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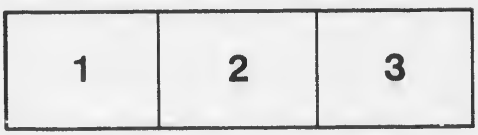

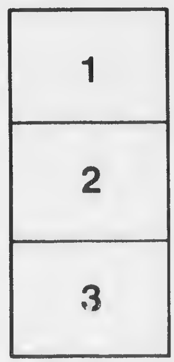

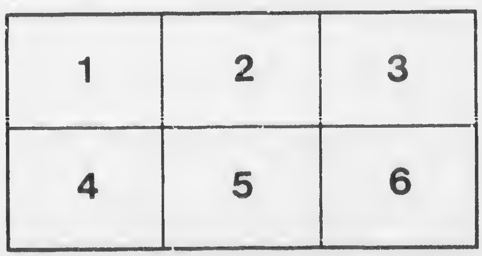

TELEPHONE.

BY

F. N. GISBORNE,

M. CAN. SOC. C.E.

BY THE PERMISSION OF THE COUNCIL.

EXCERPT MINUTES OF THE TRANSACTIONS OF THE SOCIETY

VOL. II. PART. I. SESSION 1888.

Montreal:
PRINTED BY JOHN LOVELL & SON.

The Society will not hold itself responsible for any statements or opinions which may be advanced in the following pages.

Canadian Society of Civil Engineers.

SESSION 1888.

TRANSACTIONS.

6th January, 1888.

E. P. HANNAFORD, Vice-President, in the Chair.

Paper No. 12.

THE TELEPHONE.

By F. N. GISBORNE, M. Can. Soc. C. E., F.R.S.C., &c., &c.

Many and bitter have been the writings and discussions as to the *Original Inventor* of the Telephone.

The earliest *record*, vide copy of the "Jahresbericht," of 1861, in the British Museum, proves that Philip Reis, of Berlin, had then experimented with the avowed object of *transmitting speech* by electricity, and that musical sounds had been conveyed by his apparatus. Moreover, his original instruments now reproduce speech, when the electrodes are moistened with a drop of water, or oil.

Fifteen years later, 1876, Professor Elisha Gray, while endeavoring *to transmit speech*, invented his *harmonic telegraph*; and Graham Bell, who was in search of a *harmonic telegraph* (vide his original United States Patent of 1876), discovered the simple and beautiful method of *transmitting speech*, which has since bestowed upon him fame and fortune.

Two years later, 1878, Professor Hughes gratuitously gave to science and the world, his microphone; and based upon such discovery, viz., the varying resistance of carbon electrodes under more or less pressure, Thomas A. Edison invented and improved telephonic transmitters; and now the combined inventions of Bell, Edison, Gower, Blake and others constitute the commercial value of those Bell Telephone Company's acquired patents which have been upheld by the law courts of the United States and Europe with such liberality of scope as greatly to astonish the scientists of the world.

Innumerable attempts have consequently been made to transmit speech *without infringing* upon original patents, and to such efforts are we, in great measure, indebted for the researches of and results obtained by electricians of note; for although admirably effective under favorable environment, the telephone is still susceptible of material improvement, and already we have mathematically correct formulæ and laws as guides for experimenters in the practical transmission of sound waves by electrical impulses.

The diverse theories advanced by prominent electricians, at a late meeting of the Society of Telegraph Engineers and Electricians, London, is the speaker's apology for preparing the present paper for discussion, he may at once state, that the following requirements are *essential* ~~and~~ to the *satisfactory* transmission of speech:—

1st. That articulation shall be clear and natural in tone.

2nd. That the apparatus shall be free from inductive or extraneous sounds.

3rd. That increased electrical energy shall be provided for long-distance transmission of speech and loudness of sound.

4th. That a material reduction in the number of wires or circuits, at present required for a Telephonic Exchange, is the basis for economic maintenance.

At the meeting already referred to, Professor Sylvanus Thompson stated:-That all diaphragms and springs have distinctive tones, and thus those of low fundamental pitch impart a *boomy* sound in reproduced speech, while higher keyed ones, yield a metallic or *tinny* sound.

That the transmission of electric impulses from sound waves are not dependent upon the varying resistances of the electrodes under pressure, but are occasioned by the millions of minute electrical discharges between the molecules which fly to and fro, between the adjustable electrodes, from higher to lower potential, as they approach or recede under the varying forces of sound waves; and that the effectiveness of transmitters was improved, as their electrodes rise in temperature, either by applied heat or from the passing of the electric currents.

This statement was in part endorsed by Mr. Stroh (formerly assistant to Sir Chas. Wheatstone), who remarked, that he did not believe in the effectiveness of *applied* heat; but that when the current first passes through the electrodes, their minute points offer so much resistance, that heat is produced and they burn off, so that the surface contacts become larger and the instruments convey speech; but when too large, silence ensues;—that when properly adjusted, a rapid bombardment of moveable atoms between the electrodes occur, very quickly from the positive and more slowly from the negative poles. And he instanced the following curious experiment, under microscopic observation, that when a drop of oil was placed between two platina pointed electrodes and a current passed through them, a great disturbance took place between the particles of oil, which rotated between the points with wonderful rapidity, one point becoming hotter than the other, as in the electric arc light, although reversing the polarity did not *invariably* reverse their heat.

Professor Sylvanus Thompson stated that the snap sounds heard in telephones, which are generally attributed to make and break contacts, are really due to sparks between the electrodes, and that when such sparks are suppressed the noises cease and that they can be almost entirely eliminated (even when very strong currents are used) by introducing double differentially wound electro magnet into the circuit.

In this connection Mr. Stroh observed that when new carbons are used, at their first contact, they click and then vibrate, with such rapidity as sometimes to produce musical sounds, which cease as the spring or weight pressure is increased, and until vibrations are again started by sound waves. Again, if a watch were placed upon a microphone, all kinds and qualities of sound could be obtained by manipulating the points, thus clearly proving that it is not the tick of the *watch* which is heard, but the microphones *own sounds*, started by the tick of the watch; and that from such fact it would appear that the mechanical movements due to sound waves have the effect of governing and controlling the frequency, amplitude, and form of the vibrations which the microphone sets up through every disturbance of its equilibrium.

Professor Thompson further stated that by using a differentially wound induction coil in the transmitter, not only is articulation greatly improved, but the vibratory induction disturbances, from approximate running machinery, are innocuous even to a sensitive Blake transmitter, and that two small induction coils, having their primary wires united in parallel and their secondaries in series, gave a much more satisfactory result than is obtainable from the ordinary coil in present use.

That granulated hardened coke, as used in the Hunning's transmitter, presents more numerous points of contact than two solid electrodes, and hence the greater vibratory effect produced in a distant receiver; but that comparative tests between metallic alloys, demonstrate, that a platina point, resting upon an electrode of copper, treated either with a mixture of selenium and sulphur, or with tellurium, reproduces speech with a clearness of articulation far superior to anything obtainable from hard carbon, although such alloy requires a greater initial pressure, at the electrodes, than is required by carbon.

For many practical reasons, the speaker considers this latter statement of Professor Thompson's an important one.

Professor Thompson then exhibited a transmitter, designed with the object of dispensing with the patented diaphragm. At the small end of a speaking tube, a ball or valve of metal rested upon three metallic points and the sound waves suspended, or in part relieved, the weight of the ball; but Professor Hughes observed, that if the tube were plugged below the valve and the air allowed to escape through side holes, the instrument remained equally effective, thus proving that the tube itself became a diaphragm of different form, and that under any circumstances, for well known mechanical reasons, the practical limitation of three points of support would render the instrument less powerful than many others in use.

The experimental transmitter just described will serve in great measure to explain the broad claim allowed at law in favour of the *diaphragm*, as patented by Professor Bell.

It appears, however, that a simple grid of small carbon bars, suspended upon a platina wire, within a non-vibrating leaden frame, and acted upon direct by sound waves, proves to be an effective transmitter, and by such device a diaphragm may be totally dispensed with.

Professor Hughes stated that if a series of small bars or pencils of carbon were attached to the inside rim of a bowl, or box, filled with water in order to eliminate the hollow tones of such receptacle, such a transmitter would operate with increased power, because every portion of the water would then be in a state of tremor from the sound waves.

This remarkable power of water for conveying sounds has already been utilized for discovering leaks in water pipes; even the leakage of a few drops may be localized by the application of a delicately constructed telephonic receiver; and there can be little doubt that under favourable circumstances distinct signals can be telephonically conveyed through several miles of water.

Magneto-electric transmitters have, since the introduction of the microphone, been superseded by local circuit battery power transmitters; but from the results of practical experiments made with the "Gisborne & Keeley" patented telephone, now owned by the Bell Telephone Co. of Canada, it seems desirable, if possible, to dispense with the always uncertain and varying action of introduced galvanic battery power.

Professor Thompson suggested a transmitter based upon the principle of a dynamo-electric machine; but the advantages of such mode of increasing the power of the currents would be more than counterbalanced by the increased inertia consequent upon the to and fro movement of the armature.

In concluding his observations at the meeting referred to, Professor Thompson stated that in his opinion the progress of long distance transmission of speech would depend upon increasing the power of the transmitter, and reducing the sensitiveness of receivers to induced sounds from extraneous disturbances.

To such general conclusion Mr. W. H. Preece (electrician to the London Post Office and telegraphs) took exception, and stated that clearness of articulation and long distance telephony depended entirely upon the line wires being freed from electro-static and electro-magnetic induction, and that when the environment was favorable, the most ordinary form of instruments would convey speech as well over long as over short circuits. That the law, which determines the transmission of currents through a wire, to produce speech is precisely the same, in every respect, as the law which determines the flow of currents through submarine cables, and that it is absolutely impossible, to obtain any greater number of signals, along a given conductor, by any alteration or improvement in the instruments.

That the ratio values of conductors were as follows: iron 1,000, copper in cables 1,200, copper exposed 1,500. That the difference between iron and copper was due to the self induction of the iron; and between copper in cables and copper exposed, the difference was entirely due to the insulation of the former; the leakage from suspended wire enabling it to discharge its static charge, and still more quickly from a suspended copper than from an iron wire.

That experiments showed, that when the speed of the currents was .004 to .003 of a second, the transmission of speech was bad; when .003 to .002, it was fair; when .002 to .001, it was good; and if under .001, perfect.

That the average number of sonorous vibrations in the human voice, was about 1,500 per second. Experiments made upon the Irish cables and lines proved the relative values of the different circuits, and that even with a powerful "Berliner" transmitter, the rate of speaking was neither increased nor varied from the result obtained when ordinary transmitters of much less power were used.

That Professor Fleeming Jenkin had verified the law of static induction and consequent retardation of signals, through the French Atlantic cable of 2500 miles in length, when he found it possible to obtain $2\frac{1}{2}$ reversals of current, per second; and that both theory and practice demonstrated that speech was limited in such class of [illegible]e to a distance not exceeding 96 to 100 miles of its length.

That telephonic disturbances are principally due to secondary currents induced by primary currents in neighboring lines, and that short circuits are more disturbed by such influences than are long circuits, such disturbances being due, not merely to the strength or potential of neighboring currents, but to the rate at which the said currents rise and fall.

That although the effects of induction might in some measure be neutralized by strengthening the transmitter and weakening the receiver, it would be almost impossible to convey intelligible speech, when very strong currents (such for instance as were used in a Wheatstone transmitting telegraph) were traversing neighboring lines, the induction effects from said currents being 100,000 times stronger than telephonic currents.

Professor Hughes was of opinion that greater attention should be given to the transmitter induction coils, and that the battery cells and primary wire of the coils should be in proportion to the internal resistance of the transmitter; and he agreed with Professor Thompson, that more powerful transmitters and less sensitive receivers indicated the path of progress in telephony.

Mr. Bidwell held, that the constituent elements of a transmitter should be an arrangement in multiple-arc of heavy carbon pencils, with light points of contact, that the resistance of such a microphone should be proportionately as small as the rest of the circuit, and that the current should be as strong as the number of contacts and amount of pressure would warrant.

With due regard to the foregoing views and experiments of eminent electricians, the speaker ventures to express the opinion:—

That clearness of articulation and natural tones are best obtainable from magneto-electric transmitters, which are free from the disturbing and varying action of local galvanic cells.

That loudness, and progress in long-distance telephony, will depend in great measure upon increased power in the transmitter and decreased sensitiveness in the receiver.

That whereas it is impracticable to control the environments of telephone wires, attention must be given to the elimination of induced disturbing currents, by utilizing twisted all-metallic circuits, or some equivalent device.

That economy in line construction can be effected by utilizing one such twisted all-metallic circuit, of low resistance, for several exchange connections.

In conclusion the author begs to state that this paper has been compiled with the sole object of inviting discussion upon one of the most important inventions of the nineteenth century, by the members and associates of the Canadian Society of Civil Engineers.

DISCUSSION.

Mr. Keeley explained that his presence was due to the fact that Mr. Gisborne was unable to travel through illness. He further stated that Mr. Gisborne had considered it advisable that he should bring some apparatus, in order to make clear any points that might be brought into question, such apparatus was now on the table, and Mr. Keeley thus continued :—

Mr. Keeley. It occurred to Mr. Gisborne, that as this paper would be the first one on the subject of Telephony brought before the Society, it should be made as comprehensive as possible; and for that reason he has in it set forth his own ideas and the views of the several prominent electricians who participated in the discussion at a meeting of the Society of Telegraph Engineers and Electricians, when the whole subject was thoroughly considered. Having read the full report of that discussion, and noticed what an amount of acrimony was exhibited by some of the participants, it might be stated, that Mr. Gisborne has given in his paper, all of the valuable information elicited, just as one would serve up honey, without a hint of the stings that had been associated with it.

Without entering into a discussion of the question as to the origin of the telephone, but simply dealing with the subject as we now find it, the speaker would direct attention to one particularly important point that to his mind is conspicuous amongst the many other discussable points with which Mr. Gisborne's paper fairly bristles.

Papers treating broad subjects of this character in a general way are necessarily provocative of much discussion; and unless it be for purposes of criticism, little good is derivable from an attempt on the part of any single individual to discuss such a paper, clause by clause or point after point, where numbers of points are discernable. Attention will therefore be directed to one important point.

It is pretty generally admitted that the British electricians, whose names figure so prominently in Mr. Gisborne's paper, are authorities upon the subject of telephony. If they be so, the importance of the point which the speaker desires to consider is beyond doubt.

It is this:—The *Question* as to the possibility of improvement in telephony.

Now, one would hardly believe this possible with advanced scientists, in view of the fact that it was only a little while ago the telephone was introduced, and almost daily the journals remind us that the thing is yet in its infancy. Nevertheless, there appears to be good ground for the doubt that has arisen; and an attempt will be made to shew wherein it lies.

Every question has necessarily two sides. In this instance we have as representatives of the contrary views, Prof. Sylvanus Thompson on the one hand, and Mr. W. H. Preece on the other.

Both of these gentlemen have actually experimented; they speak authoritatively from the results of their experiments; and they are agreed that the real impediment to uniformly successful operation consists in circuit induction.

They are not agreed, however, as to what is requisite for the elimination of this difficulty.

Each claims the other's conception to be erroneous and impracticable.

Hence, if each is an authority and if both are wrong in their conceptions, as the speaker has reason to believe they are, the future of the telephone is still problematical.

To be more explicit Prof. S. Thompson considers the apparatus at present in use to be at fault; it is far too sensitive. He conceives the requirement to be a receiver insufficiently sensitive to be affected by currents induced from extraneous sources; and a transmitter sufficiently powerful to produce currents to modify any extraneously induced, and consequently sufficiently strong to be effectual in the receiver.

Mr. Preece, on the other hand, considers the apparatus at present in use as faultless. He conceives the difficulty rests with the circuit, and that uniform results can only be secured by its isolation, or, as he would express it, by getting rid of its mischievous environment.

Each of these gentlemen combats the other's view, and with good reason.

It is quite certain there would be a limit, a low one, to the power of Prof. Thompson's transmitter; whereas, the strength of currents induced from adjacent wires (electric-light circuits, for instance) is practically unlimited.

It is also evident that the isolation of any one of a number of adjacent wires is physically impossible without the interposition of an invulnerable screen between it and the others throughout its length; and as the material for such a screen has yet to be discovered, Mr. Preece's idea is less hopeful than Prof. Thompson's.

It therefore follows that as these gentlemen are recognized authorities, that as both are decided as to the impediment existing, and that as they are mutually skeptical as to each other's conception of what is needful to remove it, the development of the telephone is at a standstill, and it is actually questionable with them whether any further improvement is possible.

Now, assuming that it will be considered this point is well taken, it may be stated, for the comfort of those who have the future of the telephone at heart, that there is no good cause for alarm. It can be borne in mind that the mere fact of a standard time-piece, coming to a full stop, does not necessarily throw the entire time service of a community out of gear.

Further, it may be said that perhaps there is another way out of the difficulty that has not occurred to the minds of our British collaborators other than that advocated by Mr. Gisborne, who proposes the use of twisted all-metallic circuits, an expedient that would certainly bridge the difficulty, and whose only disadvantage consists in the cost. The way the speaker would suggest is one that will involve neither the abandonment of the apparatus at present in use nor the reconstruction of the circuit; it has reference solely to the disposition of the apparatus *in* the circuit.

In order to convey a clear understanding of this idea, will you recall the explanations given in the text books with reference to the origin of the quadruples in telegraphy. It will be remembered the duplex was in existence, the duplex enables us to operate a wire from both ends simultaneously—that is a system of double transmission, but the transmission is in opposite directions; the problem was to devise a system whereby we should have double transmission in the same direction. At that time, as at present, the open-circuit system of ~~Morse~~ telegraphy was in existence in England, and the closed-circuit system in America. The former is operated by reversals of the transmitting battery, and the latter is operated by the introduction and withdrawal of the battery. The idea occurred to two electricians (experimentalists they were, too), Messrs. Edison & Prescott, that these systems might be combined. That idea was the solution of the problem.

Now, it was in a somewhat analogous manner the speaker viewed this telephone difficulty. The apparatus is worked in the one way all the world over; but if there are not two continents to look to, we have two departments in the system itself, the Primary and Secondary circuits; the former is operated by the variation of resistance, and the latter is operated by induction. Suppose we combine these two, and arrange the whole so that the induction currents will be neutralized, while the direct current will control the instrument. It seems probable that it can be done. Some time ago the speaker conceived that the receiver and battery might be so disposed in the circuit, that, while currents induced in the circuit from extraneous sources would traverse the receiver in opposite directions, thus producing no effect in it, the latter, having the battery current conducted through it in *one* direction, would be responsive to the fluctuations in the current strength occasioned by variations of resistance in the circuit. But, exactly how this result is to be secured, cannot be said. The speaker has made a large number of experiments, the results of which, if not satisfactory as regards the solution of the problem, are yet interesting, in that they throw more light upon the subject, and afford a better understanding of the actions obtaining in the premises.

It would hardly be in order to go into a further explanation of this idea now; but the experiments in connection with it are nearly completed, and if the matter is considered of sufficient interest, the details may be communicated to the Society at one of its future meetings.

Mr. Thornberry Very little of any thing can be added to the very clear explanations and remarks, as given by Mr. Keeley. A few remarks, respecting the delicate character of the Blake transmitter, may now be made.

It is interesting to know just how delicate an instrument the Blake transmitter is; and when it is stated that it is possible to use but 10 or 15 per cent. of the current supplied by one cell, such as you see on the table, you can comprehend its delicacy. By the expression "use but 10 or 15 per cent. of the current," it is meant that the variation of the contact caused by the voice waves causes a variation of only 10 to 15 per cent. of the current supplied to the instruments.

A word might be added in reference to the instrument designated, the Draubaugh. This instrument has been very much improved in the States. The Bell Telephone Co. has adopted it on its lines between New York and Philadelphia, and between New York, Boston and Albany. When the first experiments were made by the American Bell Telephone Co. with this transmitter, the speaker was connected with that company, and has frequently whispered between New York and Boston. The line between Boston and New York is about 300 miles long, and cost in the neighborhood of $30,000.

Conversation is now carried on between Boston and Philadelphia, 350 miles, and the line also goes to Albany.

Perhaps a few remarks in reference to the underground question may not be out of place. An expression very frequently heard is to the effect that "the telephone wires are a nuisance and should go under ground." The remarks Mr. Keeley read in his paper when he said, telephony is impossible on sub-marine cables, except within 95 to 100 miles, illustrated the difficulty to be contended with in an underground cable; and that is the effect of the charge the cable has a capacity for. The charge referred to of is the capacity of the metal of the conductor, and the metal surrounding the cable in connection with the earth to take on a charge of electricity, which charge opposes the currents sent out by the speaker and so retards his conversation. This is what makes underground work so unsatisfactory. Then the expense is so great that necessarily the rate must be raised. Few would wish for this, especially as the present rate is thought to be too great, while the service is also as good as it can be made.

A misapprehension is prevalent respecting the way in which a Blake transmitter should be spoken, to and should be corrected. No advantage is gained by talking in a loud tone of voice; that only does an injury, and "breaks up the conversation" so that it is misunderstood. A full even voice, three or four inches away from the instrument, is the best.

In reply to the remarks of Professor Bovey, a humming noise heard in the telephone at night, which is often so loud as to drown at a time all conversation, the speaker stated it to be due to induction caused by the Electric Light. The Electric Light Co. runs its wires regardless of ours.

Mr. L. B. McFarlane said: There seems to be a statement made in Mr. Gisborne's paper, to the effect that Prof. Thompson had found platinum and copper treated with selenium the best microphonic contact for Transmitters. It will be asked, by those not familiar with the telephone business, why this contact is not used in practice. For their information it might be explained that platinum and copper so treated will answer for a short time only. The Telephone companies are constantly experimenting in this direction, and have found nothing to equal what they now use. Mr. McFarlane

In reply to the question that has been asked, with reference to a form of telephone in which the south pole of the magnet is bent round and fixed to the outer edge of the diaphragm, it may be said that the object of that arrangement is to strengthen the magnetic field by bringing the north and south poles as nearly as possible together. The object can hardly be said to be attained, however, as the mass of iron in the diaphragm is too little to conduct the lines of force. A great many instruments have been constructed in which that feature is found. The Crown telephone has a system of eight magnets, each with its south pole in contact with the outer edge of the diaphragm, and all of the north poles directed towards its centre. In the Gisborne-Keeley instrument (Fig. 8), there are four magnets on each side of the diaphragm similarly disposed. The speaker has handled a good many instruments with and without this feature. In some forms the magnet is arranged in that way for convenience, or for neatness in design; beyond that it has no advantage. Mr. Keeley.

Mr. Hannaford. Mr. Hannaford next requested Mr. Keeley to describe the apparatus.

Mr. Keeley. Two or three years ago an impression somehow got abroad that the Superintendent of Government Telegraphs (Mr. Gisborne) wanted to get hold of a telephone that would beat everything of the kind in existence. The result was that a great many inventions were sent or brought to him by the inventors or their representatives, and each claimed that his was *the best in the world.* All inventors do that. In the midst of all this there was a certainty, and that was the necessity for a standard for comparison. Mr. Gisborne examined all the instruments that were sent to him. It was the speaker's privilege to assist him in his examination and tests. The instruments of the Bell Telephone Company were taken as the standard—the same that you are all familiar with, and which you make use of every day. Here

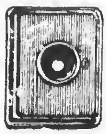
FIG 1


FIG 2

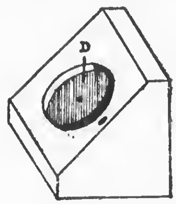

FIG 3

they are—the Blake transmitter (Fig. 1) and the Bell receiver (Fig. 2). These were our standards. Few of the instruments tried were as good, none were better. There was one form of transmitter, somewhat different from the Blake, and possessing some good features that held our attention. It is this one (Fig. 3), made by the Consolidated Telephone Company of London, England. It is a first rate instrument. You observe there is a number of carbon pencils and blocks

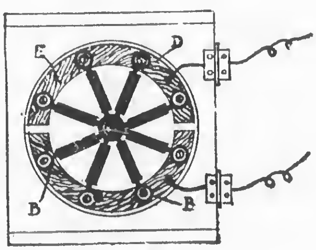

FIG 4

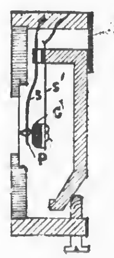

FIG 5

here (Fig. 4, plan of microphone of instrument shewn in Fig. 3), arranged radially like the spokes of a wheel, the hub fixed to the centre of a mica diaphragm (*d*). Half of the number of blocks (*b*) are fixed to a semi-circle of metal, E, on one side, and the other half similarly fixed on the other side of the annular space (*a*) back of the diaphragm. This device seems to have originated with Dr. Herz, of Vienna, and was independently invented by Mr. Crossley, in Scotland. It is a form of instrument used very extensively in England and France. (They have a mouth-piece on it there; this open-faced diaphragm is an improvement, suggested to the makers of the instrument by Mr. Gisborne.) It seems that the Bell Telephone Company's patents cover this instrument, and it may be interesting to shew how it compares with the Blake transmitter, in order that you may conceive why it is not made use of in this country. In this Blake transmitter (Fig. 1) the microphone (Fig. 5, plan of microphone of instrument shown in Fig. 1) consists in a carbon button (*c*) and a platinum point (*p*); that is what is called a single contact. You see these parts are hung in a very pretty piece of mechanism; a wonderfully nice system of springs, whose appearance alone clearly proclaims the scientific construction of the instrument. By means of these springs (s, s', s",) the adjustment of this transmitter is practically unlimited; it can be made extremely sensitive, and the reverse. In practice, as you are all aware, it is so adjusted that it is possible to communicate through it in ordinary conversational tones. Now, look at this English instrument. The microphone consists in these pencils and blocks of carbon (Fig. 4); this is called multiple contact. You perceive there is nothing adjustable about this; it is put together, once and for all; so that what is true of almost everything else made in England is true of this transmitter,—it is substantial and reliable. Comparing the two, therefore, one would hardly expect to find this one so sensitive as the Blake—and it is not so. Consequently, when we approach a Blake transmitter, we are disposed to say, in a tone as low as possible: "Do you hear me now?" Whereas were we using this multiple contact microphone we would in a louder tone enquire: "*Are you there—!—!?*" However, this latter instrument has one great advantage: it is possible to talk loudly into it with perfect success, the louder the better; and sometimes it is a great satisfaction to a man to talk loud. This cannot be done with the Blake as ordinarily adjusted; it must be spoken to quietly, naturally, and without effort at precise utterance. For this reason it is preeminently fitted for the field it occupies. If you want to put up a telephone out in the country far beyond the reach of the experts who adjust the Blake instruments for exchange work, and far away from people acquainted with apparatus of this kind, then send the English style of instrument. Mr. Gisborne sent a pair of them out to the North-West, during the trouble there in 1885; they were put up and operated by parties who had never handled such apparatus before. On the other hand, if you wanted connections in town or in any place where if required the apparatus could be adjusted, it would be better to put in the Blake.

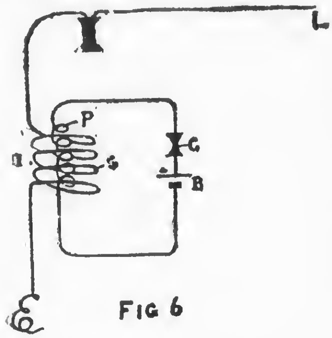

FIG 6

The peculiarity of the Blake transmitter is that you cannot operate it successfully with more than a single cell of battery. In these transmitters you know the arrangement consists of an induction coil (I. Fig 6), the primary wire (p) of which is in circuit with a battery (B) and microphone contact points (c). In the Blake instrument the microphone is a single contact between the platinum point (p, Fig. 5) and the carbon button (c). Now there is a theory that bodies apparently in contact are not actually so unless they are incorporated and solidified; there is a film of air between them. In this Blake microphone, therefore, a film of air—a minute space—is interposed between the carbon button and the platinum point, and if we put in circuit with it a battery of sufficient intensity, the current will pass in a series of spark discharges across this space and produce a clicking and roaring noise in the telephone (in circuit (Fig. 5) with the secondary wire (s), of the induction coil, I.). Two cells of battery will afford a current of sufficient intensity for this discharge. If the roaring is overcome by increasing the normal pressure between the carbon and platinum point, the microphone will be rendered less sensitive and it will be necessary to talk loud in using it. On the other hand, a single cell of battery does not afford a sufficiently intense current to produce these discharges; hence, the finest adjustment and the best results can be secured with a single cell in connection with this transmitter. The telephone companies on this continent have used this instrument in preference to all others, although it is evidently a much more costly transmitter than this English machine, which is probably the best and cheapest multiple contact transmitter in existence. Perhaps the most valuable feature of this latter form of microphone—the multiple contact arrangement—is that several cells of battery may be put in circuit with it. As there are so many contacts presented for the passage of the current, the force of the battery is not directed to any one point, but is divided up amongst them all, and there is consequently none of that discharge or sparking effect that we get in the Blake; and since there is no variation in the adjustment of the parts, it follows that an increased battery power will increase the effectiveness of the transmitter.

There is another form of instrument—the Drawbaugh long-distance transmitter. In this, the microphone is composed of a chamber containing granulated carbon, and a metal plate; the latter forming at once the cover of the carbon chamber and the diaphragm of the instrument. It was designed to be operated in a peculiar way. (Fig. 7) shews the

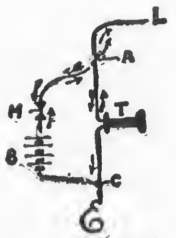

FIG 7

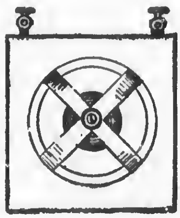

FIG 8

arrangement of the circuit. The receiver (T) is in the main circuit (E. L.), and the transmitter (*m*) and battery (B) are shunted around it. When the local circuit (a.m.B.C.) is closed, the current from the battery (B) divides at the junction (*a*) of main and local circuit, one part goes to the line (L) and distant receiver; and the other part flows round through the telephone (T), in the direction of the plain arrows. The passage of the current through the telephone coil induces a pulsation in the opposite direction; this induced current, represented by the feathered arrows, also divides at the junction (*a*); the part that flows to line (L) is in the same direction as the battery current, and augments the effect of the latter in the distant receiver. This system requires a large battery in consequence of the greater part of the direct and induced currents being absorbed in the local circuit. The transmitter is not sensitive; and the entire arrangement presents no advantages over the other apparatus that we have here.

Consider now the receivers. This instrument is the Gisborne-Keeley telephone (Fig. 8), mentioned in Mr. Gisborne's paper, and as it was allowed a little while ago that inventors claimed that their own inventions were the best in the world, there is no reason why this instrument should be considered exceptional in that respect. Mr. Gisborne has referred in his paper to experiments made with this instrument as a magneto transmitter. It is a good *transmitter;* but not so reliable and uniform in its operation as is requisite in a transmitter; its adjustment does not hold good. It is however a splendid and very excellent *receiver*. An illustration on the black-board will shew wherein its excellence lies. You know that the ordinary telephone receiver (Fig. 2) contains in the handle a permanent bar magnet, which is in contact with the soft iron core of the coil that influences the diaphragm; and that the object of that magnet is to polarize the soft iron core. Well, omitting the permanent magnets in the illustration the polarized cores only will be shewn. There are two of them (A. B.,

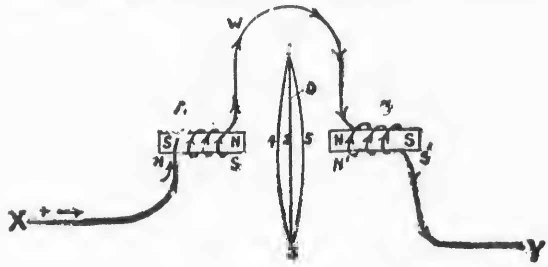

FIG 9

Fig. 9); one on each side of the iron diaphragm (D); and the north poles (N) are presented to the diaphragm. Now put a coil of wire (*w*) on each of these cores; you perceive the direction in which it is wound, from right to left, starting from the outside (*s*) end of left hand core (*a*); and from right to left, starting from the inside (N) end of the right hand core (B). As currents of electricity induce magnetism, it stands to reason that if a current be put through from this end (*x*) to the other (*y*) in circuit—its course round the cores being in the same direction, and the polarity of the cores being reversed—the magnetism of one core will be partially neutralized and lessened, and that of the other augmented; and the diaphragm (D) will be attracted to the stronger side. For instance, viewing the diaphragm (D) from the left hand side (*x*), if a positive (+) current is sent through from this end (*x*), the magnetic effect of the current, represented by n. s., n' s'., will partially neutralize the magnetism S N in the left hand core (A), and proportionately augment the magnetism N S in the right hand core (B). The diaphragm (D) will consequently leave the plane (1, 2, 3,) and assume the concave (1, 5, 3,); and if a negative (—) current is sent through from the same end, the conditions are reversed and the diaphragm assumes the convex (1, 4, 3.). Therefore, each succeeding pulsation will vibrate the diaphragm between the lines 4 and 5 and, the amplitude of that vibration is referable solely to the strength of the currents transmitted. In the ordinary instrument (Fig. 2), there is only the vibration obtaining between the plane and concave; there is no convex effect; besides that, the diaphragm is at a disadvantage, being under a constant strain due to the presence of the magnet on only one side, whereas in this new instrument the magnets are on both sides exerting an equal influence, and in consequence leaving the diaphragm free from strain and perfectly free to vibrate in response to variations in the strength of the magnetism on either side.

A good idea of the relative powers of these two instruments may be obtained by fingering the microphone with which they are here in circuit. You will perceive a much louder sound in this new instrument than in the other, as, in addition to its more powerful construction, the permanent magnets are so arranged as to afford the greatest possible room for the sounds to issue from the diaphragm. You will find, however, that to perceive these effects it is necessary to bring both instruments close to the ear; and then there naturally arises a question as to wherein the advantage lies with this new instrument which is so much more cumbersome than the other. This brings the speaker back to the transmitters. It was explained just now that the amplitude of the vibration of the diaphragm depended upon the strength of the transmitted currents. It will be noticed there is but a single cell of battery here. With three or four cells in connection with this English transmitter a very loud effect can be produced in this new instrument; and when the transmitter is spoken at with a loud voice, the words are reproduced in this receiver more loudly than in any other instrument that the speaker knows of. That is why he says it is the best; although possibly many persons might object to having three or four cells of battery, when for all ordinary purposes he can get equally good results from a sensitive Blake transmitter with one cell of battery and the ordinary Bell receiver held to his ear. This little instrument (Fig. 2) with which you are all so familiar is a scientific triumph in its way. If Prof. Bell and his associates had spent twenty years in considering the design for its construction, they could hardly have produced a neater or more perfect thing than this which made its appearance at the very beginning of their operations. When this instrument was first introduced, you will remember it was used as a transmitter as well as receiver. You can converse well if you yell into it; some people like that sort of thing. It was only the other day, it was reported in one of the electrical papers that the government of one of the European countries—Germany—had just decided to adopt a microphone transmitter; an improvement without which they had so far managed to get along. An explanation might be given of the operation of a magnetic transmitter—for that is what the ordinary receiver becomes when spoken into.

You know that if a strong magnet is brought into the vicinity of a coil of wire and then withdrawn, it induces a pulsation of current in the wire at each approach and withdrawal; and that if the magnet were put into the coil, and its power increased and diminished it would induce these currents. You also know that if a piece of soft iron is brought near a permanent magnet, it will have magnetism imparted to it. Now what is the case in the present instance? The telephone handle contains a powerful magnet (S.N., Fig. 10) which imparts its magnetism to the iron core (*s.n.*) of the coil (*c*). The outer end (*n*) of the core thus becomes the end of the powerful magnet, and imparts its magnetism to the diaphragm (D). Now, if the diaphragm be vibrated, it is evident that when it approaches the end (*n*) of the core the magnetism increases, and when it recedes the magnetism diminishes, not only in the diaphragm, but also in the core (*s.n.*), and these latter fluctuations will induce currents in the coil, which if arranged in circuit will transmit them to a similar instrument at a distance where the fluctuations and vibrations will be reproduced.

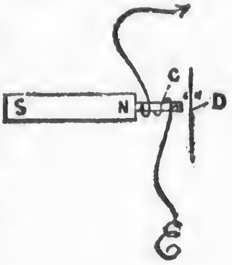

FIG 10

The apparatus has now been pretty fairly explained, and probably you will be disposed to agree that the instruments are all right; Mr. Preece says they are. The noises that interfere with our operations are, as every one admits, caused by currents traversing neighboring wire; the currents induced from the adjacent wires operate in the receivers just in the same way as the currents produced by the transmitter itself; hence, the development of these noisy effects is due to no fault in the apparatus. Besides this it appears the trouble encountered in long distance transmission is also due for most part to the proximity of other wires. Mr. Preece experimented upon a long line that was far away from any electric light or telegraph wire, and got excellent results; the poorest form of instrument he had worked as satisfactorily as the best. That experiment speaks for itself, and in the speaker's opinion establishes a fact that ought to be sufficient to shew that Mr. Preece has substantial grounds for his argument.

With reference to the question as to why the dry battery is not made use of in connection with telephone work, Mr. Keeley said that its high internal resistance, if nothing else, renders it unsuitable for the purpose. That Prof. Hughes and a good many others consider it very desirable that the resistance of the battery and microphone should be as nearly as possible equal to that of the primary wire of the induction coil. The resistance of the primary wire cannot be increased without rendering the coil less effective. It is less than a single unit. The microphone is greatly in excess of that, and it is therefore necessary to keep the battery resistance as low as possible. It is principally to secure a low internal resistance that the single cells of Le Clanche used with the telephone apparatus are so large. The internal resistance is increased as the size of the plates and volume of fluid is decreased.

In reply to Mr. McFarlane's remarks, concerning the use of electrodes composed of selenium and copper, it may be that he is right as to the failure of the combination to act for any considerable period; the speaker had no knowledge of the composition in question and was not aware that it had ever been used excepting in an experimental way. It will be noticed that in Mr. Gisborne's paper reference is made only to the result of experiments made by Prof. Thompson. Besides, Mr. Gisborne remarks that the combination requires a greater initial pressure than required in the carbon microphones. From this it may be inferred that it is not so sensitive as the latter, and in that case it would need to be spoken to loudly.

The member who enquired as to whether the coldness of these nights had any effect on telephones must have misunderstood his informant as to the kind of telephone referred to. The buzzing sound heard in the electric telephone is due to induction from the electric light wires. It is probable reference was had to an acoustic telephone; it is not unlikely that effects would be produced on it on a cold night that would not be produced on any other night, for the reason that the wire, already tightly strung and under tension, would be contracted by the frost, and be thereby subject to such a high tension that the least thing would vibrate it. As electric currents produce heat, it is not at all impossible that currents induced from neighboring electric light wires would obtain in this tightly strung wire, and each pulsation would in a minute degree vary the temperature of the wire; a constant repetition of this effect would very soon create a vibration in the wire, that would produce in the acoustic telephone precisely the same sounds we get in the electric telephone from the same primary source.

With reference to Mr. Thornberry's remarks relative to the operation of the metallic circuit between Boston and New York, it might perhaps be explained how it is that the instruments on such a circuit are not affected in any way by induction from neighboring wires. Suppose

FIG 11

this line (A, Fig. 11) is a telegraph wire, with an intermittent current traversing it in the direction of the plain arrow, and this other line (B), below, is a telephone wire, it is known that currents flowing in one direction induce currents in the opposite direction; so there is an induced current in this telephone wire, in the direction of the feathered arrow. Suppose this third line (C) is another telephone wire; in it an induced current from the telegraph wire is also set up in the direction of the feathered arrow. Suppose now these two telephone wires are connected into one round circuit through the telephones (T and T,' Fig. 12), at either end of the line. Is it not quite evident that the current induced in the wires will be opposed in the instruments, and will mutually neutralize each other? Now, that is just what does occur; hence the telegraph current does not affect the telephone at all. But a current sent out from the transmitter at one end will circulate round in one direction (plain arrows) in the circuit, and the receiver at the other end will respond to it.

FIG 12

If it were not for the expense and inconvenience of the thing, the metallic circuit, and Mr. Gisborne's twisted metallic circuit in particular, might be considered as the solution of all telephone difficulties. Electricians are however looking for other means for getting rid of the trouble. The speaker has already stated what his own idea is in this connection; and as so much attention is now being given to the matter in all quarters, no doubt there will be some further interesting developments before long.

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