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LECTURE.

Friday, 21st December, 1877.

Lieut.-General Sir DANIEL LYSONS, K.C.B., Quar
General, in the Chair.

THE TELEPHONE AND ITS APPLICATION TO LAND AND NAVAL PURPOSES.

By W. H. PREECE, Vice-President Society Telegraph Eng
Member Institution Civil Engineers.

No one can deny the enormous value of the electric telegraph like purposes. It has well nigh revolutionized the art of war, become a great weapon of offence, as well as a great shield. Operations that were a few years ago impossible are now essential. The strategist in his office can now grasp a countless combinations. The actual manoeuvres of armies can be controlled directed like the toy figures of the game of *Kriegs-spiel*. The maintenance of the lines of telegraph to an army in the field is as essential as that of the more material lines of communication. The telegraph, in fact, has become a necessity of the age. No war can be undertaken without its aid.

But it is not only in annihilating space, and bringing a new mental view of the master mind a dozen armies and a new world that telegraphy is so valuable; it is in the rapid communication of intelligence and orders to and from the Commanding Officer of each limb of each army, however small; it is in connecting the different parts of a fort, the different parts of an immediate communication, the different parts of a fort, the different parts of an entrenched camp, however much they may be scattered; it is in maintaining an uninterrupted connection between all parts of an army, however extensive may be the lines of circumvallation, however serviceable. It would have been impossible to have kept the defence of Paris and Metz without it. Indeed, it has a civilizing influence, it not only tends to shorten the duration of war, but to diminish the loss of life, by rendering possible those combinations which were impossible in the case of Sedan as well as of Metz, swallowed up temporary two great armies. Moreover, it facilitates the supply

regulates the traffic on railways, it aids the transport home of the sick and wounded, it satisfies the craving for news, and it alleviates suffering at home. It is well known that the Germans, guided by the experience of 1866, commenced the war of 1870 with a very well organized and extensive system of telegraphs for field service, but the French had a system wanting in efficient organization and was deficient in men and material. We know little of the present system, excepting the fact that by its aid the army around Metz maintained its bear-like hug on the doomed fortress, and endeavored to thwart, with overpowering force, the tiger-like rush of the Prussian Pasha.

So important is efficient telegraphy now considered for the Army that 6 officers and 160 men are being trained and maintained in efficiency in the British postal telegraph system, so as to be in time of war. They are, in fact, daily rehearsing that part of their duty they may have some day to perform in earnest in an enemy's hands. Moreover, we have our field telegraphs in constant training by means of shot, Chatham, and elsewhere, though it is very doubtful whether the telegraph department has been nearly sufficiently developed, or is anywhere being properly equipped, for such an army as ours. I am here, not to criticise or describe the equipment of our telegraphic system, but to describe an apparatus which may be the most useful and valuable adjunct to the already well matured system of waggons and barrows and cables in actual use. I make a distinction between the permanent telegraphic system of the Army occupied by an army, the semi-permanent lines of telegraph which connect head-quarters, as it advances, with this system, and the "line" or temporary system of field telegraphs which follow the movements of the various corps in the field, and maintains communication with head-quarters. The first two must necessarily be worked on the ordinary telegraphic system in use, and require much technical skilled labour, and worked by well trained, experienced telegraphists. The flying line need not necessarily be so manned. There is also the visual system, intended for outpost and reconnaissance duties, and which necessarily must be continued under circumstances which render field telegraphs impractical. I do not intend to describe this admirable system.

At present, the apparatus in use for field telegraphy is the Morse recording apparatus, which records its messages in the dot and dash alphabet, understood only by the initiated, supplied by a sounding instrument, which appeals, by a similar language, to the ear. Thus, to convey intelligence from one to another, a message has to be written down on paper, it has to be translated by a telegrapher into the Morse language, which is re-translated at the distant end into the ordinary written language, and then read by the recipient. These operations are subject to have not secured faith in their reliability. Is there any Colonel here present who would not wish such an uncertain and very warm place? Those who were present at the Autumn Meeting on Salisbury Plain know how to value its services. It is unquestionably

that the telegraph has not inspired confidence, and this is due to its natural uncertainty as to the want of knowledge of it is used. Accuracy in the transmission of orders is the *sine qua non* of a military telegraph. We know of one great disaster that was a mistake. "Some one has blundered." It was the very day determined upon in our late Ashantee War, and the rapid materials drawn from the Post Office stores were dispatched at the last moment, by passenger train, and stowed in the office room. Yet we have the authority of Sir Lintorn Simmon that the operations in that war could not have been carried on were without its assistance, and that it was productive of great economy to this country by shortening the expedition and affording the greatest amount of benefit to be derived from the means that were placed at the disposal of the General in command.

Now, the telephone, if it prove a practical instrument in the hand of every officer an instrument which will transmit the actual words and tones of his own voice to his correspondent at a reasonable distance. I have spoken distinctly, at various times, to ninety miles; last week I spoke from Holyhead with Mr. Dublin, through the cable joining those two places, and I was able to recognise, with absolute certainty, the voices of the people at sixty-seven miles. It will solve the moot question as to the best form of instrument for military telegraphs, about which there is much diversity of opinion.

How is it that the human voice itself can be reproduced at great distances? When I strike a bell, blow a whistle, or clap my hands, or speak to you, how is it that these different sensations are conveyed through your ears so as to produce that sensation which is called *sound*? The air itself, which we breathe and move and have our being, is a highly elastic medium which readily receives and transmits any motion imparted to it. I clap my hands, I suddenly throw this air into motion, and it is formed, just like a stone thrown into water generates concentric circles round and round, striking and enveloping every object in its course. This air-wave likewise envelops everything in its path, impinging upon the tympana of your ears, it there affects in such a way as to convey to the brain that sensation which we have been taught to be that sound due to the clapping of hands. We therefore simply the undulations of the air; but there is no sound. I shake this box of nails; it makes a most disagreeable noise; I blow this reed; it makes a soft musical tone. Why have we called the one *noise* and the other *music*? In the one case the waves strike each other in irregular spasmodic fashion, shivering the drum of the ear with unpleasant shocks; in the other case the waves follow each other regularly, periodically, and rhythmically, blending together to form a continuous and pleasant sensation. Let us ignore the drum of the ear with pleasant sensations. Let us ignore the drum of the ear and confine ourselves to this musical instrument. I blow a tube of air between the reed and any one of your ears, you would see the reed vibrate and moulded into the most beautiful and regular undulations.

risers and falls, like the vertical waves of the sea, but condense and rarefactions—close order and open order—more like a barley in autumn time responding to the motion of a gentle breeze. We conceive a line of particles to be arranged along this tube, long file of men or a row of marbles, then if each particle excursion to and fro for the same distance (the same amplitude, however small, then if the motion of each particle be successive, not simultaneous, the line will be excited into waves or vibrations, as shown in Fig. 1.

FIG. 1.

Now, let us fix our attention upon this musical instrument supposititious tube of air. I can produce various notes. C differs from another note only in the number of waves or vibrations produced per second. Middle C of the piano makes these vibrations, E 330, F 352, A 440, and the octave to C second. The lowest note that can be heard by the human ear makes complete vibrations per second; the highest, 38,000. The human voice is between 65 and 1,044 sonorous vibrations per second. Whenever and however we produce air vibrations, each other regularly between these two limits, we have notes. One note differs from another note in its pitch, which is the number of its sonorous vibrations per second. But these notes may be gentle or rough and loud. Hence notes differ, not only in their pitch but they differ in their loudness. Loudness depends upon the force of the source of sound and upon the amplitude of the vibrations of the particles of air. If I blow gently, the excursion to and fro is small. If I blow fiercely, the excursion to and fro is large. The former undulations strike the ear gently, and the sensation is low; the latter strike it fiercely, and the sensation is loud. I can take three or four different instruments and I sound the same note each with the same force. The pitch is the same, the loudness is the same, but there is no mistaking their difference. This difference is called their quality, clang-tint, or timbre. Now, what can I call this? I must beg your attention here, for here lies the secret of the new articulating telephone. This clang-tint is due to the form of the wave of air. It is very difficult to conceive a difference in the form of a wave of air. It is simple enough when we regard the surface of a pond. We see this for ourselves upon the surface of a pond or of the deep. But the difference of an air-wave lies, not in its general form so much as in the rate of motion of its different parts. If my hand moves backwards and forwards regularly or irregularly, I can make it move at any given rate, at any given time, and the number of excursions and the amplitude of excursion per unit of time may be the same, I can vary the form or rate of excursion at will. This produces difference of quality, and the

middle C, sounded on a piano, on a harp, on a bugle, or l is the same note, but differing so much in clang-tint. It is to picture in the mind the beauty and minuteness of the so The ear, though approached by a channel the diameter quill, will receive the vibrations from a hundred voices ; ments and can separate each by attention. Hence we ar first proposition, that sound is due to the undulations of t that, as these undulations vary in number per second, in amp in form, so we have noise or music, varying in pitch, in lo in clang-tint.

We have now to consider how we can catch up, as it sounds, and convey them into something else. It is said th could sound a note so deep and loud that he could crack Whenever anyone sings in a room, something can be alway rattle. If you open the piano, and sound the vowels on notes, you will hear the piano repeat them. Hence we lea air vibrations can be imparted to other grosser matter in I hold before my mouth this disc of parchment—a small It responds to the tones of my voice. I can make this evid It is so constructed that it makes and breaks an electric cu time it vibrates. This electric current operates as an elec The electro-magnet actuates an armature. If the moti armature are of the same number as the disc, we shall ha repeated. There you are. Every note I direct upon the peated by the magnet. But I cannot vary this note. shout or whether I hum; whether I sound the note upon ment or upon a tuning-fork, the note given out by the m same. It varies only in pitch, and not in loudness or in This is the first telephone ever made, that of Riess of Frie and it is illustrated in Fig. 2.

Fig. 2.

Now I must make a temporary diversion into the electricity.

There are many ways of producing electricity. We hav a battery where the electricity was produced by the chemi position or combustion of zinc, just as heat is produced by cal decomposition or combustion of coal. We can produce i or by heat, but one very common mode is to produce it by of a coil of wire in the neighbourhood of a permanent

vice versd, by the motion of a magnet near a coil of wire. an ordinary shocking coil is made. Here is a large perman and here is a coil of wire. I suddenly move that coil current is produced, and I have rung a bell. But even if be fixed and the coil be fixed, any variation in the stren magnetism about that coil will produce a current of electric coil. Thus if in front of that magnet which has a coil of pole, I move this mass of iron, a current will be produc

FIG. 3.

coil. And for every motion of that piece of iron I can current of electricity. But more than that, the current will fall in intensity exactly as the iron moves. Hence the electricity produced in that coil will vary exactly as the that mass of iron. Now suppose that mass of iron to be a like our parchment drum-head, but of iron; and I speak to We know that that disc will respond to my voice. What I sound, however I vary them in pitch and loudness at that disc will vibrate in number, amplitude and form, exactive, and currents of electricity will be produced in that will vary exactly in number, strength, and form, with the utter. Let this coil be connected with an exactly similar c distance off, and let the currents in the first coil circula the second, then if the second coil surround a mass of soft currents will induce magnetism in the soft iron, and the s this magnetism will vary exactly with the currents pro If in front of this iron coil we plant an iron disc exactly li one, then every time the iron coil is magnetised it will attri disc, and will cause it to move. Now the motions of thi vary exactly with the variation of the magnetism of the magnetism of the coil will vary exactly with the stren currents producing it. The strength of the currents will v with the motions of the first disc, and hence the motions of disc will vary exactly with those of the first. In fact they exact reproduction of the first. Hence with whatever not disc vibrates, however much it varies in pitch and lo quality, the second disc reproduces those vibrations exact vibrations are imparted to the air and thus we have sounds

with all the delicate variations of the human voice. The sound of the human voice is transmitted into electric currents, and these again produce sonorous vibrations which exactly reproduce the human voice. Indeed, there is no sound which the human lips cannot produce, or the human ear can detect, which cannot be reproduced by the telephone, and where it not for practical difficulties, such as the "mellow to sadness now madden to crime," could be as easily transmitted from the east to the west as from this hall to the room. In fact, to "waft a sigh from Indus to the Pole," is to remove the poet's dreamland, and has become as much a matter of fact as "tracting sunbeams from cucumbers."

But not yet—the vapourings of imaginative newspaper correspondents are not yet practical. The articulating telephone is an extremely delicate apparatus. It is subject to interference from every waif and stray current that wanders into a telegraph wire, and its name is legion. Atmospheric electricity, earth currents and the influence of neighbouring wires, all generate these troublesome disturbances and interfere with its action. So that on existing lines of telegraph except for short distances, it has not yet been found useful. It is practical, but on short independent isolated lines like those of the field telegraphs, it is a thorough practical instrument, and is serving the fullest trial that actual service can give it.

It works to perfection in mines. There it is not only free from extraneous troubles, but the silence of the grave facilitates the transmission of its "still small voice." It is not even necessary in some cases to put it to the ear. Wherever, however, extraneous sound is present, not only is it necessary to put it close to the ear, but to shut out all disturbing elements, two telephones are used, one for each ear. A bi-aural stethoscope applied to it is also found useful as an adjunct. By its means reading is very simple. How far it can be heard amidst the roar of artillery and the din of battle remains to be tried.

What it does is this: it transmits to a distance far beyond the range of the ear, or of the eye, the words of command, the tones of warning, the distinct and unmistakable articulation of the general as well as the private. Such an apparatus must be valuable for military purposes.

How far it can be utilized for naval purposes remains to be seen. Wherever a wire can extend there can the voice be sent, and it is communicating between the bridge and the wheel, between the engine room, between the look-out and the officer of the watch, it ought to be useful. For diving operations it is invaluable. For operations and range-finding it may prove useful.

But at present it is a mere child. It has startled us by its novelty, its beauty, and its simplicity. Time alone is to establish its utility. Probably no instrument that has ever been invented has created more sensation, or has attracted so much attention. I feel highly honoured in having been allowed to bring before a distinguished audience the incomparable invention of Graham Bell.

Major WEATHERHEAD: I should like to ask how it happens that

continues so much longer in the case of the bell being struck, than in the case of the sound of the voice?

Mr. PREECE: The simple reason is, the vibrations of the bell are not rapidly stopped. When I take a whistle, blow it and it ceases at once the moment you remove the source of the sound. But the bell, as in the case of the glass, the vibration continues. If you touch the glass to sound, you can see the musical wavelets on the surface of the glass very prettily show the vibration of the body itself. There is a loss of sound in the case of the telephone however at a great distance; as the distance increases the effect is the same as it would have upon the voice itself, for when a person is far and further away, the sounds come gentler and gentler; and in the end when you add resistance or increase the length of your line, so the sound comes from a greater and greater distance.

Captain MAYNE, R.N.: I should like to ask you how far the voice can be carried whether you have any idea of being able to communicate in this way across the Atlantic?

Mr. PREECE: I am not prepared to say that there is much hope of communicating across the Atlantic, but I think it possible to talk to distances great distances across the Atlantic. The reason we cannot talk across it is because there is a peculiar electric effect in submarine cable called in as though the electricity were absorbed by the gutta-percha, and small signals in at one end never arrive at the other. They get rolled up as it were on that on a long submarine cable, instead of getting the finer sounds vibrations are rapid, they would all come out as one current, not producing all. It does not seem at present practicable to apply to a greater distance 200 miles, but in the present day that man would be a very rash man to affirm that it is impossible to do anything.

The CHAIRMAN: We must, I think, thank Mr. Preece very much for his interesting and able lecture that he has given us on the Telephone. There are many gentlemen who have had greater experience in telegraphy than Mr. Preece, a member of that department to which we all owe so much—the Post Office Department. I think that none will deny the great advantages of the telephone; there are few Officers who are not well aware of its great importance in the service. I can hardly speak so much of the Navy, but I dare say the telephone will also be of great use. There is no doubt that in all the cases that have been mentioned by Mr. Preece, it will be most valuable. There is that I think will bear much on its advantages in the Army, viz., to get away with a great deal of difficulty in providing a sufficient number of men on service. Here every man will be as it were a trained telegraphist; he will be able to speak through the telephone without having received a special instruction in telegraphy. It only remains for scientific gentlemen to perfect the telephone which can only as yet be considered as in its infancy. There lies the work we must try experiments and endeavour to perfect it as soon as we are quite sure that the result will be to the great advantage of our service. I beg to thank Mr. Preece for his interesting lecture.

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