opportunity of informing the meeting that it is intended to have a special telephonic night towards the end of this month, if it can be so arranged without inconvenience to the Institution of Civil Engineers, to whose kindness we are indebted for the use of this room. On that occasion Dr. Blake's paper will be discussed, together with other matters of great interest connected with the telephone.

The vote of thanks to Dr. Blake was unanimously and very heartily carried.

The CHAIRMAN: I have now the pleasure to introduce to the Society Mr. Frederic A. Gower, who will read a paper on the same subject, under the title of "The Telephone Harp," and the instrument to be shown is of his invention.

THE TELEPHONE HARP.

Mr. GOWER said: Mr. President and Gentlemen of the Society of Telegraph Engineers: It seems especially fortunate or especially well advised, that the production of distinctly audible telephonic sound, which I hope to accomplish this evening, should have been assigned to the same occasion as the more learned and interesting paper on a kindred subject to which we have been listening. And I am glad to have the opportunity of saying, for the benefit of any who may not have heard it before, that Dr. Blake has been among the most earnest and successful investigators of the speaking telephone and its laws, at a time when such investigations promised little of profit or distinction. It is largely to his intelligence and zeal that the telephone owes its early growth, and I regret that he is not able to be with us this evening to examine some of its later developments.

Since we have had, in the paper just read, a discussion of some of the more intricate physical and physiological principles involved in the action of the telephone, it seems the more desirable that I should employ a part of the limited time which I venture to use, in a brief survey of the progress of the telephone, and the extent of its practical use, as well as in the exhibition of the special form of instrument which I have to bring before you.

If, as it has been said, the year 1877 is to be remembered as the

year of the articulating telephone, so may the telephone itself be said to mark the era of popular interest in scientific *methods* as distinguished from ready acquiescence in the practical results. From the time when, in the spring of 1876, the researches of Professor Bell gave the word telephone a place in current speech, and linked it with a fact accomplished, there has been an active interest among all civilized peoples, not only in the instrument itself, but also in the abstruse scientific reasoning upon which the laws of the instrument stand. The newspaper press in the United States gave itself over to scientific research without delay; the professedly scientific journals followed. At the Philadelphia Exposition, in the summer of 1876, Sir William Thomson set upon the new wonder the stamp of accepted scientific judgment, and then its fame, as you remember, ran about the world. It supplied imagery to the Press, a mild inspiration to the poet, and suggested to the progressive pulpit a time "when the sea should be reft by the lightest whisper, and the earth be belted by one spoken word," a state of things towards which we are still upon the way. In the winter of 1876 a number of dual lectures were given, Professor Bell and myself addressing an audience at either end of the line, while Mr. Thomas A. Watson transmitted telephonic effects to both audiences simultaneously from a midway station. The total length of wire used at these times varied from thirty to sixty miles, and though the sounds produced were not loud, the fact that sound could thus be produced at all, gave stimulus to the public interest in the telephone. As a relic of these earlier lectures, there is before us this evening one of the identical instruments used in them, and which was, as I believe, one of the very first instruments employed to convey the human voice along a wire. It stands precisely as it was made, is available as a speaking telephone, and embodies the principle contained to-day in the speaking telephone throughout the world.

Few of these dual lectures had been given before the American public began to draw the inference that if speech could thus be *faintly* sent from city to city it might be *loudly* sent from house to house, and thus the telephone be made available for every-day communications. A demand for practicable telephones sprang up, and telephonic experiment tended more sharply towards utility. The

instruments used for public lectures were comparatively loud, but not distinct; and this has been the bane of all loud telephones so far as I am aware. But it was soon learned that distinctness could be gained at the expense of volume of sound, and at length, through investigations undertaken for Professor Bell by Mr. John Pierce, Professor Eli. W. Blake, and Dr. Wm. F. Channing, at Providence, Rhode Island, as well as the unceasing efforts of Mr. Thomas A. Watson, the resonant box was quite done away with, and the telephone reduced to the convenient and effective form in which you see it now beside the original lecture instrument—these two types exhibiting the telephonic evolution.

The practical success of these "hand telephones" was beyond question, and this, in turn, led Mr. Watson to a modified form of the box telephone, in which a horse-shoe or double-pole magnet is used. These two classes now form the majority of telephones used in the United States, and the total number in use at the end of the first year (June 1, 1878,) will exceed 20,000, most of them under licence from Professor Bell. As to the forms of use of this mass of instruments, it may be said that they are employed upon lines ranging in length from thirty or forty feet to as many miles, and for almost every sort of public or private communication—from the intercourse of the White House and the Treasury Department at Washington, to the exchange of village gossip in the remoter sections of New England. A few cases may, perhaps, not improperly be cited. In the seaside city of Newport, Rhode Island, there is an over-house line having forty-six stations, with a single wire circuit carried to earth at each end. At each house or station is a Morse "sounder" and a telephone; and signal having been made upon the sounder by a battery current supplied from the main office of the line, the telephone is brought into circuit and conversation carried on. Similar systems, though with usually a less number of stations, are found in other large towns. A more common form, however, is the central-office system, in which lines radiate from a central station, ten to twenty houses or shops being joined together upon each line. It is not found that this union of different interests upon the same wire is practically an obstacle to the development of the system, unless the number of stations on

one circuit comes to exceed the working capacity of the line, in which case a new circuit is begun. In perhaps the greater number of these town and city systems, no batteries are used, the manufacture of magneto-electric bells, under Mr. Watson's patents, having produced a satisfactory quality in these instruments. Nor is this use of the telephone restricted to comparatively quiet situations. The instrument has been found to make itself quite at home under the conditions usual in manufacture and trade. The central-office system at Boston included, at the time of my departure in March, 256 telephones placed in shops and offices in the busiest parts of the city, besides those in the residence and suburban quarters. I have seen these instruments at work in railway managers' offices, and the counting-rooms of factories, where the noise was so great as to lead the visitor speedily to escape to the open air. The clerks, in these cases, being questioned, usually answered that practice enabled them to disregard the local noises, while the holding a telephone at each ear enabled them to listen with the greater effect. It is, however, but just to say that the average quality of telephones supplied in the United States, has, until lately, been superior to that at command of the public in England. But I observe that instruments are now making in London nearly, if not quite, equal in power and distinctness to those made elsewhere, and I am therefore led to believe that at no distant day the commercial importance of the telephone will be as well recognized in England, which gave the inventor, as in the United States, which fostered the invention.

But I am conscious of straying too far from the special topic assigned—the Telephone Harp. This instrument originated from the need of some means of making telephonic effects more clearly audible for large assemblies. Sound, and occasionally something like the words of a song, could be heard at a distance from the receiving telephone, but this did not satisfy the public curiosity. Something new was evidently needed, and therefore I began, at the time of Professor Bell's departure for England in August, 1877, the attempt to produce a transmitting instrument which should enable the box telephones which we had been using to produce musical notes audible in any room. The Mason and Hamlin

Organ Company of Boston gave me every facility for experimenting at their factory, and Mr. M. J. Matthews, a member of that Company, contributed invaluable assistance in musical and mechanical skill; and thus, after six months' experiment I was enabled to produce an instrument which seems, in some measure, to meet the demands of public telephone exhibitions, and which, in its audible effects, I hope now to bring before you.

The arrangement for bringing the sound-producing currents into the room is so simple as hardly to need description. From the transmitting instrument, placed in the small room behind the platform, the wire comes to my table, passes through the telephones here, is continued through the two telephones in the farther corners of the room, and returns as it entered, giving us a metallic circuit, with the privilege of using one, two, or four telephones at once, as we may chose. In the transmitting room is placed the Telephone Harp, with a battery of four Leclanché cells, and a Ruhmkoff coil giving a spark of $\frac{1}{3\frac{1}{2}}$th of an inch in air—a coil of the insignificant sort often supplied with electro-medical apparatus. The length of the circuit is a matter of very little consequence, and I have not thought it necessary upon this occasion to remove the transmitting instrument farther than merely out of our hearing, through the air. To communicate with the transmitting room I have the telephones, as you see them, and I will ask you to regard their use as merely incidental to the experiments, quite as one might address oneself to assistants visible upon the platform. As my chief assistant, I have the honour to present to you Mr. Thomas Fletcher, a member of this Society, and connected as an electrician with the Telephone Company. I will now ask the musician to begin playing. [Audible music proceeded from the telephones about the room.] You perceive the power which is latent in the ordinary telephone, and which is yet, I think, to be more generally applied. I do not, as a matter of course, regard this music as excellent in quality, nor am I unaware of means by which its quality might be improved. But I have chosen to receive and diffuse this effect through the ordinary telephones which can be used for conveying articulate speech, rather to use receiving instruments which, though giving us smoother and more melodious sounds,

would have no especial significance as speaking telephones. But being now provided with a clearly audible telephonic sound, we are enabled to attempt a variety of experiments with telephonic vibrations, to a few of which I will invite your attention.

As the transmitting instrument is so near, we will first ascertain what sound, if any, reaches us through the air. The music again being heard, I shorten the circuit to exclude the telephones, and hear no sound. Restoring the longer circuit we hear the musician going on as before. Being thus assured that the whole volume of sound comes to us through the telephones, we may naturally examine next the extent and kind of power developed to form these sounds in the telephonic apparatus. Referring especially to the large—or, as it may be called, the original—telephone, you observe that it consists of a magnet with coils, and a vibrating diaphragm, in the usual form, except that the magnet is mounted upon a moving bed controlled by a thumb-screw by which the position of the magnet may be changed.

Confining the circuit to this instrument alone, I draw back the magnet, increasing the distance between the poles and the diaphragm, the loudness of the musical sound falls off in proportion. There is now a clear half-inch between the poles and the diaphragm, yet the sympathy is not so weakened as to prevent our hearing the sound. I place the palm of my hand full against the diaphragm upon the one side, and the tips of three fingers against it upon the other, yet I cannot dampen the extraordinary persistence of this vibration. Removing the magnet still further, there is now a clear inch of space between the magnet and the diaphragm, yet the sound is still audible, though faintly, to the President and Gentlemen in the immediate vicinity of the instrument. Restoring the magnet to its usual place, the sound regains its volume, and increases up to the moment of contact between magnet and diaphgram, and then it suffers loss both in quantity and quality. But still there is a sound, and that, although I have now sent the magnet against one side of the diaphgram with the whole power of the screw, and also placed the tips of three fingers firmly against the other side. It is, as you see, quite impossible to suppress this vibration without either breaking the electric circuit or destroying

the instrument. I think it may be said that this persistence of sound producing vibrations is exceptional at the least, and seems to give colour to the theory of molecular vibration. Yet I hope to show within a few moments that these same sounds are attended with a distinct movement of the diaphragm from the centre, so that we may secure an amplitude sufficient to open and close a galvanic circuit by the vibration of the diapragm in a receiving telephone.

It is of interest, perhaps, in passing, to note that the intensity of these sounds can be reproduced from even a small hand telephone intended only for practical speaking purposes. Shortening the circuit, I concentrate the effect upon the ebonite telephone which I have been using to speak through to the transmitting room, and you perceive that the notes are still easily heard throughout the hall. The quality, of course, suffers, since this instrument is wholly without a resonance cavity, but I think that the quantity may be said to be quite beyond question.

Of the transmitting instrument, I can say only that it consists in a series of contact-breakers working with delicacy sufficient to open and close the circuit at such rate as the natural vibration of each note may require. In outline it consists of a harp of steel tongues struck by pianoforte hammers and action from beneath, and made to vibrate through supplemental tongues against the points of contact screws. The duration of each note, as heard in the receiving telephone, is controlled by an automatic circuit-closer, worked by the musician's touch upon the key, and in this way confusion of notes is avoided, even in rapid movements like that from the overture to "William Tell," which you have heard. Various details in the construction may be of interest, and therefore the harp itself will be brought visibly before you at the close of the experiments.

Having thus obtained clearly audible sounds which did not, at the least, offend the ear, it occurred to me, in January of the present year, that these sounds might also be rendered visible in the form of their equivalent electric currents. With the aid of Mr. Watson, whose ingenuity is unfailing, this idea was put into practicable form, and I shall endeavour to show it as my last experiment this evening. In this, we proceed upon the theory that the vibration of the diaphragm is membranous—from the centre in

and out--just as, in the attempt to dampen the vibration we seemed to show that it could only be molecular. In circuit with the other receiving telephones, and only far enough away to avoid offending our ears with its jangling, is a form of box telephone, in which a double-pole magnet and coils impart to an iron disc of the usual form such *amplitude* of vibration that the movement of its central part opens and closes a galvanic circuit, of which the whole disc forms a portion. This circuit is joined to the primary wire of a Ruhmkoff coil, which you see upon the table, and whose secondary circuit is made through a vacuum tube.

We will now have the room darkened, the musician will begin to play upon the harp, and you will both hear and see the effect. The currents passing through the telephones produce audible sounds. The same currents, considered with respect to the relay, or interrupting telephone, produce also the rhythmic interruptions in an auxiliary circuit which the vacuum tube converts into light. The effect in the tubes is not strictly constant to the audible sound, because the consumption of the platinum at the points of contact makes it well-nigh impossible to maintain that close adjustment which so very slight an interruption of the primary circuit requires, but the response is sufficiently accurate to show, as I think, that the telephonic disc has a distinctly membranous vibration.

What office this vibration performs in the production of sound, or how it persists—if persist it does—in spite of attempts to check it by mechanical pressure, are questions which have for me an absorbing interest, but upon which I must confess to the possession of very little accurate knowledge.

I have now, in closing, only to thank you for the kind attention and the generous applause which you have given to these experiments, and to say that it will give me pleasure to explain any part of the apparatus used to gentlemen who may wish to make personal inspection.

A cordial vote of thanks was passed to Mr. Gower on the motion of the Chairman.

The following Candidate was balloted for and declared to be duly elected—

MEMBER: John Perry.

The Meeting then adjourned.