MINUTES OF PROCEEDINGS,

14TH JANUARY, 1886.

Walter Shellshear, President, in the chair.

The following candidates were balloted for and duly elected as

MEMBERS :

PERCY ALLEN.

H. P. FROST.

MR. ALBERT LEAHY then read the following paper, and explained that it was a compilation, and also a translation from the French of papers by Mons. M. J. Banneux, Engineer-in-Chief of Telegraphs, Belgium, and Mons. Mourlon :

THE VAN RYSSELBERGHE SYSTEM OF SIMULTANEOUS TELEGRAPHY AND TELEPHONY,

BY ALBERT LEAHY, C.E.

Since the first installation of the telephone in the commercial centres of the world, it has been seen how admirably the invention of Graham Bell has lent increased facilities to the transactions of commerce and of industry, and it has only remained, in order to enable us to derive the greatest possible benefit from that invention, to extend its use to long distance communications, not merely from house to house, but from town to town, and from country to country. Some idea has naturally been entertained of utilising the telegraph poles, already in existence, by placing upon them for purposes of telephonic experiment a wire or wires parallel to those of the telegraph. Directly, however, that is done we find an apparently insurmountable obstacle in the way of success in the shape of "induction," which has the effect of producing in the telephone a frizzling sound, which, for want of a better name, has been called "telephonic frying." These discords, which drown articulation and render all communication impossible, proceed from the telegraphic currents conveyed by the wires adjoining or in the vicinity of those employed for telephony. It is in effect a reciprocal influence exercised by one conductor upon another, which is parallel to it, and it is goverened by the variation of the electric current in the disturbing circuit. Such was the great obstacle opposed in the first instance to long distance telephony.

If these repercussive noises were of such intensity in the circuit of a wire which was merely in the vicinity of a telegraphic conductor, what would have been the result if a telephone had been placed actually in the circuit of the telegraphic wire? Could one have dreamed of suppressing the tumult, the deafening uproar which would then have arisen? Nevertheless that is the problem which M. Van Rysselberghe has had the audacity to attempt and to solve. We say audacity, because the difficulties of the problem were not only great, but they were numerous.

Having once mastered the "induction" it was necessary to maintain the secrecy of the telegraph by rendering its signals inaudible in the telephone; it was necessary to prevent the possibility of the telephone intercepting even the smallest portion of any telegram passing by the wire to which it was connected, and it was required to find the means by which the telephonist having the telegraph circuit in his charge should be unable to prejudice that circuit, as by interfering in any way with its conduction or insulation or by putting it to earth. That others have had presented to them the same ideas, and that they have engaged in the discussion of the same problem, before or after M. Van Rysselberghe, it is quite possible. The fact, however, is uncontestable, that to him alone the honour of its practical solution is due.

The Van Rysselberghe system is based almost solely upon the remarkable fact discovered by him, that "when the suddenness of the emissions and extinctions of the currents is eliminated those currents become inaudible in the telephone." For the sudden changes of electricity now in use for telegraphic purposes he substitutes gradual currents; that is to say, currents which gradually increase at the commencement and as gradually decrease in strength at the end of each signal. This graduation, which occupies but an infinitesimal portion of time, is obtained by the interculation in the circuit of small graduating electro-magnets, or again by placing upon the line certain condensers, which act as derivators, or, finally, by a combination of electro-magnets and condensers absorbing a certain quantity of the current, which they restore on the circuit being broken. Under the influence of the currents graduated in this manner the diaphragm of the telephone is yet subject to movement, but it no longer vibrates. The telegraphic current, therefore, produces no sound in the telephone. In other words the telegraphic currents are completely silenced or rendered inaudible, whether they be direct, induced, or derived. By means of this system not only can an effective telephonic service be organised from town to town by utilising the ordinary telegraph poles to carry the telephone wires, but the telegraph wires can themselves be employed for the purpose. The system is one of *anti-induction*, and completely assures the independence of the two services. It establishes between the telegraph and the telephone circuits a separation of such a kind that, whilst the rapid undulations of the low tension currents of the telephone are readily transmitted, an impassible barrier is opposed to the telegraphic currents, which, it is scarcely necessary to observe are of an essentially different nature. The greatest beauty of the system is its simplicity. We will now endeavour to explain with the assistance of these diagrams some of the tests and ideas applied by M. Van Rysselberghe with the idea of suppressing in a telephonic compass the effects of conduction caused by the telegraphic working of the conducting wires that adjoin and run parallel, as well as the utilization of these same wires for the duplex correspondence—telegraphic and telephonic.

Graduation of the Telegraphic Currents.

As we have already remarked under what circumstances M. Van Rysselberghe was induced to fight telegraphic induction in the primary circuit, which is different to the other processes in general use, which tend to neutralize the effects produced in the secondary or telephonic circuit.

The most marked, and consequently, the prejudicial currents are those which correspond to closing and opening the inducing circuit, and their strength is in direct proportion to the strength of the currents which have caused them at the time of the transmission of a signal. From that time the emission and destruction of the first current should be graduated in such a way that from zero to I it should go on gradually increasing, and from I to zero gradually diminishing. You will then be reducing the strength of the currents induced, and so let them die out gradually, that is in short cause the inside of the receiver to bend only, without however, giving rise to any sound.

After having tried as graduators, manipulators that modified of their own accord the resistance of the first circuit, Van Rysselberghe obtained far better results by making use of electro-magnets and condensors, whose purely electric play is more fitted for the application, and do not call for any modification of the usual telegraphic transmittors.

Take two wires L1 and L2 adjoining and parallel (fig. 1). ; M and R respectively a telegraphic manipulator and receiver ; E a straight electro-magnet of a resistance of about 1000 ohms placed between the battery and the key.

The currents set on the wire L1, by the manipulator M will not be felt or very little so, in telephone T2, and their direct action on telephone T1 is consequently less than if the electro-magnet E were not there.

You would meet with a better result if you had a condenser between the pile or battery P and the line L1 of the transmitting key. (Fig. 2).

In short you will not get any sound from telephones T1 and T2 whatever may be the strength of the pile P when the condenser is connected from the earth between the two electro-magnets E1 and E2, which have then a resisting power of 500 ohms. (Fig. 3).

So that this test may prove an entire success, the telegraphic wire L must be of a certain length, and the resisting power of receiver R must not be less than 500 ohms, and the capacity of the condenser graduator must be roughly speaking of two microfarads for the setting of telegraphic wires.

As regards the Morse system of working, electro-graduators are not necessary when the currents cross (from the start) the reels of the receiver R.

In the case of the Hughes apparatus, a good reduction of the sounds, that are induced, is obtained by simply suppressing the current —putting aside any inclination to graduate. It is then preferable to put an electro-magnet of 1000 ohms in that direction, but the combination which goes best with the varying state of the lines and apparatuses is that of plan 3, namely :—In each terminus office an electro-graduator for the battery, another for the line, and a condenser connected with the earth line.

A very interesting application of the anti-inducing system was made in Belgium after the enquiries made by M. Van Rysselberghe and M. Buels, head of department, on a line 45 kilometres long, working on the Hughes duplex system between North Brussels and Antwerp (exchange). The working of this line gave cause to a great telephonic noise in the adjoining circuit, which had to be done away with, without interfering with the telegraphic balance. The placing of the wires as follows, (fig. 4), solves that problem. The two sides of the bridge are represented by two electro-magnets, E1, and E2, with movable iron nuts. You regulate the balance in the usual way by means of the rheastat R. Then by sending interrupted currents, you can modify by feeling the length of the inside of the nuts in such way as the equilibrium is maintained under the influence of the powers of statics and dynamics of which the electro-magnets are the seat. The graduator condenser then becomes useless.

We then find from this that

1st.—On a given line one can have a telephonic service by the aid of a simple wire with earth lines, when all the other conducting wires adjoining and parallel traversed by telegraphic currents are provided with Van Rysselberghe's anti-inductor, and

2nd.—That if all the wires are all so provided without distinction, any one of them can allow of a duplex telegraphic-telephonic correspondence being carried on, quite regardless of the noises caused by the induction, as experience will show, of those arising from the derivation of currents from one wire to another. In the first place, telegraphic communication is lost, and, in the second, the absolute identity of the telegraphic and telephonic circuits will give effect, in practice, to inconveniences such as to render the combination anything but a desirable one. Having observed this, the inventor has striven to make the two series as independent from one another as possible.

Let TLT1, fig. 5, be a telephonic circuit with an incline, KMN to the earth, C a condenser of $\frac{1}{2}$ microfarad or less : R with a resisting power of 500 ohms or more : T and T1, telephones whose resisting powers can vary from 0·1 to 4000 ohms.

Let the incline KMN be suppressed or maintained, the persons corresponding will not perceive any tangible difference in the strength of the telephonic currents. We have tested this on (overhead) lines of 45 to 110 kilometres. On the line from Brussels to Paris, 320 kilometres long, and on the submarine cable from Dover to Ostend, 138 kilom. long.

As regards the relations of resistance to be established between the line, the telephonic receivers, the second wire of the inducing reel of the microphonic transmitters, the battery, the microphone, and the first wire of the reel, experience has showed, by the admitted laws in telegraphy, telephones having only a few turns of thick wire, work very well on overhead lines of more than 300 kilometres long, and that the results are most favourable when the resistance of the inducing circuit at the transmission place is reduced as much as possible. That is the reason why M. Van Rysselberghe has made use of an electrical generator of batteries, with small inside resisting power, such as accumulators have, and so multiplies the microphonic contact by coupling them at the surface.

Simultaneous Telegraphing and Telephoning.—By applying to a telegraph wire the principle indicated in fig. 5, you set up the duplex system as shown in fig. 6. In which the condenser graduator C1 has a capacity of 0·5, or, if desired, of 0·1, of microfarad only. And condenser separator C2 a capacity of 2 microfarads. The utter independence of the two ways of corresponding is thus realised.

Van Rysselberghe's anti-induction system has been tried on several occasions on the Belgium telegraphic net work with the greatest success. We shall specially mention a case where three operators, placed respectively at the Brussels, Ostend, and Antwerp observatories have conversed without any difficulty by means of a wire of 4 millimetres thickness, placed on the line poles connecting these localities, and that, too, during the busiest time of the Morse and Hughes system, with a number of wires running parallel with the first, some of which, the ones that made the most vibration only, had been set up on this system. They at that particular time made use of microphonic transmittors, and of bell receivers, modified by Van Rysselberghe with a view of reproducing the voice as loud as possible, to overcome those prejudicial noises, which had been intentionally allowed to exist.

We also beg to point out the transmission by telephone regularly from the Legislature Palace, Brussels, to the offices of a daily paper at Gand, of the full account of the parliamentary debates, quotations of change and markets by an overhead wire of the telegraphic line from Brussels to Ostend, which wire serves at the same time for the transmission of the voltaic currents working the *telemeterograph* placed at the observatories of these two cities.

This last test is an instance of the resources possessed by the system used to obtain a mutual independence of two services, with one same conducting wire. Two stations, A and D, can correspond by telegraph, whilst two other intervening stations, B and C, can carry on a conversation by the wire which connects the two first ones. But better still, you can connect telephonically a telegraph wire of a given length in such a way as to increase without interfering with the number of stations in connection. E1 and E2, fig. 7, are electro-magnets of 1000 ohms, E3 and E4 are reels, or rather electro-magnets of about 500 ohms, R1 and R2 receivers of at least 500 ohms, and C1 — — — C5 condensers of 0·5 microfarads. By these conditions T1 and T2 on the one hand, and T3 and T4 on the other, can communicate by telephone at the same time, as the end stations can exchange telegrams.

Let us admit for argument's sake that all the wires of a given overhead line are provided with the anti-induction system, and also with side connecting wires, those that touch the earth at the central office, and in general all telegraphic conducting wires whose working is likely to cause induction currents or derivation in a telephonic circuit. Is it possible to make use of several single wires of this line for independent and simultaneous verbal communications? We decidedly deny it: all that is said by one wire is distinctly understood by the others. The greatest enemy, therefore, the telephone has, is no longer the telegraph, but the telephone itself.

Henceforth, every time you may want several telephonic circuits between two given points, you must have double telegraphic wires which shall possess independently their usual strength. M. Van Rysselberghe gives the two following solutions to the question:—

FIRST SOLUTION, FIG. 8.

In this plan S1 and S2 represent resisting powers of at least 500 ohms.

R2 is a receiver with resisting power of at least 1000 ohms or more, and E2 is an electro-magnet of about 1000 ohms.

The formula S1 x L2 = S2 x L1 is not disregarded. According to the rules of the telephone there is an advantage in taking for E1, S1 and S2 for electro-magnets in order not to fulfil too rigorously that condition of equilibrium.

SECOND SOLUTION, FIG. 9.

L1 and L2 are telegraphic wires, E1, E2, E3 and E4 are electro-magnets of 500 ohms. C1 and C2 condensers of 0·5 microfarads ; C3 and C4 condensers of 2 microfarads. R1 and R2 telegraphic receivers with a resisting power of not less than 500 ohms. It is this latter combination which has been so successful in Belgium on the Brussels and Antwerp line, between Haeren and Berchem (35 kilometres) and in Holland between Amsterdam and Haarlem (18 kilometres).

Should you desire to make use of an international telegraphic wire for a telephonic service, or prevent it from interfering with a verbal communication exchanged on wires of the same line, you can forego the appropriation of a conducting wire in a foreign territory, all you have to do is to place at the frontier, or at a suitably convenient given spot, an electro-magnet of 500 ohms, and to place a condenser of two microfarads at the branching off of the line to the ground.

We cannot dwell too long on the necessity of insulating electrically with the greatest care, in all duplex systems, the connecting wires and the instruments of telephonic stations, in order to avoid the mixing of telegraphic signals or the loss of them in the earth line.

Condensers require the greatest care, because they must withstand the working of the potential caused by the most powerful batteries used in the telegraphic system. They are submitted to the following test :—A circuit consisting of a battery of 300 element (Leclanché) of three electro-magnets of 500 ohms, and of a disconnector with quick vibration, at the edge of which are connected a branching off circuit, the appurtenances of a condenser being protected by a conductor. The condenser ought to stand without injury the extra currents thus produced.

Nevertheless in the case of accidental waste, it is essential that you should combine matters in such a way that the replacing of condensers and conductors should be done instantaneously.

We now have to show the way of connecting the metallic circles of the town lines with single line circles of the subscribers to the suburban lines.

This problem was entirely solved in England at the time the post-office decided to establish, on its telegraphic poles, for the use of the subsidized companies, special circles composed of wires wound round one another, after the principle of Professor Hughes (see Journal of the

Society of Telegraph Engineers, Vol. VIII., 1879). We know that the solution consists in the placing of an induction reel, one of whose wires form part of the metallic circle of the trunk line, and the other of the conducting wire connecting the subscriber, and whose two extremities touch the earth.

In spite of the double inductive transformation introduced by increase in the telephonic system, and the increase of the resisting power of the intervening circle, correspondence at great distances is still possible, provided the relation of the resisting powers of the wires of the repeating reels are properly regulated. In the Van Rysselberghe plan, the question gets rather complicated on account of the interference of the telegraphic currents, and of the necessity of making sure of the discharge of the condensers separators (fig. 9.) The inventor connects to earth the centre of one of the two circles of the induction reel, which composes the telephonic bridge. You can picture to yourself, as the arrows in fig. 10 show, the direction of the telephonic currents. In fact, you must prevent the mutual reaction of the two parts of the reel, and divide that one. Each half makes a reel of a distinct inducing power, having nothing in common with one another, by the connection with the earth and the axis or nuts of soft iron (fig. 10) are placed perpendicularly between them.

This placing of the axis is also carried out in the putting up of several graduating electro-magnets—when you are compelled to place these accessories side by side—at all events Van Rysselberghe's obtains the desired result in inserting each electro-magnet in a cylinder of soft iron.

A peculiar coincidence of a combination is the following, fig. 10. If in the absence of any telegraphic working, you were to insulate wires L1 and L2, there is very little difference between the intensity of the reception, and that obtained by aid of the double circle.

It is clear that the carrying, or rather the repeating reels, and the condensers separators ought to be in the central telegraphic offices of the trunk line, and not at the central telephonic offices ; it is also desirable that each connection between these offices should be made by a wire coupled on one side through the induction reel, with "return" wires that touches the ground, and that these conducting wires should be insulated in the same way as telegraph wires. Up to the present, whilst depending on the telephonic currents reaching in sufficient quantity the end of a town line placed on very bad insulators, insulation has hardly been taken into account, reciprocal echoes of neighbouring conducting wires can then arise as much from the branching off as from the induction.

We are of opinion that this should not be neglected if one desires to see correspondence at great distance between subscribers of different towns a success. Perhaps, in certain cases, the strength of telephonic transmittors in general use ought to be increased, pending the invention of a real telephonic "relay." Now, if one central office wants to communicate with another on the Van Rysselberghe system, one ought to avoid the bells worked by voltaic currents and ordinary magnets call, so as not to disturb the telegraphic working of the wires used in the duplex system. Henceforth, telephonic apparatuses ought to produce by themselves a signal sufficiently loud to excite the attention of the office that has been called. We have admitted so far that a telegraphic wire cannot be used for telephonic purposes between two given points, unless it be of a one continuous unbroken length from one end to the other. This is not an absolute condition. Suppose two wires connecting respectively stations A and C to a third B, where they take the earth through telegraphic apparatuses : all you have to do is to shunt these by means of a bridge placed between the line wires in office B, provided each set of apparatuses show a resisting power to telephonic currents of at least 500 ohms.

Supposing you make use—between two given spots—of several telephonic circles, each composed of two telegraphic wires running parallel on the same poles, and used after Van Rysselberghe's system, it is essential that the amount of power (telephonic) which these circles have over one another should be ascertained.

In case conversations held on one of these wires should re-echo to such a degree as to be understood on the neighbouring one, the advantage of having a double wire would disappear, and one would be compelled to limit the duplex correspondence to one single conducting wire, with earth lines. The remedy, in this case, would lie in crossing the wires, as has been done in England, but this new mode of setting up would mean a complete rehandling of the telegraphic lines, and it would not be appreciated in countries where the insulators are fastened on to the poles themselves, and not to arms or cross-trees.

Tests made up to the present day in Belgium on lines of 100 kilometres and less have shown that when each pair of wires are placed parallel and close to one another, the voice thus induced is heard, and words, *i.e.*, portions of sentences are sometimes understood. The induction however diminishes and even disappears when these wires deviate, or better still cross one another in such a way as to run perpendicularly. A very good result is obtained for instance by connecting the first wire on the right of the poles with the second of the left, and the first of the left with the third of the right.

THE VAN RYSSELBERGHE SYSTEM

generally puts a stop to the unequality of the effects of induction of the neighbouring wires on each of the telegraph conducting wires composing the telephonic couple.

To do this you cause to slip on one another the two parts of the repeating reel corresponding with the telephonic wire, which is the most influenced, in such a way as to diminish the induction action of the first and second solenoids. Thus the reciprocal induction of double circuits, placed on the same supports, is hardly felt. It is not of much consequence, in practice, whether a conversation transmitted on a neighbouring wire be heard or not as long as it is not understood.

A direct result of the use of the Van Rysselberghe system, is the strengthening of the telegraphic batteries—to take into account the *extra* fixed resisting power 1500 ohms, brought by the electro-graduators in each circle.

It is only right that a person at the outset should feel alarmed at the expenses they are drawn into, for the setting up must be completed in all the offices whose wires can act on the telephonic wires, either by the induction or branching off of the currents. However if you reckon the expenses caused by telephonic lines, specially put up, for a number of circles equal to that furnished by telegraphic wire, existing in a given network, the advantages, from an economical point of view of the Van Rysselberghe system, are at once recognised. Quite recently the inventor has adopted a new combination, reducing the resisting power to 1000 ohms. Guided by these considerations, and with a view of organising, without delay, the telephonic service between the principal towns of Belgium—the first step towards an international service—M. Oliver, Minister for Public Works, gave his assent to a contract, by virtue of which the firm of Maurlon and Co., of Brussels, binds itself to provide, under the direction of the inventor, all accessories of the Van Rysselberghe system, necessary for the appropriation of the Belgium network. In conclusion we have to mention an objection raised by Mr. Preece, at a meeting of the British Association, at Southampton, 1882. "What advantage is there in corresponding verbally on a wire to the detriment of telegraghic communication? In England speed is everything, and we eliminate all causes which interfere with speed; consequently there can be no question of electro-magnets and condensers in telegraphic circles: they interfere with telegraphy."

If the automatic Wheatstone were used in Belgium we should have sought to determine *in anima vile*, the influence of the anti-induction plan on the speed of the working of this apparatus, after having taken care to increase the electro-motive force in order to allow the current its primitive strength.

But we do not doubt that the countries which use the rapid system, such as Great Britain, France, Italy, Russia, and Sweden, will consent to make on their lines the tests destined to elucidate pratically that point, and to publish the results for the benefit of the community. Nevertheless they have worked in Belgium, on a line of 244 kilometres, by means of Hughes apparatuses regulated to 150 revolutions without the placing in and the suppression alternately of an electro-magnet of 1000 ohms in the circle producing a false letter or any disarrangement; in fact the most complicated classical combinations were transmitted. Besides, during a period of two months, the North Brussels carried on the service with Paris 320 kilometres at 145 revolutions; the electro-graduator being then inserted in the branching off of the Hughes reel.

This anti-induction system, we believe, can be applied to the Morse system.

The paper was illustrated by a number of diagrams, from which Plate 6 has been prepared.