Three Addresses

by

Emile Berliner

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Compliments of the author.

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EMILE BERLINER

THE LOOSE CONTACT TRANSMITTER

Address made before THE TELEPHONE SOCIETY, OF WASHINGTON, D. C., December 1, 1910.

MR. CHAIRMAN AND GENTLEMEN: If we would divide the history of inventions or the technical development of science into off-hand periods, we could do so by starting with the time of the Greek mathematicians and the achievements of Archimedes; we would then have to bridge over a considerable period until we arrive at the invention of the printing press in 1438; then would come the telescope in 1609 and Newton's discovery of the principles of gravitation and his celebrated work on Celestial Mechanics in 1675. Next there would be a century intervening when we would get to the steam engine in 1765. Then would follow photography in 1820, magneto-electric induction in 1831, the telegraph in 1844, the telephone in 1876, and finally the flying machine in 1904.

The telephone is distinguished in this enumeration because with it started a very marvelous development in science, and between the invention of the speaking telephone and the flying machine there were the following discoveries and inventions put before the world: the talking machines, the commercial electric light, the Roentgen rays, color-photography, wireless telegraph, liquid air, and radium. Of course, I do not mention a great many other important progresses in invention, but I would call those that I have mentioned "epoch-making," and among them the speaking telephone undoubtedly ranks very high.

In 1888 I read a paper before the Franklin Institute on the invention of the gramophone or disc talking machine at its first public exhibition, and, having seen the development of the telephone from its very childhood, I could not help starting my discourse with reference to the invention of the telephone, about which I stated as follows:

"The year 1876 came, and when the jubilee was at its very height, and when this great city of Philadelphia was one surging mass of patriots, filling the air with the sounds of millions of shouts, a still small voice, hardly audible, and coming from a little disc of iron fastened to the center of a membrane, whispered into the ear of one of the judges of the exhibition, and one of the greatest of living scientists, the tidings that a new revelation has descended upon mankind, and that the swift and fiery messenger of heaven's clouds had been harnessed to that delicate, tremorous, and yet so potent form of energy called the human voice.

"The speaking telephone had been born.

"The stimulus which this event gave to science can best be measured by the enormous advance made since, especially in that now most prominent branch, electricity."

I do not believe there are many of you here to-night who can imagine the world without the telephone, and I thought I would give you a picture—in an off-hand statement—of thirty-three years ago, when there was no speaking telephone.

I lived in Washington then, as I do now, and there was one little store that dealt in electrical goods, the store of Mr. George C. Maynard. Mr. Maynard is still living, and is in charge of the scientific department of the National Museum, and I know he would enjoy being here to-night. He had a store on G Street, between 14th and 15th Streets —a little bit of a store, not larger than this corner here— and there were a few keys and sounders and bluestone batteries (they did not have any other to speak of) and some relay and some tapes, and some wire, and probably one or two more highly scientific induction coils and galvanometers. But that was all. That comprised the electrical stores of Washington. There was no commercial electric light, but there was at the Capitol, near the dome upstairs, a large room in which was a big battery consisting of about one hundred so-called Smee cells. At that time these were very well known among scientific men. Each consisted of a jar full of sulphuric acid and water, a piece of carbon and a piece of zinc. That was a Smee cell. Of course, you know it polarized very quickly. Every 4th of July the daily papers announced: "To-night the electric light will be shown from the Capitol," and everybody was down on Pennsylvania Avenue. All at once we would see a brilliant arc light at the lower part of the dome. The electrician was at work. By and by it went out because the battery polarized, and then they had to wait about twenty minutes or a half hour, and then we had another glimpse of the shining electric light. It was quite an interesting exhibition and everybody enjoyed it very highly. There were no dry cells known, and there was no electric bell. The house bells were mechanical. In those times iron bell wire was used, and every blacksmith, or every locksmith, knew how to fix the house bell, and from time to time the wire would stretch, or something of the kind, and they had all kinds of trouble with the bell. Of course, it was a pretty good sized bell, and gave the old-time jingle such as you hear now and then in boarding houses.

Then there were horse-cars. There were no electric cars, simply horse-cars. Afterwards they had the cable-car, and one day, as you may remember, the power-house was burned, and they had to supply horses for the cars. I recall that I then had the privilege of riding up to Mt. Pleasant in a mule car. They got the mules over in Alexandria to help out. Of course, it required some time to get around, but people had plenty of time then. If you wanted anything, you had to send a messenger, and you could attend to only two or three transactions a day, where you can now attend to a hundred with the aid of the telephone.

There was but one electrical paper in the United States, and that electrical paper was the official organ of the Western Union Telegraph Company, and was known as the *Journal of the Telegraph*. It came out once a month on a bit of a sheet, such as you showed me, Mr. Chairman, referring to your own telephone journal—and there were one or two semi-scientific articles, and the rest was taken up with the official orders of the Western Union Telegraph Company.

Those were the conditions thirty-three years ago. Then came the Centennial Exposition, and Professor Bell has, in that connection, told you himself, I am informed, how he invented the telephone. I need say but very little about the principle of what you know as the receiver to-day—a diaphragm, a magnet and a coil—while at the Centennial Exposition it was not an iron diaphragm, still it was a diaphragm, and the Bell telephone was used both as a transmitter and as a receiver. We did not have for several years anything of what is now known as a transmitter, except that The Bell Telephone Company, in the early years, put out what was called the Box telephone, which was a large Bell telephone, as a transmitting instrument. You have no doubt seen pictures of them, or maybe an original instrument. Some are in the National Museum. The Box telephone was fixed against the wall, and you spoke against it by getting quite close and pressing your mouth into the mouthpiece. Then you had the small telephone with which to listen. That was the system in 1877 and 1878, in the first telephone sets that were put out. The change did not begin until about the latter part of 1878, or the beginning of 1879.

I had become interested in the telephone in 1876. I had heard of the Bell telephone, although I had never seen it. I had thought of it, and I got some electric wires and some other things from Mr. Maynard's store, and some batteries, and it occurred to me right away that the proper manner to transmit speech should be by means of the battery current. I thought since Mr. Bell had made the invention with the magneto current it might be possible to do it some other way, so I set to experimenting in the latter part of 1876, before the Bell telephone was fairly known, except to a few scientists or a few people who had seen it at the exhibition in Philadelphia. I was then clerking here, and I spent my leisure hours on Sundays and evenings in experimenting. It occurred to me that what I should be able to do would be to take a diaphragm and a contact-pin, or screw, touching it in the center, and in some way produce an undulatory electric current by continuous action of that contact, not by interrupting it, but by some form of continued current. I did not catch on right away to the pressure principle, but I thought if I would take a flat spring and attach that to a screw, I could adjust that spring against the diaphragm (and the current, of course, passing across the contact)—so that if I spoke against it, the pressure of each vibration would give a little broader contact of that spring against the diaphragm and thereby produce electric sound waves in the current.

That was the first idea, and I rigged up a sort of telephone, consisting of a membrane and a piece of spring in front, and I tried to transmit speech, but it would not work; somehow or other there was no action that I could discern. Of course, with the sensitive receiver of to-day it might give some results, but the real results would not be such that the flattening out of that spring would produce sufficient of variation to give sufficiently loud speech.

There was at that time here in Washington a gentleman named Richards, who was the chief operator at the fire alarm telegraph office. I knew him very well, and he invited me to come up and visit him at the fire alarm office. At that time, of course, they had the bluestone cells—I do not know whether they still have them—and the usual paraphernalia of instruments and of alarm bells, etc. One day—it was in the early part of 1877, in January, I think—I went up to see him, and, since I had gotten interested in all kinds of electrical experiments, I had tried to learn telegraphing. I said to him, "I have been practicing telegraphing, and I want to show you." He said, "Come back and let me hear what you can do." There was an instrument which was out of use, and I began to send an alleged message. He said, "Hold on, this is not right. You must press down the key—not simply touch it."

I said, "What difference does that make whether I press it down or not, if it makes a contact?"

He said, "Yes, but you have to make a *firm* contact; otherwise your message might not be readable at the other end; for instance, in long distances where the resistance is high, you have to press down considerably, in order to get efficient long-distance work in telegraphing. We use men for long-distance work exclusively because they naturally press down hard. Women would not do that, and, therefore, for long-distance work, women are not adaptable."

That struck me very forcibly. I said, "Do you mean to say that more current passes over that contact when I press hard?"

He said, "Decidedly."

I said, "All right. Good-bye."

I went home, and I knew I had it. I rigged up a diaphragm and made a contact with a steel button, polished it up nicely so as to make a clean contact (it is still in the National Museum in one of the cases). I began to adjust it, until the galvanometer showed the current. I then very gently pressed, and found that each time I pressed against it I got the galvanometer to deflect a larger angle, and I knew the principle was right. I want to say right here that my receiver was not in a good condition; it was still the old membrane, the skin membrane with a patch of iron glued to the center. I had not then heard of Bell's further development of the iron diaphragm, which came a little later. It came out only in the patent of 1877, which showed for the first time an iron diaphragm. It occurred to me that maybe an iron diaphragm might also improve what I had, the loose-contact idea. So I rigged up my instrument with an iron diaphragm and made contact at its center with the little round highly polished steel button at the end of a screw, and while I connected it to the battery all at once I heard a sound coming from that iron diaphragm. I listened and I took my terminals and connected them off and on, and I heard a loud tick, tick, tick. That was strange to me. So I took a tuning-fork and tied one of the wires around it, to make an electric connection. I then struck the tuning-fork and held the prongs to the other wire, and, lo and behold, the sound of that tuning-fork—came from the diaphragm. Now, I said, I have here something entirely different from Mr. Bell; I have a transmitter which is different from his, and a receiver which is different from his. And so I made two instruments, each of nothing else but an iron diaphragm and a steel ball, and I connected them, one upstairs and one downstairs in the building, three stories, I think. I had a friend talk into the instrument upstairs and I listened carefully downstairs, and I could plainly understand what he said. It was, I claim, the simplest instrument—electrical instrument—ever made for the transmission and reproduction of speech.

Now, let me speak about the loose contact. It was something to be avoided in electricity. It was the rule, and it is today, that you screw everything tight; any other contact is a bugaboo in electricity. A loose contact is to be avoided, as it burns the terminals, or does something of the kind, and it does not transmit the current properly. I had, however, as I have showed you, found a way to utilize that which had been avoided before, and to make a speaking telephone out of it. Well, I tried hard to make the loose contact receiver talk loud. I continued experimenting in my leisure time, and in April of 1877, I filed my petition for patent, first in the form of a caveat.

By and by I found that a trouble I had was that when I adjusted one instrument and went to the other one downstairs—or in a stable over in the yard—and adjusted it, before I got through, the warmth of the current would bring one out of contact, and I could not transmit anything. It occurred to me, why could I not interpose two induction coils, and put the primary at each end in circuit with the instrument, bring the secondary over the line, and again through the secondary of the second coil, and affect the receiver or other contact instruments that way? That was the first time an induction coil had been used in telephoning. In fact, I got a patent for that early in 1878, before there was any use for it, because the transmitter was not introduced until a year after I got the patent for the use of the induction coil. The idea worked, and for a long time during that year and the next I carried on experiments with friends of mine that way. So you see that the induction coil idea started originally with the intention to improve the local, and not the line conditions.

The telephone remained for a time in obscurity. The people heard of it, but they never listened to one, or saw one. They thought it was a little plaything, and there seemed to be but little progress made. All at once we heard that they had been used on longer distances, and a few people in Massachusetts were using it for intercommunication between their houses, but I was still here in Washington waiting for my opportunity. Then it was said that Mr. Edison had also invented a new telephone; I heard of that. He had what was known as the carbon button transmitter. He had taken some lampblack and compressed it into a button, and put two platinum discs on it. That was the old Edison telephone, and his idea was that when he spoke against the diaphragm and compressed that lampblack inside the carbon button he would get speech through that. He was on a tack similar to mine, only in some other direction. His idea was to compress loose conducting matter and get the undulation of the voice, so to speak, or have an undulatory current by that means. I want to point out here that in my earliest application, in the summer of 1877, there was shown a hard carbon button, so-called gas carbon (they did not have electric light at that time; that came a year later)—and a round metal bead against it. That was to be used as a loose contact on the surface, not as Mr. Edison wanted to use his, by compressing a soft carbon button, and that figure is still on record in the Patent Office, and became a prototype of what was afterwards the Blake transmitter, of which I will speak later.

I told you that I filed my application for patent and soon I was informed by my patent attorney that there was a big interference declared in telephone applications. There were not so many; they involved Mr. Bell and Mr. Gray and Mr. Edison, and one or two other people, of whom I had never heard, and myself. By and by The Bell Telephone Company instructed its attorney here, Anthony Pollock, to find out, among the applications in the Patent Office which were in interference with Mr. Bell, whether there were any which they had rather try and control. Mr. Pollock went over the applications and reported afterwards—so I heard —"The only application that you would want to control is that of Mr. Berliner, of Washington." Whereupon Mr. Thomas A. Watson, who was Mr. Bell's assistant, and who had been appointed Superintendent of The Bell Telephone Company, came to see me. I took him around to my little room on Sixth Street, between H and I, and exhibited to him my loose contact telephone, and he was very much surprised. He said, "We want that, Mr. Berliner." And soon afterwards Mr. Gardiner G. Hubbard sent for me and said, "Mr. Watson and Mr. Pollock tell me you have something valuable; we want that, and I would like to make a contract with you." By and by Mr. Theodore N. Vail, afterwards the President of The Bell Telephone Company, and now also President of the Western Union Telegraph Company, who was then Superintendent of the Railway Mail Service in Washington, joined Mr. Hubbard and his associates. Mr. Hubbard had gotten hold of him through some investigation that Congress had asked him to undertake as Chairman of some committee. He came across Vail and was very much impressed by him, and said, "Mr. Vail, we would like to have you manage and work up the Bell telephone"—which then did not exist commercially. I was in a store here then on Seventh Street, between H and I, and Mr. Vail was in the Post Office Department, right at the corner of F and Seventh Streets, and it was very easy for us to meet and have discussion about my contract.

He was very much interested in the experiments, as a matter of course, and after a while we drew up a contract, which I signed and the Company signed, and from that time began my connection with The Bell Telephone Company. But they had not yet gone into big business, and they did not yet need my services. They only thought they would want me, and I said I was very anxious to get into a scientific field; I had a smattering of it and was studying and preparing myself. They said, "You will have to wait." The year went along until September of 1878—when they told me: "Now, we would like to have you come with us to help." Before that happened, I will say, that I was taken sick and was in the hospital, but after I got out of the hospital I went to the office of The Bell Telephone Company in New York. Now, you must not imagine The Bell Telephone Company as you know it to-day. They had half a loft at 66 and 68 Reade Street, New York. That was their headquarters, and the personnel was Mr. Vail, Mr. Watson and Mr. Devonshire, who is still with the American Bell Telephone Company as Chief Clerk and Assistant Comptroller of The A. T. & T. Company, and myself. That was the active staff of The Bell Telephone Company in the latter part of 1878, but during the summer Mr. Francis Blake, Jr., had joined them. Mr. Blake was a scientific man, and was connected with the service here—the Geological Survey. He got to tinkering with transmitters and got onto the idea that the correct way to mount the two loose contact electrodes—that is, the carbon and the little bead, was to suspend them on two springs and let them lean against the diaphragm, and that became what was afterwards known as the Blake transmitter, and for a number of years the Blake transmitter was considered the standard instrument. Mr. Blake had invented it, to be sure, but it was not in practical shape. Mr. Blake was taken sick before he finished it, and they asked me to come as soon as possible. I went from the hospital, and they said: "Mr. Berliner, you must finish that Blake transmitter for us; it is not entirely in shape. The thing is there, and works beautifully; the idea is correct, but it can't go on the market as it is. When we put it in adjustment at night, in the morning it is out of adjustment, and, of course, such a condition is out of the question." We could not make ten transmitters alike; they were all different. Each one had a separate adjustment, and the next morning they were out of adjustment. So on the 1st of February, 1879, we all went to Boston, and there the headquarters were established and remained for years. My particular office was in the factory of Charles Williams, Jr., who was the first man who made telephones, and at whose place Mr. Bell invented the telephone. You will remember Mr. Bell's telling you how in that factory he experimented with Mr. Watson. I went there and worked on the Blake transmitter.

I soon found that the principal trouble with the Blake transmitter was in the carbon button. We cut up electric light carbons into buttons, and there was only the firm of Wallace & Sons, in New England somewhere, who made them. They were the only ones to be had. They made carbon pencils for the first time that could be used in a semi-commercial electric light.

Now, those carbon buttons were very soft, and the trouble was that the vibration of the metal bead would dig a hole into the carbon button and destroy the adjustment. So one day one of the firm came to see us, and I said: "Can't you make these carbon pencils hard?" He said: "Well, yes, we could make them harder, but they wouldn't be homogeneous, but would be full of little holes and all that, and that I suppose would not do at all." So I set to work. After thinking the matter over it occurred to me that if we would take some of those soft carbon buttons and send them to the gas works where they make gas in a retort, put them in a cage and in the retort, that the carbon gas might condense itself on the surface of those soft carbon buttons and thus give us a coating of hard gas carbon. (This could not be used in blocks, because it was too difficult to saw it.) So I rigged up a cage, filled it with buttons and sent it down, and they sent it back the next day. When I opened the cage I was very much disappointed. The buttons had all shriveled up, were partly burned, and the idea seemed to be an utter failure. But I took a piece of emery paper and rubbed off the loose burned crust from one of the carbon buttons, and all at once I could not rub any more; it was so hard that I could not rub it and it took the highest kind of polish. I then thought there must be some way of doing that without burning the carbon. I was told how the thing had been put in the retort, and became familiar with the place in the retort where the carbon gas condensed. The next day I sent another lot down, and they came back without being burned, and gave the most beautiful carbon buttons, which were used ever since, and after a few more minor improvements we had no trouble with the Blake transmitter. We could make two hundred a day, which was considered at that time a very large number, and we adjusted them, and they stayed there, working absolutely perfect.

That was my practical work in the development of what was known as the Blake transmitter—the Blake type of loose contacts suspended on two springs.

I want to tell you a curious incident in connection with that Blake transmitter. I know those of you who have to do with the troubles in instruments will appreciate it. I went to Europe soon afterwards, and while I was away Mr. E. T. Gilliland, a well-known electrical engineer at that time, was put in charge of the Bell instruments. I remained in Europe four or five months, and when I came back, Mr. Devonshire called me and said: "Mr. Berliner, there is something wrong with the transmitters; they do not work as well as they used to."

I said: "Is that so? I will take a look at them."

I tried them, and found them rather poor. I studied for some time, and made experiments, but could not make it out until I thought that perhaps the process of the hardening of the carbon buttons, which I had adopted, was not scientific enough and might give rise to impurities in the carbon, and that, of course, the carbon would become a poor conductor. Sulphur, for instance, might get into it, and the process might be a failure after all. So, at my request, a professor of chemistry in the Massachusetts Institute of Technology was engaged to go through the whole process and find out if it was possible for any impurities to get into the carbons, and after three or four weeks the professor —I have forgotten his name—reported that there was no possibility, in the process that I had adopted, for any impurities to get in, and that there was nothing but pure carbon inside. Of course, that satisfied us that the trouble was not in the carbon, and yet we could not discover it, and still complaints were coming in from all over the country that the transmitters were no good. So finally Mr. Vail called me and said: "Mr. Berliner, you have got to do something; something is wrong somewhere."

It bothered me a great deal. Now, while I was away Mr. Gilliland had adopted a new lock—you remember in the old Blake transmitter there was a small box of black walnut, which had a sort of a Yale key, which is still in existence to-day wherever they can be shown—but before that they had an ordinary lock. One day I thought I would take that whole transmitter to pieces. I took off even the diaphragm, and all at once I saw that Mr. Gilliland, in order to put his new lock in, had drilled a hole inside, in front of the sound chamber opposite the diaphragm, and when one spoke into the transmitter and against the diaphragm the full pressure of the air was not used, but part went out sideways into the box. I called my assistant and said: "Richards, have some of these transmitters made and have a piece of pasteboard glued over the hole and see what results from that." And the boxes were made ready and they sent up a batch of about twenty while I went to lunch. Hardly had I come back from lunch when all at once Richards came storming down to my office, saying: "We have got it."

I said: "What have you got?"

He said: "The whole trouble has been that lock. The transmitters are fine!"

So we removed that difficulty by making the casting a little different, and from that time on we had good transmitters. It shows you to what extent you may go in scientific investigation and then right before your nose you will find the difficulty, if you only take the trouble to investigate more thoroughly. It was ridiculous, really.

About that time it became known in Europe that in the United States there was a speaking telephone. There was a scientist named Reis in Germany, who made the Reis telephone, which gave nothing but a buzzing sound by make and break of contact, and it was asserted that he had invented it years before. It was never proved to be a speech transmitter, and there were a good many scientific discussions as to whether there had been a speaking telephone before Mr. Bell's. I have (and I am sorry I did not bring it along) a Washington paper, printed in German, however, of the year 1877. There was in Germany a scientific man named Bernstein, who wrote on scientific subjects for the people, like Tyndall did in those days in England. And one day I saw an article in that German paper headed: "Scientific Lies." This was written by Professor Bernstein, who had discussed various claims in which somebody had been trying to show that we could do away with gravitation and other "fakes," and then he said: "Recently the news has come to us from America that a man named Bell has invented a speaking telephone. Concerning the transmission of sounds, that is old. Philip Reis, of Frankfurt, has done that some years ago. But," he continued, "when it comes to the transmission of speech, that is quite impossible. You might get sounds of melodies by uninterrupted currents, and you might get something analogous to speech or rhythm by it, as laughter or exclamation, but you cannot get speech, and German papers ought not to publish every American exaggeration that is dished up in the American press." Now when the telephone really came, when they found it was true, they dug out some writings, and they commenced to explain its theory, which they are great in finding—Germans are very deep thinkers, and when they commence to take hold of a subject they get to the bottom of it—and then they said (in a report made by the Postmaster-General to the old Emperor): "Yes, Mr. Bell has invented a speaking telephone, but it remained for German scientists to give the true explanation of its workings." And bye and bye they came along and said: "Of course Reis has done that long ago," and later they erected to him a monument in Frankfurt with the inscription: "Philip Reis, the inventor of the telephone." First, it is not possible; next, we know more about it than the Americans; and finally that was invented by us long ago.

You may have heard considerable about the lawsuits that The Bell Telephone Company had to fight with the Western Union Telegraph Company and others, especially the People's Telephone Company, which owned the claims of a man named Drawbaugh who asserted that he had invented the telephone before Bell. One day a very prominent lawyer asked me when I was in New York to come up to his office. Mr. Drawbaugh was an old tinker, bellhanger, or something of that sort, in Pennsylvania in some obscure town, and this company called the People's Telephone Company had put him forward as the inventor of the telephone, fighting the Bell patents, and the case was in litigation for many years and cost a good deal of money. I went to the lawyer's office and he showed me a lot of drawings, and said: "I want you to look over these drawings; these are Mr. Drawbaugh's drawings." I looked them over and all at once I saw a Blake transmitter. There was the induction coil and the diaphragm and the bell, the box and the casting, the Blake transmitter springs and the carbon button. I said: "Do you mean to say that Mr. Drawbaugh invented this?"

"Yes, invented that in 1876."

Now 1876 was just the time that Mr. Bell had evolved the membrane telephone. I said: "Well, your man Drawbaugh is either the greatest genius that ever lived or he is the biggest liar." Later my transmitter patent was fought in the courts for many years, and even by the United States Government, using the assertions of the People's Telephone Company and others, and endeavoring to prove that my transmitter patent was no good, and among other things they said: "Yes, Mr. Berliner had a fine idea." (I had brought this principle of the Morse key instrument from which I evolved the transmitter, into my patent, and I based the transmitter on that experiment with the key; when you press down the key firm or loose); they said: "Oh, well, that is a beautiful idea, but it is no good. Mr. Berliner had metal contacts and the Morse key has platinum. You cannot use platinum to transmit speech; it takes carbon, and we claim Mr. Edison was ahead of Mr. Berliner in using carbon"—meaning Mr. Edison's lampblack buttons. So they said: "His invention is not complete, and unless you can prove that you can transmit speech that way commercially you cannot claim that your patent is a complete invention." But I had prepared for that very thing, and we said we would furnish proofs and a meeting was arranged in the Bell Telephone office in Boston between the Government attorneys and the Government experts, several professors and experts on our side, and when the time came I took an ordinary learners' key, a five-dollar set, and I took the heavy spring out and substituted a light spring, a relay spring, and I adjusted that relay spring carefully until I had a very loose contact (I had made it before and therefore was prepared), and I put my watch on the base board of the key instrument, and when I heard the "tick, tick," I said to the Government's attorney, "Go ahead." He said: "What do you mean?" I said: "Talk to your man at the other end downstairs." He said: "Do you mean I shall talk to that Morse key?" I said, "Yes." He said, "Hello," and he carried on a conversation with the loose contact of the Morse key without any diaphrgam or any carbon; and he then turned around and exclaimed: "It does seem incredible." That knocked them out on the proposition that I did not have a completed invention when I filed my caveat.

Now something about the theory of the scientific principle of a loose contact transmitter. It is not so easy to explain. You have a loose contact and you press it. Now what happens there? You do not press it hard enough to make any mark and yet you can speak to a loose contact, or speak in a Blake transmitter for years, and when you examine it there is no mark. What then is happening at that loose contact? The theories about this have been widely different, but my original one, which I arrived at very early, has finally been accepted, and that is this: I know that there are a great many of you here who have not studied physics, and yet it is now so simple a proposition that I think you will all understand it. Air is a conductor of electricity as well as a wire, the only difference being that a wire conducts electricity better; it has less resistance than the air. If I had a current, a spark, from a friction machine or from an induction coil, I could send it over quite a distance through the air. That shows that the air conducts electricity as well as the wire, but it takes a higher voltage to bridge the air, and when you have a voltage like a flash of lightning you can bridge over miles of air. And you can make the air a conductor, as for example, in the wireless telegraph, over thousands of miles, although the wireless telegraph works somewhat differently, there is the ether which is a conductor, but air is undoubtedly in it. Now when you have a loose contact between, for instance, the metal and carbon or between two metals or platinum, or anything, there is an intervening layer of air that can be shown by proper instruments, and when the current passes over that contact it has to pass over a very thin layer of air, and when you vibrate the diaphragm you increase or decrease the thickness of that layer of air, and that is what gives you these considerable variations of resistance which are necessary for the production of a speech current.

I forgot to mention to you that while the Bell telephone was employed independent of any other transmitter, that you could use it both for speaking and for listening as it used the magneto current, and after the discovery of the microphone you could use a loose contact both for transmitting and for receiving. It was found, however, after a short time that the best results were obtained in using Mr. Bell's receiver and the loose contact transmitter so the two completed each other, taking part of one principle and part of the other, and ever since such a pair has been used. Other transmitters have been invented experimentally on scientific principles, for instance, liquid transmitters, gas transmitters and others, but the effective transmitter remains the same as it was thirty-three years ago—the loose contact.

There are a great many other interesting episodes in the early telephone history, but this really completes my connection with it.

Your Chairman has asked me in his letter (and I wound up my classification of epoch-making inventions with the flying machine), whether I would say something about that, and I will give you just a very brief talk on it. There are at present three kinds of flying machines, two completed aud one uncompleted. The first is the dirigible balloon. It is a gas bag, and you put a propeller to that and send it, unless the wind is too strong, anywhere. The next is the aeroplane, invented by the Wrights, although the general idea is very old. You will find in the old "Encyclopedia Brittanica" of thirty years ago the picture under "flight" of an aeroplane almost identical with that of the Wrights. Of course, in those years they did not have the light motors; they did not have anything but steam motors, which were very heavy, and it was not until the development of the gasoline motor that flying became possible. But the general idea is so old that the Wrights, who got out a temporary injunction against the other users of the aeroplane, having been the first to fly successfully, were thrown out of court because there were so many other ideas shown to be old that theirs was really not such a novel invention. They may eventually receive a monopoly, but it is very much doubted but that it would be based on very or comparatively slight inventions which they added to old devices, but they were the first ones to fly successfully and deserve all credit for that.

Now there is a third idea, and that is one on which I have been at work for some time, which is known as the Helicopter. That is also very old, as an idea, but has never been successfully brought to perfection. It is nothing really but a ceiling fan on a very large scale run by a gasoline motor of considerable power. You have seen these little toys known as Japanese tops that fly up in the air. That is the idea—just a horizontal screw that by revolving lifts itself up. A great many have tried it and once in a while we hear of one who claims to have succeeded in lifting somebody up, but no real, substantial demonstration has ever been given. I have been at work on it for some time and last summer we succeeded in lifting the machine, the motor and two men from the ground, but the machine was anchored and we did not attempt free flight. It is possible undoubtedly to do it and we are at work on another construction, and I hope before very long to be able to show that it can be done successfully. The difficulties are much greater than in the aeroplane because you have to lift yourself up bodily. Now you may say, suppose you do that, how can you fly forward? But that is very simple, much simpler than appears on first consideration, because all you have to do is to tip your screws slightly forward and you immediately push forward in that direction. We have done it, not in a complete flight, but with a small instrument run by a little spring, by just tipping it and it will fly across the room until it stops. If such a machine can be made to lift an operator or two, all the operator has to do is to step forward and tip the machine by his own weight and it will move in the direction of the dip. That is the principle of the helicopter. We are working on it. I do not know whether we will succeed. It looks very promising just now, and maybe soon we will have it perfected, and I shall be very glad to show you a completed one, and after a while I may be able to add another little leaf to the book of my experiences.

I thank you very much.

[NOTE: The so-called "long distance" transmitter, now in general use, was first evolved by Hunning in England. The loose hard carbon granules therein form multiple loose contacts, and the idea of using several contacts being affected by the voice at the same time was mentioned by Mr. Berliner in his earliest patent paper. So was also the idea of having the primary of the coil on the line, mentioned in his earliest publication describing the use of the induction coil, in 1877.]

A REMINISCENCE

Address made before The Telephone Pioneers of America, November 14, 1912.

Mr. Chairman and Fellow Pioneers: I am afraid this audience is very much spoiled by this time by the splendid addresses that have been made this afternoon. Particularly did we enjoy the fine recital of reminiscences by Mr. Watson, and I was delighted, being a man of musical tastes, at the fine artistic bits of elocution, the result, as you all know, of his early shouting into the telephone, as related in the now justly celebrated poem, "Waiting for Watson." I am also grateful to Mr. Carty that he called attention to a paragraph of our Constitution, which says that anything which the early pioneers might contribute to reminiscences or historical accounts would be welcome. The fact is that most of my reminiscences, nearly all, were given at an address before the Telephone Society in Washington several years ago and were printed, I think, in a paper called the *Telephone News*, of Philadelphia, and there was really very little left for me to say this afternoon. But I recalled that there was something which it might be worth while to put on record, and that is the reason why I am here to contribute that much. I hope, at least, to make it interesting. I also hope that there is no patent counsel of the American Bell Telephone Company here, except my good friend, Mr. Lockwood, whose friendship I have enjoyed for so many years, and I know he will not think hard of it if I am going to uncover a secret page of the telephone litigation history of the United States. But, in the first place, the patent to which I refer is now obsolete and has been for some years; and then, again, I doubt very much if the counsels of the Bell Telephone Company themselves knew of the existence of this secret page, and, as I appear to be the only one acquainted with it, I am going to give it to you, and I beg the pardon of this Society of Telephone Pioneers if I have to be a little technical now and then and ignore for a time the practical and business problems which this Society was created for to foster. I say I will try to make it interesting. Brother Watson began with his boyhood days, and I will begin with mine.

When I was a boy about eleven or twelve years old, we had in our school a reader which contained a poem relating an incident in the life of the celebrated philosopher, Immanuel Kant. That poem began with the following high-sounding and very impressive verse, of which I will give you a free translation, as follows—don't get scared:

Every child knows that what is meant
By Categorical Imperativus, was fully explained
And is clear to all, by Immanuel Kant.

I remember distinctly how ashamed and mortified I felt that I didn't know what a Categorical Imperativus was, when the book said every child knew all about it, and I was afraid to ask, lest I would be met with the reproof: "You stupid boy, the idea of not knowing what a Categorical Imperativus is." In later years I looked it up and read that it referred to two entirely logical conlusions which, in spite of being logical, contradicted one another; and that is not so easy.

I got myself into a similar dilemma when, early in the year 1877, I came across two new electrical phenomena: one, that a loose contact would transmit speech, and the other, that a loose contact would reproduce speech.

Please remember that at that time electricity was only a small section of general physics, and there existed in the

United States only one electrical paper—and it is still existing—the well-known *Journal of the Telegraph,* the official organ of the Western Union Telegraph Company, that little pamphlet which appeared every month, and which, besides the general orders of the company to its officers, had a few articles on electrical subjects. Also, there were then only about four or five people in the whole world whose minds were occupied with the telephone phenomena, which at that time meant the original magneto-telephone, which was used both as transmitter and as a receiver. In literature, the loose contact was spoken of only as something to be avoided, and the few text-books that were at my disposal gave no reference whatsoever to any other phenomena that might explain or throw light on the two phenomena that I had come across.

When, therefore, I was called upon, in order to protect myself, to describe what I had invented and discovered in a patent office document (and I selected a caveat as the handiest and cheapest form), I found it difficult to properly explain what I had invented, and I confined myself to the mere statement that the transmitting action was accomplished by a decrease and increase of pressure, and that the receiving function rested upon a certain electrical repulsion at the contact.

It would have been easy enough to speak of decrease and increase of resistance at that point of contact, but how was that increase and decrease of resistance to be explained? Besides the changes in resistance or changes of current strength which showed themselevs on the galvonometer were only obvious when the contact was loose but ceased entirely when the contact was fairly made; hence I felt timid in my lack of understanding, and even when I showed the phenomena to Professor Joseph Henry, of the Smithsonian Institution, he did not volunteer an explanation, but he was very much more interested in the use I had put the induction coil to, or, as he called it, inductorium. He thought the application of the induction coil to the transmission of speech was of much greater importance than the mere mechanical means of throwing an electrical current into undulations by a loose contact.

The position I found myself in of having invented something for which I could not give a good, scientific explanation, was not improved, when, a year later, I joined the staff of the Bell Telephone Company. We had there one or two university-bred gentlemen, who kindly intimated, good-naturedly, to be sure, that I had a pretty good sort of scientific intuition, meaning that I felt the truth, without, however, always being able to understand it.

But not very long afterwards, Mr. James J. Storrow, the elder, that brilliant legal luminary who fought successfully so many important legal battles for the Telephone Company, said to me one day: "Mr. Berliner, if you had only written the application for patent yourself as you did the caveat, it would have been very much better." The fact was that in my timidity I had entrusted the drawing up of the application for the patent for the loose-contact transmitter to an attorney who, I thought, knew more about it than I did, and he in turn gave it to a clerk, who made a mess of that application, and it caused the lawyers of the Bell Telephone Company much work to get the tangle out of that application for the loose-contact transmitter. In fact, they worked it over entirely and put in most of the language of my caveat, crude and simple as it was.

But a more interesting situation was to develop.

When the loose-contact transmitter began to be discussed by the electrical experts, they propounded a number of theories to explain its action.

The first was that heat waves were produced at that contact which, in turn, gave rise to changes of resistance and to undulations in the current. The trouble with that theory was that, of all the substances, carbon had been found to be best for the transmitter, and carbon was, of all those substances that had been tried, the poorest conductor of heat, and as a rapid dissipation of heat was necessary for the production of heat waves, that theory was soon abandoned.

The next theory was that as the contact became firmer, more molecules on both sides of the contact were brought together and engaged with one another, and that there were fewer of such molecules when the contact was loose; but how could it be explained that with such rough surfaces as, for instance, carbon, you could get such good transmission of speech? It was out of the question that the number of molecules in contact at any time would be proportionate to the pressure applied, so that theory also failed to make good and lacked reasonable probability of being correct.

There remained a third theory which I advanced about that time and according to which there was a layer or cushion of air intervening between the electrodes in so-called contact with one another. That layer of air, I argued, became wider and narrower, according as the contact was firmer or looser, and it formed a normally constant resistance, which, therefore, had to change exactly according to the width of the gap, according to the pressure applied with each sound vibration.

That this air or cushion of air existed was shown in the year 1880 by the late J. H. Cheever and myself, when we enclosed a Blake transmitter in the receiving chamber of an air pump, and we found that the resistance of that contact decreased as we pumped air out and increased again when the air was let in and it returned to its original resistance, and we made that experiment a number of times to verify it. We also rigged up and put in service a loose-contact transmitter, consisting of a highly polished carbon pin leaning loosely against a highly polished carbon button, and we used that transmitter for three months constantly. At the end of three months we took it apart and there was not the slightest mark of any kind to be found at the point of contact, and we, of course, had been careful to use a low electro-motive power, a single cell battery, as would not burn the contact.

Now, in this last experiment, the electrodes had pounded against each other many, many millions of times, and there was no mark to show where they had pounded against each other.

But this theory meant nothing more or less than that the so-called loose-contact transmitter was, in reality, a species of liquid transmitter in which a gaseous fluid, the air, separated the electrodes. Where real contact began depended entirely upon the proportion of pressure to contact area; but, when once real contact was made—and it could be done very easily with a pointed electrode on one side—speech transmission became extremely difficult and ceased altogether with the application of even moderate pressure.

This theory also explained why carbon was such a good material with which to make the contact, because physicists tell us that carbon has, in an eminent degree, the property of condensing air or gases on its surfaces, which, therefore, helped the transmission of speech.

I had, then, invented and patented—and you remember that the patent was in litigation for many years—something, namely, a contact made by two electrodes, and the contact maintained during speech transmission, received therefore a patent for something which did not exist, and which, in fact, was to be avoided if you wanted to transmit speech. In other words, it was found that a contact, when it is a loose-contact, *was* no contact. It belonged, then, as Immanuel Kant would have put it, coming back to my premises, into the category of those imperative conclusions by means of which you can prove that something is because it is not, or which is not, because it is. Brother Kant's philosophy had at last become clear to my understanding.

Mr. Chairman, I thought it would be of interest if I related this incident in my connection with this science and put on record something of what passed through my mind at a time when I took a hand in the development of the speaking telephone. Because the time is not so very far distant when we, the older pioneers, will have answered the last call from that Greater Central Office, and future students of telephone history may then perhaps be enabled to perceive something of the mental atmosphere that pervaded some of the experimental work on which this adjunct to civilization, telephony, was founded.

THE DEVELOPMENT OF THE TALKING MACHINE

Read before THE FRANKLIN INSTITUTE, of Philadelphia, May 21, 1913.

To receive the commendation of the Franklin Institute in recognition of endeavors relating to technical or scientific developments should in itself be ample reward for satisfying the higher aspirations of the engineer. Those in particular who appreciate the high standing of the Institute before the world and the eminence of the men that are its leaders and compose its committees will always be profoundly gratified when they are favored by the awards with which the Institute vouchsafes its good opinion. Needless, therefore, for me to assure you how grateful I am because it has been my good fortune to labor in promising fields and because I was able to win your expressions of approval.

Nor is it the first time that the Institute has invited me here to speak in this hall. It was twenty-five years last week that I gave here the first public exhibition of the gramophone and read a paper describing its then short history and its processes.

On that evening of May 16, 1888, I showed in this auditorium how a voice could be etched into metal and, while the etching was being done, I rendered a program of songs, recitations and instrumental solos previously prepared which, crude as they were, presaged the possibilities of more perfect results for the future. These disc records, the first of their kind, were reproduced on a machine turned by hand and all of them were originals. One duplicate was shown and reproduced and this had been made by electrotyping an original sound etching in the same manner as an etched half-tone is electrotyped. It was, however, easy to foresee the vast possibilities of the invention and under the paragraph "Practical Applications" I ventured the following predictions:

"A standard reproducing apparatus, simple in construction and easily manipulated, will, at a moderate selling price, be placed on the market.

Those having one may then buy an assortment of Phonautograms, to be increased occasionally, comprising recitations, songs, chorus and instrumental solos or orchestral pieces of every variety.

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.

Languages can be taught by having a good elocutionist speak classical recitations, and sell copies of his voice to students. In this department alone, and that of teaching elocution generally, an immense field is to be filled by the gramophone.

Addresses—congratulatory, political or otherwise—can be delivered by proxy so loudly that the audience will be almost as if conscious of the speaker's presence.

A singer unable to appear at a concert may send her voice and be represented as per program, and conventions will listen to distant sympathizers, be they thousands of miles away."

On that evening the status of talking machines was as follows: The tinfoil phonograph of Edison had been known for ten years and was a scientific curiosity only, though of historic value. The wax cylinder phonograph or graphophone of Chichester Bell and Sumner Tainter had been invented and its aim as pronounced by its promoters was to become a dictograph for private and business correspondence. Both machines represented a system of sound recording in which sound waves were either vertically indented as in the Edison phonograph or vertically engraved into a wax cylinder as in the Bell-Tainter graphophone. In reproducing these records a feed screw was provided which turned either the cylinder past the needle or the reproducing sound-box past the cylinder.

The Gramophone changed all this. Its record was made horizontally and parallel with the record surface and by itself it formed the screw or spiral which propelled the reproducing sound-box, so that while the needle was vibrated it was at the same time pushed forward by the record groove, and as the sound-box was mounted in such a manner that it was free to follow this propelling movement it made the reproducer adjust itself automatically to the record.

I pointed out at the time that the horizontal record of the gramophone was better capable of recording sound in its entirety while in the vertical record of the phonograph-graphophone a certain distortion took place which became more pronounced the deeper the sound waves indented or engraved the record substance.

When I returned from this exhibition to Washington I set to work trying to develop a duplicating process which should enable me to make any number of records of the same selection in hard, wear-resisting material like celluloid or hard rubber. The first successful duplicate so produced was made for me in the same year in celluloid by Mr. J. W. Hyatt, well-known to you as one of the inventors of celluloid and this duplicate is still in exsitence (now in the National Museum in Washington), being the first sound record duplicate in hard material which was made by pressing a reverse of the original record into hard material while the latter was softened by heat, and then chilling it while still under pressure. This process is at the bottom of the present industry of making many millions of sound record copies annually.

The trouble I found with celluloid was that it was not quite hard enough for the gramophone system and I therefore turned my attention to hard rubber. After several years of experimenting trying to make accurate electrotyped reverses or matrices from original zinc records, so that the very surface, even to its microscopic details, should be copied, I finally succeeded, and with the help of a rubber company in the Middle West, to make large numbers of accurate copies from a matrix, and soon afterwards I launched the disc talking machine on the market.

By 1895 the invention was so far perfected that it began to gain many admirers by its simplicity and ease of manipulation. But it soon developed that many rubber records were imperfectly pressed and showed flat places, and the Rubber Company was unable to correct this part of their work and furnish a reliable output.

In this emergency I remembered an attempt made by the Bell Telephone Company in 1879, while I had charge of their laboratory, to substitute a shellac composition for the hard rubber of which their hand telephones were made and I got in touch with a factory that made electrical fixtures of such composition. I gave them a nickel-plated copper matrix of a record and the first copies they pressed from this matrix in shellac composition showed remarkable uniformity, and, moreover, because the material was harder than hard rubber, the reproduced sound was louder and more crisp. These composition duplicates proved at once a great success and ever since shellac composition has been used for making disc records, although recently attempts have been made to employ for them a substance like Bakelite.

As early as 1887 I had tried to make records by pressing a matrix into sealing wax and it is interesting to realize that these modern composition disc records are in reality seals of the human voice because the substance they are made of is a modified sealing wax, both containing shellac as a basic substance. Few people have a conception of the untiring efforts which have been made year after year, and still continue, in order to obtain a composition which will answer all the requirements necessary for resisting the wear of the needle or prevent the latter from being ground blunt too fast. If the material is too hard and gritty it will wear the point of the needle so that before the end of the record is reached the reproduction becomes weak or blurred. If the material is too soft the record groove will quickly wear rough and the record reproduction becomes scratchy. Shellac is much adulterated and the mineral and fibrous substances which are added require careful selection and this whole department is in the hands of experts who do nothing else all the year around but test the substances and the mixing processes which are employed for producing record material.

Of recent years Mr. Joseph Sanders of Washington, D. C., has perfected a record disc having a solid fibrous core which is faced on both sides with a very thin layer of shellac composition of a superior quality. Records pressed in such discs are remarkably smooth, and withstand climatic changes better than the others so that they may be sent to the tropics without danger of being affected by the combined heat and moisture which abounds in those parts of the world. Moreover, these discs are light in weight and have sufficient flexibility to successfully withstand careless handling and breakage resulting therefrom.

After the hand-driven gramophone had been on the market for a few years the company which had been organized for exploiting the invention secured the co-operation of Mr. Eldridge R. Johnson, now the president of the Victor Talking Machine Company. An able mechanician and of shrewd technical perception, Mr. Johnson succeeded in developing a motor-driven reproducing machine which ran with great regularity of speed, was readily adjustable and, last but not least, ran silently so as not to disturb the sounds of the record by its own noise. Such a motor machine had been made by a New York clockmaker as far back as 1891, but had not been quite noiseless at that time. Mr. Johnson also took note of the fact that the patents of Bell and Tainter covering the method of cutting a sound record in wax were approaching their final term of legal existence. He decided to take advantage of this circumstance and applied himself to the abandoning of the difficult etching process and of combining the much easier wax-cutting technique of the graphophone with the gramophone method of horizontal recording. He of course adhered to the automatic reproducing, to the disc form of record and to the method of duplicating discs by impressing an electrotype reverse or matrix into shellac composition under heat and pressure.

We strike here an experience parallel to that which occurred in the early development of the telephone when two independent systems—the magneto transmitter and reproducer and the loose-contact transmitter and reproducer—were combined to form a system superior to either alone, when the loose-contact was finally used as a transmitter and the magneto telephone as the receiver for telephonic intercommunication, the system which has been in use ever since.

In a similar manner Mr. Johnson took from the graphophone the recording in wax and added it to what the gramophone already had and thereby produced the modern gramophone also known as the Victor Talking Machine, Disc Graphophone, Columbia Phonograph and other trade names.

And the machine which hitherto had confined itself to popular musical talents, to low comedy, simple songs, cornet and clarinet solos and to military music, rapidly improved to such a degree that it began to appeal to grand opera stars, to the great masters of the piano, to the wizards of the violin, to symphony orchestras, to virtuosis on every kind of musical instrument and to celebrated actors and elocutionists. The gramophone repertoire expanded to comprise the whole gamut of audible phenomena and voice reproductions in particular became so startlingly perfect that big hotels and restaurants were able to have their orchestras accompany the great singers of the day as they appeared by proxy out of the horn of the talking machine.

The predictions made before this Institute in 1888 were being fulfilled even to the application of the gramophone to national politics. Last year the speeches of the three Presidential candidates were heard and reheard all over this country and the recognition of the individual voices, something I had noticed in the very first gramophone records, was one of the notable characteristics of these speeches. The speakers were present in all but their bodies; the proxies were complete.

And down in extensive fire-proof vaults, built by the big companies here and in Europe, and securely closed to all but a few trusted employees, are stored away the copper or steel matrices, the indestructible and precious legacies which the masters of song and performance are leaving to future generations. Their immortality is secure because the very air pulses which smote the ears and brains of their own generation are already being resurrected above the graves of those who have died.

What had in the meantime become of the cylinder machines? The graphophone or wax cylinder phonograph, true to its original program had developed into a most serviceable dictograph and it is astonishing how much time and trouble is saved by such a machine to the business manager, to the press reporter, and to the chief of office. Instead of calling for the stenographer, just when the latter is perhaps busy transcribing from her notes on the typewriter, the manager takes one wax cylinder after another and dictates his letters or orders to the lifeless machine. He may do so in his leisure moments, immediately as a thought strikes him, and when the rack of wax cylinders has been loaded with his dictation or orders, he rings for a boy who distributes the cylinders among the typewriters. These in turn place the cylinders on reproducing machines, and, with ear tubes over their heads and with nimble fingers on the keys, they transcribe from the talking record, now stopping to repeat a sentence, now taking notes of special orders with which the manager has interrupted his letter dictations. No time is lost in waiting; the strenuous life has permeated from the corporation manager to the most distant workers of his will and the high speed of modern machinery has a counterpart in those wonderful combinations of money and brains which grind out twentieth century enterprise in the steady flow of a rushing stream and as a continuous performance.

Thus does modern technical science in all its branches fill the pressing demands of an eager humanity even to overflowing. But a hand is raised in protest, and out from a misty past there looms up an ancient landmark of human history, an achievement of an earlier civilization. It is the Day of Rest, when tired brains turn to the woodland and the mountain stream, to green fields and meadows, and to the low song of birds, the chirping of crickets, and to the call of the whip-poor-wills, who decline to perform for talking machines and who, like some other ideals that appeal to the romantic within us, must be pursued before they will yield to us the rewards of their charms. Machines may give us talk and melody, light and comfort, speed, and even flight, but they will never give us life's poetry: and it is well that it be so.

The companies making cylinder machines soon began to observe that wax cylinders also contained possibilities as means of amusement and they set to work invading this apparently profitable field of application.

Their principal problem consisted in finding a proper process for duplicating from the original cylinder record. The best method appeared to be that of the gramophone, namely, make an electrolytic negative or cylinder matrix from the original record and use this as a mold for casting duplicate cylinders. Unfortunately, however, cylinder records do not lend themselves readily to such a process. To deposit metal on the wax cylinder was easy and the producing of a good negative or mold appeared to be a very simple matter because the wax record was simply melted out of the copper shell leaving on the inside a reverse of the sound waves. But having produced this mold and pouring into it a cylinder of copy wax it was difficult, and at first impossible, to separate the copy and get it out of the mold. So for a time they abandoned this method and developed a mechanical duplicating machine in which by means of a carefully mounted lever, having a tracing point on one end and a cutting point on the other, the record was transcribed from the original cylinder upon duplicate blank cylinders and this system was used commercially for a number of years with a certain degree of success.

However, the laboratories of the several cylinder factories continued experimenting with the electrolytic method and finally they produced a wax for casting the duplicate cylinders which on the application of cold would sufficiently contract inside the copper cylinder as to permit the duplicate to be slipped out. This obstacle having been overcome it was then found, however, that the matrix or mold did not represent the original record in all its perfection, but had lost in quality and surface because of the brushing with graphite necessary for making the original wax surface electrically conductive.

This difficulty was finally overcome by Mr. Edison through the development of a so-called process of gold molding. This consisted in passing a high tension current through a vacuum in which the wax cylinder record formed one terminal and a gold anode the other. Infinitesimal particles of gold are thereby transferred upon the surface of the wax record until it is entirely covered and it is then placed in an ordinary copper bath and a good thickness of copper deposited over the gold, after which the wax is melted out.

Such a mold is a perfect reverse of the original record and it enabled the Edison Company to place upon the market complete assortments of cylinder records in competition with the gramophone or Victor disc records.

While I cannot admit that such phonograph-graphophone records ever came up to the expectations of the most critical, they still satisfied thousands of people who appreciated the fact that, in reproducing these records of a softer material, they were not obliged, as in the gramophone, to change the needle with every record, since wax or even celluloid does not wear a needle like rubber or shellac composition does.

Of the many minds working on talking machines some presently turned to the very natural idea of producing records of the phonograph up-and-down system in disc form. This was not a new idea, but had never been developed. The advantages were obvious, because discs can be duplicated easier than cylinders and can be made in hard materials which could be more easily handled and occupied less space.

The first commercial discs with phonograph up-and-down recording were placed on the market by the firm of Pathé Frères, the well-known cynemetograph and film manufacturers in France. The method employed by this firm, however, was not the simple one of recording sound into wax discs and then duplicate by the same method as employed in the gramophone. Pathé, owing to some technical difficulties in direct recording, first recorded on a very large cylinder of about 12 inches in diameter after which they mechanically transferred this record to a wax disc by means of a system of levers, and from this disc they developed a matrix in the usual manner.

Recently, however, the Edison Company has been engraving phono-vertical records directly into a wax disc and then following the gramophone method of duplication. We have, therefore, on the market to-day, disc records not only of the gramophone type where the sound waves are of even depth and vary horizontally, but also those of the phonograph-graphophone system in which the sound waves are represented by corresponding variations only in the depth of the record groove.

On the theory advanced by me 25 years ago, that a vertical record must distort the original sound in proportion to the depth of indentation or cutting, we have then arrived at a point where a phonograph-graphophone or vertical record in disc form may closely approach the perfection of an horizontal or gramophone record provided the phonograph record is cut extremely shallow. In this condition, however, the record grooves cannot readily guide or propel the stylus and it requires a feed screw for propelling either the disc or the sound box. It has been tried to first cut a plain spiral groove, deep enough for propelling the stylus, and then super-impose at the bottom of this groove a phonograph-graphophone record, but this method has shown sufficient difficulties for preventing its introduction up to the present time. The gramophone type of talking machines still prevails and every year brings it closer to a fidelity in recording and duplicating which should satisfy the most exacting critics. The celebrated stars of grand opera would hardly entrust the keeping of their voices to any talking machine except they felt that the records represented their art in a satisfactory manner.

And such is the status of the talking machine at the present time. Considered critically the principal further advances should be the making of disc records in a material of the character of glass or hardened steel in which they would retain a polished surface indefinitely and which, on account of great hardness, would prevent the slightest loss in the most delicate vibrations recorded on the original disc. Bakelite would appear to be a promising substance, but it needs adaptation to requirements which escape the chance observer.

In the mere mechanical part of talking machines an electrically driven reproducing disc machine, generally introduced, would undoubtedly commend itself to a discerning public. Such an electrification of disc talking machines, by relieving the present hand organ energy, would make for an increase in esthetic enjoyment such as the promoters of talking machines are ever anxious to secure for their products.

Before closing this paper mention should be made of that very ingenious device, the telegraphone, developed by Mr. Poulson of Denmark. In this instrument telephone sound waves are made to record themselves as localized magnetic fields of different lengths and intensities in a steel wire, on a steel tape or as a spiral record on a steel disc. In the reproduction these magnetic fields, by passing in touch with a small electro-magneto, cause electric undulations corresponding to the original sound waves in the helix of this magnet. The circuit of the helix includes a telephone receiver which then emits the sounds originally spoken into the telephone transmitter.

Beautiful as this system appears to be, it suffers from the inherent fault that you cannot confine a localized magnetic field representing a sound wave as you can define a mechanical record of the same. As a consequence articulation is impaired because the magnetic halo of one wave superposes the halo of the next and this is fatal to those delicate overtones which form the essential characteristics of most consonants. To remedy this the liniar speed of the record was increased, but it then became cumbersome on account of too great length and it still showed losses in articulation because of the several electro-magnetic transformations which are embodied in this system.

Magnetic fields were long ago localized in the well-known experiment of writing with a magnet on a piece of steel and then strewing iron filings over it when the writing appeared as lines of iron filings which stuck to the magnetic tracings. The first who proposed to apply this principle to the recording of sound by fixing telephone undulations on a steel ribbon or wire and cause such a magnetic record to induce telephonic undulations by magneto-electric impulses and reproduce the original sound, was Mr. Oberlin Smith, now of Bridgeton, N. J., who published this idea in a prominent electrical journal several years before the advent of the telegraphone. Mr. Smith himself, however, did not carry the plan into successful execution and I do not know whether Mr. Poulson knew of the Smith publication when he took up and successfully completed the telegraphone.

The instrument remains to-day a beautiful combination of electrical and magnetic phenomena as applied to the transmission, recording and reproduction of speech, but its ultimate development into as perfect and practical an apparatus as the mechanical talking machines appears to be precluded by the existing conditions.

We have in one of our offices a photograph which one of our traveling salesmen brought back from a business trip to the trade centers in the wilds of Canada. It shows a giant lumberman reposing placidly on a rough bench in front of his crude log cabin. Nothing but forest and mountains surround him. His axe and his shot-gun lean against the cabin within easy reach, he is smoking his pipe, and his faithful dog crouches at his feet. His nearest neighbors are miles away and in days gone by the solitude of his existence would have been but rarely relieved by diversions or pleasures, and then only by occasional visits to the centers of supplies, where bar-rooms, gambling dens and low dance halls satisfied his yearning for a change from his laborious daily life.

But now there stands in front of him a rough dry goods box and on it he has placed an old-time horn gramophone and a stack of disc records. The concert halls, the vaudeville and opera houses of the world are represented in that pile, English statesmen and American Presidents may talk to him as if face to face and he can entertain his occasional visitors with the same choice selections that are heard in the drawing rooms of mansions occupied by the favored few, be they of the capitals and metropoles in the far away.

We framed that picture and wrote under it the words: "In Touch With Civilization."