
THE DEVELOPMENT OF SOUND RECORDING AT THE VOLTA LABORATORY

By Raymond R. Wile

PREFACE

In all probability the least known developmental work devoted to the improvement of recording sound was that accomplished by the Volta Laboratory Association between 1881 and 1885. The three individuals connected with the Laboratory—Alexander Graham Bell, Charles Sumner Tainter, and Chichester Alexander Bell—took a crude idea for recording and reproducing sound and developed it into a viable process. Thomas Alva Edison, who in a brilliant flash of intuition first conceived the idea, had reached a dead-end in his experimental work and abandoned it after late 1878 when he became increasingly involved with the electric light.

The fierce patent battles, engendered when the promoters of the original Edison process refused to join forces with Volta in 1885-87, left bitter enmities that were never healed. The forces exploiting the new improvements were dubbed by partisans of Edison as “pirates,” “crafty,” “unprincipled,” or at best “thieves.” This was unfortunate since certainly there was enough glory in these early developments for all.

I believe that I have been the first to examine the majority of the surviving documentary records and as such to have had an opportunity to arrive at what I hope is an unbiased judgement. I might add that while my original admiration for Edison has remained unchanged I have been slowly induced by new evidence to change my original assessment of the events of the Eighties. It would have been impossible to do this without the cooperation of the several documentary collections I have utilized in the course of my research. With few exceptions I have been warmly welcomed and encouraged to prepare as full an evidential record as possible.

In addition I should like to acknowledge, with thanks, awards from the New Jersey Historical Commission, the Faculty Research Award Program (FRAP 11042) and the Professional Staff Congress/Board of Higher Education Award Program (PSC/BHE 12061) which partially funded my continuing research into the business organization of the early sound recording industry.

It is almost impossible to recreate the excitement that took possession of post-Centennial America when it became known that a method of recording and reproducing sounds and speech had been developed. The new phonograph was exhibited

widely and great hopes were held out for its rapid and further improvement, but the bubble soon burst. Thomas A. Edison exhausted the monies allocated to him by the Edison Speaking Phonograph Company for the development of the invention and then admitted defeat. In a later interview with the *New York World* he stated that the first machine that was marketed

Weighed about 100 pounds; it cost a mint of money to make; no one but an expert could get anything intelligible back from it; the record made by the little steel point upon a sheet of tin foil lasted only a few times after it had been put through the Phonograph. I myself doubted whether I should ever make a perfect Phonograph ready to record any kind of ordinary speech, and to give it out again intelligibly. But I was perfectly sure if we did not accomplish this the next generation would. And I dropped the phonograph and went to work on the Electric Light.¹

A few tinkerers and experimenters attempted to develop the abandoned invention but were also forced to admit failure. After eluding man for centuries, the art of recording and reproducing sounds continued to be a will-o'-the-wisp. By 1885, a grand total of five patents had been issued in the United States: the three to Edison, one to A. Wilford Hall, and one to the intriguingly named Christopher Columbus Reynolds. Not one of these recording instruments was to surmount the problems of an unsuitable recording medium, imperfect indentation, inflexible diaphragms and impermanent recordings.²

That other major nineteenth century American worker in sound, Alexander Graham Bell, also had been attracted to the phonograph.

It is a most astonishing thing to me that I should possibly have let this invention slip through my fingers when I consider how my thoughts have been directed to this subject for so many years past. So nearly did I come to the idea that I had stated again and again in my public lectures the fundamental principles of the Phonograph. In showing to an audience the tracings produced by the Phonautograph I had said if the motions indicated by the curves could be produced mechanically in any way the sounds would be audible. For instance I have said in my lectures that if I were to move my hand in the way indicated by these curves articulate sounds would proceed from the hand. And yet in spite of this the thought never occurred to me to indent a substance and from the indentations to reproduce sound. Two French Physicists have been working on this subject for a couple of years past and were much chagrined at Edison's phonograph anticipating their invention.³

He later disclosed that his ideas involved recording on a metallic cylinder coated with lamp-black. The lines would be cut out to form a continuous slit on the thin metallic surface of the cylinder. The sound would be reproduced by blowing air through a slit-like nozzle placed at right angles to the line of the phonautographic tracing. He imagined that a pencil of air could be projected at the intersection of the slots and that the movement of the cylinder would cause a vibration of air in accordance with the sinuosities of the phonautographic tracing, and that this would cause the reproduction of the original sound. But the idea was never reduced to practice.⁴

In mid-1878 he conceived a notion that is quite similar in principle to today's various talking dolls with their embossed strips of plastic from which a series of recorded messages emanate. Bell had the idea of placing embossed messages on the periphery of a toy top so that a resonator placed against it would repeat the message. Dubbed the "Swearing Top," it is not known if any were constructed by him.⁵

Confined in his experimental work to a bench in the loft of his father-in-law Gardiner Greene Hubbard's stable on Brattle Street in Cambridge, Massachusetts, the inventor began to frequent the shop of a maker of "philosophical devices" located about a block away from Harvard Square. The young proprietor, Charles Sumner Tainter, had an extensive background in this form of work and at one time had worked in the same shop of Charles Williams, Jr., as had Thomas Watson of telephone fame. Bell had noted Tainter's sign and first called to induce him to construct a piece of apparatus that he wished to present to Professor S. F. Baird, the Secretary of the Smithsonian Institution. He then engaged Tainter to construct other experimental pieces and sometimes utilized him to assist in experimental work. In this way, Tainter said, he "got well acquainted with Bell, and also greatly attached to the man, for he possessed a strong magnetic temperament, and our association was a very pleasant and harmonious one. He used to discuss his ideas with me, and I offered him suggestions about working them out, as he had very little mechanical skill himself."⁶

As the friendship grew, the subject of the tin foil phonograph arose. Gardiner Greene Hubbard, Bell's father-in-law, had invested in the first phonograph company and had become its president. He must have communicated his disappointment that the instrument had not developed as had been anticipated. By the fall of 1879, the instrument maker was privy to the fact that the Bell family intended to remove to Washington so that Bell's young wife would be near her family, which had recently moved. Bell proposed to set up a laboratory there and asked if Tainter would be willing to relocate so that the two could conduct investigations into broad areas of sound technology. Tainter agreed and signed a formal agreement in which he was to receive a salary of \$15.00 a week and a 10 percent interest in all inventions developed at the laboratory. Bell, as the director and financier of the laboratory, would receive a half-interest in any invention that Tainter should perfect.⁷ After concluding his business in Cambridge, the new worker in sound preceded the Bells to Washington, D.C., setting up a laboratory in a vacant house at what is now 1879 L Street, near the proposed Bell residence at 904 14th Street NW.⁸

The idea of establishing a research laboratory for the purpose of scientific investigation certainly was not new, but the concept of establishing an industrial investigative laboratory clearly made Bell one of the pioneers in this peculiarly modern concept. As long as Professor Bell received his retainer from the Telephone Company, the existence of the Laboratory would be assured, but with its imminent cessation in 1881 the facility would have to produce other devices in order to justify its existence. The decision of the French Government in 1880 to grant its Volta Prize to Bell for his work on sound and telephony temporarily solved the problem of finance. Besides the honor and prestige attendant with the medal, a carryover from the Napoleonic period, there was a cash award of 50,000 francs, then the cash equivalent of \$10,000. This amount would allow the continuation of experiments and hopefully the development of marketable devices. The widening of the Laboratory's horizon forced an increase in operating expenses when it was realized that a physicist was required. The need was met by employing a cousin—Doctor Chichester Alexander Bell—who also was to receive a salary and a portion of the proceeds resulting from any invention. The group now consisted of Tainter, the two Bells, and an occasional workman secured to assist in the construction of models and in the general operation of the facility. For obvious reasons, the laboratory was named the Volta Laboratory and the group the Volta Laboratory Association.

By now, in the fall of 1880, the facility had been moved to 1221 Connecticut Avenue, a house fitted up as a laboratory near the site of a proposed new home for Alexander Graham Bell.

The west half of the square between Rhode Island Avenue and N Street back to the alley dividing it from north to south, was vacant at that time, except for the house mentioned, which was formerly the residence of a gardener named Jardin, who used to grow flowers upon it for the market. Bell had purchased a large lot at the southwest corner of this property, facing Connecticut and Rhode Island Avenues, with the intention of building a house there, but he later gave up this scheme, and built his house a block further up Connecticut Avenue in the square between N St. and Dupont Circle, nearly opposite Mr. Hubbard's house. . . . In 1883, he purchased the ground where the laboratory was located, back from Connecticut Avenue to the alley, and the Volta Laboratory Association built a workshop upon it, where [they] employed three or more workmen to make [the] experimental apparatus, when they were developing the Graphophone.⁹

Immediately before the organization of the Association, Bell and Tainter demonstrated the last of the inventions to which the Telephone Company could lay claim under its agreement. The device was designed to transmit sound on a beam of light which actuated a selenium cell at the receiving end. This method of transmitting sound excited sufficient interest at the time, but it was not until much later that the full implications were developed. The original device was limited by the varying intensities of natural light and the distressing tendency of the cells to absorb water and lose their efficiency. The experiments provided a basis for much of our later microwave technology which took its inspiration from this invention. Using the photophone as a bargaining element, attempts were made to have the telephone retainer reinstated, but Theodore Vail of the Telephone Company reasoned that any developments had to be turned over to the Company anyway—so why pay for them? The details of the original telephone contracts thus forced a turning away from any telephonic experimentation.

The actual beginnings of the Bell and Tainter work on the improvement of the phonograph is not clear. Charles Sumner Tainter mentioned that as early as 1879, Gardiner Greene Hubbard suggested they work on the instrument since Edison was doing nothing to improve it. This was promised as soon as the selenium and light ray scheme was developed. It was Hubbard who obtained a phonograph to experiment with.¹⁰ Later in June of 1881 Bell summarized the previous discussions:

Upon looking over the ground Dr. C[hichester] A. Bell, Mr. [Charles Sumner] Tainter and I [Alexander Graham Bell] decided that the most promising field for *joint* work would be to perfect the 'Phonograph' or 'Graphophone' or whatever we may decide to call it. To perfect a means of reproducing sound from a record. Dr. C. A. B. has also some special chemical work which promises preliminary results.

The points upon which we agreed before April 21st were the following:

1. The method adopted by Edison in his Phonograph is defective in this that the record perfectly controls the vibration of the diaphragm during only one half a vibration.
2. Tin foil is unsuited for a permanent record.
3. If paper could be used for the record it would have special advantages.
4. It would be better to reproduce the sound without contact with the record.¹¹

It will be seen that although much of the experimental work was accomplished by Chichester Bell and Charles Sumner Tainter, Alexander Graham Bell was intimately connected with all of the work of the laboratory. Unlike Edison, Bell allowed his associates to obtain credit for much that germinated in his fertile mind. Later in the eighties, when he felt that Tainter was not being given enough credit for his part, Bell was careful to point out the injustice to Tainter in a paper reported on in the magazine *Science*.¹² Significantly, the notebook entries demonstrate that the three had already begun to discard the misconceptions that had so hampered Edison. They also could attack the problem of sound and its reproduction unhampered by the need to quickly develop the invention. This had been the fatal difficulty for Edison after he prematurely unveiled his conception in 1877. The exclusive concern of the Volta Laboratory with sound contrasted vividly with the wide-ranging and multi-faceted activities of the Edison Laboratory at Menlo Park. The Volta group would repeat many of the Edison experiments, as an examination of the surviving Edison experimental record and the notebooks of the Association members will show—but the Association succeeded in its quest.

The earliest firm date that can be assigned to any significant work is evidenced by the first entry of March 28, 1881, the first of Tainter's *Home Notes*, sometime before the arrival of Chichester Bell and the formal organization of the Volta Laboratory Association. The device pictured is quite sophisticated and obviously represents the results of some months' work and thought utilizing a lateral cut disc record mounted on the end of a lathe chuck for convenience. It was even suggested that the reverse side of the disc might be used to receive a recording. Among the notes also is the suggestion that the disc could be duplicated by using accepted electroplating methods or by preparing a plaster of Paris casting. The first model proved unsatisfactory and was abandoned for another. Experiments also were attempted with etching out a sound-groove, a technique later utilized by Emile Berliner for his Gramophone records. Another interesting concept involved utilizing ink with magnetic particles in suspension. Here the message was reproduced by the magnetized iron deflecting the needle and vibrating the diaphragm.¹³

With so many promising experiments in progress, Bell characteristically examined the linguistic connotations of the terminology that Edison utilized in describing his instrument:

'Phonograph'—an instrument for recording the vibrations of sound.

'Phonogram'—the record made by sound.

'Graphophone'—an instrument for producing sound from a phonogram—for reproducing the sound that caused the record. A 'writing-speaker'.

I would look upon Edison's instrument as a 'Phonograph' only while it is being operated by the voice of a speaker—and would call it a 'Graphophone' while reproducing the sound from the record.¹⁴

The ideas of the three associates were so promising that the eventual Articles of Association dated October 8, 1881 were very carefully prepared. In the articles, all possible areas of potential controversy were anticipated and to their credit no major falling-out of the three signatories is known to have occurred, unless it was the return of Chichester Bell to Great Britain, which caused the dissolution. Clauses specified that if the group were successful Alexander Graham Bell's expenses in operating the laboratory would be reimbursed, that costs of interference proceedings

and of defense of a patent should be a lien on that patent only, that trustees should hold the patents granted, that no associate might dispose of his interest without first offering it to one of the others, that the Association would be dissolved upon the written notification of any member's intention to withdraw, and that the agreement was to be effective on May 1st, 1881!¹⁵

Work progressed rapidly in 1881 as the three went beyond the ideas previously discussed by Alexander Graham Bell and Charles S. Tainter. Because they realized that tin foil was an inadequate recording medium, the three took an Edison phonograph (perhaps the one obtained through Gardiner Greene Hubbard), widened the cylinder grooves, embedded wax in them, smoothed it, and then proceeded to cut a recording having discovered that cut wax provided a much better recording than tin foil although it did not allow a loud reproduction. Then, like Edison, they adopted a method of using compressed air in reproduction. Edison, in his Aerophone, vibrated an already existing column of air in order to magnify a sound. The Volta group directed a jet of air against the recorded grooves reasoning that an air jet would not cause as much wear as a "rubbing stylus." Other jets of liquid also were tried.¹⁶

Enough had been accomplished by the middle of the summer (1881) that it became necessary to protect the concepts in the event of later conflicts. A caveat would have had an operable existence of one year, so another expedient was resorted to that had, on an earlier occasion, been utilized by Bell and Tainter. Some of the more important pieces of apparatus were gathered and deposited with the Secretary of the Smithsonian Institution. The group also may have realized at this time that their developments were not sufficiently distinct from those of Edison to allow the Patent Office to issue a patent.

Work progressed slowly in preparation for the deposit, and by the end of September the major work was completed.

The following words and sounds are recorded upon the cylinder of the enclosed Graphophone: T-r-r- T-r-r. There are more things in heaven and earth Horatio, than are dreamed of in our philosophy—T-r-r. I am a Graphophone and my mother was a phonograph.

Upon the 25th of September the Graphophone with the above words and sounds recorded upon the cylinder was arranged as shown in the diagram on page 41—Vol. III of Sumner Tainter's *Home Notes*, a copy of which is enclosed.

An air pressure in the reservoir A. of from 40 to 80 lbs. per square inch was used; but owing to some defect in the apparatus, the loudness of the sounds reproduced was much inferior to that obtained in experiments made last July with the same air pressure.

The following persons were witnesses of the experiments made September 25th: Mrs. G. G. Hubbard, Miss Grace B. Hubbard, Mrs. David C. Bell and Prof. A. Melville Bell. Since these experiments were made we have slightly enlarged the aperture of the glass jet by cutting off a portion of the end which has been found to improve the loudness of the sounds reproduced. With this exception the apparatus in this packet is in the same condition as when used in the experiments made on the 25th of September.

We also enclose an electro-type copy of a Phonogram, which has just been completed. This copy, which is the reverse of the original was made in the following manner:

A thick disk of metal was placed in the lathe and a recess turned in one side. This recess was then filled with the paraffin-wax composition, (paraffin 2/3, wax 1/3) and

again placed in the lathe, when the surface was turned off flat and smooth. A diaphragm and mouthpiece were then fitted to the slide-rest of the lathe, and a lever attached to the center of the diaphragm carried a cutting tool.

When the lathe revolved the mouthpiece, lever, and cutting tool received a slow and regular motion towards the center of the disk held in the chuck of the lathe, and the result was a spiral line traced upon the surface of the composition.

When no sounds were uttered this line was smooth and regular; but when words and sounds were shouted into the mouthpiece, the vibrations of the diaphragm were communicated to the cutting tool and corresponding irregularities formed in the spiral groove.

The disk with the record or phonogram upon it, was then placed in the well known mixture used for silvering mirrors and a film of pure silver deposited upon the phonogram. It was then placed in a solution of sulphate of copper, and connected to a battery of one cell, the second pole of the battery being connected to a plate of copper placed opposite the phonogram as in the ordinary arrangements for electro-plating.

After remaining in the plating solution about 40 hours the phonogram was taken out and gently heated over a lamp until the copper film separated from the composition.

The irregularities and holes in the copper film are due to the irregularities of the silver film, as the solution acted upon the metal of the disk (zinc) and caused a poor deposit of silver upon the phonogram.

The phonogram copied in this case is of the zig-zag form but there is nothing to prevent copies of an Edisonian record being made in the same manner.

It is our intention to 'back' an electro-type of this kind with a solid plate of metal and then use it as a stamp or die for forming copies in various material from each of which the original sounds can be reproduced.¹⁷

Tainter placed what equipment and pieces of apparatus he could fit into a soda-biscuit tin, prepared an inventory, added transcriptions from his *Home Notes*, prepared a statement which all three signed and then soldered the whole affair shut.¹⁸

The contents were to wait 56 years before they were again examined. In 1937 Charles Sumner Tainter, the last of the members of the Association, gave the necessary permission for its opening but was too frail and ill to attend the ceremonies himself even. The box was found to contain the modified Edison phonograph and the air jet nozzle necessary to reproduce the message. The air tank and pressure reduction devices needed to actuate the jet were not included since they had been too large to fit into the container. Those who witnessed the reopening were privileged to experience a moment of invention, frozen in time, for the process of cutting a message in wax was a major claim of one of the Graphophone patents.¹⁹

Many other varieties of experiments would be undertaken at the Volta Laboratory, but the attempted assassination of President Garfield temporarily turned their attention to the development of an induction balance to locate the bullet in his body. The group was unsuccessful in developing a sensitive enough instrument and also were defeated by the metal bed springs although the device performed well when used experimentally with sides of beef. The death of the President ended these experiments.²⁰

The majority of later experimental approaches to the problems of recording were attempted at one time or another at the Laboratory. One of the more interesting of these was the process of photographing sound. This project of Chichester Bell was noted in his *Home Notes* for Thursday, April 3rd, 1884.

Mr. Tainter has recently designed a dark disc, in which the phonograph figured on page 3 is mounted, so that a rotating photographic plate may be exposed to a varying beam of light. I presume Mr. Tainter has given a complete description of the box in his notes.

Yesterday and Friday Mr. [J. Harris] Rogers and I took some photographs of an illuminated slit varied by means of this apparatus. In the diagram M represents a mirror for reflecting sunlight on to an eight-inch condensing lens L¹ by which a powerful beam is concentrated upon the slot at S. An achromatic lens L within the tube T forms an image of this slot on the sensitized (gelatine dry) plate P, which was connected to the rotating axis of the phonograph.

The slot (I believe the same used by Mr. [Alexander] Graham Bell in some of his spectrographic experiments was formed by two plates P and P¹ sliding in a groove in a brass plate which closed the end of tube T (preceding figure). The length of the slit could be varied by means of little brass plate Q and Q¹.

The jet liquid used was a nearly saturated solution of bichromate of potash. The result has shown that such a jet is sufficiently opaque to actine rays.

The jet could be arranged so as to vary only one side of the slot, or so that the spiral line on the photographic plate represented a continuous series of sections of the jet. . . .²¹

As the major experimental work of the associates on talking machines was culminating, the effect of the constant work on the Volta Prize monies was all too obvious. As a result, overtures again were made to the Telephone Company for financial assistance in the experimental work on sound. In these overtures Bell showed great good sense. He could show the representatives of the phone company a long record of serious research and development in the science of recording and reproduction. He also could dangle the promise that several telephonic ideas had occurred to the members of the Association, but that the necessities of the original agreement between the Telephone Company and Alexander Graham Bell prevented their exploration and development. This time Gardiner Greene Hubbard acted as an intermediary. "Hubbard says the *cousin* already has a valuable improvement in long distance telephones, which Bell is barred from helping him on by our present arrangement."²²

W. H. Forbes, the President of the Telephone Company, was favorably disposed toward the proposition, but some time was to elapse before this became clear. His first reaction was to offer the old retainer of \$5,000 which could be used for any purpose.

We have been considering the question of Prof. Bell and how to compensate him for his future inventions, and had decided to offer to pay him \$5,000 a year again, which he could use for himself or his Volta Laboratory—all inventions (Telephonic) made there by him and associates to belong to us; *his* do now by the old contract, without pay, the result being that he makes none. . . . Can you think of any better way than an outright annual payment and we to have the whole. And how far can we afford to go for the chance of his finding out something.²³

Understood was the importance of maintaining amicable relations with Bell, for with the large number of potential infringers and inventors who were attracted to the telephone, it was important to turn Bell's attention again to things telephonic. With the stakes as high as they were, it would have been folly not to a chance. Negotiations dragged on throughout the spring. The first proposal called for the contract to commence on March 1, but "for various causes . . . the agreement does not get made until now, and I don't think Mr. Bell has bestowed any thought on the

subject meantime and I doubt if his associates have much. Therefore the pay should begin the first of July [1882]." The agreement was both retrospective and current—calling for a flat payment of \$5,000 for which the telephone company received the right of refusal for any telephone or telephone-like invention produced by the Association through July 1, 1883. Thereafter, a yearly payment of \$8,000, made quarterly, would be applied toward the support of the Laboratory. In all eventualities the Telephone Company was to have the first refusal on any telephonic invention. Significantly, the agreement excluded "any invention for the recording of speech or sound or reproducing recorded speech or sound, although capable of use in sending or recording telephonic messages." Foreign rights to any invention were to remain with the Volta Association unless a foreign patent's term should limit that of the American patent. Litigation would be handled by the Telephone Company. Should any invention be of great commercial value the telephone company agreed to pay a just and reasonable additional amount to the group. A significant section reiterated the dissolution clause contained in the Volta Articles of Association concerning the right of a member to dissolve the Association. As a corollary, either party was given the right to terminate the contract by providing six months' written notice of intent to do so. The financial basis of the Laboratory was now secure.²⁴

By the end of 1883, the major experimental work concerning recording was finished and, seemingly, the task of the Association would be to perfect the instruments that had been developed. At this point, the extensive series of Tainter notebooks ceases, and the less complete notes of Chichester Bell likewise end by mid-1884. Both were replaced by a series of detailed drawings used in the construction of laboratory models of the new machines. With the construction of simplified machines, the group then turned its attention to things telephonic.

The contract with American Bell Telephone Company, under which an important part of the laboratory expenses were subsidized, called for a six month notification of an intention to dissolve. On October 31, 1884 the members indicated their intention to dissolve.²⁵

Dr. Chichester A. Bell has a feeling that he may be able to better his condition in life by returning to Europe: and in order that he may be free to do so has given notice of his intention to withdraw from the Association, on the first of May, 1885. He fixes this date because the lease of the building now occupied as the Volta Laboratory expires on that day so that some change will be necessary about the time spoken of and Dr. Bell thought that his withdrawal would occasion less inconvenience than that at another time.²⁶

It now became even more important that the experimental graphophone be made commercially successful.

Alexander Graham Bell recorded his thoughts on the matter upon a dictation cylinder:

I believe that the [Graphophone] is and has been for a long time past, in a condition for practical commercial use and that all of our efforts should now be directed to placing the apparatus on the market. There are two lines of improvement open to us. In the first place we may attempt to improve the character of the reproduced speech so that it may be clearer and more distinct than it is at present; we may accept the articulation as clear enough for many practical purposes and simplify the apparatus so that it may be better adapted for immediate commercial use. The former plan will involve much labor and time and after all we need never expect perfection. There is nothing perfect in this world . . .

I am quite sure also that the Phonograph in its present form may be made of great use and I would, therefore, urge upon you both the importance of devoting attention to the mechanical details of the apparatus rather than spend all your time in attempting to improve the *character* of the articulation.

We should aim at portability and simplicity. I would urge the importance of making a [Graphophone] of minimum size. I have no doubt that a paper cylinder six inches long and half an inch in diameter would have capacity enough for an ordinary business letter. The whole apparatus should be made of such a size that it can be placed in a box and carried readily. This means reduction in size and weight and in number of parts as the great object of immediate effort.²⁷

During the late spring the associates consulted with the patent attorney Anthony Pollok who previously handled telephone patent matters successfully for Bell. A long series of applications was proposed, but soon the absence of sufficient financial resources available for the Association to cover the costs became clear. The total number of applications was then reduced to nine—each one covering many basic features. Later, this was to cloud not only which associate invented what, but also placed one or two patents constantly in litigation as each claim ran the gauntlet of having its validity tested in court. Tainter, who actually was the basic inventor, complained bitterly in later years that reducing the number of applications had done him an injustice as his name was inextricably woven with that of Chichester Bell in the fundamental patent, No. 341,214, which was among the formal patent applications filed on June 25, 1885, two months after the expiration of Edison's British Patent 1644.24.²⁸

Gardiner Greene Hubbard decided that it was time to regularize the position of the new invention with Edison's phonograph patents which were controlled by the Edison Speaking Phonograph Company. Hubbard, who was both a Director and the President of the Edison Co., began to sound out the other Directors concerning a merging of interests.

I wrote to you a few days hence about the Phonograph but have no answer. Some arrangement must be made at once, or Dr. [Chichester] Bell & Mr. Tainter will be discouraged & throw it up. Please give the matter attention & have a meeting of the Phonograph Co. called. We can meet an hour or two before & decide what shall be done. How would it answer to give the new patent a right to work on paying a royalty of say \$1 an instrument.²⁹

Edward H. Johnson who, other than Edison, had done the most to develop the Edison tin foil phonograph for the Edison Company, questioned the propositions.

To form a new company and give the inventor one half the stock by which term I suppose he means Bell and his friends, and Edison the original inventor don't count, is wholly out of the question, and if their invention is to be secured on the basis of paying them one dollar royalty on each instrument, I see no object in organizing a new company. . . .

He also questioned their ability to construct machines—there was a vast difference between making experimental models and a 'commercial product.'³⁰

As a result of these questions, the Associates decided to prove that the machine was susceptible of regular production. Bergmann & Company, a manufacturer of electrical products and the maker of many of the original tin foil machines, was con-

tracted to construct a grouping of six of the new machines.³¹ It is not generally known that both E. H. Johnson and Thomas A. Edison were investors and actually formed the latter part of the Bergmann Company's title. The former laboratory associates agreed among themselves

to postpone experimenting on the phonograph [graphophone] until we have had made 10 instruments of the cylinder form constructed to the pleasure of Mr. T[ainter] and 10 instruments of the disk form to suit the pleasure of Mr. C. A. Bell necessitating you [Alexander Graham Bell] to supply the necessary funds and the instruments to be delivered to your order when completed.³²

Johnson was quite impressed with the potential of the machines and prepared a proposition which he felt was fair both to the Phonograph Company and the Bell group—but it was unacceptable.

You see I was right—they refused our offer point blank—now shall we let them go ahead as they please? I am of the opinion that in this matter old man Hubbard will eventually walk away with you. Don't you think we should take some steps towards putting the old Co. in such shape that it cannot be snapped up by some one more familiar with legal technicalities than our worthy selves.³³

Even though the old Speaking Phonograph Company controlled the Edison patents, Johnson, ever the friend and defender of Edison, wanted the inventor to have an opportunity to judge the quality of the Volta machine. By the middle of the summer, Tainter was stationed in New York City supervising the manufacture of six demonstration machines being constructed by Bergmann and Company. It was probably here that Edison, who maintained laboratories on the upper floor, first became acquainted with the new device. Construction was delayed by various modifications and the unfamiliarity of the Bergmann workers with the instruments. Apparently there also was an unwillingness on the part of the Company's owners to put a large number of people to work on the project.³⁴

Negotiations continued with Tainter reporting to Washington on September 30th. He noted that his associates could do nothing without the permission of the old Speaking Phonograph Company since it held what were considered the fundamental patents. Without that permission the field would be open to innumerable competitors since there would be no exclusive license. Even though Johnson had suggested a merger in which the Volta group would receive a smaller share, it seemed that it was the only possible path. If the experimental machines being constructed by Bergmann & Co. were satisfactory to Johnson, Tainter was sure that the group would be willing to reorganize the company

“giving one half the stock for the inventions and reserving one half to be sold at par for working expenses. Of the half given for inventions one half will go to us [the Volta Group] and the balance to the Edison interests. This seems to me to be as fair an arrangement as we can expect and one that I would be perfectly satisfied with.”³⁵

But Edison was apparently obdurate, and Johnson and Uriah H. Painter, who were tied to Edison through other investments, apparently were unwilling to do anything without his consent. This he apparently refused to give. With the death of his first wife late in 1884, Edison's whole personality had changed. In the case of his electrical work he became a burden rather than an asset.

Like all persons of colossal creativity, Edison was possessed of a colossal ego. Hence, systematic as he was when pursuing his own ends, he had an almost pathological hostility to any form of system, order, or discipline imposed from without. . . . Hence, too, his invaluable habit of paying careful attention at all points to the economics of his inventions, and his seemingly contradictory habit of abandoning all sensible business methods at unpredictable and sometimes critical moments.³⁶

This seemed to be the situation with the phonograph at the time of the Volta negotiations.

Chichester Bell suggested that the only course would be to set up a manufacturing company to work on the Graphophone—possibly paying the old phonograph group a royalty.

. . . are you willing to form a Company to own and dispose of our patents, possibly to work them or (but very cautiously) to do experimental work, and are you willing to get some business men (especially Charlie) into it—not mere friends like ourselves? And are you willing to leave the organization of the Company to the aforesaid business men.³⁷

Even though Tainter was unhappy with the workmanship being provided for the six experimental graphophones, he pushed one through to completion and exhibited it for Edward H. Johnson about October 3, 1885. He determined to take the remaining machines back to Washington and to have them completed at the Volta Laboratory workshop. Ever meticulous, he provided a detailed breakdown of the cost of each machine when the work was finally completed—\$138.72.³⁸

One person flits in and out of the scene during this period. Charles J. Bell, another relation, had set up business as a private banker in Washington. Charles Bell was constantly in the Volta Laboratory and clearly was advising the members. But his name seldom appears in the surviving documents and his family unfortunately does not hold an accumulation of his personal papers. I believe that Charles Bell guided the Laboratory associates in a quest for possible favorable locations for incorporation. Chichester Bell had mentioned New York as a possibility, but the state finally agreed upon was Virginia. After the formal notification of the granting of the Graphophone patents on December 24, 1885, it became feasible to incorporate. Alexander Graham Bell, Charles Sumner Tainter, Chichester A. Bell, Charles J. Bell and James H. Savelle organized the Volta Graphophone Company in Alexandria, Virginia on January 6, 1886 although formal incorporation had to wait until February 3, 1886.³⁹ Preparing to exploit the invention, the group established a new experimental facility at 2020 F Street, NW in Washington, D.C.⁴⁰

By now the Edison group had unwittingly played into the hands of its rival. Edison, just prior to the Volta negotiations, had caused vital portions of his fundamental patent and his other two American phonograph patents to become invalid by allowing the basic English patent to expire. Because of litigation involving his English telephone patent, he also had been forced to have its section concerning the phonograph expunged. At that time, an American patent's term was limited to the shortest running foreign equivalent. Once the fact became known, there would be no impediment to a successful exploitation of the Graphophone.⁴¹

With the formal issuance of the Graphophone patents on May 4, 1886 an active publicity campaign began. In June the new machine was demonstrated publicly and

formed the subject of a long illustrated article in *Harper's Weekly*.⁴² As the demonstrations occurred, Tainter was inspired constantly to add new improvements which became the subject matter of several additional patents.⁴³

Several of the prominent stockholders of the Volta Graphophone Company urged that appropriate public measures be instituted to make the eventual marketing of the new machines easier. Andrew Devine and John H. White were both official reporters for the House of Representatives. James O. Clephane was a former reporter who now had a large stenographic business and, among his several investments, had interests in the Mergenthaler Linotype Co. and the Lanston Monotype Company. He later utilized a method of setting type directly from dictation cylinders. As soon as an extra machine was available, Andrew Devine took it to the Capitol to experiment with in his regular work of reporting the debates.

These debates were taken down in short-hand by one of the House reporters who kept close to the member while speaking, and followed him about the chamber if he moved from his seat during the time he was talking. This would continue until the reporter had taken down enough to fill a column of the Congressional Record, when he would be relieved by a colleague. The first reporter would then take the notes he had made, out to the reporters room, where he would read them to a short-hand clerk to be taken down a second time in short-hand before they could be transcribed on the typewriter. This complication was necessary as no one could read the reporter's notes besides himself. After this was done the second set of short-hand notes had to be read over by the clerk, and carefully compared with the reporter's notes, to guard against errors. This took up much valuable time of both and was also tedious work, and time was important, for the day's debates had to be in the hands of the printers in time to be issued in the next morning's edition of the Congressional Record, which was distributed around to the houses of the Members early in the morning.

When Mr. Devine got the machine, he read the notes quickly to it, and was able to compare the work all by himself in much less time than before, and also with less labor. The record on the cylinder could then be copied by any good typist, and high salaried short-hand clerks became unnecessary, and much time was also saved in this part of the work as well. As soon as this was demonstrated the system was adopted by the other House reporters, and later by the Senate reporters as soon as they were able to get the machines to use.⁴⁴

Clephane, Devine and White were impressed with these demonstrations and the potential of the machines. As a result they signed an agreement with the Volta Graphophone Company to market the new machines. This agreement dated March 28, 1887 actually marks the beginning of the American Graphophone Company, although the formal incorporation was not to occur until May 15, 1887 and its final organization on June 22, 1887.⁴⁵ At this time, the group again began to sound out the Edison Speaking Phonograph Company concerning a merger of interests. By marketing a machine incorporating the new features, there would be a practical monopoly and the two groups would not be spending their time in futile in-fighting.⁴⁶ Both the Volta and American groups badly wanted a combination. On May 10, 1887 the Volta Directors met to "consider the advisability of submitting a proposal for harmonious arrangements. . ."⁴⁷

As matters began to move rapidly in the fall, Hubbard frantically requested in September that nothing be done to reorganize the Edison Speaking Phonograph Company, but if it were necessary Painter should act for him. Further complicating matters, Edison, apparently acting on the advice of his lawyer John C. Tomlinson,

had decided to go ahead and organize a new company. The company which was formed, the Edison Phonograph Company, had a name similar enough to that of the Edison Speaking Phonograph Company to cause constant confusion.⁴⁸ On October fifth James O. Clephane telegraphed Edison: "Will you please inform me by telegraph when and where during today or tomorrow it will be convenient for you to meet a committee from Washington to talk over phonograph matters."⁴⁹ The situation was becoming strained since the American Graphophone Company had already contracted with the New York branch of the Western Electric Company to construct 300 Graphophones. Uriah H. Painter was understandably concerned.

I learn the Bell crowd are going to sound Edison to see what he is doing & where he stands. I want you to see him and get his word at once under no circumstances to intimate that he has or is going to have anything or give them any satisfaction about the old Color indicate any disposition to have any deal with them. They won't have any machines out before January or February [and] then only 300.⁵⁰

After seeing Edison, the group met with Painter who reported:

Their visit to N. Y. was on account of having rec'd information that 'E' has recently perfected Phono & proposes to put it on the market through a new Co. or the old one reorganized. . . . Their visit to Edison was partially successful, he 'E' confirmed their information that he had a machine *now*. They then offered to unite the two & only have one on the market—he declined saying he thought two were better & let the best one win. They revived their request for a license & he said he would consult some of his associates, that he had never been insulted up to this time and if he had been and they had not changed the name by reversal, and tried to put it out by a new name and invention he would have given them a license at a nominal figure. I replied that I didn't believe 'E' had any commercial machine . . . That 'E' claimed *they* had nothing & his machine was as good a commercial machine as theirs, that he was a man whose talk was always loudest when he had the least to back it up & etc. . . . I cross questioned them pretty sharp about Edison's new machine & found they had nothing *specific* about it; that E said it was 'being made,' but gave no information further—I said 'yes, that's been his story for 11 years.'⁵¹

With the organization of the new Edison Phonograph Company completed, Edison signed an agreement with it on October 28, 1887. There was an attempt to grant the members of the old company stock in the new organization, but this was met with a rebuff. On the same day, the direction of the new organization was placed in the hands of a General Agent—Ezra T. Gilliland.⁵² Gilliland was a former exhibitor who had been assigned a territory in Ohio at the time of the 1878 tin foil excitement. He also was the individual who had introduced Mina Miller, the woman who was to become Edison's second wife. A factory was established in Bloomfield, N.J., and preparations were being taken to commence manufacturing activities.⁵³ Painter suggested to Hubbard that the old company should get its house in order and make sure belatedly to conform to the regulations concerning meetings of Connecticut corporations. Once that was accomplished a warning could be given to Edison that he, under the terms of his contract with the Edison Speaking Phonograph Company, should be prepared to bring suit against both the new Graphophone Company and the Edison Phonograph Company for infringement.⁵⁴

By now Edison had openly broken with his former associates:

My action in the phonograph matter is based on the assumption that the phonograph patents are void, they cannot be set right by a decree of the Supreme Court like our electric lamp patents because they were *filed* after the granting of the foreign patent while the lamp patent was filed *before*. The statute is clear, and the foreign patents have expired. After ascertaining this I determined to go into it as a business enterprise with the risks and struggles of competition, I did not want to see the old phono people left out so I offered them a 1/3 interest in the business. My feelings were outraged when in a letter to E. H. J[ohnson] Hubbard insinuated dishonesty and further by you flatly refusing the proposition, as I under all the circumstances thought I was doing a generous action. After these events I submitted the whole thing to disinterested persons, who also considered that I had acted very generously . . .⁵⁵

The break was now complete and the experimental work of the Volta Laboratory in bringing new life to “Edison’s favorite invention” was finished. From now until the turn of the century further developmental work primarily occurred because of the competitive rivalry between the American Graphophone Company and the Edison group which consisted of the Edison Phonograph Company, the Edison Phonograph Works and, after 1896, the National Phonograph Company. It was to take the Courts until the end of 1896 to sort out the conflicting claims that had arisen between the Bell and Edison factions. Both groups eventually had to admit defeat after a growing realization that each held important patents and that neither could operate without infringing. The impasse was settled when the American Graphophone Company accepted consent decrees in cases directed against its chief experimenter Thomas H. MacDonald while the Edison Phonograph Works accepted a similar verdict. A host of subsidiary cases were discontinued at the same time. Both groups then cross-licensed one another in a secret agreement of December 7, 1896. The competitive stance was continued by successor companies and only ceased in 1929 when Thomas A. Edison, Incorporated withdrew from the phonograph business leaving the field to its major competitors, the Columbia Phonograph Company and a later entrant, the Victor Talking Machine Company, which had recently merged into the Radio Corporation of America. Although Alexander Graham Bell may still have regretted his failure to invent the talking machine before Edison, it was the patents emerging from the Volta Laboratory that successfully rekindled the phonograph industry, and perhaps inspired the works of Emile Berliner. 🗨️

NOTES

- ¹ As reported in Henry Edmonds *The Graphophone*, [paper] read 9/7/88 p. 6-7. Edmonds did not date the issue of the *World* from which he was quoting.
- ² Testimony regarding several of these efforts may be found in the case record of *American Graphophone Company versus Edison Phonograph Works*. (U.S. Circuit Court. District of New Jersey. In Equity No. 3500.) Partial files exist at Edison National Historic Site and at the Regional Archives Center at the Federal Record Center-Bayonne, N. J. This portion is from the Archives Center. A few other patents that have some connection with the concept of the phonograph are detailed in Allen Koenigsberg’s *Patent History of the Phonograph, 1877-1912*, c. 1990, p. 3.
- ³ Alexander Graham Bell to Gardiner Greene Hubbard 3/18/78 LC. The two French physicists are probably M.M. Napoli and Marcel Duprez. See Theodore Du Moncel. *The telegraph, the telephone and the phonograph*. p. 238.
- ⁴ See Alexander Graham Bell “Deposition” in *American Graphophone Co. versus Edison Phonograph Works* ... Answers to Cross Questions 17 and 18. At Regional Archives Center, Bayonne and as a copy in Bell Papers at LC.

- ⁵ Letter from Alexander Graham Bell to Thomas A. Watson, Jr. 8/12/78. Offered for sale and described in a circular of the American Autograph Shop, Merion Station, Pa., December 1937. The pages of the circular are at LC. Also mentioned in Charles Sumner Tainter *The talking machine and some little known facts in connection with its early development* (typescript) p. 46, Nat. Mus.
- ⁶ Letter from Charles Sumner Tainter to William Chauncey Langdon, Hist. Librarian, ATT 5/6/31. Tainter in *op. cit.* mentioned that the apparatus for Baird was “for the purpose of indicating at all times through electrical and magnetical means, the direction a wind vane was pointing on the roof of the building in which the indicator was situated. Prof. Baird had a vane on his house, but was obliged to go outside to find out how it was pointing, and Prof. Bell wanted to save him this effort.” p. 2. ATT.
- ⁷ Agreement between Alexander Graham Bell and Charles Sumner Tainter 10/15/79. Bell Papers.
- ⁸ Charles Sumner Tainter *op. cit.* p. 3.
- ⁹ Letter from Charles Sumner Tainter to W. C. Langdon 5/6/31. AT
- ¹⁰ Letter from Tainter to Langdon 5/6/31 AT. See also Tainter *op. cit.* p. 4.
- ¹¹ Alexander Graham Bell, *Home Notes* Vol. IV, p. 55-61 6/1/81 LC.
- ¹² See Alexander Graham Bell to Charles Sumner Tainter 3/20/88 BP. Bell did discuss Tainter’s contribution at a Washington meeting that was reported in *Science*.
- ¹³ Tainter *op. cit.* p. 19 *passim*. The official date of the beginning of the Volta Laboratory Association was 5/1/81 although the agreement was not signed until 10/8/81. See p. 24 and also the Agreement included among the Tainter and Bell papers. NM and LC.
- ¹⁴ Alexander Graham Bell, *Home Notes*, 6/1/81 p. 63 LC
- ¹⁵ See copies of the Agreement found in both the Bell and Tainter papers. Volta Laboratory Association. *Articles of Association. 10/8/81.* (typescript). The agreement contained 29 clauses and occupied seven typewritten pages. A draft also is present—Bell Papers. LC.
- ¹⁶ See Thomas D. Lockwood to John H. Hudson 5/27/86 for example. AT.
- ¹⁷ “The following is a copy of a portion of the written matter contained in the sealed package marked ‘Package No. 1 V.L.A.’ which was deposited in the Smithsonian Institution, 10/20/81.” Taken from a transcript of pages 97-113 of Alexander Graham Bell, *Laboratory Rough Notes* for Sunday, 10/23/81. p. 3, 4, 5 *passim*. The Smithsonian gave a receipt as follows: “Washington, D. C. 10/20/81. Received from the Volta Laboratory Association for deposit in the confidential archives of the Institution a sealed package in box marked ‘Package No. 1 V.L.A.’ to be delivered on the written request of two of the members named on the cover of said package. Signed Wm. B. Taylor for Wm. J. Rhees, Chief Clerk Smithsonian Institution.” p. 6. See Tainter *op. cit.* p. 24-29.
- ¹⁸ See Tainter *op. cit.* p. 24-25.
- ¹⁹ See Leslie J. Newville “Development of the phonograph at Alexander Graham Bell’s Volta Laboratory” in the U.S. National Museum. *Contributions from the Museum of History and Technology, Nos. 1-11.* The Newville paper is No. 5, pages 69-79 and was also available as a separate publication. Newville utilized only the Tainter material at the museum which necessarily limited his brief account and conclusions. The paper is valuable for pictures of various pieces of apparatus and for reproductions from the Tainter *Home Notes* and drawings.
- ²⁰ See Tainter *op. cit.* p. 22-24.
- ²¹ Carbon copy of typescript of Chichester A. Bell *Experimental Notebooks maintained at the Volta Laboratory (Home Notes)*. Book VI, entry for Thursday, 4/3/85. p. 26-27 *passim*. The transcript does not reproduce the original drawings. LC in Bell Papers.
- ²² W. H. Forbes to J. J. Storrow 2/15/83 AT.
- ²³ *Ibid.* AT In a letter from J. J. Storrow to W. H. Forbes 3/19/83 the Volta Laboratory was described: “What they call the ‘Volta Laboratory Ass’n.’ consists of Mr. A. G. Bell, Dr. C. A. Bell, and Mr. Sumner Tainter. They have a small machine shop with engine and four workmen also and a good set of apparatus and tools. During the past two years they have done considerable work on telephones and on some other lines of invention. They have produced two new kinds of telephones. Dr. Bell’s shows great originality and he has struck upon an entirely new line of ideas. His apparatus is not fit for commercial purposes and as a whole I do not think it can ever

be but it exhibits such a new departure in the way of producing (and utilizing) electrical undulations that it may lead to much, and is a kind of thing the Co. ought to control. Tainter's instrument is not good now but it struck me as affording promise of a practicable instrument.

"The organization of their ass'n is such that Dr. Bell and Tainter have each drawn hitherto \$100 a month. Their actual expenses for the laboratory including that and nothing for A. G. Bell's time have been about \$10,000 since they started. Their expenses at the present time, including about \$2500 a year for Dr. Bell and the same for Tainter, are upwards of \$12,000 a year. This includes no payment for A. G. Bell's time and services." ATT.

- ²⁴ Agreement between the American Bell Telephone Company and Alexander Graham Bell, Dr. Chichester A. Bell and Sumner Tainter, 7/20/83. AT In a previous work I did not have access to the actual agreement and my account was based in part on a summary of rights *Opinion and Analysis Concerning the Legal Status of the North American Phonograph Company in Relation to the American Graphophone Company and Others, Arising Out of Contractual Relations Relating to the Phonograph and Graphophone*, 1893? (Typescript) Edison Nat. Hist. Site. See Raymond R. Wile "Introduction" to National Phonograph Association. *Proceedings of the 1890 Convention of Local Phonograph Companies.*, c1974. p. xi, xiii.
- ²⁵ A. G. Bell, C. A. Bell and C. S. Tainter to Amer. Bell Tel. Co. 10/31/84 AT.
- ²⁶ Theodore N. Vail to C. S. Tainter 11/7/84; A. G. Bell and C. S. Tainter to Theodore N. Vail 11/14/84 AT.
- ²⁷ Transcript of cylinder message of A. G. Bell to Chichester Bell and C. S. Tainter 6/14/85 Bell Papers.
- ²⁸ The patent office questioned the omnibus quality of 341,214 and at first insisted upon division. See Tainter memorandum inserted after page 83 of Tainter *op. cit.* The papers relating to the application and issuance of patent 341,214 are in Record Group 241 at the National Archives Annex in the Washington National Record Center at Suitland, Maryland.
- ²⁹ G. G. Hubbard to U. H. Painter 6/29/85. Painter Papers.
- ³⁰ E. H. Johnson to U. H. Painter 7/3/85. Painter Papers.
- ³¹ E. H. Johnson to U. H. Painter 7/27/85. Painter Papers.
- ³² Memo on back of envelope backstamped 8/5/85. Bell Papers, LC.
- ³³ Johnson to Painter 9/2/85 Painter Papers. The Edison Speaking Phonograph Company had not held annual meetings at Norwalk, Connecticut as required by Connecticut Law.
- ³⁴ Johnson to A. G. Bell 8/11/85 Bell Papers. Tainter *op.cit.* p. 73 and 74. Tainter also described the Summer construction in his testimony in *American Graphophone Co. vs. Edison Phonograph Works* . . . "Question 22. When and where were the first graphophones made, except those made in your workshop?" Answer "The first graphophones made outside of our laboratory comprised a lot of six machines which were made in August, September and October 1885 at the factory of Bergmann & Co., located at Nos. 292-298 Avenue B, New York City. Bergmann & Co. were engaged in the manufacture of fixtures and appliances for the Edison Electric Light. Mr. Edison and Mr. E. H. Johnson, so I was informed at the time, were part owners of the business of Bergmann & Co. I was also told that Mr. Edison occupied the upper floor of the building for laboratory purposes. The manufacture of these machines by Bergmann & Company was the result of an interview with Mr. E. H. Johnson, some time in the summer of 1885. The consolidation of our interest with those of the Edison Speaking Phonograph Company were under discussion and it is my recollection that Mr. Johnson thought it necessary to have a number of machines constructed before the arrangement could be consummated. He recommended the factory of Bergmann & Co. for this purpose, and I went to New York on August 17, 1885 for the purpose of designing and superintending the construction of the six machines. Work was in progress on these machines until about the middle of October 1885, when on account of the slowness with which it was proceeding, I decided to cease work at the factory of Bergmann & Co., and have them completed at our own workshop at the laboratory in Washington. One machine, however, was completed in New York in advance of the rest, and its working was exhibited to Mr. Johnson about October 3, 1885. During the progress of this work at Bergmann's workmen reported to me a number of times that Mr. Edison had been seen in the building."
- ³⁵ C. S. Tainter to A. G. Bell 9/30/85 Bell Papers.

- ³⁶ Forrest McDonald *Insull* p. 32-33 passim.
- ³⁷ Chichester Bell to A. G. Bell 10/8/85 Bell Papers. Charlie refers to Charles J. Bell.
- ³⁸ C. S. Tainter *op. cit.* pp. 73 and 74. Statement of costs 12/15/85 p. 4 Bell Papers.
- ³⁹ The details of the organization and incorporation of the Volta Graphophone Co. are found in C. S. Tainter *op. cit.* pp. 75-79. The agreements are also found in the Bell Papers. Charles J. Bell later became the President of the American Security and Trust Company of Washington. On the death of his first wife he married Mabel Bell's sister.
- ⁴⁰ C. S. Tainter *op. cit.* p. 83.
- ⁴¹ This situation was also utilized by Edison when he later organized the Edison Phonograph Company. We are not certain when the facts became apparent to the opposing Volta and Edison groups.
- ⁴² *Harper's Weekly*, 7/17/86.
- ⁴³ C. S. Tainter *op. cit.* pp. 84-87 passim, gives details of some of these developments.
- ⁴⁴ Tainter *op. cit.* pp. 93-95. James O. Clephane appears as a witness in the impeachment proceedings against Andrew Johnson. In his testimony on Friday, 4/3/68 he testified that "I am at present a deputy clerk of the Supreme Court of the District of Columbia." Q: "What was your employment on the 18th of August, 1866." A: "I was then secretary to Mr. Seward, Secretary of State." U.S. Congress. *The impeachment and trial of Andrew Johnson, President of the United States*. . . (Dover reprint) p. 87.
- ⁴⁵ Charles Sumner Tainter *op. cit.* includes the American Graphophone papers.
- ⁴⁶ *Ibid.* p. 96.
- ⁴⁷ Volta Laboratory Association. "Extracts from Minute Books" in *American Graphophone Company versus the Edison Phonograph Works* . . . [Plea] Record p. 303 ENHS.
- ⁴⁸ The similarity of names and functions even confused the R. G. Dun Mercantile Agency. See Report on the Edison Speaking Phonograph Company in the New York books. Baker Library-Harvard.
- ⁴⁹ James O. Clephane to T. A. Edison 10/5/87 ENHS.
- ⁵⁰ U. H. Painter to E. H. Johnson 10/6/87 Tissue press copy in Painter Papers.
- ⁵¹ U. H. Painter to E. H. Johnson 10/9/87 Tissue press copy in Painter Papers. The copy is poor and was made on yellow tissue. There are possibly some errors in transcription.
- ⁵² For details see Raymond R. Wile *op. cit.* p. xvii.
- ⁵³ Charles Batchelor. *Notebooks* Entry 490 10/15/87. Batchelor Papers—ENHS.
- ⁵⁴ U. H. Painter to G. G. Hubbard 10/28/87 Copy in Painter Papers.
- ⁵⁵ T. A. Edison to U. H. Painter 12/5/87. PP A preliminary draft may be found cited in Raymond R. Wile *op. cit.* p. xvi. 🌀