CASES ADJUDGED

IN THE

SUPREME COURT OF THE UNITED STATES,

AT

OCTOBER TERM, 1887.

THE TELEPHONE CASES.

Nos. 10, 361, 362, 709, 770, 771. Argued January 24, 25, 26, 27, 28, 31, February 1, 2, 3, 4, 7, 8, 1887. — Decided March 31, 1888.

DOLBEAR *v.* AMERICAN BELL TELEPHONE COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE DISTRICT OF MASSACHUSETTS.

MOLECULAR TELEPHONE COMPANY *v.* AMERICAN BELL TELEPHONE COMPANY.

AMERICAN BELL TELEPHONE COMPANY *v.* MOLECULAR TELEPHONE COMPANY.

CROSS-APPEALS FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

CLAY COMMERCIAL TELEPHONE COMPANY *v.* AMERICAN BELL TELEPHONE COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE EASTERN DISTRICT OF PENNSYLVANIA.

VOL. CXXVI—1

Syllabus.

PEOPLE'S TELEPHONE COMPANY *v.* AMERICAN BELL TELEPHONE COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

OVERLAND TELEPHONE COMPANY *v.* AMERICAN BELL TELEPHONE COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

It appears from the proof in these causes that Alexander Graham Bell was the first discoverer of the art or process of transferring to, or impressing upon, a continuous current of electricity in a closed circuit, by gradually changing its intensity, the vibrations of air produced by the human voice in articulate speech, in a way to cause the speech to be carried to and received by a listener at a distance on the line of the current; and this discovery was patentable under the patent laws of the United States.

In order to procure a patent for a process the inventor must describe his invention with sufficient clearness and precision to enable those skilled in the matter to understand what his process is, and must point out some practicable way of putting it into operation; but he is not required to bring the art to the highest degree of perfection.

Bell's fifth claim under his patent of March 7, 1876, No. 174,465, is not confined to the magneto instrument, or to such modes of creating electrical undulations as could be produced by that form of apparatus.

Bell's fifth claim under his patent of March 7, 1876, also covered his invention of an apparatus to make useful his discovery of an art or process for electrical transmission of speech, and this invention was patentable under the laws of the United States.

The discovery and invention patented to Bell by his patent of March 7, 1876, were not described in the publication made by Charles Bourseul in Paris in 1854, nor in the publication in Germany in 1861–63 respecting the experiments and inventions of Philipp Reis, nor in the publication in Germany in 1862 of what are known as the Reis-Legat experiments; and they were not anticipated by the experiments of Dr. Van der Weyde in New York in 1869, nor by the invention of J. W. McDonough of Chicago in 1876, nor by the invention patented in the United States to C. F. Varley of London, June 2, 1868, nor by the invention patented to said Varley in England, October 8, 1870.

For reasons stated in its opinion the court holds that the alleged invention of the telephone by Daniel Drawbaugh prior to Bell's discovery and invention patented to him March 7, 1876, is not made out.

For reasons stated in its opinion the court holds that the charge of a fraud-

ulent interpolation in Bell's specification after the filing of it in the Patent Office, between February 14 and February 19, 1876, is not sustained; and that not a shadow of suspicion can rest on any one, growing out of the misprint of the specification in the Dowd case.

The authority conferred by the special act of Massachusetts "to incorporate the American Bell Telephone Company," authorized the corporation organized under § 3, Mass. Stat. 1870, c. 224, to select its corporate name, and made the statutory certificate provided for by § 11 of that act conclusive proof of its corporate existence.

Section 4887 of the Revised Statutes does not invalidate an American patent which bears a different date from that of a foreign patent for the same invention, but only limits its term to the term of the foreign patent.

Letters patent No. 186,787, dated January 30, 1877, granted to Alexander Graham Bell for an improvement in electric telephony, is a valid patent, and the fifth claim under it was not anticipated by the magnet described by Schellen.

In Equity. The bills were filed in Circuit Courts of the United States by the American Bell Telephone Company and others, as owners of two patents, known as the Bell-telephone Patents, to enjoin the several defendants against infringements of those patents.

The two patents thus alleged to have come into the ownership of the complainants and to have been infringed were:

1. No. 174,465, dated March 7, 1876, granted to Alexander Graham Bell for new and useful improvements in telegraphy; and,

2. No. 186,787, dated January 30, 1877, granted to the same inventor for new and useful improvements in electric telephony.

The following are copies of the drawings and specifications of these two patents:

I. *Bell's Patent of March 7, 1876.*

A. G. BELL.

TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig. 1

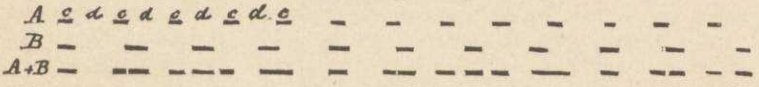


Fig. 2.

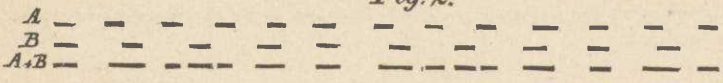


Fig. 3

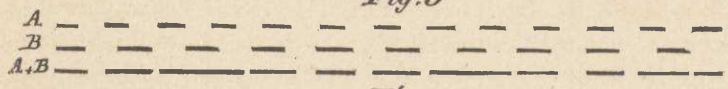


Fig. 4.

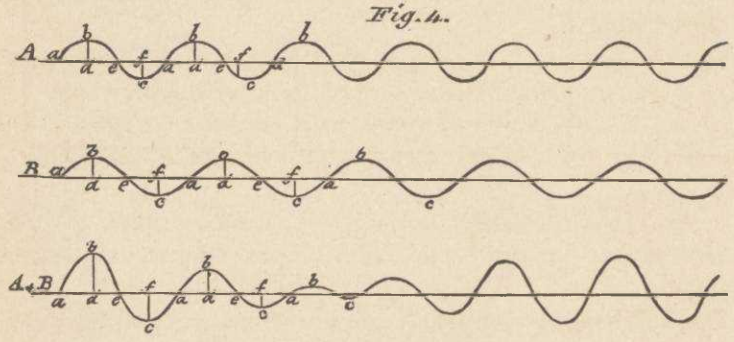
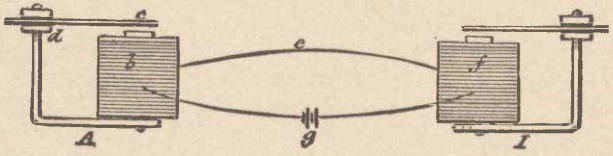


Fig. 5.



Statement of the Case.

A. G. BELL.
TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig 6.

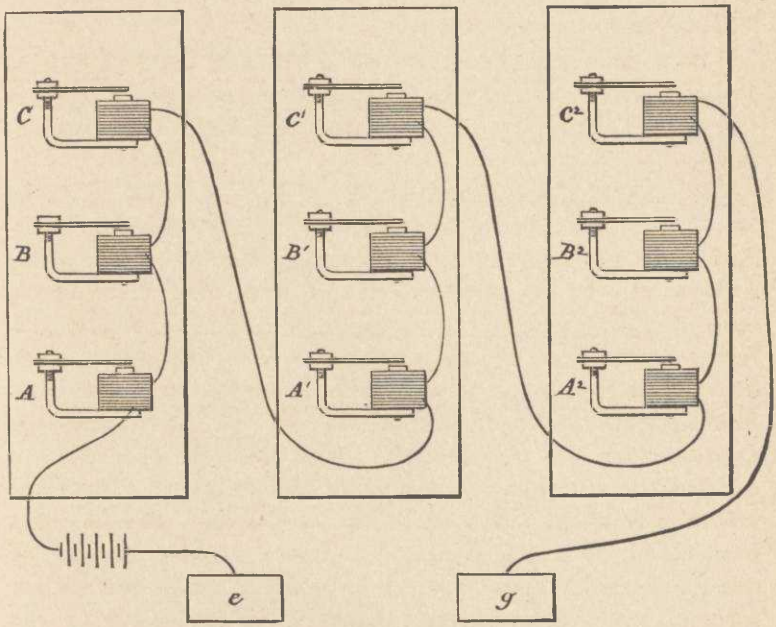
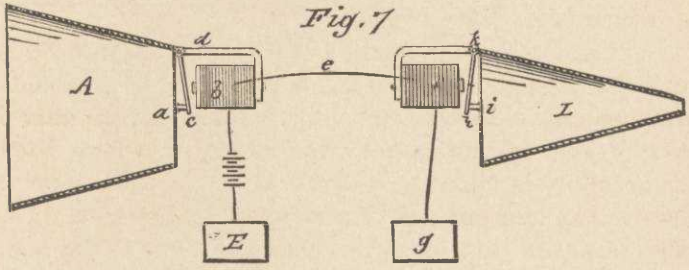


Fig. 7



"UNITED STATES PATENT OFFICE.

"ALEXANDER GRAHAM BELL OF SALEM, MASSACHUSETTS.

"IMPROVEMENT IN TELEGRAPHY.

"Specification forming part of Letters Patent No. 174,465, dated March 7, 1876; application filed February 14, 1876.

"*To all whom it may concern:*

"Be it known that I, ALEXANDER GRAHAM BELL of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification:

"In Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for, transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting instruments; and of vibratory circuit-breakers operating to convert the vibratory movement of the receiving instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed a Morse sounder, register, or other telegraphic apparatus. I have also therein described a form of autograph-telegraph based upon the action of the above-mentioned instruments.

"In illustration of my method of multiple telegraphy I have shown in the patent aforesaid, as one form of transmitting instrument, an electro-magnet having a steel-spring armature, which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for, when a number of transmitting instruments, having different rates of vibration, are simultane-

ously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current.

"In a pending application for Letters Patent, filed in the United States Patent Office February 25, 1875, I have described two ways of producing the intermittent current — the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current without actually breaking the circuit. The current produced by the latter method I shall term, for distinction sake, a 'pulsatory current.'

"My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of, and apparatus for, producing electrical undulations upon the line-wire.

"The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve or by the resultant of several sinusoidal curves.

"Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity or are alternately positive and negative.

"The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction-coils; fourth, that cable despatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use; for, as it is unnecessary to discharge the cable before a new signal can be made,

the lagging of cable-signals is prevented; fifth, and that as the circuit is never broken a spark-arrester becomes unnecessary.

"It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet an undulatory current of electricity is induced in the coils of the electro-magnet, 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.

"That the difference between an undulatory and an intermittent current may be more clearly understood I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously — first upon the one plan and then upon the other. Let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. 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, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. *c c c*, &c., show where and for how long time the circuit is made, and *d d d*, &c., 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.

"When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same

circuit the current upon the main line becomes for all practical purposes continuous.

"Next, consider the effect when an undulatory current is employed. Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the including body — that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration — that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body — that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinusoidal curve A or B, Fig. 4, represents, graphically, the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line *a d e f*, &c., represents the zero of current. The elevations *b b b*, &c., indicate impulses of positive electricity. The depressions *c c c*, &c., show impulses of negative electricity. The vertical distance *b d* or *c f* of any portion of the curve from the zero-line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, of 4 to 5 — that is, four oscillations of B are made in the same time as five oscillations of A.

"The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A + B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A + B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence, the co-existence

upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

"There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire through which a continuous current of electricity is passing is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar-magnets is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

"Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting-wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting-wire is immersed in the mercury or other liquid the less resistance does the liquid offer to the passage of the current. Hence, the vibration of the conducting-wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

"In illustration of the method of creating electrical undula-

tions, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet, A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring armature, *c*, is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch.

"When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f* causes vibration in its armature *h* when the armature *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

"A number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus, if A, Fig. 6, is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note the instruments B B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued, but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic despatch may be indicated by alternately interrupting and renewing the sound. When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the

circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison. Thus the signals of A, Fig. 6, are repeated by A^1 and A^2, but by no other instrument upon the circuit; the signals of B^2 by B and B^1; and the signals of C^1 by C and C^2 — whether A, B^2, and C^1 are successively or simultaneously caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

"I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

"When the armature *c*, Fig. 5, is set in vibration the armature *h* responds not only in pitch but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So, if A and B, Fig. 6, are sounded simultaneously, (A loudly and B softly,) the instruments A^1 and A^2 repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

"One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

"The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound — that is, they are represented graphically by similar curves. The undu-

latory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

"In this specification the three words 'oscillation,' 'vibration,' and 'undulation,' are used synonymously, and in contradistinction to the terms 'intermittent' and 'pulsatory.' By the term 'body capable of inductive action,' I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action brass, copper, and other metals, as well as iron and steel.

"Having described my invention, what I claim, and desire to secure by Letters Patent, is as follows:

"1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.

"2. The combination, substantially as set forth, of a permanent magnet or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim whether the permanent magnet be set in vibration in the neighborhood of the conducting-wire forming the circuit, or whether the conducting-wire be set in vibration in the neighborhood of the permanent magnet, or whether the conducting-wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

"3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself, in the neighborhood of such bodies, as set forth.

"4. The method of producing undulations in a continuous voltaic circuit by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.

"5. The method of, and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the

air accompanying the said vocal or other sounds, substantially as set forth.

"In testimony whereof I have hereunto signed my name this 20th day of January, A.D. 1876.

"ALEX. GRAHAM BELL."

"Witnesses:

THOMAS E. BARRY,

P. D. RICHARDS."

II. *Bell's Patent of January* 30, 1877.

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787. **Patented Jan. 30, 1877.**

Fig. 4.

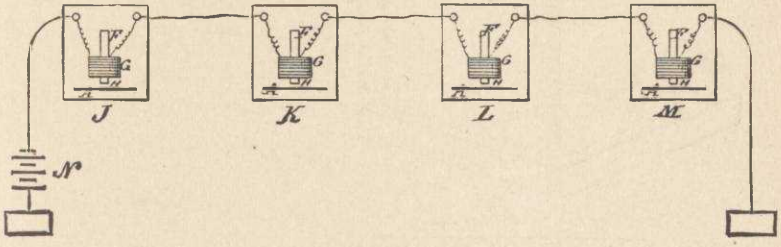


Fig. 5.

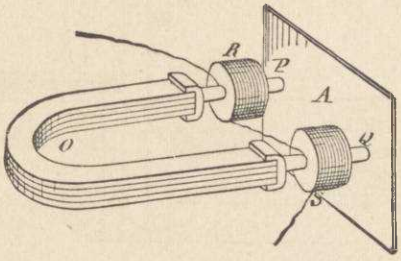
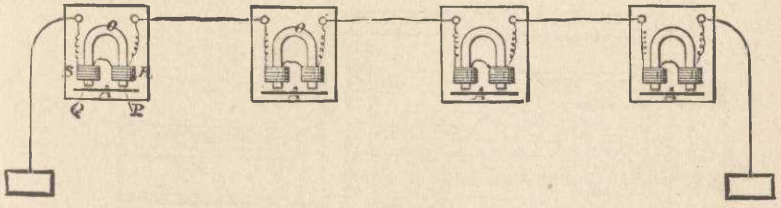


Fig. 6.



Statement of the Case.

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787. Patented Jan. 30, 1877.

Fig. 1.

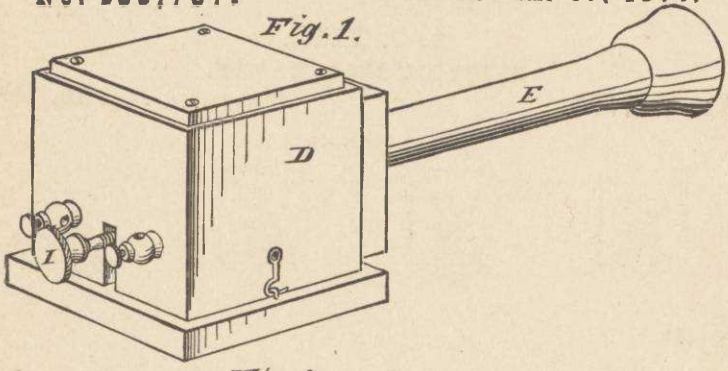


Fig. 2.

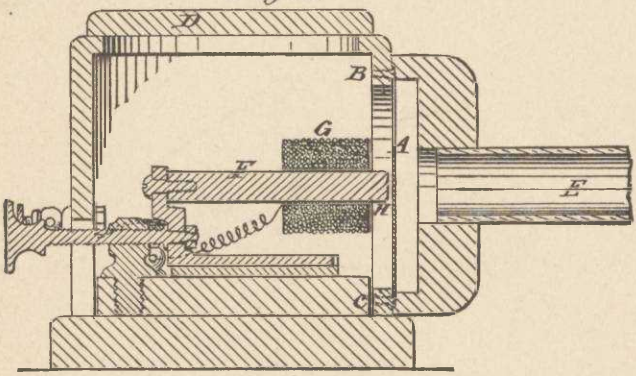
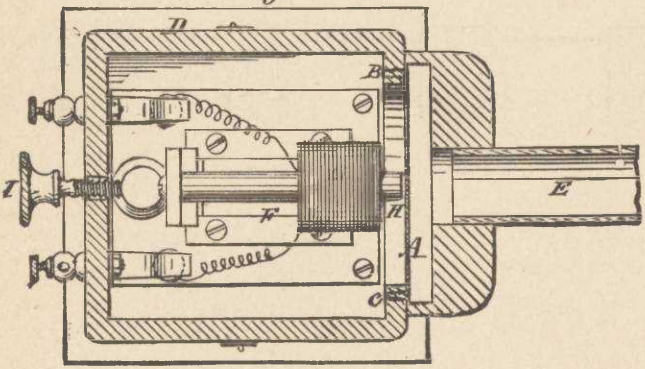


Fig. 3.



"UNITED STATES PATENT OFFICE.

"ALEXANDER GRAHAM BELL, OF BOSTON, MASSACHUSETTS.

"IMPROVEMENT IN ELECTRIC TELEGRAPHY.

"Specification forming part of Letters Patent No. 186,787, dated January 30, 1877; application filed January 15, 1877.

"*To all whom it may concern:*

"Be it known that I, ALEXANDER GRAHAM BELL, of Boston, Massachusetts, have invented certain new and useful Improvements in Electric Telephony, of which the following is a specification:

"In Letters Patent granted to me the 6th day of April, 1875, No. 161,739, and in an application for Letters Patent of the United States now pending, I have described a method of and apparatus for producing musical tones by the action of a rapidly interrupted electrical current, whereby a number of telegraphic signals can be sent simultaneously along a single circuit.

"In another application for Letters Patent now pending in the United States Patent Office I have described a method of and apparatus for inducing an intermittent current of electricity upon a line-wire, whereby musical tones can be produced and a number of telegraphic signals be sent simultaneously over the same circuit, in either or in both directions; and in Letters Patent granted to me March 7, 1876, No. 174,465, I have shown and described a method of an apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit, in either or in both directions, and a single battery be used for the whole circuit.

"In the applications and patents above referred to, signals are transmitted simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others, and are received without confusion by means of receiv-

ing-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments. A separate instrument is therefore employed for every pitch, each instrument being capable of transmitting or receiving but a single note, and thus as many separate instruments are required as there are messages or musical notes to be transmitted.

"My invention has for its object, first, the transmission simultaneously of two or more musical notes or telegraphic signals along a single wire in either or both directions, and with a single battery for the whole circuit, without the use of as many instruments as there are musical notes or telegraphic signals to be transmitted; second, the electrical transmission by the same means of articulate speech and sound of every kind, whether musical or not; third, the electrical transmission of musical tones, articulate speech, or sounds of every kind, without the necessity of using a voltaic battery.

"In my Patent No. 174,465, dated March 7, 1876, I have shown as one form of transmitting-instrument a stretched membrane to which the armature of an electro-magnet is attached, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument, or by sounds produced in any way.

"In accordance with my present invention I substitute for the membrane and armature shown in the transmitting and receiving instruments alluded to above a plate of iron or steel capable of being thrown into vibration by sounds made in its neighborhood.

"The nature of my invention and the manner in which the same is or may be carried into effect will be understood by reference to the accompanying drawings, in which —

"Figure 1 is a perspective view of one form of my electric telephone. Fig. 2 is a vertical section of the same, and Fig. 3 is a plan view of the apparatus. Fig. 4 is a diagram illustrating the arrangement upon circuit.

"Similar letters in the drawings represent corresponding portions of the apparatus.

"A in said drawings represents a plate of iron or steel,

which is fastened at B and C to the cover or sounding-box D. E represents a speaking-tube, by which sounds may be conveyed to or from the plate A. F is a bar of soft iron. G is a coil of insulated copper wire, placed around the extremity of the end H of the bar F. I is an adjusting-screw, whereby the distance of the end H from the plate A may be regulated.

"The electric telephones J, K, L, and M are placed at different stations upon a line, and are arranged upon circuit with a battery, N, as shown in diagram, Fig. 4.

"I have shown the apparatus in one of its simplest forms, it being well understood that the same may be varied in arrangement, combination, general construction, and form, as well as material of which the several parts are composed.

"The operation and use of this instrument are as follows:

"I would premise by saying that this instrument is and may be used both as a transmitter and as a receiver — that is to say, the sender of the message will use an instrument in every particular identical in construction and operation with that employed by the receiver, so that the same instrument can be used alternately as a receiver and a transmitter.

"In order to transmit a telegraphic message by means of these instruments, it is only necessary for the operator at a telephone (say J) to make a musical sound in any way in the neighborhood of the plate A — for convenience of operation, through the speaking-tube E — and to let the duration of the sound signify the dot or dash of the Morse alphabet, and for the operator who receives his message (say at M) to listen to his telephone, preferably through the speaking-tube E. When two or more musical signals are being transmitted over the same circuit all the telephones reproduce the signals for all the messages; but as the signals for each message differ in pitch from those for the other messages, it is easy for an operator to fix his attention upon one message and ignore the other.

"When a large number of despatches are being simultaneously transmitted it will be advisable for the operator to listen to his telephone through a resonator, which will reenforce to his ear the signals which he desires to observe. In this way he is enabled to direct his attention to the signals for

any given message without being distracted or disturbed by the signals for any other messages that may be passing over the line at the time.

"The musical signals, if preferred, can be automatically received by means of a resonator, one end of which is closed by a membrane, which vibrates only when the note with which the resonator is in unison is emitted by the receiving-telephone. The vibrations of the membrane may be made to operate a circuit-breaker, which will actuate a Morse sounder or a telegraphic recording or registering apparatus.

"One form of vibratory circuit-breaker which may be used for this purpose I have described in Letters Patent No. 178,-399, June 6, 1876. Hence by this plan the simultaneous transmission of a number of telegraphic messages over a single circuit in the same or in both directions with a single main battery for the whole circuit and a single telephone at each station is rendered practicable. This is of great advantage in this, that for the conveyance of several messages, or signals, or sounds over a single wire simultaneously, it is no longer necessary to have separate instruments correspondingly tuned for each given sound, which plan requires nice adjustment of the corresponding instruments, while the present improvement admits of a single instrument at each station, or, if for convenience several are employed, they all are alike in construction, and need not be adjusted or tuned to particular pitches.

"Whatever sound is made in the neighborhood of any telephone — say at J, Fig. 4 — is echoed in fac-simile by the telephones of all the other stations upon the circuit; hence this plan is also adapted for the use of the transmitting intelligibly the exact sounds of articulate speech. To convey an articulate message it is only necessary for an operator to speak in the neighborhood of his telephone, preferably through the tube E, and for another operator at a distant station upon the same circuit to listen to the telephone at that station. If two persons speak simultaneously in the neighborhood of the same or different telephones, the utterances of the two speakers are reproduced simultaneously by all the other telephones on the

same circuit; hence by this plan a number of vocal messages may be transmitted simultaneously on the same circuit, in either or both directions. All the effects noted above may be produced by the same instruments without a battery by rendering the central bar F H permanently magnetic. Another form of telephone, for use without a battery, is shown in Fig. 5, in which O is a compound permanent magnet, to the poles of which are affixed poll-pieces of soft iron, P Q, surrounded by helices of insulated wire, R S.

"Fig. 6 illustrates the arrangement upon circuits of similar instruments to that shown in Fig. 5.

"In lieu of the plate A in above figures, iron or steel reeds of definite pitch may be placed in front of the electro-magnet O, and, in connection with a series of such instruments of different pitches, an arrangement upon circuit may be employed similar to that shown in my Patent No. 174,465, and illustrated in Fig. 6 of Sheet 2 in said patent. The battery, of course, may be omitted.

"This invention is not limited to the use of iron or steel, but includes within its scope any material capable of inductive action.

"The essential feature of the invention consists in the armature of the receiving-instrument being vibrated by the varying attraction of the electro-magnet so as to vibrate the air in the vicinity thereof in the same manner as the air is vibrated at the other end by the production of the sound. It is, therefore, by no means necessary or essential that the transmitting-instrument should be of the same construction as the receiving-instrument. Any instrument receiving and transmitting the impression of agitated air may be used as the transmitter, although, for convenience and for reciprocal communication, I prefer to use like instruments at either end of an electrical wire. I have heretofore described and exhibited such other means of transmitting sound, as will be seen by reference to the proceedings of the American Academy of Arts and Sciences, Volume XII.

"For convenience, I prefer to apply to each instrument a call-bell. This may be arranged so as to ring, first, when the

main circuit is opened; second, when the bar F comes into contact with the plate A. The first is done to call attention; the second indicates when it is necessary to readjust the magnet, for it is important that the distance of the magnet from the plate should be as little as possible, without, however, being in contact. I have also found that the electrical undulations produced upon the main line by the vibration of the plate A are intensified by placing the coil G at the end of the bar F nearest the plate A, and not extend it beyond the middle, or thereabout.

"Having thus described my invention, what I claim, and desire to secure by Letters Patent, is

"1. The union upon and by means of an electric circuit of two or more instruments, constructed for operation substantially as herein shown and described, so that if motion of any kind or form be produced in any way in the armature of any one of the said instruments, the armatures of all the other instruments upon the same circuit will be moved in like manner and form, and if such motion be produced in the former by sound, like sound will be produced by the motion of the latter.

"2. In a system of electric telegraphy or telephony, consisting of transmitting and receiving instruments united upon an electric circuit, the production, in the armature of each receiving-instrument, of any given motion by subjecting said armature to an attraction varying in intensity, however such variation may be produced in the magnet; and hence I claim the production of any given sound or sounds from the armature of the receiving-instrument by subjecting said armature to an attraction varying in intensity, in such manner as to throw the armature into that form of vibration that characterizes the given sound or sounds.

"3. The combination, with an electro-magnet, of a plate of iron or steel, or other material capable of inductive action, which can be thrown into vibration by the movement of surrounding air or by the attraction of a magnet.

"4. In combination with a plate and electro magnet, as before claimed, the means herein described, or their mechanical equivalents, of adjusting the relative position of the two

so that, without touching, they may be set as closely together as possible.

"5. The formation, in an electric telephone such as herein shown and described, of a magnet with a coil upon the end or ends of the magnet nearest the plate.

"6. The combination, with an electric telephone such as described, of a sounding-box, substantially as herein shown and set forth.

"7. In combination with an electric telephone, as herein described, the employment of a speaking or hearing tube for conveying sounds to or from the telephone, substantially as set forth.

"8. In a system of electric telephony, the combination of a permanent magnet with a plate of iron or steel, or other material capable of inductive action, with coils upon the end or ends of said magnet nearest the plate, substantially as set forth.

"In testimony whereof I have hereunto signed my name this 13th day of January, A.D. 1877.

"A. GRAHAM BELL"

"Witnesses:

HENRY R. ELLIOTT,

EWELL A. DICK."

The complainants alleged infringement of claim five of the first patent by all the defendants below, and infringement of claims three, five, six, seven and eight of the second patent, or of some of them, by some of the defendants below.

The respondents all contested the validity of both of Bell's patents. They also contested the scope of claim five of the first patent. The question of infringement turned upon the scope of this claim, as none of the defendants used instruments which were indentical with the forms shown in the drawings of that patent. Dolbear's instrument differed from those of the other appellants, and his contention as to the scope of this claim varied from that of the others, as will appear more fully in the report of the arguments *infra*.

All the respondents denied that Bell was the original and first inventor of the things patented, as the patents were construed by the complainants' counsel, and by the courts below, and all maintained that if the construction given below to the fifth claim of the first patent was correct, it covered matters not patentable.

Dolbear, the Molecular Company, the Overland Company, and the Clay Commercial Company in their respective answers set out long lists of printed publications and patents[1] prior to

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[1] The following lists are taken from the answer of the Molecular Company.

1. *Persons by whom the invention patented by Bell's first patent had been invented and discovered prior to his invention.*

Philip Reis, then of Friedrichsdorf, Germany, now dead, at Friedrichsdorf and Frankfort, Germany.

Elisha Gray, of Highland Park, Ill., at Oberlin and Cleveland, Ohio; Highland Park and Chicago, Ill.; Milwaukee, Wis., Washington, D. C., and New York City.

Thomas A. Edison, of Menlo Park, N. J., at Menlo Park, N. J., and New York City.

Daniel Drawbaugh, of and at Eberly's Mills, in the county of Cumberland and State of Pennsylvania.

Amos E. Dolbear, of Somerville, Mass., at Somerville, Mass., and elsewhere in the United States.

Alfred G. Holcomb, of Granby, Conn., at New York City, N. Y., and elsewhere in the United States.

Philip H. Van der Weyde, of Brooklyn, at New York City, N. Y., and elsewhere in the United States.

James W. McDonough, of Chicago, Ill., at said Chicago, at New York City and elsewhere.

W. F. Channing, of Providence, R. I., at Providence, R. I.

Benjamin F. Edwards, now deceased, formerly of Boston, Mass., at Boston, Mass., Washington, D. C., and New York City, N. Y.

James Hamblet, Jr., of Brooklyn, N. Y., at Boston, Mass., Washington, D. C., and New York City.

Edward Farran, of Keene, N. H., at Keene, N. H.

Antonio Mencci, of Clifton, Staten Island, N. Y., at Staten Island and New York City.

W. S. Voelker, of Morton, Delaware County, Pa., at Philadelphia, Pa., Morton, Delaware County, Pa., and other places in the United States.

Edward C. Pickering, of Cambridge, Mass., at Boston and Cambridge, Mass

the issue of Bell's patents, and averred that the inventions patented to him in his first patent had been substantially

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2. *Letters Patent prior to Bell's first patent, describing the patented invention.*

Letters Patent granted by the United States to Thomas A. Edison and George Harrington, dated Aug. 12, 1873, No. 141,777.

Letters Patent of the United States granted to William Thompson, dated Nov. 17, 1874, No. 156,897.

Letters Patent of the United States granted to Elisha Gray, July 27, 1875, No. 166,096.

Letters Patent of the United States granted to Elisha Gray, July 27, 1876, No. 166,094.

Letters Patent of the United States granted to Elisha Gray, July 27, 1875, No. 166,095; caveat filed by Elisha Gray in the United States Patent Office, Feb. 14, 1876.

Letters Patent of the United States granted to Elisha Gray, April 11, 1876, No. 175,971.

Letters Patent of the United States granted to Elisha Gray, Jan. 16, 1877, No. 186,340.

British Letters Patent granted to C. F. Varley, 1870, No. 1044.

British Letters Patent granted to J. H. Johnston, July 29, 1874, No. 2646.

British Letters Patent granted to George T. Bousfield, dated May 4, 1876, and numbered 1874.

French patent granted to Leon Scott, dated March 25, 1857; certificate of addition to same dated July 29, 1859.

British Letters Patent granted to John Henry Johnston, dated March 16, 1875, No. 974.

British Letters Patent granted to Charles Wheatstone, dated Jan. 21, 1840, No. 8345.

British Letters Patent granted to David Hughes, dated April 27, 1858, No. 938.

United States Letters Patent granted to Elisha Gray, dated Feb. 15, 1876, No. 173,460.

3. *Letters Patent prior to Bell's second patent, describing the patented invention.*

United States Letters Patent to Elisha Gray, July 27, 1875, No. 166,095; to Elisha Gray, April 11, 1876, No. 175,971; to A. G. Holcomb, May 16, 1860; to Elisha Gray, July 20, 1875, No. 165,728; to Elisha Gray, Feb. 15, 1876, No. 173,460; and to the same of the same date, No. 173,618.

British Letters Patent to J. H. Johnston, July 29, 1874, No. 2646; to J. H. Johnston, March 16, 1875, No. 974; to George T. Bousfield, May 4, 1876, No. 1874.

Canadian Letters Patent to Elisha Gray, July 7, 1875, No. 4749.

described in these publications and patents; and they also set up a number of like publications and patents as anticipating his second patent.

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4. *Printed Publications prior to Bell's first patent, in which the patent was described.*

"Electricity and Magnetism," by Jenkins, a book printed and published in London, England, and in the city of New York, in 1873, at p. 334.

"Der Electromagnetische Telegraph," by H. Schellen, a printed book published in Brunswick, Germany, in the year 1867, at pp. 468 and 469.

"The Electric Telegraph," by R. Sabine, a book printed and published in London, England, 1867, at pp. 164, 165, 166 and 167.

"L'Eco d'Italia," 1860.

"Lehrbuch der Technischen Physik," by Hassler Pisko, a book published at Vienna, 1866, Vol. 1, p. 648.

Also in a printed publication in the German language entitled "Jahres Bericht des Physikalischen Vereins zu Frankfurt am Main," a book printed and published in 1862, and particularly at pp. 57–64.

A printed publication in the German language entitled "Zeitschrift des Deutsch-Oesterreichischen Telegraphen-Vereins," Vol. 9, a book printed and published at Berlin in 1862, particularly at pp. 125–130.

A printed publication in the German language entitled "Die Neueren Apparate der Akustik," von Dr. Prof. Fr. Jos. Pisko, printed and published in 1865, particularly at pp. 96–103 and pp. 241, 242.

Yearly report of the Physical Society at Frankfurt-a-M., 1860, 1861, at p. 57, etc.

A French publication entitled "Petit Traité de Physique," par M. J. Jamin, Paris, 1870, and particularly at p. 421.

The "Telegraphic Journal," published in London in 1872, Vol. 1, at p. 4.

"Electricity," by R. M. Ferguson, a printed book published in London and Edinburgh in 1867, at pp. 257 and 258.

"The Telegrapher," published in the city of New York in 1869, Vol. 5, No. 39, at pp. —.

"The Manufacturer and Builder," for May, 1869, a newspaper published in the city of New York in 1869, Vol. 1, at p. 129.

"Wonders of Electricity," by J. Baile, published in New York City in 1872, at pp. 140, 141, 142 and 143.

"The Telegraphic Journal," published in London in the year 1875, Vol. 3, at pp. 286, 287 and 288.

"Dingler's Polytechnic Journal" for 1863, Vol. 163, pp. 23 and 185, a book published at Leipsic in 1863.

"Cosmos" for 1864, Vol. 24, pp. 349, 352, a printed book published in Paris in 1864; article by M. St. Edmé.

"Description Reis Telephone, Koenig's Catalogue of Apparatus for 1865," a book printed and published in Paris.

"Applications de l'Électricité," by Du Moncel, Vol. 2, p. 255, etc., a printed book published in Paris in 1854 (Bourseul Apparatus).

Statement of the Case.

In the arguments in this court those known as the Bourseul and Reis publications were chiefly relied upon, either to defeat

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"L'Anneé Scientifique" by Louis Figuier, 1858, Vol. 1, p. 62, a book printed and published at Paris, France, in 1858.

"Cosmos," by l'Abbé Moigno, 1859, eighth year, Vol. 14, No. 11; article about the "Scott Phonautograph," a book printed and published in Paris in 1859.

"Traité Elementaire de Physique," by M. Ganot; eleventh edition, 1854, p. 224; a book published in Paris in 1854; article, "Scott Phonautograph."

"Comptes Rendus de l'Académie des Sciences," Vol. 53, p. 108, 1861.

"Poggendorf Annalen," 1843, Vol. 59, p. 177, a book printed and published at Leipsic, 1843.

"Didaskalia," a journal published in Frankfort-on-the-Main, Sept. 28, 1854, No. 232, and on May 11, 1862, No. 130, and on May 14, 1862, No. 133.

"Du Moncel's Exposé des Applications de l'Électricité," a book published in Paris, France, in 1856 (p. 246), and in 1857 (p. 110).

"Frankfurter Konversationsblatt," a journal published in Frankfort-on-the-Main, Nov. 29, 1861, and June 30, 1863.

"Die Fortschritte der Physik," a journal published in Berlin (pp. 171, 173), and in 1863 (p. 96).

"Aus der Natur," published in Leipsic, 1862 (Vol. 21, pp. 470, 471 to p. 484).

"Müller Poillet's Lehrbuch der Physik und Meteorologie," published in 1862 in Germany, and in 1863, Vol. 2, p. 352, Fig. 325, and 1868, pp. 386, 388, Figs. 348–350.

"Friedrichsdorf Zeitung," a journal published in Homburg in 1862, and also that of 1867 and 1868 (pp. 386, 387, 388, 389).

"Jahres Bericht des Physikalischen Vereins" (Vol. 4, pp. 129 to 135), annual report for 1860, 1861, published in 1863, in Frankfort-on-the-Main.

"Böttgers Polytechnischen Notizblatt," Nos. 1–24 inclusive, pp. 65, 81–255, published in 1863.

"Deutsche Klinik," No. 48, pp. 468, 469, published in 1863 in Berlin.

"Deutsche Industrie Zeitung," published in 1863, in Chemnitz (pp. 184–208, 239 and 249).

"Die Gartenlaube," published at Leipsic, 1863 (pp. 807–809).

"Prospectus of Philipp Reis," published in 1863 in Frankfort, and in "Pisko's Die neueren Apparate der Akustik," published in Vienna, in 1863.

A further circular or addition to the preceding, published in Frankfort in 1863.

The two were published with the circular or prospectus of J. Wehl Albert, mechanician, in Frankfort, in 1863.

"Polytechnische Centralblatt," published in 1863, pp. 857, 858.

Letter of Philipp Reis to W. Ladd, Aug. 13, 1863.

"Tagesblatt der 39 Versammlung Deutscher Naturförscher," published in Giessen, in September, 1864.

the first patent or to limit its scope. The counsel for the People's Company referred to these, though not set up in their

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"Zöllner's Buch der Erfindungen," published in Leipsic and Berlin in 1865 and in 1872.

"Karl Kuhn's Handbuch der Angewandten Elektricitätslehre," pp. 1016–1021, published in 1866.

"Albert's Catalogue," in 1866 and 1872 and 1873.

"Kneeland's Annual of Scientific Discovery," in 1866 and 1867.

"New York Tribune," Jan. 8, 1869.

"Christian Union," New York, Dec. 25, 1875.

"Scientific American," New York, March 4, 1876.

"Scientific American" (Supplement), Feb. 5, 1876.

"Scientific American" (Supplement), No. 48, 1876.

"Electricity and Magnetism," by Jenkins, in London, 1876.

"Journal of the Franklin Institute of the State of Pennsylvania," Vol. 42, published in Philadelphia in 1869, pp. 419 *et seq.*

"The Manufacturer and Builder," April, 1870.

"Dublin Medical Press," 1863, Vol. 50, No. 1293, p. 471.

"Cosmos," 1863, Vol. 23, p. 705.

"Zeitschrift des Architectur und Ingenieur Vereins," 1866, Vol. 12, p. 147.

"The Electric Telegraph," by Dr. Lardner, new edition, revised by E. B. Bright, published in London, England, in 1867, at pp. 164, 165, 166 and 167.

"Transactions Royal Scottish Society of Arts," Edinburgh, Vol. 6, 1864, Appendix Q, pp. 184–187.

"Annual Report of American Association for the Advancement of Science" for 1869.

"Knight's American Mechanical Dictionary," 1876, Article "Telephone."

5. *Printed publications prior to Bell's second patent, in which the patented invention was described.*

"Der Electromagnetische Telegraph," by Dr. H. Schellen, published at Brunswick, Germany, in the year 1867, at pp. 411, 412, 413, 414, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 468 and 469.

"Zeitschrift des Deutsch-Oesterreichischen Telegraphen-Vereins," published at Berlin, Prussia, in the year 1862, Vol. 9, p. 125.

Yearly report of the Physical Society at Frankfort-a-M., 1860, 1861, p. 67, etc.

"Die Neuren Apparate der Akustik," von Dr. Prof. Jos. Pisko, printed and published in 1865.

"Journal of the German-Austrian Telegraph Association," Vol. 9, p. 125, 1862, and pp. 94–104.

"The Electric Telegraph," by R. Sabine, published in London, England, in 1867, at pp. 136, 137 and 138.

answer, it having been agreed that the court should treat all the evidence, in all the cases, as applicable to each one of them.

"The Telegraphic Journal," published in London in 1872, Vol. 1, p. 4.

"Electricity," by R. M. Ferguson, published in London and Edinburgh in the year 1867, at pp. 257 and 258.

"The Telegrapher," published in the city of New York in the year 1869, Vol. 5, No. 39, at p. —.

"The Manufacturer and Builder," published in the city of New York in the year 1869, Vol 1, at p. 129.

"Wonders of Electricity," by J. Baile, published in the city of New York, in the year 1872, at pp. 140, 141, 142 and 143.

"The Telegraphic Journal," published in London in the year 1875, Vol. 3, at pp. 286, 287 and 288.

"L'Eco d'Italia," 1860.

"Lehrbuch der Technischen Physik," by Dr. Hassler Pisko, published at Vienna, 1836, Vol. 1, 648.

"The Scientific American," of Oct. 20, 1860, p. 264, a newspaper published in the city of New York.

"Didaskalia," a journal published in Frankfort-on-the-Main, Sept. 28, 1854, No. 232; and on May 11, 1862, No. 130; and on May 14, 1862, No. 133.

Du Moncel's "Exposé des Applications de l'Électricité," a book published in Paris, France, in 1856 (p. 246), and in 1857 (p. 110).

"Frankfurter Konversationsblatt," a journal published in Frankfort-on-the-Main, Nov. 29, 1861, and June 30, 1863.

"Die Fortschritte der Physik," a journal published in Berlin (pp. 171, 173), and in 1863 (p. 96).

"Aus der Natur," published in Leipsic, 1862 (Vol. 21, pp. 470, 471–484).

"Müller Poillet's Lehrbuch der Physik und Meteorologie," published in 1862, in Germany, and in 1863, Vol. 2, p. 352, Fig. 325; and 1868, pp. 386–388, Figs. 348–350.

"Friedrichsdorf Zeitung," a journal published in Homburg, in 1862, and also that of 1867 and 1868 (pp. 386, 387, 388, 389).

"Jahres Bericht des Physikalisches Vereins" (Vol. 4, pp. 129–135), annual report for 1860, 1861, published in 1863, in Frankfort-on-the-Main.

"Böttger's Polytechnischen Notizblatt," Nos. 1 to 24 inclusive, pp. 65, 81, 225, published in 1863.

"Deutsche Klinik," No. 48, pp. 468, 469, published in 1863, in Berlin.

"Deutsche Industrie Zeitung," published in 1863, in Chemnitz (pp. 184–208, 239 and 249).

"Die Gartenlaube," published at Leipsic, 1863 (pp. 807–809).

"Prospectus of Philipp Reis," published in 1863 in Frankfort, and in Pisko's "Die neueren Apparate der Akustik," published in Vienna in 1863.

A further circular or addition to the preceding, published in Frankfort in 1863.

The Bourseul publication (there were several in the records) chiefly cited in argument was the original communication from M. Charles Bourseul printed in Volume XXIV. of "L'Illustration," Paris, August 26, 1854, of which the following is a translation:

"The electric telegraph is based on the following principle: An electric current, passing through a metallic wire, circulates through a coil around a piece of soft iron which it converts into a magnet. The moment the current stops, the piece of iron ceases to be a magnet. This magnet, which takes the

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The two were published with the circular or prospectus of J. Wehl Albert, mechanician, in Frankfort, in 1863.

"Polytechnische Centralblatt," published in 1863, pp. 857, 858.

Letter of Philipp Reis to W. Ladd, Aug. 13, 1863.

"Tagesblatt der 39 Versammlung Deutscher Naturförscher," published in Giessen, in September, 1884.

Zöllner's "Buch der Erfindungen," published in Leipsic and Berlin in 1865 and 1872.

"Karl Kuhns Handbuch der Angewandten Elektricitätslehre," pp. 1016–1021, published in 1866.

"Albert's Catalogue," in 1866 and 1872 and 1873.

"Kneeland's Annual of Scientific Discovery," in 1866 and 1867.

"New York Tribune," Jan. 8, 1869.

"Christian Union," New York, Dec. 25, 1875.

"Scientific American," New York, March 4, 1876.

"Scientific American" (Supplement), Feb. 5, 1876.

"Scientific American" (Supplement), No. 48, 1876.

"Electricity and Magnetism," by Jenkins, in London, 1876.

"Journal of the Franklin Institute of the State of Pennsylvania," Vol. 42, published in Philadelphia in 1869, pp. 419 *et seq.*

"The Manufacturer and Builder," April, 1870.

"Dublin Medical Press," 1863, Vol. 50, No. 1293, p. 471.

"Cosmos," 1863, Vol. 23, p. 705.

"Zeitschrift des Architectur und Ingenieur Vereins," 1866, Vol. 12, p. 147.

"The Electric Telegraph," by Dr. Lardner, new edition, revised by E. B. Bright, published in London, Eng., in 1867, at pp. 164, 165, 166 and 167.

"Transactions Royal Scottish Society of Arts," Edinburgh, Vol. 6, 1864, Appendix Q, pp. 184–187.

"Annual Report of American Association for the Advancement of Science," for 1869.

name of electro-magnet, can thus in turn attract and then release a movable plate (*plaque mobile*) which by its to-and-fro movement produces the conventional signals employed in telegraphy. Sometimes this movement is directly utilized, and is made to produce dots or dashes on a strip of paper which is drawn along by clockwork. The conventional signals are thus formed by a combination of those dots and dashes. This is the American telegraph, which bears the name of Morse, its inventor. Sometimes this to-and-fro movement is converted into a movement of rotation. In that way we have either the dial telegraph used on railroads, or the telegraph used in the government system, which by means of two line-wires and two indicating needles, reproduce all the signals of the aerial telegraph or semaphore which was formerly used. Suppose, now, that we arrange upon a movable horizontal circle letters, figures, signs of punctuation, &c. One can understand that the principle we have stated can be used to choose at a distance such and such a character, and to determine its movement, and consequently to print it on a sheet of paper appropriately placed for this purpose. This is the printing telegraph.

"We have gone still further. By the employment of the same principle, and by means of a mechanism rather complicated, it has been possible to reach a result which at first would seem to be almost a miracle. Handwriting itself is produced at a distance, and not only handwriting, but any line or any curve; so that, being in Paris, you can draw a profile by ordinary means there, and the same profile draws itself at the same time at Frankfort. Attempts of this sort have succeeded. The apparatus has been exhibited at the London Exhibition. Some details, however, remain to be perfected. It would seem impossible to go beyond this in the region of the marvellous. Let us try, nevertheless, to go a few steps further. I have asked myself, for example, if the spoken word itself could not be transmitted by electricity; in a word, if what was spoken in Vienna may not be heard in Paris? The thing is practicable in this way:

"We know that sounds are made by vibrations, and are made sensible to the ear by the same vibrations, which are

reproduced by the intervening medium. But the intensity of the vibrations diminishes very rapidly with the distance; so that even with the aid of speaking tubes and trumpets, it is impossible to exceed somewhat narrow limits. Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately makes and breaks the connection with a battery: you may have at a distance another disk which will simultaneously execute the same vibrations.

"It is true that the intensity of the sounds produced will be variable at the point of departure, at which the disk vibrates by means of the voice, and constant at the point of arrival, where it vibrates by means of electricity; but it has been shown that this does not change the sounds. It is, moreover, evident that the sounds will be reproduced at the same pitch.

"The present state of acoustic science does not permit us to declare *a priori* if this will be precisely the case with syllables uttered by the human voice. The mode in which these syllables are produced has not yet been sufficiently investigated. It is true that we know that some are uttered by the teeth, others by the lips, &c.; but that is all.

"However this may be, observe that the syllables can only reproduce upon the sense of hearing the vibrations of the intervening medium. Reproduce precisely these vibrations, and you will reproduce precisely these syllables.

"It is, at all events, impossible, in the present condition of science, to prove the impossibility of transmitting sound by electricity. Everything tends to show, on the contrary, that there is such a possibility. When the application of electromagnetism to the transmission of messages was first discussed, a man of great scientific attainments treated the idea as Utopian, and yet there is now direct communication between London and Vienna by means of a simple wire. Men declared it to be impossible, but it is done.

"It need not be said that numerous applications of the highest importance will immediately arise from the transmission of speech by electricity. Any one who is not deaf and dumb may use this mode of transmission, which would

require no apparatus except an electric battery, two vibrating disks and a wire. In many cases, as, for example, in large establishments, orders might be transmitted in this way, although transmission in this way will not be used while it is necessary to transmit letter by letter, and to make use of telegraphs which require use and apprenticeship. However this may be, it is certain that in a more or less distant future, speech will be transmitted by electricity. I have made some experiments in this direction. They are delicate, and demand time and patience; but the approximations obtained promise a favorable result.

"CHARLES BOURSEUL.

"PARIS, August 18, 1854."

Of the Reis publications the record contained over sixty separate papers, from 1861 to 1876, and also a large amount of expert testimony concerning them. It is not practicable to reproduce most of this evidence, except as it is referred to by counsel in the synopses of their arguments. The following are the translations of some of the principal publications under this head, which were referred to in argument in this court. It appeared that Reis delivered two lectures before the "Physikalischer Vereins" of Frankfort. The first of the following papers was written by him as a report of those lectures.

JAHRESBERICHT DES PHYSIKALISCHEN VEREINS ZU FRANKFURT AM MAIN, für das Rechnungs Jahr 1860–1861. Published in 1862.

"[Yearly Report of the Physical Society at Frankfort-a-M., 1860–61, pp. 57–64.]

"On telephony by means of the galvanic current, by Philipp Reis.

"The extraordinary results in the field of telegraphy have probably often raised the question, If it might not be possible to transmit musical tones themselves [Tonsprache] to a distance? Experiments made in this direction could not,

however, produce any result at all satisfactory, because the vibrations of sound-conducting media soon lose their intensity to such an extent that they are no longer appreciable by our senses.

"A reproduction of tones [Tönen] at certain distances by means of a galvanic current has probably been thought of, but the practical solution of this problem has certainly seemed the most doubtful to the very persons who, from their knowledge and appliances, were in the best condition to attack it. To a person having only a superficial knowledge of physics, the problem presents far less difficulties, simply because the most of them are unperceived. About nine years ago I also (having an extraordinary enthusiasm for what was new, and an insufficient knowledge of physics) had the boldness to attempt the solution, but was soon forced to desist, because the very first experiment convinced me of the impossibility of its solution.

"Later, after further study and experience, I came to see that my first experiment had been a very rough and by no means conclusive one; I did not, however, follow up the subject seriously, because I did not feel myself equal to the difficulties in the way.

"Youthful impressions, however, are strong, and therefore not easily effaced. I could never get rid of the thought of that first experiment and its occasion, notwithstanding all that reason says to the contrary, and thus, half unwillingly, this project of my youth was reviewed in hours of leisure; the difficulties and the means for overcoming them were weighed; but for the present, at least, no experiment was made.

"How indeed could a single instrument reproduce the combined effect of all the organs occupied in human speech? This was always the cardinal question; finally I got the notion of putting the question in another way:

"How is *our ear* affected by the totality of vibrations produced by the organs of speech all simultaneously active? Or more generally;

"How are we affected by the vibrations of several simultaneously sounding bodies?

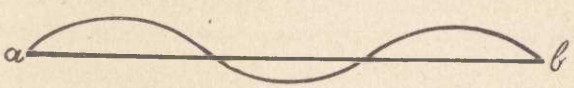
Statement of the Case.

"To answer this question, we must, in the first place, understand what must happen in order that we may perceive a single tone.

"Without our ear, any tone is nothing else than a recurrent condensation and rarefaction of some body repeated at least seven or eight times in a second. If this occurs in the same medium in which we are, the membrane of the ear is at each condensation forced towards the middle ear, to be moved at the subsequent rarefaction in the opposite direction. These vibrations produce a synchronous raising and falling of the hammer upon the anvil (according to other authorities, an approach or receding of the ear-bone particles), and a similar number of tremors in the fluid of the cochlea, in which the filaments of the auditory nerve are distributed. The greater the condensation of the sound-conducting medium at any given moment, the greater is the amplitude of vibration of the membrane and hammer, and consequently the more powerful the blow upon the anvil, and the vibration of the nerves by means of the fluid.

"The office of our organs of hearing is, therefore, to transmit with certainty up to the auditory nerve every condensation and rarefaction occurring in the surrounding medium. But the office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, both as regards number and amplitude. Here, for the first time, certain combinations receive a name; here, certain vibrations are *tones* or *noises* [*Töne* oder *Misstöne*].

"What our auditory nerve perceives is, then, simply the effect of a force coming within the range of consciousness, and this force can be represented both as to duration and magnitude graphically by a curve.



"Let *a b* represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (−), then any ordinate raised from the end of any abscissa will

represent the degree of condensation, at the time represented by its base, in consequence of which the drum of the ear vibrates.

"Our ear can under no circumstances appreciate more than can be represented by these curves, and this indeed is entirely sufficient to give us a clear perception of any tone [Ton] or any combination of tones.

"If several tones [Töne] are produced at the same time, the conducting medium is subjected to the influence of several simultaneous forces, and the two following laws will hold good: If the forces act all in the same direction, the amplitude is proportional to the sum of the forces; if the forces act in opposite directions, the amplitudes are proportional to the difference of the opposing forces.

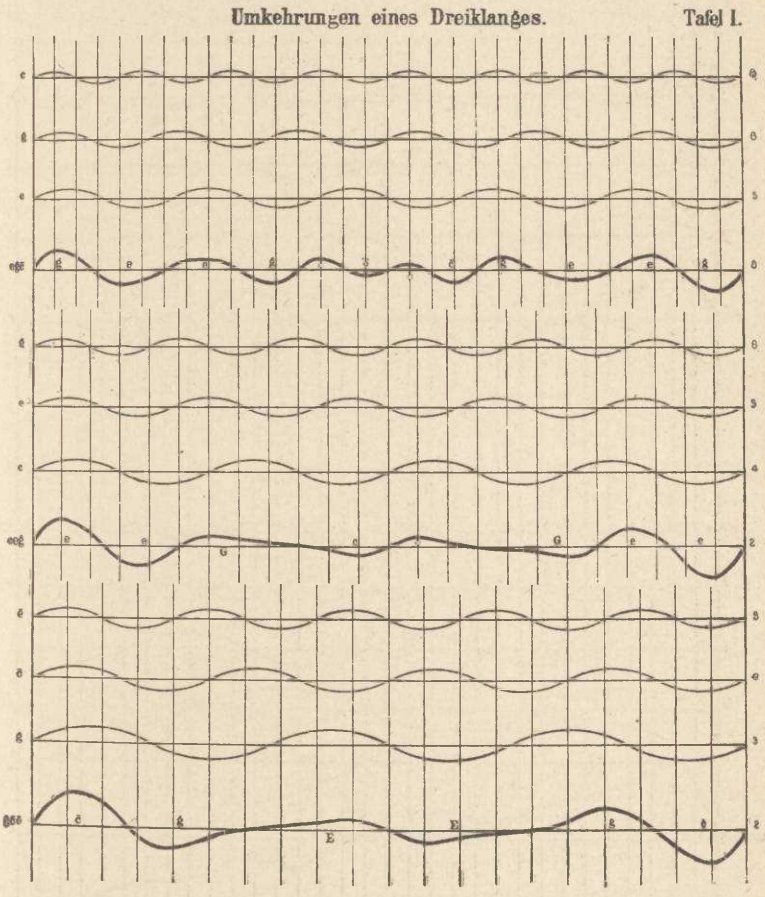
"If, for example, in the case of three tones, we draw the curve of condensation of each separately, then by a summation of the ordinates of corresponding abscissas, we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous tones. The fact that the musician can distinguish the three tones need not surprise us any more than the fact that any one acquainted with the theory of colors can in green discover blue and yellow; but the combination curves in Plate I. show that this difficulty is a slight one, for in these curves all the relations of the components successively recur. In the case of chords of more than three notes, the relations are not so readily seen from the drawing, Plate II., for example. In the case of such chords, however, the skilled musician also finds difficulty in recognizing the separate notes.

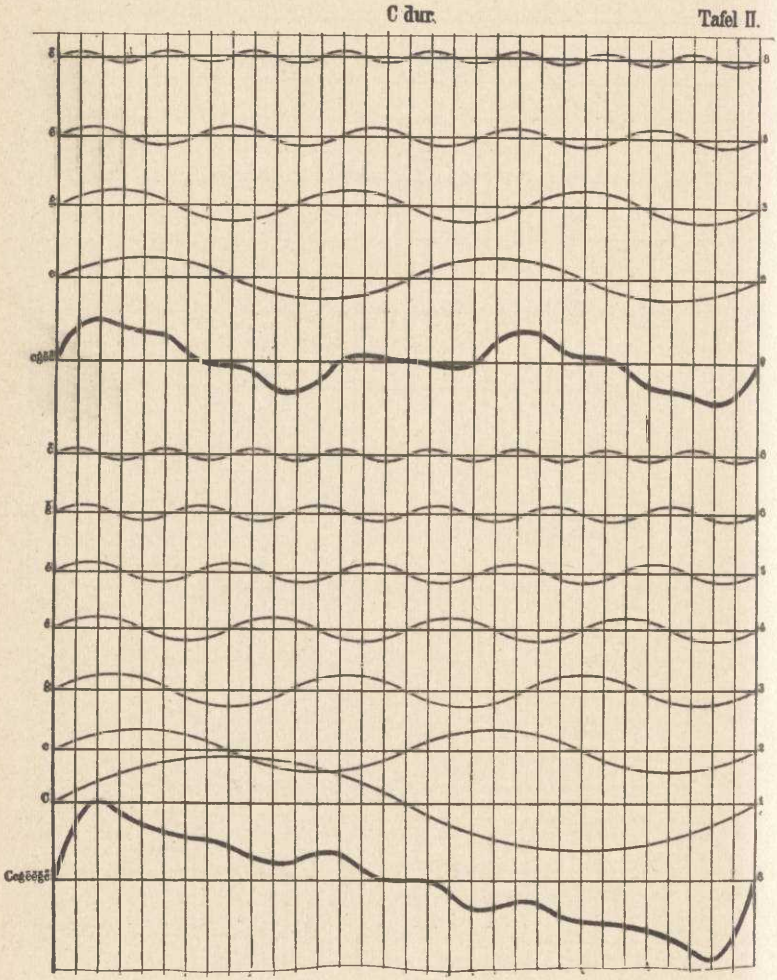
"Plate III. illustrates discord [Dissonanz]. Why discords impress us unpleasantly I will leave my readers to judge at this time, though I may perhaps return to the subject subsequently in another paper.

"From the preceding it follows:

"*First.* Every tone [Ton] and every combination of tones, on striking our ear, causes vibrations on the drum of the ear, the succession of which may be represented by a curve.

Statement of the Case.

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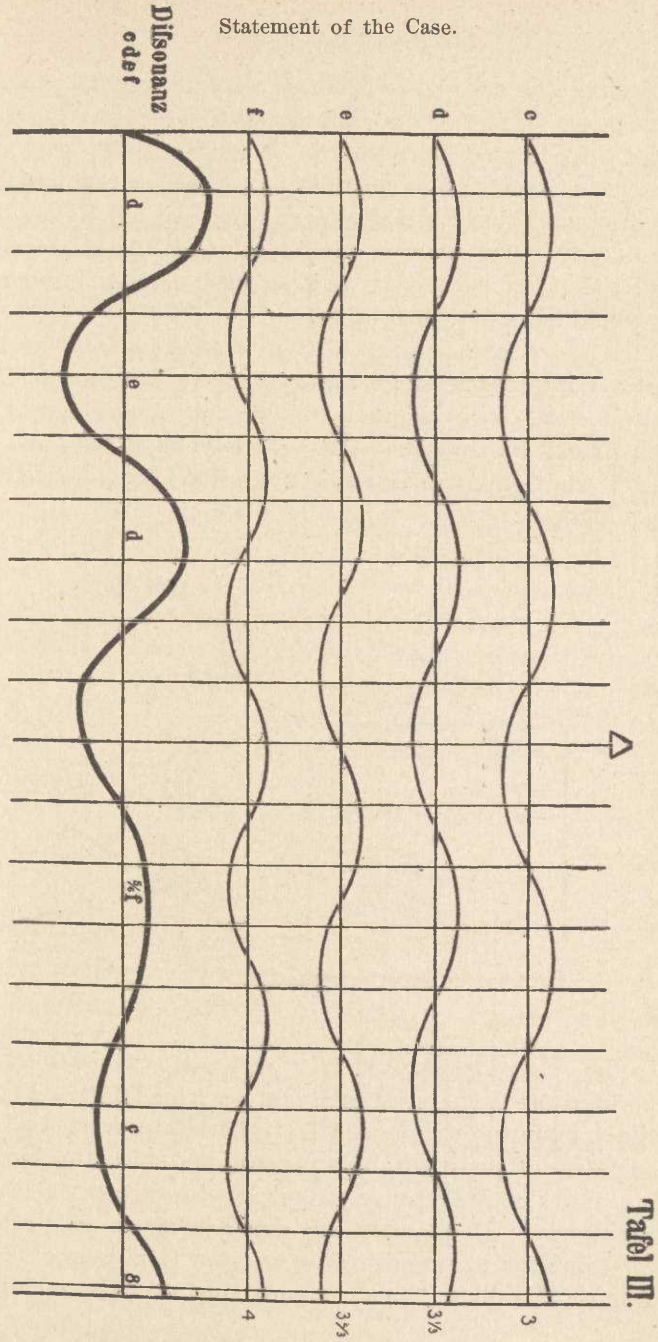
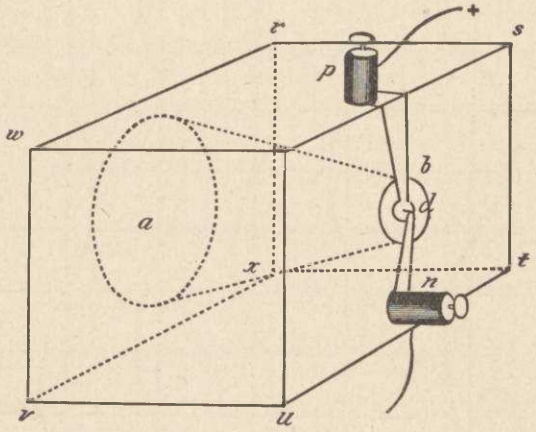
Statement of the Case.



"*Second.* The succession of these vibrations alone gives us a conception (sensation) of the tone, and every alteration changes the conception (sensation).

"As soon, then, as it is possible to produce, anywhere and in any manner, vibrations whose curves shall be the same as those of any given tone or combination of tones, we shall receive the same impression as that tone or combination of tones would have produced on us.

"With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent the human voice. It is very simple, and by means of the figure will be easily understood from the following explanation:



"In the cubical block of wood *r s t u v w x* there is a conical perforation *a*, closed at one end by a membrane *b* (pig's intestine), upon the middle of which there is cemented a conducting strip of platinum; this is connected with the binding screw *p* [auf deren Mitte ein stromleitendes Streifchen Platin, festgekittet ist. Dieses steht mit der Klemme *p* in Verbindung]. From the binding screw *n*, another thin strip of metal [ein dünnes Metallstreifchen] extends until over the middle of

the membrane, and ends here in a platinum wire placed at right angles to its length and surface.

"From the binding screw *p*, a conducting wire runs through the battery to a distant station, being connected with a coil of silk-covered copper wire, and this again is connected with a conductor leading back to the binding screw *n*.

"The coil at the distant station is about six inches long, is composed of six layers of fine wire, and, as a core in its centre, has a knitting-needle which projects about two inches at both ends. By means of the projecting ends, the coil rests upon two bridges of a resonant case. (All this part can, of course, be replaced by any other apparatus by means of which the well-known 'galvanic tones' can be produced.)

"If now tones or combinations of tones are produced in the neighborhood of the block, so that sufficiently powerful waves enter the opening *a*, then these sounds cause the membrane *b* to vibrate. At the first condensation the hammer-like wire *d* is pushed back; at the rarefaction it cannot follow the retreating membrane, and the current traversing the strips remains broken [Strom bleibt so lange unterbrochen bis, etc.], until the membrane forced by a new condensation again presses the strip (proceeding from *p*) against *d*. In this way each sound wave causes a breaking and closing [ein Oeffnen und ein Schliessen] of the current [Stromes].

"At each closing [Schliessen] of the circuit [Kette], the atoms of the iron wire inside the distant spiral are moved away from each other (Pouillet Müller, p. 304, Vol. II., fifth edition); on breaking the circuit [beim Unterbrechen des Stromes], these atoms seek to regain their position of equilibrium. When this happens, in consequence of the reciprocal actions of elasticity and inertia, a number of vibrations are produced, and they give the longitudinal sound of the rod (see as above). This is the case if the making and breaking of the current [Unterbrechungen und Schliessungen des Stromes] occur with comparative slowness. If they occur more rapidly than the oscillations of the iron core, due to its elasticity, the atoms cannot complete their course. The paths described become shorter in proportion as the interruptions are more frequent, but then are just as numerous as these.

"The iron wire no longer gives its longitudinal normal tone, but a tone whose pitch corresponds to the number of interruptions [Unterbrechungen] (in a given time); this is the same as saying that *the rod reproduces the tone* [Ton] *impressed upon the interrupter* [dem Unter brechungsapparat]. The intensity also of this tone is proportional to that of the original one, for in proportion as this is more intense, the motions of the membrane are greater; the motions of the hammer, also, and finally the time during which the circuit remains opened, is greater; and consequently, up to a certain limit, the motions of the atoms in the reproducing wire are greater, we perceiving them as greater vibrations, in just the same way as we would have perceived the original sound-wave.

"As the length of the conducting wire can undoubtedly be made as great as in direct telegraphy, I have called my instrument 'telephone.'

"Now, in reference to the capabilities of the telephone, it may be stated that I was enabled to render audible to the members of a large assembly (The Physical Society at Frankfort-a-M.) melodies which were sung (not very loud) into the apparatus in another house (three hundred feet away) with closed doors.

"Other experiments showed that the sounding wire was capable of reproducing complete chords of three tones of a piano, upon which the telephone was placed, and that it reproduces equally well the tones of other instruments, accordion, clarinet, horn, organ pipes, etc., provided that the tones are within the compass F — $\overline{\text{f}}$.

"Of course, in all experiments, sufficient precautions were taken to insure that there was no direct conduction of sound. This is very easily done by making a momentary short circuit immediately in front of the coil, by which means its action is temporarily interrupted.

"Hitherto it has not been possible to reproduce the tones of human speech [Tonsprache des Menschen] with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels as yet not in an equal degree. The cause of this I will attempt to explain.

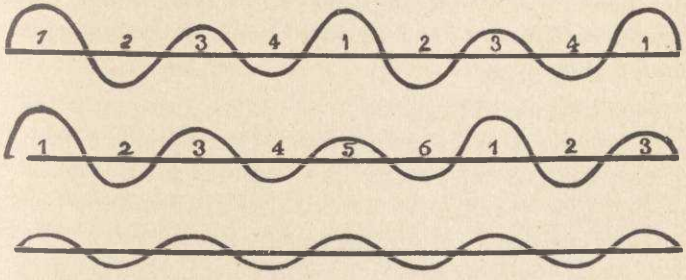
Statement of the Case.

"According to the experiments of Willis, Helmholtz and others, vowel tones can be produced artifically, if the vibrations of one body are from time to time augmented by those of another, somewhat as follows:

"An elastic spring is set in vibration by the blow of a tooth on a toothed wheel; the first vibration is the greatest, and each subsequent one is smaller than the preceding.

"If, after a few vibrations of this kind (the spring not coming to rest in the mean time), the tooth wheel imparts a new stroke, the following vibration will be again a maximum, and so on.

"The pitch of the tone produced in this way depends upon the number of vibrations in a given time, but the character of the tone upon the number of swellings [Anschwellungen] in the same time. Two vowels having the same pitch would differ in about the way represented by the curve (Figs. 1, 2), while the same tone without any vowel character would be represented by the curve (Fig. 3).



"Our organs of speech probably produce the vowels in the same manner, through the combined action of the upper and lower vocal cords, or of these latter and the cavity of the mouth.

"My apparatus reproduces the number of vibrations, but with an intensity much less than that of the original ones; though, as I have reason to believe, to a certain degree proportional among themselves. But in the case of these generally small vibrations, the difference between large and small vibrations is more difficult to perceive than in the case of the original waves, and the vowel is therefore more or less indistinct.

"Whether or not my views as to the curves corresponding to sound combinations are correct could perhaps be decided by means of the new phonautograph of Duhamel ('Vierordt Physiologie,' page 254).

"It may be that for the practical application of the telephone much remains to be done; for physics it has already sufficient interest from the fact that it opens a new field for research.

"Friedrichsdorf, near Frankfort-a-M., December, 1861."

"Die Fortschritte der Physik, Dargestellt von der physikalischen Gesellschaft zu Berlin, XVII., im J., 1861, pp. 171–173.

"[Progress in the Natural Sciences. Published by the Physical Society of Berlin. 1861, Vol. XVII., pp. 171–173.]

"Ph. Reis. *Telephony by means of the electric current.* (*Annual Report of the Physical Society of Frankfort on the Main*, 1860–1, *pp.* 57–64.)

"By the name 'Telephone' the author designates the following apparatus of his own construction, by means of which and with the help of the galvanic current he is enabled 'to reproduce at a distance the tones [Tönen] of different instruments and even to a certain degree the human voice.'

"A wooden cube is bored through from one of the faces to the opposite one, the cavity taking the shape of a cone; the smaller opening is closed by means of a membrane [hog's intestine, Schweinsdünndarm]. On the middle of the membrane and parallel with it is a thin strip of platinum cemented fast at one end whilst the other end is held by a binding post

[Klemme] *p*. From another binding post *q* extends a similar thin strip of metal as far as over the centre of the membrane, and carries a little platinum wire directed towards the membrane at right angles to the strip and the surface of the membrane. From binding post *p* a conductor leads through a battery to a distant coil, which again is connected by another wire to binding post *q*.

"The coil at the distant station is about six inches long, consists of six layers of thin wire and encloses as a core a knitting needle which protrudes about two inches at each end. By these protruding ends the coil is supported on two bridges of a sound-board. If now tones or combinations of tones are produced in the vicinity of the large opening of the conical cavity so that sufficiently strong waves enter it, these waves will set the membrane into vibration; by the outward motion of the membrane the platinum strip cemented on it is pressed against the hammer-shaped wire *d* and the galvanic current [Strom] is closed [geschlossen]; by the inward motion of the membrane the current is reopened. The alternate magnetizings and demagnetizings of the core of the coil resulting therefrom will bring forth, if the alternation is slow, the longitudinal tone of the core, and if the alternation [aufeinanderfolge] is quicker, a longitudinal vibration of the same, the period of which corresponds to the period of the interruptions of the current [Unterbrechungen des Stromes] or of the vibrations of the membrane, and consequently to the rate or pitch of the tone which entered the conical cavity. That means according to the author that 'The rod [Stab] reproduces the tone which was impressed upon the interrupting apparatus [Unterbrechungsapparat].' 'The strength of this tone is also proportionate to the original tone, for,' as the author, though not very accurately, explains, 'the stronger this is, the greater the motion of the little hammer, the greater finally the time during which the circuit remains open, and consequently the greater, up to a certain limit, the motion of the atoms in the reproducing rod, which motions affect us as greater vibrations, as the original wave itself would have done.' By means of this telephone the author made audible to the members of a

large meeting of the Physical Society in Frankfort-a-M. melodies sung not very loud into the apparatus, in a house situated about three hundred feet distant, with closed doors. 'Other trials showed that the resounding rod is capable of reproducing full chords [Dreiklänge] of a piano on which the telephone rests, and that, in short, it reproduces just as well the tones of other instruments, such as the harmonica, clarinet, horn, organ pipe, &c., provided the tones are within a certain range, from F to f^2 or thereabout.

"'As a matter of course, sufficient care was taken to ascertain whether direct transmission of the sounds had not a share in the result. This was ascertained very simply by establishing for a given time a good shunt circuit directly before the coil, in consequence of which, of course, the activity of the latter ceased for that time.

"'It was not possible thus far to reproduce spoken tones [Tonsprache des Menschen] with a distinctness satisfactory to all; the consonants are for the most part distinctly reproduced, the vowels not in the same degree.' The author attempts to explain this imperfect reproduction of the vowels by saying that the apparatus reproduces the vibrations to a certain extent indeed with proportionate, but also reduced strength, and the ear can no longer satisfactorily discern the relation of the proportionately great vibrations which determine the pitch [Tonhöhe] to the small vibrations on which vocal quality [vocal Farbe] depends."

"Zeitschrift des Deutsch-Oesterreichischen Telegraphen Vereins, Berlin, 1862. Vol. IX., p. 125.

["Journal of the German-Austrian Telegraph Association, Vol. IX., p. 125, 1862.]

"*Concerning the reproduction of sounds by means of galvanic electricity: by V. Legat, Royal Prussian Telegraph Inspector at Cassel, accompanied by copperplates VIII. and IX.*

"It might not be uninteresting to make known, in wider circles, the following ideas lately communicated by Mr. Philip Reis

to the Society of Physics, and to the meetings of the Free German Institute, at Frankfort on the Main, concerning the reproduction of tones [Tönen] by means of galvanic electricity, and also what has been hitherto accomplished towards the realization of this project, in order that the accumulated experiments may serve as a foundation to build upon, and that the capacity of the electric current, which by human ingenuity has already been made serviceable for correspondence, may be developed in this direction also.

"In this essay we shall not deal with the electric current as to its capacity for operating telegraphic apparatus of whatever construction for the reproduction of *visible* signs, but of the application of this current to the production of *audible* signals, of *tones* [Tönen].

"The air waves, which by acting upon the ear excite in us the sensation of sound by primarily setting the tympanum of the ear into the vibratory motion, are, as is well known, transmitted to the interior parts of the ear and to the auditory nerves there located by means of a lever apparatus of wonderful delicacy, the auditory bones (hammer, anvil, stirrup); and the attempt to reproduce tones therefore depends upon this, to actuate an artificial imitation of this lever apparatus by means of the vibrations of a membrane corresponding to the membrane of the ear drum, and thereby to open and close (zum Oeffnen ŭ Schliessen) a galvanic circuit, connected with a distant station by a metallic conductor.

"Before describing the apparatus to be used, it would be proper to inquire how our ear apprehends the vibrations of any one particular tone, and the combined vibrations of all simultaneous tones acting upon it, because thereby we may determine the operations which are to be performed by the transmitting and receiving apparatus in the solution of the problem.

"Examining first the processes which take place in order that the human ear may apprehend any single tone, we find that each tone is the result of alternate rarefactions and condensations repeated within a fixed time. If this operation occurs in the same medium in which the ear is placed, then at

each condensation the membrane is forced toward the cavity of the drum and toward the opposite side at each rarefaction.

"These vibrations cause corresponding movements in the auditory bones, and are thereby transmitted to the auditory nerves.

"The greater the degree of condensation of the sound-conducting medium is at a given time, the greater will be the amplitude of vibration of the membrane and auditory bones, and the greater the consequent result; and in the opposite case, so much the weaker. Hence it is evidently the function of the auditory apparatus to impart with faithfulness to the auditory nerves every condensation and rarefaction which occurs in the surrounding medium. On the other hand, the function of transmitting to our consciousness both the number and amplitude of the resulting vibrations occurring within a given time devolves upon the auditory nerves.

"It is here, in our consciousness, that a certain complex phenomenon receives a specific name; it is here, in our consciousness, that the transmitted vibrations become tones [Töne].

"Accordingly, that which is apprehended by the auditory nerves is the effect of a force, reaching to our consciousness, and which can be made more easy of comprehension as to duration and strength, by graphical delineation.

"For example, let the length of the line *a-b* represent a definite period of time, the curves above this line the condensations (+), and the curves below this line the rarefactions

(−); then every ordinate erected at the end of any abscissa will indicate at the moment of time indicated by this abscissa the degree of condensation in consequence of which the membrane of the drum vibrates.

"The ear is not capable of perceiving more than can be represented in this way, or more than can be represented by similar curves; this is, however, sufficient to convey to our

consciousness any single tone [Ton] or any desired combinations of tones. For if several tones are generated simultaneously, then the sound-conducting medium is influenced by several forces, acting at the same time, and subject to mechanical laws.

"If all the forces act in the same direction, then the amount of motion is in proportion to the sum of all the forces; if on the other hand the forces act in opposing directions, then the amount of motion is in proportion to the difference between the opposing forces.

"From these principles it follows that the curves representing the condensations of a number of simultaneously generated tones may be combined in a single curve of condensation, which will indicate with precision what our ear apprehends through the reception of these simultaneously acting tones.

"The objection generally made to this proposition, that a musician, or any person, is able to distinguish the simple tones out of which these composite curves are formed or arise, should not be allowed to militate against it; as it is also possible for some who are familiar with the study of colors to distinguish, in green, for example, the mixture of yellow and blue, in their varied shades; and the one phenomenon as well as the other is referable to the fact that in both cases the observer is familiar with the factors of that product which has been conveyed to his consciousness.

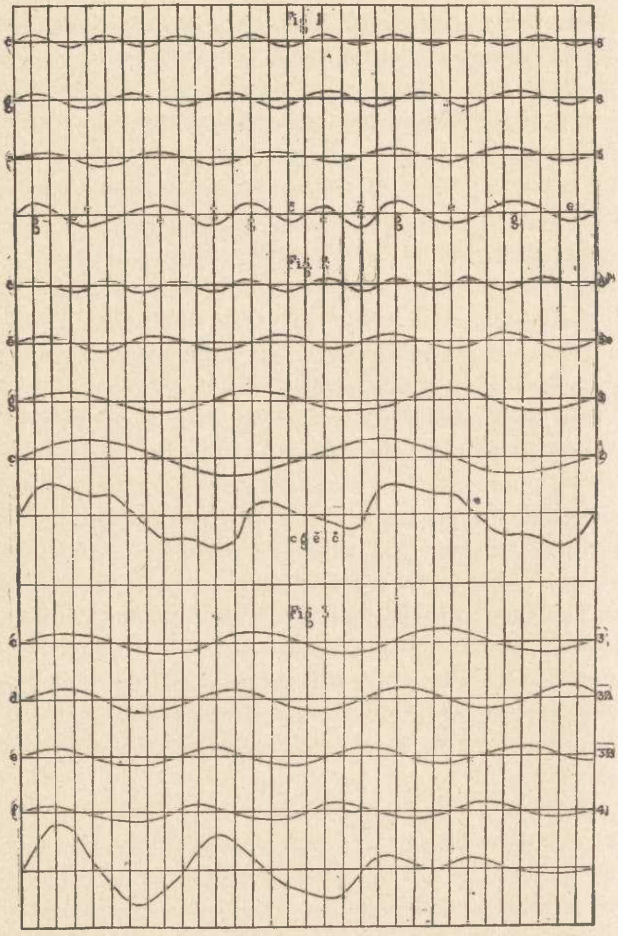
"By the explanations heretofore given, it is easy to construct the curves representing the condensations of various tones, chords, etc., and a few examples are given by way of illustration:

"Fig. 1, Plate VIII., represents a composite curve formed of three tones, in which all the proportions of the components recur successively.

"Fig. 2 represents a similar curve formed of more than three tones; in this case, however, it is no longer possible to represent the proportions so clearly in the drawing, yet an experienced musician will be able to discern them even here, although in practice it might be difficult even for him to recognize the separate tones in such a chord.

Jahrg. IX. Bl. VIII.

Legat Reproduction von Tönen auf elektro galvanischem Wege.



Ernst & Korn Berlin

Statement of the Case.

"The advantage of representing the operation of tones upon the human ear after this manner is that it gives the clearest view possible of the process; the representation here given also shows why a discord [Dissonanz], Fig. 3, must affect the ear disagreeably.

"This apparent digression from the subject under consideration was necessary to demonstrate that as soon as we are able, in any place and in any manner, to reproduce vibrations of such curves and intensities as are equivalent to the curves and intensities of the vibrations of any particular tone, or of any particular combination of tones, we shall have the same impressions as were produced upon us by this original tone, or these original combinations of tones.

"The apparatus described hereafter offers the possibility of producing these vibrations in every manner desired; and by the use of galvanic electricity it is possible to evoke, at any distance, vibrations like [gleiche] those which have been so produced, and in this way to reproduce at any place the tones which have been generated at another place.

"In Plate IX., Fig. 4 A is the tone transmitter [Tonengeber], and B the tone receiver [Tonenpfanger], and these two instruments are set up at different stations. I must observe at the outset that the arrangement of the instruments for sending backwards and forwards is omitted for greater clearness; and likewise, as the whole thing is not presented as a completed fact, but only to call to the notice of a wider circle what has been already ascertained, the possibility of the working of the apparatus at a distance greater than the limited direct working allows at present is left out of consideration, since these points are easily accomplished by mechanical arrangements, and since the most important facts of the phenomena treated are not influenced thereby.

"Let us now turn to the tone transmitter, Fig. 4 A. This on the one hand is connected by the metallic conductor with the tone receiver, Fig. 4 B, at a neighboring station; on the other hand it is connected by means of the electric battery C with the earth (or with the metallic return conductor). The tone transmitter, Fig. 4 A, consists of a conical tube *a b*, about

15 centimetres in length, having a front opening of about 10 centimetres, and a rear opening of about 4 centimetres.

"(It appears by practical experiments that neither the material of this tube nor any increase in its length influenced the accuracy of the action of the apparatus. An enlargement of the diameter of the tube impairs the working of the apparatus, and it is desirable that the inner surface of the tube be as smooth as possible.) The smaller or rear end of the tube is closed by a collodion membrane *o*, and upon the centre of the circular surface of this membrane rests one end *c* of the lever *c d*, the supporting point *e* of which is sustained by a bracket, and is kept in electrical connection with the metallic conductor. The proper lengths of the respective arms *c e* and *e d* of this lever are regulated by the laws of the lever. It is advisable to make the arm *c e* longer than the arm *e d*, in order that the least motion at *c* may operate with greatest effect at *d*. It is also desirable that the lever itself be made as light as possible, that it may follow the movements of the membrane. Any inaccuracy in the operation of the lever *c d* in this respect will produce false tones at the receiving station. When in a state of rest the contact at *d g* is closed, and a delicate spring *n* maintains the lever in this position.

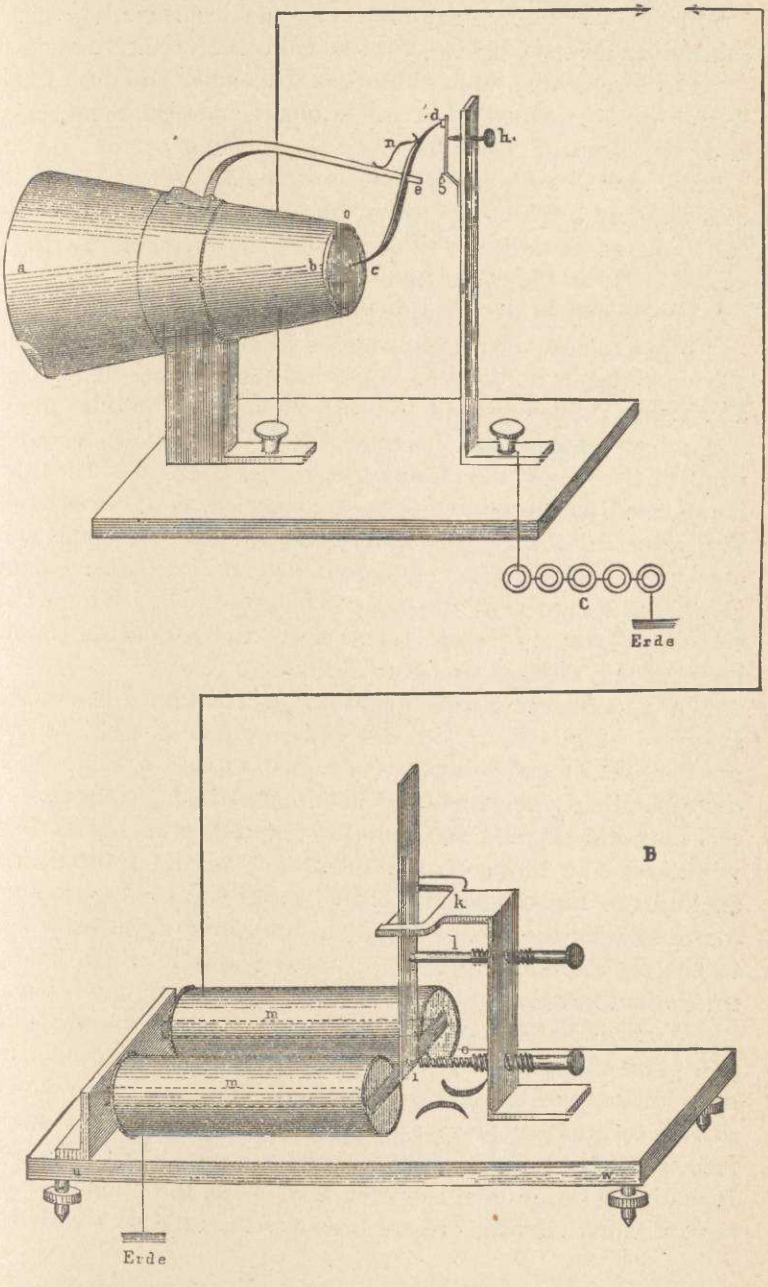
"The second part of the apparatus, the standard *f*, consists of a metallic support, connected with one pole of the battery C, the other pole of which is connected to the earth, or to a metallic return wire leading to the other station.

"Upon the standard *f* is arranged a spring *g*, with a contact point corresponding to the contact point *d* of the lever *c d*; the position of *g* is regulated by the screw *h*.

"In order not to impair the operation of the apparatus by the action of the air waves against the rear side of the membrane, it is desirable to place upon tube *a b*, a disk of about fifty centimetres in diameter at right angles to the longitudinal axis of the tube *a b*; this disk may be attached to the tube by a fastening surrounding its outer circumference.

"The tone receiver, Fig. 4 B, consists of an electro-magnet *m m*, which rests upon a sounding board *u w*; its coil is connected respectively with the metallic conductor and the earth or the metallic return conductor.

Statement of the Case.



"Facing the electro-magnet *m m* is an armature, to which is attached a very long but light and broad lever *i*.

"The lever *i* with the armature is suspended from the standard *k* in the manner of a pendulum, its motion being regulated by means of the screw *l* and the spring *q*.

"In order to increase the effect of the apparatus, the tone receiver may be placed at one of the focal points of an elliptically arched chamber of suitable size, and the listener may place his ear at the other focus of this chamber.

"The operation of the apparatus described is as follows:

"When at rest the galvanic circuit [Kette] is closed. When the air, which is in the tube *a b* of the apparatus, Fig. 4 A, is alternately condensed and rarefied, by speaking into it (or by singing or introducing the tones of an instrument), a movement of the membrane closing the smaller opening of the tube is produced, corresponding to such condensation or rarefaction. The lever *c d* follows the movements of the membrane, and opens and closes [öffnet und schliesst] the galvanic circuit [Kette] at *d g*, so that at each condensation of the air in the tube the circuit is opened, and at each rarefaction the circuit is closed [ein Oeffnen und ein Schliessen erfolgt].

"In consequence of this operation, the electro-magnet of the apparatus, Fig. 4 B, in accordance with the condensations and rarefactions of the column of air in the tube *a b*, Fig. 4 B, is correspondingly demagnetized and magnetized [demagnetisirt und magnetisirt], and the armature of the magnet is set into vibrations like those of the membrane in the transmitting apparatus. But the beam [Balken] *i* attached to the armature communicates these corresponding vibrations of the armature to the air surrounding the apparatus Fig. 4 B, which finally transmits the vibrations so produced to the ear of the listener.

"We have not here to consider the question of the transmission [Fortpflanzŭng] of tones by means of the galvanic current, but only of the conveyance [Uebertragŭng] of generated sounds to another place, and in this way, that at the latter place a similar cause is produced, and a similar effect obtained. It must not be ignored, however, that while the apparatus described reproduces the exact number of the original vibrations,

but not of the same strength [die gleiche Stärke der reproducirten Schwingungen noch nicht erreicht nurde]; and that the achievement of this result is reserved for an improvement of the apparatus.

"In consequence of the imperfection of the apparatus at this time, the minor differences of the original vibrations are distinguishable with more difficulty, — that is, the vowel sounds appear more or less indistinct, — inasmuch as each tone depends not merely upon the number of the vibrations of the medium, but also upon its condensation and rarefaction.

"This also explains why chords and melodies were transmitted with marvellous accuracy in the practical experiments hitherto made, while single words in reading, speaking, &c., were less distinctly recognizable, although even in these the inflections of the voice, as in interrogation, exclamation, surprise, calling, &c., were clearly reproduced.

"There is no doubt that the subject we have been considering, before it becomes practically valuable for use, will require considerable improvement; it will especially be necessary to perfect the mechanism of the apparatus to be employed; but I am convinced, by repeated practical experiments, that it is of the greatest theoretic interest to pursue these investigations, and also that a development of practical value will not elude our intelligent century."

Deutsche Industrie Zeitung, Chemnitz, May 29, 1863.

Extract.

"A friendly communication was sent us some time ago by Mr. J. F. Quilling, of Frankfort-a-M., according to which the capacity of the apparatus to transmit tones to a considerable distance clearly and with their characteristic timbre (Klangfarbe), is fully established. Mr. Q. writes us that by means of the telegraphic conductor with which the apparatus of Mr. Ph. Reis was connected, two remote parts of the city were united, and although it was not possible with the present construction of the apparatus to transmit spoken words (gesprochenen worte), they succeeded so well with the tones that were

sung that not only were the melodies of songs reproduced distinctly and perfectly at a tolerably remote station, but known voices could be recognized.

"All present capable of judging, Mr. Q. adds, who availed themselves of the opportunity of witnessing the experiment, agreed that the possibility is before us of making one's self understood verbally at any distance in the way shown by Mr. Reis."

JOURNAL OF THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS for March, 1883, No. 46.

REIS'S TELEPHONE.

The following is a copy of an autograph description of Reis's telephone which has been presented to the library by Mr. Wm. Ladd, Member:

"INSTITUT GARNIER,
"FRIEDRICHSDORF.

"*Dear Sir:*

"I am very sorry not to have been in Frankfort when you were there at Mr. Albert's, by whom I have been informed that you have purchased one of my newly invented instruments (telephons), though I will do all in my power to give you the most ample explanations on the subject. I am sure that personal communication would have been preferable, specially as I was told that you will show the apparatus at your next scientific meeting, and thus introduce the apparatus in your country.

"Tunes and sounds of any kind are only brought to our conception by the condensations and rarefactions of air or any other medium in which we may find ourselves. By every condensation the tympanum of our ear is pressed inwards, by every rarefaction it is pressed outward, and thus the tympanum performs oscillations like a pendulum. The smaller or greater number of the oscillations made in a second gives us, by help of the small bones in our ear and the auditory nerve, the idea of a higher or lower tune.

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"It was no hard labor, either to imagine that any other membrane beside that of our ear could be brought to make similar oscillations, if spanned in a proper manner and if taken in good proportions, or to make use of these oscillations for the interruption of a galvanic current. However, these were the principles which guided me in my invention; they were sufficient to induce me to try the reproduction of tunes at any distance. It would be long to relate all the fruitless attempts I made until I found out the proportions of the instrument and the necessary tension of the membrane. The apparatus you have bought is now what may be found most simple, and works without failing when arranged carefully in the following manner: [See page 57 for plate.]

"The apparatus consists of two separated parts, one for the singing station, A, and the other for the hearing station, B.

"The apparatus A is a square box of wood, the cover of which shows the membrane, *c*, on the outside, under glass. In the middle of the latter is fixed a small platina plate to which a flattened copper wire is soldered, on purpose to conduct the galvanic current. Within the circle you will further remark two screws; one of them is terminated by a little pit in which you put a little drop of quicksilver, the other is pointed. The angle, which you will find lying on the membrane, is to be placed according to the letters, with the little hole *a* on the point *a*, the little platina foot *b* into the quicksilver screw, the other platina foot will then come on the platina plate in the middle of the membrane.

"The galvanic current coming from the battery (which I compose generally of three or four good elements) is introduced at the conducting screw near *b*, wherefrom it proceeds to the quicksilver, the movable angle, the platina plate and the complementary telegraph to the conducting screw *s*. From here it goes through the conductor to the other station B, and from there returns to the battery.

"The apparatus B, a sonorous box on the cover of which is fixed the wire spiral with the steel axis, which will be magnetic when the current goes through the spiral. A second little box is fixed on the first one, and laid down on the steel

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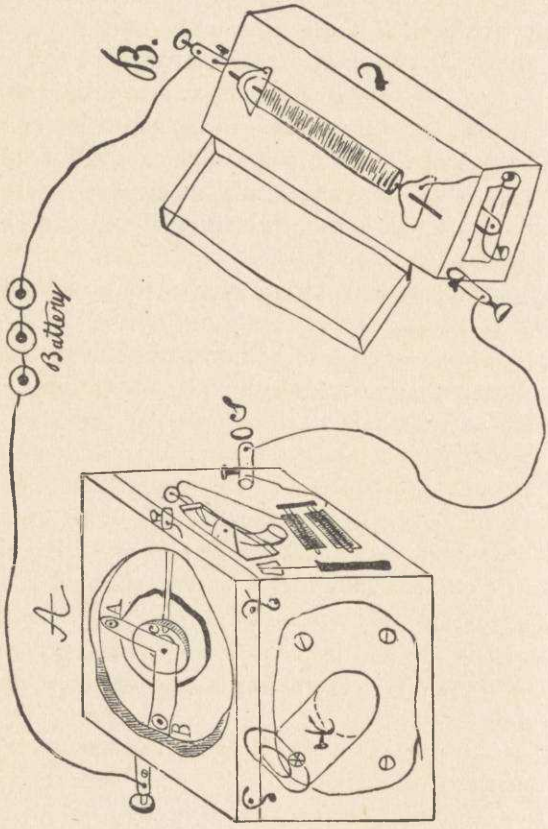


Reis's Telephonic Apparatus.—Facsimile of Drawing sent by Reis to Mr. Ladd.

axis to increase the intensity of the reproduced sounds. On the small side of the lower box you will find the corresponding part of the complementary telegraph.

"If a person sing at the station A, in the tube *x*, the vibrations of air will pass into the box and move the membrane above, thereby the platina foot *c* of the movable angle will be lifted up, and thus will open the stream at every condensation of air in the box. The stream will be re-established at every rarefaction. In this manner the steel axis at station B will be magnetic once for every full vibration, and, as magnetism never enters nor leaves a metal without disturbing the equilibrium of the atoms, the steel axis at station B must repeat the vibrations at station A, and then reproduce the sounds which caused them. *Any* sound will be reproduced if strong enough to set the membrane in motion.

"The little telegraph which you find on the side of the apparatus is very useful and agreeable for to give signals between both of the correspondents. At every opening of the stream, and next following shutting, the station A will hear a little clap, produced by the attraction of the steel spring. Another little clap will be heard at station B in the wire spiral. By multiplying the claps and producing them in different measures, you will be able as well as I am to get understood by your correspondent.

"I am to end, Sir, and I hope that what I said will be sufficient to have a first try; afterwards you will get on quite alone. I am, Sir,

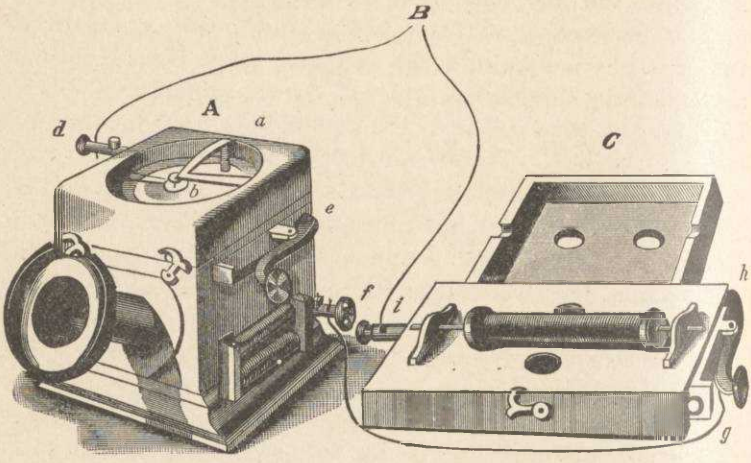
"Your most obedient servant,

"PH. REIS.

"FRIEDRICHSDORF, 13–7–63.

"To Mr. William Ladd."

CIRCULAR OF REIS.



"*Sir:*

"Having succeeded two years ago in demonstrating the possibility of reproducing tones with the aid of the galvanic current and in manufacturing an apparatus for that purpose, the subject has been so highly appreciated by the most renowned men of science, and I have received so many encouragements, that I have striven since that time to improve my originally very imperfect apparatus, in order to give to others also the facility of experimenting.

"I am now able to offer an apparatus which satisfies my expectations, and with which every physicist will succeed in repeating these interesting experiments regarding the reproduction of tone (Ton = reproduction) at distant stations.

"I believe that it is the wish of many that these instruments should come into the possession of laboratories; as, however, their manufacture demands a complete knowledge of the leading principles and a great experience in this matter, I have resolved to make the most important parts myself, and to intrust to the mechanician only the secondary parts and the external outfit. Mr. J. Wilh. Albert, mechanician at Frank-

Statement of the Case.

fort on the Main, is commissioned to sell them. I have enabled him to offer them at the prices of 21 and 14 florins (12 and 8 Prussian thalers) in two qualities, which differ only in the external outfit. The instruments can also be had directly from me at the same price by cash payment. Every apparatus is examined by me before being shipped, and has attached my name, the serial number and the date of construction.

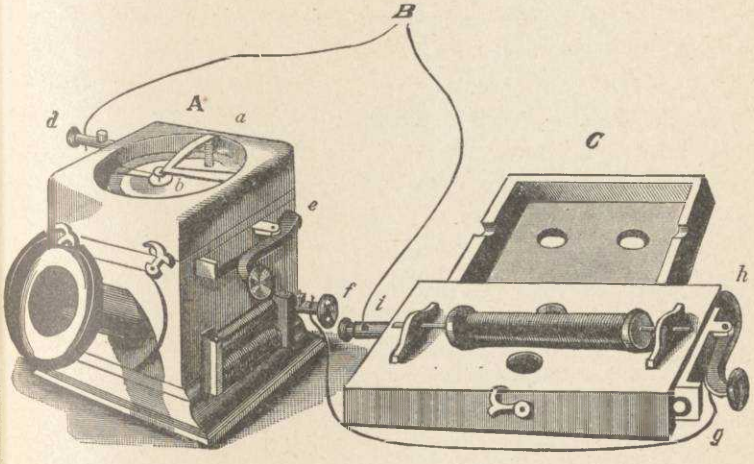
"FRIEDRICHSDORF b. HOMBURG, v. d. HÖHE,
"August, 1863.

"PHIL. REIS,
"*Teacher at L. F. Garnier's Boys' Institute.*"

(In manuscript on the foregoing is the following:)

"Descriptions of the above are to be found in Müller-Pouillet's Lehrbuch der Physik, Braunschweig, Vieweg & Son; Pisko, die Neueren Apparate der Akustik, Wein, Gerold's Son, 1865."

REIS'S DESCRIPTIVE CIRCULAR.



TELEPHONE.

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"The apparatus consists of two parts, as may be seen in the woodcuts above, the telephone proper A, and the reproducing apparatus C. These two parts are to be placed at such a distance from each other that singing or the sound of a musical instrument can be heard in no other manner except through the apparatus from one station to another.

"Both parts are connected with each other and with the battery B, the same as in an ordinary telegraph. The battery must be sufficient to produce at station A the attraction of the armature of the electro-magnet placed at one side (three or four six-inch Bunsen cells are sufficient for several hundred feet of distance).

"The galvanic current then goes from B to the binding post *d*, from there through the copper strip, to the platina disk in the centre of the membrane, then through the foot *c* of the angle towards the binding post B, *in the small hollow of which a drop of quicksilver is inserted.* From here the current goes through the small telegraph apparatus *e f*, then to the key of the station C and through the coil surrounding *i* back to B.

"If now sufficiently strong tones are produced before the mouthpieces, their vibrations will put in motion the membrane and the angular little hammer [winkelförmige Hämmerchen] which lies on it; for every full vibration the circuit is once opened and again closed [einmal geöfnet und wieder geschlossen], and thereby are produced at station C in the core of the coil, just the same number of vibrations [ebensoviele schwingungen hervor-gebracht] which are there perceived as tones or as combinations of tones [accords]. By placing the cover tightly over the axis of the coil the tones at C are greatly strengthened. Besides the human voice [menschlichen stimme] there can be reproduced (according to my experience) just as well the tones [töne] of good organ pipes from F to C and those of the piano; to that end the box *a* must be placed on the sounding board of the piano; out of thirteen chords a skilled experimenter could make out ten clearly. The telegraph apparatus placed on one side is evidently unnecessary for the reproduction of tones, but it is a very useful addition for convenient experimenting. With its aid it is

possible to easily and surely make one's self intelligible [sich verständigen] with the person at the other station.

"This may be done somewhat in the following simple manner: After the apparatus has been put up completely, one satisfies one's self of the continuity of the connection and the strength of the battery by opening and closing the circuit whereby at A is heard a striking of the armature and at C a very perceptible ticking of the coil.

"By a quick succession of makes and breaks at A, C is asked whether he is ready for experimenting, whereupon C answers in the same manner.

"By agreement between the two stations simple signals can be given by opening and closing the circuit 1, 2, 3 or 4 times, *e.g.* one stroke — sing; two strokes — speak, etc.

"I telegraph words by numbering the letters of the alphabet and communicating their numbers.

1 stroke A,
2 strokes B,
3 strokes C,
4 strokes D,
5 strokes E, etc.

"Z would consequently be indicated by 25 strokes.

"But these numbers of strokes would take too much time and not be sure in counting. Therefore I put a dactyl for every 5 strokes, hence

— U U for E,
— U U and 1 stroke for F, etc.

"Z: – UU – UU – UU – UU – UU, which is quicker, and more easily executed and better understood.

"Still better is it to indicate the letters by numbers which are in inverse proportion to the frequency of their occurrence.

"9 August, 1863, Friedrichsdorf, near Homburg, v. d. Höhe.

"PHIL. REIS,

"*Teacher of A. L. Garnier's Boys' Institute.*"

"GARTENLAUBE REIS IMPROVED APPARATUS.

"(*The* '*Gartenlaube*,' *No.* 51, *December*, 1863.)

"THE MUSICAL TELEGRAPH.

"The surprising results in telegraphing have often excited the question whether it may not be possible to communicate the language of sound itself to a distance. The trials made in this direction had, till now, produced no satisfactory results, because the vibrations of sound-conducting bodies soon diminish so much in force that they are no more perceptible for our senses.

"People, perhaps, had already thought of a reproduction of sound at certain distances with the aid of the electric current, but those who have been the best fitted to attack the question, by their knowledge and resources, were the ones who doubted the most of a practical solution of that question. Those who are but superficially acquainted with natural science do not see the many difficulties this problem offers, if they are at all acquainted with it. Thus, about eleven years ago, a young man, Mr. Philipp Reis, at present teacher of natural science at the Garnier Institute for Boys, at Friedrichsdorf, near Homburg, had the hardihood to work at the solution of this problem. But soon he was obliged to desist from it because his very first effort seemed to convince him of the impossibility of a solution. Later, however, after further studies and many experiments, he saw that his first effort was but a rudimentary one, and by no means convincing. However, he did not recommence to attack the question seriously for some time, not feeling himself strong enough to vanquish the obstacles on his road, although he never banished his early idea entirely from his thoughts.

"How can a single instrument reproduce simultaneously 'the combined effects of all the organs active in human speech?' This seemed to him the chief question. Later he put this question more methodically: 'How does our ear perceive the composite vibrations of all the organs of speech acting at the

same time?' or, expressed more generally, 'How do we perceive the vibrations of several bodies sounding simultaneously?' If we throw a stone into quiet water there are produced on the surface uniform waves which progress symmetrically outward; the further they go the weaker they become, till they finally disappear.

"It is quite similar with that which we call sound and tone. A body made to vibrate through any impulse affects the surrounding air, and causes waves in it, which follow each other at the same rate as the vibrations of the body. As those rings on the water consist in swellings and depressions, so also the vibrations of the air consist of alternate condensations and rarefactions. If they reach our ear every condensation presses the tympanum towards the interior of the cavity, and puts in motion the adjacent group of small bones which communicates the motion to the liquid of the cochlea, in which the auditory nerves terminate. The latter are excited and produce the *sensation of sound.*

"Now, if the waves of vibration follow regularly and with a certain swiftness (sixteen in the second at least), we shall have the sensation of a musical *tone.* The latter is the *higher* the quicker the condensations follow each other and the louder the *stronger* or higher the waves rise, as it were.

"Our ear cannot perceive anything except condensations and rarefactions, wave crests and wave hollows. And, nevertheless, we receive the most varied auditory impressions, we distinguish the sound of the voices, we hear at the same time in quite different directions and can distinguish the different sources; nay, in a complete large orchestra, each of the numerous instruments is specially noticed by its peculiar sound, so that we decompose at every moment the total impression into its several parts, according to the height and depth, strength and weakness, or according to the timbre (or quality) [Klangfarbe].

"Referring to our simile, this is about the same as if we throw two or more stones at different places into a calm pond. The wave lines cross each other, strengthen each other at some points, weaken each other at others, and the surface has a ruf-

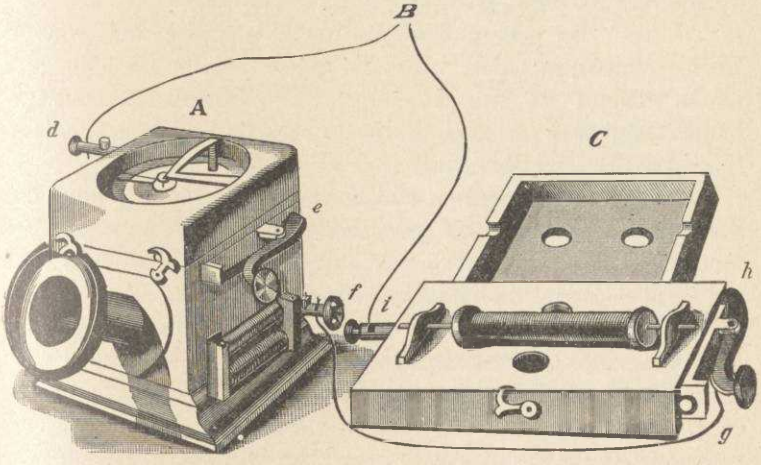
fled, hillocked aspect. But, nevertheless, our eye can detect the different systems of rings and can trace them back to their several causes. If we succeed in transmitting with the galvanic current the oscillations of a sounding body to a distance, so that there another body is put to equally rapid and, in respect to each other, equally strong oscillations, the problem of 'telephoning' is solved.

"For then exactly the same phenomena of waves are called forth on the distant points as the ear receives at the place of origin; therefore they also must make the same impression. The ear will distinguish at the distant points not only the single tones, according to their varying height and depth, but also to the proportionate force of the vibrations, and not only single melodies, but the performance of a whole orchestra; yes, even speech must be heard at the same time in places very distant from each other. Mr. Reis was the first one to prove by experiments the possibility of solving this problem. He has succeeded in constructing an apparatus to which he gives the name *Telephone*, and which enables one to reproduce tones, with the aid of electricity, at any given distance. Already, in October, 1861, he made rather successful experiments with a very simple, rudely made apparatus, before a numerous audience at Frankfort. On July 4th of the present year he presented an essentially improved apparatus at an assembly of the 'Physical Union,' which transmitted by closed doors and windows a melody sung moderately loud, to a distance of about three hundred feet, so that it could *be heard plainly*.

"In order to give an opportunity to larger circles, especially to scientific men, to convince themselves of the efficiency of this essentially improved apparatus, Professor Böttger of Frankfort-a-M. made lately (at an assembly of German physicists and doctors in Stettin, in the sectional meetings for natural sciences) several experiments which certainly would have been crowned with still more success if the hall in which the session was held had been located in a less noisy part of the city and filled with a less numerous audience.

"Although, for the present, we are not so far along as to

be able to converse with a friend at a distance of several hundred miles, so much at least is certain, that with the aid of the telephone songs of all kinds, melodies, especially in the middle registers, can be reproduced most clearly at unlimited distances. These wonderful results are obtained with the following simple apparatus, which we show here in one-fourth of its size:



"A small box A (the telephone proper), a kind of hollow cube, has a mouthpiece S on the front side, and a somewhat smaller opening on the upper side of the box. The latter is closed with a fine membrane (skin from the intestines of a hog) tightly stretched. A narrow strip of platina *m*, connected with the screw post *d*, touches directly the membrane on its centre; a slender platina point *k*, attached to the angle *a b*, touches the strip of platina which rests on the membrane. If one sings into the mouthpiece S (by filling the same entirely with the mouth), the thin membrane vibrates, and the attached platina strip receives likewise a vibrating motion so that it is alternately pressed against and leaves the platina point *k*.

"From the binding post *d* which communicates with the platina strip resting on the membrane a conducting wire is connected with one of the poles of a galvanic battery B (about three to four six-inch Bunsen elements), and then the elec-

tricity is led through a wire attached to the second pole of the battery to the distant station C; there at *i* it passes through a coil *l l* formed of copper wire covered with silk thread, then back again to screw *f*, and there to the platina point *k*. At every vibration of the membrane an interruption of the electric current [unterbrechung des electrischen Stromes] takes place by the platina point parting from the platina strip.

"Within the wire coil at station C is a thin iron wire (a strong knitting-needle) which is about ten inches long, and which with its two ends projecting out of the coil for about two inches, each rests on two bridges of a sounding box. This is the *reproducing* apparatus.

"At every interruption of the current [Unterbrechung des Stromes] in the coil the iron rod is made to vibrate. If the motions follow with a certain rapidity, they produce a tone which is rendered audible by the sounding box. As the rate of the interruptions depends on the pitch of the tone that has been sung into the mouthpiece, the same tone is sounded with the same pitch from the sounding box. The length of the circuit has no influence upon this. It is true the electric current loses force the farther it goes, but there is no reason why relays should not be employed, the same as in telegraphing, and with their aid any number of reproducing apparatuses be set into simultaneous vibrations. Mr. Reis has endeavored to give to his improved apparatus a form which should also be pleasing to the eye, so that it might fill worthily its place in any physical laboratory. He has applied, moreover, to the side of the telephone, as well as to the reproducing apparatus, a small telegraph arrangement, which is a very good addition for convenient experimenting. (It is indicated in the drawing by the letters *e f h g*.) By alternately opening and closing the circuit with the key *e* or *h* the most varied signals may be given after mutual agreement; for instance, if one is ready for singing; if everything has been understood; whether one should stop singing or commence anew, &c.

"Mr. Reis himself manufactures the principal parts of the telephone, for which no small amount of physical knowledge and experience is necessary. The mechanician, Wilhelm Albert,

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at Frankfort, is charged with manufacturing the less important parts and the external outfit, as well as with the sale of the instrument at a low price."

ANNALEN DER CHYMIE UND PHARMACIE, Leipzig, 1864—1865, III., Supplementband, p. 134.

[Foot-note of an article by H. Buff, entitled "On the Tones generated in Iron Rods by the Electric Current."]

ARTICLE ITSELF COMMENCES ON P. 129.

"This tone, appearing only as a secondary phenomenon, has been utilized with success by Dr. Reis of Friedrichsdorf in the instrument which he invented and named 'the telephone,' for transmitting tones telegraphically by means of the periodic impact of the sound-waves of the same against an elastic skin.

"The arrangement is such that the skin, which vibrates in equal periods with a source of sound acting upon it, serves as a means for interrupting the electric current, which, at a distance, circulates around an iron wire, the ends of which are clamped upon a resonating plate.

"Unfortunately, by this otherwise ingenious arrangement, the pitch only of musical tones within several octaves, but not the quality [Wohllaut] of the same, could so far be transmitted through wire circuits."

HANDBUCH DER ANGEWANDTEN ELEKTRICITÄTSLEHRE, von Karl Kuhn, 1865, pp. 101–721.

[Manual of applied Electricity.]

"The experiments made by Reis in Frankfurt-a-M., on the 26th October, 1861, have proved, however, that when the breaks of the current [Stromunterbrechungen] follow each other almost continuously and very quickly in a coil provided with a thin iron core, the iron wire can enter into longitudinal vibrations, and in this way be enabled to reproduce sounds of different pitch. An exact reproduction of the sounds does not take place, however, but only an imitation; for this reason it cannot be questioned here of transverse vibrations [transver-

sal Schwingungen]. A phenomenon [Erscheinung] has otherwise been heard of, which belongs to the afore-mentioned class, in which the intensity and the timbre [Klang] of the sound accompanying it (the phenomenon) depend among other things on the strength of the current [Stromstärke] and on the number of breaks of the same, and in which, as it seems, the pitch of the tones also can vary under different circumstances. We can, however, hardly imagine by what arrangements it could be feasible to coax tones of any given height or depth out of an iron or metal tube split on one side, while it (the tube) is affected by the alternate currents of an induction apparatus the coil (Rolle) of which surrounds it. Yet the possibility cannot be controverted that the principle of Neef's circuit-breaker [Unterbrecher] might contribute to the solution of the problem in question. It has been employed for local purposes either with or without modifications in the study and investigation of acoustic phenomena. Thus Petrina has used the principle of Neef's circuit-breaker [Unterbrecher] for his electric harmonica in this way, that instead of the Neef hammer a little rod was chosen, the transverse vibrations of which rendered the tone. 'There are four little rods of various lengths side by side, the motions of which are checked by means of levers managed by finger keys.' That principle was used previously by Dove, in a modified manner, to set strained strings and elastic springs into acoustic vibrations of constant amplitude by means of an electric magnet, and, in this way, to be enabled to investigate constant tones. It appears from Legat's published communications that 'the ideas submitted by Ph. Reis of Friedrichsdorf in the Physical Society and in the meeting of the German Hochstift in Frankfurt-a-M. about the reproduction of sounds by means of electricity' referred to arrangements of a similar kind. Legat mentions in his paper all that has been done thus far towards the realization of that project, and we borrow from it that part only which throws some light on the construction of a telegraphic apparatus with which it is said to be possible to produce vibrations and make sounds in any desired manner and through which the employment of electricity is said to make it feasible to

bring forth at any given distance vibrations similar to the first produced ones, and in this way to reproduce at a certain place tones originally produced at another place.

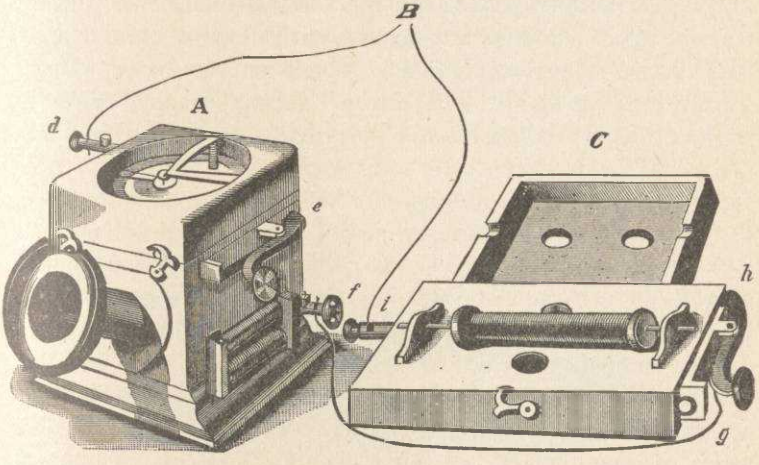
"This apparatus is composed of a transmitter and of a receiver. The transmitter (see page 53[1]) consists in a conical tube *a b* about 15 cm. long, 10 cm. at the front, 4 cm. at the back opening; the choice of the material as well as a greater length is indifferent; a greater width, on the contrary, is disadvantageous; the surface of the interior must be as smooth as possible. The narrower back opening is closed by a membrane of collodion *o*, and on the middle of the circular surface formed by this membrane rests one end *c* of lever *c d*, the fulcrum of which is held by a support and remains connected with the metallic circuit. This lever, one arm *c e* of which must be considerably longer than *e d*, should be as light as possible so as to follow easily the motions of the membrane, as an uncertain obedience [folgen] on part of lever *c d* would produce imperfect tones at the receiving station. In the state of rest, the contact *d g* is shut and a weak spring *n* holds the lever fast at rest. On the metallic support *f* which is connected with one of the poles of the battery is a spring *g*, with a contact which touches the contact of lever *c d* at *d* and the position of which is regulated by screw *h*; over tube *a b* a disk must be placed which encircles the outer circumference of the tube closely, so that the efficacy of the apparatus may not be impaired through the effect of the air-waves coming round and striking against the rear end. This disk at right angles with longitudinal axis of the tube measures about fifty(?) cm. in diameter. The receiver (page 53) consists of an electro-magnet *m m* which rests on a sounding board, and the coil of which is in connection with the metallic conductors and with the ground. Opposite the electro-magnet is an armature connected with a lever as long as possible, but light and broad, which latter, with the armature, is fastened pendulum-like on the support *k*. Its motions are regulated through screw *l* or spring *o*. 'In order to increase the efficacy of the apparatus,

[1] The cut given by Kuhn is a copy of that in the previous Legat article, page 50, *supra*.

this receiver can be placed in one focus of an ellipsoidal enclosing box of suitable size, while the ear of the hearer is placed at the other focus.' The working of the two apparatus (the mode of connection of which is visible in the wood-cuts), the transmitter being placed at one station and the receiver at the other, is as follows: By speaking, singing, or the intromission of instrumental sounds into tube *a b*, in consequence of the condensation and rarefaction of the column of air, a motion of the membrane *c* corresponding to these changes is brought about. Lever *c d* follows the motions of the membrane, and opens or closes the circuit, according as a condensation or a rarefaction of the air inside takes place. As a consequence the electro-magnet *m m* (Fig. 505) is correspondingly demagnetized or magnetized, and the armature affixed to it (as well as the armature lever) is set into similar vibrations as the membrane of the transmitter. Through lever *i* connected with the armature, similar vibrations are communicated to the surrounding air and (the increasing effect of the sounding board helping) the tones so produced finally reach the ear of the listener. In respect to the operations of this apparatus, the author remarks that the receiver does reproduce the exact number of the original vibrations, but that a reproduction of the original intensity has not yet been attained. For that reason, it is added, small differences in the vibrations are appreciated with difficulty, and in the practical experiments made thus far, it was possible to transmit with astonishing faithfulness chords, airs, etc., whilst in reading, speaking, etc., single words were more indistinctly heard. The apparatus just described is said to have been one of the constructions which Reis has used himself in his experiments. The underlying principles might give hopes of a farther improvement of the apparatus, but the telephone which, according to later reports, Reis has finally decided upon, has the disposition (represented on page 73), although the principle on which it is founded does not stand quite in harmony with the above-mentioned investigations of Wertheim, for instance.

"The telephone proper, A, consists of a hollow wooden box provided with a short sound-funnel S, and the upper side of

which is open in the centre and covered over tightly with a delicate membrane. On the middle of the latter a thin platinum disk is fastened, from which on one side a platinum strip establishes circuit connection with the contact of the key at *e*, from which place the metallic connection is effected with one end of the coil of a small electro-magnet provided with a spring armature, whilst the other end is in contact with screw *f*. The reproducing apparatus C set up at the receiving station consists simply of a coil about six inches long formed by



winding six layers of copper wire; in the axis of the coil a thin iron wire ten inches long (a knitting needle), protruding out of each end of the coil about two inches, is so disposed that with its bridge-like supports it rests on a sounding board. By means of screw *i* and of the key at *h g* the coil is thrown into the circuit and the connection of both apparatuses is effected in the manner mentioned; a battery being placed at B, the course of the current is easily followed out. It can flow from B through *d c* and *c b* to *e* and *f*, and from here to the receiving station, and at *i* return to the battery, or it can start in the opposite direction according as *d* or *i* forms the starting point of the current. The circuit can be broken at will at each of the two stations by pressing the key lever, and a connection can be established thus in either direction, but the

discontinuous currents which are to produce the sounding of the iron wire at C are obtained in this way: By singing or the blowing of instruments towards the sound-funnel S the membrane at A is made to vibrate; if this can be brought about, it will happen, as was demonstrated by the experiments, that the iron wire of the receiver assumes isochronal vibrations, and whenever this is the case, it reproduces the same tones which set the membrane to vibrating at the transmitting stations.

"My own experiments have demonstrated that every melody starting from *c* and embracing the entire extent of an average male voice, when sung into the telephone, can be reproduced by the receiver at C. The timbre [Klang] or quality of the sounds thus reproduced is not pleasant, — they are almost like the sounds of toy trumpets, at times also like the buzz of a fly caught in a spider's web and the like; yet the experiments of Reis are certainly interesting enough to challenge attention.

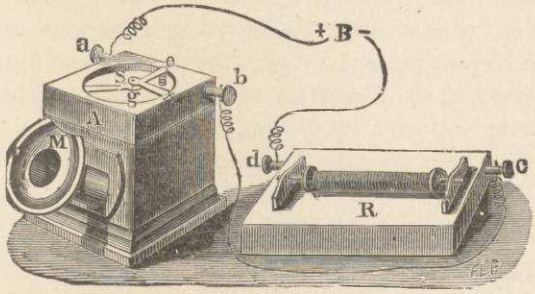
"A reproduction of the words spoken into the telephone with or without variation of pitch was audible at the receiver only in a corresponding noise [entsprechendes Geräusch], while a discriminate perception of single vocal sounds, syllable or words could not be had. According to communications made on this subject by Reis, he has succeeded in reproducing the tones of organ pipes not covered, and those of a piano; in this latter case the transmitter was placed on the sounding board of the piano."

Electricity, by Robert M. Ferguson. William and Robert Chambers, London and Edinburgh, 1867.

"The telephone. This is an instrument for telegraphing notes of the same pitch. Any noise producing a single vibration of the air, when repeated regularly a certain number of times in the second (not less than thirty-two), produces, as is well known, a musical sound. In Art. 115, we found that when a rod of iron was placed in a coil of insulated wire, and magnetized by a current being sent through the coil, it gave out a distinct tick when it was demagnetized by the stoppage

of the current. A person when singing any note causes the air to vibrate so many times per second, the number varying with the pitch of the note he sings, the higher the note the greater being the number of vibrations. If we then, by any means, can get these vibrations to break a closed circuit in which the coil just mentioned is included, the note sung at one station can be reproduced, at least so far as pitch is concerned, at another. Reis's telephone (invented 1861) accomplishes this in the following way: —

"A A (Fig. 141) is a hollow wooden box with two round holes in it, one on the top, the other in front. The hole at the top is closed by a piece of bladder S, tightly stretched on a circular frame; a mouthpiece M is attached to the front opening.



"When a person sings in at the mouthpiece, the whole force of his voice is concentrated on the tight membrane, which in consequence vibrates with the voice. A thin strip of platinum is glued to the membrane, and connected with the binding screw *a*, in which a wire from the battery B is fixed. A tripod *e f g* rests on the skin. The feet *e* and *f* lie in metal cups on the circular frame over which the skin is stretched. One of these, *f*, rests in a cup containing mercury, and is connected with the binding screw *b*. The third foot *g*, consisting of a platinum point, lies on the circular end of the strip of platinum just mentioned. This point, being placed on the centre of the oscillating membrane, acts like a hopper, and hops up and down with it. It is easy to understand how, for every vibration of the membrane, the hopper will be thrown

up for the instant from connection with its support, and how the close circuit is thus broken at every vibration. The receiving apparatus R consists of a coil of wire placed in circuit, enclosing an iron wire, both being fixed on a sounding box. The connections of the various parts of the circuit are easily learned from the figure. Suppose a person to sing a note at the mouthpiece which produces three hundred vibrations a second, the circuit is broken by the bladder three hundred times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind: The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper, silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sending apparatus produces a current in the secondary circuit which charges and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The musical notes are rendered by these electric discharges, and are loud enough to be heard in a large hall."

All contended that the inventions were not novel, and set up prior inventions and discoveries by other persons and other patentees. Of the many persons named in the answers by whom the inventions covered by the first patent were averred to have been invented, known or used prior to Bell's invention, in the arguments in this court the following were chiefly relied upon. (1) The Philipp Reis invention, already described; (2) The invention of Elisha Gray of Chicago; (3) The invention of Daniel Drawbaugh of Eberly's Mills in Pennsylvania; (4) the inventions patented to C. F. Varley in the United States, June 2, 1868, and in Great Britain, October 8, 1870; (5) the invention of J. W. McDonough of Chicago, for which he applied for a patent in 1876; and (6) the machine constructed in New York in 1869–70 by Dr. Van der Weyde.

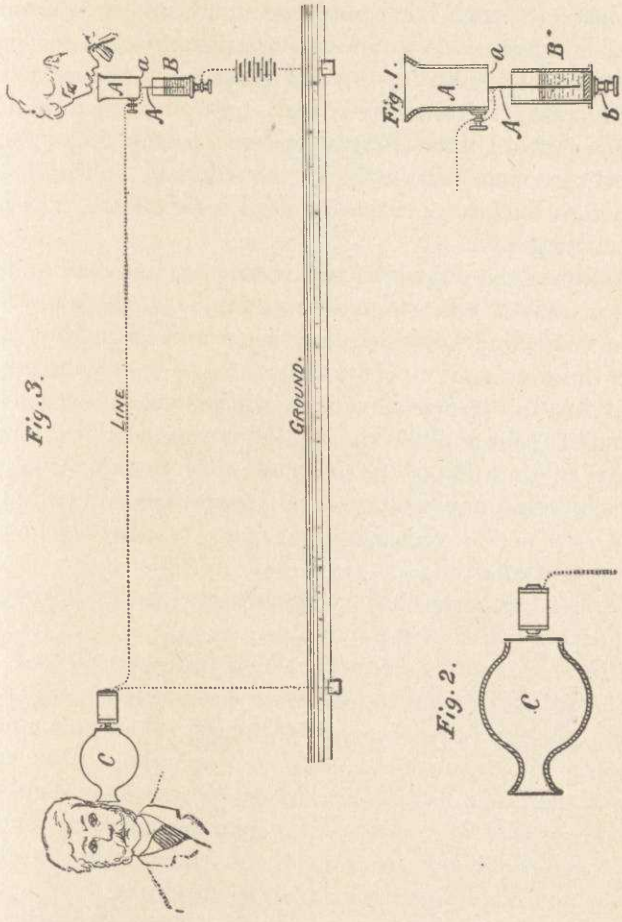
Statement of the Case.

The invention of Gray was set forth in a caveat filed in the patent office February 14, 1876. The following is a copy of that caveat, and of the office marks and proceedings therein:

ELISHA GRAY

INSTRUMENTS FOR TRANSMITTING AND RECEIVING VOCAL SOUNDS TELEGRAPHICALLY.

CAVEAT FILED FEBRUARY 14TH 1876.



Statement of the Case.

"*To all whom it may concern:*

"Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented a new art of transmitting vocal sounds telegraphically, of which the following is a specification.

"It is the object of my invention to transmit the tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart.

"I have invented and patented methods of transmitting musical impressions or sounds telegraphically, and my present invention is based upon the modification of the principle of said invention, which is set forth and described in letters patent of the United States, granted to me July 27, 1875, respectively numbered 166,095 and 166,096, and also in an application for letters patent of the United States, filed by me February 23, 1875.

"To attain the objects of my invention, I devised an instrument capable of vibrating responsively to all the tones of the human voice, and by which they are rendered audible.

"In the accompanying drawings I have shown an apparatus embodying my improvements in the best way now known to me, but I contemplate various other applications, and also changes in the details of construction of the apparatus, some of which would obviously suggest themselves to a skilful electrician, or a person versed in the science of acoustics, on seeing this application.

"Figure 1 represents a vertical central section through the transmitting instrument.

"Fig. 2. A similar section through the receiver; and

"Fig. 3. A diagram representing the whole apparatus.

"My present belief is, that the most effective method of providing an apparatus capable of responding to the various tones of the human voice, is a tympanum, drum or diaphragm, stretched across one end of the chamber, carrying an apparatus for producing fluctuations in the potential of the electric current, and consequently varying in its power.

"In the drawings, the person transmitting sounds is shown

as talking into a box, or chamber, A, across the outer end of which is stretched a diaphragm *a*, of some thin substance, such as parchment or gold beater's skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphragm is a light metal rod A′, or other suitable conductor of electricity, which extends into a vessel B made of glass or other insulating material, having its lower end closed by a plug, which may be of metal, or through which passes a conductor *b*, forming part of the circuit. This vessel is filled with some liquid possessing high resistance, such, for instance, as water, so that the vibrations of the plunger or rod A′, which does not quite touch the conductor *b*, will cause variations in resistance and consequently, in the potential of the current passing through the rod A′.

"Owing to this construction, the resistance varies constantly, in response to the vibrations of the diaphragm, which, although irregular, not only in their amplitude, but in rapidity, are nevertheless transmitted, and can, consequently, be transmitted through a single rod, which could not be done with a positive make and break of the circuit employed, or where contact points are used.

"I contemplate, however, the use of a series of diaphragms in a common vocalizing chamber, each diaphragm carrying an independent rod, and responding to a vibration of different rapidity and intensity, in which case, contact points mounted on other diaphragms may be employed.

"The vibrations thus imparted are transmitted through an electric circuit to the receiving station, in which circuit is included an electro-magnet of ordinary construction, acting upon a diaphragm to which is attached a piece of soft iron, and which diaphragm is stretched across a receiving vocalizing chamber *c*, somewhat similar to the corresponding vocalizing chamber A.

"The diaphragm at the receiving end of the line is thus thrown into vibration corresponding with those at the transmitting end, and audible sounds or words are produced.

"The obvious practical application of my improvement will be to enable persons at a distance to converse with each other

through a telegraphic circuit, just as they now do in each other's presence, or through a speaking-tube.

"I claim as my invention, the art of transmitting vocal sounds or conversations telegraphically through an electric circuit.

"ELISHA GRAY.

"Witnesses:
"WM. J. PEYTON,
"WM. D. BALDWIN."

"STATE OF
"County of } ss:
"*District of Columbia,*

"ELISHA GRAY, the within named petitioner, being duly sworn, doth depose and say, that he verily believes himself to be the original and first inventor of the Art of Transmitting Vocal Sounds described in the foregoing specification; that he does not know or believe that the same was ever before known or used; and that he is a citizen of the United States.

"ELISHA GRAY.

"Subscribed and sworn to before me this 14th day of February, A.D. 1876.

"[SEAL.] JOHN T. ARMS,
Notary Public."

"*To the Commissioner of Patents:*

"The petition of Elisha Gray, of Chicago, in the County of Cook in the State of Illinois, respectfully represents, that he has made certain improvements in the Art of Transmitting Vocal Sounds telegraphically, and that he is now engaged in making experiments for the purpose of perfecting the same, preparatory to applying for letters patent therefor.

"He therefore prays that the subjoined description of his invention may be filed as a caveat in the confidential archives of the Patent Office.

"ELISHA GRAY."

"Copy sent Feb. 19, S. R. A."

"DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb'y 19, 1876.

"SIR — You are hereby notified that application has been made to this office for letters patent for Telephonic Telegraph, &c., with which the invention described in your caveat, filed on the 14th day of February, 1876, apparently interferes, and that said application has been deposited in the confidential archives of the office under provision of Section 4902 of the Revised Statutes of the United States, which section reads as follows:

"'SECTION 4902. Any citizen of the United States who makes any new invention or discovery, and desires further time to mature the same, may, on payment of the fees required by law, file in the Patent Office a caveat, setting forth the design thereof, and of its distinguishing characteristics, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the office and preserved in secrecy, and shall be operative for the term of one year from the filing thereof, and if application is made within the year by any other person for a patent with which such caveat would in any manner interfere, the Commissioner shall deposit the description, specification, drawings and model of such application in like manner in the confidential archives of the office, and give notice thereof, by mail, to the person by whom the caveat was filed. If such person desires to avail himself of his caveat he shall file his description, specification, drawings and model within three months from the time of placing the notice in the post office in Washington, with the usual time required for transmitting it to the caveator added thereto; which time shall be indorsed on the notice. An alien shall have the privilege herein granted if he has resided in the United States one year next preceding the filing of his caveat, and has made oath of his intention to become a citizen.'

"If you would avail yourself of your caveat it will be necessary for you to file a complete application within three

months from date, three days additional, however, being allowed for the transmission of this notice to your place of residence.

"Very respectfully,
"R. H. DUELL,
Commissioner.

"ELISHA GRAY,
"Care W. D. Baldwin,
Present."

"EXAMINER'S ROOM No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb. 19, 1876.

"E. GRAY,
"Care W. D. Baldwin:

"In relation to the foregoing notice in relation to your caveat it may be well to add that the matters in the App'n referred to seem to conflict with your caveat in these particulars, viz.:

"1st. The receiver set into vibration by undulatory currents.

"2d. The method of producing the undulations by varying the resistance of the circuit.

"3d. The method of transmitting vocal sounds telegraphically by causing these undulatory currents, &c.

"Z. F. WILBUR,
Examiner."

"Copy sent Feb. 25. S. R. A."

"EXAMINER'S ROOM No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb. 25, 1876.

"E. GRAY,
"Care W. D. Baldwin, Present:

"Caveat for Art of Transmitting Vocal Sounds Telegraphically.

Statement of the Case.

"Feb. 14, 1876.

"The notice to complete having been given under a misapprehension of the rights of the parties is hereby withdrawn.

"Z. F. WILBUR,
Examiner."

"$10 Mail.

MEMORANDUM OF FEE PAID AT U. S. PATENT OFFICE.

Paper will be filed to-day.

Inventor,

E. GRAY."

"CAVEAT.

Invention,

Transmitting Vocal Sounds Telegraphically.

Date of Payment,

Feby. 14, 1876.

Fee,

$10.

Solicitor,

Wm. D. Baldwin.

Patent Office,

Feb. 14, 1876.

U. S. A.

(Official Stamp.)"

"1876.

No. CAVEAT. Wilbur, 48.

ELISHA GRAY,

Of Chicago, County of Cook, State of Illinois.

Art of Transmitting Vocal Sounds Telegraphically.

Rec'd, Feb. 14, 1876.
Petition, " " "
Affidavit, " " "
Specification, " " "
Drawing within, " " "

Statement of the Case.

Model,	"	"	"
Cert. dep.	"	"	"
1 cash, $10,	Feb.	14,	1876.
Circular,	"	"	"
2.	"	"	"
3.	"	"	"

"W. D. BALDWIN,
Present."

"1. Letter to Caveator, Feby. 19, 1876. (Notice to complete,
2. Letter, Feby. 25, 1876."

"Simmons
vs.

158 | S. X.
58"

"Copy sent Sept. 20, 1877, M. E. S."

"DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Sept. 20th, 1877.

"ELISHA GRAY,
"Care Baldwin, Hopkins & Peyton, Present:

"'SIR: You are hereby notified, that application has been made to this office for Letters Patent for Speaking Telegraph, involving the use of a series of diaphragms in a common vocalizing chamber, with which the invention described in your caveat, filed on the 14th day of February, 1876, renewed February 14th, 1877, apparently interferes, and that said application has been deposited in the confidential archives of the office, under provisions of Section 4902 of the Revised Statute of the United States, which section reads as follows:

"'SEC. 4902. Any citizen of the United States who makes any new invention or discovery, and desires further time to mature the same, may, on payment of the fees required by law, file in the Patent Office, a caveat, setting forth the design

thereof, and of its distinguishing characteristics, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the office and preserved in secrecy, and shall be operative for the term of one year from the filing thereof; and if application is made within the year by any other person for a patent with which such caveat would in any manner interfere, the Commissioner shall deposit the description, specification, drawings and model of such application in like manner in the confidential archives of the office, and give notice thereof by mail, to the person by whom the caveat was filed. If such person desires to avail himself of his caveat, he shall file his description, specification, drawings and model within three months from the time of placing the notice in the post office in Washington, with the usual time required for transmitting it to the caveator added thereto, which time shall be indorsed on the notice. An alien shall have the privilege herein granted, if he has resided in the United States one year next preceding the filing of his caveat, and has made oath of his intention to become a citizen.'

"If you would avail yourself of your caveat, it will be necessary for you to file a complete application within three months from date, three days additional, however, being allowed for the transmission of this notice to your place of residence.

"Very respectfully,

ELLIS SPEAR,

Commissioner of Patents."

"MEMORANDUM OF FEE PAID AT U. S. PATENT OFFICE.

108

Inventor,

$10.

ELISHA GRAY.

Renewal of Caveat,

Filed Feb. 14, 1876.

Invention,

Telegraphy.

Statement of the Case.

Date of Payment,
Feb. 14, 1877.
Fee,
$10.

WM. D. BALDWIN,
Solicitor.
Present.

Patent Office,
Feb. 14, 1877.
U. S. A.
[Official Stamp.]"

"1877.

48 WILBUR.

—

23

1st. Renewal of Caveat of Feb. 14, 1876.

No.

ELISHA GRAY,
Of Chicago, County of Cook, State of Illinois.
Art of Transmitting Vocal Sounds Telegraphically.
Telelogue.

Rec'd,	Feb.	14,	1877.
Petition,	"	"	"
Affidavit,	"	"	"
Specification,	"	"	"
Drawing,	"	"	"
Model,	"	"	"
Cert. dep.,	"	"	"

1. Cash $10, Feb. 14, 1877.
2. Circular, " " "
3.

WM. D. BALDWIN,
Present."

"Notice to Caveator,
Sept. 20, 1877."

Statement of the Case.

One contention of all the respondents in regard to the Gray invention and caveat is stated in the answers of the Overland People's and Molecular cases in the following language: — "that it has long been notorious that for years past interferences have been and now are pending undetermined in the Patent Office between said Bell, Gray, Edison and many others, to determine who is the original and first inventor of the matters described, shown and claimed in said two patents here in suit and in each of them respectively; and that it has long been and still is notoriously understood and believed that the owners of the said Bell patents, distrusting the ultimate result of said pending interferences, and fearing the decision or decisions of the Commissioner of Patents declaring said Bell not to be the original and first inventor of the inventions shown in his said patent or patents, have entered into an agreement and contract, or agreements and contracts, with said Gray, Edison and others, or with their assignees, in writing, providing for the contingency of a decision of the Commissioner of Patents adverse to said Bell in said interferences, and of decisions of the court adverse to said Bell's claim as the original and first inventor of the matters claimed in his said patents or either of them, and arranged the terms and conditions upon which said Bell telephones shall be licensed by said Gray or by said Edison respectively, or by their respective assignees in the event that said Gray or said Edison shall be adjudged the original and first inventor thereof."

The Overland Company and the People's Company further contended that certain evidence cited by their counsel, and which is contained or referred to in the report of the argument of their counsel *infra*, justified the inference that the Gray caveat was filed in the Department of the Interior prior to the filing of Bell's application, specification and claims of 1876; that information of this caveat was surreptitiously furnished to Bell's solicitors; that Bell's specifications and claims as originally filed varied from his specifications and claims as stated in the patent in several important respects; that these changes were made within four days

after the filing of Gray's caveat; and that, after they had been made, the altered copy was placed in the files of the Department as the original. The following copy of these specifications, known as the Bell George-Brown-specification, is from the record in the People's case, and is referred to in argument in this connection; and other evidence in this respect on which counsel on one side or the other relied is also referred to in the arguments. The origin and nature of this specification is fully set forth in the argument of counsel hereafter.

"BELL'S GEORGE-BROWN-SPECIFICATION, NO. V.

"UNITED STATES PATENT OFFICE.

"[ALEXANDER GRAHAM BELL OF SALEM, ASSIGNOR TO HIMSELF AND THOMAS SANDERS OF HAVERHILL, AND GARDINER G. HUBBARD OF CAMBRIDGE, MASSACHUSETTS.][1]

"To all whom it may concern, be it known, that I, Alexander Graham Bell of Salem, Massachusetts, have invented certain new and useful improvements in Telegraphy, of which the following is a specification:

"In [another application for] Letters Patent granted to me [in] April 6th, 1875 (No. 161,739), I have described a method of and apparatus for transmitting two or more telegraphic signals simultaneously along a single wire by the employment of *Transmitting Instruments*, each of which occasions a succession of electrical impulses differing in rate from the others; and of *Receiving Instruments* each tuned to a pitch at which it will be put in vibration to produce its fundamental tone by one only of the Transmitting Instruments; and of *Vibratory Circuit Breakers*, operating to convert the vibratory movement of the Receiving Instrument into a permanent make or break (as the case may be) of a local circuit in which is placed a Morse Sounder Register, or other telegraphic apparatus. I

[1] Words in square brackets [ ] erased in original.

have also therein described a form of Autograph Telegraph based upon the action of the above mentioned instruments.

"In illustration of my method of Multiple Telegraphy I have shown in the [application] PATENT [1] aforesaid, as one form of Transmitting Instrument an electro-magnet having a steel spring armature which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same circuit is very speedily reached; for when a number of Transmitting Instruments, having different rates of vibration, are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to *one continuous current.*

"My present invention consists in the employment of a vibratory or undulat[ing]ORY current of electricity in place of a merely intermittent one; and of a method of, and apparatus for, producing electrical undulations upon the line-wire. The advantages [claimed for the undulatory current over the] I CLAIM TO DERIVE FROM THE USE OF AN UNDULATORY CURRENT IN PLACE OF A merely intermittent one, are,

"1. That a very much larger number of signals can be transmitted simultaneously over the same circuit.

"2. That a closed circuit and single main battery may be employed.

"3. That communication in both directions is established without the necessity of using special induction coils.

"4. And that — as the circuit is never broken — a spark arrester becomes unnecessary.

"It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede, a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to *vibrate* in front of the pole of an electro-

[1] Words in small capitals interlined in original.

magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond in rate 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. That the difference between an undulatory and an intermittent current may be more clearly understood, I shall describe the condition of the electrical current when THE ATTEMPT IS MADE TO TRANSMIT two musical notes [of different pitch are] simultaneously [transmitted along the same wire] FIRST UPON THE ONE PLAN AND THEN UPON THE OTHER. Let the interval between the two sounds be a major third. Then their rates of vibration are in the ratio of 4 : 5.

"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 [instrument].

"A[1] and B (Figs. I., II. and III.) represent the intermittent currents produced; four impulses of A being made in the same time as five impulses of B. *c*, *c*, *c*, &c., show where and for how long time the circuit is made, and *d*, *d*, *d*, &c., indicate the duration of the breaks of the circuit.

"The line A + B shows the total effect upon the current when the transmitting instruments for A and B are caused [to] 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. I. the rate is as 1 : 4; in Fig. II. as 1 : 2; and in Fig. III. the makes and breaks are of equal duration.

"The combined effect A + B (Fig. III.) is very nearly equivalent to a continuous current.

"When many transmitting instruments of different [pitch] RATES OF VIBRATION are simultaneously making and breaking the same circuit, the current upon the main line [loses altogether its intermittent character and] becomes for all practical purposes continuous.

[1] Three sheets of figures accompany the patent in the record. They are fac-similes of the original ink sketches, evidently intended to represent the same Figures which form part of the Bell patent of 1876.

Statement of the Case.

"[But now] Next consider the effect when an undulatory current is employed.

"Electrical undulations induced by the vibration of a body capable of inductive action can be represented graphically without error by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air.

"For, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body, that is, to the pitch of the sound produced; the intensity of the current varies with the amplitude of vibration, that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the motion of the vibrating body, that is, to the condensations and rarefactions of air produced by the vibration. Hence the sinusoidal curve A or B[1] (Fig. IV.) represents graphically the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

"The horizontal line (a, d, b, f) represents the zero of current; the elevations (c, c, c) indicate impulses of positive electricity; the depressions (e, e, e) show impulses of negative electricity; the vertical distance ($c\,d$ or $e\,f$) of any [point on] PORTION OF the curve from the zero line expresses the intensity of the positive or negative impulse at the part OBSERVED; and the horizontal distance (a, a) indicates the duration of the electrical oscillation.

"The vibrations represented by the sinusoidal curves A and B (Fig. IV.) are in the ratio aforesaid, of 4 : 5, — that is, four oscillations of A are made in the same time as five oscillations of B.

"The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A+B (Fig. IV.), which is the algebraical sum of the sinusoidal curves A and B. This curve (A+B) also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously.

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[1] "A or B" interlined in original.

"Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies.

"Hence the coexistence [of] UPON a telegraphic circuit of electrical vibrations of different pitch is manifested, — not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations; or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

"[Undulatory currents of electricity may be produced in many other ways than that described above, but all the methods depend for effect upon the vibration or motion of bodies capable of inductive action.]

"There are many [other] ways of producing undulatory currents of electricity, but all of them depend for effect upon the vibration or motion of bodies capable of inductive action. A few of the methods that may be employed I shall here specify.[1]

"[I shall specify a few of the methods that may be used to produce the effect.]

"When a wire through which a continuous current of electricity is passing is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter.

"When a cylinder upon which are arranged bar-magnets is made to rotate in front of the pole of an electro-magnet an undulatory current is induced in the coils of the electro-magnet.

"Undulations may also be caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting wire itself in the neighborhood of such bodies.

"In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect.

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[1] This paragraph (four lines) interlined in original.

Statement of the Case.

"I prefer to employ for this purpose an electro-magnet (A, Fig. 5) having a coil upon only one of its legs (6). A steel spring armature (*c*) is firmly clamped by one extremity to the uncovered leg (*d*) of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature (*c*) can be set in vibration in a variety of ways (one of which is by wind), and in vibrating it yields a musical note of a certain definite pitch.

"When the instrument (A) is placed in a voltaic circuit (*g*, *b*, *e*, *f*, *g*) the armature (*c*) becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature (*c*) remains at rest no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note a powerful inductive action takes place, and electrical undulations traverse the circuit (*g*, *b*, *e*, *f*, *g*). The vibratory current passing through the coils of the distant electro-magnet (*f*) causes vibration in its armature (*h*), when the armatures (*c*, *h*) of the two instruments (A, I) are normally in unison with one another; but the armature (*h*) is unaffected by the passage of the undulatory current when the pitches of the two instruments (A, I) are different [from one another].

"A number of instruments may be placed upon a telegraphic circuit (as in Fig. VI.). When the armature of any one of the instruments is set in vibration all the other instruments on the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus if A (Fig. VI.) is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit remain still. So also if B^1 is caused to emit its musical note the instruments B, B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued, but become silent the moment its motion stops. The duration of the sound may be made to signify the dot or dash of the Morse alphabet, and thus a telegraphic despatch can be transmitted by alternately interrupting and renewing the sound.

"When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of correspond-

ing pitches upon the circuit are set in vibration, each responding to that one only of the Transmitting Instruments with which it is in unison. Thus the signals of A are repeated by A^1 and A^2, but by no other instruments upon the circuit; the signals of B^2 by B and B^1, and the signals of C^1 by C and C^2, whether A, B^2, and C^1 are successively or simultaneously set in vibration.

"Hence by these instruments, two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

"I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes differing in *loudness* as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

"When the armature *c* (Fig. V.) is mechanically set in vibration the armature *h* responds not only in pitch but in loudness. Thus when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*, and when *c* vibrates forcibly the amplitude of vibration of *h* is considerably increased, and the sound becomes louder. So if A and B (Fig. VI.) are sounded simultaneously (A loudly and B softly) the instruments A^1, A^2 repeat loudly the signals of A, and the instruments B^1, B^2 repeat gently those of B.

"One of the ways in which the armature (*c*) Fig. VI. may be set in vibration has been stated above to be by wind. Another mode is shown [by] IN Fig. VII. [which] WHEREBY motion can be imparted to the armature by means of the human voice, or by the tones of a musical instrument.

"The armature *c* (Fig VII.) is fastened loosely by one extremity to the uncovered pole (*d*) of the electro-magnet (*b*), and its other extremity is attached to the centre of a stretched membrane (*a*). A cone A is used to converge sound vibrations upon the membrane. When a loud sound is uttered in the cone the membrane (*a*) is set in vibration; the armature *c* is forced to partake of the motion, and thus electrical undulations are caused upon the circuit E, *b*, *e*, *f*, *g*. These undulations are similar in *form* to the air vibrations caused by the sound,—

that is, they [are] CAN BE represented graphically by similar curves. The undulatory current passing through the electro-magnet (*f*) influences [the] ITS armature (*h*) to copy the motion [s] of the armature (*c*). A similar sound to that uttered into A is then heard to proceed from L.

"[Having described my invention, what I claim and desire to secure by Letters Patent is as follows:

"1. A system of telegraphy in which the receiver is set in vibration by the employment of (vibratory or) undulatory currents of electricity.

"2. The method of creating an undulatory current of electricity by the vibration of a permanent magnet or other body capable of inductive action.

"3. The method of inducing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action.

"4. The method of and apparatus for transmitting vocal or other sounds telegraphically by (inducing in a continuous voltaic circuit) CAUSING ELECTRICAL undulations similar in form to the vibrations of the air accompanying said vocal or other sounds the whole for operation substantially as HEREIN shown and described.]

"In this specification the three words 'oscillation,' 'vibration' and 'undulation' are used synonymously.

"By the term 'Body capable of inductive action' I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action, brass, copper and other metals, as well as iron and steel.

"Having described my invention, what I claim and desire to secure by Letters Patent is as follows:

"1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity.

"2. The combination of a permanent magnet, or other body capable of inductive action with a closed circuit, so that the vibration of the one shall produce electrical undulations in the other or in itself.

"Thus (*a*). The permanent magnet or other body capable

of inductive action may be set in vibration in the neighborhood of the conducting wire forming the circuit.

"(*b.*) The conducting wire may be set in vibration in the neighborhood of the permanent magnet.

"(*c.*) The conducting wire and the permanent magnet may both simultaneously be set in vibration in each other's neighborhood; and in any or all of these cases electrical undulations will be produced upon the circuit.

"3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting wire itself in the neighborhood of such bodies.

"4. The method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds."

"(INDORSEMENT.)

"These papers were received by me from Professor Alex. G. Bell in the winter of 1875–6, shortly before I left for England. I can fix the exact date by reference to my books and papers, but have not these at hand now.

"GEO. BROWN.

"Toronto, 12 Novem., 1878."

Two of the publications respecting the Van der Weyde experiments were (1) from *The Manufacturer and Builder*, published in New York in May, 1869; and the other from *The Scientific American*, published in New York, March 4, 1876. They were as follows, omitting illustrations.

I. *From The Manufacturer and Builder, May, 1869.*

"One of the most remarkable recent inventions connected with telegraphy is the telephone, an instrument which transmits directly the pitch of a sound by means of a telegraph wire, — either an air wire or submarine cable; so that, for instance, when the operator at one end of the wire sings or

plays on an instrument any tune, as 'Yankee Doodle,' or 'Hail Columbia,' it will be heard and distinguished plainly at the other end. This invention may, in its present state, have no direct practical application, but be a mere scientific, although highly interesting curiosity; but who can say that it does not contain the germ of a new method of working the telegraph, or some other useful practical purpose?

"The telephone is not the result of an accidental discovery, but of a thorough study of the laws of electro-magnetism and of sound. It is founded on the fact that the difference in pitch of different tones is caused by different velocities of vibrations of the elastic sounding body; which vibrations are transmitted to and by the air with exactly the same velocity, and from the air may be communicated to a properly stretched membrane, like a piece of bladder or very thin sheet of india-rubber, stretched like a drum head, which these also will vibrate with exactly the same velocity as the air and the original sounding body, be it the human voice, organ pipe, string or any musical instrument. If, now, at the centre of this little drum head there be attached a small disk of some metal not easily burned by electric currents, — for instance, platinum, — while at the same time a platinum point may, by means of a screw, be so adjusted as to come very nearly in contact with this small platinum disk, it is clear that, when the membrane is put in vibration, a succession of contacts between the disk and point will be produced, of which the number in each second will exactly correspond with the number of vibrations in each second of the sounding body or the tone produced by it. That part of the apparatus which serves to send off the tune or melody is represented in the illustration. It consists simply of a square wooden box, provided at the side with a kind of mouthpiece similar to that of a speaking-tube, and at the top with an opening, over which the membrane just mentioned has been stretched. The small piece of platinum attached to the centre of this little drum head is, by means of a very flexible strip of some metal that conducts well, attached to one pole of the galvanic battery, of which only one cup is represented in the figure,

although for a long wire several cups will, of course, be required. The reason why this connection near the platinum disk is a flat, thin and flexible strip is, that any rigidity would interfere with the freedom of vibration of the membrane to which it is attached. The point coming in contact with this small vibrating disk is connected with the ground wire, the other pole of the battery with the air wire or submarine cable. It is clear, from this explanation, that at every contact of the platinum point a wave of electricity will be sent over the wire, and as many waves in a second as there are contacts; and as there are as many contacts as there are vibrations in every second, the number of electric waves will be always exactly equal to the number of vibrations corresponding with the pitch of each tone, be it fifty, one hundred, two hundred or five hundred in every second.

"The instrument in which this succession of waves is made audible at the other end of the telegraph wire is founded on the fact — first investigated by Professor Henry, of the Smithsonian Institute at Washington — that iron bars, when becoming magnetic by means of electric currents passing around them, become slightly elongated, and at the interruption of the current are at once restored to their original length. It is represented in the cut, and consists of an elongated wooden box, of which the top is made of thin pine wood, similar to the sounding-board of a stringed musical instrument, to which are attached two bridges carrying long pieces of moderately thick and very soft iron wire, which, for nearly their whole length, are surrounded by a coil similar to the coil of the electro-magnets used in telegraphing. One end of this coil is attached to the telegraph wire, the other to the ground wire, as represented in the figure. At every instant that a contact is established at the station where the sound is produced, and a current wave thus transmitted, these wires will become magnetic, and consequently elongated; and they will be shortened again at every interruption of the current. And as these currents and interruptions succeed each other with the same velocity as the sound vibrations, the elongations and shortenings of the magnetized iron wires will succeed each

other with exactly the same velocity, and consequently they will be thrown into a state of longitudinal vibrations corresponding with the original musical tone, which vibrations will then be communicated to the sounding-board in exactly the same manner as is the case with the vibrations of the strings in all stringed instruments, thus becoming more audible at the receiving station.

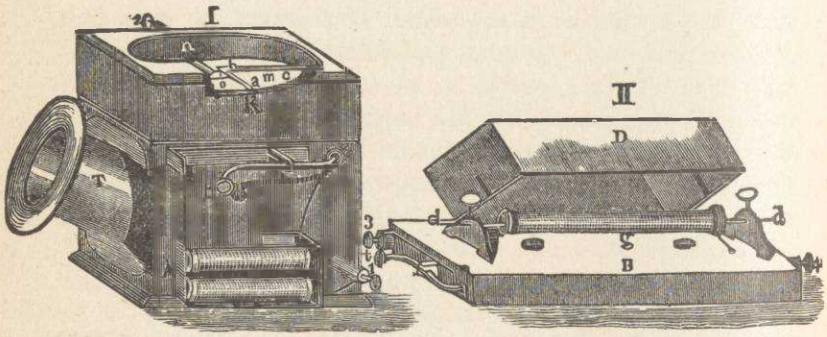
"It is clear, from the foregoing explanations, that no quality of tone can be transmitted. Much less can articulate words be sent, notwithstanding the enthusiastic prediction of some persons, who, when they first beheld this apparatus in operation, exclaimed that now we would talk directly through the wire. It is from its nature able to transmit only pitch and rhythm, — consequently melody, and nothing more. No harmony nor different degrees of strength or other qualities of tone can be transmitted. The receiving instrument, in fact, sings the melodies transmitted, as it were, with its own voice, resembling the humming of an insect, regardless of the quality of the tone which produces the original tune at the other end of the wire.

"This instrument is a German invention, and was first exhibited in New York, at the Polytechnic Association of the American Institute, by Dr. Van der Weyde. The original sounds were produced at the farther extremity of the large building (the Cooper Institute), totally out of hearing of the Association; and the receiving instrument, standing on the table of the lecture-room, produced with its own rather nasal twang the different tunes sung at the other end of the line; rather weakly, it is true, because of the weak battery used, but very distinctly and correctly."

II. From The Scientific American, New York, March 4, 1876.

"In connection with Mr. Gray's application of the telephone to the simultaneous transmission of several different telegraphic messages over one wire at the same time, and his paper read before the American Electrical Society (published on p. 92, *Scientific American*, Supplement for Feb. 5), it may be inter-

esting for the readers of this paper to obtain some information in regard to the invention of the telephone, by Reuss. As mentioned in the article above referred to, Page and Henry observed that, by rapid magnetization and demagnetization, iron could be put into vibrations isochronic with the interruptions of the current; and later, Marian experimented extensively in this direction, while Wertheim made a thorough investigation of the subject, which induced Reuss, of Friedrichsdorf, near Hamburg, Germany, to apply this principle to the transmission of musical tones and melodies by telegraph; and he contrived an apparatus which we represent in the engravings.



"The telephone of Reuss consists of two parts, the transmitting and the receiving instrument. Fig. I. represents the former, and is placed at the locality where the music is produced; Fig. II., the latter, is placed at the station where the music is to be heard, which may be at a distance of one hundred, two hundred, or more miles, in fact, as far as the battery used can carry the current, while the two instruments are connected with the battery and the telegraph wire in the usual manner. One pole of the battery is connected with the ground plate, the other with the screw, marked 2 of Fig. I., and thence over a thin copper strip *n*, with a platinum disk, *o*, attached to the centre of the membrane stretched in the large top opening of the hollow and empty box, K, intended to receive and strengthen the vibrations of the air, produced by singing before the funnel-shaped short tube attached to the opening in

Statement of the Case.

T. Over the platinum disk, *c*, attached to the elastic membrane, is a platinum point attached to the arms *b c* and *b* K, while a set screw brings this point in slight contact with the platinum disk mentioned. A part of the box is represented as broken and removed in order to show the internal construction. The strip *a b c* is connected with the end *s*, of the switch *t s*, and the screw connection, 1, at the lower right-hand corner, and also through the telegraph wire, to the instrument Fig. II., at the receiving station, which may be situated at a distance of many miles. Here the current enters by the screw connection, 3, and passes through the spiral *g*, surrounding the soft iron wire, *d d*, of the thickness of a knitting needle, and leaves the apparatus at the screw connection, 4, whence it obtains access to the ground plate, and so passes through the earth back to the battery. The spiral and iron wire *d d* is supported on a hollow box, B, of thin board; while a cover D, of the same material is placed on top, all intended to strengthen the sound produced by the vibrations which the interruption of the current caused in the iron wire, *d d*, so as to make these vibrations more audible by giving a large vibratory surface, in the same way that the sounding board of a piano-forte strengthens the vibrations of the air, caused by the strings, and makes a very weak sound quite powerful.

"If a flute be played before the opening T, or if a voice be singing there, the vibration of the air inside the box K causes the membrane *m* to vibrate synchronically, and this causes the platinum disk *o* to move up and down with corresponding frequency. At every downward motion the contact of this disk with the platinum point, under *b*, is broken, and therefore the current is interrupted as rapidly as the vibrations occur. Let, for instance, the note C be sounded; this note makes sixty-four full vibrations in a second, and we have, therefore, sixty-four interruptions of the electric current, which interruption will at once be transmitted through the telegraph lines to the receiving instrument, and put the bar *d d* into exactly similar vibrations, making the very same tone, C, audible; and so on for all other rates of vibration. It is clear that in this way not only the rhythm of music can be transmitted (and this can

be done by the ordinary telegraph), but the very tones, as well as the relative durations and the rests between them, can thus be sent, making a full and complete melody. The switch *t s*, Fig. I., is intended, in connection with a similar one in Fig. II., to communicate between the stations, with the help of the electro-magnet E, to ascertain if station, Fig. II., is ready to receive the melodies; then it gives the signal, by manipulating the switch, which is received by the attraction of the armature A, the latter arrangement being a simple Morse apparatus attached to the telephone.

"Professor Heisler, in his *Lehrbuch der technischen Physik* (3d edition, Vienna, 1866), says, in regard to this instrument: 'The telephone is still in its infancy; however, by the use of batteries of proper strength, it already transmits not only single musical tones, but even the most intricate melodies, sung at one end of the line, to the other, situated at a great distance, and makes them perceptible there with all the desirable distinctness.' After reading this account in 1868, I had two such telephones constructed, and exhibited them at the meeting of the Polytechnic Club of the American Institute. The original sounds were produced at the further extremity of the large building (the Cooper Institute), totally out of hearing of the Association, and the receiving instrument, standing on the table in the lecture-room, produced (with a peculiar and rather nasal twang) the different tunes sung into the box K, at the other end of the line; not powerfully, it is true, but very distinctly and correctly. In the succeeding summer I improved the form of the box K, so as to produce a more powerful vibration of the membrane, by means of reflections effected by curving the sides; I also improved the receiving instrument by introducing several iron wires in the coil, so as to produce a stronger vibration. I submitted these, with some other improvements, to the meeting of the American Association for the Advancement of Science, and on that occasion (now seven years ago) expressed the opinion that the instrument contained the germ of a new method of working the electric telegraph, and would undoubtedly lead to further improvements in this branch of science, needing only that a competent person give

it his undivided attention, so as to develop out of it all that it is evidently capable of producing.

"Before leaving this subject, I wish to draw special attention to the fact that the merits of the invention consist chiefly in the absence of musical instruments, tuning forks, or their equivalents for producing the tones; any instrument will do: flute, violin, human voice, &c. If the aerial vibrations are only conducted into the box, Fig. 1, the apparatus will send the pitch as well as the duration of the different tones, with the rests between, therefore not only transmitting perfect rhythm, but a complete melody, with its long and short notes. The two parts of the apparatus may even be connected each to a separate piano-forte; and if this were done in a proper manner a melody played on the piano-forte connected with the transmitting instrument, Fig. 1, would be heard in the pianoforte at a great distance, connected with the receiving instrument, Fig. 2."

The following are the drawings and an extract from the specification in McDonough's application for a patent.

Fig. 1

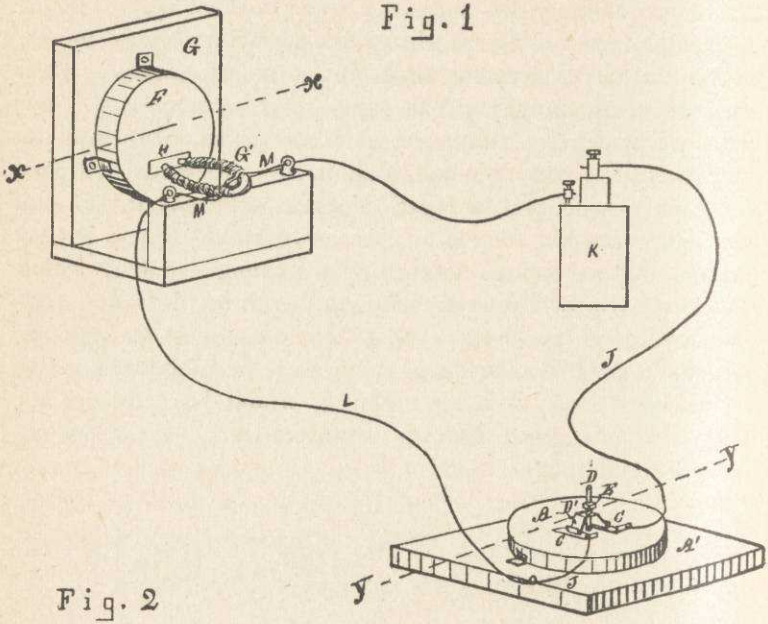


Fig. 2

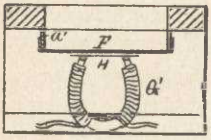


Fig. 3

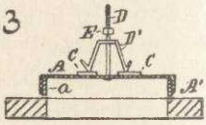
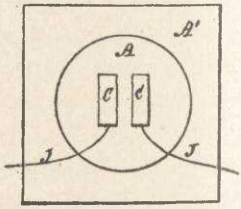


Fig. 4



Statement of the Case.

"The object of my invention is to provide a means for transmitting articulate sounds from one place to another through the medium of electricity, and it consists in the combination with an electrical battery circuit wires, armature, magnet and circuit-breaker, of a transmitting and a receiving membrane or sounding apparatus, so constructed as to vibrate in accord with the vibrations of articulate sound, and so arranged relative to the magnet and circuit-breaker that the vibrations of the transmitting membrane or apparatus produced by articulate sounds, are transmitted by the electrical current to the receiving membrane or apparatus, and so as to cause a like vibration of the receiving membrane or apparatus, and [cause] it to reproduce the articulate sounds transmitted from and by the transmitting membrane or apparatus. My invention also consists in the novel construction of the circuit-breaker, as is hereinafter more fully described.

"In the drawing A represents the transmitting membrane or apparatus, composed of vellum, or any suitable material that is sensitive to the vibrations of sound, which is stretched upon a metal hoop or band *a*, permanently attached to the bed A′, and is so arranged upon the hoop or band as to admit of being tightened or loosened at will. C C are metal plates attached to the upper surface of the membrane A, at its centre, and are insulated from each other. D is a metal bolt permanently attached at its lower end to said membrane A, centrally between the plates C C, and is insulated from them. D′ is the circuit-breaker, which consists of an arched-shaped piece of metal loosely secured at its centre upon the bolt D, and is bent upward at each end, and from the membrane A, as shown in Fig. 3, so as to form depending V-shaped points adapted to rest upon the respective plates C C. The circuit-breaker D′ is so fitted upon the bolt D as to admit of a free and easy ascending and descending movement, the limit of its ascending movement being determined by its contact with the nut E on the bolt, and the descending movement being limited by its contact with the plates C C. F is the receiving or sounding membrane, which is also composed of vellum or any suitable material that is sensitive to the vibration of sound,

and is stretched upon a metal hook or band a', secured to the side frame G, of the receiving or sounding apparatus, as shown in Fig. 1, and is so adjusted as to admit of being loosened or tightened as may be required.

"G' is the magnet surrounded by a helix of insulated wire, and connected to the instrument immediately in front of the membrane F; and at a point near its centre. H is the armature plate permanently attached to the membrane F, between it and the magnet, as shown in Fig. 1.

"To each of the plates C C is connected a wire J, one of which is connected with the battery K, and the other with the ground wire L. To each of the poles of the magnet is connected a wire M, one of which is connected with the battery K, and the other with the ground wire, as shown in Fig. 1.

"The operation of my said teleloge is as follows: the transmitting membrane A, being sensitive to the vibrations of articulate sounds produced thereon, is caused to vibrate in sympathy therewith, thereby imparting an upward movement to the circuit-breaker at each vibration, and disconnecting it from the plates C C, and alternately breaking and closing the circuit, when the intermittent current alternately magnetizes and demagnetizes the magnet G', attracting the armature H, and causes it and the membrane F to vibrate simultaneously with the vibrations of the transmitting membrane A, and in accord therewith, and so that the said membrane F reproduces the articulate sounds transmitted from and by the membrane A.

"I do not limit myself to the construction and arrangement of the circuit-breaker D', as shown and described, as other means may be employed, as for example, only one of the plates C may be attached to the membrane, and the other made either in the form of a plate or needle and attached direct to the connecting wire, and adjusted to rest upon the plate, so as to break the connection by the vibrations of the membrane, which will accomplish the same result. It will be observed that each end of the circuit-breaker D' is bent upward from the membrane, the object being to prevent local attrac-

tion and render its action more sensitive to the lighter vibrations of the membrane. The articulate sounds may be taken direct from the magnet, or through any substance or material sufficiently sensitive to the vibrations of sound to reproduce them by contact with the magnet.

"Having thus described my invention, what I claim as new, and desire to secure by letters patent, is:

"1. The combination with the battery, circuit wires, magnet, armature and circuit-breaker, of the transmitting membrane A, and receiving membrane F, substantially as and for the purpose specified.

"2. The combination with the plates C C, of the circuit-breaker D', whereby the circuit is alternately opened and closed by the vibrations of the membrane A, substantially as specified.

"3. The combination of the bolt D and adjusting nut E, of the circuit-breaker D', substantially as and for the purpose specified."

There were two Varley patents. The United States patent, dated June 2, 1868, set forth the object of the invention thus: "The objects of my invention are to cut off the disturbance arising from earth-currents, to obtain a high speed of signaling through long circuits, and, should the conductor become partially exposed, to preserve it from being eaten away by electrolytic action"; and made the following claims:

"Having now described my invention, and the manner in which the same is or may be carried into effect, what I claim, and desire to secure by Letters Patent, is —

"1. In so arranging telegraphic apparatus as to work by the variation of the increment and decrement of electric potential, and not by the direct action of the electric current itself, as and for the purposes set forth.

"2. The use of an induction-coil at the receiving end of the cable, one of its wires being connected between the cable and the ground, and the other or secondary wire connected with the receiving-instrument, as and for the purposes set forth.

"3. The use of a condenser or condensers between the receiving end of the cable and the earth, with or without resistance-coils between the cable and the earth, as and for the purposes set forth.

"4. The use of a condenser at the sending end of the cable, with or without resistance-coils connecting its two armatures, as and for the purposes set forth.

"5. The use of a condenser at each end of the cable, the cable being connected with the ground through a resistance-coil and a battery, so as to keep the cable always negatively electrified, as and for the purposes set forth."

The object of the British patent, dated October 8, 1870, was said to be "the increase of the transmitting power of telegraph circuits by enabling more than one operator to signal independent messages at the same time upon one and the same wire to and from independent stations"; and the claims were as follows:

"Having thus described the nature of my invention and the manner of performing the same, I would have it understood that I claim the construction of electric telegraphs in such manner that current signals and wave signals may be simultaneously transmitted through the same line wire, and may be rendered sensible at the receiving station by separate instruments, the one sensitive to currents of appreciable duration, and the other to electric waves or vibrations.

"I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a strained wire, a tongue, or such like instrument adjusted to vibrate in unison with the electric waves, and, being magnetized by them, oscillating to and from the pole or poles of a magnet in its vicinity.

"I also claim, in the construction of electric telegraphs, the dividing a conducting wire into sections by instruments which I have called 'echocyme,' which allow current signals to pass freely but stop wave signals, so that, whilst the wire is being used as a whole for through signals, the sections into which it is divided may each or all be employed for the transmission of local messages.

Statement of the Case.

"I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a condenser consisting of thin sheets capable of being agitated by such waves.

"I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station an instrument which, on receiving such waves, delivers a current of electricity to an indicating or receiving instrument suitable to be worked with ordinary current signals.

"I also claim the combination with Dr. Gintl and Frischen's double speaking apparatus of a hollow helix connected between the receiving instrument and the line wire, such helix having rods or pieces of iron inserted into it."

The People's Telephone Company claimed as assignees of Drawbaugh's inventions and of his rights, and in their answer made the following averments respecting them.

"11. Further answering, this defendant says, that Daniel Drawbaugh, of Eberly's Mills, Cumberland County, Pennsylvania, was and is the original and first inventor and discoverer of the art of communicating articulate speech between distant places by voltaic and magneto electricity, and of the construction and operation of machines and instruments for carrying such art into practice; that long prior to the alleged inventions by said Alexander Graham Bell, and long prior to the respective inventions of said Gray and said Edison, said Daniel Drawbaugh, then and now residing at said Eberly's Mills, constructed and operated practical working electric speaking telephones at said Eberly's Mills, and exhibited their successful operation to a great number of other persons resident in his vicinity and elsewhere; that the said electric speaking telephones, so constructed and successfully and practically used by him, as aforesaid, contained all the material and substantial parts and inventions patented in said patents No. 174,465 and

No. 186,787, granted to said Bell; and also contained other important and valuable inventions in electric and magneto telephony, and were fully capable of transmitting, and were actually used for transmitting, articulate vocal sounds and speech between distant points by means of electric currents; that some of the original machines and instruments invented, made, used, and exhibited to many others, long prior to the said alleged inventions of said Bell, or either of them, are still in existence, and capable of successful practical use, and are identified by a large number of persons who personally tested and used, and knew of their practical operation and use, in the years 1870, 1871, 1872, 1873, 1874, and both subsequently and prior thereto; that certainly more than fifty, and probably not less than one hundred persons, or even more, were cognizant of said Drawbaugh's invention and use of said telephones, and of his claim to be the original and first inventor thereof, prior to the alleged inventions of said Bell, or either of them; that said Drawbaugh, for more than ten years prior to the year 1880, was miserably poor, in debt, with a large and helpless family dependent upon his daily labor for support, and was, from such cause alone, utterly unable to patent his said invention, or caveat it, or manufacture and introduce it upon the market; that said Drawbaugh never abandoned his said invention, nor acknowledged the claims of any other person or persons thereto, but always persisted in his claims to it, and intended to patent it as soon as he could procure the necessary pecuniary means therefor; that said Drawbaugh never acquiesced in the public use of said Bell, Gray, Edison, Blake, or other telephones, nor in the claims of the alleged inventors thereof, nor gave his consent to such use; and that, in view of the facts aforesaid, neither said Bell nor any other person or persons whatever, except the said Drawbaugh, can now obtain a valid patent therefor, nor are the patents granted to said Bell as aforesaid, or either of them, of any validity or value whatever.

"12. Further answering, this defendant says, that the said Daniel Drawbaugh, after making, testing, using, and extensively exhibiting his invention to others, and allowing them

experimentally to personally test and ascertain its successful practical operation and utility, as aforesaid, and after the full and repeated demonstration of its successful working, as aforesaid, conceived that its range and capacity of usefulness to the public might be very greatly enlarged; that many improvements of great value might be made and added to it which, without departing from its principle, might increase its value to himself and to the public, and therefore set himself at work to discover and invent such improvements; that he discovered and invented some of said additional improvements prior to any alleged invention by the said Bell; and that, notwithstanding his embarrassed and impoverished pecuniary condition, and his utter want of proper mechanical tools, materials, and appliances to conduct such work, he labored with all reasonable diligence to perfect and adapt his said improvements, and did finally, in due exercise of such reasonable diligence, perfect and adapt the same; and that, in so far as the said Bell has incorporated such improvements in his said two patents, or either of them, he, the said Bell, has surreptitiously and unjustly obtained a patent or patents for that which was in fact first invented by said Drawbaugh, who was using reasonable diligence in perfecting and adapting the same; and therefore the patent or patents of the said Bell therefor is, or are, invalid and void.

"13. Further answering, this defendant says that it has, by purchase, and for a valuable consideration, acquired the right, title, and interest of said Daniel Drawbaugh in and to all his said inventions, discoveries, and improvements in electric speaking telephones, and has full right, at law and in equity, to make, sell, and use electric speaking telephones, embodying the inventions, discoveries, and improvements of said Drawbaugh, without interference from or molestation by said Bell or his assigns, and without liability to these complainants therefor.

"14. Further answering, this defendant says that it has, in good faith, and relying upon its legal rights aforesaid, caused applications to be made and filed in the Patent Office for Letters Patent upon the inventions of the said Daniel Drawbaugh,

with the intention of procuring interference proceedings to be instituted, in accordance with the statute, against the patents of said Bell, and the pending applications of said Gray, Edison, and others, in order that said Drawbaugh may be adjudged by the Commissioner of Patents to be, as he rightfully is, the original and first inventor of the electric speaking telephone, and may be adjudged entitled to receive a patent or patents therefor.

"15. This defendant, further answering, denies all and all manner of unlawful conspiracy and confederacy with other persons and parties, as charged in the complainants' bill of complaint; denies all knowledge of the alleged newspaper publications referred to in said bill, and calls for due proof of said alleged publications, if the complainants shall be advised that they are of any materiality to this suit, which this defendant denies; and denies all the allegations of the complainants' bill as to the said Drawbaugh invention, and, particularly, the allegations that said Drawbaugh's invention was a mere experiment, was incomplete, imperfect, unfruitful, and that knowledge of it was withheld from the public, except so far as disclosed by said alleged newspaper publications in said bill mentioned and set forth. And this defendant charges that the contrary of all said allegations is true; that this defendant has done no unlawful or inequitable act in the premises; that it is not responsible for said alleged newspaper publications; that said Drawbaugh's original invention was complete, successful, operative, and practically and successfully operated, and reduced to practice as a 'Speaking Telephone' on many occasions, in the presence and hearing of many other persons, and knowledge thereof was freely communicated to the public by said Drawbaugh; and that said Drawbaugh's improvements, additional to his said original invention, were complete, successful, and practical inventions; that all of his said inventions were fully reduced to practice and communicated to others; but that said other persons, having knowledge of his legal and equitable right in and to his said inventions, and respecting and acquiescing in the same, desisted and refrained from making and using his said inventions, and acquiesced in his right

thereto, and never did, so far as this defendant is informed and believes, any act to impair his said rights or which would prevent the grant of a good and valid patent or patents to him, the said Daniel Drawbaugh, or his assigns, for any or all of his said inventions.

"16. This defendant, further answering, says that so far and to such extent as electric speaking telephones were put on sale and into public use in this country, by others than said Drawbaugh, prior to said Drawbaugh's application for a patent thereon, as aforesaid, such specific machines and instruments, so put on sale and into public use, were not the specific machines and instruments invented by said Drawbaugh, as aforesaid, but were machines and instruments invented by others, subsequently to the original and first invention of the electric speaking telephone by said Drawbaugh, and subsequently to the invention of his said improvements thereon, as aforesaid; and that, as this defendant is informed and believes, such machines and instruments were so put on sale and into public use, not from or by reason of any information derived from or through said Drawbaugh, but by an independent invention, or independent inventions thereof, by others subsequently to said Drawbaugh's original and first invention as aforesaid, and while said Drawbaugh was unable, by reason of his poverty and other controlling circumstances, as above set forth, to patent his said inventions; and that such public use and sales were without the consent, allowance, or acquiescence of said Daniel Drawbaugh.

"And this defendant, as advised by its counsel, further answers and says, that the alleged invention of the electric speaking telephone by said Bell, subsequently to said Drawbaugh's invention thereof, as aforesaid, conferred upon said Bell, or his assigns, no legal right to a patent or patents thereon, nor did it impair the legal right of said Drawbaugh to a patent or patents upon his own prior inventions; and that the alleged public use and sales of such subsequently invented telephones, without said Drawbaugh's consent, allowance, or acquiescence as aforesaid, and by reason of knowledge and information of their construction and operation, not derived from or through

said Drawbaugh, have in law no effect to forfeit or bar said Drawbaugh's right to the exclusive use of his own prior invention, nor to prevent him or his assigns from obtaining a valid patent or valid patents thereon."

It was claimed by the People's Company, that Drawbaugh's inventions and the inventions covered by Bell's patents were for substantially the same thing. The main issues in this respect argued by counsel were issues of fact — whether Drawbaugh's instruments were made prior to Bell's discovery, and were practically operative, and whether the Drawbaugh witnesses to these points were to be believed. The record contains a great mass of testimony on these issues. Much of this is referred to in detail by the counsel on each side and by the court. It is not practicable to report it further than they have regarded it as material, and presented it in quotations and references.

There was before the court in the Drawbaugh case a book containing a series of plates, (with references and notes written upon them,) marked respectively from "A" to "Q," both inclusive. It was claimed on his behalf that these plates represented his invention at various stages of its development. The claim was made in the following language by his counsel:

"The story of Drawbaugh, and of the record, overwhelmingly corroborated by the witnesses for the defence, is as follows:

"Early conception and experiments with the continuous current, 1862, 1866, and 1867.

"Teacup transmitter and receiver, 1866, and 1867.

"Tumbler and tin cup and mustard can ('F' and 'B'), 1867 and 1869.

"Improvement upon 'B' ('C'), 1869, 1870.

"Further improvement upon 'C' and the more perfect magneto instrument 'I,' 1870, 1871.

"Mouthpiece changed to centre, and adjusting screw inserted (Exhibit 'A'), 1874.

"'D' and 'E' perfectly adjusted and finished magneto instruments, January and February, 1875.

"'L,' 'M,' 'G,' and 'O' from February, 1875, to August, 1876.

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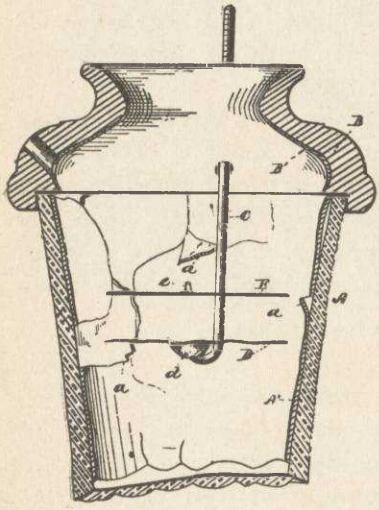
"'H,' August, 1876.

"'J,' 'N,' and 'P,' 1878.

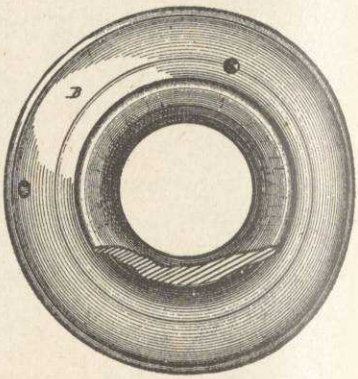
"With the exception of the old teacup transmitter, representations of all the instruments are in evidence, in whole or in part; parts of those produced prior to the instrument 'I' of 1871 being in evidence, and 'I,' with all thereafter produced being in evidence in their entirety."

The following are such of these plates, to which the counsel assigned a date prior to Bell's patent of March 7, 1876, as are deemed to be necessary for a proper understanding of the arguments of counsel, and of the opinion of the court, upon this point. They are arranged in the order of the dates in which Drawbaugh was said to have constructed the instrument which they represent.

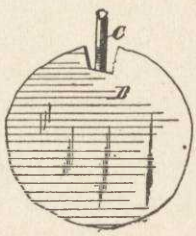
Instrument marked F. Full size. (Tumbler.)



Longitudinal section.



Cap; top view.



Lower plate.

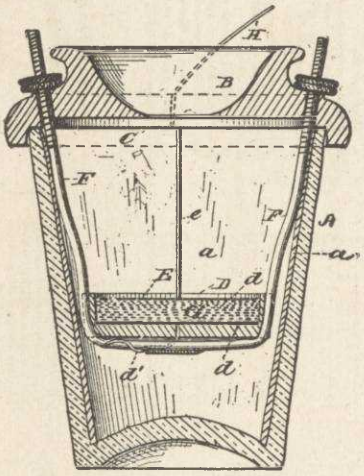
Upper plate.

REFERENCES.

A. Glass tumbler; bottom broken off.
B. Wooden cap.
B'. Plaster-paris lining to cap.
A'. Plaster-paris lining to tumbler.
a. Breaks in lining *A'*.
C. Adjusting rod for lower plate.
D. Lower plate.
d. Solder joint.
E. Upper plate.
e. Wire to plate *E*.

Statement of the Case.

Instrument marked F Reproduced. Full size. (Tin Cup and Mustard Can.)



REFERENCES.

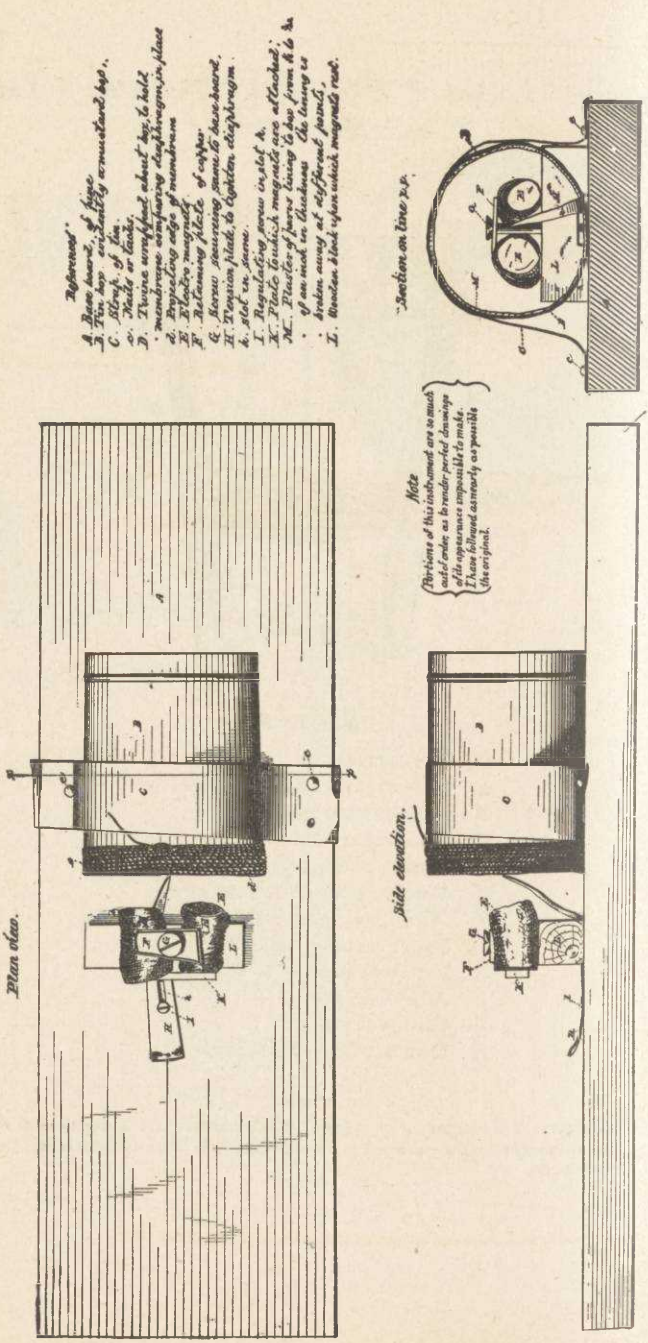
A. Glass tumbler.
a. Plaster-paris lining to same.
B. Wooden mouthpiece.
C. Diaphragm; tin.
D. Carbon holding cup; wood.
d. Metallic plate at bottom of *D*.
d'. Wire from plate *d* to adjusting posts.
E. Upper metallic plate in cup *D*.
e. Bar from plate *E* to diaphragm.
F. Adjusting posts.
G. Carbon in cup *D*.
H. Conductor to diaphragm.

NOTE.

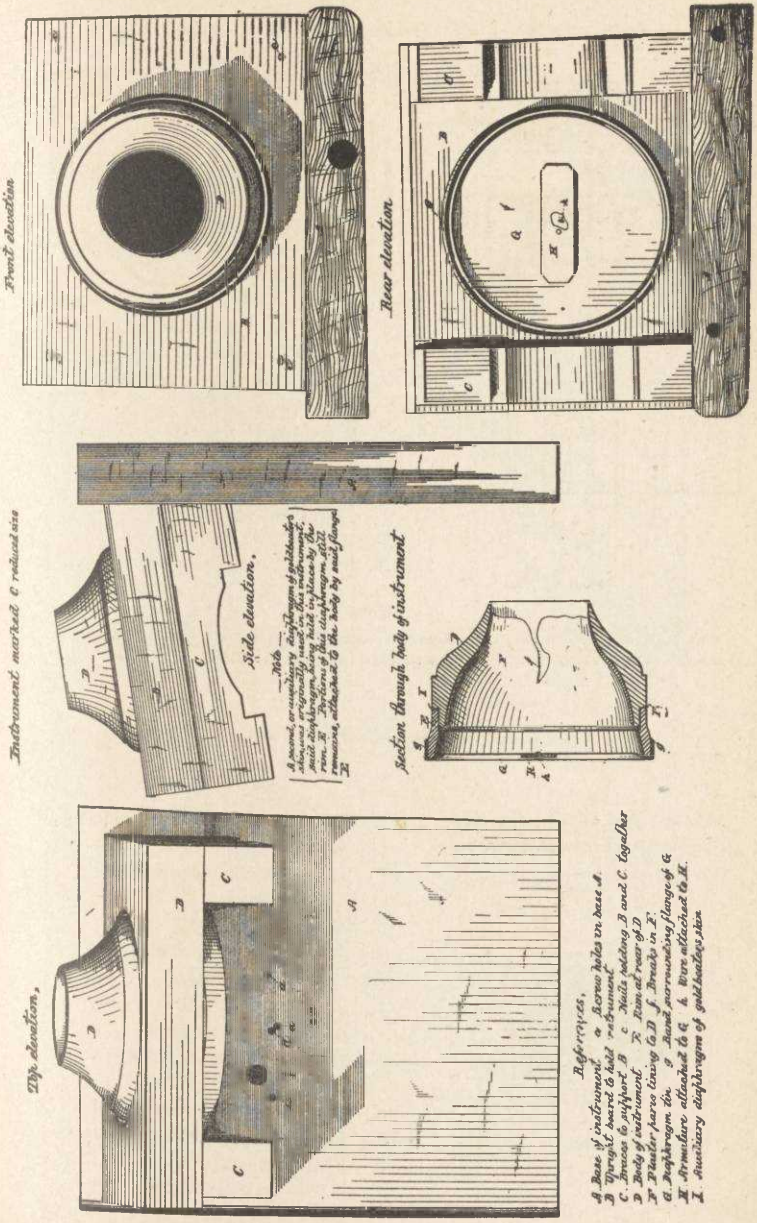
The conductor *H* is attached to the edge of the diaphragm; the opposite edge of the diaphragm is notched, to allow passage for a conducting wire (not on instrument) through the cap to the wire *d'*.

Statement of the Case.

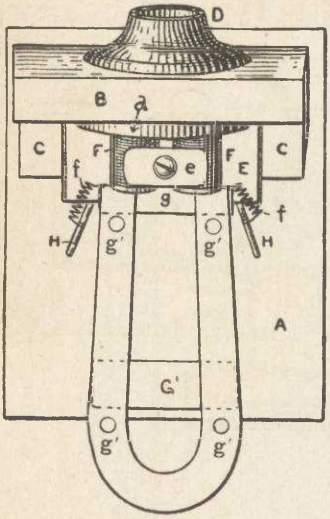
Instrument marked B. ½ size.



Statement of the Case.



Reproduction of Instrument C. Plan View.



REFERENCES.

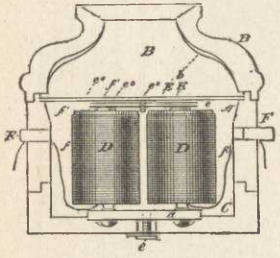
A. Base board.
B. Upright to hold body of instrument.
C. Supports of *B*.
D. Body of instrument.
d. Band on rim of *D* to hold diaphragm in place.
E. Block to support electro-magnets.
e. Plate to hold electro-magnets in place, brass.
e'. Screw to secure *e* and *E* to *A*.
F. Electro-magnets.
f. Wires to *F*.
G. Permanent magnet.
G'. Block to support *G*.
g. Paper to raise end of *G*.
g'. Rivets in *G*.
H. Studs in block *E* to receive wire.

NOTE.

This instrument is similar in all respects to original instrument marked *C* having armature attached to diaphragm, therefore I have thought two views sufficient in this case.

Instrument marked I. One form.

Longitudinal section showing electro-magnets and diaphragms.



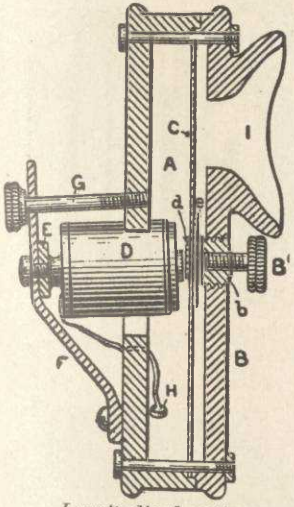
I. *Second State.* ½ *size.*

REFERENCES.

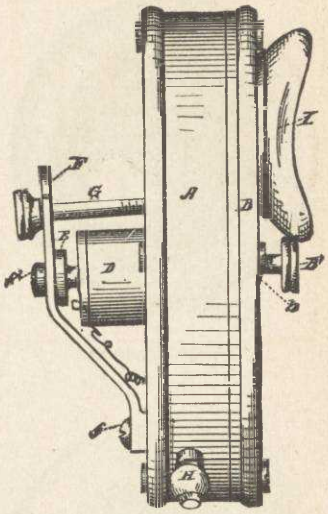
A. Body of instrument; black walnut.
B. Cap of instrument.
b. Plaster-paris lining to *B*.
C. Lower cap.
D. Electro-magnets.
d. Bar supporting magnets.
E. Upper diaphragm.
E'. Lower diaphragm.
e. Armature of magnets.
e'. Screw holding *d* in place.
e^2. Screw holding *E'* to *e*.
e^3. Paper ring between *E* and *E'*.
e^4. Paper ring or gasket above *E*.
F. Plugs to hold wire.
f. Wire or conductors.

Statement of the Case.

Instrument marked A. $\frac{1}{2}$ *size.*



Longitudinal section.

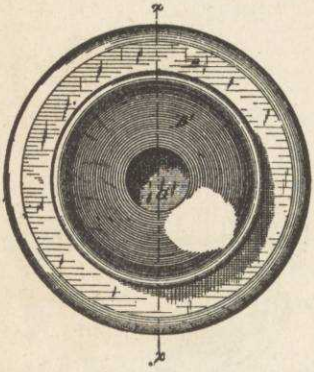


Side elevation.

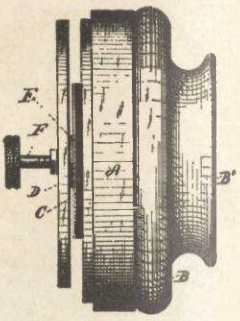
REFERENCES.

A. Case of black walnut.
B. Cover or cap to same.
B'. Adjusting screw for diaphragm; brass.
b. Screw block in cap through which *B'* passes.
C. Diaphragm; of thin black walnut.
c. Rubber cemented to *C*.
D. Electro-magnets.
d. Armature on diaphragm.
E. Plate connecting magnets.
F. Bracket to support magnets.
f. Screws securing same to case.
f^2. Screw holding plate *E* to bracket.
G. Adjusting screw for bracket.
H. Screw cups.
I. Mouth or ear piece.
i. Conductors or wires.

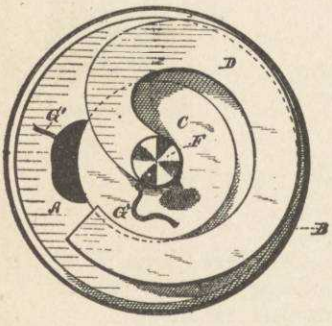
Instrument marked D.



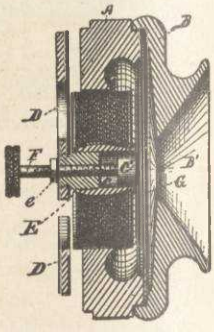
Front elevation.



Side elevation.



Rear Elevation.



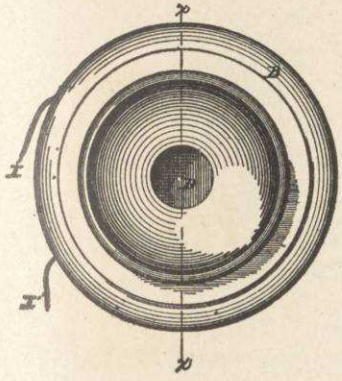
Section on line x x.

REFERENCES.

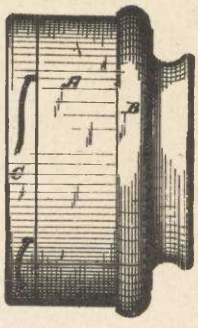
A. Body of instrument.
B. Cap of instrument.
B'. Mouthpiece.
C. Electro-magnet.
c. Hollow core of *C*; iron.
c'. Adjustable plug in *c*.
D. Permanent magnet.
E. Screw plug to support *D*.
e. Jam nut on adjusting screw.
F. Adjusting screw for *c'*.
G. Diaphragm tin.
G'. Conductors or wires.

Statement of the Case.

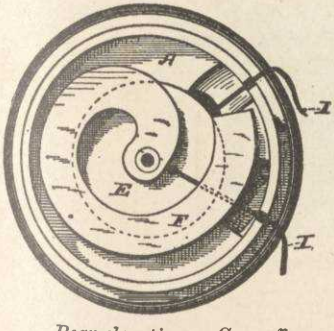
Instrument marked E. Full size.



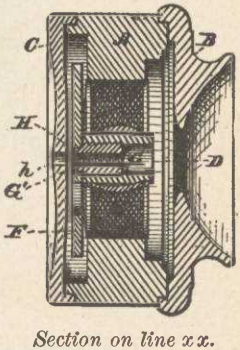
Front elevation.



Side elevation.



Rear elevation. Cap off.



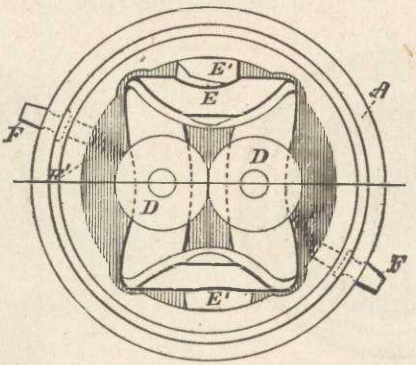
Section on line x x.

REFERENCES.

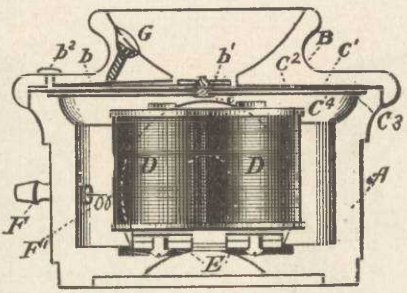
A. Body of instrument.
B. Cap of instrument.
C. Rear cap of instrument.
D. Diaphragm.
E. Electro-magnet.
F. Permanent magnet.
G. Hollow core of *E*; iron.
G'. Screw plug to support *F.*
H. Female screw in *G'.*
h. Aperture in *C.*
I. Wires.

Statement of the Case.

Instrument marked L. ½ size.



Top view. Cap and Diaphragm removed.



Section on line x x.

REFERENCES.

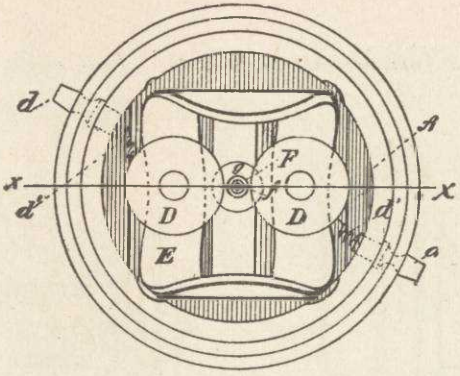
A. Body of instrument.	*B.* Cap of same.
b. Pressure spring.	*b'.* Metal block on spring.
b^2. Rivet in same.	*C.* Compound diaphragm; two part.
C'. Upper diaphragm.	C^4. Lower diaphragm.
C^2. Perforations in C'.	*c.* Rivet connecting C' and C^4.
C^3. Paper ring between C' and C^4.	*D.* Electro-magnets.
E. Permanent magnets.	*E'.* Wood wedges to hold *E* in place.
F. Binding posts.	*F'.* Wires from *D* to *F*.
G. Adjusting screw to spring *b*.	b^2. Rivet holding spring *b* to cap.

NOTE.

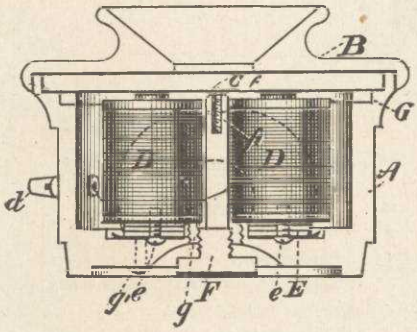
The upper diaphragm is made of copper, perforated; the lower one is made of iron.

Statement of the Case.

Instrument marked M.



Top view. Cap and diaphragm removed.



Longitudinal section on line x x. Top view.

REFERENCES.

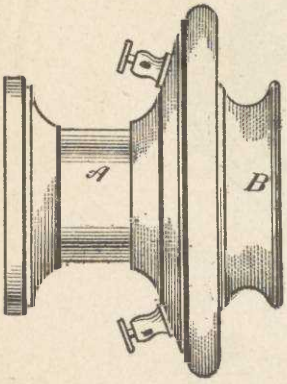
A. Body of instrument.
B. Cap of instrument.
C. Diaphragm.
D. Electro-magnets.
d. Binding posts.
d'. Wires.
E. Permanent magnet.
e. Screws connecting *E* to *D*.
F. Adjusting screw or post.
f. Recess for screw in end of *F*.
G. Rubber ring.
g. Nut in end of body *A* for adjusting post *F*.
g'. Screw to secure *E* to *A*.

NOTE.

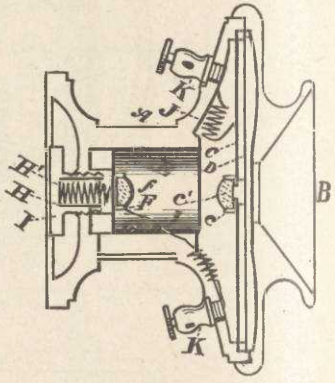
The magnet *E* is secured to the body of the instrument by screws, one of which is shown by dotted lines at *g'*.

At one time the diaphragm of this instrument was made of tin, and was rigidly attached to the post *F* by a screw which entered the recess *f* in the post *F*.

Instrument marked O. Full size.



Side elevation.



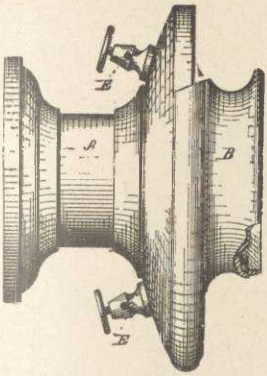
Longitudinal section.

REFERENCES.

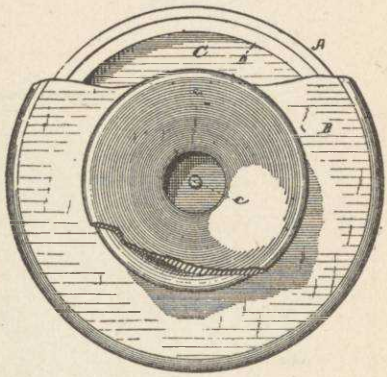
A. Body of instrument.
B. Cap of same.
C. Diaphragm.
c. Carbon cup on diaphragm; brass.
c'. Carbon ball in cup *c*.
D. Cardboard ring.
E. Recess for carbon holder.
F. Lower carbon cup; brass.
f. Carbon ball in same.
G. Wood ring.
H. Recess in adjusting screw.
H'. Spiral spring in same.
I. Screw; adjusting.
J. Wires or conductors.
K. Screw cups.

Statement of the Case.

Instrument marked G. Full size.



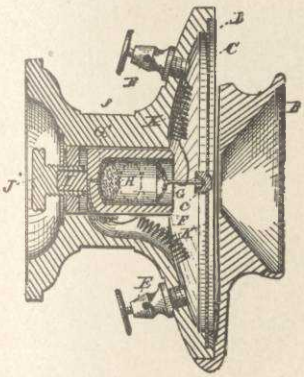
Side elevation.



Top plan view.

Fragment of cap.

Contact tips.

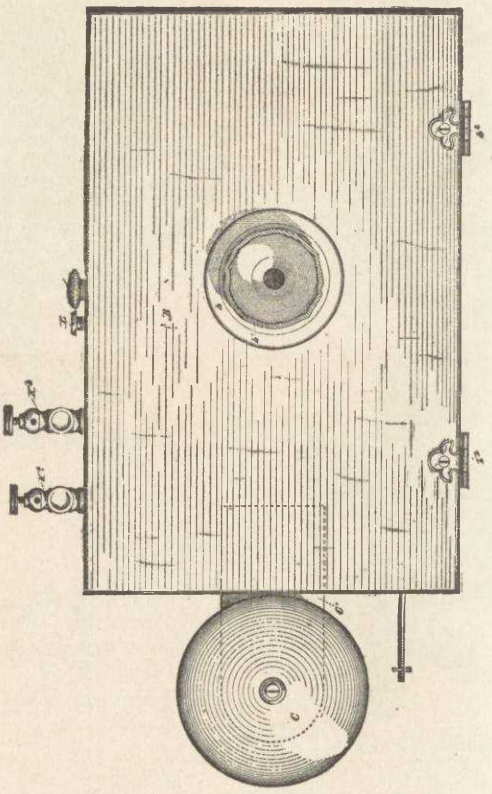


Longitudinal Section.

REFERENCES.

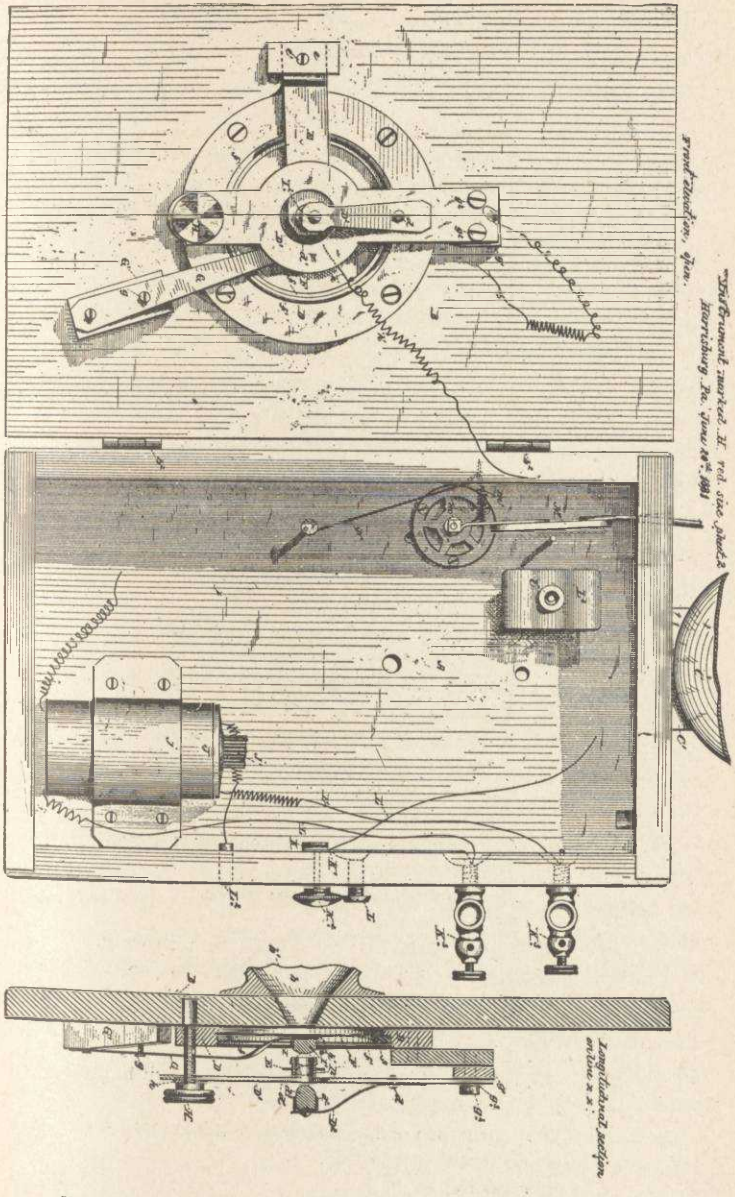
A. Body of instrument.
B. Cap of instrument.
C. Diaphragm.
c. Contact cup on diaphragm.
D. Paper ring.
E. Screw cups.
F. Carbon holder; wood.
GG'. Contact tips in holder.
H. Carbon ball.
I. Rubber spring in adjusting screw.
J. Adjusting screw.
K. Conductors.

Instrument marked H. ¼ size.



Elevation.

Statement of the Case.



Statement of the Case.

REFERENCES TO THE DRAWINGS OF INSTRUMENT H.

A. Body of instrument.
B. Door of instrument.
b. Mouthpiece.
b'. Break in *b*.
b^2. Hinges to door.
C. Bell to instrument.
C'. Support to bell.
D. Casting for supporting diaphragm; iron.
D'. Plate to support contact spring.
D^2. Contact spring.
d. Screw securing D^2 to *D'*.
d'. Aperture through *D'*.
d^2. Carbon holding cup; brass.
d^3. Carbon block in d^2.
E. Plate or bracket to hold intermediate carbon cup; brass
e. Block of wood on end of *E*.
e'. Screw securing *e* and *E* to *B*.
F. Diaphragm; corrugated iron.
f. Rubber ring.
f'. Wire to hold diaphragm in place.
G. Pressure spring for diaphragm.
G'. Block to which *G* is attached,
g. Adjusting screw to *G*.
g'. Wood insulator between *D* and *D'*.
g^2. Screw securing *D'* to *D*.
g^3. Rubber sleeve insulating *D'* from g^2.
H. Adjusting screw to *D'*.
h. Rubber sleeve insulating *D'* from *H*.
h'. Wire to diaphragm; conducting wire.
I. Carbon holding cup.
I'. Carbon ball in *I*.
I^2. Intermediate carbon holding tube; wood.
J. Induction coil.
j. Band holding *J* in place; brass.
j'. Wire core of *J*.
K. Signal plate. *K'*. Contact spring.
K^2. Key. K^3. Binding posts.
L. Screw to secure switch.
L'. Conductors.
L^2. Switch contacts.
L^3. Plate to hold electro-magnets for bell in place.
l. Bolt to plate L^3.
M. Armature connected with bell hammer.
m. Pivotal point of *M*.
m'. Spring to *M*.
N. Cord to increase power of spring *m'*.

Statement of the Case.

Dolbear's answer also made the following allegations.

"12. These defendants have never been concerned in the manufacture or sale of telephones embracing the inventions or either of them, or any substantial or material parts of either of them, described in either of the patents mentioned in the bill of complaint; but they admit the manufacture and use of telephones invented by the defendant Dolbear and described in his Letters Patent No. 239,742, dated April 5, 1881; No. 240,578, dated April 26, 1881; and aver that they have full right to manufacture, use, and sell such telephones, and that they are radically different in all substantial respects from any invention described in either of the said Bell patents. The transmitter used in the Dolbear telephone is in all material respects identical with the Reiss-Wright transmitter. It is a Reiss transmitter in a circuit of small resistance, having a helix as a part of it, with the transmitting core in that helix; the line is an open circuit, and is the first open circuit ever used for any practical purpose, and it was wholly unknown until Dolbear's discovery that such a line was capable of any practical use. The receiver is wholly new, wholly unlike any prior instrument, and operates upon a principle never before applied in any of the useful arts. The method invented by Dolbear, and the only method practised when his apparatus is used, is precisely the same as the Reiss-Wright method so far as concerns the use of the energy of the sound-waves to vary the electric current in a circuit of small resistance, and the use of the current so varied to vary the magnetic energy of the transmitter core; but is wholly new with Dolbear in all other respects, for the magnetic variations of the transmitter core must be converted into electric variations of many times greater electro-motive force than any ever before utilized for any practical purpose, and must be generated in a line whose resistance is practically infinite, and must be transformed directly into sound-waves. Dolbear's method is his own discovery and invention, is radically different from all other methods of transmitting sounds, except as to its first step, which is the same as that of the Reiss-Wright method, and is of the highest value and importance, inasmuch as it remedies

fully some very serious faults in the Bell method, which was the best known before Dolbear's discovery."

The following are copies of those two patents.

UNITED STATES PATENT OFFICE.

AMOS E. DOLBEAR, OF SOMERVILLE, MASSACHUSETTS.

APPARATUS FOR TRANSMITTING SOUND BY ELECTRICITY.

Specification forming part of Letters Patent No. 239,742, dated April 5, 1881. Application filed October 11, 1880. (Model.)

To all whom it may concern:

Be it known that I, AMOS E. DOLBEAR, of Somerville, in the County of Middlesex and State of Massachusetts, have invented a new Apparatus for Transmitting Sound by Electricity, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, making a part hereof, in which —

Figures 1 and 2 are two views of the best form of apparatus for practising my invention. Fig. 3 is a cross-section, enlarged, of the receiver shown in Fig. 1. Fig. 4 is a plan of one of the plates. Fig. 5 is a diagram illustrating the system.

My invention consists, mainly, in a new mode of transmitting articulate and other sounds by an open circuit.

It also consists in new apparatus for this purpose.

My receiver is based upon the well-known principle that one terminal of an open circuit will attract the other terminal when both are charged; and my invention consists, mainly, in the arrangement of the enlarged terminal of the secondary coil of an induction-coil so that it will be vibrated toward and from the other terminal by variations in the electric state of the coil, and in such a manner as to reproduce sound-vibrations of all qualities, including articulate speech, when the primary circuit of the induction-coil contains a suitable transmitter.

Another feature of my invention relates to the system of

Statement of the Case.

I. *Dolbear's Patent of April* 5, 1881.

(Model.) 2 Sheets—Sheet 1.

A. E. DOLBEAR.

Apparatus for Transmitting Sound by Electricity.

No. 239,742. Patented April 5, 1881.

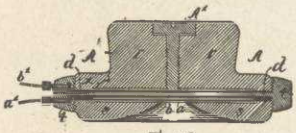


Fig. 3.

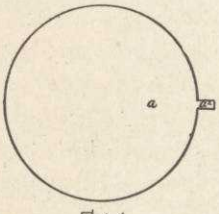


Fig. 4.

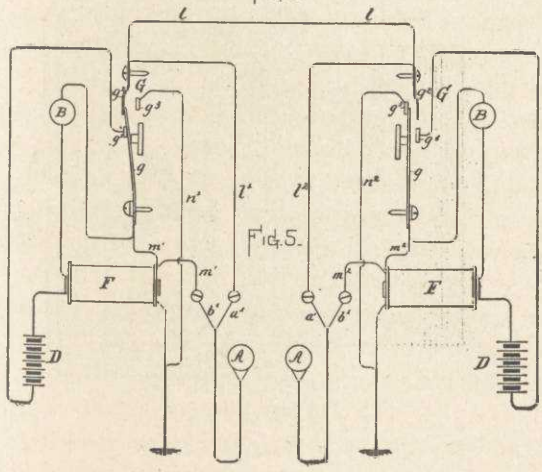


Fig. 5.

Statement of the Case.

(Model.) 2 Sheets—Sheet 1.

A. E. DOLBEAR.

Apparatus for Transmitting Sound by Electricity.

No. 239,742. Patented April 5, 1881.

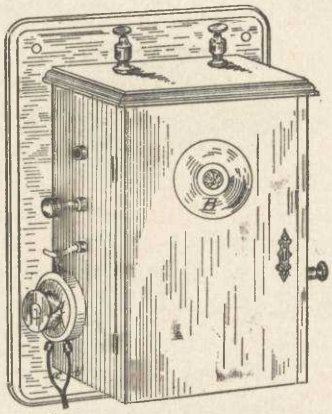


Fig. 1.

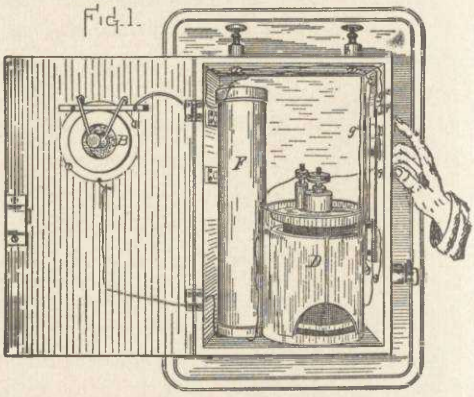


Fig. 2.

Statement of the Case.

connecting two or more receivers and two or more transmitters for practical use; and it consists in the combination of two induction-coils, two receivers, and two transmitters in a novel manner, fully described below.

The best form of my receiver is that shown in elevation in Fig. 1, and in cross-section in Fig. 3.

In Fig. 3 the case of the receiver A is shown as made up of three pieces — a back piece, *r*, an ear-piece, *s*, and an annular connecting-piece, *t*, for connecting the pieces *r* and *s* together.

a b are thin elastic plates, preferably of iron, forming terminals of the secondary coil of an induction-coil. These plates are securely fastened about the edges and brought very near to each other, but not in contact, a thin annulus, *d*, lying between them. This is best effected by forming a thin flange, *d*, on the interior of the connecting-piece, *t*, and placing the terminals *a b* on opposite sides of this flange. The ear-piece *s* of the case holds the terminal *a* in place with the proper tension around the edge to insure mass vibrations of that terminal. The terminal *b* is held in place by the back piece, *r*, of the case. Each of the plates *a* and *b* is formed with a small tongue, a^2, (see Fig. 4,) with which the binding-screws are connected, as shown.

As the section-plane in Fig. 3 will pass through but one of the binding-screws, (that for the wire *a'*,) the receiver is shown broken away at *x*, in order to show the binding-screw for the wire *b'*. Both are shown in Fig. 1. One of the binding-screws connects with plate *a*, the other with plate *b*. By the use of the tongues an even pressure around the whole edge of the plate is possible.

The adjustment of the instrument is effected by the screw A'; and this screw, by contact upon the back plate, *b*, prevents any vibrations of that plate which interfere with the proper vibrations of the front plate, *a*.

My system requires electricity of a very high electro-motive force, and this is best obtained by means of a secondary coil with a high resistance, the best results having been obtained from four or five thousand ohms of No. 36 copper wire.

Transmitters such as are in common use will answer with

my receiver; but the best form of transmitter is that shown in the drawings, (which is not here described, as it forms the subject of an application for a patent filed by me May 31, 1880.)

The main advantages of my new system over all others known to me are, that it is not appreciably affected by ordinary induced currents on the line, it has no magnet to deteriorate, the adjustment is more simple and is not affected by barometric and hygrometric variations, and it lacks the fine-wire helix of the common receiver, which is very liable to get out of repair. It is very efficient also on very long lines.

The best system for the practical use of my invention is illustrated in the diagram, Fig. 5, and the best form of apparatus is that shown in Figs. 1 and 2. In these figures, A represents the receivers, B the transmitters, D the batteries, F the induction-coils, and G switches.

The transmitter B and battery D are in the circuit with the primary coil of the induction coil F, and this circuit is completed, when the transmitter is to be used, by throwing over the member g of switch G until it makes contact with the member g', thereby completing the battery-circuit through the transmitter and primary coil. The electricity induced in the secondary coil affects the plates in the distant receiver by means of that branch of wire m' which extends from one end of the secondary coil to member g of switch G, members g and g^2 of switch G, the line-wire l, which is a continuation of member g^2 of switch G, wire l^2, which is a branch of line-wire l, receiver-wires a' b', wire m^2, members g g^3 of switch G, wire n^2, to earth, thus cutting out the receiver at the sending-station (on the left of the diagram) and the secondary coil on the right of the diagram.

When the sending-station is at the right of the diagram, the switch G at the right will be arranged as is the switch G at the left, and the receiver at the left is electrified by means of wire l', receiver-wires a' b', (at the left of the diagram,) wire m', members g g^3 of switch G, (at the left of the diagram,) wire n', to earth.

The switch G is composed of two springs, g g^2, and two

stops, $g' g^3$, arranged as shown, so that when spring g is brought in contact with stop g' it will also be in contact with spring g^2, and when spring g is in contact with stop g^3 it will be out of contact with both spring g^2 and stop g'. One end of the secondary coil on the left of the diagram is connected with spring g on the left of diagram by means of one branch of wire m' and with receiver-wire b' on the left of diagram by means of the other branch of wire m', and one end of the secondary coil on the right of the diagram is connected with spring g on the right of diagram by means of one branch of wire m^2, and with receiver-wire b' on the right of the diagram by means of the other branch of wire m^2.

I am aware of the apparatus mentioned as used by Dr. Wright in "Ferguson's Electricity," published by William and Robert Chambers, of London and Edinburgh, in 1867, pages 258 and 259, in which two sheets of paper silvered on one side were placed back to back and connected with the two ends of an induction-coil, the primary circuit of which contained a Reis transmitter; and I disclaim that apparatus. My receiver differs from it in that the sounds transmitted are reproduced by the mass vibrations of one of the terminals, while in the Wright receiving apparatus the sound produced was mainly, if not altogether, due to molecular motion, and not to mass vibrations. Moreover, Wright's sheets of silvered paper were so arranged that each would damp any mass vibrations of the other; and in his apparatus any slight mass vibrations, even if not wholly damped, would be necessarily so irregular as to be worthless as a means of reproducing sounds. The fact, also, that the mass vibrations of each sheet damped those of the other sheet would make all the mass vibrations worthless for this purpose.

I am also aware of English Patents No. 4934 of 1877 and No. 2396 of 1878, and disclaim all therein shown.

What I claim as my invention is —

1. The receiver above described, consisting of the plates $a\,b$, mounted in case $r\ s\ t$, and separated by the annulus d, in combination with induction-coil F, substantially as described.

2. In combination, two induction-coils, the primary of each

containing a battery, D, and transmitter B, and the secondary circuits, each containing receiver A, by means of switches G, consisting of members g g' g^2 g^3, whereby the receiver at the sending-station and coil at the receiving-station are switched out of the line, substantially as described.

AMOS E. DOLBEAR.

Witnesses:

W. A. COPELAND,

J. R. SNOW.

UNITED STATES PATENT OFFICE.

AMOS E. DOLBEAR, OF SOMERVILLE, MASSACHUSETTS.

MODE OF TRANSMITTING SOUND BY ELECTRICITY.

Specification forming part of Letters Patent No. 240,578, dated April 26, 1881. Application filed February 24, 1881. (Model.)

To all whom it may concern:

Be it known that I, AMOS E. DOLBEAR, of Somerville, in the county of Middlesex and State of Massachusetts, have invented a new Mode of Transmitting Sounds by Electricity, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, making a part hereof.

My invention consists, mainly, in a new mode of transmitting articulate and other sounds by an open circuit.

It also consists in new apparatus for this purpose.

My receiver is based upon the discovery that one terminal of an open circuit will attract and be attracted by a neighboring body when the terminal is charged.

Figure 1 shows two modifications of my receiver, in section, connected in circuit with a transmitter and induction-coil. Fig. 2 shows another modification of my receiver.

Three forms of my receiver are shown in the drawings. In each the casing is formed of three pieces, r being the back-piece, s the ear-piece, and t the connecting-piece which connects r and s together. The plate a of receiver I is a thin

Statement of the Case.

II. *Dolbear's Patent of April* 26, 1851.

(Model.)

A. E. DOLBEAR.

Mode of Transmitting Sound by Electricity.

No. 240,578. Patented April 26, 1881.

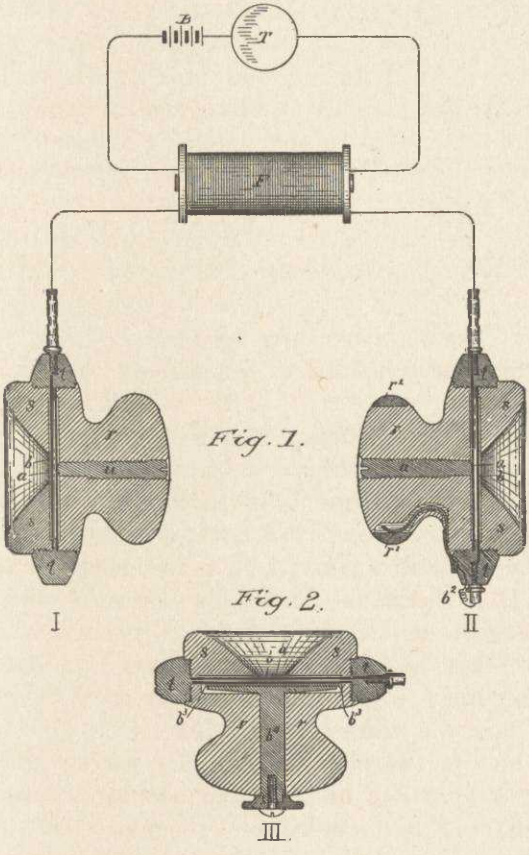


Fig. 1.

Fig. 2.

elastic disk, preferably of iron, the vibrations of which reproduce the sound which causes the diaphragm of the transmitter T to vibrate, T representing a transmitter of suitable construction, the form preferred being that shown in my application for a patent filed May 31, 1880, the transmitter T and the battery B being in circuit with the primary coil, as will be clear without further description.

In receiver I the plate *a* is one terminal of the secondary coil F, and any change in the electrical state of coil F varies the potential of this plate *a* in receiver I and causes it to attract plate *b*, which is mounted close to, but not in contact with, plate *a*; but as plate *b* in receiver I is so mounted that it cannot vibrate, plate *a* will vibrate as its potential varies. In receiver I the plate *b* and back-piece *r* and adjusting-screw *u* are all of metal.

It will be seen that neither the plate *b* nor back-piece *r* nor screw *u* of receiver I is connected to the coil F, but that only one terminal of coil F — viz., plate *a* — forms any part of the receiver I. The plate *b* may be made in one piece with back-piece *r*, but for purposes of adjustment is best made as shown.

The force of the attraction between the charged terminal *a* and any neighboring body is slight, unless the neighboring body be many times larger than the terminal and itself capable of being readily electrified, and for this reason, when the neighboring body is a plate, (as it is best made for purpose of adjustment,) it should be electrically connected with a larger body. Consequently the back-piece *r* of the case of receiver I is made of metal, and is in metallic contact with plate *b*. The neighboring body, which is attracted by plate *a* in receiver I, (being, in fact, the plate *b*, piece *r*, and screw *u*, which are all of metal and in metallic contact,) acts as one body in this receiver I; but, as will be clear, the back-piece *r*, plate *b*, and screw *u* may be one single piece of metal, and some other provision be made for the necessary adjustment.

In receiver I I the terminal *a* is mounted upon back-piece *r*, so that it cannot vibrate, and must therefore be insulated. Consequently the back-piece *r* is made of hard rubber. The

plate *b*, which is the neighboring body in receiver I I, is connected by the wire b^2 with a metal band, r^2, upon back-piece *r*, in order to increase the attractive force due to the electrification of a greater mass than plate *b*, and without interfering with the proper vibration of plate *b*, which, in receiver I I, vibrates as the potential of terminal *a* varies.

It will be clear that either of the plates *b* may be grounded, and thereby increase the electrification of these plates; but it is not necessary to ground either of them, and the audibility of the sounds reproduced is practically as great when the back-piece of the receiver is held in the hand as when the plates *b* are both grounded; and it makes no difference whatever whether both be grounded or only one. In other words, receiver I will reproduce articulate and other sounds, even if back-piece *r* be of hard rubber or other non-conductor and plate *b* be wholly disconnected from coil F, but the sounds reproduced are faint, although distinct and audible. The sounds will be louder if the piece *r* be of metal, as above described, or if the plate *b* or metallic piece *r* be grounded; but the difference is very slight, the sounds being practically as loud when the metal piece *r* is used as when the plate *b* is grounded. And so of receiver I I the sounds are distinct and audible when wire b^5 and metal band r^2 are omitted, but louder when metal band r^2 and wire b^2 are used, as shown, or when plate *b* of receiver I I is grounded. Moreover, the reproduction of sound by receiver I does not depend at all upon the grounding of any part of receiver I I, for receiver I will act with plate *b* of receiver I I not grounded precisely as it does when plate *b* of receiver I I is grounded, and receiver I I will act when plate *b* of receiver I is not grounded precisely as it acts when that plate of receiver I is grounded.

In my application filed October 31, 1880, I have described a receiver in which both the plates *a* and *b* are connected with the coil F, and I therefore disclaim in this application any receiver having both the plates connected with that coil, my present invention consisting in a receiver in which only one terminal of the coil is used, as above explained.

Instead of making plate *b* of metal and connecting it metal-

lically with back-piece r or band r^2, it may be made of any non-conductor, and in this case the increased loudness is produced by electrifying plate b before it is put in place; or, as shown in receiver I I I, where b is a rubber plate, and b^3 is a disk of felt fast to the hard-rubber support b^4, which is turned by the thumb and finger to electrify rubber plate b by friction.

What I claim as my invention is —

In combination, a primary coil in circuit with battery B and transmitter T, and a secondary coil with its enlarged terminal a mounted in case r s t, and arranged near plate b, plate b being also mounted in case r s t, but not connected with the secondary coil, all substantially as described.

AMOS E. DOLBEAR.

Witnesses:

J. E. MAYNADIER,

JOHN R. SNOW.

The answer of the Molecular Company further contained the following averment: "Defendants admit that the Molecular Telephone Company does intend and purpose when it shall have hereafter made the necessary arrangements to manufacture and use electric speaking telephone instruments of the character, kind and description substantially as described in said Letters Patent Nos. 228,824 and 228,825, but defendants allege that said Molecular Telephone Company has lawful right so to do. Defendants deny that the said instruments so described in said patents Nos. 228,824 and 228,825, and about to be used by defendant, the Molecular Telephone Company, are substantially like those described in either of said Bell patents, or that said instruments operate by or according to the method set forth in either of said Bell patents." No. 228,824 there referred to was granted to Robert M. Lockwood and Samuel H. Bartlett, June 15, 1880, for improvements in transmitters for telephones; and No. 228,825, to the same persons on the same date for an improvement in telephone receivers.

Statement of the Case.

This company and the Overland Company also relied upon a description of a magnet used in the Hughes printing telegraph, printed in a German work by Schellen, (of which the following is a translation,) as anticipating the invention covered by claim 5 in Bell's second patent.

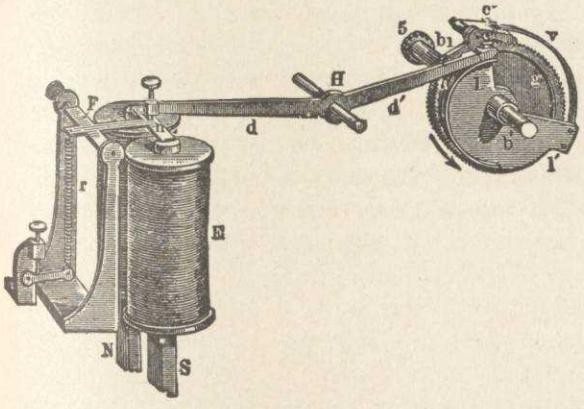


FIG. 375.

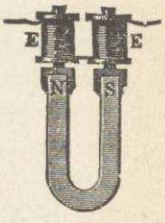


FIG. 376.

"The rapidity with which successive signals can be transmitted depends essentially upon the time required to charge and discharge the line. This time increases with the length and section of the conductor; moreover, as the discharge always occupies a longer interval than the charge, it follows that the signals will become indistinct at the receiving end if they are sent into the line before the discharge shall have been effected, as in this case the charge and discharge combine and cause a prolongation of the signals, causing them, as it were, to run together.

"It will be readily understood from this, that the armature of an electro-magnet or the needle of a galvanometer may be caused to move even before the current in the line has attained its permanent condition, and may in like manner return to a position of rest before the line is completely discharged.

"The armature of an ordinary electro-magnet is necessarily at a greater distance from its poles at the moment when it is

attracted than at the moment when it is released after having been attracted; consequently, the strength of current which will be required to attract the armature must be much greater than that which will permit it to be released or drawn away by the retracting spring. Therefore, a telegraphic signal which is to be produced by means of the armature of an electro-magnet, cannot be completed until the current has attained the necessary strength to cause it to be attracted, and has again sufficiently diminished to allow it to be drawn away by the tension of the spring. The more nearly the values of these two strengths of current can be made to approximate each other, the more rapidly successive signals may be received. Consequently, when the receiving instrument consists of an electro-magnet, the rapidity of signalling depends essentially upon the distance of the armature from its poles, and upon the amount of play which the latter is permitted to have. The less the distance through which the armature moves, the more rapidly the signals may be made to succeed each other. The degree of sensitiveness of an electro-magnetic instrument has but little influence upon the rapidity with which the signals may be made to succeed each other. For example, let us suppose that the current in the permanent condition of the line is equal to 25, but that the armature of the electro-magnet is attracted as soon as the current has gained a strength of 10, and that it falls off again as soon as, by the disconnection of the battery, the strength of the current has diminished to 7. A distinct signal will be obtained in this case whenever the current increases from 7 to 10 and decreases again to 7. If the apparatus is made less sensitive by increasing the tension of the spring, then the current must be increased in order to overcome this tension and attract the armature. If we suppose that this attraction takes place when the current has attained the strength of 15, and that the armature is released when the current is diminished to 12, the margin will be as great, if not greater, in the latter case, and therefore the less sensitive instrument will operate at least as rapidly as the other.

"In the arrangement of the electro-magnet which was in-

vented by Hughes, the action is entirely different. In its normal position of rest, the armature is held nearly in contact with a permanent magnet, the tension of the retracting spring being increased to an extent almost sufficient to overcome the attraction of the latter. When this permanent magnetism is diminished in the smallest degree by the action of the current, the armature instantly falls off, and is afterwards replaced in its original position, not by the action of the current, but by means of a mechanical device, which is set in action by the falling off of the armature. Therefore, the sooner the current attains sufficient strength to release the armature, the quicker the electro-magnet operates."

Dr. Van der Weyde was also relied upon as having anticipated some of the inventions claimed under the second patent.

The Clay Commercial Company contested the regularity of the formation of the Corporation complainant (the American Bell Telephone Company) and further made the following averments respecting the infringements of the Bell patents charged in the bill.

"This respondent denies it to be true, as in said bill alleged, that it has at the city of Philadelphia, or elsewhere, since the first day of February, in the year of 1884, or at any other time, made and used, or furnished to others to be used, or sold, or caused to be sold, electric speaking telephones, constructed and adapted for the transmission of articulate speech, by and according to the method described and claimed in said patent to the said Bell, No. 174,465, and embracing and embodying in one integral organization the alleged inventions and improvements, or material and substantial parts thereof, described and claimed in said patents to said Bell, No. 174,465 and No. 186,787 respectively. On the contrary, this respondent saith, that the telephones made, used and sold by it have been made and constructed under and in pursuance of certain Letters Patent of the United States, issued and granted, upon due application, and in conformity with law, unto one Henry Clay, as the first and original in-

ventor of said patented improvements respectively, and by him duly assigned to this respondent, which said Letters Patent are respectively of the dates, numbers, and titles, following; to wit, May 8, 1883, No. 277,112, for a new and useful improvement in Telephones; July 3, 1883, No. 280,351, for Switch-board for Telephones; July 3, 1883, No. 280,451, for Telephone Call-bell; July 3, 1883, No. 280,580, for Transmitter for Telephones; Nov. 6, 1883, No. 288,017, for Telephonic Transmitter. And the respondent saith, that the devices and methods of operation set forth in these said several Letters Patent, and used by the respondent, are not similar to, but are wholly different from, the devices described and claimed in the said Letters Patent of the said Bell, and are not violations or infringements of said Letters Patent, and do not embody or embrace the method, principle, operation, or construction therein or thereby set forth described and claimed."

The Overland Company in its answer made the following averment respecting Drawbaugh's invention: "Because the said Bell, in obtaining said patent, surreptitiously and unjustly obtained a patent for that which was in fact invented by another, to wit, said Daniel Drawbaugh, who was using reasonable diligence in adapting and perfecting the same:" and the following denial of infringement of Bell's patents: "This defendant on information and belief denies that it has ever infringed the said two patents numbered 174,465 and number 186,787, here in suit, or either of them, but further answering, says that it has become the owner, by assignments from Myron L. Baxter, of Aurora, Kane County, Illinois, of certain inventions in transmitting and receiving telephones described and shown in two several Letters Patent of the United States, granted to said Baxter, to wit, Letters Patent No. 277,198, dated May 8, 1883, for transmitting telephone, and Letters Patent No. 277,199, granted to said Baxter May 8, 1883, for receiving telephone; and that it has on a few occasions within two or three months last past privately, and merely for experimental and test purposes, operated a few of said Baxter instruments, but that it has never sold any of said

instruments, nor put them on sale, nor put them into use for gain or profit or for any business purpose, nor for any other purpose than merely to test their novelty, working capacity and value, and to determine whether any, and, if so, what, further improvements could be made upon them, and to ascertain to the satisfaction of its experts and counsel whether the said Baxter telephones infringe any lawful or valid patent or patents heretofore granted to others."

The proofs and record in a case known as the Dowd case, heard and adjudged in the Circuit Court of the United States for the District of Massachusetts, and in which the Western Union Telegraph Company, the American Speaking Telephone Company, and the Gold and Stock Company were the real parties defendant, and also the proofs and record in another case, known as the Spencer case, heard and adjudged in the same court, were imported into the Overland case. The Spencer case is reported 8 Fed. Rep. 509.

In the Dolbear case the final decree was "that the letters patent referred to in the complainants' bill, being letters patent of the United States, granted unto Alexander Graham Bell, No. 174,465, for improvement in telegraphy, dated March 7th, 1876, is a good and valid patent; and that the said Alexander Graham Bell was the original and first inventor of the improvement described and claimed therein; and that the said defendants have infringed the fifth claim of said patent and upon the exclusive rights of the complainants under the same," and a perpetual injunction was ordered. From this decree the respondents appealed. See 15 Fed. Rep. 438, for the opinion of Mr. Justice Gray in granting the preliminary injunction; and 17 Fed. Rep. 604, for the opinion of Judge Lowell on final hearing.

In the Molecular case, 23 Blatchford, 253, the final decree was "that the several letters patent upon which this suit is brought, viz.: Letters patent granted to Alexander Graham Bell for an improvement in telegraphy, dated March 7, 1876, and numbered No. 174,465, and letters patent granted to said Bell for an improvement in electric telegraphy numbered No. 186,787, and dated January 30th, 1877, are good and valid in

law; that the said Alexander Graham Bell was the original and first inventor of the inventions described in said several Letters Patent Nos. 174,465 and 186,787; that the title thereto, and to the inventions described and claimed therein, is vested in the complainants; and that the defendants have infringed the fifth claim of said letters patent No. 174,465, and the sixth, seventh, and eight claims of said Letters Patent No. 186,787, and the exclusive rights of the complainants under the same." The defendants appealed from the whole decree; and the complainants from it "in so far as it fails to adjudge that the fifth claim of Letters Patent No. 186,787 is good and valid in law, and that the defendants have infringed the same, and in so far as it fails to decree the relief prayed for in the bill of complaint herein under said fifth claim."

In the Clay commercial case it was decreed that the patents were valid, and that the defendants had "infringed the fifth claim of said Letters Patent, No. 174,465, and the third, fifth, sixth, seventh and eighth claims of said Letters Patent, No. 186,787, and the exclusive rights of the complainants under the same"; and a perpetual injunction was ordered. The defendants appealed from this decree.

In the Overland case the decree was that the patents were valid; "that the said Alexander Graham Bell was the original and first inventor of the inventions described in said several Letters Patent Nos. 174,465 and 186,787; that the title thereto, and to the inventions described and claimed therein, is vested in complainants; and that the defendants have infringed the fifth claim of said Letters Patent No. 174,465, and the third, fifth, sixth, seventh and eighth claims of said Letters Patent No. 186,787, and the exclusive rights of the complainants under the same;" and a perpetual injunction was ordered. The defendants appealed from this decree.

In the People's case (22 Blatchford, 531) the decree was "that the several letters patent, upon which this suit is brought, viz.: letters patent granted to Alexander Graham Bell for an improvement in telegraphy, dated March 7, 1876, and numbered No. 174,465, and letters patent granted to said Bell for an improvement in electric telegraphy, numbered

186,787, and dated January 30, 1877, are good and valid in law; that the said Alexander Graham Bell was the original and first inventor of the inventions described in said several Letters Patent, No. 174,465 and No. 186,787; that the title thereto and to the inventions described and claimed therein, is vested in the complainants; and that the defendants have infringed the fifth claim of said Letters Patent No. 174,465, and the fifth, sixth, and eighth claims of said Letters Patent No. 186,787, and the exclusive rights of the complainants under the same." Also see 22 Fed. Rep. 309; and 25 Fed. Rep. 725.

A perpetual injunction was ordered. The defendants appealed from this decree.

Mr. J. E. Maynadier for Dolbear. *Mr. Causten Browne* was with *Mr. Maynadier* on the brief.[1]

I. The Bell Patent of 1876 describes and claims but one method of transmitting vocal and other sounds, which method is: (1) convert the energy of sound-waves into (2) magnetic energy; convert that into (3) vibratory currents of electricity; convert those into (4) magnetic energy; and with that cause sound-waves; or, briefly (1) sound; (2) magnet; (3) currents; (4) magnet; (5) sound.

The undisputed prior methods are (*a*) The Speaking Tube; (1) sound; (2) vibrating in column; (3) sound. (*b*) The Mechanical Telephone; (1) sound; (2) vibration of line; (3) sound.

Bell carefully limits himself in his fifth claim to the *described apparatus;* that is, "to the apparatus for transmitting vocal or other sounds telegraphically, *as herein described* [that is to say] by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other

[1] In the oral argument counsel spoke in the following order: *Mr. Maynadier*, *Mr. Lowrey*, *Mr. Hill*, *Mr. Storrow*, *Mr. Ker*, *Mr. D. M. Dickinson*, *Mr. Edmunds*, *Mr. Storrow*, *Mr. E. N. Dickerson*, *Mr. Browne*, *Mr. Peckham*, *Mr. Crosby*, and *Mr. Hill*. The arguments of *Messrs. Maynadier*, *Lowrey*, *Storrow*, *Dickinson*, *Edmunds*, and *Dickerson* are reported from abstracts prepared by them for the use of the reporter.