GLIMPSES OF THE INTERNATIONAL ELECTRICAL EXHIBITION.

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NO. 8. REIS'S INVENTION OF THE ARTICULATING TELEPHONE.

In telephonic communications, mechanical vibrations of the transmitting diaphragm, are, through the agency of electricity, mechanically reproduced at the receiving diaphragm. The question in dispute between Reis and Bell, is, as to the nature of the electrical currents that transfer the motion from the receiving to the transmitting end of the circuit.

Can an electrical current in which makes and breaks occur successfully transmit articulate speech? This question it will be perceived is vital to the interests of Bell, since, unless he can maintain the absolute necessity for his undulatory current, the extent of his alleged invention is very considerably decreased. Instead of having created a new genus of apparatus, he has merely produced a modification of what has already existed. Apart, therefore, from the question of what Reis really intended by his makes and breaks let us carefully examine this question.

Scientific men have by no means given unqualified assent to the necessity for the employment of an undulatory current in the telephonic transmission of articulate speech. On the contrary many of the ablest physicists and electricians have expressed grave doubts in the matter. I will give a few quotations to this effect, taken from testimony in some of the Bell Telephone suits for alleged infringement. Dr. Wm. F. Channing testified in one of these suits as follows; viz.,

Q. "And don't you also know or believe that the electric transmission of speech depends on the precise mode of operation stated in that question?"

A. "I do not. It is the merest assumption that no other method exists for the transmission of articulate sounds than what is called the undulatory current. The vibrations of sound which enter

into articulation are not undulatory (in the form usually represented by graphic curves) In their ultimate analysis they are to-and-fro vibrations in a straight line.

They do not resemble the waves of the ocean nor the undulatory curves which for convenience are made to represent the form of simple or compound sounds in their relations to time. We have no evidence whatsoever that any articulate sound cannot be reproduced in the telephone by as many separate electrical impulses as there are separate sound vibrations, the electrical impulses corresponding precisely in number, intensity and combination with those of sound."

Again, speaking of certain tracings, or records, obtained by means of a machine devised by Prof. E. W. Blake, for describing Compound Harmonic Curves, he says,

"The characteristic to which I wish to draw attention in all these records, is that the effect of compound sounds, such as enter into articulation, is to produce a very few abrupt and marked changes in the motion of the telephone diaphragm, and of its equivalent in the phonograph. I wish also to draw attention to the fact that these changes in the motion of the diaphragm, which are the principal characteristics of its articulatory action, are often or mainly arrests or reversals of its motion. An arrest of the motion of the diaphragm means an arrest of the current. A reversal of the motion of the diaphragm, means an interruption and reversal of the electric current."

"Interpreting thus these graphic records, I have no hesitation in saying that the elements of articulation which are actually influential on the plate, and which ever actually reach the distant receiving end of the line, may consist entirely of makes and breaks of different order, duration, and force."

Again in the same answer

"I do not believe that the electric undulations are ever similar in form in any accurate sense to the vibrations of the air accompanying the sounds of the voice made in a transmitter. The method of electric transmission is complex and artificial, and for reasons already stated differs widely from the air vibrations which originate it."

Prof. Cyrus F. Brackett testifies in one of the above suits as follows:

Q. "Do you know it to be true that a simple sound represented by a sinusoidal curve cannot produce an electrical undulation by the intervention of an inductive action which can be represented graphically without error by the same sinusoidal curve; and if you know that to be true when and how did you make that discovery?"

A. "I am as sure as I am of most facts on which we place implicit confidence that while such undulations may be graphically represented with approximate similarity, they cannot so be represented without error; and as I have been asked when I made that discovery, I may answer generally that the results in telephonic transmission, as a matter of fact, never do, to the best of my knowledge and belief, exactly correspond with and copy the sounds delivered to the transmitter. Accurate date as to when I made this discovery I cannot give. It is notoriously a subject of discussion by mathematicians and experimental physicists to determine the laws which govern the changes found to exist between the spoken and received words of a telephone. My knowledge is partly derived from experience and is partly theoretical."

Again the same witness,

Q. "Assume it to be true that the circuit is broken and closed at each vibration, is it your opinion that such an apparatus as that combined with the best receiver now in use, and without any other apparatus, except the battery and wires, can transmit articulate speech practically?"

A. "I have no question whatever that it is entirely possible on the hypothesis in the question to so transmit articulate speech, and I will give my reasons in part: When a circuit is closed, as that term is commonly used, it by no means follows and is not true that the current suddenly reaches its maximum, and it is not true that when the circuit is interrupted, as assumed in the question, that the current suddenly and immediately ceases along the whole line. Several conditions will determine its establishment and cessation, among which may be mentioned the length and resistance of the line, its static induction, its mutual induction arising from the necessary introduction of magnet in the circuit, etc. It, therefore, follows that if the making and breaking, assumed in the question, are properly timed relatively to each other that the effect at a distant point at which a telephonic receiver may be placed will be such that it will be thrown into vibration under the impulses of

the electric pulses or undulations which reach it and which may be made to be of the proper form to reproduce the words spoken in the said assumed interrupting transmitter."

Again in answer to another interrogation the same witness testifies

"It is still (Mar. 15, 1884) an open question, whether that class of instruments known, popularly as circuit breakers, of which Reis, McDonough, Hughes' microphone, Blake transmitter, etc., are examples, operate by making and breaking the circuit, so as actually for minute intervals of time to thereby reduce the current to a minimum, or whether they act through continuous contact by varying pressure to alter the resistance in the line in substantial accordance with the vibrations constituting sound as employed in articulate speech."

So also Prof. C. A. Young, deposes as follows :

Q. "Did you mean to say that in your opinion the microphone operates by making and breaking the circuit, and not by varying the strength of current which is maintained through the joint during the operation of transmission ?

A. "I intended to say that in my opinion it is not yet (Feb. 13th, 1884) certain in what precise manner the microphone produces variations in the strength of the current at the receiving end, and that in my opinion the theory that it is done by minute makes and breaks is not demonstrated to be false."

Again. *Q.* "In your opinion, does the intelligible transmission of speech require that the motions of the receiver-membrane or diaphragm should be a strict copy of the motions of the air in contact with the transmitter, and if not, why not ?

A. "It does not. Undoubtedly speech can be transmitted by such a strict copying—but such a copying is by no means necessary. The characteristics of a spoken word which render it intelligible as such, do not consist either in the absolute pitch of the sounds made, nor even in the quality of the sound, as that term is commonly understood. A fact, which is evident from this, that a given word spoken by a woman and by a man will differ in both these respects."

These opinions could be readily multiplied but those given above will suffice for the present.

With the above and similar opinions Mr. Bell is at variance.

Simple sounds, in his opinion, may be transmitted by means of complete makes and breaks in the electrical currents, but complex sounds, even such as simple chords, cannot be readily so transmitted. Let us examine carefully the argument as given in his U. S. letters patent and elsewhere, by which he endeavors to prove this assertion. He is discussing, in his patent of Mar. 7, 1876, the attempt to simultaneously transmit, by what he terms intermittent currents, two sounds the interval between which is that of a major third, or 4 to 5; he speaks as follows; viz., "Now, when the intermittent current is used, the circuit is made and broken four times, by one transmitting instrument, in the same time that five makes and breaks are caused by the other. *A*, and *B*, Figs. 1, 2, and 3, (*our Fig. 17*)

FIG. 17. Bell's ideal representation of effects produced by the simultaneous transmission of pulsatory currents of different rates.

represent the intermittent currents, produced; four impulses of *B*, being made in the same time as five impulses of *A*; *c, c, c*, etc., show where and for how long the circuit is made, and *d, d, d*, etc., indicate the duration of the breaks of the circuit. The line *A* and *B*, shows the total effect upon the current when the transmitting instruments for *A*, and *B*, are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In *Fig. 1*, the ratio is as 1 to 4, in *Fig. 2*, as 1 to 2; and in *Fig. 3*, the makes and breaks are of equal duration. *The combined effect, A, and B, Fig. 3, is very nearly equivalent to a continuous current. (Our italics.)*

"When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same circuit, the current upon the main lines becomes for all practical purposes continuous."

The idea intended to be conveyed is that when an endeavor is made to simultaneously transmit several rates of vibration by intermittent currents, the intervals that exist between the successive makes of any one of the tones, during which it is assumed that no current passes, will be occupied by some or all of the intervals that exist between the breaks of the other tones, so that a continuous current will result in which the characteristics of its separate components cannot be detected.

Would this be the case? We think it can be shown that Mr. Bell has thus introduced into his specification graver errors than those imputed to Mr. Reis in the interpretation often put on his description of makes and breaks.

Before discussing this, however, let us enquire more fully into the artificial distinctions which Mr. Bell has endeavored to sharply draw as to the different kinds of currents possible in telephony.

FIG. 18. Bell's classification of Electrical Currents.

Fig. 18, is taken from a chart used by Bell in a lecture delivered before the Society of Telegraph Engineers, in London, Eng., on Oct. 31, 1877. This chart recognizes three primary varieties of telephonic currents, viz., the intermittent, the pulsatory and the undulatory.

The *intermittent current* is one which is alternately present and absent from the line.

The *pulsatory current* is one which "results from sudden or instantaneous changes in the intensity of a continuous current."

The *undulatory current*, is "one in which the intensity varies in a manner proportional to the velocity of the motion of a particle of air during the production of a sound."

Of each of these primary currents there are two varieties, viz., the direct and the reversed.

In speaking in a public lecture, of the effects produced by the simultaneous transmission of several notes of different pitch by means of intermittent currents, he calls attention to the diagram

shown in *Fig. 19*, which with *Fig. 18*, is taken from Prescott's work on the Speaking Telephone.

FIG. 19. Simultaneous Transmission of Several Intermittent Electrical Currents.

In this figure as before, the interval between the two tones is that of a note and its major third. The lines A , and B , are intended to represent the currents produced by two tuning forks r , and r' , tuned to the above interval, and vibrated so as to simultaneously open and close the circuit of the battery B . The line A and B , is supposed to represent the effect produced on the circuit by the simultaneous presence of both the notes, and is intended to show that the result is still an intermittent current with, however, some of the intervals extinguished.

In the case represented in this figure the intervals in which there is supposed to be no current are assumed to be equal to those in which the current exists. Both in the patent already referred to, and in his lecture, Mr. Bell has represented a state of things that it is difficult to conceive of as ever actually existing in practice. Certainly he can not realize it by the use of the means he describes. We refer to his representation of the current as suddenly beginning and as suddenly ceasing to flow. With the arrangement of parts as shown in *Fig. 19*, and indeed with the actual condition of all telephonic circuits, such a condition could never be attained in practice. In even comparatively short lines, some time would be required to charge the line and thus establish the current, and some time would undoubtedly be required to discharge the line, and thus cause the current to cease, while in large lines the intervals of charge and discharge would necessarily be prolonged. So too, the effect produced by the induction of the current on itself, both on making and closing the circuit, would beyond question make the representations

of the abrupt beginnings and endings of the currents pictured by Mr. Bell, as false and misleading. The inverse current on closing, being in the opposite direction to the direct current, might make the starting of the current more sudden by opposing it, while the direct current on breaking would tend to prolong it. The true representative then would not be the rectangular spaces as figured in Bell's patent and lecture, but the edges of the rectangles should be cut off rounded, thus making them approximate more closely to half circles, or circular segments.

Now let the makes and breaks follow one another more rapidly ; then the adjacent semi-circles would touch one another and the line would never be quite free from an effective current. It would, however, be subject to variations in strength, which Mr. Bell conceives may take place suddenly or instantaneously, thus producing the pulsatory current, or rather, as we have shown, necessarily taking place gradually, and thus producing the undulatory current.

The distinctions therefore drawn by Mr. Bell between the intermittent, pulsatory, and undulatory currents appear in actual practice to be rather differences of degree than of kind, and the assertions so frequently made that mere makes and breaks cannot possibly produce undulatory currents in a line, are apparently groundless.

But Mr. Bell asserts that the necessary effect of simultaneously throwing on the line a number of variously timed intermittent currents is to produce a uniform or practically constant current, in which the peculiarities of its separate components are necessarily lost. Let us enquire carefully into the truth of his assertions, since if he is correct then the statement we have made in the preceding paragraph is inaccurate

Mr Bell's manifest error in this regard has been ably pointed out by Loch-Labye, in a recent number of *La Lumière Electrique*, who suggests, referring to Mr. Bell's lecture, that if a single battery be employed for each interrupter of the current then the statement of the uniformity of the resulting current is entirely erroneous and based on a failure to properly consider the conditions of the problem. For, it is evident, that taking the case of a note and its major third as represented in *Fig. 19*, if each interrupter had its separate battery, there would necessarily be times during which the interrupters would be jointly throwing their currents into the line, thus producing a current whose intensity would at such moments

be the sum of the two: there could not then possibly result the hypothetical uniform current so positively stated by Bell as necessarily ensuing.

FIG. 20. Effect of Simultaneous Transmission of a Note and its Major Third.

In *Fig. 20*, which is collated from the *Scientific American Supplement* for May 23, 1885, the upper drawing shows the effect which Bell asserts would be produced on a telegraphic line from the simultaneous transmission of a note and its major third by the use of an intermittent current. The lower line, Bell's representation of the effect produced by the simultaneous transmission of the same notes by means of undulatory currents, while the middle line represents the effect which would probably be produced by the simultaneous transmission of these notes by intermittent currents when each interrupter was furnished with a single battery. The evident similarity of the second line with the third will be apparent.

If currents represented by the middle line in the above figure can be produced by the simultaneous transmission of but two different rates of intermittent currents, what must be the result when more than two are thus transmitted? Must not the result be the practical production of the undulatory current?

Examining again, therefore, in this light, Bell's classification of currents as shown in *Fig. 17*, is it not evident that the direct intermittent current must become in some cases truly undulatory, and that the direct pulsatory current cannot fail in actual practice to be invariably undulatory? And if this be true of the direct currents, must it not be still more apparent in the case of the reversed currents?

We repeat, therefore, that the differences pointed out by Mr. Bell between the intermittent, pulsatory, and undulatory currents, are in practice rather those of degree than of kind. We therefore conclude that it is not impossible to transmit articulate speech

through the proper succession of discontinuous currents of sufficiently short duration.

It has been pointed out in some of our previous articles that in the great majority of cases in actual practice the telephone circuit employs the induction coil, the transmitter being in the circuit of the primary and a battery, while the line wire is connected with the secondary of the coil. Now it is well known that the use of an induction coil, so far from decreasing the intensity and clearness of the transmitted speech, actually increases both. This could hardly be the case if the currents sent into the primary wire by the transmitter had the gradual variations in intensity, that the undulatory current would seem to necessitate. They must, therefore, have sudden variations.

Commenting on Bell's assertion that for any sound to be transmitted telephonically "electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds," must be thrown into the line, Loch-Labye in the article before alluded to very neatly says :

"If Prof. Bell's theoretic ideas were admissible in a general way, and if an application were made of them in the other departments of physics, it would be necessary to adopt this formula: A physical phenomenon, during its diffusion through several media, and by different agents, must preserve all its peculiar characters without alteration in duration or form. This is an absolute negative of the law of the transformation and *reversibility* of phenomena recognized in a general way in physics. Can this formula, which, applied to the different departments of physics and chemistry, would constitute a scientific heresy, be the expression of truth in telephony? Such derogation with so general a rule would at least be surprising!"

In conclusion he speaks as follows :

"The abrogation of the law recognized in physics does not, as Prof. Bell has supposed, exist."

"Telephonic transmission by electricity obeys the general law of the reversibility of the phenomena of nature, which, after a series of successive transformations, in which their peculiar characters and phases may be absolutely modified, reappear with all their constituent qualities."

"The original sound is produced by mechanical action. In its

propagation through the air, and then through the solid parts of the telephone, the mechanical motions are effected with the qualities proper to each of these media. Mechanical motion is afterward partially converted into magnetic or electric motion of several natures, though one or several inductions, in order to become again magnetic and then mechanical, with phases in the receiving telephone contrary to those it had in the transmitter.

We will now discuss a difficulty that perhaps with some has stood in the way of an admission of the possibility of mere intermittent or pulsatory electrical currents transmitting articulate speech. We refer to the fact that speech can be transmitted with the use of the magneto-electric telephone. Now it is probably argued that by the use of the magnetic inductions produced by the movements of the diaphragm by the sound waves that undulatory currents are thereby set up in the coils surrounding the magnets: or, as Bell would say, "an undulatory current of electricity" "the undulations of which correspond, in rapidity of succession to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration." It must not be forgotten, however, that though such currents may theoretically be produced, in reality, owing to the time required to charge a long line, and the impossibility of instantaneously or suddenly changing the direction of a current already established, as well as to the retarding effects of induction of the current on itself, or on neighboring wires, or of neighboring wires on the current, it may be regarded as scarcely probable that true undulatory currents in the sense described by Bell are transmitted over the line even in such cases. It is because these currents have generally been regarded as undulatory, and are known to transmit speech, that some have doubted the ability of any others to transmit speech.

Admitting, for sake of argument, the true undulatory character of the magneto-electric telephone currents, the objection against the possibility of intermittent or pulsatory currents transmitting speech is based, it appears to us, as a misconception of what actually occurs in the undulatory field in close proximity to a speaker, and in the undulatory field near the ear of an even moderately distant hearer. It has been assumed that all the peculiarities of the field at the transmitting end, must necessarily be reproduced at

the receiving end in order that intelligible articulate speech may be transmitted. Now such is not even generally the case. The finer vibrations or overtones, that constitute what is recognized as the quality of a speaker's voice, may be gradually dropped out of the sound waves without at all interfering with the intelligible reception of the speech. Indeed, were this not true it would be impossible for two persons to converse at even inconsiderable distances apart, since, as is well known, the amplitude and the energy of the overtones of all compound sounds are exceedingly small so that the overtones fade off very rapidly from the point of origin of the original sound. Mayer has shown that the finer overtones are so rapidly extinguished that at no very considerable distance from the speaker they become too weak to be heard. The author, too, has found that in the transmission of the human voice through rods of deal, the overtones were practically extinguished at even short distances. Such extinctions do not, however, prevent the intelligible transmission of speech. Speakers can be understood even when at such considerable distances that none but the stronger vibrations are transmitted.

Articulate speech may therefore be rendered by air waves that omit some of the original components. The undulatory motions at the hearer's ear are not only not necessarily, but not even generally exact copies of those at the speaker's mouth. There is no physical reason therefore why articulate speech may not be transmitted electrically by means of suitably timed makes and breaks.

A similar analogy exists in case of the eye. The brain takes correct cognizance of a printed page, though never read before, even if an opaque body like a sheet of paper be so held as to obscure all of a single line except about one-fourth or one-fifth of the letters. Habit permits us to mentally supply the portions effaced. So too with the ear. We can supply intelligently the portions needed, and this not only in the case of detached words, or portions of conversation, but in extended discourse.

It is not impracticable, therefore, in view of these facts, and of the conditions of the establishment and discontinuance of currents in long lines of conductors, that speech may be successfully transmitted by means of intermittent currents, even when comparatively extended breaks occur in the same.

That speech actually has been transmitted by means of strictly

intermittent currents, we will deduce a few of the many experiments tried by different investigators.

The London *Electrical Review* describes an experiment in which there was interposed in the circuit of a microphone transmitter, a ribbon of paper similar to that employed in automatic telegraphy. The paper had small holes very near each other, extending longitudinally through its middle. The paper, which was placed beneath a wire brush and over a metallic drum, and moved at the rate of 1,000 words per minute. There were thus, beyond any possibility of doubt, makes and breaks introduced into the telephone circuit at the rate of several thousand per minute. When now under these circumstances, that is while the paper was in rapid motion, speech was uttered at the microphone, it was intelligently received at the receiving telephone. Speech can therefore be transmitted though makes and breaks are continually occurring in the circuit.

But can speech be transmitted by means of the currents which are thus actually made and broken? I will quote here the description given by Dr. Wm. F. Channing, of an experiment made by McDonough.

"I am able to adduce, what I will not call a proof, but an evidence, much more direct than this, that articulation may be produced by the method of an electric current actually made and broken. An instrument has been constructed and is in existence, in which what I think must be accepted as undoubted, articulation is produced by simply making and breaking the electric current. This instrument consists of a toothed-wheel rheotome of about thirty-seven inches diameter. The wheel is of iron with a brass tire. This tire has a large number of minute serrations, on which in rotation, a spring bears. The spring is connected with a single Leclanché cell, the other pole of which passes to a large electromagnetic telephone receiver, the return wire of which is connected with the axis of the rheotome wheel. The serrations on the tire of the wheel, I understand, were planned, as regards their distance and grouping upon a careful study of a phonograph record. When this wheel was turned by hand, I heard the word "hello" proceed from the tambourine receiver. The sound of the aspirate *h*, and the *e*, and the *o*, were very good. The articulation, as good as I have often heard it in telephones, was due simply to makes and breaks of the electric current, so arranged as to effect changes in the pitch and the intensity of the sound produced in the receiver."

Other experiments have been made in this direction, but the above will suffice.

We have already pointed out that the undulatory movements of the diaphragm of the receiving telephone, though not exact copies of the undulatory movements at the transmitting diaphragm, are nevertheless undulatory in their character. Let us now briefly enquire whether properly timed makes and breaks sent over the line are capable, on theoretical grounds of producing such movements in the receiving diaphragm.

It appears to be tacitly admitted by the advocates of Bell, that although in transmitting instruments of the microphone type, partial makes and breaks may take place in the electrical contacts, yet, if the circuit is not completely broken that such a current may transmit intelligible speech, since the variations thus thrown on the continuous current passing in the line produces therein a true undulatory character. Now apart from the fact that it is by no means clear to us that such a current is not pulsatory rather than undulatory, still, since we have already pointed out, the difference between pulsatory and undulatory currents is one of degree rather than of kind, we may for sake of argument admit its undulatory character, and agree that it is so because the current is never entirely absent from the line. But according to the same argument, if a sufficiently great number of separate electrical sources were throwing their current on a continuous current they would thereby render it undulatory.

Fixing our attention now on what occurs when any current reaches the magnetizing coil surrounding the magnet at the receiving instrument, we will at once perceive that if this is a permanent magnet, as used by Reis in some of his instruments, *that the permanent magnetism of the receiving instrument plays exactly the same part as the continuous current is obliged to play in the microphone transmitter.* The varying currents passing over the line either increase or decrease the strength of such permanent magnetism and set up therein true undulatory effects. If these makes and breaks can produce undulatory effects in a continuous current, *then makes and breaks, pure and simple, passed over a telegraph line, must necessarily be able, when changed into magnetism, to similarly produce undulatory effects in the magnetic field of the receiving instrument.*

We would infer, therefore, that it should on theoretical grounds be possible to convert undulatory effects at the transmitting telephone into properly timed intermittent currents, *i. e.*, makes and breaks; to transmit them over a line and produce at the other end in the receiving diaphragm, undulatory effects that are sufficiently exact copies to correctly reproduce the speech uttered into the receiver. It is by no means clear therefore that Reis did not more accurately describe the operation of his telephone than Bell claims to have done.

In concluding the brief history we have given of Reis's invention of the articulating telephone, we have thought it advisable, as far as possible, to append the views of some of the leading scientific men in the United States concerning the position, which in their opinion, Reis occupied as regards the invention of the articulating telephone. The list is by no means exhaustive; nor has any attempt been made to obtain the opinions of those known to be adverse to Reis. It fairly shows the error of the statement that the leading scientific men of America, recognize and fully endorse the pretensions of Bell.

The following circular letter was sent, viz :

HALL OF THE FRANKLIN INSTITUTE, PHILADELPHIA, 1885.

My Dear Professor :—I purpose concluding my articles on the Reis Telephone, with a publication of the opinions, as far as I can obtain them, of some of the scientific men in the United States, as to the part taken by Reis in the invention of the articulating telephone.

Will you therefore write me at your earliest convenience, your opinion as regards the following interrogatories, viz :—

First. Please say whether or not in your opinion Reis was the inventor of the speaking telephone ?

Second. Whether, if it was a speaking telephone, it worked substantially in the same way as the Bell Telephone, or not ?

Third. Whether the electrical current employed in the transmission of speech was an undulatory current in the same sense as it is in the Bell Telephone, or not ?

Fourth. Whether Reis ever actually succeeded in transmitting articulate speech as he claimed ?

Fifth. Whether the defects in the Reis apparatus are to be attributed to his transmitters, or to a want of sensitiveness in his receivers ?

Sixth. Whether the modern transmitting telephones of the variable contact type are anything more than the Reis transmitters with carbon substituted for the platinum contacts ?

Thanking you in advance for your courtesy in the matter, I am,

Very respectfully,

EDWIN J. HOUSTON.

Prof. A. E. Dolbear in answer to the above kindly sent me in addition to a very full reply by himself, a number of letters received by him from scientific men, referring to the same subject, with permission to publish the same.

TUFT'S COLLEGE, COLLEGE HILL, Mass., Oct. 1885.

PROF. EDWIN J. HOUSTON :

My Dear Prof. :—I have taken great pains to learn what Reis did with his telephone and what is possible with it, and I think it possible that I have made many more experiments with it than Reis himself did. The whole interest in the present controversy centres in Reis's transmitter, as to whether it is, and was in Reis's hands, capable of so modifying an electric current, through the automatic action of sound vibrations, as to produce what is now called the undulatory current, and of transmitting articulate speech. Now the structure of Reis's transmitters is so well known that a detailed description is not needed. All of them (for he made eight or ten forms) were so made that sound vibrations of any sort should act upon a diaphragm, carrying an electrode, upon which rests with gentle pressure, either by a spring or by its own weight, another electrode, these being part of an electric circuit, the intent evidently being that the actual movements of these electrodes, when actuated by sound vibrations, should modify the strength of the current so that it should represent as nearly as possible the wave movements in the air. If Reis's apparatus was not *intended* to duplicate such air movements by changing the energy of the current by the transmitter, I can see no use for Reis's figures of compound sound waves and his extended explanations of them. Whether apparatus so made and used will so modify a current is simply a matter of fact and in no wise depends upon any one's theory of electricity, or sound, or molecular action, or of make and break of circuit. It ought not to be lost sight of, nor kept obscure, although every effort has been made to divert attention from it, that Reis's transmitter like every other kind of transmitter acts *automatically* when it works at all, and its individual vibrations cannot be controlled by any one. Whether there will be a make and break of contacts or not, depends upon the rate of vibration and the amplitude of vibration of the diaphragm. If the amplitude be great and the rate low, the electrodes will not separate, for the free one can follow the movements of the membrane. If the amplitude be small and the rate high they cannot separate; in either case there will be only a variation of pressure of the electrodes at the point of contact. So much is purely mechanical and automatic, but it needs to be said and emphasized, for, first: it is true; and second: because this was lost sight of by the courts, and has cunningly been evaded by those interested in the denial of Reis's claims to be considered as the inventor and maker of the first speaking telephone. Every one who has experimented with Reis's transmitter knows that it will transmit articulate speech, except a few, a very few, who have an interest in not knowing. I have known one such to find a convenient excuse for absence when he had good reason for thinking that by staying his expressions of opinion would have to undergo revision.

Now Reis invented a device which he called *The Telephone*. He described its structure so that others could make similar ones, and in addition he undertook to explain throughout its mode of operation, a work which it is impossible to complete even to-day with all the advance in the knowledge of electricity and mechanics. It is in his explanation of the mode of operation of the instrument that he speaks of making and breaking the current. It might fairly be asked how Reis could absolutely know that there was a make and break for every vibration supposing that it did actually occur. He could not prove it, and, as a matter of fact, it is mechanically impossible that it should make and break the circuit for every vibration for complex sounds.

Let us suppose that we are in Reis's room, where his apparatus is set up, and we ask him how it is to be used? He says to one at the transmitter "Make sounds of *any kind*, it will transmit them," and to the one at the receiver "simply listen at the receiver." The first sings and speaks, and the latter says he heard the singing and words. Ask Reis to explain how the thing is done and he talks about makes and breaks of the current at the movable contacts of the transmitter. But Reis, how do you know that it makes and breaks for every vibration when it is transmitting words? Reis didn't and couldn't know. What Reis was doing, was helping his auditors to an easy conception of the possibilities of his apparatus, and I submit that at this day his explanation is the shortest and simplest for any who are not somewhat skilled in physics. I am not saying that it is not possible to transmit speech by a make and break circuit for every vibration, because McDonough with his wheel has demonstrated that it can be done and has thus proved that Reis was right, if such a construction be put upon his words. What I am saying, is, that if Reis *intended* that his apparatus should make and break the circuit for every vibration, then he failed, for his apparatus won't do it. It works *automatically* when it works at all and does not depend upon the *intention* of the speaker to make and break for every vibration. In the Spencer case, Judge Lowell gave the famous decree that 100 years of Reis would not make a speaking telephone. The 100 years is up, however, and McDonough with his *make and break* wheel says *hello*, easily recognized by Profs. Young, and Brackett, and many others as well as by myself.

When Sir Wyville Thomson sent home from the *Challenger* his observations on *bathybius*, Prof. Huxley sought the first print to say that he was mistaken when he gave the substance its name and philosophical importance—an example which a \$20,000,000 monopoly could not afford to have followed.

Again, it is admitted everywhere that there is no *mechanical distinction* between the Reis transmitter and the Blake transmitter, and that the efficiency of the latter depends upon the employment of carbon where Reis used platinum. Does any one think that Reis would have explained his device differently if he had used the substitute? or, that he would not have had a speaking telephone comparing well with any we have to-day?

It has been affirmed again and again that if Reis's transmitter will transmit now, it is because we apply knowledge to it which has been acquired since 1876. Take then a Reis transmitter that has not been touched since

1864, if such an one can be found, and connect it properly in circuit with a battery and connecting wire. If it be spoken to will it act microphonically or not? Any one having knowledge enough of the apparatus to be entitled to an opinion, who should say that it would not, would be entitled to admiration for his hardihood. If it will work microphonically it is because such action is *inherent in the mechanism* and not on account of any knowledge imported into it, and any such assumption is a fiction, warranted by nothing except the necessity for denying the right of the public to use that instrument for the purpose for which it was made. One may sing to it, may whistle or screech at it, but remember that if anyone hears a word from it the Bell Company is entitled to his head. "The law allows it and the court awards it."

But making no distinction between the description of a piece of apparatus and the explanation of its mode of operation, giving the merit of the invention to the man who properly explains it would make fine work throughout science. Let us see! When Crookes made and exhibited those wonderful tubes called *radiometers*, he explained their action as being due to the direct action of light upon the delicately-poised vanes. He *intended* that the impact of light waves should propel the vanes, and they certainly rotate as he also *intended*. Afterwards Stoney and others, better acquainted with thermo-dynamics than was Crookes, gave a more consistent interpretation of the motion, but I have yet to hear that 100 years of Crookes wouldn't make a radiometer. Is it because there was no \$20,000,000 behind it? Brewster invented the kaleidoscope, but as long as he lived he explained its phenomena on the basis of the corpuscular theory of light. Brewster's claim was not denied. Was it because there was no \$20,000,000 behind it?

If Daguerre explained the action of light upon his sensitive silver plate as being due to the formation of a solar salt upon it, the degrees of shade depending upon the amount formed, he was altogether wrong, but the one who explained the chemical action upon the plate, made no claim to the discovery of photography. Was it because there was no \$20,000,000 behind it? Let one invent a new galvanic battery cell and describe it, telling what solids and liquids to use and their proper disposition in the cell. Let him explain that it is his *intention* that the ammonia shall combine with the zinc, and the chlorine be set free upon the carbon. The battery shows when it is set up, that that evidently was the intention, for the elements are placed in proximity and are free to *if they will*. The courts may declare that what he invented was what he explained, not what he made,—if there be \$20,000,000 that wants the invention.

Grove invents a galvanic battery and describes its make-up, and explains its action on the *chemical* theory of electricity; Bunsen improved it by substituting carbon for the platinum and explains the whole on the *contact* theory of electricity, which is endorsed by Sir Wm. Thomson and many other physicists. What Grove had in mind was to produce electricity chemically, Bunsen had in mind the correct conditions for generating it, and his battery exemplifies it. A hundred years of Grove will never make a galvanic battery; if there be \$20,000,000 that wants his invention.

Another point which has been made much of on one side, namely, that it

Reis had succeeded in transmitting speech, that it is incredible that no more should have been heard of it, and that it is extremely unlikely that such a success should have remain uncredited for so many years as to be almost lost sight of. But the answer is at hand. It is not denied that Yates, of Dublin, did transmit speech telephonically, in 1866, with his improved Reis apparatus, Did it attract any attention? Was it even chronicled? Why was no public mention made of it? Simply because it was considered a curious toy and not of commercial importance.

To sum up then, in my opinion :

1st. Reis invented a speaking telephone capable of transmitting words, that he intended it for that purpose and used it with success, for he says in his so-called *prospectus* when giving directions for using it "sing," "speak " He also says directly in one of his lectures, "*words were transmitted.*" This is also the testimony of a considerable number of those who were with him, Quinke, Messel and others. One of the most eminent scientific men in the United States said to me: "The testimony of Quinke alone is enough to settle that point."

2nd. That Reis's transmitter works in precisely the same way, while transmitting speech, as do the modern ones, namely by what is called *microphonic action*.

3rd. That the only difference of any importance between the Reis transmitter and the modern commercial one, is in the material, carbon being substituted for platinum for an electrode, which renders it more efficient but does not change the method of operation.

4th. That the main reason why Reis obtained no better results than he did, was due much more to the lack of sensitiveness in his receiver than to defects in his transmitter. The weaker vibrations though present, being so much diffused as to be often inaudible. The modern receiver is more efficient on account of its boxing. There is no principle or mode of operation in the modern telephone, which was not known and embodied in instruments made for the purpose twelve years before the famous patent of 1876. This patent could not have been for a *new art*. The Bell Company knows all this as well as anyone, and is in constant fear that the courts will find it out. Ask a Bell man: "What is a Reis transmitter?" and he will answer: "One that wilj not transmit speech." "What is a Bell transmitter?" Ans. "One that will transmit speech." "If a Reis transmitter transmits speech, whose transmitter is it?" Ans. "Bell's."

To show that I am not alone in my opinion upon these points I append the opinions of other scientific men in the country to whom I applied, asking them to state what their views were upon Reis's telephone, and give me permission to quote them. As will be seen, there are not two opinions about it any more than there are two opinions as to whether the earth is flat, though there may be here and there a man like "Parallax" in England who is stoutly defiant.

Yours truly,

A. E. DOLBEAR.

PHYSICAL LABORATORY OF WASHINGTON UNIVERSITY,

ST. LOUIS, May 21, 1885.

PROF. A. E. DOLBEAR :

Dear Sir :—Replying to your question concerning the difference between the action of the Reis transmitter and the ones now in use by the Bell Company, I reply that I cannot see that there is any difference in the method or manner of working. It is a source of amazement to me that the courts have decided differently, and I regard it as a very great disgrace, arising I hope from ignorance.

I do not think that either Reis or Bell were perfectly successful in describing the working of the transmitter, but of the two Reis is ahead.

Reis describes clearly the character of sound-waves, and wishes to have these sound-waves act upon his transmitter so as to produce changes of a similar character in the electrical apparatus, in order that these sound-waves may be again reproduced by his receiver. He seems to have fixed his attention upon the magnetic field, or magnetic condition of his receiver, and knowing that a break in the circuit did not abruptly extinguish the current, by reason of the self-induction of the wire coils, and that the closing of the circuit was followed by a gradual rise to the maximum current, he thought a make and break between spring contacts would accomplish what he clearly saw was necessary. He knew also that similar retardation occurred in the magnetization and demagnetization of the iron core. He seems to have understood all this much more clearly than Bell, who draws lines like this to represent the case of a make and break circuit.

Reis seems to have intended to produce wave-like changes in the magnetic condition of his receiver, and this is precisely what is necessary, *and it is precisely all that is necessary, in order to transmit articulate speech.*

When a circuit containing an electro-magnet is opened and closed, the changes in the magnetic condition of the magnet are necessarily wave-like, and Reis may have thought therefore that a make and break would serve to accomplish the result at which he aimed. But we know now that under the conditions which are supplied in the Reis transmitter, the wave-forms are not of the proper shape to reproduce speech if the circuit is opened and closed at the working contact. The fact is that when the Reis instrument does transmit speech, the circuit does not open and close, and whatever Reis may have thought about it, it did not make and break the circuit when it worked successfully in his hands. It worked by varying the resistance at the loose contact, precisely as the "modern" instruments work to-day. The result at which Reis aimed was to produce the proper variations in the magnet strength. He succeeded in doing this in an imperfect manner. But that he did succeed in doing it I cannot doubt. His main weakness was in the receiving instrument, which was not sensitive enough.

What I have written here seems so clear and evident to me, that I cannot avoid thinking ill of a man who says it is not true. Unless other considerations prevent, I class him among those who say the earth is flat.

I am not in any way financially interested in any kind of telephone, but I

think it is time for scientific men to speak out on this subject, and so far as I happen to know they are practically of one mind.

It is not very likely to influence the legal decisions, but it may at least relieve American scientific men of the disgrace of giving even tacit countenance to a monstrous imposition. Very sincerely yours,

FRANCIS E. NIPHER.

3208 RACE STREET, PHILADELPHIA, Pa., July 22, 1885.

PROF. A. E. DOLBEAR,

Dear Professor :—(1.) There *will* be a telephone report.

(2.) I had supposed, without pretending to be a specialist that there was but one way a telephone *could* work, and that therefore Reis had the idea which was made available later. I have not made that accurate historical research without which I simply should hold my judgment in suspense.

(Signed)

Yours truly,

LEONARD WALDO,

Yale College Observatory.

STATEMENT.

Having received a Reis instrument, same as "Fourth form" described in Reis's own paper "On Telephony" in the annual report of the Physical Society of Frankfurt-on-the-Main for 1860-61, (see p. 20 of Thompson's "Reis Inventor of the Telephone," I had no slight curiosity to know whether it would or not transmit speech.

I connected my lecture room with the Physical work shop using about twenty lbs., of 18 office wire, one Grenet cell, and two Bell receivers in circuit. One of the receivers was located at opposite end of line in shop, while the other and Reis transmitter with the battery were on my table.

After securing fine *singing* adjustment (by *singing* I mean one that would cause the Bell receiver at my ear to hum freely when talking with the Reis) I found that my assistant in the shop could carry on conversation quite readily—so much so that we were both astonished at the results. He called others into the shop, and in more cases than one we fooled the hearers so completely that they supposed that we were using the regular Bell outfit at my end of the line.

We still use the circuit for communication between lecture room and shop without difficulty.

Surely no one who had ever seen a Reis Telephone could claim thereafter to have invented the system of transmission of speech by electric pulsations or undulations.

(Signed)

JOHN B. DEMOTTE,

Prof. of Physics.

De Pauw University, Greencastle, Ind., July 21, 1885.

SHEFFIELD SCIENTIFIC SCHOOL OF YALE COLLEGE.

NEW HAVEN, Conn., June 3, 1885.

PROFESSOR A. E. DOLBEAR :

Dear Sir :—It is certainly my impression that Reis's telephone embodies all the essential features of the systems now used and that if it had been

generally known, the exclusive patents which have proved so valuable would not have been granted ; but I am unable, under the pressure of annual examinations and much other work, to undertake to either write out a carefully formulated opinion, or to make experiments in a field which is now chiefly of a historical or technical interest.

(Signed) Yours very truly,

CHARLES S. HASTINGS.

OHIO WESLEYAN UNIVERSITY,
DELAWARE, O., June 30, 1885.

PROF. A. E. DOLBEAR, *Tufts College, College Hill, Mass. :*

Dear Sir :—I have been experimenting with a telephone, made according to the description that Reis gives of one that he made. It is an exact pattern of the one described by Reis. I am irresistibly forced to these conclusions from all the knowledge I can gain on the subject, viz., that Reis did invent a speaking telephone, and that as he invented and constructed it, it is capable of transmitting articulate speech, and that it did so in Reis's hands, and that as a transmitter it substantially works in precisely the same manner as any modern transmitter does when transmitting articulate speech. Reis's invention, the telephone, was undoubtedly what he made, he probably did not fully understand its mode of transmitting speech, nevertheless he made a telephone that in my hands fully and completely transmitted entire sentences. Reis's description of the operation of his instrument is one thing and its work another in my opinion ; his invention is the telephone, an articulate speech transmitter, and not a description of its operations.

(Signed) I am, very truly yours,

W. O. SEMANS,
Prof. Chem. and Physics.

COLUMBIA COLLEGE, N. Y., May 28, 1885.

A. E. DOLBEAR, Esq. :

Dear Sir :—In answer to yours of April 29th, I would say, that in my opinion the Reis transmitter, when made and adjusted as the maker intended, is capable of transmitting articulate speech, operating like the Blake transmitter, the action being microphonic, and differing only in efficiency from modern instruments of this class ; in other words, Reis in my opinion invented a speaking telephone, operating with precisely the same kind of currents now so commonly employed, the defect of the apparatus being in the lack of sensitiveness of the receiver.

(Signed) Very truly,

OGDEN N. ROOD,
Prof. of Physics in Col. Col.

DEPARTMENT OF PHYSICS, CORNELL UNIVERSITY
ITHACA, N. Y., June 1, 1885.

My Dear Professor Dolbear :—I am under obligations to you for showing me, while you were in Ithaca last week, a genuine Reis by which, when used as a transmitter in connection with a Bell magneto telephone as a

receiver, conversation could be carried on with nearly the same facility as by the Blake transmitter. The experiment showed conclusively that the Reis telephone, with only platinum contacts, not only can transmit speech, but does so so clearly and distinctly that if we had not something better it would be considered a thoroughly successful transmitter.

Had Reis succeeded with his receiver as well as with his transmitter the speaking telephone would have been in universal use ten years earlier than it was.

Yours very truly,

(Signed)

WM. A. ANTHONY.

Prof. of Physics.

PRINCETON, N. J., May 28th, 1885.

My Dear Professor Dolbear :—As to the matter we talked about, the case stands about thus in my opinion. Reis set out to make an instrument that would convey sounds electrically; there is no evidence that there was in his mind any limitation whatever as to the kind of sounds to be conveyed, and there is on the other hand considerable and conclusive evidence that he had in mind articulate sounds as well as musical tones. He constructed apparatus which would communicate musical sounds very well, and articulate speech partially; that is, he occasionally got speech through it: but not hitting upon *carbon* as the material of his transmitter electrodes, his success as regards articulate speech was not complete or satisfactory.

Being no business man, and looking at the thing from a scientific rather than a business point of view, he took out no patents, and made no attempts that I ever heard of to introduce his invention as anything more than a piece of interesting scientific apparatus. He did *publish* his results somewhat widely, and his instruments were put on sale as scientific apparatus.

His instruments, just as they came from his hands, will talk now, if manipulated carefully enough, and if *improved* by merely inserting a bit of carbon at the loose contact of the transmitter, would to-day answer satisfactorily for telephonic business; though of course any one would admit that the receivers and transmitters now in use are better than such an apparatus would be. But his *receivers* will any of them operate fairly well with our modern microphone transmitters, and his *transmitters*, fitted with carbon electrode are excellent, even judged by the latest standard.

The fact that he spoke of his transmitter as working by "opening and closing" the circuit, and did not enter into any discussion as to the question of the completeness of the "make and break" in the transmission of words, does not appear to me to justify at all any attempt to deprive him of the credit of his invention. Perhaps the question did not raise itself in his mind, and perhaps it did; but however that may be, he invented an apparatus that would talk—rather capriciously it is true, for want of carbon, but still, when exactly adjusted, it would talk until the adjustment was disturbed. Nor, I think, can there be any question that the action of his apparatus, when thus talking under successful adjustment, is precisely the same as it would be if one of the electrodes was tipped with carbon, and the same also as the action of any of the ordinary carbon transmitters now in use.

As to the precise nature of the action at the "loose contact" of a transmitter, I think no one is yet entitled to speak with confidence. That it *may* consist of actual "makes and breaks" of the current in the ordinary acceptance of the term is proved to my satisfaction by McDonough's revolving wheel experiments; that it *may* consist on the other hand in a rapid variation of the strength of the current without complete "makes and breaks" is of course possible, since in the magneto telephone this is unquestionably the way the current acts. But as I view the matter, *whatever* the action may be, no man has a right now to claim exclusive ownership of it for having discovered an explanation of it, even if his explanation should turn out to be more accurate and exact (which need not yet be admitted) than that of the man who first used that action for the transmission of words. If Mr. Bell's explanation proves correct, well and good, he deserves *scientific credit* for it, but not *patent right* in it, as against Reis.

I do not know that this letter will answer your purpose, but if you can make any use of it, it is quite at your service to do what you like with it.

Very truly yours,

(Signed)

C. A. YOUNG.

U. S. DEPARTMENT OF AGRICULTURE.—DIVISION OF CHEMISTRY.

WASHINGTON, D. C., May, 21, 1885.

PROF. A. E. DOLBEAR, *College Hill, Mass.*

Dear Sir :—I have had the pleasure of testing a model of the Reis telephone, and was surprised at the distinctness with which his transmitter allows the passage of articulate speech. In the trial which I made of the instrument, the distinctness of the transmitted conversation was as marked as that of the ordinary telephone.

It seems to me that the only difference between the Reis transmitter and those of the modern telephone is in efficiency and not in principle. The trouble which Reis encountered in his experiments I am now convinced, was in his receiver and not in his transmitter. Had he been provided with a receiver as delicate as those now in use, the telephone would have been a commercial success twenty years ago.

The transmitter which was used in the trials made in my presence was an exact reproduction of the one described in Reis's original drawings; and the result of the experiment leaves no doubt in my mind that Reis was the inventor of a speaking telephone.

Messrs. Richardson and La Dow, who were with me during the experiment were also much pleased with the excellent action of the instrument.

Respectfully,

(Signed) H. W. WILEY.

ANN ARBOR, Mich., June 17, 1885.

PROF. A. E. DOLBEAR :

My Dear Sir :—I can confidently assure you that I have heard speech transmitted in a satisfactory way by means of a Reis's transmitter. The instrument was a careful copy of one of the forms figured in Thompson's

book on Reis's telephone, and the results were nearly or quite as satisfactory as I usually obtain with more recent forms of patented instruments.

Sincerely yours,

CHARLES K. WEAD,

Prof. Physics, Univ. of Mich.

NORTHWESTERN UNIVERSITY,

EVANSTON, Ill., Oct. 10, 1885.

PROFESSOR A. E. DOLBEAR,

Dear Sir :—Respecting the Reis telephone, the evidence appears to me to be entirely conclusive on three points :

First. The Reis telephone, or a faithful copy of it, transmits speech to-day, "with a distinctness sufficient for everyone" to understand plainly.

Second. It transmitted during the lifetime of Reis himself. Of this we have evidence from contemporary printed accounts of its performance, and from *ear-witnesses*, if the word may be allowed.

Third. Reis designed the "*Telephone*" to transmit speech. His own account of "*Telephony*," published in 1862, is unmistakable on this point.

Philip Reis conceived the idea of transmitting speech and music by Galvanic Electricity, and constructed an instrument that actually did this, even though the laws of the composition of vocal and other sounds were not at that time well understood ; and he should certainly have the credit arising from so great an invention.

Very truly yours,

(Signed)

H. S. CARHART,

Prof. of Physics.

BOSTON, Oct. 10, 1885.

PROFESSOR A. E. DOLBEAR,

Dear Sir :—In reply to yours asking for information concerning my knowledge of Philipp Reis and his relation to the telephone would say that I had, previous to 1881, become so much interested in the subject that, happening to be in Germany, I resolved to visit the field of his labors that I might not only satisfy my curiosity but also judge for myself from the testimony of living witnesses, and from apparatus which Reis has left of the character of the work accomplished by him. Near the centre of the small village of Friedrichsdorf, and directly opposite the Post Office, stands the modest house where Philipp Reis formerly lived and which is still occupied by his family. There remain many evidences of his former presence. In the casement of the sitting-room window, electrical binding posts with wires leading to a room in the rear may still be seen. Placed there by Reis himself and used by him in making probably the greater part of those important investigations in the endeavor to perfect his apparatus for the transmission of speech. This was his aim and anything short of that he considered of little importance—so said Mrs. Reis. A short distance further up the main street stands the Garnier Institute, where Reis as a teacher displayed a wonderful ingenuity in devising apparatus for illustrating the usual experiments in Physics and also evinced, as shown by several pieces in the collection, an originality in invention and research of a very high order.

Prof. Leon Garnier, Principal of the Institute, said he had often witnessed Reis's telephone experiments and repeated many words and sentences which he himself had heard through the apparatus.

I was next introduced to Herr Henry Holt. He thus related his first successful experience with the telephone. "I had been listening a long time, and heard nothing intelligible, when suddenly I plainly heard the words, '*I am through ; come up.*' I went up, and was considerably surprised to find that that was exactly what Reis had said, and he then explained to me that the speech had been transmitted by the electric current." Mr. Holt said Reis was at the time highly elated over it. After that, he listened with much greater faith, and hence with closer attention, and, on many occasions, heard words and sentences. Reis was evidently sorely tried by the incredulity of those who, in the earlier experiments assisted him, and who, consequently, were very careless and inattentive listeners. Many a joke did poor Reis encounter from his co-laborers and associates, but he eventually silenced them all ; and, although they could not realize its importance, they yet recognized the fact that Reis had then made a speaking telephone, and that it was to him as the inventor of the speaking telephone, that the monument in the cemetery at Friedrichsdorf was erected by the Frankfort Society. Many have, as you know, for selfish reasons, endeavored to belittle that testimonial by claiming that it was the invention of the *musical* telephone, which it was intended to commemorate. Owing to the difficulty of making such delicate tests before a popular audience, the transmission of musical tones was given prominence at his lecture. It was with much pleasure that I visited the very building and room at Frankfort, in which that famous first lecture of Reis on the telephone was given, and strolled through the garden, across which the wires, on that memorable occasion, were stretched.

The original manuscript in Reis's handwriting had previously been shown to me by Mrs. Reis ; she still has it I believe in her possession.

At the shop and factory of Albert, philosophical instrument maker, I learned several interesting facts. The Reis transmitter known as the *collar box* pattern was shown to me by Mr. Albert and he said, as seems probable, that it was made previously to the *square box* and subsequent to the *bored block* pattern. It seems to me that this must have been the order of sequence. I feel sure that Reis did not employ Albert until after his lecture before the Frankfort Society where the *bored block* transmitter was used ; moreover, Albert says he made the collar box pattern himself and this more nearly resembles the *square box pattern* ; involves the same ideas ; and seems like its crude beginning.

The *collar box* and the *square box* patterns were, however, not intended as superior instruments *i. e.* instruments from which Reis could himself obtain better results, but were so made because they were automatic in their action. At that time there was a call for his apparatus and Reis reasoned that an instrument which dispensed with such delicate adjustment as the *bored block* required would be better to put into the hands of the unskilled experimenter.

Mr. Albert said there was a great difference in the performance of the

transmitters even when made as nearly alike as possible. I have myself verified this experience of Mr. Albert. For example I have had a dozen of each of the parts of the *bored block* transmitter made and placed in piles by themselves each piece like its neighbor, and interchangeable like the parts of a Waltham watch. When set up, taking a piece from each pile, for each instrument, the transmitters could not be told apart except by the number stamped upon them. Upon testing them a great difference was observed in their performance. With some, talking could be transmitted at once, while others needed much adjusting and patience before they would do well even if they ever would. This explains why the various early writers concerning these telephones differ as to their capabilities. Some by chance obtained good instruments, others not so good although all seemed alike.

It was my good fortune, while in Europe, to obtain a pair of instruments which were exact fac-similes of those now held by the German Government and claimed to have been the first set sent out by Reis.

The transmitter was of the square box pattern and the receiver (the knitting needle pattern) corresponded to Pisco's minute description.

With these instruments I have at various times performed many hundred experiments. I have heard both words and unexpected sentences as plainly as with the best modern instruments. When so transmitting speech, the transmitter does its work in precisely the same manner as does the Blake, Edison, or other ordinary varying-contact transmitter. The current produced has variations precisely similar to the variations caused by carbon transmitters. By substituting a small piece of electric-light carbon for piece of platinum foil, which terminates one of the electrodes of the *bored blocks* transmitter, I have obtained an instrument as good and as practical as a Blake transmitter. Indeed, the latter is then but a close imitation of the *Reis bored block*. With a transmitter thus modified, the Reis knitting needle receiver is a good practical receiving telephone. Its tones are clear and articulation excellent.

As the result of my investigations and experiments, I am thoroughly convinced that the Reis apparatus can and in the hands of Reis did transmit articulate speech, and that Reis should and will go down in history as the first and original inventor of the Electric Speaking Telephone.

(Signed.)

H. C. BUCK,

Electrician, 70 Washington St., Boston.

PROF. A. E. DOLBEAR:

Dear Sir:—I tried in connection with Prof. Van Dyck the Reis transmitter (an exact duplicate of the instrument made by Prof. Reis as I am informed and believe) with an ordinary receiver, and was surprised at the ease and distinctness with which I could hear the sentences transmitted. They seemed at times as clear as though sent by the modern telephone, but the instrument required occasional adjustment. It seems to me there is no doubt that Reis invented a speaking telephone that worked on the same principle as the modern one and not by a make and break circuit, though I am not certain what his theory about it was. I think his telephone would have successfully

worked in the transmission of speech if his receiver had been sufficiently sensitive. The fault was chiefly in the receiver and not in the transmitter. The telephone of to-day is an improvement on his, but retaining the same principle on which his works—variation of current from variation of pressure.

Very respectfully,

(Signed.)

GEORGE B. MERRIMAN,
Prof. Astronomy and Mathematics, Rutgers College.
New Brunswick, N. J., August 22, 1885.

COLLEGE HILL, Sept. 27, 1885.

PROF. A. E. DOLBEAR :

*Dear Sir :—*In reply to your request I will say that in the Spring of 1878, while studying for the degree of Master of Arts at Tuft's College, I undertook a series of experiments in telephony, much of my time being spent in working with Reis's transmitters.

The results obtained were by no means uniform, but very often whistling, singing, and *talking* were reproduced with great power and clearness.

No intelligent physicist can for a moment fail to perceive the close similarity in every essential detail of Reis's transmitters and the more improved instruments of modern date. Each consists of a diaphragm the vibrations of which alter the contact resistance of a point in an electric circuit.

The vibrations of the diaphragm alter the contact resistance at the given point by setting up a varying pressure at that point. This is all there is to the ordinary telephonic transmitter.

Secondary coils are merely accessories ; they are not at all *necessary*. The assumption that carbon greatly alters the specific resistance under varying pressures is erroneous. It is true that the contact resistance of carbon points is more manageable than that of most other substances, but good transmitters can be made by employing contacts of almost any conductors.

There is no difficulty in making the unmodified Reis transmitter talk well with almost any good receiver.

The assertion that Reis instruments are necessarily "make and break" instruments can only be made by one financially biased or ignorant of physical laws.

That they do frequently "make and break" is true, but so does the Blake transmitter, if spoken to too strongly. It is far more difficult to adjust the voice to the Reis instrument than to the Blake, but when once the voice is adjusted the Reis talks.

The Reis receiver is not quite so satisfactory. His knitting needle receiver is mechanically poor. The needle should have been perpendicular to the sounding board not parallel to it. Yet in spite of this defect the knitting needle receiver will talk with any good transmitter, Reis's included, and with some of the more modern transmitters, I have heard very good talking.

Reis's electro-magnetic receiver was better ; indeed it was identical in principle with Bell's 1876 form.

In conclusion I would say that in view of the historical evidence, in view of the testimony of prominent scientific men still living who are contemporaries of Reis, and in view of Reis's instruments themselves, it seems to me nonsense to assert that Reis did not talk with his instruments or that he did not design them to talk.

(Signed.)

Very truly yours,

W. L. HOOPER,

Asst. Prof. of Physics, Tuft's College.

PRINCETON, NOV. 12, 1885.

PROFESSOR E. J. HOUSTON :

My Dear Sir :—An absence has prevented an earlier reply to your favor of Oct. 21.

(1) I have no hesitation in saying that in my opinion Reis was the inventor of the speaking telephone. No one who has carefully studied the literature of the subject can have failed to be convinced of the truth of this position, it seems to me.

(2) Actual experiment with apparatus constructed in accordance with Reis's description of his own apparatus, and with apparatus constructed by Koenig, and sold as an embodiment of Reis's invention, has in my hands transmitted speech and in substantially the same way as the Bell apparatus when employing a Blake transmitter.

(3) Bell has set up a distinction among currents and claimed the use of an undulatory current in the process of transmitting signals for the purpose of "multiple telegraphy" and subsequently he has claimed the use of such currents for the purpose of transmitting speech. The undulatory current was as old as the first experiments with dynamic electricity. It had been expressly spoken of and employed by others before Bell and for a use exactly the same as that for which Bell claimed it in his celebrated patent which is now sought to be made the foundation of the great monopoly! (See Varley's English patent). There can be no distinction in the nature of the currents employed by Reis and Blake, and there is no reason for any distinction between the current employed by Reis and Bell when his apparatus is used as a telephone.

(4) There is not the least reason to doubt that Reis did succeed as he says he did in transmitting speech; since it can certainly be done at present with his apparatus. And there is competent testimony that he did so succeed.

(5) The Reis-Legat receiver is a good one and might be employed to-day in commercial business. Indeed it contains everything which Bell's receiver contains and acts in precisely the same way. One merely has to employ carbon for the contact pieces of the Reis transmitter, instead of platinum, to have an apparatus with which speech can be transmitted with certainty and clearly. *The use of carbon is not the invention of Bell.*

(6) The modern transmitting telephones with variable contact are nothing but Reis transmitters with carbon substituted for Pt.

I have not the least hesitation about taking any one of the positions here assumed with reference to the so-called invention of Bell.

Yours very truly,

C. F. BRACKETT.

NEW BRUNSWICK, N. J., Nov. 14th, 1885.

PROF. E. J. HOUSTON ;

Dear Sir :—Yours of the 5th duly received. Not having made any extended study of the telephone in its historical aspects, I have been debating with myself how to reply to your questions seriatim.

I conclude to state what I have done and heard, as matters of fact. I have made a Reis transmitter with thin copper plate and platinum contact point. With this articulate speech has been transmitted most unmistakably, a Bell receiver being employed to receive.

That no absolute break of contact between point and plate of transmitter occurred I inferred from my failure to observe induction shocks while operating. These shocks are painfully prominent when transmitting music in the usual way. Nor could any spark be perceived while transmitting speech. Hence I believe that my Reis instrument does not give zero as minimum of current while transmitting *speech*. So far as my opinion is formed, it is that the *onus probandi* rests with those who assert an essential difference between the Reis transmitter and those of other patterns which operate by producing currents of varying intensity.

I write, as I said, what I can hold to as matters of fact, and I hope you will find it as pertinent to your purpose as would be seriatim replies to your questions.

Yours respectfully,

F. C. VAN DYCK.

1346 SPRUCE STREET, PHILADELPHIA, Nov. 4th, 1885.

PROF. E. J. HOUSTON.

Dear Sir :—Having some time ago made a careful study of the Reis telephone, and the literature on the subject including his lecture in German, I shall be happy to answer your questions regarding his claim to the invention of the speaking telephone.

First. I most emphatically declare that in my opinion Reis was the original inventor of the speaking *Electric Telephone*.

Second. This question is somewhat analogous and must be answered in two parts. The Bell telephone as originally invented by Bell and used by him is a magneto-telephone in which the current is developed by the vibration of the iron plate in front of the pole of the magnet in the transmitter and is therefore unlike the Reis instrument. But the present telephone of Bell in which a battery transmitter is used in connection with the Bell receiver the electric current is "*manipulated*" (if I may use such a term) in precisely the same manner as in the Reis apparatus.

Third. This question is one which in my opinion no one can answer positively for the reason that we do not as yet know whether there is such a thing as a "current of electricity" or what takes place in a conductor during the passage of that force called electricity. Since this is so we can neither say what form this so-called current takes in its passage through or upon the conductor. Even if we assume that there is such a thing as a "current" and that it is capable of assuming a shape it is in my opinion not necessary for the transmission of articulate speech that this current should be an undulatory

continuous one and such as Bell describes it, but may be an interrupted one provided the interruptions in the continuity are so small as to bridge over the residual sensation of the ear *i. e.* $\frac{1}{16}$ — $\frac{1}{184}$ of a second. Moreover this is *the* vital question in the law suits of the Bell Telephone Company against so-called infringers of the patent.

Fourth. The evidence of the contemporaneous literature on the subject, as well as Reis's lecture, points indisputably toward the fact that he transmitted articulate sounds, and it is my opinion that with slight improvements in his apparatus Reis could have transmitted articulate speech.

Fifth. It is my opinion that the chief defect was in the want of sensitiveness in the receiver and not in the transmitter.

Sixth. The modern battery transmitter is identically the same as the Reis transmitter with carbon instead of platinum for one of the contacts. In particular I will instance the Transmitter of Berliner, of Boston, which was bought by the Bell Company.

Hoping that these answers will be sufficient for your purposes I will in closing refer you for further information to the expert testimony in the case of Bell *vs.* Clay, in which you will also find all the important papers of the Reis literature.

Very truly yours,

C. SEILER.

DICKINSON COLLEGE,

CARLISLE, Pa., Dec. 15, 1885.

PROF. EDWIN J. HOUSTON, *Phila.*

My Dear Sir:—Pardon my apparent neglect of your two communications in regard to the Reis Telephone. It was not oversight, nor altogether want of time, and in no degree indisposition, but I happened to be present in 1865 at the trial of Prof. Reis's telephone at Giessen, in Prof. Buff's lecture room.

My recollection is not very clear as to the details of the apparatus or of the testing of it, as I was at that time more interested in many other things, persons, and places, but my recollection of the impression made upon me and as it seemed to me, on Prof. Buff and the others, that it was interesting and curious, perhaps, but not likely to grow into anything of great practical value. The Bell telephone at first created somewhat similar impression, but having acquired more interest in electrical applications in meantime, and electrical science being so much more advanced than in 1865, I regarded it as involving greater possibilities than I had done in case of the Reis instrument. In looking at the latter now, I cannot but regard it as simply born out of due season, a little too early to be appreciated and wrought out into a practicable instrument.

In answer to your interrogatories I would say then: I believe that Reis invented a speaking telephone as early as 1865, and that he succeeded in transmitting articulate speech at that time, and at the time I attributed the defects of the instrument, and in that, perhaps, reflected the opinions of others present, to the variable character of the contact of the transmitter, that seemed to be unavoidable in any instrument for the purpose. Regretting the delay, and hoping the above may meet your questions.

I am, yours truly,

CHARLES F. HIMES.

417 WALNUT STREET, PHILA., NOV. 21, 1885.

PROF. EDWIN J. HOUSTON,

Dear Sir : My replies to your queries are as follows :

(1.) In my opinion Reis invented an electrical speaking telephone, but he was not the first inventor of that class of telephones. An extended and critical examination of many certified records and repeated interviews with Antonio Meucci, now of Staten Island, N. Y., have convinced me that he produced a practical speaking telephone as early as 1857.

(2.) When the Reis instrument was operating as a speaking telephone, it worked substantially in the same manner as does the instrument known as the Bell telephone.

(3.) I have never succeeded in transmitting sound by the use of an undulatory current (produced in the manner described in the Bell patent) and in my opinion it is impossible so to do, consequently I consider that when the Reis instrument transmitted speech, it must have been by the use of a current dissimilar to the undulatory described in the specification of the Bell patent.

(4.) I can see no reason why Reis should not have occasionally transmitted words, and I consider the testimony relating to the performances of his telephone to be conclusive, especially when coupled with results which are occasionally obtained by the use of instruments made in accordance with the descriptions published contemporaneously.

(5.) The defects of the Reis instruments seem to be chiefly due to crudeness of construction of both transmitter and receiver, but chiefly in the receiver.

(6.) The "modern transmitting telephones of the variable contact type" are interrupters of the electric current. I have clearly demonstrated some time since that unless the current is interrupted, no transmission of speech (or sound) is possible; of course the interruptions must not be of such duration as to become evident to the ear, for in that case communication is prevented by the interposition of gaps which cut off a part of the representative impulses necessary to produce the desired sounds.

The replacement of one platinum electrode by a carbon point undoubtedly allows of a greater separation of the parts without an actual breach of contact, so that interruptions which would otherwise be of too great duration to allow of the transmission of a majority of impulses are bridged over by an elastic conductor of vapor of carbon.

The Telephone of Meucci, to which I have made reference, was very similar to the present Bell receiver, and was used both for transmitting and receiving. It can be readily demonstrated that the result of the successful use of this magneto-electric device is the production of an interrupted and not an undulatory current.

The ordinary contact transmitter produces an interrupted current by breaking the continuity of the conductor, whilst the magneto transmitter produces a precisely similar current by causing momentary cessations of the current in a continuous conductor. Interruptions of the continuity of the current is an essential to successful transmission of speech with either sort of apparatus.

Respectfully yours,

CHARLES M. CRESSON, M. D.

In concluding this brief and somewhat incomplete history of the articulating telephone and of the distinguished part taken therein by its originator and inventor Reis, the author trusts that despite the limited time which a busy life has somewhat grudgingly afforded him for the work, he has been able to show the singularly complete and masterly way in which Philipp Reis, the first and true inventor of the articulating telephone, solved the problem of transmitting sounds of all kinds by means of electrical currents. He will feel satisfied, if even in a slight degree, he has helped to hasten the time when Reis will be universally acknowledged as the man whose genius invented the most wonderful instrument of modern times.

CENTRAL HIGH SCHOOL,

Philadelphia, December 2, 1885.

"ELECTRICITY IN WARFARE."

BY LIEUTENANT B. A. FISKE, U. S. NAVY.

[*Lecture delivered before the FRANKLIN INSTITUTE, November 13, 1885.*]

The first practical plan for using electricity in warfare was devised and executed by Colonel Samuel Colt, the inventor of the revolver, who, in 1841, wrote to President Tyler, stating that he had invented an apparatus by means of which he could destroy in a moment the most powerful man-of-war, even though miles away, and asking that the Government give him opportunity for demonstrating the truth of his statement.

The truth of his statement he demonstrated a year later by exploding a torpedo under water in New York harbor by means of electricity. Following up this success, he totally destroyed by similar means an old gun boat named *Boxer*, and six weeks later, in sight of the President, General Scott and others, he destroyed a schooner in the Potomac, distant five miles. Congress at once appropriated \$17,000 to continue his experiments and perfect his apparatus; and in two months from this time he blew up the brig *Volta* in New York in the presence of 40,000 spectators. All of these vessels were at anchor; but in the spring of 1843, Colonel Colt demonstrated the further value of his invention by blowing up a vessel while underway in the Potomac, he being at Alexandria, five miles distant.