describes, and that you use another process, a different process?

Mr. Hill: Yes, your Honor, if it be called a process.

MR. JUSTICE BRADLEY: There may be some dispute about words.

Mr. Hill: He called it a current. He sought to patent the magneto-electric current; and if we call that a process, then it is a process.

MR. JUSTICE BRADLEY: Then in regard to this last point, your position is that that portion of this patent which describes a varying resistance — a mode of obtaining variable resistance — and which claims it in the fourth claim, was not his invention, but was the invention of Mr. Gray and clandestinely obtained by him and inserted in his patent. That is your position on that?

Mr. Hill: That is my position on that.

MR. JUSTICE BRADLEY: You do not allege it as a ground for making void the whole patent and avoiding it, but as a matter of clandestine appropriation of another man's invention?

Mr. Hill: I think, your Honor, that we are entitled to use it to that extent. Whether it would go to the other extent or not is for the court to determine.

Mr. James J. Storrow for the American Bell Telephone Company. *Mr. E. N. Dickerson* and *Mr. Chauncey Smith*[1] were with him on the brief.

The charges of fraud in the Patent Office.—The Overland and Drawbaugh companies have made an elaborate argument, charging that the Patent Office files have been three times violated and three forgeries committed on them, and that these forgeries consist in writing into the Bell specification matter which they allege was learned by a dishonestly acquired knowledge of Elisha Gray's caveat. One defence pleaded is, that Bell unjustly and surreptitiously obtained his patent for that which

[1] It was arranged that Mr. Smith should take part in the oral argument. He fell ill during the progress of the hearing, and the part of the case which he intended to present was spoken to by his associates.

was in fact invented by Elisha Gray. The charge is competent under that issue, and must be passed upon.

They characterize the charge by the severest language, and they accompany it with protestations of the sense of responsibility under which it is made. They do not overstate the gravity of the crime if it has been committed, nor the awful responsibility which rests on them if the charge shall turn out to be false, and without justifiable foundation. But the brief filed in this court contains the first intimation ever made in this long litigation that such a charge was thought of. Under these circumstances, strained inferences, or the absence of specific disproof in the record, cannot establish so foul a crime; and our opponents pretend to nothing else to rest it upon. But fortunately there is that in the record which conclusively disproves it.

This charge, contained in the briefs signed by *Mr. Hill* and his partner, *Mr. Dixon*, is, that the application sworn to by Mr. Bell, January 20, 1876, and filed in the Patent Office February 14, 1876, contained no reference to the liquid transmitter, but was limited to a magneto telephone, operating, they say, by what they call a to-and-fro or wiggle-waggle current. They charge that within four days after the application was filed, Mr. Bell's solicitors obtained dishonest knowledge of the contents of Gray's caveat, which described a liquid transmitter; that thereupon, they, in Mr. Bell's absence, and without his knowledge, stole Bell's application from the Patent Office, dishonestly rewrote it or part of it, inserting a description of a liquid transmitter learned from Gray's caveat, adding a claim based thereon, and dishonestly replaced in the files the application with these interpolated sheets.

To understand the relation of the liquid transmitter part to the rest of the patent it should be stated that Mr. Bell first invented the "method" specifically described in his patent and in his fifth claim, and devised the "magneto" form of speaking telephone to embody it. They confess that his original application, by Fig. 7 and the letter press connected with it, described this magneto telephone and the novel method or principle by which it transmits speech, and contained his present

fifth claim which is in terms for that "method." No attack is made on his originality as regards this, and the fifth claim is the only claim sued on. The liquid transmitter part of this patent is the sole subject of this charge. That part describes an alternative, or, if you please, an improved type of apparatus embodying the same "method" and principle, and claim 4 is a special claim for this particular modification. But the liquid transmitter as a form, is too inconvenient for practical use. As matter of law it is not needed to sustain the broad claim 5. The only use we make of its description in the patent is to base upon it the merely cumulative argument that the existence of an actual intention not to limit claim 5 to the magneto form is not an open question, because the patent itself points out that there are alternative forms.

I return now to the charge that the liquid transmitter part was copied from Gray's caveat — for that is the extent of the charge.

Gray's description calls for the use of water or some liquid of "high" electrical resistance. The description in the Bell patent specifies "mercury or some other liquid;" mercury is a liquid of "low" electrical resistance. They say that the suggestion of mercury, or any "low" resistance liquid, involves an electrical impossibility or absurdity proving that a good electrician like Mr. Bell never could have written that description, and that it must have been written in by some ignorant person — they say by his solicitors — presumably ignorant of electrical science, and without his knowledge. How or why a copyist could have made such a change they do not, however, and cannot, suggest. They say that this interpolation could not have been made except between February 14 and 19, 1876, because two independent official records in the Patent Office show that these clauses were in the application on February 19; and that is true. They agree that this proves that Mr. Bell could not have committed the alleged crime, for he was not in Washington during the whole of that month until February 26th. They aver that when he came to Washington, on February 26, he was informed of the forgery his solicitors had committed in his behalf, and joyfully ratified it; that he then

went to the examiner's room to look over the application; by permission of the examiner sat down to make in pencil various purely verbal amendments of no importance; and that while making these he perceived that his solicitors had made their interpolations so clumsily that they had left in a part of the old specification which was specifically inconsistent with the liquid transmitter clauses; that he thereupon drew his pencil through the objectionable words, and, in pencil, interlined others consistent with the liquid transmitter, and wrote many other pencil emendations, thirty-eight in all, making the paper read as it now does in the patent; and that the specification issued in the patent is this twice-forged and corrupted paper. That is their story, and each one of these steps is a necessary part of it, constructed to account for some existing fact which they find they cannot dispute.

They are met at once with the fact that the original application now in the files of the Office, a photograph of which, taken in October, 1885, is in the case, is exactly, letter for letter, like the specification in the patent which was printed and left the Office March 7, 1876; and that that original paper now on file has every word fair-written in ink, without any sign or indication of any pencil interlineation whatever, and without any place where any interlineation or change could have been made. To this they reply that the present clean paper is itself a forgery, — for if it is not, it absolutely destroys their charge of interlineations. They say that the Bell company in April, 1879, procured a certified copy which showed all these mutilations, and that soon afterwards Mr. Bell, or some one in his interest cognizant of what they aver had been done, perceiving that its condition would disclose the alleged fraud, stole the supposed interlined and altered specification as it then existed in the files, rewrote it, making a fair, clean paper in ink, and placed this in the files as if it were the original; and they say that it is because of this third forgery that the paper in the files reads to-day in fair writing like the specification issued by the Office in March, 1876.

They are again met by certain facts. One is that the employment of some kind of a variable resistance (a liquid

transmitter is one well-known instance of variable resistance) was in Mr. Bell's mind as a device to be employed in the transmitter as early as May 4, 1875, nine months before the Gray caveat existed, and was disclosed by him in a letter of that date which is in the record. They are also met by the fact that the character and structure of Mr. Bell's liquid transmitter is as different from that of the Gray caveat as one liquid transmitter can be from another; and by the further fact that, instead of the use of mercury being an electrical absurdity, it is a fact proved in the case that Mr. Bell actually made a mercury transmitter, and that it talked, while there is no evidence whatever even tending to show that the water transmitter of Gray ever did or ever could talk, the only proof touching the subject being that the one he tried to make in the summer of 1876 would not talk at all. Thus the idea of employing a variable resistance transmitter was expressed by Mr. Bell in writing nine months before Gray thought of the subject, and the form in which Mr. Bell embodied it was so strikingly different from that of Gray as of itself to prove originality and disprove copying. So Bell already had the idea, and did not copy the form. They are met by the further fact, stated in their brief, that the file of the Bell patent was, in 1879, well known and had been examined by many people. Indeed it is an essential part of their hypothesis that it was read and handled so much that many pencil marks which they aver were there in 1876, and were not there when a certain certified copy was made in April, 1879, had been entirely obliterated by handling. According to their story, there were thirty-eight different passages altered in pencil. It is impossible that such a peculiar and well-known paper in such an important case could have been at that time replaced by a clean copy, all written in ink, without at once attracting the attention of the official in charge of the file, and all of those who had occasion to examine it; and it is certain that any man must have known that such a substitution could not be concealed, but would at once draw attention, and therefore that no man would have attempted it.

These considerations, the infamous character of the act

alleged, and the fact that no evidence supports it, dispose of the charge thus tardily made.

They say, however, that one piece of evidence does support it. They refer to a certain certified copy of the application procured by the Bell Company from the Patent Office April 10, 1879, soon afterwards filed in the Circuit Court at Boston and printed in the summer of that year in the Dowd case, the printed record of which was, by stipulation and for convenience, introduced into or reprinted in the other cases before this court. They aver that that certified copy (here called the Boston exhibit) had thirty-eight erasures or interlineations, indicated, as there printed, by parenthesis marks or by redundant words on the printed page; and they allege that that paper shows that when that certified copy was made, on April 10, 1879, the original was in that interlined and altered condition (because the habit of the Patent Office in making a copy of a specification is to make it, as near as may be, in facsimile) and that the clean paper now in the files must therefore be a forgery. That is the ground, and the only specific proof on which they assert this forgery. One answer to that is that this copy of 1879 was originally put in evidence by Mr. Bell himself, as part of his own deposition, and it is impossible to believe that he would have voluntarily put into the case conclusive evidence of these interlineations just at a time when, according to our opponents' story, he and his associates were so terrified at the prospect of the alleged interlineations being known that they were perpetrating a third forgery to conceal them. They do not produce the original certified copy of April 10, 1879, but rely on what they assume to be a correctly printed copy of it in the printed transcript.

Our opponents point to another circumstance. It appears that in the fall of 1875 Mr. Bell prepared several copies of an early draft of the specification in the condition in which it then was. One of these copies so written by Mr. Bell was afterwards much altered and amended by him; the changes were completed about the middle of January, 1876, when this particular paper went to Washington; and a fair copy of it as amended, made in his solicitors' office at Washington, became

the application sworn to in Boston, January 20, and filed February 14, 1876. Another copy of the early draft went to Mr. George Brown of Toronto, who, on January 25, 1876, took it to England with several other specifications of Mr. Bell, intending to take English patents on all of them. Mr. Brown did not take out any English patents whatever, but brought back the papers with him, and in the fall of 1878 Mr. Bell obtained them from him and himself offered them in evidence. The specification as it now appears in the files, and the patent as issued in 1876 (both exactly alike), differ from the George Brown specification, in that they contain the liquid transmitter clauses and also vary in thirty-seven or thirty-eight other passages from the George Brown specification. Attention was not called in taking testimony, nor at the trial below, to these differences, but Mr. Bell, in giving a history of his work, stated that he repeatedly corrected and altered and improved his American specification up to the last moment, and did not complete his amendments until just as he sent it to Washington in the middle of January, 1876. Nor is there any specific testimony as to when he last touched pen to the George Brown specification. The proof is that he prepared it in October and November, 1875, and that on December 29, in pursuance of a previous verbal understanding of September, 1875, he made a contract with George Brown which required him to at once furnish the specifications. He testified that he began to prepare the specification for Brown early in October, 1875, and that he furnished it to Mr. Brown between the date of that contract and January 25, 1876, when Mr. Brown sailed for England. He did not remember during which part of that period the specifications were furnished, but the just inference is that it was a day or two after the contract, because they had been prepared some months previously in order to be furnished, and he agreed to furnish them at once, as Mr. Brown was expecting to immediately sail for England, and he returned from Toronto to Boston instantly upon the execution of the contract. There was nothing in the case which seemed to make the precise date material. The fair conclusion from the testimony is that immediately after signing the Brown contract

of December 29, 1875, he furnished the specifications which he had had on hand two months for that purpose just in the condition in which they had been, — a rough paper with many corrections and interlineations, which is the condition of the paper, now an exhibit in the case; that he continued to improve and amend the American specification, and, after he had parted with the Brown one, during the ensuing two weeks before the American specification went to Washington, wrote the liquid transmitter clause into it. This is corroborated by the fact that a sworn paper filed by him in the Patent Office in 1878, states under oath that the precise form known as the liquid transmitter was devised by him in the first half of January, 1876, though the idea of employing some form of variable resistance as distinguished from the magneto transmitter had been expressed by him in a letter of May 4, 1875. The date thus stated for the liquid invention is between the time when we believe he furnished the drafts to Mr. Brown, and the day when he sent his last corrected specification to the solicitor at Washington. It is impossible therefore to draw from the George Brown papers any inference unfavorable to Mr. Bell.

To support their charges, our opponents have really but one piece of evidence, and that they rely on and have argued at great length in their brief. The printed copy of the Bell file found in the printed Dowd record, and reprinted in some of the other cases, contains thirty-eight instances of what appear to be interlineations or cancellations.

Thus one paragraph as there printed reads: "The duration of the sound may be used (made) to indicate (signify) the dot or dash of the Morse alphabet, and thus a telegraphic despatch may be indicated (can be transmitted) by alternately interrupting and renewing the sound."

They argue that this paragraph was written in the application as filed with one set of the synonymous words, *e.g.* "signify," regularly written in ink; that afterwards that word was cancelled by drawing a pencil mark through it, and the other word, "indicate," interlined in pencil; and that the printer printed both in the same line. There are thirty-eight passages which they point out as containing such changes. Among

such supposed interlineations or alterations, generally indicated (but not always correctly) by parenthesis marks in the printed copy, are the clauses about the liquid transmitter, which are included in parenthesis in that Dowd print. Now, it is found in every one of these cases of a duplication of words, *e.g.* "indicate (signify)" etc., that one of the two words is the word of the patent as issued, and the other word is the word of the older George Brown specification. Our opponents say that this arose in the following way: That the application filed by Mr. Bell February 14, 1876, was an ink copy of the George Brown specification; that after it was filed he dishonestly altered it by pencil cancellation and interpolation, between February 27 and March 3, and that this altered copy became the patent; that the cancelling marks have been rubbed out by constant handling of the paper before April, 1879 (and it is an essential part of their hypothesis that the alleged cancelling marks were thus accidentally obliterated), while by some curious freak of nature every one of the interlineations remained, so that both sets of words appeared in the certified copy made April 10, 1879. From this they argue that the application as filed was a copy of the George Brown specification, and did not have the liquid transmitter part in it, and that that was interpolated afterwards in the dishonest and criminal manner alleged.

It may be assumed that the printed paper in the Dowd record which contains the duplication of words, one of which in each case is that of the George Brown specification, and the other of which in each case is that of the patent, could not have come into existence except by the act of some one who had both sets of words before him or in his mind, and was interlining one set into a paper which originally had the other. But whether the person had the George Brown form, and interlined the words of the patent, or whether he had the form of the patent and interlined the George Brown words, the paper would equally have the same two sets. The original paper itself, however, would show which he was doing. If he had a paper ink-written in the words of the patent, and was interlining the George Brown words, so as to show

them also, then, in the actual paper, the words of the patent would be found regularly fair-written in ink, with the George Brown words interlined; if he were writing with pencil on a fair copy of the George Brown draft, to make it read like the patent, then the George Brown words would be fair-written in ink and the words of the patent interlined. Now, the copy, *as printed*, does not show in which of these two ways the duplication occurred. The original exhibit itself, filed in Boston, would show the fact, but they do not exhibit that to the court.

The truth about it is simply this: The certified copy of the application, procured April 10, 1879, by the Bell company, was a fair-written copy in ink, and that ink writing reads letter for letter, word for word, line for line, and page for page (it is the custom in the Patent Office to copy applications in such fac-simile) like the application now on file, a photograph of which is furnished to the court. Counsel for the Bell company, in preparing the Dowd case in 1879, took that certified copy, which was procured for his office use, and, with the George Brown specification beside it, proceeded to compare the two, to learn for himself the progress between November or December, 1875, when the one was completed, and January 20, 1876, when the other was sworn to. For greater convenience, he made memoranda of the differences of the two in pencil on the certified copy itself, by generally making pencil parenthesis marks around the words in the certified copy which were not in, or had no corresponding phrases in, the George Brown draft, and interlining in pencil, on the ink-written certified copy, George Brown words which were not in the certified copy. Subsequently, that certified copy was put in evidence in the Dowd case, without remembering to rub out the pencil marks. It was printed in the Dowd case, — not under the supervision of counsel, but by some one else, who printed the pencil marks and all, and the printer added some other parenthesis marks, according to his own notions. As the Dowd case was not argued, the attention of counsel was not called to the accident. Several hundred pages of the Dowd printed record were put into the Drawbaugh case and

other later cases for convenience, by stipulation, these among them, and were there reprinted, and the accidental error still escaped notice. In February, 1886, however, counsel for the Bell company noticed the error, and at once wrote to the counsel for the Drawbaugh company that that paper was incorrectly printed in the Dowd record, saying, "there were some pencil marks on the copy that went to the printer in the Dowd case, with brackets, etc., and that got reproduced in your case." He asked that a new and correct copy be substituted and printed. This was agreed to in writing, a correct copy was printed by the defendants, and is a part of the record, and a further stipulation was made that the court, for greater accuracy, might refer to the originals.[1] The original

[1] The correspondence between Mr. Storrow, counsel of the Bell company, and Mr. Andrews, counsel of the Drawbaugh company contained the following:

(*Bell counsel to Drawbaugh counsel.*)

"NEW ORLEANS, February 18, 1886.

"*Dear Sir*, — I want to make one correction in the original record of the Drawbaugh case. The file of the Bell patent is in evidence, but the copy of the application is not printed correctly. I believe there are no errors in it which are of any importance, but there were some pencil marks on the copy that went to the printer in the Dowd case, with brackets, etc., and that got reproduced in your case. There has been lately printed a very careful and accurate copy from a photograph of the original papers, and I directed two copies of this to be sent to you from Boston. I propose to you to substitute that for the print that now exists among our exhibits in the Drawbaugh record, and also to stipulate as inclosed that the court on appeal may, if it desires, refer to a certified copy made by the Patent Office, for greater accuracy."

(*Reply — Drawbaugh counsel to Bell counsel.*)

"NEW YORK, March 25, 1886.

"*Dear Sir*, — Herewith please find stipulation that parties may, on the appeal, refer to a copy of the Bell patent on file, certified to by the Patent Office."

(*Enclosure.*)

"It is agreed that upon the appeal of this case the Supreme Court may, if it desires, refer to a copy of the Bell patent and file made and certified by the Patent Office. L. HILL, Sol'r for Def'ts."

Similar correspondence took place with the counsel for the Overland company, and a corrected copy was reprinted in that case also.

of this paper is part of the files of the Dowd case, in the Circuit Court in Boston, where it has been since 1879. The clerk of that court is in this court room, with the paper in his possession, and I ask that he hand it to the court, and that the court examine it.

[A discussion ensued, and the court decided that under the stipulation this could be done, and the clerk handed the original to the Chief Justice.]

That paper, now in the hands of the court, shows this state of facts. It is asserted by my opponents as the basis of their hypothesis, — and it is true, — that the ink-written part of that Boston exhibit is a fac-simile of all that was in ink in the original application. Now what was in ink in that original application? It appears that the ink-written part of that Boston exhibit is in the exact words of the patent as issued, and that its ink-written part is exactly the same as the paper to-day in the files of the Patent Office. Its ink part is a fac-simile of that paper, — the same words, the same words in each line, the same lines on each page. Particularly the words which are in the patent, in the application on file at the Patent Office, and in the Boston exhibit, but are not in the George Brown draft, including the passage about the liquid transmitter, are fair-written in ink in the Boston exhibit, and generally (in the original Boston exhibit) have parenthesis marks around them in pencil. The words of the George Brown draft, which are not in the patent, are not in ink in the Boston exhibit, but are interlined in it with pencil. And the Dowd print is a copy of this paper, ink, pencil, and all, with a few typographical errors, but with the words printed consecutively, so that it does not show what is interlined and what is fair-written.

This will be better understood from examination of one passage by way of illustration.

From the Boston exhibit as printed in the Dowd case:

"The duration of the sound may be used (made) to indicate (signify) the dot or dash of the Morse alphabet, and thus a telegraphic despatch may be indicated (can be transmitted) by alternately interrupting and renewing the sound."

Fac-simile from the Boston exhibit.

The duration of the sound may be made
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.

The words regularly written in the line are all in ink, and are the words of the patent. The words interlined are in pencil, and are the George Brown words. The parenthesis marks are in pencil and inclose words which are not in the George Brown draft. The paper itself absolutely proves, therefore, that the original specification was written in ink just as it now stands in the Patent Office, and as it was copied into the patent March 7, 1876.

The stress of the argument for the Drawbaugh and Overland companies on this point turned on one particular passage. The George Brown draft, made in November, 1875, described various instruments which would produce the patented undulations, but all of them did it by "inductive" action. The patent as issued states that they can also be produced by varying the resistance, which is not an "inductive" action. One passage in the George Brown draft reads:

"There are many ways of producing undulatory currents of electricity, but all of them depend for effect upon the vibrations or motions of bodies capable of inductive action."

Our opponents argue, and rightly, that an inventor who had described the variable resistance liquid transmitter contrivance in his specification would not write in it that "all" of the contrivances depended on "inductive" action.

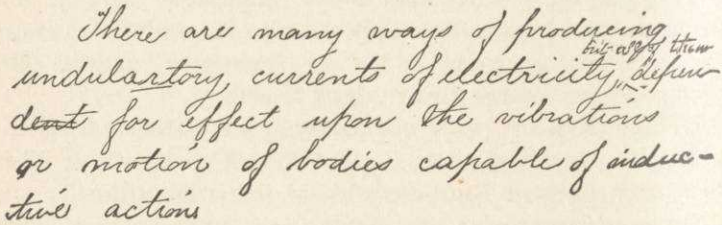
The *patent*, on the other hand, reads:

"There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action."

That statement is true. It is followed by the examples of "inductive" contrivances which are named in the George Brown draft and which are "dependent" on inductive action, and, after them, there follows in the *patent* the description of the variable resistance liquid contrivance, which does not depend upon inductive action.

Our opponents argue that the change in this passage from "all of them depend," found in the November, 1875, George Brown draft, to "dependent," the words of the patent, marks the instant when Mr. Bell put the liquid transmitter into his specification. We agree with them. When was it?

They say that the application, filed February 14, was in the George Brown language: that between February 15 and 19, Mr. Bell's solicitors stole the liquid transmitter from Gray's caveat and wrote it into Bell's application, but did not observe this telltale statement on another page of the paper. But Bell, they say, re-reading the dishonest specification on February 27, perceived this proof of the dishonest interpolation, and, in pencil, changed "all of which depend" to "dependent." The Dowd print again does not show what is in ink and what is interlined in pencil, but the original Boston exhibit does. Here is a fac-simile from it, the interlineation and the cancellation of "*ent*" being in pencil:



Their contention is that what is *in ink* in the Boston exhibit constituted the application before Mr. Bell could have dishonestly touched it, and exactly as it remained on April 10, 1879.[1]

[1] Brief of Mr. Hill, p. 101.

" . . . The 1879 certified copy showed that the original Patent Office specification *was full* of erasures and interlineations which are faithfully reproduced for the most part in the 1879 copy."

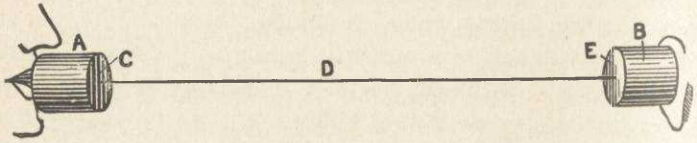
They are right in that. So the very paper to which they appeal proves upon their own theory, when the original is looked at, that this telltale phrase which establishes the contemporaneous presence of the liquid transmitter clause was in the application as filed February 14, 1876, and was written before the Gray caveat existed, and was not interlined by Mr. Bell afterwards. The whole story of forgery by the solicitors and interpolation by Mr. Bell is disproved the moment the paper they rely on is looked at. Their infamous charge of fraud is not only false, but it is based on the errors of a printed copy after they had been warned, and had agreed, that that copy was a misprint and contained those very errors in printing.

The case at large. — Eleven years ago Mr. Bell asserted that he was the first inventor of the electric speaking telephone and claimed for his invention and for his patent the same breadth and scope we insist upon. The Patent Office and many Circuit Courts have examined those claims in the most exhaustive and protracted litigation to which any patent ever gave rise. All his claims have invariably been sustained. Every tribunal in the Patent Office, and twelve judges in six circuits have entered judgment in his favor. The record before this court consists of twenty-two printed volumes, containing all the testimony in all the cases ever tried under this patent which have reached a final hearing. Some of these cases — as the Spencer and Dowd cases — have not been appealed, but their whole record has been put by our opponents, with our consent, into other cases which have been appealed. In the same way, substantially all the evidence that the Patent Office passed upon in the interferences between Mr. Bell and various claimants of his inventions is in these records. All these courts and the Patent Office, and every tribunal anywhere in Christendom before whom the question has come whether Mr. Bell was the first inventor of the speaking tele-

The brief of his partner, Mr. Dixon, pp. 217–230, is also based on the assumption that the 1879 copy is a fac-simile of the actual paper thus existing on the files in respect of what is fair-written in ink and what is interlined in pencil.

phone, both in this country and abroad, has always decided that he was.

What the Electric Speaking Telephone is. — Here is a string telephone, a contrivance at least two hundred years old. It consists of two tin tubes, A and B, generally two or three inches long, each with bladders, C and E, stretched over one end. A string, D, has one end passed through the centre of each diaphragm, and tied with a knot inside. The instruments are drawn apart until the string is stretched tight. A person speaks into one tube, as A, and the listener who places the other tube, B, to his ear, hears what is said. The sound vibrations produced by the voice in A cause its diaphragm to copy their vibratory motions. As this diaphragm C in its vibrations tugs at or relaxes the pull of the connecting string D, it pulls and relaxes alternately the diaphragm E, and thus compels it to copy the motions of the diaphragm C. The



diaphragm E, thus vibrating to and fro, throws the air inside of the tube B into the same vibrations, and those vibratory motions in the air strike upon the drum of the listener's ear. As the sensation of sound is due to vibrations in the air, and as the difference between one sensation and another is due to the difference in vibrations, it follows, and is a well-known fact, that the utterance of one word produces one particular set of vibrations, which, falling on the ear of the listener, produce the sensation of that word, and the utterance of another word produces a different set of air vibrations which, acting on the listener's ear, excite in him the sensation of that different word. In the case of the string telephone the vibrations excited in the air by the word "yes" in A cause similar vibrations to take place in the diaphragm C. These are imparted correctly by the string D to the diaphragm E, and thence to the air inside of the tube B. The

consequence is that the air vibrations in B which impinge on the listener's ear are not only caused by the voice of the speaker, but they are *the same in "kind" or character* as the vibrations made in A by the speaker's vocal organs. The listener at B, therefore, acted on by vibrations exactly like those in A, is conscious of the sensation of the same word that he would be conscious of if he listened at A.

Mechanically, this contrivance consists of two diaphragms made to vibrate at stations distant from each other by causing the movements of the one to compel the other to copy the motions of the first. That when the second diaphragm was compelled to copy the movements of the first in all respects, the word uttered against one would be heard to proceed from the other, was thus a fact long known and used. No one in our time can claim any originality for discovering that.

What makes the second diaphragm copy the vibrations of the first is the mechanical connection by a string or wire. These instruments are called "mechanical" telephones, or "string" telephones. If, now, *electricity* can be employed to make the second diaphragm copy the motions of the first, we shall have an "electric" speaking telephone. The problem left for the inventor of the first "electric" speaking telephone was, to discover how electricity could be employed to establish that connection and make the motions of the second diaphragm copy those of the first. That was his whole problem. The invention consists, therefore, in finding out how electricity can be used to accomplish that purpose. To state as Reis, an alleged anticipator of Bell, did, that *if* he could by electricity make a distant diaphragm copy the motions of one spoken to he would reproduce the sound, was not a statement of an invention, but a statement of what everybody knew was desired but had not been invented.

To produce at the ear of the listener, whether he be within earshot or at the end of a telephone line, the sensation of a particular word uttered by the speaker, it is not enough that the voice of the speaker at the sending station should produce *some* vibrations at the receiving station; it must there produce vibrations which shall have the characteristic motions

belonging to that particular word as distinguished from those which belong to any other word. "Sound waves," as they are generally called, consist of zones of alternate condensation and rarefaction, produced at one place and propagating themselves onward. These condensations and rarefactions, however, are directly due to extremely short (perhaps 0.00001 of an inch), to-and-fro vibratory movements of the air particles, and it is usually more convenient to study those motions directly. Sonorous vibrations may vary, and therefore differ from each other, in several respects. The *length* of the path over which the vibrating air particle passes in its to-and-fro motion, or, as it is called, the *amplitude* of the vibration, may vary; the *time* occupied in passing over its total path from the beginning of one swing back to its starting point, or the number of times it will pass over it in a second, called the *rate* or *period* of vibration, may vary. The amplitude of the vibration determines the loudness of the sound; the rate, period or frequency of this vibration determines the pitch of the sound. But the differences between one word and another, or between the sound of a flute and of the human voice, for example, are not differences of loudness nor differences of pitch. The third characteristic of sound, which enables us to distinguish sounds from each other and recognize them, independently of pitch and loudness, is called "quality," a word here used with a specialized, technical meaning. It includes the difference between articulate sounds or different words as part of it. It depends, not upon the length of the path of the vibrating particle, nor on the frequency with which it passes over that path, but upon *the manner in which it performs its journey.* If it were to start from a definite point at a definite time, and return to the same point at the end of a definite time — that is, if it were strictly limited as to the amplitude and as to the period of its complete vibration — it might (and does) pass over that path in many different ways; it may move at first fast, then slow, then perhaps return a little, and then go on at a different speed, and still reach the same goal at the same time. It is the difference in the manner in which it performs its journey,

as distinguished from the length of its journey, and from the time occupied, which gives rise to difference in the "quality" of the resulting sound. To produce the sensation of a word by vibrating at a distant station the diaphragm of a telephone, it is necessary, therefore, to make that diaphragm perform vibrations which, in their "*character*," as it is called, as distinguished from their frequency and their amplitude, correspond to that particular word. If we know how to produce this kind of control over the vibrations at the distant diaphragm, we shall know how to transmit speech; if we do not know how to do it, then we shall not know how to make a speaking telephone.

The invention of Mr. Bell consisted in finding out how to so employ electricity that not only would the voice of the speaker produce *some* vibrations in the moving part of the distant instrument, but would produce vibrations which *in their character* or "kind" would copy the movements caused in the air by the utterance of whatever word might be spoken for the moment at the transmitter.

There had long been known an instrument called the *Reis telephone*, in which words uttered into the transmitter did, by means of electricity, produce motions in the receiver. It was the most advanced instrument in those arts to which the speaking telephone pertains. But the motions thus produced in the receiver of the Reis telephone copied those of the transmitter only as respects the characteristic of period or frequency. The same number of complete swings as were performed by the transmitter at one end were performed by the receiver at the other, but the *character* of the swings at one end did not control the "character" of the vibrational swings at the other. That characteristic of sound which depends upon the number of vibrations per second, to wit, musical pitch, was therefore reproduced by this instrument; but the characteristic of sound which depends upon the *character* of vibration, or, as it is technically called, "*form*" of vibration, to wit, "*quality*," including those peculiarities which constitute articulation, was not reproduced by this instrument, and could not be reproduced by any instrument operating upon its principle. The distinction be-

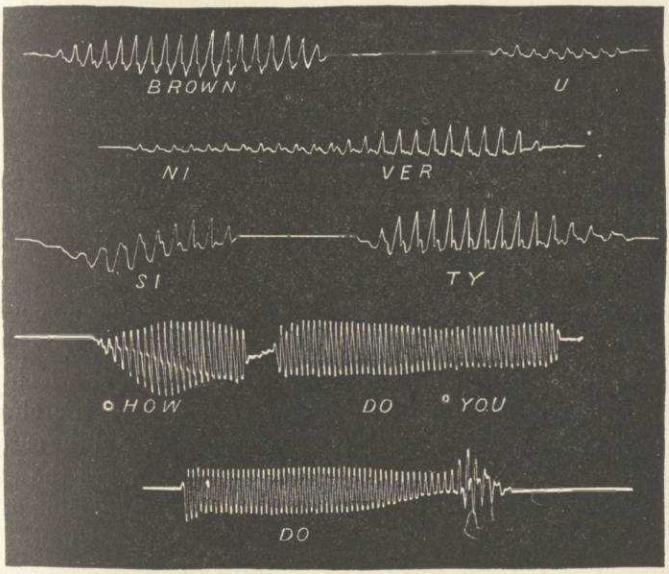
tween this old musical telephone and the speaking telephone described in the Bell patent, consists, therefore, essentially in the difference of method or principle employed as well as in the difference in the kind of result produced. The method of Reis secured correspondence in frequency of vibration or pitch of sound, but did not secure, and could not secure, anything else. All the experts on both sides agree that this method was absolutely inadequate for speech, and was not only inadequate, but, while that method was being employed, the method adequate for speech could not be used at the same time in the same instrument.

It is obvious that that which particularly made Mr. Bell's instrument to be an *electric* speaking telephone was some electrical action not exhibited in the operation of the previous instrument which enabled it to control the character, as distinguished from the mere frequency, of the vibrations of the receiver diaphragm. In that electrical action will be found, therefore, his most important and characteristic novelty, and his leading patentable invention.

To signify that characteristic of sonorous vibration which gives rise to "quality" of sound as distinguished from loudness or pitch, the patent employs some technical phraseology of long known meaning. It is the habit of physicists to represent sound vibrations in a sort of graphic shorthand way by drawing curves which are not drawings of the movements actually made by the sounding body, but which are a graphical representation of a mental conception of the character of those movements. In the same way, the height of the thermometer or barometer at successive times, or the price of stocks or gold or cotton, is represented by curves which to the instructed mind tell a long story at a glance. From this habit there has arisen a scientific slang or technical term, — "*form* of vibration." It is used because each different "*character*" of vibration is represented by a particular characteristic of the curve which typifies it, and this particular characteristic, although it is not the only one shown in what would popularly be called the "shape" of the curve, is scientifically recognized as constituting what is called in acoustics its "form." Helmholtz, and

all the other standard writers for many years before the Bell patent, employed the phrase "*form* of vibration" to signify that characteristic upon which "quality" or articulation depends; and the Bell patent, adopting this established use of the word, employs it to signify the reproduction of that particular characteristic of vibration.

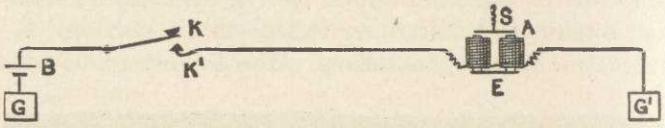
By a form of speech which is adopted in science and is scientifically correct, the lines which thus graphically express the idea of sonorous vibrations are called curves, although to the eye they look jagged and sharp. The following cut is taken



from a tracing made by Professor Blake, of Brown University, by means of a photographic contrivance in which the vibrations of the telephone diaphragm, produced by shouting against it the words printed, were caused to inscribe certain curves characteristic of their motions on a sensitized paper drawn under a spot of light reflected from the quivering diaphragm. They are enlarged about 112 times from the most violent motion the voice could possibly give to the diaphragm in articulation, and the nicer differences are slurred over by the

imperfection of the apparatus; but they convey an idea of the nature of the movements which constitute articulation, and which the receiving diaphragm of a telephone must copy.

The Morse telegraph and how it works. — This cut represents a single-circuit Morse telegraph, — the simplest typical form of an electric signalling apparatus. B is a battery; K is a key. In its present condition the circuit is "open," as it is called —



that is, K and K', the two parts of the key, are out of contact, and no current can flow from the battery. If the key K is depressed, so that it touches the end of the wire K', then the current flows from the battery B through K, K', through the "line," through the receiving instrument E, down to the earth or "ground" at G', through the earth to the other "ground," G, and up to the battery again. If the key K is raised, the electrical connection is destroyed by what is called "opening" the circuit — that is, opening the wires apart — and no current passes. The receiver E consists of an electro-magnet. That is composed of two small cylinders of iron, around which are wound coils of wire which form a part of the electric circuit. When the key K is depressed so as to touch K', and the current flows, it passes through these coils. That makes the cores inside the coils (shown as little cylinders protruding from their upper ends) to be magnetic while the current flows, and that pulls down the flat piece of iron or armature, A, suspended above those cores by a spiral spring S, and holds it down so long as the current flows. When the key K is raised to its position shown in the cut, the current is "broken" and no longer flows, the cores of the electro-magnet cease to be magnetic, they no longer attract the armature A, and the spiral spring draws it up again. Each time, therefore, that the key K makes contact with its anvil K' the armature A is pulled down; when the key K is lifted up, the armature A flies back. As often as the current is made and broken at K,

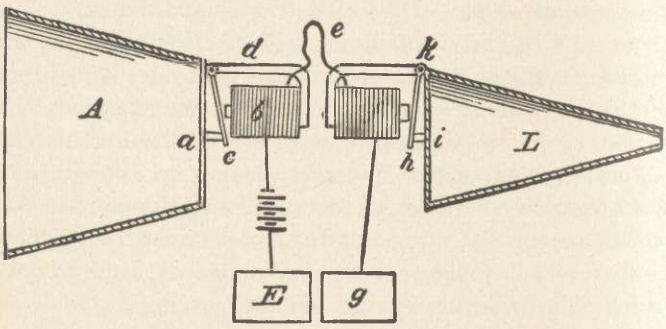
by moving the key down and up, just so often is the armature A moved down and up again.

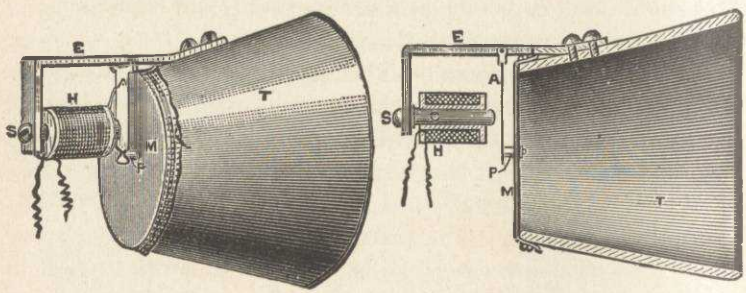
Musical or "pitch" telephones. — If now the key K be connected with the centre of a horizontal diaphragm which is vibrated by a sound, it will move up and down, and the parts can be so adjusted that when it moves down it will make contact with K′ and let the current flow, and when it moves up they will part contact and interrupt the current; each up and down motion of this diaphragm will thus cause an up and down motion in the armature A of the receiver. As many times as the key K vibrates up and down under the influence of words or other sounds, it interrupts the current at K K′, and therefore just so many times will the armature A vibrate up and down. The vibrating armature, A, will give forth a sound the pitch of which will depend upon the number of its vibrations per second, and as that number will agree with the number of interruptions of current caused by the vibrations of the diaphragm to which K is attached, it follows that that characteristic of the sound acting on the diaphragm and attached key at K which depends solely upon *the number* of vibrations will be reproduced by the vibratory motions of the armature A. That characteristic consists simply in musical pitch. This circuit-breaking machine, acting on the receiver by an interrupted current, will reproduce the musical pitch of the sound. But it will reproduce no other characteristic; it cannot therefore reproduce speech.

The speaking telephone. — The instrument Fig. 7 of Mr. Bell's patent has, however, an entirely different mode of operation. The first diagram here given is a fac-simile of Fig. 7 of the patent. The other is a view and section of an actual structure (a transmitter) built in literal conformity to the description of Fig. 7. The transmitter consists of a cone or flaring tube of wood, the large end of which is open so as to be spoken into, while the smaller end is closed with a tightly stretched membrane *a* (M).[1] To the frame is hinged at *d* a

[1] The *italic* lettering is that of Fig. 7 and the patent; the CAPITALS refer to the lettering of the second cut.

piece of soft iron, *c* (A), called the armature. The lower end of *c* (A) is fastened by a stud to the centre of the diaphragm *a* (M). The arm *d* (E) is of iron, and carries an electro-magnet *b* (H), consisting of a small core or cylinder of iron, the end of which is seen projecting towards *c* (C in the section), wound round with a coil of wire (H in the section). The receiving instrument L is the same as the transmitting instrument, except that for convenience the cone tapers down from the diaphragm to the small end which can enter the ear of the listener. When any sound is made into the cone A, its diaphragm *a* (M), is caused to vibrate in accordance with the particular sound uttered, just as in the case of a string telephone. The arma-



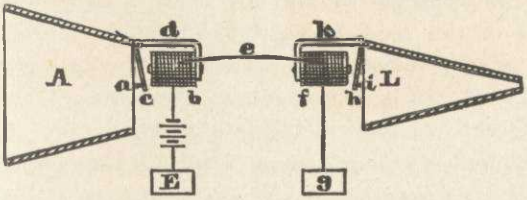


ture *c* (A), fastened to the centre of the diaphragm, partakes of that motion. When so vibrating it moves to and fro in front of the core of the electro-magnet *b* (H), which core is kept magnetic in this instrument by means of a current of

electricity constantly passing through the whole apparatus from the battery shown by the cross-lines below *b*.

It is a fact in electricity, discovered by Faraday about 1831, that when an armature is moved in front of such a magnetized electro-magnet, that very motion itself generates ("induces" is the technical word) in the coils of the electro-magnet electrical disturbances which are shown as currents in telegraph wires properly connected, and that these disturbances or currents correspond to the movements of the armature in duration, in direction, and in strength. While the armature moves, these "induced" currents, as they are called, flow; when the armature, instead of moving towards the core moves away from the core, the direction of the so-called electrical flow is reversed. When the armature moves violently, the electric current is violent; and when gently, the flow is gentle. While the armature *c* (A), is made to vibrate to and fro in front of this electro-magnet by the action of sound vibrations or waves on the diaphragm, electrical disturbances or currents are all the while caused, but these vary from instant to instant as the motion of the armature varies, and, therefore, the variations in the flow correspond to the variations in that movement, in duration, in direction, and in violence. In accordance with the habitual usage of science, they may be, and are properly said to be, copies of the vibrational movements of the armature; that is, every change in one produces a corresponding change in the other.

When this current, varying in accordance with the sound waves that act on the transmitter, reaches the electro-magnet *f* of the receiver, it acts upon the core of that magnet, in front



of which is the armature *h*. The current from the battery always keeps that core somewhat magnetic, and therefore

always pulls the armature *h* towards the little cylindrical core projecting from *f*. If the magnetic pull of *f* be increased, the armature *h*, and consequently the diaphragm *i* attached to it, is drawn nearer to *f*; if the magnetic pull be relaxed, the elasticity of the diaphragm draws *h* back again. Every variation in the magnetic strength of the core produces, therefore, a motion in the armature *h* and attached diaphragm *i*. It not only produces *some* motion, but produces a motion which corresponds at each instant with the variations in the magnetic strength of the core. The greater these variations, the more violent the motion; when the magnetic strength increases, the movement of the armature is towards the electro-magnet; when it decreases, the movement is in the other direction. The currents produced in the manner already stated, and varying like the sound waves of the sound uttered into the transmitter, reach the receiver electro-magnet *f*, by virtue of the well-known fact that every electrical change produced at one end of a telegraph wire is instantly felt in every part of it. These currents, corresponding to the sound waves which act on the transmitter, are added to the general and steady current from the battery, so that the total actual current passing through the electro-magnet of the receiver is now stronger, now weaker, in exact accordance with those sound waves. The stronger it is, the more magnetic is the core *f*; the weaker it is, the less magnetic is that core; and as the movements of the armature *h* depend upon and correspond to and copy the magnetic changes of the core *f*, and as these magnetic changes are due to and correspond to and copy the changes in the electrical current, so it follows that the vibratory movements of the armature *h* and attached diaphragm *i* of the receiver copy the changes in the electrical current. Every variation in that current produces not only *some* variation, but a *corresponding* variation in the vibratory motions of the armature *h* and diaphragm *i*.

It is evident upon reflection that all this correspondence between the movements of the diaphragm *a* and armature *c* of the transmitter and the currents its movements cause, and this correspondence between those currents and the move-

ments of the armature *h* and diaphragm *i* of the receiver L which the currents in turn produce, holds not only for the greater and general disturbances and changes, but for each minute variation or variety of them. The consequence is that in this apparatus the *electrical changes* are copies of the sonorous movements at the *transmitting* end. The sonorous movements at the *receiving* end are copies of these electrical changes. They are therefore copies of the sonorous movements at the transmitting end of which these electrical changes themselves are copies. The final consequence is that the vibratory movements at the receiver are the same as those in the transmitter, not only as respects general frequency, but as regards *all* their characteristics; and the *result* is that the sound which actuates the transmitter is reproduced and heard to proceed from the receiver with *all* its characteristics, and not with the characteristic of its pitch alone. This instrument, therefore, is an instrument which can reproduce not merely the characteristic of pitch, but all the characteristics of sound; or, to state it in a more ordinary, concrete form, it will transmit not only musical notes but "noises and sounds of all kinds."

That is the telephone Fig. 7 of the patent, usually called the magneto telephone.

Comparing this with a string telephone we find that we have, in each, a diaphragm spoken to at one end and a diaphragm listened to at the other, and that, in each, speech is transmitted because the motions of the latter are copies of the motions of the former. But in Mr. Bell's telephone we have got rid of the mere mechanical connection or link formed by the string, and have employed electricity to connect the two. The knowledge how to use electricity for this link constitutes the invention of the *electric speaking telephone.*

It will be observed that, in the nature of things, the movements of the receiver copy the electrical changes which produce them, and necessarily must copy them, in any receiver where the attraction on the elastic diaphragm varies with the amount of electricity which arrives from the transmitter. Any form of instrument of which that holds true can therefore be substituted for Mr. Bell's precise structure without changing

the apparatus as a whole, or its mode of operation, or its result. Those motions at the receiver are like the sound waves uttered into the transmitter, because the electrical changes which move the receiver, and which therefore its motions copy, are themselves copies of the sound waves uttered into the transmitter. What makes this apparatus to be an electrical machine is the employment of electricity in some form; but what makes it to be an electrical *speaking* machine is the presence, not only of *some* electrical current, but of an electrical current which copies the sonorous movements of the transmitter in those characteristics on which "quality" or articulation depends. In other words, in the figurative language of science, the electricity is here moulded into the form of the sound waves, and when that feature is present in the operation of the machine, speech will be transmitted; when it is not present, speech will not be transmitted. It is present in this apparatus of Mr. Bell's; his specification contains the first description of any apparatus which was ever intended or adapted to embody this idea and the first suggestion of the idea itself. This correspondence between the electrical current and the sound waves acting at the transmitting end, therefore, is exactly that which makes Bell's instrument a speaking telephone, and which, beyond any peculiarities of structure, distinguishes it in principle and idea from anything ever known before.

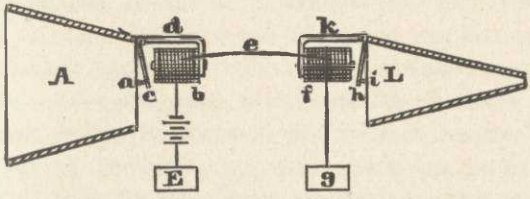
The Bell patent points out that this is the distinctive characteristic to which the new result is due; and claim 5 of the patent in terms secures to him this "method" as the means for the desired results.

The following is the description in the patent. After describing the use of one specified undulatory current apparatus, (Fig. 5) for the purpose of harmonic telegraphy, the patent says:

"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 voices or sounds of any kind.*"

He then proceeds to state how this latter result can be accomplished.

"One of the ways in which the armature *a*, Fig. 5," [the telegraph instrument], "may be set in vibration, has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imputed 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 *undulatory 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."

"Claim 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."

Professor George F. Barker, expert for the Overland company, characterized the invention very happily. He was of those who witnessed Mr. Bell's exhibition at the Centennial. He spoke of the interest excited by "the remarkable result" and their astonishment at hearing "for the first time the trans-

mission of articulate speech electrically." He added: "The mode of operation of the instrument was obvious at once as soon as it was exhibited. It was one of those marvellously simple inventions that causes one to wonder, on seeing it, that it had not been invented long before."

Every speaking telephone used by all the defendants differs from every instrument before the Bell patent, and resembles the instrument of the Bell patent, in that it has these electrical changes which are copies of the sound waves. It transmits speech because it has them. That principle, that "method," and that mode of operation first came into the world in Mr. Bell's instrument and by the description in his patent. His was a speaking telephone because it had it; previous instruments could not be speaking telephones because they did not have it. It is in the defendants' apparatus, and it is because they have it that their instruments talk.

These electrical changes are not something that existed in nature and he found. He first created them. They are not the "result" which Mr. Bell sought to attain; the "result" is the transmission of noises and sounds of all kinds. They are the essential *means* to that result; and they are novel. The defendants' instruments owe their capacity to transmit speech to the employment of that means which is in common between them and Mr. Bell, and is not in common between them and any one who preceded Mr. Bell. There is no better test of infringement. *Howe* v. *Morton*, 1 Fish. Pat. Cas. 586, 588.

To this, Dolbear makes an objection. He says Mr. Bell cannot cover "all" ways of transmitting speech. We reply that our patent does not cover "all" ways, but only our way. "But," rejoins Mr. Dolbear, "I cannot find any other way, and I do not believe any other is possible. Your patent only appears to cover one way; yet, if there is no other way, you cover all ways. *O'Reilly* v. *Morse*, 15 How. 62, does not permit that."

In deciding the Dolbear case at the circuit, Mr. Justice Gray answered this argument. He said:

"The evidence in this case clearly shows that Bell discovered that articulate sounds could be transmitted by undulatory

vibrations of electricity, and he invented the art or process of transmitting such sounds by means of such vibrations. If that art or process is (as the witnesses called for the defendant say it is) the only way by which speech can be transmitted by electricity, that fact does not lessen the merit of his invention or the protection which the law will give to it."

It is said in defence that the Reis circuit-breaker and several old instruments can *now* be compelled to so operate as to produce this peculiar character of electrical disturbance, and if they produce it they will talk; and that speech can now be transmitted by talking to a Morse or a House telegraph. But that is not material, if true. If Mr. Bell in 1876 had said: "I can make the Morse telegraph perform a new kind of operation, and produce a new kind of electrical changes, and by so doing I can transmit speech," and had told how, he would have improved the useful arts by inventive genius; he would have made a patentable invention. He could not patent the machine, for the Morse telegraph was old. He could patent his new mode of electrical operation, and that mode of electrical operation could only be described by pointing out the essential difference between the electrical changes that Morse produced and the electrical changes that Bell produced.

This court has given a perfect description of such an invention in the Fat Acids case (*Tilghman* v. *Proctor*, 102 U. S. 707). A man, said the court, may have a patent for "the means by him invented and described," and those means need not be a machine. What is the difference between a machine and a process? "A machine," said this court, "is something visible to the eye, the object of perpetual observation. A process is a conception of the mind, known only by its results when being executed or performed. Either may be the means of producing a useful result." Either, therefore, may be a patentable means. When my opponents say "What, patent a conception? Patent a result? Patent an operation which you cannot know except by its results?" the reply is obvious.

An inventor, until he has not only got a conception, but has described how that conception can be so applied and employed as to lead to a result, — "be known by a result," — has not

made his work a part of the useful arts; has not come within the language of this court; nor within the domain of the patent law. But when he has entered into the useful arts, and thereby got within the domain of the patent law, then one must be very blind and very narrow-minded who can see only the machine visible to the eye, and not the conception which gives life to it. That is the lesson of the Fat Acids case.

Is there any better statement of the great inventions that have improved the useful arts, than "a new idea introduced"?

In the Clay case, the defendants' counsel below said that this whole Bell patent and all the stories its counsel told about it were pure pieces of imagination; that they were asking the court to base its decrees upon nothing but imagination. "Why," said he in substance, "they talk about a 'form' of electrical undulations, and they say that there is a 'form' of electrical disturbances in their instrument, and the same 'form' in ours," and he pulled a piece of crooked wire out of his pocket, and said, "I can see the form of this, and if a man brings me another one I can see the form of that, and if the form of the electrical undulations is the same in those two instruments, why does not the Bell company pull them out and put them on the table, that the court may compare them?"

Apply that criticism to the great invention of Faraday which he described in his imaginative phrase "Lines of Force;" apply it to the decision in the Fat Acids case; it only destroys the critic. What is there so real, so enduring, or so useful as a new idea so stated that it can be employed and lead to a practical, useful result? There is no better statement of a great patentable invention — a new idea so stated that it can be employed and lead to a practically useful result; a new idea harnessed into the service of man. The harness is indeed requisite to use the idea, but the great thing, and the fruitful thing, is the new idea which is brought in.

The Patent Act, in express terms, says that the inventor is to describe his machine, and "the principle" thereof, "by which it may be distinguished from other inventions." The "principle" is the distinguishing characteristic in the patent

law. The Act again formulates this idea still more explicitly. He is to describe, says the Act, "the best mode in which he has contemplated applying that principle," implying that there may be modes of application not described. And, with that idea brought forward, the statute provides in terms that the patent is to be for his "invention or discovery," and not for any particular mode of application. See *Bell* v. *Gray*, 15 O. G. 778; *Am. Bell Tel. Co.* v. *Spencer*, 8 Fed. Rep. 509; *Am. Bell Tel. Co.* v. *Dolbear*, 15 Fed. Rep. 448; *The Neilson Patent*, Webster Pat. Cas. 683, 715; *Davis* v. *Palmer*, 2 Brock. 298; *Evans* v. *Eaton*, 7 Wheat. 356; *McClurg* v. *Kingsland*, 1 How. 202; *Parker* v. *Hulme*, 1 Fish. Pat. Cas. 44; *Howe* v. *Underwood*, 1 Fish. Pat. Cas. 160, 180; *O'Reilly* v. *Morse*, 15 How. 62; *LeRoy* v. *Tatham*, 14 How. 156; *Winans* v. *Denmead*, 15 How. 330; *Corning* v. *Burden*, 15 How. 252; *Burr* v. *Duryee*, 1 Wall. 531, 567; *Jacobs* v. *Baker*, 7 Wall. 295; *Mitchell* v. *Tilghman*, 19 Wall. 287; *Tilghman* v. *Proctor*, 102 U. S. 707; *Cochrane* v. *Deener*, 94 U. S. 780, 787; *James* v. *Campbell*, 104 U. S. 356, 377; *McCormick* v. *Talcott*, 20 How. 403; *Waterbury Brass Co.* v. *Miller*, 9 Blatchford, 77; *Bischoff* v. *Wethered*, 9 Wall. 812; *Smith* v. *Nichols*, 21 Wall. 112, 118; *Blake* v. *Robertson*, 94 U. S. 728; *Clough* v. *Barker*, 106 U. S. 166; *Penn. Railroad* v. *Locomotive Truck Co.*, 110 U. S. 490; *Consolidated Valve Co.* v. *Crosby Valve Co.*, 113 U. S. 157; *Blake* v. *San Francisco*, 113 U. S. 679; *Miller* v. *Foree*, 116 U. S. 22.

This court has often spoken of the value of the mental idea which lies behind a particular machine, the first of its class in the arts. *Bischoff* v. *Wethered*, 9 Wall. 812. There is no illustration of that better than Faraday's great discovery that waving a magnet in front of an electro-magnet or a wire, generates electrical currents. That magnet, moved by his hand, was the first magneto machine that ever was. He discovered that fact; but that fact was only a small part of what he discovered. *He discovered the relation between the motions and the currents*, and he expressed that relation by a figure of speech — by the phrase "Lines of Force." If he had died on the day after he had so announced that discovery, the world

would have been as much indebted to him as it is now. For though he had not then worked out all of its results, he had given the rule for doing it. Every man who makes a dynamo machine to-day, in calculating its form, its proportions, and its parts, to fit it for the particular use he wants, not only avails himself of the fact that Faraday discovered, but of the rule that Faraday laid down for all future constructors. He did the work of the originator as distinguished from the work of the improver.

So it is with this specification of Mr. Bell. It certainly described one speaking telephone. But its greatest merit was that it also laid down the rule for all future speaking telephones. It said, — get into the operation of your machine this which never was in any machine before, and get it in in accordance with a particular rule which it stated. Every man who has endeavored to improve the speaking telephone since that time, has endeavored not only to avail himself of the fact that Mr. Bell found, but has endeavored to conform more and more perfectly to the rule which Mr. Bell laid down.

One of my opponents said that it seemed to him that this whole telephone system was like a pyramid balanced on its apex; that this vast system all over the world to-day was based on this one little imperfect machine in the Bell patent. "Great oaks from little acorns grow," answers the nursery rhyme. That patent had the germ of life in it; and that is why this great structure grew out of it.

[Counsel then explained a number of details about the various forms of telephones, and the varieties in the current which could be produced without departing from the essential characteristics already described.]

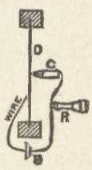
The Microphone. — It is obvious that any variations in the form of the transmitter which still enable it, under the influence of the spoken word, to produce a current which in its variations of strength corresponds to those vibrations, may be patentable themselves as improvements, but would still give an apparatus which as a whole employs Mr. Bell's method. The microphone transmitter is such a variation of form. The strength of an electric current can be varied by varying the

electric energy poured into the circuit, or by varying the obstruction or electrical resistance which that energy has to overcome, just as the flow of gas in a pipe can be varied by varying the pressure at the gas works, or by turning more or less the cock which obstructs and regulates the flow. In the case of electricity the relation is simple, and was ascertained and expressed by Ohm (whence it is called Ohm's law) in the form:

$$\text{Strength of current} = \frac{\text{Electro-motive force.}}{\text{Resistance of the circuit.}}$$

The strength of the current increases, therefore, in direct ratio to either an increase in the numerator or a diminution in the denominator of that fractional expression.

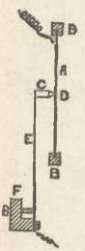
The "microphone" is an apparatus which so varies the electrical resistance. This cut is a diagram of a section of the device exhibited for this purpose by Emil Berliner in his caveat of April 14 and application of June 4, 1877. The line D represents a diaphragm, shown edgewise, supported by a framework at its edges. C is a pointed "electrode" or wire-end held in contact with the central part of the diaphragm. The current from the battery B goes by the wire to the diaphragm D, thence to the electrode C through the point of contact, thence through the receiver R (a Bell receiver, essentially like L of Fig. 7, but in the improved form of Bell's second patent). When the diaphragm D is vibrated by sound waves it moves towards the electrode C, or in the opposite direction. A movement towards C increases the pressure at the point of contact, and a movement in the opposite direction diminishes it.



In an uncut wire the electric current (the phrase by which the phenomenon of the propagation of electricity is expressed) passes from molecule to molecule with ease. If the wire be cut, and the two ends placed in contact, it will still pass, but less freely than before, because the union of the molecules of the two severed ends is less perfect than in the uncut wire. If the two ends (or "electrodes") are firmly pressed together, the union is more perfect, and the current experiences less resistance and is less enfeebled than if they touch lightly. This

was a fact well known before the Bell patent, though such variations in pressure had never been directly utilized. In our microphone, therefore, the vibrations of the diaphragm will produce variations of pressure at the contact, and consequent variations of electrical resistance, and, consequently, corresponding variations of current.[1] This microphone may therefore be substituted for the transmitter A of Bell's Fig. 7, and the vibrations of its diaphragm, like those of the diaphragm of A, will produce electrical undulations similar in form to the actuating air vibrations. The same effect will be produced on the receiver as in Fig. 7, and the word will be transmitted by the method of the patent.

The chief mechanical essentials of the microphone are, (1) that there shall be no substantial break of contact, such as would be caused by the diaphragm vibrating entirely away from the electrode; (2) that variations of pressure shall be developed to as great an extent as possible; (3) that the variations of electrical resistance shall directly and uniformly correspond to the variations of pressure. Berliner's first papers show the electrode C made of German silver or other metal, and held rigidly, while the diaphragm was much strained, so that its excursions would be very small. Edison, who invented the microphone independently, showed in his application of July 20, 1877, a form indicated by this diagram.

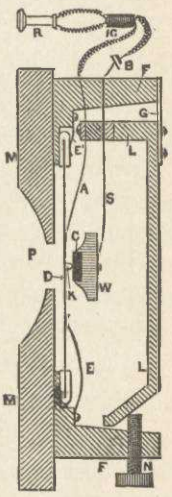


The electrode C is mounted on the end of an adjustable spring E, strained by the screw F to press towards the diaphragm. Afterwards he discovered that it was better to give a notable weight to a spring-carried electrode, C, because, while the spring gave an automatic freedom of adjustment, the inertia of the weight furnished a mechanical resistance which developed a large variation of contact pressure. He also in his application of July 20, 1877, and in a previous newspaper publi-

[1] It is a well-known law of electricity that electrical variations produced in one part of a good conductor are equally, exactly, and instantaneously (within any length of conductor usually employed) felt in all other parts. That is what enables electricity to be used for conveying signals to a distance.

cation, pointed out that carbon was the best material for one or both of the variable pressure electrodes. The reasons are that with carbon the range of variation of pressure without sudden break is greater, and the variations of electrical conductivity correspond more closely and evenly to the variations of pressure than when the usual metals alone are employed.

Early in 1878 Professor Hughes, in England, independently invented the carbon microphone in a very simple but excellent form, and gave it its name, "microphone." Finally, in the summer and fall of 1878, Mr. Francis Blake, formerly an officer in charge of the electrical determinations of longitude for the United States coast survey, and now a director of the Bell company, invented the highly organized Blake transmitter.



In it D is the diaphragm, K is a teat of platinum with a face about the size and shape of the head of a small pin, C is a bit of gas carbon, artificially hardened and polished, mounted in a piece of brass, W, which is carried on the end of a watchspring S. That spring is itself carried on a long lever L, hinged by a spring hinge at G, and capable of a very delicate adjustment by the screw N. The instrument is spoken to through the mouthpiece P. The current comes from battery B through the spring S to W, C, K, through the delicate spring A, and through the primary of the induction coil I C the secondary of which goes to the distant receiver R. The working contact is between the platinum teat K and the carbon C. The brass W usually weighs about 75 grains, and gives inertia to the freely suspended electrode C. The sheet-iron diaphragm is not screwed to its seat, but has its edges cushioned by folds of soft india-rubber (letter bands slipped over the edge), and is held in its seat by a short and narrow metal clip E′ and a long steel finger-spring E,—an arrangement which leaves it free to vibrate truly.

All these inventors did, in fact, make their microphones after the Bell patent, and for the express purpose of producing Bell's electrical undulations similar in form to the sound

waves. They do produce such undulations, and for that reason their use has always been decided to infringe Mr. Bell's fifth claim.

Mr. Bell, moreover, in the patent itself, stated explicitly that the described variations of current could be produced by varying the electrical resistance instead of employing the magneto transmitter particularly shown, and he indicated a type of instrument (the liquid transmitter) which could be used to vary the resistance.[1] It is, however, the microphonic form of variable resistance instrument which is now generally commercially used. The Bell patent covers the use of a telephone apparatus which employs a microphone for its transmitting member, because the novel variations of current which constitute the essence of the Bell invention are employed as the essential means of transmitting speech by the microphonic form, as well as by the magneto form; and if Mr. Bell had described nothing but the magneto form, his claim would have that breadth. That it does have that breadth, however, is put beyond discussion, for the patent itself states that for its purposes the variable resistance mode is the equivalent of the magneto mode.

The following is the usual commercial form of the Bell magneto instrument invariably used as a receiver, and to some substantial extent also used as a transmitter:

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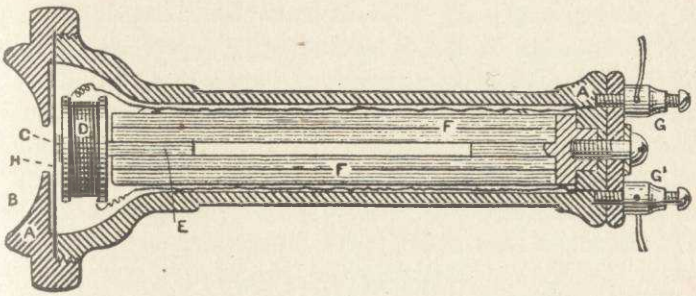
[1] After describing the magneto or "inductive" plan the patent says:

"Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit. . . . 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."

Claim 5 was for his "method" as a whole. Besides that, he had one special and subordinate claim (3) for the inductive mode of working that method, and another special and subordinate claim (4) for the variable resistance mode of working it.

Claim 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."



The Bell Magneto Telephone in Commercial Use since December, 1877.

The diaphragm is H, placed in front of the small soft iron core C which is screwed into the permanent steel magnet F and around which a coil of fine wire D (usually 75 yards) is wound.

The origin of the Electric Speaking Telephone. — There are more than half a million of these telephones in daily use. They are so simple that anybody can make them, and anybody can use them. Where did they come from? Trace back the history of each one of them. Go to the man who made it, and ask him where he learned how an electric telephone must work in order to speak. Go to the man who put the last improvement into it, and ask him where he found a speaking telephone to improve, and where he learned the rule to improve it by. All these lines of search end in one man. Whatever anybody did or did not do secretly in his workshop before Mr. Bell's time, it is nevertheless a fact in history that every speaking telephone at work in the world traces its origin right up to Mr. Bell. No man ever used, and no man offered for use, any instrument for the purpose of transmitting intelligence by word of mouth for any practical or useful end, before Mr. Bell. There is no such pretence. Yet it is an invention which once known could not be kept secret, and when offered, every one wanted it.

There is no better way to find the origin of so striking an improvement in the useful arts, than to ascertain where it was that everybody learned it. When Mr. Bell exhibited his instrument at the Centennial, all the learned men and all

the practical men, said, "This is a new and unheard-of thing." They did not say he had got a new way of doing an old thing; they said that the transmission of speech at all by electricity was a novelty. They went further than that. They said, "We know Reis and his publications; we know that the community got no speaking telephone from his work. Now that Mr. Bell has told us the true way, we see why his predecessors failed." This was the verdict of Professor Henry and his fellow judges at the Centennial, of the British Association, the American Academy, the Society of Telegraph Engineers, the French Academy of Sciences, of an assemblage in New York of all the men most prominent in commercial telegraphy and in science. No man denied it until the great commercial success of Mr. Bell's invention aroused infringers to assert in 1881 that publications in which no man up to that time had ever found a speaking telephone, could now be sworn to by experts as containing one.

The Reis Telephone. — Philip Reis, in Germany, attempted about 1855 to make an electric speaking telephone, and in 1861 first exhibited it and described it in print. From 1861 to 1874, he brought it extensively to the notice of scientific men and the public by exhibitions before scientific societies in Germany, and before the British Association in England. It was exhibited to the American Association in 1869 and 1870. In 1863 he advertised his instruments for sale, and, until the present time, they have been on sale by the principal dealers in philosophical apparatus. He manufactured them himself, and others were made from his models by Koenig of Paris, the most famous maker of acoustic apparatus in the world. He lived until November, 1874, but he never deviated from the form he adopted in 1863. He stated in his advertisements that that form satisfied all his expectations, and that with it unskilled persons could repeat all of his experiments. From 1861 until these suits began, the structure and operation of the apparatus were described by Reis, by Koenig and the other makers in their catalogues, by the principal standard writers on electricity and acoustics, and in the scientific and other periodicals. The instruments themselves were found in

the cabinets of the Smithsonian and other institutions. His work, therefore, whatever it was, was perfectly well known. The best instrument makers applied their skill to the construction of his machine in accordance with his directions, and eminent scientific men personally experimented with it and published their results. Fifty such publications between 1861 and 1877 are in the record. If the thing was not known as a speaking telephone, it was not because it was not known, but because it was not a speaking telephone.

We assert that it was simply a circuit-breaking contrivance such as we have already described, reproducing the musical pitch of sounds, but not reproducing "quality" or articulation.

The actual standing of the instrument in the hands of the community is conclusive. Reis's own publications and conduct express that standing. In the prospectus furnished with the completed instrument of 1863, and from 1863 until his death in 1874, he advertised it as a contrivance which would reproduce the pitch of sounds made by the voice or any musical instrument, but did not pretend or suggest that the listener could ever recognize words. It was never offered, nor bought, nor attempted to be used by any purchaser as a speaking telephone, but only as a philosophical toy for the reproduction of pitch. This is not controverted. When Bell exhibited his apparatus scientific men hailed it as the first speaking telephone, and contrasted it with the Reis, saying that Reis tried to make a speaking telephone, but only produced a musical telephone or pitch transmitter. Neither Reis's well-known actual work nor the many publications about it ever did in fact give the art of transmitting speech to the community. Reis did not pretend that they would. There can be no higher proof of their insufficiency in fact and in law.

The history as read in the publications themselves by the unscientific reader is equally conclusive. In 1861 Reis made his first public exhibition and lecture. Of this there are two accounts. One, published in the local papers at the time, said, "Up to the present the reproduction of the tones is indeed weak and words cannot be reproduced. We leave here the question as to whether this hereafter will be successfully accomplished."

Some months later Reis wrote out his lecture and published it. He said that he had hoped to transmit speech, but had been disappointed, adding: "Hitherto it has not been possible to reproduce the tones of human speech with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels are as yet not in an equal degree." That is the strongest statement Reis ever made. Subsequent experience led him in all his later papers to claim for it the transmission of pitch alone.

A writer, during the next year (1862), professing to speak of trials by others heard of at second hand, and not trials by himself, said that "the experimenters could even reproduce words, although indeed only such as had been often heard by them." This is the only intimation anywhere in literature, of the transmission of a single word. It is not legal evidence of any such fact. *Seymour* v. *McCormick*, 19 How. 107. Experimenters with telephones know what tricks imagination plays, and it appears specifically that upon the occasion referred to the circumstances were such that the transmission of words was impossible, for the listeners are shown by the publication itself to have been at such a distance from the instrument that only the loud, inarticulate sounds due to circuit-breaking could be audible.

On the other hand, the apparatus was universally called "The music telegraph"; no other writer out of the fifty, including Reis in his later writings, hints at the transmission of words, while all those who speak from personal experiment say that it was impossible to transmit them. Thus *Mr. Quilling* published in May, 1863, the results of actual experiments by Reis which he had just witnessed, saying: "It was not possible with the present construction of the apparatus to transmit spoken words." *Pisco*, in his standard treatise on "*Acoustic Apparatus*" (Vienna, 1865), says, as the result of a long series of experiments with it, that "the only means for the transmission of speech is the old speaking tube." *Mr. Ladd*, a celebrated instrument maker of London, having experimented with an original Reis instrument, under Reis's special instructions, before the British Association in 1863, reports

that it will only transmit "*musical* notes and sounds." *Kuhn*, in *Handbuch der Angewandten Elektricitätslehre* (1865), says that he has experimented with it, but "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, syllables or words could not be had."

An elaborate series of experiments with it were carried on by Reis and Professor Buff of Giessen, in the laboratory of the latter in 1863–4. In September, 1864, Reis exhibited it in that laboratory to the physical section of the German Society of Natural Sciences. His lecture was not published, but was followed on the same afternoon by a lecture by Professor Buff; this was published at once in *Annalen der Chemie und Pharmacie*, 1864–5, iii, *Supplementband*, p. 134. In it Professor Buff says of the Reis:

"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."

All this agrees with the actual history of the instrument in the world. The strongest pretence in favor of Reis is that since these suits were brought some men have been found to testify in them, from a mere memory twenty years old, that they think they heard words at some private experiments which were never published. The worthlessness of such "memories" is shown by the fact that one of the most respectable of those persons — a professor at Heidelburg, says he remembers that at the occasion of the Buff lecture just quoted the audience were aroused to a high pitch of enthusiasm by the transmission of speech which the contemporaneous publication of course disproves. But there is not a pretence that the instrument, widely as it was known, was ever in fact a speaking telephone in the hands of the community.

This was summed up by the court in *Am. Bell T. Co.* v. *Spencer*, 8 Fed. Rep. 509, as follows: "Reis appears to have been a man of learning and ingenuity. He used a membrane and electrodes for transmitting sounds, and his apparatus was well known to curious inquirers. The regret of all its admirers was that articulate speech could not be sent and received by it. The deficiency was inherent in the principle of the machine. . . . A century of Reis would never have produced a speaking telephone by mere improvement in construction."

The only method and mode of operation disclosed by the Reis publications is simple circuit-breaking, which will transmit pitch, but not quality or articulation.

A scientific examination of the published description shows that the Reis apparatus was not a speaking telephone, because the principle and mode of operation embodied in it are incapable of transmitting speech. Every publication stated that it was simply a circuit-breaker interrupting the current with a frequency corresponding to the pitch of the sound acting upon it. No other kind of operation is anywhere suggested or hinted at. Reis himself stated that such was his idea, such his intention, and such the actual operation of the machine in his hands. In his description of his latest form he said that this was "the principle that guided" him, and that he had carefully "proportioned" the tension of the diaphragm and the weight of the "hopping" piece to that end. Now this proportion is the mechanical element which determines the nature of the operation which will be performed under the influence of any given strength of sound waves. If the membrane is delicate so that it vibrates freely, and the "hopping piece" is light, the latter will be thrown up into the air and thus break the contact and interrupt the current. The contrary qualities will leave the vibrations insufficient to do this and the unbroken but varied current of the microphone will be produced. Indeed, an efficient production of *variations* as well as the prevention of breaks, requires a certain mass in the loose electrode. Now Reis made his membrane of thin sausage skin and gave to his free electrode a weight which

represents the inertia resistance of a mass of 10 grains. The modern microphone employs a sheet iron diaphragm and a mass usually of 75 to 100 grains. Reis, moreover, expressly directed that the applied sounds should be "sufficiently strong." This will be more clearly understood when the Reis instruments are described.

The actual proof afforded by the publications (besides the unanimous express statements to that effect) is positive that such was the operation of the instrument in fact. Some experimenters describe the chattering noise of the "hopping" piece caused by alternately parting from and again striking the other electrode at each vibration. Others mention the continual presence of the "circuit-breaking" spark at the place of contact, — a sure proof of interruption of current by break of contact. The descriptions of the experiments say that they were made with the receiver on a table, and that several persons heard it at the same time. Now, a circuit-breaker will readily produce a musical note loud enough for this, but the delicate changes of current which transmit speech are absolutely and physically incapable of yielding any sound which would even be audible from a Reis receiver under such circumstances. Those experimenters who thought that they thus occasionally heard a familiar word are necessarily the victims of their imaginations.

Every expert of our opponents who testified about the Reis was forced to admit, in terms, on cross-examination, that such was the only operation described; and also to confess that it is absolutely impossible to transmit speech by that kind of operation. The reasons for this have been already explained. This fact is of itself fatal, for, as Reis's work was done in Germany, his mere *work* cannot, under our statute, defeat a patent. The Reis defence must rest on the publications, and the moment it is confessed that when following them speech cannot be transmitted, controversy is at an end. And if the Reis apparatus, adapted to readily operate in the way described in the Reis publications, will not, when so operated, transmit speech, it cannot anticipate a patent which describes a mode of operation by which speech can be transmitted, and which is

diametrically different from the mode of operation stated by Reis.

Their only ground rests on the assertion that the Reis apparatus can to-day be made to transmit speech if the method of the Bell patent be applied to it. This possibility was never suggested until 1880, when the Bell patent was four years old. If this were true it would only show the perfection and the novelty of Bell's new method or mode of operation, which, when applied, would enable that which never had been a speaking telephone, to at once transmit speech. But it is not true. The Reis *transmitter* can, by great care and practice, be compelled to perform the Bell operation and thereby produce the Bell current to a feeble extent, but the Reis receiver, which is good enough for the coarse changes of his circuit-breaker, is too unsensitive to yield any intelligible results under the influence of such delicate *undulatory* currents as the Reis transmitter can be made to produce. This was the state of proof made by Professor Henry Morton, defendants' expert in *Spencer's* case, and repeated by him as expert for the *Molecular* and *Overland* companies in their cases, now before this court.

In *Dolbear's* case, the next after *Spencer's*, the defendants produced from Germany an exact fac-simile of an original Reis apparatus, and asserted that it would talk. Challenged to repeat their tests in the presence of witnesses, they did so on two successive days, the defendants themselves, by their experts, doing the talking and listening, but with a shorthand writer stationed at both ends. Upon comparing the results, it was found that out of about 1500 words uttered into the transmitter, the listener thought he heard 26, and out of these 26, 18 had not been spoken.

Whenever later experts undertook to say that they could talk with the Reis instrument, we challenged them to repeat their tests in the presence of witnesses, "as was done in Dolbear's case," and every one of them declined the challenge; while Professor Morton, for the defence, had to admit on the witness stand in the *Molecular* and *Overland* cases that after repeated trials, extending over several years, he found himself unable to understand anything with the Reis apparatus as a

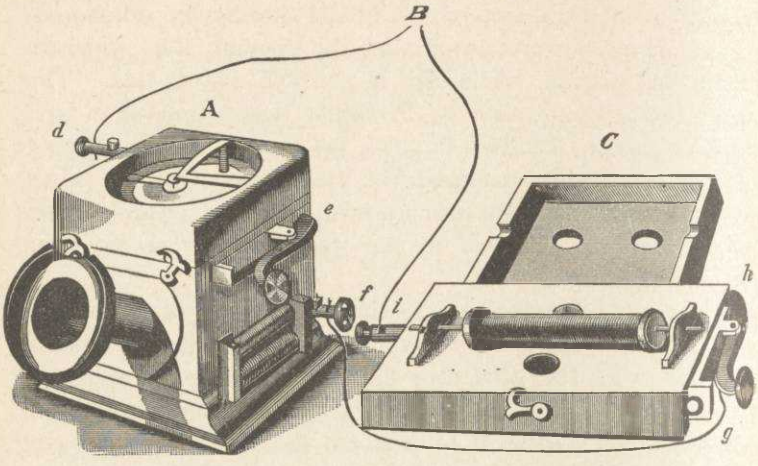
whole. It is also a fact proved in the case by the defendants' experts on cross-examination that the genuine Reis apparatus at the Smithsonian, when used as a whole, cannot talk. That apparatus was purchased by Professor Henry himself in 1874, shown by him to Mr. Bell in 1875, yet in his Centennial report of 1876 he officially declared Mr. Bell's instrument to be the first speaking telephone ever known, — styling it "the greatest marvel hitherto achieved by the telegraph;" "an invention yet in its infancy."

When any witnesses have testified that they got speech with a Reis instrument, it has been made substantially apparent in one way or another that they did it by altering the apparatus so as to prevent it from performing the Reis circuit-breaking operation, and compel it to perform the Bell current-varying operation. A slight physical change may suffice for that purpose, but any such change, or attempt at it, falsifies the instrument. The fact is that by the aid of knowledge acquired from the Bell patent, the Reis telephone can be made to perform the operation of that patent to some slight theoretical extent. But even then it is so ill adapted to that operation, for which Reis never intended it, and is so well adapted for the circuit-breaking operation for which Reis did invent it, that when the attempt is made to compel it to perform the Bell operation it does it so imperfectly that no intelligible speech results.

[In the course of this argument the various Reis publications were examined in detail and illustrated by some experiments performed in court.]

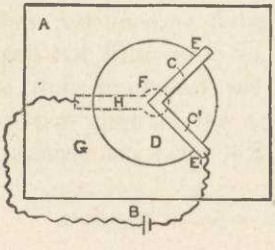
Reis made three forms of apparatus which he publicly described. The first two (1861 and 1862) were purely experimental and it is not known that more than one of each was constructed.[1] The third, made in 1863, was adopted by him as his final form, put on sale as a pitch transmitter, and continued to be the only form used by him until his death in November, 1874. It is shown in the following view of the whole apparatus (a fac-simile of the cut forming part of the advertisement he published from 1863 until his death). The

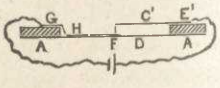
[1] These two forms are shown on pp. 40, 53, *supra*.



outline diagram below shows the working parts of the transmitter.

The transmitter A consists of a hollow box about four inches square and deep. The top or cover is pierced with a round hole over which is stretched a membrane diaphragm about $1\frac{1}{4}$ inches in diameter. To this is cemented a strip of flexible platinum foil (H in the diagram). A piece of brass (*a*, *b*, in the cut; C, C′ in the diagram) shaped like two sides of a right-angled triangle, is provided at the angle and at each extremity with a little leg made of a small pin of platinum, so that it can stand on the three like a tripod. Two of these legs (at *a*, *b*, in the cut; E, E′ in the diagram) rest on the frame of the instrument, while the third, placed at the angle, rests on the spatula-shaped end of the platinum foil, H, at the centre of the diaphragm. The instrument is so connected with





a battery B, that when at rest the current flows to the foil at G, through the foil H, to the platinum leg resting on it at F, through one branch C′, of the angle piece to its leg at E, which is connected (usually by standing in a cup of mercury) with a wire leading back to the battery. The receiver (C of the view) is included in this circuit. If the angle piece be lifted from the foil the circuit is interrupted — "broken" — and the current stops.

Sound waves from any source that is vigorous enough enter the hollow box through the tube shown at the side. They throw the diaphragm into vibration, the angular "hopping piece" is thrown into the air, like a boy tossed in a blanket, the electrical connection between it and the foil is broken, and the current is interrupted, to again flow when the hopping piece falls back into place. Thus at each vibration the current is once interrupted. This intermittent current, passing to the receiver, compels it to vibrate once for each interruption, that is, the same number of times per second as the diaphragm of the transmitter. The pitch of the resulting sound is therefore the same as the pitch of the sound which acts on the transmitter.

Reis in his lecture of 1861, speaking of his first form (the bored block, p. 41, *supra*), says "each sound wave causes a breaking and closing of the current" and therefore the receiver "gives a tone whose pitch corresponds to the number of interruptions in a given time." The only description of the next form (Legat article, *Journal of the German-Austrian Telegraph Association*, vol. 9, p. 125, 1862, on p. 33, *supra*) says, "at each condensation of the air in the tube the circuit is opened and at each rarefaction the circuit is closed." In his printed advertisement of his perfected instrument of 1863 (the hollow box form shown in the cut on pp. 60, 290, *supra*), Reis offered it purely as an apparatus for scientific experiment in the reproduction of pitch. He says of it: "I am now able to offer an apparatus which satisfies my expectations and with which every physicist will succeed in repeating these interesting experiments," etc. What that instrument would readily and habitually do in the hands of any user was therefore all that

he expected of it or had accomplished with it. Describing the operation he says, "for every full vibration the circuit is once opened and again closed and thereby are produced" in the receiver "just the same number of vibrations."

In a letter sent to Mr. Ladd, July 13, 1863, instructing him how to exhibit to the British Association the telephone Ladd had purchased of Reis a few days before, Reis writes in English (*Journal Soc. Tel. Engrs., March, 1883*):[1] "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[2] in a proper manner 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 tones at any distance. It would be long to relate all the fruitless attempts I made, until I found out *the proportion* of the instrument and the necessary tension of the membrane. The apparatus you bought is now what may be found most simple and works without failing when arranged carefully in the following manner.

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

"If a person sings at the station A, in the tube *x*, the vibrations of air will pass into the box and move the membrane above, thereby the platinum foot C of the movable angle will be lifted up, and will open the stream [of electricity] at every condensation of air in the box. The stream will be reëstablished at every rarefaction. In this manner the steel axis at station B will be magnetic once for every full vibration," etc.

So, according to his own statement, "the *principles* which guided me in my invention" were "the interruption of the current" by throwing up the hopping piece so that it parted contact. Observers published that they noticed the chattering noise made by these blows and the "circuit-breaking-spark" which resulted.

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[1] This letter and Reis's sketch are on page 56, *supra*.

[2] Stretched.

Reis so constructed his machine as to insure this circuit-breaking operation. We have already pointed out (p. 286, *supra*) that whether the circuit-breaking operation or the new variable-pressure microphonic operation is performed depends upon the relation between the force of the sounds applied, the delicacy of the diaphragm and consequent freedom and violence of its vibrations produced by those sounds, and the lightness of the hopping-piece. Now Reis employed a diaphragm of thin sausage skin, says that the tension he gave even to this delicate membrane, and the proportions he gave to the parts, were essential, and expressly directs in his published directions for use that the actuating sounds are to be "sufficiently strong." These directions, contained in papers which state the circuit-breaking operation and none other, are statements that the structure is to be such as will insure that operation; and when these directions are followed, that operation invariably results. The modern microphone, on the other hand, restricts the range of vibration of the diaphragm by making it of sheet iron, or wood, or cork, and sometimes by dampening springs and other devices; increases the weight of the free electrode so that, instead of a weight of 18 grains distributed in such manner as to give an inertia resistance of 10 grains, which Reis had, an inertia resistance of 75 to 150 grains is now employed; while the voice is generally applied at four or five inches from the diaphragm.

As the operation depends upon a due "proportion" between the mass and the force acting upon it, some experts for the infringers, departing from the "proportion" "determined" by Reis, to make it break "without failing," have so altered the proportions that it will not break and will thus serve as a microphone. They have thus altered the proportions between the forces and the resistances, in order to introduce new relations of the parts when in action, to thereby set up a new mode of operation, and by it produce a new result. No ingenuity of experts can state the case otherwise.

In *Neilson* v. *Betts*, L. R. 5 H. L. 1, 15; *S. C.* Goodeves's Pat. Cas. 56; Lord Westbury said: "I must say that when we come to examine the scientific evidence I think I never met with a

case where I was more pained to observe the manner in which the efforts of the men examined had all been directed, after their minds were fully informed of Betts's invention, to endeavor to strain the description of Dobbs, so as to include in the application made of Dobbs's design and Dobbs's processes, something which should approximate to the invention of Betts."

In *McCormick* v. *Talcott*, 20 How. 403, 409, this court spoke of such depositions as "the opinions (the reveries they may often be called) of a class of men styled experts; men as often skilful and effective in producing obscurity and error as in the elucidation of truth."

Such depositions will not overthrow the consensus of the scientific world and the verdict of history.

Consensus of the scientific world that Reis did not anticipate Bell. The moment Mr. Bell's invention became known, it was contrasted with the well-known Reis telephone, and all the learned societies agreed that Mr. Bell had introduced an entirely new mode of operation, and thereby accomplished a new result.

Professor Henry, in 1875, with a Reis instrument actually before him, praised Mr. Bell for his untried undulatory-current idea as *the first clue* to the transmission of speech, and in his Centennial report declared the transmission of speech at all to be an absolute novelty.

In 1877, Professor Barnard, President of Columbia College, and other scientific men, declared at a public meeting that the name of Mr. Bell would be handed down to posterity as that of "the inventor of the telephone"; and all the experts for the defence admit that, until they were employed by the infringers, they believed Bell to be the first inventor of the transmission of speech. Dolbear himself, in his published book on the telephone, says that Bell's "was the first speaking telephone that was ever constructed."

In 1877, Mr. Preece, the electrician at the head of the English Postal Telegraph, explained the telephone to the British Association. He asserted, and that body agreed with him, that the Reis machine was a mere musical telephone, and the

report adds, "the interest in the subject culminated on the arrival of Professor Graham Bell, the inventor of the talking telegraph."

On October 31, 1877, the English Society of Telegraph Engineers, the most eminent electrical society in the world, held a special meeting "to welcome Mr. Bell to England," and to hear from Mr. Bell his account of what its president styled "one of the most interesting discoveries of our age." Mr. Latimer Clark, an eminent electrician, offered the vote of thanks to Mr. Bell, saying, "There has never been a subject brought before us since my connection with this society, and that is from its beginning, so interesting or so important as the one we have heard this evening, or one which will form a greater epoch in the history of electricity."

When the microphone was offered to the English public by Professor Hughes, in 1878, he, in his communication read by Professor Huxley before the Royal Society, and the other gentlemen who described it, declared that Reis merely produced music, but that Bell, by the correspondence of form which he introduced into the current, "reproduced all the delicacies of the human voice."

The French Academy of Sciences publicly expressed the same views, and on their recommendation Mr. Bell received the great Volta prize.

The Government of Reis's own country, Germany, indeed refused Mr. Bell a patent, as their patent law required, because he had himself published his own invention before he filed an application. But through its patent office it has declared, after two years' study, that the Reis was a mere circuit-breaker, and not a speaking microphone. It did this in terms in the patent granted in Germany to Lüdtge for a microphone, on an application filed January 12, 1878. It has since sustained that patent on the ground that the speaking microphone (which the Reis was, if it was a speaking telephone at all) had never been described in Germany before that application.

Finally, in the summer of 1886, at its 500th anniversary,

the University of Heidelberg gave Mr. Bell a degree for inventing the speaking telephone.[1]

The courts treat such recognition as the highest proof that the invention was before unknown. *Tilghman* v. *Proctor*, 102 U. S. 707, 717.

Some authorities as to the effect of prior publications are: *Seymour* v. *Osborne*, 11 Wall. 516; *Cohn* v. *Corset Co.*, 93 U. S. 366; *Cahill* v. *Brown*, 15 O. G. 697 (Clifford J.); *Atlantic Giant Powder Co.* v. *Parker*, 16 O. G. 495 (Blatchford, J.); *Betts* v. *Menzies*, 10 H. L. Cas. 154; *Neilson* v. *Betts*, *L. R.* 5 H. L. 15.

Mr. Bell's history. — His father's profession (vocal physiology) for which he was fitting himself, led him from boyhood to study with peculiar care the nature of articulating sonorous vibrations. The effort to construct for himself Helmholtz's electrical vowel apparatus induced him to devote attention to electricity, and he made some important inventions in a new form of multiple harmonic or musical telegraph. In 1874, he thought out theoretically the speaking telephone in the form of Fig. 7 of his patent, such as has been described. It seemed to him, however, considering the feeble electrical forces due to currents generated solely by the action of the voice on that instrument, and comparing them with the forces needed to operate the most delicate instruments theretofore known, that

[1] Our opponents have attempted to argue that this University so honored Mr. Bell, not because he was the first inventor of the speaking telephone, but merely because he made a particular form of apparatus — the magneto transmitter. But, on their own showing, such action would have been an empty frivolity. They themselves aver that the magneto telephone is a practically worthless contrivance; and although this is not true, it is nevertheless a fact that the microphone has supplanted it in commercial use; and their claim is that Reis invented the microphone long before Mr. Bell was heard of. The construction of an inferior form of an existing instrument would not make Mr. Bell illustrious, nor lead that great University to send its degree, *honoris causa*, across the water. Nor could one describe the magneto telephone as an instrument which day by day ministered more to the convenience of men. Yet the language which their degree applied to Mr. Bell is, "*qui ut apparatu telephonico ingeniose invento societati humanæ magna negotiorum peragendorum emolumenta largitus est atque in dies crescentia*," etc.

the electrical operation and consequent results at the receiving end, though necessarily perfect in kind, would be too feeble to be of practical utility. But the idea had taken firm possession of his mind. In March, 1875, he saw Professor Henry at Washington, and explained his views to him. He wrote to his father and mother a few days afterwards, describing that interview, saying (the capitals and italics are in the original):

"I felt so much encouraged by his interest, that I determined to ask his advice about the apparatus I have designed for the transmission of the human voice by telegraph. I explained the idea, and said, 'What would you advise me to do; publish it and let others work it out, or attempt to solve the problem myself?' He said he thought it was the germ of a great invention, and advised me to work at it myself, instead of publishing. I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to overcome the difficulties. His laconic answer was, 'GET IT.'

"I cannot tell you how much those two words have encouraged me. I live too much in an atmosphere of discouragement for scientific pursuits. Good . . . is unfortunately one of the *cui bono* people, and is too much in the habit of looking at the dark side of things. Such a chimerical idea as telegraphing *vocal sounds* would indeed, to *most minds*, seem scarcely feasible enough to spend time in working over. I believe, however, that it is feasible, and that I have got the clue to the solution of the problem."

It further appeared that at that very interview Professor Henry showed him a Reis telephone, bought the year before in Paris. He had the clue, and left Professor Henry's room with a confirmed certainty that he was not fighting against a law of nature, and therefore that success was only difficult, and not impossible. Within a year from that time his patent had issued, and presently Henry, who had approved his conception, publicly proclaimed his success. Since in so short a time he went so far, it is impossible to criticise his methods of work or to accuse him of want of diligence.

In performing, on June 2, 1875, an experiment with a new form of multiple musical telegraph which employed two reeds or springs vibrated in front of an electro-magnet, like Fig. 5 and Fig. 6 of his patent, one of the springs was accidentally knocked, and thus set in vibration.[1] He found that this slight vibration produced a sound from the spring of another instrument connected in electrical circuit. With another man the trivial accident might have passed unnoticed. But he instantly joined it with his older thoughts. The marriage was fruitful and the speaking telephone was born. It thenceforth needed only nurture. It at once struck him that if he was right in his observation of this accident, then the feeble vibrations of a spring in front of an electro-magnet had developed sufficient electric currents to produce audible sonorous effects at a distance. He repeated the experiment for an hour or two, and sanguinely satisfied that his former fears about the feebleness of the currents were ill founded, he instantly gave orders for the construction of a speaking telephone with a membrane diaphragm, such as he had conceived and described eight months before to his friend Professor C. J. Blake, of Boston, and to others, two of whom have testified to his description. The instruments were ill-made, and broke to pieces at the first trial. He repaired them and tried them again.[2] His success was indifferent. It is not certain whether a single word was intelligibly understood. Nevertheless, his study of the subject and his experiment proved absolutely that the most he had to contend with was a question of workmanship or technical mechanical skill and nicety in the construction of precisely such a form of apparatus as he had made; and it has so turned out.

He was in great trouble financially, and in some other ways. He pawned his watch and borrowed of his friends, and for a time was heart-broken for other reasons. He was in no condition to go into elaborate experimenting, but he crystallized his ideas into a letter which he wrote August 14, 1875 (presently to be quoted), and in which he stated his pur-

[1] The instrument is shown on p. 305, *infra*.

[2] The instruments are shown on p. 321, *infra*.

pose as *the transmission of speech*, and also the transmission of many telegraphic messages simultaneously over a single wire, described his "method" of electrical undulations similar to sound waves, and all the results that would flow from their employment, and debated with his correspondent whether he should file a caveat or take a patent. More mature reflection determined him to the latter course. He drew the specification and claims, every word of which, as they stand in the patent, are his work, and the patent issued.

I will assume that the pair of instruments he had made never yielded an intelligible word, but still the question of the validity of the patent does not depend upon previous experiments, but upon the sufficiency of the description. If the instruments of the patent will talk, will transmit vocal and other sounds so that the listener can know them apart, know each for what it is, doing all this *in the mode pointed out*, the patent is good; if they will not, then it is not good. Mr. Bell was so thoroughly convinced that he was right, that he determined to run the risk, and did. If he had died the moment after he wrote the specification (he wrote it all himself), without ever trying the experiment again, and that specification had gone to the world as a publication, the world would have had a speaking telephone. It would have had a rule by which to make all speaking telephones. No one after such a publication could ever have taken a patent as first inventor of the speaking telephone.

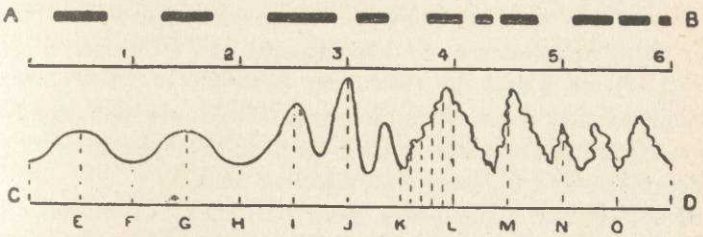
[Counsel then examined in detail the Bell telephone and the Reis telephone, and compared them, and performed some experiments in the presence of the court.]

The Bell patent No. 174,465, March 7, 1876. Its meaning and construction. — The signification of the technical phrases used must be understood. An "intermittent current" cannot, properly speaking, exist, but a current can flow for an instant and then be interrupted and cease for an instant, and a succession of such instants of current and no current is called for convenience an "intermittent" current. There is also no such thing in nature or art as an "undulatory" current, literally so called; but a current may be at this moment of one

strength, and the next moment of a different strength; and if those successive strengths at successive instants bear to each other the relation which is expressed by a curve known as an undulatory curve, then for convenience the current is spoken of as an "undulatory" current. That does not mean that the current has waves on it like the waves of the sea; it means that at one instant it has one strength, and at a succeeding instant another strength, and that the relation of its strength at one instant and its strength at another, is expressed by a curve of an "undulatory" character, as indicated by the diagram on p. 301, *infra.* This phrase is borrowed from the language of acoustics. Physical vibrations which take place in the air, or in any mechanical medium transmitting sound, have many differences, but they all have in common one peculiarity which comes from the nature of the physical medium in which they take place. Every medium which transmits sonorous vibratory physical motions possesses both elasticity and inertia, and the peculiarities which the elasticity and inertness of a medium impress upon vibrations which take place within it consist in a certain gradualness, as distinguished from abruptness, of change. Although many of these changes, when exhibited by curves, sometimes seem extremely abrupt and sharp, yet, from their essential nature they are known as gradual, undulatory, or wave-like; or more specifically, to use a still more technical term, "sinusoidal" — the mathematical name of the curve which, either simple or in various combinations, expresses the free vibratory movements of elastic and inert bodies, and therefore all sonorous vibrations. An air vibration may be simple, such as is produced by a tuning fork; it may be extremely complex, such as is produced by the human voice or the violin. But whether simple or complex, the nature of the medium in which it takes place makes the mathematical statement of the character of the vibration necessarily capable of representation either by a simple sinusoidal curve, or by a line which though curiously curved, and apparently ragged, is nevertheless made up of certain combinations of simple sinusoidal curves.

All changes, whether in vibrations of the air, or fluctuations

in the height of the barometer or thermometer, or of the tides, at successive hours, or in the strength of an electric current at successive instants, are often represented to the eye by such curves, which are used as a graphic shorthand representation of ideas and relations which would otherwise be expressed by pages of words. In Mr. Bell's patent they are so represented. The intermittent current is conventionally represented by a series of blocks, as A B in the upper line of this cut:



This does not mean that there are on the line at any one instant a succession of spurts of electricity — electricity at some parts of the line and not at others. It means that for a period of time represented by the length of one block, there is, all over the line, a current whose strength is represented by the height of the block; and that after that, for a period of time represented by the blank space, there is no current at all anywhere. That phenomenon is called an intermittent current.

If, now, the current varies, so that at one instant it is of a strength represented by the height of the line E, in the lower diagram C D, and at the next instant by a strength represented by the length of the perpendicular line F, and so on, and the variations of strength, or the curve which represents those variations by joining the tops of those lines, are "undulatory" in their character, then we speak of that current as undulatory, because of that variation in its strength at successive instants. Those are the symbols that are used in the patent.

Any succession of strengths of current can obviously be represented by drawing perpendicular lines of relative lengths, E, F, G, etc., representing the relative strengths at successive

instants. Joining the upper ends of those perpendiculars, when they are taken very close, as between K L, gives a curved line whose contour represents, to the trained eye, the succession of lengths or strengths. From this graphic mode of expressing the facts arises the phrase "form" of current variations, or in abbreviation, "form of current," signifying the current whose changes are represented by a curve of a particular form.

An amendment to the application originally filed in the Patent Office was made by the usual correspondence; but it was merely explanatory and surplusage. It is entirely immaterial. That I may be free from criticism on that point, I shall read only those parts of the specification which stand in the patent itself exactly as they stood in the application originally filed; and my case may stand on that.

Mr. Bell, for some years before he took this patent, had been at work on a multiple telegraph which operated by the production of sounds of certain musical pitches, produced by circuit-breaking and by intermittent currents. They were like the circuit-breaking and intermittent currents of Reis, and they produced musical pitch just as the Reis did, although Mr. Bell worked his machine by mechanism, and not by the voice. His present patent, the contents of which are a picture of several years of his work and of the growth of the ideas in his mind during that time, begins by referring to his former circuit-breaking multiple telegraph, and states that he proposes to discard the instruments previously used in it in favor of a new kind. He says that he finds some advantages in the use of a current which is not chopped up into chunks, but varies its strength in accordance with the law of sound waves, — that is, a current which is not "intermittent," but is "undulatory," — and he proceeds to state some advantages from the one kind of current rather than the other.

It is true that every sonorous movement of the air is "undulatory"; but it is not every sonorous movement of the air which gives rise to speech. That comes only when the undulations are of the peculiar kind or "form" belonging to the spoken word. Speech is not the necessary result even of

aerial undulations, and it would have been untrue to say that speech would be one of the results of an undulatory current. Therefore Mr. Bell, in speaking in general terms of the advantages which flow from the use of a current, undulatory as distinguished from intermittent, in its character, but irrespective of the *form* of the undulations, named certain advantages and did not include speech among them, because the statement would have been untrue if he had included it. His multiple harmonic musical telegraph, Fig. 5 of this very patent, is worked by currents which are "undulatory," but which are not of the "form" requisite for speech, and which therefore do not yield speech. This same statement which I am making is found in substance in the letter written by Mr. Bell to Mr. Hubbard, August 14, 1875, six months before he filed his application. He says that the advantage of the undulatory current is that by its employment, whatever sonorous effects can be produced in the air can be produced by electricity. Musical sounds can be transmitted; many musical sounds at the same time can be transmitted; and *by giving the undulations the proper form*, speech, and indeed the utterances of several speakers at the same time, can be transmitted. He wrote in that letter (the *italics* are in the original):

"I can see clearly that the magneto electric current will not only permit of the actual copying of *spoken utterances*, but of the simultaneous transmission of *any* number of musical notes (hence messages) without confusion. . . .

"When we can create a pulsatory action of the current, which is the *exact equivalent* of the aerial impulses, we shall certainly obtain exactly similar results. *Any number of sounds* can travel through the air without confusion, and any number should pass along the same wire.

"It should even be possible for a number of spoken messages to traverse the same circuit simultaneously, for an attentive ear can distinguish one voice from another, although a number are speaking together."

If two tuning-forks of different pitches are sounding separately, we are affected by the sensation of sound, but what we perceive is not one sound, the mean of the two pitches; we hear

each sound separately. The vibrations made by one fork, and the vibrations made by the other, different as they are, travel through the same air. In a mechanical sense, they coalesce and combine into one complex vibration, yet the ear unconsciously analyzes them out again as separate sounds. This which can be done in the air, Mr. Bell says, can be done by his undulatory current in electricity; and that is true. But he can do more than just that. As the voice in uttering a word produces a peculiar "form" of undulation, which gives rise to the sensation of that word *as one sound*, — no matter though it be in itself capable of scientific analysis into a principal and subordinate set of vibrations, expressed technically by the phrases "fundamental" tone and "overtones," combined and blended together, — so an undulatory current whose undulations are due to the voice, and are copies of its aerial impulses, can convey the complex undulations of a particular spoken word and yield the same result at the distant end. The conception which possessed Mr. Bell at that time was of electrical variations of current which were to be just like the sound waves, and which therefore could serve *all* of the same purposes. They were to transmit many messages by many pitches; spoken utterances; many spoken utterances, simultaneously; according to their combinations and forms. He was possessed with the idea of moulding or forming the current so that it should be like sound vibrations generally, and also in a given case like any particular sound vibrations that he wished to reproduce by it. That is the substance of his patent. That is the cardinal key and idea of his whole patent. It was an idea wholly novel in science and the arts.

He illustrates his plan first by describing what takes place when the old "intermittent" current is used. Then he refers to what takes place when any *simple* undulatory current is used, and says that he cannot describe it better than by showing its likeness to sonorous vibrations in the air. Then he points out what happens when two independently created sets of simple electrical undulations are thrown upon the line wire at the same time, and points out that their effect in the total electrical current, and in the resulting sounds, is just like the

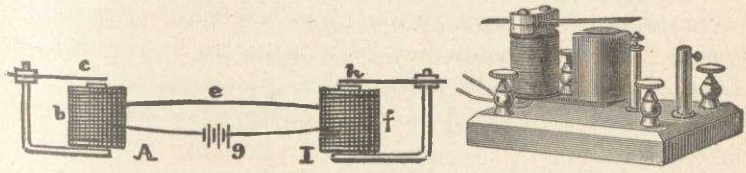
effect produced by tuning-forks sounding simultaneously. The patent expresses this as follows:

"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 coëxistence 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."

These are his leading ideas. Now he proceeds to apply them. He says in the patent:

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

He then describes his *harmonic telegraph*, Fig. 5, consisting of the instruments here shown. The diagram is from the patent and shows the connection of the two in circuit. The perspective view is from one of the actual harmonic instruments he was using when he made the discovery of June 2, 1875.



When the armature *c*, which is a steel spring, vibrates, it produces in the air a simple undulation of a definite rate, and by the generation of magneto electric currents, as explained on pp. 265–9, *supra*, it produces on the wire a simple electrical undulation of the same rate; that, passing through the wire *e*

to the receiving instrument, and operating on its electro-magnet, there causes its attuned reed *h* (the two instruments are just alike) to perform the same simple vibratory movement, and the same simple sound is heard. The patent describes how several sets of these can be connected with the same wire (as in Fig. 6 of the patent, p. 5, *supra*), and several notes produced at the same time from several different attuned reeds of several receivers, just as in the case of two tuning-forks in the air. It then shows that if you break up each set of notes into longs and shorts, you can telegraph the Morse alphabet by each set, and thus send two or more Morse messages at the same time over the single wire. The patent concludes the description just stated by saying:

"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.

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

The patent has now described the *multiple telegraph*, and it makes no further reference to that in the rest of the specification. It next advances one step further. It states that these electrical undulations, generically like sound waves, and available for pure musical tones when they are of the simplest form, can be used for other special results, and for special sounds, when they copy special sound waves:

"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*."

He then proceeds to describe Fig. 7 (cut on p. 309, *infra*), a different instrument from Fig. 5, and intended for this latter and different purpose. Some of the experts for the defence have said that they find first in this patent a multiple telegraph, Fig. 5, which is true. Then they say that because Fig. 5 is a multiple telegraph, they have a right to assume that

Fig. 7 is also. But the language of the patent itself is explicit. Having described the multiple telegraph, Fig. 5, it passes from that subject entirely, and then, going to Fig. 7, it says that that is intended for "other" uses, to wit, not merely the transmission and reproduction of pitch; not merely the reproduction of differences of loudness, as well as of pitch; that is, not merely the reproduction of musical tones, differing both in loudness and pitch, but "the telegraphic transmission of noises and sounds of any kind." This language is expressly used to distinguish the transmission of the characteristic called pitch, and the transmission of the characteristic called loudness, from the third thing which goes beyond all that, — the transmission of "noises or sounds of *any* kind;" which means their transmission in such a way that they can be distinguished from each other by that which distinguishes one *kind* of sound from another kind, and which, moreover, is something in addition to mere pitch or mere loudness. That is, he expressly contrasts the transmission of noises and sounds of *all* kinds, with the transmission of musical notes, and mentions it as something going beyond the transmission of musical notes.

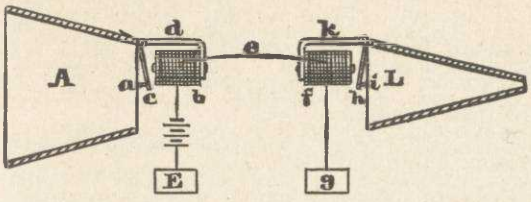
This is again made clear by his description of the apparatus, for that shows new features introduced into Fig. 7 to fit it for new functions, leading to a new kind of result. First he describes the tuned-reed instrument, Fig. 5, to be vibrated mechanically; that necessarily causes its own pitch to be reproduced. That is the transmission of pitch simply. Then he says that that instrument, used differently, will also transmit loudness. In the particular case where you control the violence of the vibration of the transmitter reed, you will control the loudness of the sound at the further end. The patent states this as follows:

"When the armature *c* Fig. 5, is set in vibration, the armature *h* responds not only in pitch, but in loudness. . . .

"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."

He has thus described how to produce a sound of the desired pitch. Next he has described how to control loudness. Finally we come to the third purpose stated, to wit, the transmission of "noises and sounds of any kind." Fig. 5 cannot do that, or at least not normally or effectively. The vibrating parts are tuned reeds, or tuning-forks, and the very essence of such an instrument is that it can be relied upon always to vibrate in its own way, and will not vibrate in any other. It therefore cannot copy "*any*" kind of vibrations, which must be done in order to produce "*any*" kind of sound. To accomplish that, the strong will of the instrument must be overcome, and it must be made subservient to the will of the operator, or rather to whatever may be at the moment the movement of the air particles set in vibration by his voice or by any other kind of sound to be transmitted. To accomplish this, Mr. Bell says that instead of having a *spring* armature (*c*) which can vibrate only in one way, he will cut the spring (he describes it as a clock spring which is a thin and light piece of metal), and put a hinge in its place and attach the whole to the diaphragm of a lover's telephone, which we know can vibrate in any way, in response to any kind of sound. He will then have got the mechanical conditions essential for the reproduction of "any kind" of sound. The patent then explains that when the transmitter of an apparatus of this sort is thrown into vibration by the sound waves — sound waves produced by the utterances of the human voice are the particular kind mentioned — it will produce electrical undulations on the line; and the electrical changes produced will not only be "undulatory," but they will be of *the peculiar kind of undulations belonging to the sound uttered.* Or, to state it in the then known language of acoustics, they will be "similar in form" to the air vibrations caused by the sound. These electrical undulations go over the line, and when they reach the receiver they, by reason of their peculiarity of form, influence the armature of the receiver to copy the motion of the transmitter in the manner stated on pp. 267–270, *supra;* and the result, he says, is that a similar sound to that uttered into the transmitter is then heard to proceed from the receiver. The paragraph is:

Mr. Storrow's Argument for American Bell Telephone Co.



"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 the stretched membrane *u*. A cone A is used to converge sound vibrations upon the membrane. When a sound is uttered into 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 undulatory 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."

This apparatus produces this result by the employment of electrical changes which are undulatory in their character; but it produces it, not simply because they are undulatory in their character, but because they are of the precise "form" of undulation which belongs to the sounds uttered into the transmitter. That "similarity of *form*" is essential to the result, and as it is the most striking novelty, he thus summed up the whole invention in his claim:

"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."

"We cannot find that in any publication before Mr. Bell's time," say even all the defendants' experts. "So marvellously simple that the only wonder is that it was not known before," says Professor Barker. "I cannot transmit speech without that," says Professor Dolbear and his experts. That is the

novelty. It is not only *a* novelty which distinguishes Mr. Bell's apparatus from what preceded him, but it is *the* novelty which makes it to be a speaking telephone. It is the very gist and soul of this invention.

The defendants' expert Professor George Barker, who witnessed Bell's exhibition at the Centennial, testified on cross-examination:

"I was greatly astonished and delighted to hear for the first time the transmission of articulate speech electrically. . . .

"I cannot speak of the others present. Perhaps very naturally their interest in the remarkable result that they had just witnessed led them to question Mr. Bell in regard to the theory of the telephone. As for myself, the mode of operation of the instrument was obvious at once as soon as it was exhibited; it was one of those marvellously simple inventions that causes one to wonder, on seeing it for the first time, that it had not been invented long before."

And yet the defendants want this court to believe that the result was old, instruments for producing it were well known, and that the operation stated is so purely imaginative that it is not statable and ought not to be accepted or believed.

The experts undertake to say that they would like to have the court believe that this patent is *only* for a telegraph, because the claim itself says "transmit vocal sounds telegraphically" which *ex vi termini*, they say, means by a Morse telegraph. Even their verbal criticism is absurd. The record contains many cases of the use of the phrases "telegraphic transmission of sounds" — and "vocal sounds," as applied to the speaking telephone by men of authority as writers. It appears from Mr. Bell's own letters before the patent, that "the transmission of vocal sounds" was the phrase which he generally used to express the transmission of speech. Sir William Thomson's formal report on Bell's speaking telephone at the Centennial, and Professor Henry's official report, both spoke of it as a form of "telegraph." They say that the transmission of speech by it was "the greatest marvel achieved by the electric *telegraph*." President Barnard, of Columbia College, one of the Centennial judges, wrote of it

as "your plan of telegraphing vocal sounds." The old string instrument does nothing but transmit speech, and yet it is called the "lover's *telegraph*." The patent is in terms for the transmission of "noises or sounds of *any* kind," and the particular kind which is mentioned in illustration are the utterances of the human voice. The operation described will transmit noises or sounds of any kind, including speech (not speech exclusively) because, by natural laws, the apparatus, if sufficient for "any kind" of sound — the language of the patent — will transmit all; and a statement that it transmits "speech" would be less comprehensive and less true. Every court has so decided.

Yet some of the experts have labored to make the court believe that under that language he meant to include not "other" uses than the multiple telegraph, nor utterances of the human voice as everybody understands them, but a contrivance for multiple telegraphy alone, excluding those utterances of the human voice which distinguish articulate speaking man from the gibbering brute. But even the Gray caveat, which is set up as a model, uses the same language — "transmitting vocal sounds." It adds the clause, "It is obvious by this means that oral conversation can be transmitted." It *is* obvious, and no man could become the inventor of the art of transmitting speech, or ever even an improver in that art, by reprinting Mr. Bell's specification and adding this "obvious" conclusion in terms.

One of the defendants' experts (Dr. Channing), having first said that he could not find better language than the fifth claim of the Bell patent to express the operation by which the telephone transmits speech, afterwards criticised it, but finally had to say again, after eight years' study of the telephone, "No better form of expression occurs to me at this moment as a general statement."

The fifth claim is the only one sued on, but the third and fourth help to show its meaning and scope. Claim 3 is for producing the undulations by the magneto mode; claim 4 is for producing them by the variable-resistance mode. But claim 5 is not a claim for producing them by any particular

mode. It is, as the Molecular brief well says, "for transmitting speech by means of them" when they are of the particular form specified. Claims 3 and 4 are for producing them in the machine, as means to be there used; but claim 5 is for transmitting speech *by* this means. They are the means, the novel means, and the effective means.

To this claim our opponents object that it specifies a mere conception — a law of nature — a mere idea. But that idea was the idea which gave birth to the speaking telephone. There were no speaking telephones before, because the world did not have that idea. Every speaking telephone since then has been the embodiment of that idea.

Watt's invention of the steam engine, or rather Watt's improvement in the steam engine, consisted simply in telling the public that instead of squirting cold water into the cylinder to condense the steam, they should let the steam escape into a separate box and squirt the water into that. "Because," said he, "squirting cold water into the steam cylinder cools it down, and when you next let the steam in you use a great deal of steam in simply heating the cylinder up again. So, have one hot chamber for a working chamber, and keep that hot, and let the steam escape into a cold chamber when you want to condense it, and keep that chamber cold." His patent had no drawings, and so far as this invention was concerned gave only the rudest description of an apparatus, which was found so imperfect in practice that it was of very little use. But, with the idea once stated, a good engineer could make a working machine. The infringers answered to his patent, "This is perfectly obvious; you have only stated an idea — a mere law of nature." But the judges said, in substance, "This man has created the steam engine that everybody wants, and the statement that he has made was all that was needed to enable people to make this engine. He has not only made his own very wretched form of engine," — indeed, he never made a working engine before he took his patent, — "but he has given the rule for future steam engines. If such an improvement cannot be encouraged by the protection of the Patent Law, then there is no Patent Law." And

so every form of engine which embodied that idea was held to infringe.

Fifty years ago appeared another great invention — the Neilson hot blast. To smelt a ton of ore in a blast furnace requires about two tons of air to be blown in. It requires more fuel to heat that air than to heat the ore; and blowing in that vast amount of cold air cools the furnace and leads to very great difficulties. Neilson said, "Why don't you blow the air in hot?" That was the invention — that was the whole of it. Of course he had got to do a little more; he had got to tell them how to heat the air. "Why," said he, "build a fire around the pipe between the blowing engine and the furnace. Indeed, enlarge the pipe over that fire into a large receptacle, in proportion to the amount of air you want to get through; then the air will stay there longer and get hotter." That was the whole patent. No man who knew that the vapor from a still is condensed by pouring cold water on the pipe, or had seen the surface condenser of Watt's engine, would pretend that Neilson's contrivance as a mere machine for changing the temperature of the inclosed gas had invention enough to sustain a patent. Blowing a hot blast into a smelting furnace was his real invention. "A law of nature," everybody said. All the old women in England heat their teapots, so as not to cool the water when they pour it in to steep the tea. "As for your machine," said the iron makers, "a large receptacle to pass the air through is practically worthless. We shall build a fire around the pipe itself without any receptacle, letting the pipe take a good many turns backward and forward in the fireplace like the worm of an old still." "But," the court said, "you avail yourself of that idea which Neilson first introduced into the arts. His form was operative enough to sustain his patent, and you adopt yours not because it does not heat the blast, but because it heats it hotter." Their form was a great deal better than his. That is always the case with great originators. The next man who comes along and uses the brains of the first as a stepping stone will go far beyond him. The first Watt steam engine, the first Neilson hot blast contrivance, the first Morse tele-

graph, the first Howe sewing-machine, the first Bessemer plant, were not worth having in a commercial sense; indeed, all the users of the first Bessemer plant threw it away, because they could not make it work successfully. But the great inventor opened the door. All that the others had to do was to enter the new house and make it more comfortable.

Infringement. — It has been apparent that if the Bell patent be limited to the particular form of Fig. 7, and to the use of its method *only when practised with a magneto transmitter*, no defendant infringes the first patent for all use microphone transmitters. But if it has the scope we have asserted for it, the defendants cannot successfully deny infringement.

To this Dolbear's form of apparatus is no exception. He uses a microphone transmitter and a "condenser" receiver. He and his experts agree that his transmitter produces the undulations of the patent, and that it cannot transmit speech unless it does. They say in terms that so far as the *transmitter* goes their apparatus is Bell's Fig. 7. But they insist that the difference in the receiver, and the changes of arrangement incident to that difference, relieve them.

Electricity has two long-known properties. When it flows *around* a piece of iron it makes that piece attract a plate in proportion to the amount flowing at each instant. When it flows *into* a piece of iron, it makes that piece attract a plate in proportion to the amount which has flowed into the plate and is in it at each instant. Bell used the first property to attract his plate; Dolbear used the second. But the novelty which makes the plate of the Bell receiver and the Dolbear receiver talk is not merely that the electricity produces an attraction proportioned to its amount, but that the amount of electricity sent from the transmitter to act on whatever receiver be placed at the distant end, varies in accordance with the rule laid down by Mr. Bell as constituting his method. The Dolbear talks because it follows this rule.

Indeed, if a Bell receiver be connected with the Dolbear line, the same electrical undulations sent from the Dolbear microphone transmitter will make the Bell receiver talk by one of its properties, and the Dolbear receiver talk by the other of

its properties. Both employ the electrical undulations of the patent. In one their special and novel characteristics manifest themselves to the ear by one well-known property, and in the other by another well-known property. Dolbear's defence reduces itself to the same kind of attempt to narrow the patent which the other defendants make.

Breaks and Dead-Points. — Some of the defendants' experts, particularly Messrs. Young and Brackett, of Princeton, and Professor Sylvanus P. Thompson, of Bristol, England, (whose deposition was taken in this case,) used language which was intended to induce the court to believe that the microphone transmitter used by the defendants produced interruptions in the current; they insisted that the fifth claim of the Bell patent was technically limited to currents that were strictly continuous; and upon this they founded the argument that by reason of the alleged breaks in the current these microphones were taken outside of the Bell patent, and that the use of these instruments did not infringe.

To this there are several answers. One is, that the experiments and reasoning detailed in the testimony of Professor Cross and Professor Wright, experts for the Bell Company, prove that speech cannot be satisfactorily, or even intelligibly, transmitted by any instrument actuated by the voice, which causes breaks in a battery circuit (and a microphone is always necessarily placed in a battery circuit) as often as even once in each complete vibration. Another answer is, that if the averments of defendants' experts as to breaks were true, their current would still be substantially Mr. Bell's current, because it would possess, as the essential characteristic which enables it to transmit speech, that characteristic which Mr. Bell introduced into the current and described and claimed in his patent.

There is nothing in the phraseology of the Bell patent which limits it to strictly continuous currents. The word "continuous" does not occur in the patent. Continuous currents were old in telegraphy, and the patent itself points out and discards one kind of continuous current which it calls a "pulsatory" current, and which will not transmit speech. The patent makes the test of the described current to be its

conformity to sonorous vibrations in the air. Any phenomena which are common to that current and to sonorous vibrations, and to which the term "break" may be applied, would therefore, if found in the defendants' current, be an element of similarity, and not of dissimilarity. Furthermore, any breaks which occur, if they are not sufficient to destroy speech, — as when they occur between words, or at the dividing line between one vibration and another, — if they can occur then without the destruction of speech, — would be negligible, and would not prevent the current in which they occurred from being substantially Mr. Bell's current. An outline of a pure curve may be substantially made, both in fact and in the patent law, by a dotted line, or by a broken line made as by the cross-stitch of worsted-work, or like the contour of a polygon of a great number of sides. *Winans* v. *Denmead*, 15 How. 330, 344; *Ives* v. *Hamilton*, 92 U. S. 430, 432.

Again, the distinction between the current of Mr. Bell and the current of Reis is, that Bell impressed upon his current those peculiarities of vibration which constitute "form" and give rise to "quality." It is absolutely certain that the current, which is the sole connecting link between the transmitter and the receiver, cannot convey these peculiarities from the transmitter to the receiver unless they are impressed upon it; they must be delivered to the messenger which is to carry them, or they will not be carried. Mr. Bell's invention and patent cover the use of a current upon which those peculiarities have been impressed, no matter what type of instrument be used as the transmitter to impress them. If it were true, as we believe it is not, that the microphone impresses them upon the current with substantial efficiency by means of a series of modified and modulated breaks (entirely different from the single, simple break of Reis) the current would be none the less substantially Bell's current, and infringe his patent.

Finally, it is clear that the statements of the defendants' experts on this subject turn chiefly on the ambiguous use of language. Thus, Professor Thompson, on cross-examination, admits that he means by "breaks" partial breaks over only

part of the surfaces in contact; breaks which, while they weaken the current, do not entirely stop it; and Professors Young and Brackett adopt that statement as probably a correct explanation of the operation of the microphone. Dr. Cresson, in the *Clay* case, points out that in the to-and-fro motion of the air particle, as in every vibratory motion, there must be an instant of rest or no motion, or, as it is more properly called, a "dead point," when the particle, having moved in one direction, turns to move back in the other. The diaphragm of the telephone, he says, has these same instants of rest, and thus produces instants of no current in the line which connects with the receiver in the simple magneto apparatus, or in the microphone which uses an induction coil. But he was forced to confess that this phenomenon, by whatever name it may be called, occurs at each extremity of each complete vibration of the air particle, and at every subordinate change or reversal of the motion, and that its occurrence, therefore, in the current is an instance of resemblance and not of divergence.

The second Bell patent, No. 186,787, of January 30, 1877.— The patent of March 7, 1876, was for a "method" and for the first instrument which embodied it. This second patent is for improvements of detail in the structure of that magneto instrument.

The first patent showed the multiple telegraph instruments Figs. 5 and 6. This apparatus required for each set (1) two instruments specially adapted for a particular musical pitch; (2) that each pair, though at distant stations, should be always kept tuned in unison. (3) According to it, Fig. 7, an entirely different instrument, was required for speech. The second patent showed Fig. 7 so improved that (1) it would transmit speech better than before; (2) the same instrument that served for speech would also, and without tuning, serve for the multiple telegraph and for all pitches; (3) the battery of the first patent could be dispensed with.

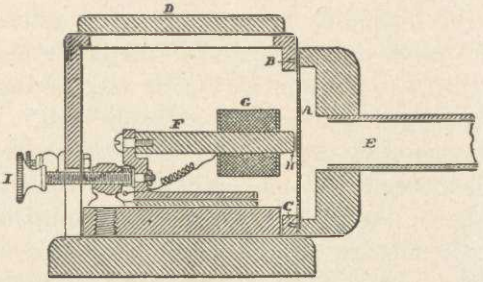
The leading features introduced by this second patent are:

(1) The use of an iron diaphragm in both transmitter and receiver, instead of a diaphragm of membrane with attached armature;

(2) The employment in the telephone of a different form of magnet combined with the other parts, giving much better results;

(3) New shapes of air spaces and casings which ward off extraneous and disturbing vibrations, and preserve the desired sound waves from distortion or weakening;

(4) The employment of a permanent magnet instead of a battery to magnetize the cores of the electro-magnets.



The Instrument of Bell's Patent, No. 186,787, *Jan.* 30, 1877.

This is Fig. 3 of the patent, which is in fact a drawing of the model filed. The diaphragm A is of sheet-iron, circular, screwed at its edges B and C to the framework. Behind it is the core F H, which the patent says is preferably magnetized. Around one end of it is the short coil G. In front of the diaphragm is the thin air space which communicates with the operator's mouth or ear by the central opening E. When the box is large and heavy this opening is usually prolonged into a tube. By making the core F H permanently magnetic, the battery of the first patent may be dispensed with. The effect is enhanced by winding all the wire of the coil around one end of the core. The patent describes the core as made either of a single bar, with one coil, as in the model, or in a horse-shoe form, with a coil around the end of each limb as in Fig. 5. The patent also prefers to make the core of a steel bar, permanently magnetized, with a

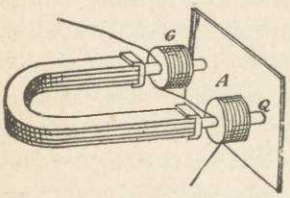


Fig. 5, *of No.* 186,787.

small piece of soft iron (pole piece) screwed into the end, the coil to be wound around that pole piece as in Fig. 5.

All these improvements have gone into universal use.

Drawbaugh asserts that he made all those inventions many years before Bell. Holcombe and some others make the same assertion as to some of them. Their stories are impostures.

The metal diaphragm. Claim 3. — Professor Pickering and Elisha Gray did upon two or three occasions, before 1876, experimentally, combine a sheet of iron and a magnet. It is clear that Gray used his sheet of iron — it was the bottom of a tin wash-basin or a tin cup — as an acoustic reflector or resonator to increase the well-known sound produced by the magnet itself (the so-called "Page effect"), and never thought of claiming for his contrivance any *magnetic* co-operation until long after he saw Bell telephones in commercial use. But apart from that, their work ranks as abandoned experiments. They did not use the contrivance in a speaking telephone, and did not make any attempt in that direction. On the contrary, when speaking telephones became known, both of them announced the opinion (Gray in his caveat) that for the feeble forces available in the telephone a delicate membrane like goldbeater's skin must be employed. Their contrivances were purely experimental in the strictest sense, used two or three times for entertainment merely, with circuit-breaking tuning-fork transmitters, to produce loud musical sounds by a powerful intermittent current, never supposed by either maker to be of any use, mentally and physically thrown away, abandoned and lost, or some of the parts only preserved by accident. Professor Pickering placed a magnet, temporarily, in front of a tin box, and has never made any claim to the invention. Mr. Gray claimed it only when the Western Union Company acquired his pretensions in the fall of 1877 and set him up as a "prior inventor." He did not describe that receiver in his caveat and had forgotten it until he joined the infringers in the fall of 1877. It remained for Mr. Bell to discover and to utilize the marvellous sensitiveness of a disk of sheet iron supported at its edges.

The special magnet in combination. Claim 5. — This mag-

net *per se* was old. But it had never been used to produce sound; it was not used or considered useful for any such operation as it performs in the telephone; and the reasons which make it a desirable form to combine with a diaphragm in a telephone are far outside of the ordinary knowledge of an electrical workman. Claim 5 is not for this magnet. It is for making a new form of speaking telephone which has this magnet as one member.

The peculiar form of the air spaces (claims 6, 7) is confessedly new.

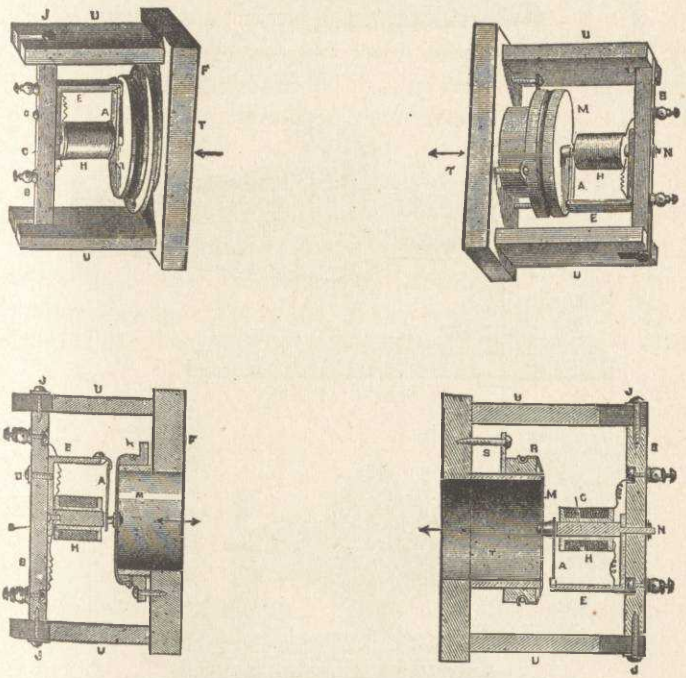
Bell's English Patent. — The inventions of this second patent were patented in England. The English patent was applied for December 9, 1876. The United States patent was applied for January 15, 1877, and was actually issued January 30, 1877. The English application was not completed by the filing of the full specification, the question of granting the patent was not passed upon by the law officers, and the patent itself was neither written, signed nor sealed, until after May 1, 1877. The invention therefore was not "patented" in England at the time the United States patent was granted. Mr. Bell could not, in January 1877, state the English patent, which did not exist until some months afterwards.

It is immaterial whether the English patent was then granted or not, because it has not yet expired, and upon either view the American patent is still in force.

See *Ex parte Bates*, L. R. 4 Ch. 577; Goodeve's Pat. Cas. 594; *Re Cutler's Patent*, 1 Webster's Pat. Cas. 420; *Re Henry's Patent*, L. R. 8 Ch. 167; *Brown* v. *Guild*, 23 Wall. 181; *Harrison* v. *Anderston Co.*, L. R. 1 App. Cas. 574; Goodeve, 223; *Newall* v. *Elliot*, 4 C. B. N. S. 269; Goodeve, 328; *Penn* v. *Bibby*, L. R. 1 Eq. 548; L. R. 2 Ch. 127; Goodeve, 369; *Stoner* v. *Todd*, L. R. 4 Ch. D. 58; Goodeve, 446; *Nordenfeldt* v. *Gardner*, Supplement to the Official Journal of the (English) Patent Office for March 25, 1884; *Holste* v. *Robertson*, L. R. 4 Ch. D. 9; *O'Reilly* v. *Morse*, 15 How. 62; *Smith* v. *Dental Vulcanite Co.*, 93 U. S. 486, 498; *The Corn Planter Patent*, 23 Wall. 211; *American Rock Boring Co.* v. *Sheldon*, 17 Blatchford, 303; *Gold & Stock Telegraph Co.* v. *Commercial Tele-*

gram Co., 23 Fed. Rep. 340; *Canan* v. *Pound Manufacturing Co.*, 23 Fed. Rep. 185.

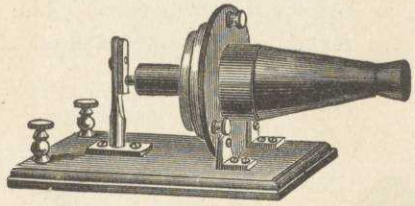
Early instruments constructed by Mr. Bell. — His first instrument was made June 2–5, 1875; another substantially like it was made shortly afterwards. Of these the essential working parts remain, to wit: most of the framework, including the straining rings which carried the membrane diaphragms, the electro-magnets with their heel-pieces, and the armatures. These prove the dimensions of all the parts. Reproductions were made in exact accordance with these, and these reproductions transmitted sentences in the presence of the counsel and expert for the Drawbaugh Company. The following are drawings of these reproductions, one-sixth of the size of the originals.



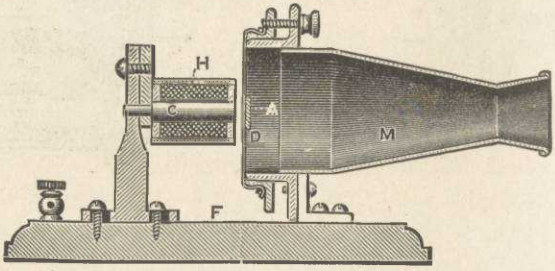
Bell's Telephones of June and July, 1875.

Mr. Bell exhibited at the Centennial Exhibition at Philadelphia, in June, 1876, the following speaking telephones.

Two *membrane diaphragm magneto instruments*, capable of use either as transmitters or receivers, but in fact used as transmitters at the public test on June 25, 1876. The base is of black walnut, the frames are of brass castings, and the cones are of japanned tin. They differ only in that one has a single bar electro-magnet and the other a horse-shoe or double pole electro-magnet. The section is drawn to scale, one-fourth size. The membranes are three inches in diameter.



Bell's Centennial Single Pole Magneto Telephone.



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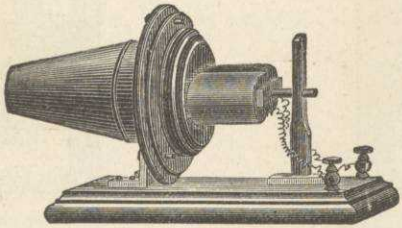
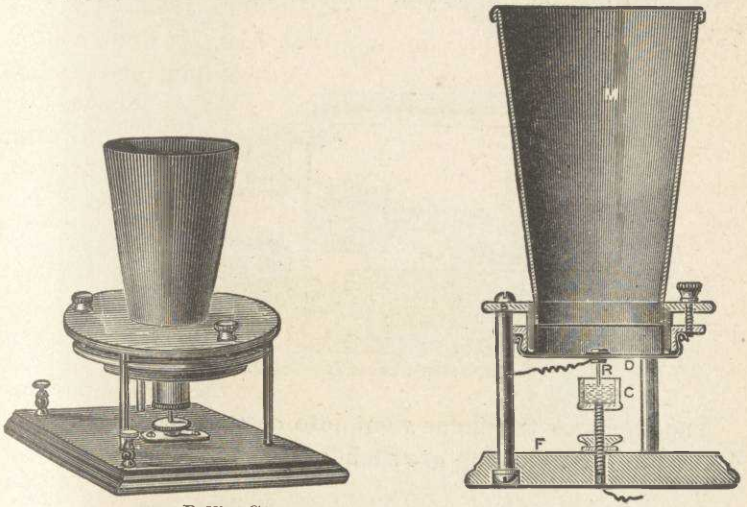


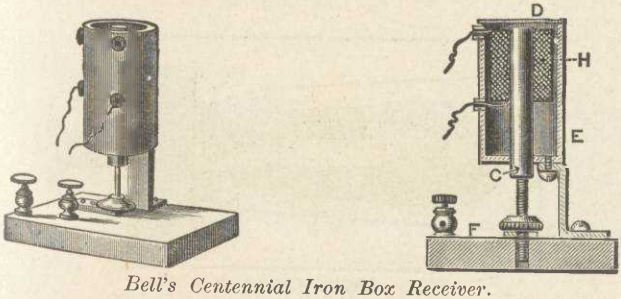
Bell's Centennial Double Pole Magneto Telephone.

He also exhibited a *liquid transmitter*. The sections given below are drawn to scale, and are one-fourth of the actual size. The frame carrying the diaphragm is the same casting used for the magneto transmitters.



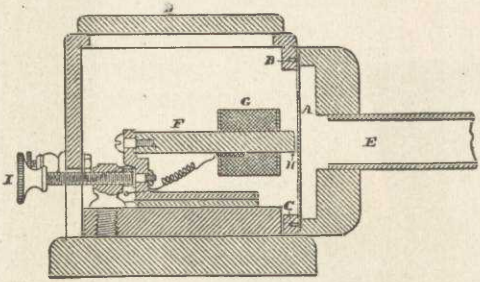
Bell's Centennial Liquid Transmitter.

The *receiver* used at the Centennial consisted of an iron tube E, on the top of which was laid a sheet-iron disc D, serving as the diaphragm. Inside the tube was a soft-iron core C, around which was the coil H. A battery of several cells was placed in circuit. The core C was in contact with the iron bottom of the iron tube E, which thus itself became magnetic.



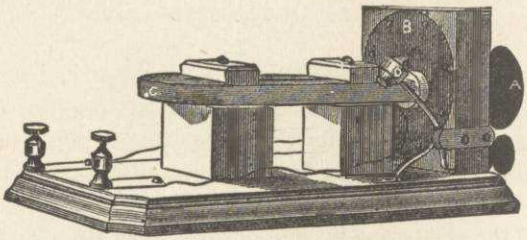
Bell's Centennial Iron Box Receiver.

On June 25, 1876, speech was transmitted in the presence of the Judges and an assemblage of 75 people, by means of the *membrane magneto transmitter* and the *iron box receiver*. During the following week the Judges transmitted speech with them, in their own pavilion, without assistance, transmitting newspaper sentences.

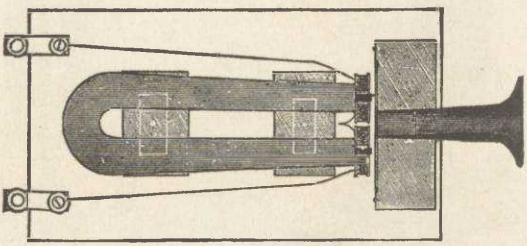


Model of Patent No. 186,787.

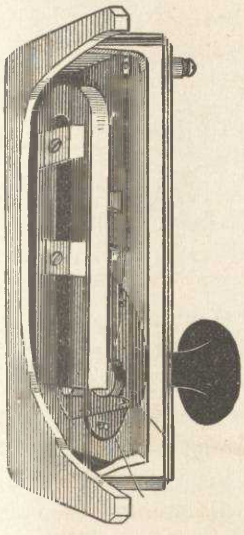
The magneto telephone went into commercial use in April, 1877, and the following are some of the early forms.



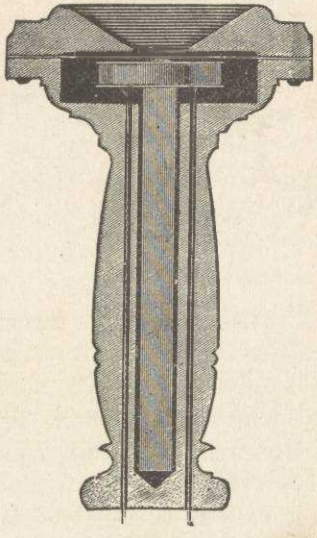
Box Magneto Telephone in use before April 5, 1877.
(*Cover Removed.*)



Plan of Same.

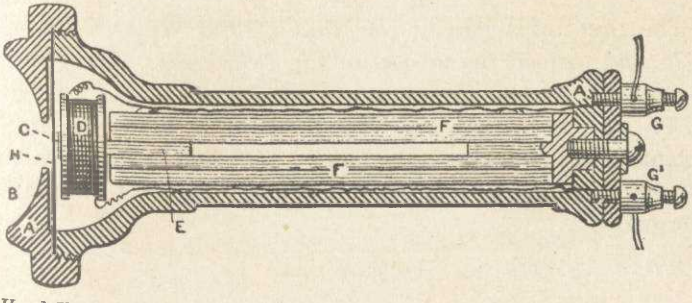


Box Telephone in use in August, 1877. (*Part of box and of diaphragm cut away.*)



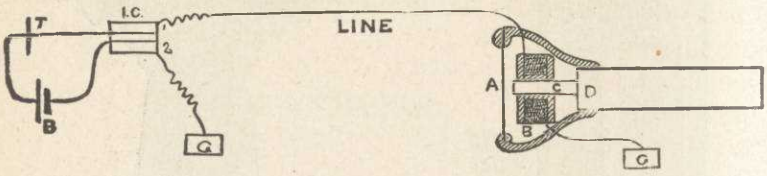
Hand Telephone of May, 1877. (*Wooden Handle.*)

About 25,000 of these magneto instruments went into use (chiefly of the upright box and the rubber handle forms) before the microphones appeared. Carbon microphones of the Edison and Blake (p. 279, *supra*) forms with induction coils went into commercial use in the summer and fall of 1878.



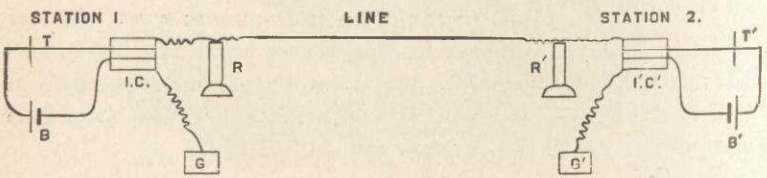
Hand Telephone, in use since December, 1877. (*Rubber Handle.* $\frac{1}{2}$ *size.*)

Circuit connections for microphone with induction coil as commercially used.



T is the microphone transmitter in a short local circuit which includes the battery B (usually one cell) and the primary of the induction coil I C. Of the secondary coil one end goes to the LINE wire which connects with the coil B of the receiver. The return circuit is usually completed through the ground (G G,) though on very long circuits, as from Boston to Philadelphia, a return wire is employed because it gives much better results.

In order to talk both ways alternately the arrangement at each station is duplicated as follows in which T talks to R′, and T′ talks to R.



The first infringement was that of the Western Union, in 1878, and formed the subject of the Dowd suit. The next was that of the Eaton Company (Spencer case) in the summer of 1880. It was in that suit that it was first alleged that Reis invented the speaking telephone. At that time there were 140,000 speaking telephones in use under license from the Bell Company.