote a letter outlining for the British capitalists his ideas of the future usefulness of his scientific toy. To quote merely a single paragraph of this remarkable document:

". . . it is conceivable that cables of Telephonic wires could be laid under-ground or suspended overhead communicating by

branch wires with private dwellings, counting houses, shops, manufactories, etc., etc., uniting them through the main cable with a central office where the wires could be connected together as desired, establishing direct communication between any two places in the City. Such a plan as this though impracticable at the present moment will, I firmly believe, be the outcome of the introduction of the Telephone to the public. Not only so but I believe that in the future wires will unite the head offices of Telephone Companies in different cities and a man in one part of the Country may communicate by word of mouth with another in a distant place."

By the middle of 1877, the telephone was put into commercial use in this country under the skillful direction of Mr. Gardiner G. Hubbard. Its immediate commercial success led to a flood of litigation over the Bell patents which lasted throughout their life. A part of this arose from mere fraud, inspired by the great value of the invention. Much of it centered about the fact that other competent men had been interested in this great problem, and had come near to solving it. But the end result of all this welter of litigation was that Bell was upheld as the inventor of the telephone because he was the first to conceive and apply the crucial idea of the undulatory current, in contrast to the older art of interrupted current. As stated in the controlling court decision, an opinion of the Supreme Court of the United States delivered by Chief Justice Waite: "It had long been believed that, if the vibrations of air caused by the voice in speaking could be reproduced at a distance by means of electricity, the speech itself would be reproduced and understood. How to do it was the question. Bell discovered that it could be done by gradually changing the intensity of a continuous electric current, so as to make it correspond exactly to the changes in the density of the air caused by the sound of the voice. This was his art. He then devised a way in which these changes of intensity could be made and speech actually transmitted. Thus his art was put into condition for practical use."

On his return to America in November, 1878, Bell was obliged to give a great deal of time to testifying in these patent suits in defense of his inventions. A man of scrupulous honesty, careful to avoid credit for anything which was not his due, Bell

naturally found it distasteful in the highest degree to be subjected on the witness stand to repeated charges of fraud and misrepresentation. He recognized the importance of these suits, however, and fully carried out his obligation to defend his patents. His masterly testimony in the numerous cases was of greatest importance in bringing about the successful outcome.

In addition to testifying in the numerous patent suits, Bell also, acting in a consulting capacity for the telephone companies, made various suggestions for the development of the telephone system and called attention to any developments which he thought might profitably be applied. He wrote in May, 1880, of his success in transmitting sound to a maximum distance of 800 feet using a beam of light and a selenium cell. He asked the company to take out a patent immediately. "If not, I wish to be permitted to publish an account of this discovery at once in some of the leading scientific periodicals."

His interests, however, were much broader than telephony, and the breadth of these interests led him to turn his attention into other fields as rapidly as his obligations to the developers of the telephone made this possible. As leisure and wealth came to him from his telephone invention, it became possible for him to devote his time to researches in numerous subjects which interested him and which gave opportunity for further service to mankind.

Running through all of Bell's adult life is his interest in improving the teaching of the deaf. This began even before he left London, and in this country as early as 1871 he accepted engagements in Boston to explain the application of his father's system of visible speech to teaching the deaf and dumb to talk. At that time, deaf children were generally taught to speak among themselves by sign language. Many leading authorities considered that it was impracticable and a waste of time to try to teach speech to the deaf and dumb—it was even commonly supposed that their organs of speech had been impaired. At one time Bell, as well as his father, had held, as he expressed it, "an obstinate disbelief in the powers of lip reading." Later he became convinced of these powers, partly perhaps through the ease

with which he could converse with Mabel Hubbard, who had become adept at lip-reading.

Characteristically, when Bell recognized his misconception he was quick to correct it in an active way. As early as 1872 he began a crusade for recognizing the intellectual possibilities of deaf children and for teaching them to speak and read lips rather than being content to teach them sign language. His influence spread rapidly, helped by the success of his application of visible speech to teaching the deaf to talk. On January 24, 1874, he addressed the first convention of Articulation Teachers of the Deaf and Dumb and he continued to take an active part in this and other organizations of a similar nature. While this work was interrupted in the years 1875 to 1878 by his activities on the telephone and associated inventions, he threw himself into the work again on his return to America in 1878.

In 1880, he received the Volta Award of 50,000 francs for his invention of the telephone. With this he founded the Volta Laboratory Association (later the Volta Bureau), which was largely devoted to work for the deaf. In 1883, after an exhaustive study, he presented before the National Academy of Sciences a memoir: "Upon the formation of a deaf variety of the human race." In this he traced the eugenic dangers of the enforced segregation of deaf people which resulted from teaching them sign language rather than teaching them to speak and read lips. In 1884, he made a plea before the National Education Association for the opening of day schools for the deaf as one means of reducing this danger.

There were tendencies for the proponents of sign language and of articulation to break into two hostile camps. However, Bell's conciliatory policy held the group together and led in 1890 to the organization of the American Association to Promote the Teaching of Speech to the Deaf. Bell was President of this organization and heavily supported its work, giving a total of more than $300,000.

In 1888, at the invitation of the Royal Commission appointed by the British government to study the condition of the deaf, Bell gave exhaustive testimony before them based upon his experience and upon an extensive study of conditions in Amer-

ica. He was appointed an expert special agent of the Census Bureau to arrange for obtaining adequate data regarding the deaf in the census of 1900 in this country and devoted large amounts of time to this work at great personal sacrifice. It is not surprising that at the World's Congress of Instructors of the Deaf held in Chicago in 1893, Dr. Bell was held as the man to whom *"more than any other man* not directly connected with the work, we are indebted for the great advance made in teaching speech to the deaf, and in the establishment of oral schools of instruction throughout the country."

Among the honors received by Dr. Bell, some of those which touched him the most were the naming for him of several schools for the deaf. Among his many honorary degrees, Harvard College in 1896 gave him LL.D. for his scientific achievements and work for the deaf child.

Bell's work on the eugenic dangers of the enforced segregation of deaf people led him into pioneer work in the general field of eugenics which, throughout his life, continued to be one of his important interests. In 1918 and 1919 he published the results of extensive studies of longevity and of the betterment of the human race by heredity. In 1921 he was made Honorary President of the Second International Congress of Eugenics at New York City. During the last 30 years of his life he carried on continuously breeding experiments with sheep, leading towards the development of a more prolific breed. These experiments are still going on with the original line in Middlebury, Vermont, with encouraging results.

In spite of all these accomplishments, Bell's incessant activity gave him time to apply his genius with profit to other fields. One of the most important of Bell's inventions outside of the telephone field resulted directly from the Volta prize. Bell's interest in speech led to the development by the Volta Laboratory of the engraving of wax for phonograph records, applicable to both the cylindrical and flat disk forms. A fundamental patent was obtained on this now generally used type of record. It is of interest to note that one of the original records developed by Bell and his associates, which was deposited at the Smithsonian Institution in 1881 in a sealed package, with in-

structions that it should be opened in 50 years, was recently played in the presence of Mr. Bell's daughters and of interested scientists.

Another invention of importance was the telephone probe, an adaptation of the telephone and the electric circuit, to determine the location of a bullet or metallic masses in the human body. In recognition of this, and other inventions, the University of Heidelberg gave him the honorary degree of M. D. in 1886.

Nothing better illustrates Bell's independence of thought than his staunch support of aviation at a time when it was considered so quixotic a subject that Bell risked his scientific reputation in so doing. As Lord Kelvin wrote to Mrs. Bell in 1898, "When I spoke to him on the subject at Halifax, I wished to dissuade him from giving his valuable time and resources to attempts which I believed, and still believe, could only lead to disappointment, if carried on with any expectation of leading to a useful flying machine."

In 1891 Bell contributed $5,000 for Langley's aviation experiments. On May 6, 1896, he saw the successful flight of Langley's steam-driven 16 foot model, which, however, did not carry a man. Speaking of this experience later, he said, "The sight of Langley's steam aerodrome circling in the sky convinced me that the age of the flying machine was at hand."

In 1898, Bell was elected a Regent of the Smithsonian Institution. His enthusiasm for Langley's experiments with small-scale models of a flying machine had much to do with obtaining from the War Department an appropriation of $50,000 to be used by Langley for the development of aeronautics.

Langley's full scale model, carrying a pilot, fell into the Potomac on its trial in 1903, and the whole project dissolved in ridicule. However, soon after this the Wright brothers made their epochal flight at Kitty-Hawk, the first man-carrying flight of a controlled airplane. These events further confirmed the abiding interest in aviation of Alexander Graham Bell.

For years Bell had been studying the flight of kites at his summer home, Beinn Bhreagh, in Cape Breton Island on the Bras D'Or. This he considered the best approach to the prob-

lem of aviation. By 1901 he was working with a tetrahedral form of kite structure, a form which gave stability. This work was greatly expanded in the following years. Giant kites of multicellular, tetrahedral form were built and flown. In 1907 his huge kite Cygnet I, towed across Baddeck Bay carrying Lieutenant Selfridge, rose to a height of 168 feet.

While Bell's tremendous experimentation in this field was without direct application to aeronautics, indirectly it was of importance. It led Mr. and Mrs. Bell to become patrons of aeronautical research and greatly to advance aviation in this way. In connection with his experimental work, Bell attracted to his home at Beinn Bhreagh a group of talented young men devoted to aviation. In October, 1907, he entered into an agreement with these men for their joint production of experiments on "aerial locomotion," "all working together individually and conjointly in pursuance of their common aim to get into the air by the construction of a practical aerodrome driven by its own motive power and carrying a man." This organization was named the Aerial Experiment Association, and its work was financed by Mrs. Bell. The Association included Bell, Glenn H. Curtis, F. W. Baldwin, J. A. D. McCurdy, and Lieut. T. Selfridge. Bell was chairman.

The Aerial Experiment Association, during its one and one-half years of activity, principally at Hammondsport, N. Y., made important contributions to the development of aviation. In March 1908, their first machine, piloted by "Casey" Baldwin, made an important public flight, rising 10 feet above Lake Keuka for a distance of over 300 feet. One of the achievements of this flight was a demonstration of the aileron as an improvement over the wing-warping method previously used by the Wrights for obtaining stability. The aileron is fundamental to all airplane construction today. The second machine of the Association introduced the doped fabric which played so important a part as a wing cover through 20 years of the development of flying. The third machine, designed by Curtis, flew so well that it was entered for the *Scientific American* trophy for the first public flight of one kilometer, straightaway. The flight was made July 4, 1908, and the trophy won. The fourth

machine of the Association used balloon fabric for the wings and proved very successful. In the winter of 1909, McCurdy made repeated flights at Beinn Bhreagh, sometimes doing nine miles at a stretch. The Association was dissolved at midnight March 31, 1909, with a resolution by the members "that we place on record our high appreciation of her (Mrs. Bell's) loving and sympathetic devotion without which the work of the Association would have come to naught."

As in the case of his work on the telephone, Bell's activity for the advancement of aviation was stimulated by a prophetic vision of the future importance of developments in this field. In 1908, asked by the editor of *Century* to comment on proofs of an article by E. C. Stedman entitled "The Prince of the Power of the Air," Bell wrote: "While, of course, the bird is Nature's model for the flying-machine heavier than air, Mr. Stedman is undoubtedly right in looking upon the fish as the true model for the dirigible balloon. It is certainly noteworthy that the dirigible war-balloon of today already approximates the fish-like form predicted by him. He is also right I think in supposing that of all the nations in the world the interests of Great Britain will be most vitally affected by progress in aeronautics. For it is obvious that sea-power will become of secondary importance when air-power has been fully developed through the use of dirigible balloons and flying machines in war. The nation that secures control of the air will ultimately rule the world."

This brief description of some of Bell's chief accomplishments gives also an indication of some of his outstanding personal characteristics. He was one of driving energy, insatiable scientific curiosity, independence of thought and individuality of action. As a young man, he was tall, dark with flashing eyes, somewhat frail in appearance. He was described by an observer in 1877 as follows: "Professor Bell is a man of most genial and kindly presence, so courteous and gracious in manner that you could not feel yourself an intruder though you chanced to drop into his room when some private class was under special training. At the same time though his affability sets you at ease, you could not fail to observe that he is one of the busiest

of men, so intent upon the development of plans which occupy his life that he has no leisure for visitors who are not interested in his work. He is young, apparently not more than five and thirty (he was just 30) with an unusually prepossessing countenance; very happy in his expression; of pale complexion with jet black hair brushed up from his forehead and pleasant, sparkling black eyes—the face of a man all engaged in his work and finding satisfaction in it."

Later in life, Bell's health became more stable, his frame filled out, his hair became white and his whole appearance impressive and commanding.

Bell's code of honor included scrupulous regard for the exact description of his own contributions to inventions or researches and credit to those of others. He was present at the Second Annual Banquet of the Aerial Club of America shortly after the successful flight of the first machine of the Aerial Experiment Association. Cheered to his feet by prolonged applause of this performance, he said, "I really had nothing to do with the success of the experiment. The credit for its success was due to Mr. G. H. Curtis, Mr. F. W. Baldwin and Mr. J. A. D. McCurdy. . . . In this company of experimenters I must include Lieutenant Selfridge of the United States Army and Mrs. Bell who supplied the capital for the scientific experiments to get the machine into the air."

His appreciation of assistance and encouragement received from others was warmly felt and often expressed in some tangible and suitable way. Though Henry died before the telephone was well established, Bell saw to it that an instrument was installed without charge in Henry's residence for the use of his family, "in recognition," Bell said, "of the efforts and services of Prof. Henry in the early history of the instrument and who did a great deal to encourage the inventor."

Bell's services to the promotion of science extended far beyond his own researches. From 1898 to 1903, he was President of the National Geographic Society and did much to develop the policy of that Society and of its magazine in the channels which have led to the present tremendous membership and influence. He served as Regent of the Smithsonian Institution from 1898

until his death. In 1890, a generous gift by him helped start the Astrophysical Observatory of the Institution and in 1894 he brought the body of James Smithson, founder of the Smithsonian Institution, from Genoa to Washington.

Honors came to Bell in great number. Some of these have been mentioned in the discussion of his achievements. He received a large number of honorary degrees from universities in America, in the British Isles and in Germany. He was elected a member of the National Academy of Sciences in 1883. He was made an Officer of the Legion of Honor of France in 1881. He was awarded a medal by the Louisiana Purchase Exposition in 1904, the John Fritz Medal from a group of national engineering societies in 1907, the Elliott Cresson Medal from the Franklin Institute in 1912, the David Edward Hughes Medal from the Royal Society, London, in 1913; the Thomas Alva Edison Medal by the American Institute of Electrical Engineers in 1914, and the Civic Forum (New York) Medal in 1917. In 1917 the Governor General of Canada unveiled a Bell Telephone Memorial erected in his honor at Brantford, Ontario, in the Alexander Graham Bell Gardens and dedicated the Bell homestead and grounds as part of the public parks system of Brantford. In 1920, his native city of Edinburgh elected him a Burgess and a Guild Brother of the city and conferred upon him "The freedom of the city of Edinburgh in recognition of his great achievement in the solution of the problem of telephone communication and of his brilliant and distinguished career as a scientist." This was an honor which deeply touched his heart.

Early in his professional work Bell determined to become a citizen of the United States, taking out his first papers in 1874 and receiving his final papers in 1882. He was immensely proud of his American citizenship, which, as he stated, was his by choice rather than by accident.

In the later years of his life, Bell spent more and more time at his summer estate, Beinn Bhreagh, in Nova Scotia. Here, on August 2, 1922, he died. Here he was buried on the top of a mountain in a tomb cut out of a solid rock, with the epitaph, "Died a citizen of the U. S. A." During the ceremony, every telephone on the continent of North America was silenced in

honor of the man who had given to mankind the means for direct communication at a distance.

Not only did Alexander Graham Bell leave the telephone as a perpetual memorial to him but the influence of his personality remains strong on those who knew and loved him. Even now, 20 years later, a scientist who for many years knew him well, writes, "The fact that he never spoke disparagingly of others was a remarkable trait, the value of which nowadays I appreciate more than I did when he was alive. I miss his personality more than that of any other human being who has come and gone in my life."

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