SOME RECENT ADVANCES IN TELEPHONY.

BY THOMAS D. LOCKWOOD.

TEN years ago a meeting of the American Academy of Arts and Sciences was held in Boston, at which Alexander Graham Bell expounded his ideas upon the electric speaking telephone.

Prior to that date, a patent had been issued to the same gentleman upon the same subject; a patent which many persons state they have since ascertained refers in no way whatever to the speaking telephone; a statement which many other persons, perhaps equally well informed, believe to be based upon a wish that such were the case.

The first line built between two distant points expressly for telephonic transmission, was completed April 4, 1877, and extended from the office of the electrical manufacturer, Mr. Chas. Williams, Jr., 109 Court St., Boston, to his house in Somerville, a distance of about three miles.

May 1st, 1877, the first lease of telephones for private line service was effected; and in May, 1877, telephones were first operated upon the exchange plan, through a switch board in the office of Mr. E. T. Holmes, 342 Washington St., Boston; the sub-stations comprising a number of different offices connected with the Holmes burglar alarm system by wires converging to Mr. Holmes's office. For a number of years it was assumed that the exclusive field of usefulness for the telephone, like that of the average and proverbial specimen of charity, not only begun, but also ended at home; that the local short line, or exchange service, was the only kind in which telephones could, or would be practically used. Recent experience proves this assumption as hardly correct. The exchange, or central office service, it is true is the more immediately practical and obvious utilization, and it was natural that the American people should measurably fill that sphere of action before looking for others, inasmuch as that was the line of operation promising the most speedy pecuniary return for the outlay. Lines of from a few yards, to a dozen miles in length have, however, been connected with exchanges, and these have in turn been supplemented as occasion served, by what are technically termed extra territorial lines; that is lines connecting different exchange centres; and from 1879 to the present time it

has been a regular practice to talk over such lines with comparative ease, perhaps for an average distance of 40 to 50 miles. In some of the western states it has been a common thing to converse by telephone over much greater distances, by switching lines together, but not always with ease.

I think it well understood now that three conditions have conspired to retard what is at present termed long distance telephony. These are:

(a.) The uncertainty of obtaining satisfactory and speedy reciprocal communication, and the consequent slowness of transmission together with the inevitable result of such uncertainty, namely, the low prospective maximum capacity of remunerative transmission.

(b.) The extreme noisiness of long lines, and increased telephonic induction, or cross talk, which in many cases renders the single or earth terminal circuit insufficient.

(c.) The lack of transmitting instruments sufficiently powerful and trustworthy to develop voice currents capable of overriding the undesired currents and the noises produced thereby, and of sufficient E. M. F. and volume to affect the distant receiver with clearness and strength.

If it be asked at the present time "what is long-line telephony?" I answer—"Telephonic communication over lines more than 50, and less than 500 miles long." Six years ago I should have limited it to lines between 20 and 50 miles long; and six years hereafter I may possibly fix the limits of long-line telephony between 250 and 1,500 miles. The term is purely comparative.

The most noteworthy advance of the telephone in the past few years has been in the direction of increasing the distance over which communication can be transmitted satisfactorily, and the advance which has been made is, I think, undoubtedly attributable to the introduction of copper line wire, and to the radical improvement of the transmitting telephone.

It must not be supposed that telephone communication over long lines was until recently entirely unknown, even when we accept the above definition of a long line.

On the contrary, it is a well authenticated fact that in the earliest days of the speaking telephone, time and space were well nigh obliterated.

In the remote period when the magneto speaking-telephone

was the only known—and was itself a new and wonderful thing—it was operated over lines of (for that time) really considerable length. On August 11th, 1876, for example, conversation was carried on at Brantford, Canada, over five miles off, between Brantford and Mount Pleasant, and on the succeeding day the length of line was increased to ten miles.

As early as November 10th, 1876, a very long line was successfully used. I find among the early records of telephony the following statement: "November 10, 1876. "We carried on a long "conversation on the lines of the Eastern railroad, using part of "the time a circuit from Boston to Salem, 15 miles; and part "of the time a circuit from Boston to North Conway and back to "Salem, and from Boston to Portland and back, about 200 miles "of actual wire."

This statement is made by Mr. Watson, (who like De Sauty, was long supposed to be a supposititious character, being always at the other end of the line) and is noticed in the *Boston Post, Globe, Advertiser* and *Herald* of November 27, 1876.

In the early spring of 1877, with a box and magneto telephone, Mr. Bell in New York, conversed with his associate in Boston on a Sunday, and he speaks of the occasion in the following words:

"The longest length of real telephone line through which I "have attempted to converse has been about 250 miles."

"On this occasion no difficulty was experienced so long as "parallel lines were not in operation. Sunday was chosen as "the day on which it was probable other circuits would be at "rest. Conversation was carried on between myself in New "York, and Mr. Thos. A. Watson in Boston, until the opening "of business upon the other wires. When this happened the vocal "sounds were very much diminished but still audible."

"It seemed indeed like talking in a storm. Conversation, "though possible, could be carried on with difficulty."

There are in fact a number of such isolated cases and I have thought proper to refer to these as showing that the idea at least is old, and that the magneto telephone is not an utterly incapable instrument, even viewed as a transmitter. There is, however, a wide gulf between an occasional successful experiment, made under favorable conditions in which experts can understand one another, and regular every day successful commercial communication.

If by recent developments this gulf has not been permanently

and solidly bridged, there has at least been a convenient and useful ferry established.

Before leaving the early years of the telephone, it may amuse, if it does not instruct, to refer to an item which appeared in the *Scientific American*, on November 29, 1879, entitled "How far can we hear with the Telephone?"

"This is a question frequently asked, but one which we believe has not yet been definitely settled. The longest distance that we have seen mentioned, is given in the item below, namely, two thousand miles. But perhaps Mr. Edison has had more extended experiences. If so, we should be glad if he would let our readers know. An exchange states that Mr. Robert A. Packer, superintendent of the Pennsylvania railroad, is at present hunting with a party of gentlemen in Nebraska. A few days ago he for two hours conversed pleasantly with his wife and friends at Sayre, Pa., his brother at Mauch Chunk, Pa., and his friends along the line. The medium was the railroad and Western Union Telegraph wires, and Edison's telephone. At the office in Bethlehem, Pa., connection was made with the Easton and Amboy wire, and at Perth Amboy with a Western Union wire and thence to Chicago and North Bend, Nebraska, where the party are. The distance was about two thousand miles and every whisper was audible."

Now if there is anything in the world that annoys one, it is to hear an apparently trustworthy account of something being done in one's own special line of work which, with every appliance for the purpose, with experience and special education, we cannot do ourselves. It is not therefore speaking too strongly when I say that this statement both mystified and exasperated me, for I knew certainly that at that time I could not accomplish such a feat; but I possessed my soul in such patience as I could make available and awaited developments; having at least a suspicion that there might be an error in fact, seeing that the veracious chronicler had already committed himself to the statement that Mr. Packer's business relations were with the Pennsylvania railroad instead of the New York and Pennsylvania Canal & R. R. Co., as it should have been. I had not long to wait however. In the issue of December 27, 1879, a second item appeared entitled "Long-Range Telephoning" (I think the original one should have been called "Long-Range Reporting,") which read as follows:

"In a recent issue of this paper an exchange was credited

“with the statement that Mr. Robert Packer, while traveling in Nebraska, had conversed with his wife and friends at his home in Sayre, Pa., two thousand miles distant, by means of a telephone. We now learn on good authority, that though Mr. Packer’s friends received his communication by telephone it was not so sent by Mr. Packer. The message was sent from Nebraska to Mauch Chunk, Pa., by telegraph; thence it was telegraphed to the Sayre office of the Pennsylvania Canal Railroad Co. (of which Mr. Packer is superintendent), and from there it was transmitted to Mr. Packer’s house by telephone, falling short of the newspaper report of the telephone’s performance by some nineteen hundred and ninety-nine miles and a fraction.”

Such is a sample of the long-range telephony of 1879.

When in the summer of 1879 a telephone line of two wires was built between Boston and Lowell it was regarded as a great achievement; for it worked well. It, however, opened our eyes to the phenomenon of induction in another phase to that in which it had heretofore been made manifest.

That phase in fact which in more recent times has been named “cross-talk.” We found that when conversation was transmitted upon either wire, it would be heard equally well upon the other at the receiving station, and until many other lines were built, it was found practically impossible to operate both lines at once.

This was the beginning of lines to connect distant telephone exchanges and the seed from which sprouted the long-line telephony of to-day. When, however, the value of copper as a material for line wire was recognized, the commercial feasibility of long-line telephony, as above defined, became a subject of serious consideration, and exchanges located 75, 100 and 150 miles apart, were brought into conversational proximity.

The possibilities of the telephone were never brought before my mind in so striking a manner as when I stood in a little room on Broadway in this city, and talked with a fellow mortal in Cleveland, Ohio. Many of the members of this Institute will, doubtless, remember that when the compound wire of the Postal Telegraph Co. was built, and communication over it completed in 1883, first to Cleveland, and later to Chicago, a noble army of telephonic patentees hastened to try their patented telephonic receivers and transmitters over it, and how each and all, after successfully exchanging words with the western cities, went forth

proclaiming to the world the unparalleled excellence of their special form of telephone.

When I first heard these statements I was firmly convinced that the achievements described, were due not to any special excellence of the instruments employed, but to the greatly superior conductivity and insulation of the Postal wire over any other that had heretofore existed, and my conviction was intensified after I had had an opportunity to make the test myself and had found that, not only could we make a Blake transmitter transmit speech which was perfectly reproduced at the receiving station, but that identical results could likewise be achieved with the magneto Bell telephone commonly used as a receiver.

To Mr. Thomas B. Doolittle, of Bridgeport, is due the credit of having first discerned the merits of copper as a material for telephone lines. A line of hard-drawn copper was erected by that gentleman in November, 1877, in Ansonia, Connecticut, a section of which was taken down in August, 1884, and found to be, when compared with any iron wire of like age, in an excellent condition. I may also say that from the first moment of my acquaintance with Mr. Doolittle, I have found him a strong and persevering advocate of copper wire for telephone lines, and, considering our present views upon the relative merits of iron and copper, it is fair to say that I think he has made out his case and was considerably ahead of the times. My own fear was that it would prove too soft for common use, would not stand up, would expand under increase of temperature and would fail to duly contract upon the resumption of normal temperatures. I had no doubts of its electrical merits.

The Postal wire, however, was electrically so far ahead of all expectation, telephonically considered, that it seemed to prove once for all that copper, if mechanically available, was decidedly the proper material to use, and it seemed also evident that if it would stand up alone it would be even more successful as a conductor, if the steel core were dispensed with.

Hard-drawn copper wire was tried after being submitted to the various electrical and mechanical tests, and was not found wanting. In fact, it promised well, and the result was the erection of an experimental line of two wires between New York and Boston, which worked satisfactorily, and with sufficient reliability to encourage its proprietors to build a line of a number of copper wires between New York and Philadelphia.

The experience gained in building, testing and operating the Boston line has been utilized in the more recent one, which is a model line in many respects.

When we began to use copper for this purpose, it was not easy to account for the comparative ease with which a line built of that material could be operated. It was attributed by many solely to the low specific resistance of copper, and I recollect instances where I have commented upon this remarkable point and have been met with the remark, "Oh, it is only a question of resistance." But it was obvious that there was some more deep seated reason than the low specific resistance; for, if we take two lines of equal resistance, one built of copper and the other of iron, the copper is invariably by far the easiest one to work.

This was, I confess, for a long time a problem to me, but has recently been wonderfully cleared up, by the masterly researches of Professor David E. Hughes, as detailed in his inaugural address, lately delivered before the Society of Telegraph Engineers and Electricians; with which every electrician interested in the communication of intelligence should familiarize himself.

His experiments showed that the *E. M. F.* of the extra current, in a solid iron wire is much greater than in a similar copper wire; that ordinary iron wire has, with rapid currents, more than three times the resistance during actual work than that supposed to be its resistance (although with standard iron and ordinary copper such is not the case), and that the extra current in wires furnished with a parallel return wire is much reduced, but much more in copper than in iron. Iron 15 per cent. and in copper 80 per cent.

It is also interesting to learn that the *E. M. F.* of the extra current in brass wire, compared with copper, is but as 13 to 20. This point may prove useful when a wire, stronger than copper, but of equal size, is at any time required.

These researches are so interesting and valuable that they gratify me nearly as much as though I myself had made them. I am aware that the statements of Prof. Hughes have been severely criticised by Prof. Weber and others, as was to be expected, but I am persuaded that his results will, in the main, be ultimately approved, and his views acquiesced in by the world of science; although it is very probable that some errors of detail may be found in them.

Approaching now advances made in instruments, I may say

that it is noteworthy that nearly every improvement has been made in the transmitter. There are two good reasons for this. The first being that the receiving telephone came into existence well nigh as sensitive and perfect an instrument as it was possible to make it; and the second, that in view of the noises, made apparent in the receiver on long lines, due to undesired currents, it was manifest that the transmitting power it was that required intensifying, to the end that it might be able to develop currents of sufficient strength to override the disturbing currents, and that if a transmitter of sufficient power could be made, it was even possible to reduce the sensitiveness of the receiver, and thus weaken the disturbing noises by thickening the diaphragm, or by removing it to a greater distance from the magnet. The form of transmitter which has been found most successful is one in which granulated carbon in a loose and free state is employed as the current regulator. When first introduced it consisted simply of a handle, having a disc-shaped cavity cut in its face, the bottom of the cavity being faced with some suitable metal or alloy as copper, silver or brass.

The front of the chamber was closed by a piece of platinum foil, which served as a vibrating diaphragm, and the sides of the chamber were formed of the same non-conducting material as the body of the handle itself. The space between the back and front plates was partly filled with the carbon granulations, and the front plate protected by a mouth-piece. The instrument was then complete, and, though exceedingly simple in construction, worked, and worked well. When in use it was most efficient when held so that the diaphragm presented an angle of about 45 degrees from the vertical position, the upper edge being inclined backwards.

When this instrument was good, it was "very, very good," and like the little girl of the nursery rhyme, when it was bad, it was "horrid."

It had one grave fault, the granulating powder would occasionally pack itself into a mass, and was then anything but as sensitive as it should be; under such circumstances it became a very poor transmitter. The customary remedy for this disease may be indicated by the familiar words of counsel, invariably found upon the apothecaries label, "When taken, to be well shaken," and, when shaken, the sick transmitter would usually resume its duties. But an ounce of prophylactic is better than a pound of

medicine, and the want was decidedly a transmitter equal to the Hunnings, but which would not pack.

The first step was the adoption of a horizontally mounted diaphragm, the speaking tube of which ended opposite to the lower face, and it was found that when the carbon granules were placed on the upper surface of this plate, the voice vibrations acted upon them with great force, and tended to loosen them if packing had begun. This was not; however, completely satisfactory. It was subsequently ascertained that the back plate should, to obtain the best results, be buried in the mass of carbon which lay on the diaphragm, or should dip into the same in the form of a pendant, and that the resistance of the entire instrument should be reduced as much as possible.

The most noteworthy, embodiment of these principles (or more properly speaking of the first of them) employs for the complementary or back electrode, a metal sieve, which is buried in a mass of granular carbon. In another form the back electrode takes a form something like that of a shade roller pulley, and has a number of holes bored through it in different directions, so that the carbon granulations can freely circulate. In both cases it is found advantageous to plate the electrode with some unoxidizable metal—such as gold; and to form the diaphragm as in the original Hunnings instrument of platinum foil.

One of the circuit wires is united to the diaphragm, the other to the back electrode, and the mass of granulated carbon lies upon the former with the whole or a portion of the latter immersed, or buried in it. These transmitters give admirable results. The tone, volume of sound, and clearness of articulation developed by them is most encouraging, and by their use the range of long-distance telephony has already greatly expanded even on long, single iron wires. The distance that they can be efficiently operated has not even yet been authoritatively ascertained, but, judging from the fact that instruments of the most inferior character can be made to maintain successful conversation between New York and Chicago over a compound wire, we are encouraged to believe that conversation can be easily transmitted over much greater distances than that by availing ourselves of the most improved forms of Hunnings's telephone. It is well known that long telephone lines are greatly troubled by the noises manifested in the receiver; these noises being due to magnetic or current induction, leakage from other wires, atmospheric and

earth currents, and magneto-electric currents induced in them when they are blown about, and thus made to move across the magnetic lines of force of the earth.

It has been found necessary in order to reduce these disturbances to a minimum to adopt an old laboratory expedient, and to provide each line with a wire return as nearly as practicable equidistant with the direct wire from all known sources of disturbance, so that the disturbing currents, proceeding in the same direction on both sides of the circuit, will neutralize one another. But when we take such a double wire we find that it is not easy to preserve its benefits, and at the same time to connect it with a short exchange line at both ends, for, if we take a parallel wire metallic circuit trunk line and connect it with a short subscriber's single wire line by absolute contact, as in drawing A, it is obvious that we have lost the basis of neutralization, and only gained a conductor of lower resistance.

There are two plans from which we may choose. We may run a double wire to each subscriber wishing to use the long line facilities—as in drawing B—in which case the problem is at once solved; for, when we unite the two terminals of the subscriber's short loop line with the two wires of the long trunk line, we have simply extended the said trunk line half a mile or a mile, or whatever distance it may be further.

This plan, however, presents some disadvantages, in that it necessitates a double wire for each subscriber's line, and the concomitant changes in apparatus at the central station; and it is, after all, rather an inordinate expense to incur, when the subscriber may possibly only use the long line once a month.

The alternative plan is to employ repeating translating coils. These are really induction coils of peculiar construction, the two circuits of which are made much nearer each other in the size of wire and resistance than is usual in the ordinary coil.

One of these circuits—that which is composed of the finest wire, and which is wound to the highest resistance—is connected in circuit with the two ends of the long metallic circuit trunk line, while the remaining coil has one terminal, united to the single central station end of the subscriber's line, and the other attached to a ground wire. This arrangement is shown in drawing C, in which one terminal of the local side of the coil is represented as being united with a button switch, by which it may be connected with any desired subscriber's line. The beneficial re-

PLATE A.

PLATE B.

PLATE C.

sults of the neutralization of the disturbing currents are thus obtained, these being at least minimized by means of the return wire; while the telephonic currents induce currents of like character in the coil which is in circuit with the shorter and local line, thereby reproducing the transmitted speech in the receiving telephones connected therewith.

The reason for making the two circuits of these translating coils so much more nearly equal in character and conductivity than are those of the ordinary induction coil, is that each is in turn the inducing and induced circuit—that is, the conversation is transmitted from the long trunk line to the short subscriber's line, as well as from the short line to the long metallic circuit. Each is, therefore, required to exercise the functions of both primary and secondary coil. I have every reason to believe that the first instance of the use of an induction coil in this capacity was by Mr. Thomas Watson and myself, in September, 1879, immediately after the completion of the two lines between Boston and Lowell.

We used the two lines between the cities as a trunk metallic circuit, and by means of two induction coils, one at each end, two exchange lines were inductively connected with the main line. I operated the ground circuit at Lowell, Mr. Watson engineered the induction coil at the Boston exchange, and Mr. Theo. N. Vail was at his own office in Boston, and talked with me through two induction coils.

The coils we then used were wound with both circuits approximately equal, about 250 ohms each, and were wound together from beginning to end, two wires being wound on the spool at the same time, a mode of construction which, by the way, experience has, I think, demonstrated to be the most satisfactory for inductoria intended for this purpose, and which will probably be adopted.

It is proper to note that we were led to this idea by considering the mode of using the transmitter induction coil, which was even then well known; this use, however, though analogous is not identical, for it must be remembered that in the transmitter coil the iron core is maintained during action in a state of magnetic polarization by the battery currents, whereas the currents, traversing the surrounding circuits of the translating coil, have not sufficient strength to effect such a state in the core, and the induction in these coils is, therefore, almost entirely current induction of one of the coil wires upon the other, the magnetic reactions

between coil and core being necessarily trifling in character. The induced effects may, however, be intensified by separately magnetizing the core either by a separate battery coil or by a permanent magnet, and I have sometimes done this with advantage.

A third plan whereby the double line may be conveniently connected with any one of a number of short grounded lines, without depriving it of any of its virtue, has been patented by Mr. Geo. H. Bliss.

PLATE D.

This is indicated by the drawing D. It consists in extending from the central station an additional line wire, which may branch into as many sub-stations as are intended to use the long double wire trunk line. Each of these sub-stations may be fitted with a button switch which, when turned in one direction, will retain the telephones in their ordinary ground circuit, but which, when turned reversely, will disconnect the subscriber's line from its ordinary earth terminal and unite it with the branch from this extra circuit, thus providing a double, although not a parallel, wire between the central and sub-station, both ends of which may be then united with the two ends of the metallic circuit trunk line.

One extra wire of somewhat abnormal length is thus enabled to serve in place of a great number. It would be easy to fit the telephone call boxes with a double gravity switch and two separate telephone receivers, one on each side of the bell box, and to so connect these switches with the circuits that it might be invariably understood that when the receiving telephone on one side is taken from its place and used, the line would be used in its normal condition, but that the other telephone, when taken up, would connect itself and the transmitter in the loop circuit. One could then be always used for short line and the other for long line work. I am very favorably impressed with this, and do not believe that it has yet had the trial it deserves.

I am conscious that this paper already is too long. I may not, therefore, on this occasion describe at length the specialties in switching and signaling appliances which have been found necessary, and have consequently developed in the practice of long-line telephony, but hope either to say or listen to something of this branch at some future time.

I have, I think, said enough to prove that long-line telephony is a reality, the *New York Times* on contract obligations to the contrary notwithstanding.

MR. LOCKWOOD: I might perhaps say a little upon another recent advance which has been made. It has been found that a great many telephone companies have not been able, in operating small exchanges, to get satisfactory remuneration, and it has been quite a problem with telephonic electricians to provide some simple system whereby any subscriber could readily connect his own line with any line of the system at pleasure and call up the subscriber himself. I am aware that there are a number of so called automatic exchanges developed especially on paper, but the result of nearly all such schemes is that any person trying to operate them, and any inexperienced person especially, is almost sure to connect himself with some undesirable party. It works all right on paper and sometimes it works right in practice. It is very easy for an electro-magnetic ratchet to make a slip of one tooth, and one tooth makes all the difference in the world when it comes to connecting telephone subscribers. Then when you have connected with the proper line, you must ring up your correspondent and the very act of ringing him up will be very apt to start the machine again and while you are ringing up one you are liable to connect yourself with another. In a small village

they can stand thirty subscribers at a reasonable price, and one plan is to divide the thirty into six lines of five subscribers each; each line runs to all the subscribers, while its own subscribers are the only ones that have a signal bell connected. For instance if this were number One it might run to station number One, it might have a bell magnet at Two, another one at Three and so all the way through. (Illustrating on the blackboard). In addition to that, each line runs by a loop or branch into every other station. This one in addition to its signal bell will have a spring-jack containing means for introducing telephone instruments, so that he may if he pleases connect his instrument with number Four. The better way is to introduce the instruments right in, instead of having a branch. Here is a card which tells him the signal for every office on every line. If he wants to ring No. 30 or 32 he simply rings that number and he at once gets it on his own line, while the act of hanging his telephone will restore him to his normal condition. There is such a system as this in operation at Leicester, Massachusetts, with the addition of a trunk line which runs to Worcester some six or seven miles, and there is an automatic clock arrangement which can be started up from the office at this end or from any one of these offices and each has an arm running around which successively connects the long trunk line with each one of the other lines and any of the stations on any of the other lines may stop this line at any point they wish. It works very fairly in practice. But the trouble which is developed is not one of operation but is one of original expense; that is that in such a place as Leicester, Massachusetts, where a system like this would be a benefit, the people taking telephones are physicians and large store-keepers and gentlemen of means, but when it comes to the gentlemen of means they are usually straggling a long way off from the people they want to talk to and it doesn't take long to make the expense of running loops and branches equal to the expense it would be to have a competent operator at the central station. I think myself the better way would be to put some fifteen or twenty telephones on one line and if a first class individual signal can be procured, give each one an individual signal, so that any one of the stations could be cut in at pleasure either from a sub-station or from the central. But the individual signals are one of the hard nuts of telephony, and while there are to my certain knowledge one hundred and twenty-five patents on the subject I fail to realize

that any one of them has gone into successful operation as yet. (Applause.)

THE PRESIDENT: I suppose we can hardly expect that any one here would be able to add a great deal to what Mr. Lockwood has said on this subject which he is perhaps more familiar with than any other person in the country, but there may be some who would like further information about it, or who desire to ask questions and perhaps make some remarks and we would be very glad to hear from them.

THE SECRETARY: I noticed the other day an extract from a Waterbury paper, saying that there was a movement among the manufacturers in the Nangatuck Valley, to dispense with their warehouses in New York and do the business at the shops. It occurred to me at that time that possibly the introduction of this long-distance telephony might have something to do with it, as I understand that some of those firms have made arrangements with a "long-distance" line between New York and Boston, to do their business during a period of two half-hours a day or something of the kind. I would like to inquire whether this is the case and whether they have got it to such perfection as to do their business and dispense with their warehouses in New York. Holmes, Booth and Haydens, I believe is one of the firms.

MR. SHELBOURNE: In answering the question, so far as I am able, of Mr. Pope, I would say that there has been in this city for a year or two, a company that is doing long distance talking between Connecticut towns and New York city, and they have an arrangement of their wires by which they connect with the principal warehouses here—connect their warehouses with the factories. For instance, they give Holmes Booth and Haydens, or the Ansonia Brass and Copper Company, a certain interval of the day in which they can have the wires exclusively for their factories and they connect them on their iron circuits. They have, I believe, one copper circuit. In favorable weather and under favorable conditions they also use some of the iron circuits—metallic circuits.

Now, of course, that is a mere question of commercial advantage. If they can dispense with their warehouses here and do their business direct with their customers through these telephone wires, that is a question for them to determine.

In connection with this service in Connecticut, an induction coil of my invention, of peculiar construction, has been in use for

some months, and that brings me to that branch of the subject that was quite elaborated by Mr. Lockwood. He spoke of the induction of parallel wires in such an induction repeater. That certainly is the case under the conditions in which he represented the matter. Some couple of years ago I conceived this way of overcoming that difficulty. I employed a core made of small soft iron wires bunched, about two and a half inches long and about a half inch in diameter. Of course when we come to the high induced current that we find upon the line in telephoning, we know that it has very little effect, because the quantity of current is not there, and the intensity does not produce that effect in the core which we might expect from a primary current in the same wire, and therefore the effect is principally due to current induction between the parallel wires. I am aware of Mr. Lockwood's efforts in that direction, and I am aware also of his use of wires for the induction repeater, one of which is somewhat larger than the other, making what is called the primary, and having in parallel circuit with it, around the core, a smaller wire, which, perhaps, may be called the secondary; but the winding of the large wire stops short of the end, and the smaller wire forms what is called an additional secondary over the large wire. Now I find that the best results, I think the best possible results—I may be mistaken in that, because we do not know what is possible in these things—are produced by having the wires exactly of the same size, so that the induction repeater is made entirely reciprocal, and to get the best possible effect out of the cores, instead of having one core, I have the cores in pairs, and these two wires are wound entirely as one, parallel of course, with the ordinary silk-covered insulation, to a very moderate extent around each of the cores, so that all the current you do get into one of the wires, which we will call, perhaps, for the purpose of illustration, the primary or the induction-giving wire, produces its best effect with a very small thickness around the core. Then the cores are associated with each other, and the spools containing these parallel wires are placed on ends, so that the cores will have the north and south poles adjacent. Then the wires being connected with the posts of the instrument, the two spools, if there is only one pair, are associated with each other, the one with the north pole adjacent to the south pole of the other, and the two are enclosed in a soft iron case or box, but before that is done a plate is put upon the base of the instrument, a soft iron plate, but

which is separated from metallic contact with the cores, and in putting the cover upon the oval box, the covers forms a soft iron plate at the top; the whole is fastened together by a brass rod, screwed down through the base of the instrument. Such an instrument as that has been used for months, as I said, in connecting with those Connecticut towns, and working between those towns and the subscribers in New York, such as the Ansonia Brass and Copper Company. It has also been used experimentally between New York and Boston. Of course the lines of force that emanate from the cores produced by the induction-giving circuit are, in such an instrument as that, condensed, and they are made to cut relatively the wires around both the cores. Now the question arose in connection with this instrument that, whether using it in connection with a metallic circuit between exchanges—Mr. Lockwood has very happily explained the advantage of a metallic circuit in avoiding induction, and also the necessity of having the wires associated, so that their induction-giving and induction-receiving effects would be from the same line and distance in space—such an instrument put in the exchanges at either end of a metallic circuit thus arranged, would repeat the voice from a subscriber inductively at one exchange, however distant, within working limits, to a subscriber connected inductively with the other exchange. But in presenting and testing this instrument in this city connected between metallic circuits, (although they were not twisted together) and ground circuits at either end, the question was suggested by the vice-president of the Metropolitan Telephone Company, whether it were possible to ring up the subscribers inductively through such an instrument as that. Well, I said that was a question I could not answer. So in connection with the electrician of the Commercial Cable Company, although we could not get the battery which was in use with the pole-changers in the exchanges because they were continually in use, we put up the same kind and amount of battery used upon the single trunk line circuits here in ringing up subscribers at either end. That is, we found in one exchange two gravity cells for quantity and ten for series, making twenty cells, and without the advantage of the pole-changers and through the ordinary magneto, we found, that this induction instrument would operate perfectly, that is, we could ring up the subscribers from a metallic circuit with the same effect as we can now through a single trunk line.

In regard to the two limbs of the metallic circuit, not giving

induction from the same distance—the experience of the countryman referred to by Mr. Lockwood is not altogether unique, for I could mention here some persons who are considered pretty well up in electricity, who started a line in Ohio in the early experience of telephony and that same question arose. In connecting Cincinnati with some other towns they did the same thing, they got up a round detour circuit, and the question was, how it was they did not avoid induction. Of course the thing is explainable very easily. You may run a metallic circuit around in a circle and you may get more induction, as Mr. Lockwood has said, than if you had a ground circuit.

THE PRESIDENT: There was one point I did not quite understand from Mr. Lockwood's paper. I would like to ask whether the variable resistance of the transmitter is in the same circuit with the primary of the repeating coil, or whether it works on an induction coil in the transmitter as usual, and that coil works on the repeating coil, so that there are three induction coils in the circuit.

MR. LOCKWOOD: The transmitter is fitted up with its own low resistance primary coil, and the secondary current repeats itself through the translator. There is little loss through the translation except at first. There is certainly a small amount of loss with this translation, but nevertheless the system will be practicable for commercial use. I can corroborate what Mr. Shelbourne says—it is very easy to ring a bell even through the two induction coils; even by simply making a break in the original battery circuits the impulse is reversed.

MR. SHELBOURNE: Our experiment was successful without the pole-changer, because we did not avail ourselves of that.

THE PRESIDENT: I might remark in reference to this question of the loss in conversion in the induction coils, that some experiments that I have recently witnessed in another branch of electrical work, which it would not be proper for me to give the particulars of at present, showed that with a properly constructed induction coil the loss in conversion is exceedingly small, so that I think there is good reason to suppose that by further researches some particular form of induction coil or mode of construction may be found in which this loss by conversion may become very trifling. Probably it will not be sufficient to be noticeable unless there are quite a number of transformations—quite a series of them. I should think from what I have observed in this matter that it is probable that the loss in three

conversions could be brought down within ten or fifteen per cent of the total effect.

MR. JONES: It would hardly be in keeping with the intelligence of the members to make any reflection upon the ability with which Mr. Lockwood has dealt with this subject, but of course after a good hearty dinner we want a little charlotte-russe, and I suppose it is the duty of each one of us to contribute to this subject while it is under our consideration. I happened to use the two first instruments that Mr. Gardiner G. Hubbard took to the west, and made the first experiments on them I believe early in 1877, and we talked readily two hundred and forty miles, and a distance of twenty miles regularly every Sunday. We put them all in circuit in a room, having a piano and a flute and an accordion, and different instruments, and had them all going at once, and somebody talking at the other end, and we could get the whole menagerie right there. We got up a musical telephone at Cincinnati, which you know is about three hundred miles off, and we were able to produce these musical sounds in one of these box relays to perfection. The Governor and Secretary of State, and all the electricians round about for miles, came around and heard it. We had a little cigar box with a slit in the top, into which they dropped a nickel, which started it; and I believe we made enough money to pay the expense of the scheme. We called up the chief operator and asked him to connect Cincinnati and start the musical telephone. By means of a button under the counter we set it going. We had a little music box inside. (Laughter.) As to the other scheme they had out there, I don't know how well it worked. I know I was in Chicago at the time and had charge of the office, and if any such conversation went through the office it was when I was sound asleep.

In regard to working circuits with a great many instruments in, we tried in the early days in Chicago to consolidate them into one line, and by putting a little coil of resistance around the electro magnet or receiving instrument, we rendered it less opaque to the voice vibrations than if they had travelled all around the convolutions. Another plan we had was to split the relay. I think that is all I can contribute to the subject.

THE PRESIDENT: If there are no further remarks to be made, we will proceed with the next paper, which is on the subject of "The Patent Office and Patent Office Practice," by Mr. Fowler, formerly one of the examiners.