
ETCHING THE HUMAN VOICE: THE BERLINER INVENTION OF THE GRAMOPHONE¹

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Gramophone: a talking machine wherein a sound record is first traced into a fatty film covering a metal surface and which is then subjected to the action of an acid or etching fluid which eats the record into the metal. This record being a continuous wavy line of even depth is then rotated and not only vibrates the reproducing sound chamber but also propels the same by the hold its stylus retains in the record groove. The original record can be duplicated ad infinitum by first making an electrotyped reverse or matrix and then pressing the latter into hard rubber, celluloid or similar material which is soft when warm and quite hard when cold. Emile Berliner, 1895.

PREFACE

Among the early talking machine industry's major inventive streams, the contribution of Emile Berliner has been the most difficult adequately to document and assess. If he maintained an extensive laboratory record, it no longer exists. He was involved in extensive litigation, but this did not result in detailed depositions like those growing out of the conflicts between the promoters of the phonograph and the graphophone. Werner Suess, Berliner's assistant after late 1887, died sometime after 1898, before he could testify at any great length, and evidently left no papers.²

Even so, we are fortunate that Emile Berliner profited from earlier difficulties in which he almost lost his microphone patent because of poor work on the part of a patent solicitor. Determined to prevent a recurrence with the gramophone, he discussed much of his work with a new adviser, Joseph Lyons, an attorney and frequent visitor to the inventor's little second floor home laboratory during 1887 and early 1888. As a result, the attorney was able to provide a detailed deposition in the action of the *American Graphophone Company versus the National Gramophone Company and Frank Seaman*. This testimony provides a skeleton upon which to base an orderly chronological framework.³

ETCHING THE HUMAN VOICE

All of the inventors connected with the three major roots of the talking machine industry first had their attentions drawn to sound through work involving the early

telephone. Edison stumbled upon the conception of recording and reproducing the human voice while working to develop a non-infringing system and apparently conceived the idea while testing a telephone diaphragm; in fact, his first concept of the phonograph was as a telephone repeating device. Alexander Graham Bell's Washington, D.C. laboratory facility was at first devoted to telephonic research. Only after the ending of the Bell Company's retainer, and the award of the Volta Prize, did he turn the attention of his co-workers towards developing a practical device for reproducing recorded sound. Emile Berliner, while working as a dry-goods clerk in Washington, D.C., developed the device that became the microphone. When it was purchased by the telephone company, Berliner entered their employ as an experimenter, thereby becoming thoroughly grounded in the theories of sound.

Apparently one other common factor was present in the backgrounds of all three inventors, the phonautograph of Leon Scott de Martinville. To Scott belongs the credit of first recording sound. In 1857, he patented a device,

[with] a sound receiving funnel, which at its narrow end, was closed by a vibratory diaphragm, and to which latter a delicate style was attached in a variety of ways. In this manner sounds could be uttered before the wide opening of the funnel and would be concentrated upon the diaphragm. The latter would then vibrate sympathetically, and the style would now inscribe the movements of the diaphragm upon the . . . cylinder. . . . It would be seen from this that the phonautograph only gives a pictorial representation of sound waves. Its only use had been formerly to study sound vibrations . . . depending on the quality of the sound. . . . The reproduction of sounds from the graphical records furnished by the phonautograph does not seem to have been contemplated.⁴

While Thomas A. Edison must have been familiar with the device, or descriptions of it, Alexander Graham Bell referred to it in the course of his lectures and telephone demonstrations. Berliner, at one time, had the instructions that accompanied the machine owned by the Smithsonian Institution copied for his own use, and Joseph Lyons, Berliner's patent attorney, conducted experiments upon that very machine while he was a patent examiner.⁵

From the state of the art of recording and *reproducing* [emphasis added] sounds which preceded Mr. Berliner's efforts . . . it appears that a laterally undulating record was first suggested by [the Frenchman] Mr. [Charles] Cros [in April 1877]; that Mr. Edison in his United States Patent No. 200, 521 again suggested a laterally undulating record, and that finally Messrs. Bell & Tainter are said . . . to have spoken of such a record in their sealed paper, which they had filed in the Smithsonian Institution. This is all that preceded Mr. Berliner. [Lyons had] characterized before these suggestions of Cros, Edison and Bell & Tainter, and [he did] not hesitate in saying they contained nothing, absolutely nothing but the statement of a *problem*, with no suggestion of any practical means of solving the *problem*. Consequently Mr. Berliner, if he had been acquainted with the suggestions of these parties, could have learned nothing from them; and he [was] therefore not indebted to the prior art.⁶

In all probability, the most important early influence upon Berliner was the work of Bell and Tainter. He had severed his connections with the Telephone Company, and in 1884 had returned to Washington, D.C. with his new wife, the former Cora Adler. Therefore, he was in a position to see the graphophone when it was first unveiled in Washington, D.C. during 1886. Its inventors had been quick to publicize

their development with demonstrations and articles in *Scientific American* and *Harper's Weekly*. After his recent work on the telephone, Berliner must have been fascinated by this machine. He already had decided to pursue a full-time career as an inventor and had fixed up a small front upstairs room in his Washington, D.C. home as an experimental laboratory. It was in this location between 14th and 15th Streets on Columbia Road that he began work on the gramophone. Since the inventive process often matures slowly, it is entirely probable that the experimental work began in 1886, but Joseph Lyons did not see it until March or April of 1887.⁷

The solicitor had been called in by Berliner to witness what had been accomplished, and possibly to advise if the conception was advanced enough to have it patented. A former patent examiner who had recently established his own practice, Lyons was very much aware of U.S. Patent Office practice, and also had been drawn to the whole problem of sound, its transmission, recording, and reproduction. He was a natural complement to Berliner, who in his telephonic studies had become familiar with all that was known about the recording and transmission of the human voice. The inventor had become conscious of the relatively small amount of energy that was present in sound waves. He reasoned that sound waves "needed but very slight mechanical resistance to modify considerably the sound vibrations" if the waves were caused to indent or cut a record in a resisting material, be it tinfoil or wax. He therefore determined to develop a method that involved the least amount of mechanical resistance.

All of the experiments which were made with the phonograph and the graphophone confirmed the correctness of all these assertions; for the louder it was necessary to speak when recording, the less distinct became the articulation of the recorded sound. A change for the better was, therefore, to be obtained--*First*. By tracing the vibrations, as in the old phonautograph, parallel to the record sheet. *Second*. By reducing the resistance offered by the record medium as near to nothing as possible.⁸

Additionally, in pursuing this concept a non-infringing system would ensue.

The apparatus first shown to the attorney crudely was patterned after the phonautograph in which a sheet of lampblackened paper was attached to a drum capable of rotation. A message was shouted into a tube or horn-loaded diaphragm on which a needle was mounted so that it inscribed a series of undulatory lines upon the cylinder. After Berliner became quite proficient in the production of these lines, he detached a tube, cut it into a strip and took it to Maurice Joyce, a Washington photoengraver, who prepared a type-metal copy by means of photoengraving. A telephone receiver then was modified by sawing off the portion that held the diaphragm, and then this section had a stylus mounted across the membrane so that it was attached to the center and yet extended some distance beyond the circumference. The inventor drew this apparatus by hand along the flat piece and was able to reproduce short snatches of recorded sound with some degree of loudness. He now knew it was possible to utilize his system.⁹

Within a few weeks, an application, No. 237,060 and dated May 4, 1887, was filed with the Patent Office. The crude device marks the first halting beginnings of what became the dominant form of recording for a large portion of the twentieth century. Both a recording and a reproducing machine were shown in the document. The application represented a "non-commercial machine but it is obvious that the

purpose was to protect the conception of producing an indestructible, or practically indestructible record, which [did not have to] be handled with care and delicacy and [did] not, like the Bell and Tainter wax record, have to be preserved in a refrigerator during hot weather."¹⁰

Primitive as it was, the process represented a major breakthrough. The shouts "were very loud, very much louder than any sounds [that Lyons] had yet heard issuing from a reproducer of either an Edison Phonograph or a Bell and Tainter Graphophone. At the same time, however, harsh foreign sounds were superimposed upon the recorded sounds, and at that time Mr. Berliner ascribed the presence of these foreign disturbing sounds mainly to the fact that he had no means of moving the tablet or the stylus regularly or uniformly." Some of the harshness was corrected by substituting a bamboo stick in place of the needle that previously was utilized, although the reproduction was much softer.¹¹

Berliner had noted that,

merely smoked surfaces were utterly impracticable, because, if sufficient black for a photoengraving [were provided] and with the extremely small sizes of waves obtained with records that are adaptable for reproduction of good articulate speech, the record lines were ragged and, under a magnifying glass, looked like a set of parallel saws whose teeth would form a grating sound which nearly drowned the articulation. I observed, however, in my experiments that the greyish deposit of lampblack, which is obtained from the center of a kerosine flame, was more oily and gave a somewhat sharper line than the deep black deposit caused by smoking with the top of the flame, and this led me to the highly beneficial process of oiling the plate prior to smoking the same, either by applying printers' ink or artists' paint by means of a printers' roller or by brushing oil over it. The smoke would then amalgamate with the oil and form a *fatty ink* of a rather dry consistency, which, when crossed by a stylus, shows, even under a microscope, a sharply cut transparent line. I also adopted for the gramophone a disc of glass as a support for the smoke deposit.¹²

On May 17, 1887, he jotted on the flyleaf of one of his books, "Today I succeeded for the first time to get an articulate speech, plainly audible from a stereotype copy of a photoengraved phonautographic record." A few days, later he also noted that, "A very good phonautographic record for phonoengraving is made on a glass surface blackened over a lamp. The glass has a permanent black or silvered back and if put in reflected light will show the record in bright white lines on a clear background." On the same day, he also attempted to prepare messages on glazed pieces of china and upon pieces of glass with whitened backs. Another experiment on June 4, 1887 involved utilizing rosin dust that was consolidated after recording by applying heat or plaster of Paris set through the action of steam.¹³ Having now adopted a glass disc as a foundation for his recording medium, new problems soon were encountered. The debris created by the recording process often fouled the delicate traces, and owing to the nature of the film it proved impossible to brush away. This difficulty was not encountered when utilizing the cylinder version since the material naturally fell away through the action of gravity. The situation was avoided by redesigning the recording apparatus to make recording take place on the bottom face of the glass plate.¹⁴

During the summer of 1887, the patent application obviously began to run into trouble. While in the office of his solicitor on August 30, 1887, Berliner made a startling discovery. Lyons, like all good patent attorneys, maintained a fairly extensive library devoted to his specialties.

Mr. Berliner always had free access to the books on my book shelves and he would pick out a book here and there and glance over it, and sometimes discuss with me what he read. On that particular day he took from my book shelves a volume of a German work entitled: *Telephon Mikrophon und Radiophon* by Theodor Schwartze, published at Vienna, Budapest and Leipzig, by A. Hartleben. This volume is one of a series of a work known as the *Electrotechnical Library*; it is Vol. VI thereof. The title of this book would not suggest that it contains any reference to the art of recording and reproducing sounds. It does, however, contain such reference and Mr. Berliner discovered it and called my attention to it. On page 225 and 226 of this book, the substance of the paper of Mr. Charles Cros deposited at the French Academy is given, and when Mr. Berliner read it, he became very much excited and said that he feared that Cros anticipated him in his work on recording and reproducing sounds. The thing came to both of us like a thunderbolt from a clear sky, since neither of us ever had the remotest idea that anybody besides Mr. Berliner had ever entertained the idea of recording sounds by etching.¹⁵

On November 18, 1887, Berliner suffered another blow. He had applied for an additional patent on November 7, 1887, and he was now informed that his application was being placed in interference with one by John H. White, who in his specifications showed a laterally undulating record cut into wax. On March 30, 1888, Berliner and his attorney hit upon a device for obtaining a ruling concerning the Cros matter.

Mr. Berliner . . . said that if Cros anticipated him he wanted a judicial decision upon the question and directed me to test this question on a motion for dissolution of the interference with White. [On March 31, the motion for dissolution was filed.] . . .

The Patent Office rendered its decision and in the same the Examiner said as follows: ". . . With the view I take of the testimony I must hold that the publication in the *Comptes Rendus* does not disclose the invention in issue.

Even if it did, it can be made to appear only as an abandoned experiment assuming that it ever reached the stage of experiment. . . . There is nothing to show that he ever reproduced sound by his process. His description seems to have produced no sensation among the savants of the Academy. He never followed it up, and it was abandoned and dead and forgotten, and cannot now be galvanized into life and importance it never possessed to defeat the claims of men who had in good faith made the invention, reduced it to practical form, and given the benefit of it to the public."

By this decision of the Patent Office both Mr. Berliner and myself had our fears of anticipation by Cros removed. . . .¹⁶

Anxious to protect his original conception, Berliner had decided to divide his May 4, 1887 application, reapplying for at least one portion on September 26, 1887. This met no opposition and letters patent were granted on November 8, 1887.¹⁷ It is ironic that the processes of the newly issued patent were already out of date. A much clearer view of his progress may be seen in the British patent applied for on November 8, 1887. This patent, Series 1888, No. 15232, shows the matter contained in the American Patent 372,786 and additional material that appeared in the American application of November 7, 1887. The American version was delayed and a patent was not issued until July 28, 1896, when a modified specification was accepted, the major changes occurring in the claims. The British patent and the American application show that Berliner had changed greatly his conception and techniques. Rather than remaining wedded to photoengraving techniques, he proposed to obtain his results more directly. The recording first was traced onto the usual

lampblackened disc of glass which then was placed in contact with a similar disc coated with bichromated albumen, a light sensitive substance. By exposing it to actine light, a negative was created. This was washed in running water causing the unexposed albumen to wash away and the remaining material to swell. The resultant raised groove could be used to press a sealing wax copy or produce a plaster of Paris casting. Another variation of this process was essayed in which a negative of the glass disc was prepared. The negative then was exposed against a bichromated albumen coated disc which could be of glass, copper, zinc or other material that would be suitable for etching. The washing of this disc would result in the original recording lines being clear lines showing against the glass or metal surface. Next the disc was etched with an appropriate acid, hydrofluoric for the glass and nitric for the metal. A zinc disc made at about this time was introduced into a court case in 1914, *American Graphophone Company versus Gimbel Brothers*, and carried a date of October 25, 1887 at the center. It probably represented the earliest surviving Berliner disc record. It was presented to RCA by Joseph Sanders.¹⁸

With the granting of his first patent, Berliner had immediately set about publicizing his invention. He apparently had made contacts at the office of *Electrical World* during his telephone days, and probably approached them about doing a story concerning his gramophone. As a result, the first known story appears as a two page article in the issue for November 12, 1887. The account closely describes Berliner's work up to November, 1887, and illustrates a recording machine which formed the basis for his November 7, 1887 patent application. The apparatus was a weight driven affair in which the rate of descent was regulated by varying the amount of shot or metal in the weight box and smoothed by a paddle-wheeled governor. Recording was achieved on the underside of an 11-inch diameter glass disc which could contain a message of about four minutes duration. Berliner hoped it could be extended to six or eight minutes. We do not know the recording speed used, but in May 1888, it was 30 revolutions per minute. The article hopefully noted,

Mr. Berliner believes that it is more than likely that the gramophone is destined to fulfill many of the expectations which were placed 10 years ago on the phonograph, and which are partially realized by the graphophone. . . . The speaking phonautograms are practically indestructible, and Mr. Berliner has used one over a thousand times without altering its character in the least. . . . As the art progresses the same will be simplified and become more refined, and within a few years we may have our choice of phonautograms recorded by popular orators, writers, singers, actors, etc. . . . For even at this early stage in the art of gramphony a recognition of the voice is unmistakable and the only practical problems now are to produce an even and regular motion and to find the most suitable material in which to mold the reproducing plate.¹⁹

As yet no regular method of reproduction existed although several were suggested in the *Electrical World* article. Berliner apparently was toying with the idea of utilizing a reproducer which would move across the disc while being supported by an overhead track. He was not completely happy with this method, although it did form one of the claims in his application of November 7, 1887. He may have been concerned that such a feed might make his ultimate conception subject to attack as an infringement by the graphophone group.

The pace of the gramophone's development now began to speed up. As a sign of his increasing concerns, Berliner met on Thanksgiving Day with Joseph Lyons, John W. Osborne, the inventor of a photolithographic process, and Werner Suess, an "experimenter and model maker" who had in the past been associated with Rudolph Bunsen. He hoped to obtain valuable advice from all three towards developing his conception.²⁰ And he now decided to indulge himself in the luxury of asking Werner Suess to join him as his mechanical assistant. Suess had earlier assisted in the construction of one of two induction coils that had been used in Berliner's telephone experiments. "He was older than Berliner--a quaint, stocky, sturdy, ruddy-faced, bespectacled German and had been a close student of Berliner's work during the intervening years. Suess, though only a mechanic, was full of intelligent interest and enthusiasm. He was also addicted to telling stories and the little Berliner laboratory was not exclusively an area of scientific discussion."²¹

In January, Professor Houston of the Franklin Institute prepared an article for its *Journal* in which he elaborated upon the previous *Electrical World* account, and upon the details of the issued patent. On the basis of this, an invitation soon ensued in which the inventor was asked to provide both a paper and a demonstration to illustrate his new methods. Although this was a great honor, Berliner begged for a postponement. Other inventions were occupying him, and he recently had formed the Berliner Radiating Mantel Company to exploit one of his other developments. The Company was demanding much of his attention and the gramophone was as yet not in a condition to warrant further publicity. He was relying for the most part on the technique of recording on lampblackened glass, but mentioned that it was now possible, by utilizing one of the processes of the Linotype Company of Washington, D.C. to develop a musical plate capable of reproduction. He complained that "If I had at my command an efficient experimenter I could make better headway. As it is, work is comparatively slow but in 2 months I may have something to show."²² Dr. Wahl, of the Institute, suggested the May 16, 1888 meeting as a forum for Berliner and attempted to arrange matters so that the inventor could then continue on to New York where he might speak before the Society of Electrical Engineers. If such a date were not suitable it might be possible to arrange a special meeting. It was at this time (early 1888) that the experimental laboratory was moved out of the Berliner home and into new quarters on the second floor of a building on G street between 7th and 8th Streets opposite the Patent Office.²³

Joseph Lyons testified that it was probably in February 1888 that the use of glass was abandoned and etching was attempted directly on the zinc plates. Berliner evidently realized that the former process was unduly cumbersome and that "the lesson of simplicity which the telephone was continuously preaching caused [Berliner] at an early day to look for a simpler plan to attain his purpose." For in order to record directly the etching ground would have to continue to provide little resistance mechanically yet resist the etching fluid. He was able to develop such a material by dissolving one ounce of finely scraped pure yellow beeswax in one pint of cold gasoline or benzene. In a cold state not all of the elements of the wax were dissolved, only the small part which had combined with the yellow coloring. The resulting decanted extract was a clear golden-hued solution which gradually bleached in the presence of light. He took a highly polished plate, generally of zinc, and flowed the mixture on and off until the entire surface was covered with a thin layer of wax which was iridescent under reflected light. Sometimes two applications were neces-

sary. The procedure resulted in a coating that was porous and extremely sensitive to the lightest touch and yet resistant to the etching fluid after the recording traces had been inscribed.²⁴

The ease of preparation using this new method was astonishing compared with the laborious methods that he previously had employed, but it soon was discovered that his etching solution produced grooves of uneven depth. He had taken a few steps forward but also had retreated at least one. Reasoning that the cause was hydrogen bubbles that accumulated during the etching with the nitric acid, he decided that perhaps a different etching fluid would correct the situation. Chromic acid had been used in a variety of ways in electric batteries as a depolarizer. Perhaps it would destroy the bubbles. He mixed bichromate of soda with the acid, but after obtaining somewhat better results discovered that the mixture seemed to dissolve some of the elements of his spongy wax covering causing the etching fluid to attack the area between the grooves. Pure chromic acid then was tried in a diluted form, and while an improvement was apparent, again the results were not perfect. Berliner finally hit upon the idea of utilizing battery fluid, a mixture of sulphuric acid and bichromate of potash. As long as this solution was freshly made, the results were fairly predictable. But if the solution were allowed to stand for a short time, long enough for some of the materials to precipitate out, problems occurred. By substituting bichromate of soda for bichromate of potash, the difficulties with the etching ended since bichromate of soda did not crystallize out. "In this manner Mr. Berliner made a great number of zinc record plates, and some of them were excellent, while others displayed peculiar defects, for the appearance of which no theory seemed to give an adequate solution. . . ."²⁵

By now, he must have been working frantically. His process was improving rapidly, but an increasing amount of publicity emanated from the Edison laboratories concerning new phonograph developments. And despite the progress he made, more new obstacles arose. He now discovered that the etching solution often seemed to create two or three phantom grooves very close to the major groove. Even though there was a primary groove, the reproducing needle often tracked these ghostly lines and reproduction became uncertain and erratic. The inventor now theorized that the fault lie not in the recording stylus, but in foreign bodies accompanying the needle which created the supplementary grooves--probably dust and minute particles of wax that accumulated at the point of the stylus. In his first attempt to correct the situation, he merely humidified the air in the hope that this would hold down the dust and fiber particles. This resulted in some improvement, but the difficulty would mysteriously reappear. "Finally the idea occurred to Mr. Berliner that if he protected his waxy film against the access of air, he would get rid of the floating particles, and he discussed . . . in a bitter, though humorous fashion, the absurdity of being called to record sound waves in a vacuum."²⁶

As a solution, he applied to the record surface a fluid that slightly adhered to the etching ground, keeping it wet while the recording was being made. Regular commercial alcohol poured over the plate just before the record was made did not evaporate rapidly enough to allow problems by the end of the recording groove. He theorized that the alcohol lubricated both the stylus and the record surface thus preventing the adhesion of filaments of dust and recording debris.²⁷

This solution occurred none too soon since the inventor had his heart set upon lecturing before the Franklin Institute on May 16, 1888. His anxiety about Edison's

improvements to his phonograph caused Berliner to inquire of Edison, "Will you kindly inform me whether the special meeting for the Edison Phonograph has been called and for what date. Please telegraph answer on receipt of this."²⁸ Now he could draw a breath since his new reproducing machine had been completed at the beginning of May.²⁹

The reason for Berliner's concern with an Edison presentation quickly became apparent. He wanted to begin his account with a long historical outline in which he could give due recognition to Charles Cros among others. An Edison presentation would take some of the wind out of his sails since the historical section might then become redundant. On May 7, he apparently was so sure that he would not be anticipated by Edison that he sent the copy of his prepared address to be printed for distribution prior to or at the meeting. He suggested two possible titles: "The Gramophone," or "Etching the Human Voice." If the latter title were to be used, the inventor requested that the paper not be distributed prior to May 14. He mentioned that he would send a few drawings to be converted for slide projection, and requested that several individuals in particular be invited to attend the presentation. Many of these invited guests became important later, either as allies or as antagonists. The delivery time was estimated at no less than one hour and fifteen minutes. He also "expected to have a baritone singer there who will during the evening sing into the Phone and it will be reproduced at the end of the paper. . . . I expect to arrive with the apparatus the 14th noon and Mr. W. Suess, my mechanician will assist me. By the way, my name spells Emile--not Emil as Prof. Houston has it. I always thought it looked better."³⁰

On May 10, 1888, Berliner gave a slight clue to his excitement. "Did I write I was coming Monday [the fourteenth]? I meant Tuesday!" The evening of the address must have been quite festive. Three hundred and ninety nine persons attended, which seems a substantial number for a scientific meeting. Of that total, 348 were members of the Institute and the remainder guests. Professor Houston, Berliner's advocate, called for the suspension of the business portion of the meeting in order to devote the entire evening to the new invention.

The speaker illustrated his subject with the aid of the lantern and by the demonstration of the apparatus in operation. He demonstrated its capabilities by recording on a prepared zinc plate several songs and spoken sentences and words, etching the plate and reproducing the songs and words then and there. Several etched record plates that had been prepared previous to the meeting were shown and the reproducing apparatus faithfully emitted the songs and spoken words recorded upon them. The reproduction was loud enough to be distinctly audible all over the lecture room. The music could be recognized easily; while speech, though not so clearly rendered, was for the most part intelligible.³¹

The reproduction was accomplished by using a recently developed machine. The original conception described in the *Electrical World* article had consisted of a reproducer mounted on an overhead slide in which the groove guided its mechanical action. Werner Suess recently had suggested that the reproducer be mounted on a pivoted arm so that the assembly traced an arc as the record played. The recording and reproducing speed was quite slow--thirty revolutions per minute. A crude prototype was rushed to completion and shown to the audience.³²

Berliner noted that,

In reproducing the sound I find it is louder with hard contact substances, like metal, than with soft ones, like rubber or plaster of Paris. Hard metals, like copper, nickel, or brass, sound louder than zinc or type metal, but the scraping sound, which is due to friction, is also increased unless the record surface is smooth and very highly polished. But when an iridium pointed stylus is rubbed over clean glass a scraping sound is barely perceptible. I am now in communication with a firm that is making ornamental glass tiles by impressing upon red hot glass plates fancy designs in relief or intaglio by strong pressure. You will readily see that if on the same plan we can impress a matrix showing the sound record in raised lines upon a glass plate we would get a groove in glass giving a loud reproduction with a minimum of disturbing sound due to friction.³³

He also was able to show a fairly good duplicate of one of his etched records. This had been made by pressing the original in wax and by then depositing copper on the wax mold as was done in electrotyping. It then could be used to make a copy.³⁴

He must have been particularly conscious of the surface noise as the records prepared in Washington, D.C. were played for the assembled guests. While the reproduction might be acceptable as representing a developing technique, it would not be later when the invention became a commercial proposition.

The selections had been chosen with a great deal of cunning to show the potential of the system. They were as follows:

1. Yankee doodle, Baby mine, Nancy Lee, O du lieber Augustein (E[mile] B[erliner])
2. Cornet--G[?] Samuels
3. Tars farewell (P[hilip] Mauro)
4. Home sweet Home, [Annie] Laurie Mrs Tone [?]
5. A wandering minstrel I (E[mile] B[erliner]) Pity O Saviour, Declaration of Independence, Counting.³⁵

Although the evening at the Franklin Institute was an emphatic success, old technical problems continued to haunt the inventor. The use of alcohol had solved many of his problems, but the obstacle of uneven groove depth began to manifest itself again. The etching fluid obviously was biting properly and the resultant etched grooves certainly were bright, but the shallower ones showed no other discernible abnormality other than the shallowness. Since it was not a problem of gas bubbles, Berliner reasoned that the alcohol must be dissolving a minute quantity of the wax etching ground causing it to interfere with the recording trace. He solved the problem by dripping the alcohol onto the section being recorded and abandoned the system of completely covering the disc with alcohol before recording. Even more important, he developed the habit of washing the newly recorded disc under a stream of water after recording. "As soon as he had done this, he obtained an excellent etching of even depth, and he had removed every trouble, every difficulty that he had to contend with."³⁶

A few other modifications occurred immediately after the lecture as reported in a letter to Dr. Wahl on June 1, 1888.

If I had my audience of May 16 again I should be able to make good my word of promise that the gramophone would be practically finished within a month or so.

You would hardly recognize the results. The reproduction is (a few feet away) *perfectly clear of other sounds* which used to disturb. Articulation is perfect and loudness unimpaired! The change has been brought about about 1st [sic] by increasing the velocity from 30 to 60 times a minute (revolutions) 2nd [sic] by using a funnel whose fundamental tone is below the average human voice Voices are readily recognized without previous knowledge.³⁷

Frederic Wile probably was referring to this period when he recounted the following Berliner traditions:

One day a couple of Spaniards arrived with an introduction from a mutual friend. They wanted to see the gramophone in action. Berliner had just made an exceptionally good record of a coloratura soprano, and he played it for his temperamental callers, placing them directly in front of the horn. One of them, a black eyed, fiery South American, became very excited, as the amorous tones of the invisible prima donna emerged from a mysterious somewhere. When the singer finished, on a beautiful high trill, the Spaniard, all enraptured, turned to Berliner and enthusiastically exclaimed: "Oh, I could just kees her!"

Once Berliner's father-in-law waited outside of the laboratory because he heard the inventor speaking as if engaged in making a record. When the monologue was finished, Mr. Adler walked in, and, to his surprise, found that Berliner had not spoken at all, but was merely playing a record of his own voice. Experiences like this convinced Berliner that he was on the high road to practical results with the gramophone.³⁸

It remained necessary to develop an inexpensive method for preparing duplicate records in a hard, wear-resistant material. The disc to matrix process was not completely worked out, but Berliner contacted J. W. Hyatt, one of the inventors of celluloid, to determine if it were possible to produce duplicate copies. Hyatt replied on August 23, 1888. "I sent you three samples celluloid disc by Adams Ex., the counterpart of the zinc disc sent by you. I have kept the zinc disc thinking you might require other impressions."³⁹

Berliner must have been quite pleased with the results, but the copies from the zinc discs were in all probability negative copies and would not be salable in the eventuality of marketing his invention. Further inquiry elicited the following from Hyatt on August 25.

We can make an exact duplicate of your zinc plate by the same method we use in stereotyping on celluloid--namely--a papier maché matrix taken from the zinc. I will have it tried for you--Perhaps a metal backing would be the best--say perforated iron or brass. What is your preference. The cost I can not estimate at present--wait till we see the *best* way. If very thick celluloid is used there might be shrinkage or warping.⁴⁰

After some delay Hyatt tried the experiment and reported on September 17, 1888. "The matrix however is completed and today some impressions will be made and then we can ascertain whether the matrix made in this way will answer or whether some metallic matrix would be necessary. . . . Will let you know tomorrow the result of the trial and will send you samples."⁴¹

The attempt to make copies in celluloid echoed the somewhat earlier experiments in 1887 when copies were made in sealing wax and in plaster of Paris while Berliner was involved in his bichromated albumen experiments. Celluloid seemed to

be an ideal substance, and in fact was utilized to make some of the first Berliner discs in Germany. However, it eventually was found that although extremely smooth, celluloid was not hard enough to stand the wear created by heavy reproducing arms. The first of these celluloid discs produced by Hyatt is in the possession of the National Museum of History and Technology.⁴²

At a later time, the inventor mentioned that the celluloid had to be of well-seasoned material and pressed hard. However, in the Franklin Institute lecture he had envisioned other methods of creating duplicates. One involved preparing printing plates, printing copies on translucent paper, and then utilizing the paper to prepare a photoengraved copy. In this manner a message could be extensively distributed. Another method involved having one gramophone talk to another by coupling a recorder to a reproducer through a tube and turning both machines simultaneously.⁴³

In August, he was so confident of success that he decided to again use the columns of the *Electrical World* to publicize his improvements. Two of the associate editors, T. Commerford Martin and Joseph W. Wetzler, were among a group of invited guests who visited Berliner's rooms at the Union Square Hotel in the week prior to August 18, 1888. The group was invited to the bedroom where the process again was demonstrated, and a newly constructed machine upon which to play the resulting records was shown. Apparently, the two editors were quite impressed. "Considering the short time that has elapsed since Mr. Berliner commenced this most interesting original study, there is no doubt that the next month or two will see the achievement of the most perfect results."

A comparison of the newly improved gramophone with that of the Franklin Institute lecture clearly showed the rapid progress of the invention. The machine, it is true, was hand driven, but it was envisioned that it would eventually be possible to harness some mode of power to propel it. One of Berliner's ideas was abandoned by later workers in recording and consequently caused innumerable problems for collectors and sound archivists.

Every disc or "phonautogram," as Mr. Berliner calls it, has engraved at its centre the name of the piece which it reproduces, and also the number 40, 50 or 60. This indicates that the recorder moved at a velocity of 50 revolutions a minute, so that whenever a disc may be used for reproduction people will know at what velocity to revolve the disc in order to obtain an accurate reproduction of pitch and quality."

In view of later patent contests the most important statement in the article concerned the fact that the grooves of the record fed the reproducer across its surface.

As is shown in the accompanying engraving there is no gear or machinery of any kind except a small friction wheel which revolves the table having clamped down upon it the reproducing disc. The reproducing stylus connected to the diaphragm is permitted to rest by its own gravity in the reproducing groove of the record, and when the plate is made to revolve it not only vibrates the diaphragm and reproduces the sound but it also leads the diaphragm box across the disc from periphery to center so that the record groove serves at the same time as a screw instead of a separate gear⁴⁴

Berliner kept hard at work attempting to develop a method of preparing inexpensive yet faithful copies of his discs. The ever friendly *Electrical World* in a small account of his progress on December 1, 1888 mentioned that electrotyping was not

meeting his needs since the copies were expensive and did not have enough durability while copper plates did not have sufficient strength. Experiments again were conducted in preparing copies by stamping the impression into softened glass or porcelain and the inventor had strong hopes of success. With some truth the writer of the article noted: "It was in that shop that [Berliner] forged that steadfast little anchor of the telephone craft, the transmitter inductorium, and at the same time, got just a little ahead of Edison, an eccentricity that he has occasionally indulged in ever since."⁴⁵ Berliner later reported that the copper matrix used in the glass experiments stuck to the softened glass and warped the copy. He was assured that the difficulty would be corrected should he supply a steel matrix. In a flight of fancy he envisioned somewhat later that, "We may then have dinner sets, the desert-plates of which have gramophone records pressed in them, and which will furnish the after-dinner entertainment when the repast is over. Gramophone plaques with the voices of eminent people will adorn our parlors and libraries."⁴⁶

In mid-1889, he experimented with the substance that was to provide the pressing medium for much of the early Berliner record production. He contacted the India Rubber Comb Company of New York and arranged to have copies pressed by them. On July 10, 1889 he received a report of partial success.

We send you this day two plate records from the Electrotype you sent us, and we enclose our bill for same; our charge includes some expenses we had for making special fixtures for the work. There is a want of clearness in the Electrotype especially in the letters and a portion of the steel facing seems to have come off.⁴⁷

Later, in 1895, Berliner described the procedure used at the time of this experiment. He had prepared a negative by depositing a copper shell on an electrotype copy. The negative was covered "with electrolytic iron, or steel-faced, as it [was] called, and turned over to a rubber manufacturer, who, by means of this mold made some hard rubber copies by vulcanizing rubber discs pressed in this negative."⁴⁸

Work continued on preparing a more sophisticated version of the gramophone and in reducing all of the recorder improvements to practice. In these efforts Werner Suess proved invaluable. Even though he was operating under Berliner's direction, Suess was allowed to apply for a patent on a gramophone reproducing apparatus. Much of the construction seems to be similar to that of the machine exhibited before the *Electrical World* editors in the summer of the previous year but there are added refinements such as an adjustable weight for regulating the pressure of the tone arm on the record. During the same period, Suess prepared linens for producing blueprints detailing the construction of a recording apparatus that formed the subject matter of a much later patent. From the efforts being made in developing recording and reproducing machines and the duplication experiments it would seem that the whole system was soon to be launched on the American market. Two flyers, one dated December 1888 and the other undated seem to bear this out: "Every detail of the process is now so perfected that as soon as standard machines have been designed an immediate market can be found for them."⁴⁹

Now work was hurried since Berliner planned an extended stay in Europe to exhibit "his gramophone to scientific societies and introduce it for practical use." Until the November 7th, 1887 American patent application emerged as fully protected from the Patent Office, an American exploitation was impossible and he could safely

leave the country. There had been no difficulty in obtaining British and German patent protection, and marketing now could take place in both countries.⁵⁰

He departed as August waned and received an enthusiastic welcome in Germany. His immediate concern focused on giving his invention the type of respectability that the cachet of the Franklin Institute lecture had provided in the United States. A similar recognition by a German scientific society was imperative. His campaign began with an address to the local society in Hanover, where he was well received. Soon afterwards, he was invited to display and elucidate his gramophonic system for the staff of examiners of the Imperial Patent Office in Berlin. The exhibition was repeated at the request of the Commissioner for a group of government engineers and scientists. Among these guests was the pianist and conductor Hans Van Bülow, whose wife was the daughter of the Commissioner.⁵¹

He soon was asked to attend a regular meeting of the Electro-Technical Society where, on November 26, 1889, an Edison phonograph was being demonstrated. Berliner also was invited to show his machine. In the inevitable comparisons, his gramophone seems to have triumphed. A few months later, this judgement was noted in Dunlap's Cable News Service, and was seized upon by the *New York World* and used as a space filler on February 5, 1890. Further details were elaborated upon in an editorial the next day.⁵²

Other highlights of his German sojourn included a visit by, and a demonstration for, the celebrated scientist Von Helmholtz on January 8, 1890. The rooms were jammed when the soirée took place. With all this activity, it would be a short time before some form of gramophone would be marketed in Germany. Since additional details had to be ironed out in the manufacture of the records, Berliner was given laboratory space in the Telephone Works owned by his relatives. Even more important, he was able to contact Louis A. Rosenthal, who then carried on duplicating experiments for him. It is possible that Rosenthal also assisted in making some business contacts in the toy gramophone matter.⁵³

Unfortunately all of the Rosenthal papers were lost in the Nazi terror, and unless additional documentary sources are unearthed his role will remain shadowy. The few documents still available give a tantalizing indication of his importance.⁵⁴

On November 30, 1889 Rosenthal wrote:

The next project will be to correct the existing defects of the gramophone which I will either cure or minimize.

In making the first attempt we should utilize copper plates brought up on galvanic (or galvanic Copper plates). On Monday I'll send a bottle of Kupferäetze (Acetate of Copper)--which you should use mixed half and half with Chromesäure (Chromic Acid).

Meanwhile the experiment with duplicating and enlarging the plate that you will supply will be conducted.

A Reflectant here offers from *M.* 400 to 500 for a complete apparatus for recording and reproducing, if he could have it soon.⁵⁵

On February 6th, 1890 Rosenthal reported:

For duplicating a large number of discs I have thought of a simple arrangement which Mr. Hasslackers assures me will work out and is patentable.

You could make about 400 or 500 plates with this system that would be hardly distinguishable from the original.⁵⁶

Rosenthal also cut lateral records into solid metal by means of a diamond cutting stylus and there was an attempt to organize a syndicate to market his ideas in England. He remains an important but indistinct figure in the industry whose influence is still to be firmly established.⁵⁷

Berliner later stated that,

The problem [of preparing matrices] was turned over to a prominent electrotyping firm there [could Rosenthal have been connected with it?], who succeeded, after a number of failures, in producing most accurate copper matrices by a direct deposition on zinc plates. Their method consists of covering the zinc with electrolytic brass; this is silvered and a copper shell is then deposited thereon, in a common sulphate of copper bath. It is at best an exceedingly delicate piece of work, because of all electrolytic solution the compounds of copper and zinc salts are the most fickle, and the judgement of the operator is continuously taxed to adapt his manipulation to the changing condition of the bath.⁵⁸

It was in Germany that the first commercial beginnings of the gramophone occurred—presumably in July 1890. The toy makers Kämmer and Reinhardt in Waltershausen (Thuringia) began to market small hand-propelled gramophones and a talking-doll. For the doll, a small 8 centimeter (just over 3") disc was prepared, and for the regular machine a 12.5 centimeter (just under 5") disc. The records were available in three substances during the period they were marketed. Without adequate documentation it is impossible to determine if the copies made in hard rubber or celluloid were contemporaneous, or which substances had precedence. For an additional price, zinc discs also were available. The records were produced by two companies, one known solely by the initials GFKC, the other the Rhenische Gummi und Celluloid Fabrik Werkes of Necharan, Mannheim. The machines and records also were imported into England, notably by J. Lewis Young, but were available for only a few years in both countries.⁵⁹

Late in 1890, after a year's stay, Berliner returned to the United States. He had successfully demonstrated that it was possible to manufacture and sell quantities of the little gramophones and their records. With this achievement, he obviously felt that he could now obtain financing for a venture in the United States, even though his key patent had not as yet emerged from the Patent Office. The first move to resume his publicity campaign was to arrange an address to the American Institute of Electrical Engineers. The address on December 16, 1890, besides revealing little that had not already appeared in previous articles for the Franklin Institute and in the *Electrical World*, repeated the woodcuts of an account in the *Scientific American*.⁶⁰

He continued his experiments in preparing matrices and stampers, and another witness to these activities now emerges. Berliner's young nephew, Joseph Sanders, began to stop off at the laboratory on his way home from school and soon was working in the afternoon as a general handyman and factotum.⁶¹

Berliner believed he had completed the major developmental work on his invention. The work had been hard and continuous, and he later remarked on the many pitfalls that might beset the unwary experimenter in gramophony. His invention definitely was ready for commercial exploitation provided a more certain means of rotating the discs could be devised. A hand-propelled machine had been the heart of his system since 1888, but efforts now proceeded to develop a clock-work or a spring-

powered machine. In 1891, a New York clock maker produced such an instrument. It was quite fancy but the noise of the mechanism and its weaknesses precluded its commercial use. The motor had provided enough power to handle not only the rotation of the discs, but also the drag of the reproducing arm. It is possible, although no firm evidence exists, that the early reliance on smaller-sized records was an attempt to compensate for the drag and the relative weakness of the springs involved. It is known that the earlier discs were prepared in sizes ranging from 5 inches up to 11 inches. At the same time, experiments also sought to prepare a small electric motor that could be hooked up to a string-powered machine so that it could be used as either a hand or motor driven instrument.⁶²

Joseph Sanders later remarked that the goal of the effort was not necessarily to produce a cheap machine—it was felt that the major eventual income would be derived from the sale of recordings.⁶³ But before such an ideal situation could occur, fears of possible patent infringement among any potential investors would have to be allayed.

The major patent contests were yet to come, but Berliner himself was kept quite busy assisting the telephone company in protecting his microphone patent. If an organization as powerful as the telephone company should have difficulties, it was only logical that the same problems might occur for a relatively weak gramophone organization. Thus, the inventor quite appropriately approached one of the Washington firms that handled patents and applications for the telephone company and asked it to deliver an opinion. Pollock and Mauro was also the firm that had handled the graphophone patents and would handle a large proportion of the litigation of the American Graphophone Company under the direction of Edward D. Easton, later its chief counsel and president.

The firm delighted Berliner with their findings, for they reassured him that the system was indeed unique and did not infringe upon either the graphophone or the phonograph.

It is beyond all dispute that in its essential and distinguishing principles of operation, the gramophone system is substantially different from the phonograph and graphophone We have not found in your instruments and method of procedure and detail, device or operative step, anything which could be properly said to infringe upon any unexpired patent.

We therefore conclude that you can lawfully make and use the gramophone in its present form

In our opinion the patents aptly describe the invention and are adequate to secure and protect it.⁶⁴

As a result, the American Gramophone Company was incorporated in New Jersey to promote the “perfected” invention.⁶⁵ Backed by a group of New York businessmen with other more pressing business matters, Berliner later complained that there was a want of push, and that, as a result, his system did not receive enough attention. The backers may have been exercising extreme caution, feeling that in a period of business and talking-machine uncertainties additional patents would have to be issued.⁶⁶ A coin-operated gramophone was developed and it was probably at this time that details were completed for the preparation of the disc to master the stamper process. Max Levy of Philadelphia later was credited with some of the success of this development.⁶⁷ The actual pressing details were eventually

worked out with a hard-rubber firm in the Midwest.⁶⁸

It was to take another company, the United States Gramophone Company, to launch the gramophone towards its rendezvous with history in 1894. Nevertheless, Berliner already had envisioned the role of his invention when he rhapsodized in a flight of fancy at the Franklin Institute lecture of 1888.

Prominent singers, speakers, or performers, may derive an income from royalties on the sale of their phonautograms, and valuable plates may be printed and registered to protect against unauthorized publication.

Collections of phonautograms may become very valuable, and whole evenings will be spent at home going through a long list of interesting performances. Who will deny the beneficial influence which civilization will experience when the voices of dear relatives and friends long ago departed, the utterances of the great men and women who lived centuries before, the radiant songs of Patti, Campanini, Nieman, and others, the dramatic voices of Booth, Irwin, and Bernhardt, and the humor of Whitcomb Riley can be heard and reheard in every well-furnished parlor?

Future generations will be able to condense within the space of twenty minutes a tone poem of a single lifetime. Five minutes of the child's prattle, five of the boy's exultation, five of the man's reflections, and five of the feeble utterances from the death-bed. Will it not be like holding communion even with immortality?⁶⁹

NOTES

- ¹ I must gratefully acknowledge the kindness of Robert Sanders and other members of the Berliner family for allowing me access to their Berliner materials. A portion of my research was funded by grants from the New Jersey Historical Commission, the Faculty Research Award Program of City University (FRAP 11042 and the Board of Education/Professional Staff Congress Program BHE/PSC 12061).
- ² It is possible that much of the Berliner documentary material perished in a fire that destroyed the building that also housed the powerhouse of the Capitol Traction Company in 1897. Both Emile Berliner and Charles Sumner Tainter, the inventor of the graphophone, maintained laboratories there. Tainter was fortunate in that ten of his *Home [Experimental] Notes* volumes were in Court custody in conjunction with the suit of the *American Graphophone Co. versus the United States Phonograph Company* . . . so that only three volumes were destroyed. Joseph Sanders, in another suit, specifically mentioned Berliner experimental discs being destroyed in the fire.
- ³ *American Graphophone Co. versus the National Gramophone Co. and Frank Seaman*. (U.S. Circuit Court. Southern District of New York. In Equity no. 7063) NARC-FRC-Bayonne for Preliminary Injunction Appeal Record (U.S. Second Circuit Court of Appeals); NARC-Bayonne for remainder of case. In most instances, I rely on Berliner's accounts but utilize J. Lyon's sequential framework through early 1888.
- ⁴ Testimony of Joseph Lyons, Dec. 26, 1899, in *ibid.*, pp. 10-11 passim. Proofs for final hearing. (Typescript, NARC-Bayonne.) The case was settled by consent in 1903 before the final hearing occurred. The author was the first person to open the sealed envelope containing the Lyons testimony.
- ⁵ One of the Edison Ledger accounts in 1878 was headed Phonautograph. Edison Ledger No. 1, ENHS. The Ledgers for previous years no longer exist. See also my "Development of Sound Recording at the Volta Laboratory" (to appear in the *ARSC Journal*) for details of Alexander Graham Bell and the phonautograph. Berliner at one time had the Smithsonian's phonautograph instructions copied. They are found in a scrapbook that Berliner once kept. BP-LC. See also Joseph Lyons, *loc. cit.*, p. 10, Answer to question 2 for details of his using the Phonautograph in experimenting.
- ⁶ *Ibid.*, p. 128. See also Raymond Wile, *ibid.*, for a portion of the text of the sealed paper of Bell and Tainter.

- ⁷ An article concerning Emile Berliner that appeared in the *American Inventor*, July 1, 1900, p. 4. places the first work in 1885, but I am inclined to doubt this. I place the first work sometime in 1886 since the apparatus that Lyons saw was still too crude to have been the work of over a year's worth of experimenting. See also Frederic Wile, *Emile Berliner*, p. 185 for additional details.
- ⁸ Emile Berliner. *The Gramophone* (1894 reprint.) p. 10 passim.
- ⁹ J. Lyons, *loc. cit.* p. 103; Frederic Wile, *op. cit.* p. 189. Joseph Sanders also mentioned the Maurice Joyce Company being used to prepare photoengravings in the 1890s. See Joseph Sanders to B. L. Aldridge, May 27, 1953. Sanders Papers. Maurice Joyce had other connections with the talking machine industry, and later took out a patent on a method of preparing cylinder molds and casting wax cylinders. It was purchased by the Edison group and used in litigation against the Lambert Company, and also against the American Graphophone Company.
- ¹⁰ J. Lyons, *loc. cit.*, p. 104 passim.
- ¹¹ *Ibid.*, p. 105.
- ¹² E. Berliner, *op. cit.*, pp. 10-11.
- ¹³ *Ibid.*, p. 11. Notes inscribed on flyleaf of Berliner's personal copy of Johann Muller, *Grundriss der Physik und Meteorologie*, dated May 17, 1887; May 19, 1887; June 4, 1887. Berliner Papers, Library of Congress. It is obvious that Mr. Berliner forgot that he made the notes since in later court testimony he was unable to supply exact details, and usually reported June as the month in which the break-through occurred.
- ¹⁴ J. Lyons, *loc. cit.* p. 109.
- ¹⁵ Joseph Lyons. "Proofs in Rebuttal," 4/01/01 in *loc. cit.*, p. 3; *Electrical World*, Nov. 12, 1887, p. 256. Both Lyons' and Berliner's memories were faulty and they mixed up some of the details. It is hoped that the actual sequence has been restored. The only other American reference to Charles Cros seems to be that in the translation of Theodore du Moncel. *The Telephone, the Microphone and the Phonograph*, 1879. It appears as a footnote on p. 236.
- ¹⁶ J. Lyons, *op. cit.*, pp. 2, 4-5. See also testimony of Emile Berliner in *American Graphophone Co. versus American Record Company*. Answer to question 44. Lyons later added that the White application comprised a system with a combination of a diaphragm, a pivoted stylus and a laterally undulating sound record cut into wax. In Berliner's testimony the cutting into wax also was emphasized. It is possible that Berliner's later reluctance to cut directly into wax stemmed from his experience in this interference. Until the interference proceedings or White's abandoned application are located, it is impossible to be certain. Berliner also prepared records the following year for another individual that were recorded in wax so that he was familiar with the technique. He later, in the mid-1890s, did experiment in cutting the wax but always felt that there was no sense in going any further since the procedure infringed on the broad claims of the Bell and Tainter patent no. 341,214.
- ¹⁷ The May 4 application has not as yet been located among the Patent Office files at the National Archives. The content and the file wrapper of the divided application that resulted in Patent 372,786 showed no changes.
- ¹⁸ Deposited with RCA by Joseph Sanders. The location of the shell (?) is currently unknown, if it still exists, since the time the exhibit was dismantled in the mid-1960s. I believe that notes prepared by B. L. Aldridge to accompany this record were partially incorrect, and I have consequently modified them on the basis of the British patent, testimony of Joseph Lyons, and letters of Joseph Sanders. See also Emile Berliner "Development of the Talking Machine" in *Three Addresses*. p. 36. H. Bennett, ed., *The Chemical Formulary*, Vol. IV, 1939, p. 375 describes a bichromate process for making relief photographs in which gelatine was used. See Lyons, *loc. cit.*, p. 109. It is probable that Berliner was utilizing ideas obtained from his recent discovery of Charles Cros, his paper, and his later French Patent no. 124,213. Cros stated: "If the tracing was obtained by a spiral on a flat glass, a hot solution of bichromated gelatine is softly poured on the glass, in a manner as not to disturb the layer of lampblack. This is allowed to coagulate, dry, or is immediately dried in a drying chamber on a leveled tripod. Then it is exposed to light by the back. It is then washed in warm water . . ." There is too much coincidence for Berliner not to have been following Cros in this situation. For details see "Translation

of Cros French Patent” in *American Graphophone Company versus United States Phonograph Co.*, p. 318 ENHS & NARC-Bayonne.

- ¹⁹ “E. Berliner’s Gramophone” in *Electrical World*, November 12, 1887, p. 256 passim.
- ²⁰ J. Lyons, *loc. cit.*, p. 109.
- ²¹ F. Wile, *op. cit.*, p. 191, 192.
- ²² Edward Houston “The Gramophone” in Franklin Institute. *Journal*, Vol. 125 p. 44, *et seq.* (January 1888); E. Berliner to W. H. Wahl February 6, 1888, FIA.
- ²³ W. H. Wahl to E. Berliner February 20, 1888, FIA; Joseph Sanders to B. L. Aldridge May 27, 1953, SP
- ²⁴ E. Berliner Gramophone p. 13 passim.; Lyons, *loc.cit.*, p. 114; U.S. Patent no. 382,790 dated May 15, 1888.
- ²⁵ J. Lyons, *loc. cit.*, p. 114.
- ²⁶ E. Berliner, *op. cit.*, p. 13; J. Lyons, *loc. cit.*, pp. 114-116 passim.
- ²⁷ J. Lyons, *loc. cit.*, p. 117; E. Berliner *ibid.*, p. 13.
- ²⁸ E. Berliner to W. H. Wahl May 2, 1888, FIA.
- ²⁹ In his paper, Berliner mentioned that the reproducing apparatus had been completed ten days previously. We are not certain if he were referring to the days in terms of the date he completed his paper or had taken into account ten days counting backward from May 16, the date of the address. I am inclined to believe that he had and that the machine was completed on May 6 since he mailed his letter and the manuscript on May 7.
- ³⁰ E. Berliner to W. H. Wahl, May 7, 1888, FIA. Those individuals Berliner asked to have invited were Louis and Max Levy, and Prof. Heilprin of Philadelphia; C. and Joseph Auerbach, Joseph Lyons, and Anthony Pollock of Washington; and Dodd, Mead & Co. of N. Y. Max Levy later worked on the process of making matrices, Lyons remained Berliner’s patent solicitor, the Auerbach’s became investors in the U. S. Gramophone Co., and Anthony Pollock was a member of the firm of Pollock and Mauro, the attorneys for the Volta Graphophone Co. and the American Graphophone Co.
- ³¹ E. Berliner to W. H. Wahl 5/10/87 FIA; Franklin Institute. *Minute Books*. Entry for May 16, 1888 passim. FIA.
- ³² E. Berliner *op. cit.*, p. 18.
- ³³ *Ibid.*, p. 17.
- ³⁴ E. Berliner. *Technical Notes on the Gramophone*, p. 14. The electrotype copies were too expensive to warrant commercial exploitation. Affidavit of Emile Berliner in *American Graphophone Company versus the National Gramophone Co. and Frank Seaman*. (Printed appeal record involving the Preliminary Injunction.) p. 18 NARC-FRC-Bayonne.
- ³⁵ Noted on preprint copy from which Berliner delivered his address, p. 21 BP. We are not certain if the listing involves five or six separate recordings. The invitation of Anthony Pollock, and the record prepared by Philip Mauro, showed the close relationship with Berliner at this time. It was not until the late 1890s, when the Berliner process became a dangerous rival to the American Graphophone Co., that Mauro’s firm attacked the Berliner Companies in court. *American Graphophone Co. versus the Berliner Gramophone Co. et al.*; *American Graphophone Co. vs. the National Gramophone Co. and Frank Seaman*.
- ³⁶ J. Lyons, *loc. cit.*, pp. 117-119; personal observation of diagrams and pictures of the recording apparatus.
- ³⁷ E. Berliner to W. H. Wahl, June 1, 1888, FIA.
- ³⁸ F. Wile *op. cit.*, p. 198.
- ³⁹ J. W. Hyatt to E. Berliner, August 23, 1888, BP.
- ⁴⁰ J. W. Hyatt to E. Berliner, August 25, 1888, BP.
- ⁴¹ J. W. Hyatt to E. Berliner, September 17, 1888, BP.
- ⁴² Joseph Wetzler “The Improved Gramophone” in *Electrical World*, 8/18/88; Emile Berliner “Development of the talking machine” reprinted in Emile Berliner. *Three Addresses*, (Privately printed, 1913?) pp. 34 and 35; Carlene E. Stephens to R. Wile December 20, 1977.
- ⁴³ E. Berliner “The Improved Gramophone,” in American Institute of Electrical Engineers. *Transactions*, December 16, 1890, pp. 27-28. Separately mounted in Berliner scrapbook.
- ⁴⁴ Joseph Wetzler “The Improved Gramophone,” in *Electrical World*, August 18, 1888; Depositions

- of T. Commerford Martin and Joseph Wetzler in *Victor Talking Machine Co. vs. Leeds and Catlin Co.* (Printed appeal record), pp. 191-197 passim.
- ⁴⁵ George C. Maynard in *Electrical World*, December 1, 1888 (clipping mounted in Berliner scrapbook).
- ⁴⁶ E. Berliner, "The Improved Gramophone," in American Institute of Electrical Engineers. *Transactions*, December 16, 1890, p. 27. Separately mounted in Berliner scrapbook.
- ⁴⁷ William Weiting (of India Rubber Comb Co.) to E. Berliner, July 10, 1889, BP.
- ⁴⁸ E. Berliner, *Technical Notes on the Gramophone*, p. 14
- ⁴⁹ W. Suess, *Gramophone*. Patent no. 427,279; *The Gramophone* (December 1888) BP; *E. Berliner's Gramophone* (undated) Bell Papers; Drawings in the hands of the family; Patent no. 534,543.
- ⁵⁰ George C. Maynard, "More about the Gramophone," in *Electrical World*, May 18, 1889 (clipping mounted in Berliner scrapbook).
- ⁵¹ F. Wile, *op. cit.*, pp. 202-204 passim.
- ⁵² F. Wile, *Ibid.*, pp. 204-206 passim.
- ⁵³ *Ibid.*, pp. 211-215 supplies the full account. Alfred Clark. Memo #1 for Howard W. Hayes, June 22, 1898, ENHS Legal Box 101.
- ⁵⁴ In a letter from Lotte B. Bertheim to R. Wile, December 21, 1977, the fate of Louis Rosenthal's papers were recounted. "I was a child when my grandfather died and all the items like records, gramophone, etc. were left with my mother, Louis R.'s daughter. All these got lost in the Nazi terror. My mother and most of my relatives (except for my sister in New York) were murdered at that time. I am sure you will appreciate the overwhelming impact of the human loss; therefore at the time the material loss seemed insignificant." In a draft of a letter to *Opera News* that was published in abbreviated form on December 10, 1977, Mrs. Bertheim also stated: "At the international exhibition in Frankfurt, Summer 1927, "Music in the Life of the Nations" recognition was given to my grandfather (Room 69, "50 Years of the Speaking Machine") with documents, patents, pictures and letters. He envisioned already the development of the long-playing record." (In possession of the author.)
- ⁵⁵ Louis Rosenthal to E. Berliner, November 30, 1889. Rough translation smoothed out by R. Wile located in Legal Box 101, ENHS. The enlarging experiment reflected a pet theory of Berliner--he believed that a record might be enlarged in diameter by means of photographic or mechanical means. The increased amplitude of the recorded waves, it was believed, would allow a truer and louder reproduction.
- ⁵⁶ L. Rosenthal to E. Berliner, February 6, 1890. Also smoothed by R. Wile, Legal Box 101, ENHS.
- ⁵⁷ See deposition of E. Berliner in *American Graphophone Co. vs. American Record Co.* Answer to question 44, p. 34 (Printed appeal record) NARC-FRC-Bayonne.
- ⁵⁸ E. Berliner, *Technical Notes* . . . , p. 15.
- ⁵⁹ For details see: Peter G. Adamson, "Berliner Discs: from Toys to Celebrity Records," in *Phonographs and Gramophones: A Symposium* . . . , pp. 74-76 passim.; F. Wile *op. cit.*, p. 216; Roland Gelatt, *The Fabulous Phonograph*, p. 64. See *Talley Machine Review International*.
- ⁶⁰ E. Berliner, "The Improved Gramophone," in American Institute of Electrical Engineers. *Transactions*, December 16, 1890, mounted in Berliner scrapbook. BP-LC.
- ⁶¹ See testimony of Joseph Sanders in *American Graphophone Co. versus American Record Company*, and various letters to B. L. Aldridge and Roland Gelatt.
- ⁶² E. Berliner, *Three addresses*, p. 37. An electric motor combination hand and motor outfit was advertised by the U.S. Gramophone Company, but none seem to have survived.
- ⁶³ Joseph Sanders to Roland Gelatt, July 12, 1954, SP.
- ⁶⁴ Pollock and Mauro's Opinion. Exhibit in *American Graphophone Co. vs. Berliner Gramophone Co. et al.*, p. 9.
- ⁶⁵ The existence of this company was first discovered in a citation in a Bill of Complaint in one of the patent contests. We do have a few letters from Berliner to Dr. Wahl of the Franklin Institute that are written on American Gramophone Co. stationery in 1893.
- ⁶⁶ One patent had been slowly working its way through the Patent Office. It was applied for, but was not to be granted until 1896.
- ⁶⁷ E. Berliner, *Technical notes* . . . , p. 15.
- ⁶⁸ E. Berliner, *Three Addresses*, p. 35.

⁶⁹ E. Berliner, *The Gramophone* (Pre-print copy), p. 21. The later 1894 reprint differs in several significant details from the pre-print copy.

SOURCES

Manuscript and Typescript

- 1) Library of Congress. Berliner manuscripts. This is a small collection which contained a few items of value concerning the gramophone.
- 2) Various members of the Berliner and Sanders family. There were several groups of papers. Several crucial for this paper. Much of the material has been transferred to the Library of Congress.
- 3) American Telephone and Telegraph Company. Historical Library. There is some material concerning Berliner's telephone connections.
- 4) Alexander Graham Bell papers. (Now at the Library of Congress). There were a few clippings, an offprint and a few manuscript mentions.
- 5) Franklin Institute. Archives. There was a fair amount of material concerning the 1888 and 1895 lectures, the award of the John Scott Legacy medal, scattered correspondence and letter book copies of letters.
- 6) Edison National Historic Site. Legal boxes. Some of the papers that once belonged to Edison's attorney Howard Hayes were later given to the Site. These included copies of the Rosenthal letters and partial transcripts of testimony used in litigation.

Court Cases

- 1) *American Graphophone Company versus the U.S. Phonograph Company*. A few papers regarding Berliner were found in Legal Box 109 at the Edison National Historic Site.
- 2) *American Graphophone Company versus the Berliner Gramophone Co., et al.* Located at the Federal Record Center--National Archives Regional Center, Philadelphia.
- 3) *American Graphophone Company versus the National Gramophone Company and Frank Seaman*. A printed appeal record involving the preliminary injunction is located at the National Archives Regional Center--Bayonne, N. J. The material gathered for final hearing is located at the National Archives Regional Center at Bayonne, N. J.
- 4) *American Graphophone Company versus the American Record Company*. A printed appeal record exists at the National Archives Regional Center at Bayonne, N. J. The case record exists at the National Archives Regional Center at Bayonne, N. J. 