The multiple telegraph

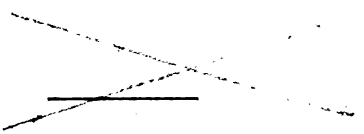
Alexander Graham Bell

THE

MULTIPLE TELEGRAPH.

INVENTED BY

A. GRAHAM BELL.



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ALEXANDER GRAHAM BELL'S

STATEMENT OF INVENTIONS

Filed with the Honorable Commissioner of Patents in Conformity with Rule 53.

I CANNOT with any great accuracy fix the date of the conception of the system of Multiple Telegraphy for which I have applied for letters-patent of the United States. I merely know that the idea had been conceived previously to my departure from England in 1870, and that it could not have occurred to me at an earlier date than 1867, in which year I commenced the study of Telegraphy with a friend in the city of Bath.

From August, 1870, until October, 1872, I resided in Canada; but during 1871–72 I visited various towns in the United States for short periods of time.

I came to the United States, to become a permanent resident thereof, on the 1st of October, 1872. By advice of counsel I do not particularize the various stages of the invention that were developed abroad.

During the winter of 1872–73, at my place of residence, No. 35 West Newton Street, Boston, Mass., I resumed experiments upon the simultaneous transmission of a number of telegraphic signals along a single wire. The theory which I was then striving to reduce to practice will be best understood by stating the train of reasoning that had originally led me to the conception of the Multiple Telegraph. If we press down

Train of Reasoning which led to the Conception of Multiple Telegraphy.

the pedal of a piano, and sing into the instrument, the sound waves cause that string to resound which corresponds in pitch to the note sung. Now, conceive that under each string is placed an electro-magnet, and that all the magnets are united in one circuit. If we transmit a series of electrical impulses along the circuit (corresponding in number and regularity to the vibrations of a sound), a similar series of attractive impulses will appear at the magnets, and the piano-string whose rate of vibration corresponds will resound. In the one instance all the strings receive a definite number of pushes per second from the air; in the other, a definite number of pulls per second from the magnets. As the effect of pulling a string on one side is equivalent to pushing it from the other, it is evident that whatever phenomena result from the action of aërial pulses upon the strings must also ensue from attractive impulses from the magnets. However many notes are sung simultaneously into the piano, each system of sound waves affects its corresponding string as readily as though the other systems had no existence: hence, however many different series of attractive impulses are made to appear simultaneously at the magnets, each one must affect its corresponding string as though it came alone. The study of sympathetic vibrations thus led me to the conclusion that a large number of telegraphic messages could be sent simultaneously along the same circuit, without confusion, if the signals for each message had a certain definite pitch different from those employed for the others, the duration of the note representing the dot or dash of the Morse alphabet.

Experiments undertaken to reduce the Theory to Practice.

The experiments undertaken in Boston during the winter of 1872–73 related more particularly to the mechanical means of transmitting vibrations. I was acquainted with Helmholtz' apparatus for the artificial production of vowel sounds; and all my earlier experi-

First apparatus constructed in the United States, winter of 1872–3.

ments were modelled upon his. Figs. 1 and 2 illustrate the first form of apparatus constructed in West Newton Street.

Tuning-forks with mercury connections.

The following letters descriptive of these experiments have been received from a witness: —

WEST MEDFORD, Nov. 9, 1874.

MR. A. GRAHAM BELL.

Letter from witness of experiments made in winter of 1872–3 (dated Nov. 9, 1874).

My Dear Sir, — At your request I write what I can remember witnessing as regards your experiments in telegraphy. Between January, 1873, and May, 1873, your rooms were at No. 35 West Newton Street, and mine at No. 36 West Newton Street, in Boston. During that time we were in telegraphic communication with each other, and together a great deal of the time evenings. I remember how you were experimenting on a new system of transmitting messages *both ways* on *one* wire *at the same time*, and how enthusiastic you were over your discovery. You used tuning-forks; and a connection or circuit was made and broken by means of the vibrations of the fork (according to its pitch) in a cup containing quicksilver (the cup you used then was a little wooden pill-box); and, as the fork vibrated in and out of the quicksilver, the circuit was made and broken accordingly The experiments were made, I should think, previous to May, 1873, but am not quite sure, or of how long a time we had the wire connecting our rooms. I *am sure*, however, that we were transmitting messages to and fro then; for I have now in my possession a little memorandum of yours, giving a copy of messages between us dated May 18, 1873. I think that your experiments with the forks were at or before that time. I cannot go more into detail (although I was with you so much, even when both of us should have been in bed), for telegraphy and electricity was a new study to me, and I was very much interested over my own experiments; but I *do* remember distinctly the interest you took, and the time you gave over your experiments.

Yours truly,

P. D. RICHARDS.

Another letter from same witness with drawing of apparatus employed in winter of 1872–73 (dated Feb. 28, 1876.)

In February, 1876, I wrote to Mr. Richards from Washington, requesting him to draw from memory the apparatus used by me in the winter of 1872–73. In a letter received from him dated Feb. 28, 1876, he says, —

"I can testify that your experiments, as illustrated below,* were made before July 8, 1873, as I have now before me a book, on the

*See fig. 1.

fly-leaf of which is written, as I took it down from the instrument, 'Receive my last taps adieu. A. G. B. July 8, 1875.' Underneath which is written, 'Bell left yesterday for Canada, July 11.' I think and am almost certain that your experiments with the tuning-forks were in winter or early spring. I have in my possession a telegraphic memento of a message between us dated in May.

"P. D. RICHARDS."

Tuning-forks with adjustable pole-pieces, and mercury connections, (Jan. or Oct., 1873.)

On account of the small size of the tuning-forks, and the imperfect means at my command, the vibrations obtained were not as satisfactory as had been hoped. The oxidization of the mercury too was a source of great annoyance, and was only partially obviated by covering it with alcohol. The instruments were taken to pieces, and put together again, without any better result, until I copied more closely the form of Helmholtz' instrument, by constructing the apparatus shown in Fig. 3. One of these instruments is still in my possession in its original form.

The work was carried on under great disadvantages. My profession occupied me from morning till evening, so that all experiments had to be conducted at night after most people had retired to rest. I felt obliged also to construct the instruments with my own hands, even to the winding of the electro-magnets, as I was afraid to employ an electrician or mechanician until the invention could be secured to me by letters-patent.

The instruments shown in Fig. 3 were constructed either in January or October, 1873, but at which period I am unable to state positively. The iron cores for the electro-magnets, with the adjustable pole-pieces, were made for me by a blacksmith in Brantford, Ontario, during one of two visits that I paid to my family in Canada. The first extended from Christmas Day, 1872, to New Year's Day, 1873, only one week.

Spent summer of 1873 in Canada.

The second was occasioned by an illness, which obliged me to relinquish all work for some months.

I remained at my father's house in Canada from July, 1873, until the 1st of October, of the same year.

Apparatus constructed abroad not described.

My impression is that the cores were made during the Christmas week in 1872, as I distinctly remember that the blacksmith had only a day or two in which to do the work. The blacksmith himself thinks, however, that the work was done in the summer of 1873.

In October, 1873, I resumed the practice of my profession in Boston, residing at No. 292 Essex Street, Salem, where the experiments with tuning-forks (arranged as in Fig. 3) were resumed.

Returned to Boston Oct. 1, 1873.

Experiments resumed in Salem, Mass.

In the same month (October, 1873), the attempt was made to substitute a free reed for the transmitting-fork, shown in Fig. 3.

The free reed (R), Fig. 4, formed the base of a hollow cone of gutta-percha (gg); and it was set in vibration by blowing through the orifice O. A platinum wire P, attached to the reed R, dipped into mercury M. The original instrument is still in my possession.

Free reeds, with mercury connections (Oct. 1873).

Somewhere about November, 1873, an article entitled "The Acoustic Telegraph," published in "The Wonders of Electricity," led me to substitute steel plates for tuning-forks in my telegraphic experiments. Two transmitting instruments and two receiving instruments (specimens of which are still in my possession in their original form) were made like those shown in Fig. 5. These were arranged on circuit as shown in Fig. 6.

Steel plates with mercury connections (Nov. 1873).

Attempt to send two signals simultaneously, Nov. 1873.

On pressing K^1, R^1 was set in strong vibration, while R^2 was unaffected save by a slight tremor, perceptible only to the sense of touch.

On pressing K^2, neither of the receiving instruments R^1 R^2 responded save by the trembling alluded to above.

On pressing K^1 and K^2 simultaneously, R^1 was thrown into strong vibration; but R^2 was not affected. Having

no means of tuning the plate, I was unable to make R^2 respond to the vibrations of T^2.

Steel-plates with platinum connections (Nov. or Dec. 1873).

Fig. 7 shows another form of instrument constructed during November, 1873.

Bassoon-reed Platinum connections (Nov. or Dec. 1873).

The instrument shown in Fig. 8 was also made about the same time, consisting of an ordinary bassoon reed. A wire W was brought to the point P of the tongue *t*, and fastened so that the vibrations of *t* caused P to strike against the metal surface M, thus causing an intermittent current to pass through the electro-magnet f.

Relinquishment of practical experiment, and development of scheme theoretically (Nov. or Dec. 1873).

It became evident to me, that with my own rude workmanship, and with the limited time and means at my disposal, I could not hope to construct any better models. I therefore from this time (November, 1873) devoted less time to practical experiment than to the theoretical development of the details of the invention.

Arrangement on circuit (Nov. or Dec. 1873.

Defect, — communication in only one direction.

The arrangement on circuit, at which I had then arrived, is shown in Fig. 9. There was one defect in the plan, for which I sought a remedy. Communications could be sent in only one direction.

While station A was sending to N, any intermediate station could also send a message to N or to any place between itself and N; but it could not communicate with A, or with any place in the direction of A, except by using another line.

Communication in both directions if free earth communication at each end of line could be obtained (Dec. 1873.)

I saw that one wire would suffice for communications simultaneously in both directions, if free earth communication could be secured at each end of the line.

My first attempt to solve the problem was by the application of artificial resistance as shown in Fig. 10. When the line was put to earth at the two extremities of the circuit A and N, any intermediate station (C) could cause half the intermittent current from its battery to pass to the earth at A, and the other half to the earth at N, by putting sufficient resistance on the shorter circuit.

Artificial resistance unsatisfactory (Dec. 1873.)

Study of the arrangement, however, convinced me that the problem could not be solved by any arrangement of artificial resistances; and I was for a time at a loss how to overcome the difficulty. Early in December, 1873, it flashed across me, that the intermittent current might be induced upon the line wire, in which case there would be no difficulty in having free earth communication at both ends of the circuit.

Induce current upon line (Dec. 1873).

Application of Duplex principle (Dec. 1874).

The arrangement as conceived is shown in Fig. 11. I saw also that the duplex principle could be applied as in Fig. 12, so as to double the number of messages possible upon the acoustical plan. I felt that the time had come for seeking assistance in carrying out the plan.

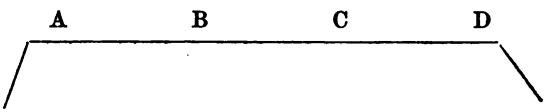
I understood that a patent in this country could not be obtained without models, and knew that I could not prepare proper models without intrusting the idea to some mechanician, who might take advantage of his practical knowledge to checkmate me in the Patent Office. I understood that a caveat could not be procured by a British subject. Not knowing how to protect my interests in this country, I resolved to make an offer of the invention to the British Government; and on the 10th of January, 1874, I wrote the following letter to the Hon. Mr. Scudamore, superintendent of telegraphs in England, requesting an investigation from the proper authorities there: —

Resolved to offer invention to British Government (Jan. 1874).

Letter to the Superintendent of Telegraphs in England requesting an investigation (dated Jan. 10, 1874).

292 Essex Street, Salem, Mass., Jan. 10, 1874.

Sir, — I have invented a method by which a large number of telegraphic messages can be sent along the same wire, at the same time, without confusing with one another.



Any station B may communicate freely with any other station C while messages are passing from A to D, from D to A, from A to C,

&c. The possible number of simultaneous messages that can be transmitted on this principle may be doubled by the use of the duplex system.

As I am a British subject, I wish to place this idea at the disposal of the British Government; and therefore, before making any efforts to interest American telegraphers in the scheme, I write to request an investigation.

Yours respectfully,

A. GRAHAM BELL, *Professor of Vocal Physiology in the University of Boston, Mass.*

HON. SCUDAMORE, *Superintendent of Telegraphs, London, Eng.*

An answer was received from the Post-office Department in London, which effectually prevented any further correspondence.

It was as follows: —

GENERAL POST-OFFICE, 22d January, 1874.

No. 11,566.

Reply from the Post Office Department (Jan. 22, 1874). Unsatisfactory.

SIR, — With reference to your letter of the 10th inst., I beg leave to inform you that if you will submit your invention it will be considered; on the understanding, however, that the department is not bound to secrecy in the matter, nor to indemnify you for any loss or expense you may incur in the furtherance of your object, and that in the event of your method of telegraphy appearing to be both original and useful, all question of remuneration shall rest entirely with the postmaster-general.

I am, sir, Your obedient servant,

JOHN TILLY.

A. GRAHAM BELL, ESQ., No. 164.
292 *Essex Street, Salem.*

Continuation of theoretical development of scheme until assistance could be obtained in carrying on experiments.

My own circumstances prevented me from taking any pecuniary risks in attempting to bring out the system here. I therefore contented myself with working quietly at the theoretical details of the invention, trusting to the future for assistance.

Single main battery sufficient at each station (Jan. or Feb. 1874).

I came to the conclusion that a single battery would work a large number of transmitting instruments, as the steel plates, in vibrating, made and broke contact at different rates of speed, and for the same reason that

each transmitter would act with the full power of the battery, even if all should be worked simultaneously.

Single Induction Coil sufficient for each station (Jan. or Feb. 1874.)

I also speedily decided that a single induction coil would answer for all the transmitters at each station, as shown in Fig. 13. The application of the duplex principle by doubling the induction coil is shown in Fig. 14.

Doubts of the operation of the Induced currents unless direct and reversed impulses at equal distances (summer of 1874).

During the summer of 1874, doubts occurred as to the operation of the induced current. When the primary circuit of an induction coil is closed, a momentary impulse of positive electricity is induced upon the secondary circuit, and when it is opened an impulse of negative electricity appears upon the secondary wire. I feared that the induced current would be insufficient to set the armatures of the receiving instruments in vibration, unless the negative impulses came exactly midway between the positive impulses, and unless the armatures of the receiving instruments were rendered permanently magnetic, so as to be alternately attracted and repelled by their electromagnets.

Polarized armatures for Receiving Instruments (summer of 1874).

The thought occurred, of inducing the impulses by means of a permanent magnet instead of a battery.

Currents induced by vibration of permanent magnet (summer of 1874).

When a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter; and, when it is made to recede, a current of opposite polarity to the first is induced in the electro-magnet. The vibration, then, of a permanent magnet in front of the pole of an electro-magnet, would produce an oscillating current in the coils of the latter, and the reversed impulses be at equal distances apart. The form which this idea took at this time (summer of 1874) is shown in Fig. 15. A B, A′ B′ are steel reeds attached to permanent magnets M M,′ vibrated by wind in front of the poles of electro-magnets E E′. A and B were to be of different pitch, and A′ B′ to be their counterparts respectively. When A

should be made to produce its musical note, A′ (its unison) would be thrown into vibration; for, when A moved downwards, the current induced upon the circuit would cause the poles of the electro-magnet E′ to be of opposite polarity to A′ and B,′ and therefore A′ would be attracted downwards; but, when A should move upwards, the polarity of E would be the same as A′, and therefore A would be repelled. As the normal rate of vibration of A′ coincides with that of A, the former would respond to the latter's vibration, and *vice versa*, but neither B nor B′ be affected. Reflection led me to believe that this idea was very valuable, as the currents induced in the coils of the electro-magnets E E′ would correspond exactly to the effects produced in the air by the passage of a musical note. The polarity of each induced impulse would depend upon the direction of the motion of the permanent magnet A to or from the pole of the electro-magnet under it, and hence would correspond to a condensation or rarefaction of air. The succession of induced impulses would be at the same rate per second as the vibrations of A, hence would correspond to the pitch of the note produced; and the intensity of each impulse would depend upon the extent or amplitude of the vibrations of A, and would correspond to the loudness of the resulting note.

Motion of current analogous to motion of air during passage of sound (summer of 1874).

The idea gradually developed, that notes differing in loudness as well as pitch could be simultaneously transmitted, and, as a corollary, the feasibility of the transmission of the timbre or quality of a sound suggested itself; for, according to Helmholtz' theory, the quality of a sound depends upon the simultaneous production of a number of musical notes differing from each other in pitch and loudness. In each sound the fundamental or lowest tone is the loudest, the overtones being comparatively weak and faint. The apparatus

Simultaneous transmission of musical tones differing in loudness as well as pitch. Transmission of the quality or timbre of sounds feasible by transmitting the fundamental tone and overtones simultaneously with their proper relations of force (summer of 1874).

shown in Fig. 16 was conceived as a means of transmitting vocal utterance telephonically.

Apparatus for transmission of vocal sounds (summer of 1874).

Steel rods were to be attached at one end to the poles N S of a permanent magnet M, as in Fig. 16 An electro-magnet E was to be placed between the two sets of rods H H. An exactly similar instrument H′ H′ was to placed upon another part of the circuit.

Upon uttering a sound in the neighborhood of H, it was presumed that certain rods would be set sympathetically in vibration by the voice. The rod corresponding to the fundamental tone would vibrate forcibly, and those corresponding to the overtones of the sound would respond faintly. Each rod, partaking of the polarity of the pole N or S to which it was attached, would induce in the coils of the electro-magnet E a series of electrical oscillations corresponding in rate per second to the number of its vibrations, and in intensity to the amplitude of its motion. The electrical impulses traversing the coils of the electro-magnet E′ would cause vibrations in the corresponding rods H′ H.′ The unison of the fundamental tone would respond loudly; and the rods corresponding in pitch to the overtones would vibrate feebly. Although the absolute loudness of all the sounds produced by the rods H′ H′ would be very faint, still the relative loudness of the notes would be preserved; and hence theoretically a repetition of the sound uttered in the neighborhood of H H should proceed from H′ H.′

Fearing that ridicule would be attached to the idea of transmitting vocal sounds telephonically, especially by those who were unacquainted with Helmholtz' experiments, I said little or nothing of this plan. Indeed, reflection convinced me that, however feasible the scheme looked upon paper, it was impracticable, as the induced currents would be far too feeble to overcome any great resistance. For the same reason the plan

shown in Fig. 15 seemed impracticable save in theory; and I began to look about for some other method of inducing alternate positive and negative impulses which should succeed each other at equal intervals of time; and at last I hit upon the plan of making and breaking contact by means of a revolving cylinder, as shown in Fig. 17.

Revolving cylinder (summer of 1874).

In the autumn of 1874, Mr. Thomas Sanders of Haverhill, Mass., offered to assist me in obtaining patents. It was decided to file a caveat; and for this purpose we employed Mr. Joseph H. Adams of Boston as our solicitor. A few days after placing the matter in Mr. Adams' hands, Mr. Gardiner G. Hubbard, of Cambridge, Mass., not knowing of my negotiations with Mr. Sanders, offered to enter into a similar arrangement with me. The result was that Messrs. Sanders and Hubbard both became interested in my telegraphic inventions.

Offer of assistance from Mr. Sanders.

Preparation of caveat and employment of Mr. Adams.

Offer of assistance from Mr. Hubbard of Cambridge (Sept. or Oct. 1874).

Messrs. Hubbard and Sanders become interested.

It was just at this time (September or October, 1874) that I first heard of Mr. Elisha Gray. I received a note from my friend Dr. Clarence J. Blake, in which he alluded to a letter received from Mr. Elisha Gray, descriptive of experiments made with Prof. Tyndall relative to the telegraphic transmission of vocal sounds. Dr. Blake stated his desire to show me the letter, and expressed his wish to have me meet Mr. Gray. I called upon Dr. Blake next day, and told him that, as I was at that time applying for a caveat for an invention which would ultimately lead to the telephonic transmission of vocal sounds, I thought it might be well for me to be ignorant of Mr. Gray's researches until I had secured my patents. For this reason, I did not see the letter; and I am still ignorant of its contents. A day or two after seeing Dr. Blake, I again heard of Mr. Gray through my solicitor, Mr. Adams. He informed me that Mr. Gray was applying for patents upon a method of trans-

First heard of Mr. Gray through Dr. Blake (Sept. or Oct. 1874).

Again heard of Mr. Gray through Mr. Adams.

mitting sound telegraphically, and that he had had a conversation with Mr. Gray's solicitor, Mr. Hayes, relative to our several inventions. I do not know what passed at this conversation; but though I have no reason to suppose that the confidence between counsel and client was violated I believe that Mr. Adams had unintentionally, by the mention of my invention, given Mr. Hayes a hint which at once set Mr. Gray upon my track.

Conversation between Mr. Adams and Mr. Hayes.

So far as I have found out from Mr. Gray's patents, his invention at that time (end of September or beginning of October, 1874) consisted of nothing more than a method of transmitting sound through living tissue, no claim being laid to the practical application of telephony to the simultaneous transmission of messages along a single wire.

No mention in Mr. Gray's patents of the idea of simultaneous transmission of messages previous to this conversation (Sept. or Oct. 1874.)

After considerable delay a caveat was completed, and forwarded to Mr. Hubbard in Washington, to be deposited in the Patent Office. The next day an article appeared in "The Commonwealth," descriptive of Mr. Gray's method of transmitting sound telegraphically. At the conclusion of the article, allusion was made to the simultaneous transmission of messages by means of musical notes, as an invention recently made by Mr. Gray; and apparatus was described almost identical with that mentioned in my caveat. I have reason to suppose that this article was written by Mr. Hayes.

Caveat forwarded to Mr. Hubbard in Washington.

Article in "The Commonwealth" descriptive of Mr. Gray's invention.

Claims simultaneous transmission of messages.

At Mr. Hubbard's suggestion I decided not to file my caveat, but to have apparatus constructed as speedily as possible, so as to make application for a patent instead. Two transmitting instruments and receivers like these shown in Fig. 18 were at once made, and were arranged upon circuit as in Fig. 19. The very first time they were tried, they worked satisfactorily. When K^1 was depressed, R^1 alone was affected: when K^2 was depressed, R^2 alone was affected. When

Resumption of experiments.

Two signals sent simultaneously along single wire satisfactory (Oct. 1874).

K^1 and K^2 were depressed simultaneously, R^1 and R^2 both responded. The attempt to use the induced current with these instruments was unsuccessful. Not knowing fully the cause of the failure, it was decided to prepare the instruments that were successful for the purpose of securing the patent, and to leave the utilization of the induced current to be investigated at a later date.

It is needless to detail the whole of my experiments. I shall seek only to point out the various stages of development.

Pitch of instrument changed with length of circuit, and with strength of battery. "Pulsatory current" (Nov. 1874).

The pitch of each transmitting instrument changed, the moment its key was depressed. The pitch varied with the length of the circuit. It was rendered independent of the resistance of the line by connections shown in Figs. 20, 21, and 22. The pitch was also affected by the strength of the battery.

The spark in the transmitting instrument at the point where the circuit was broken was lessened by the use of a condenser.

The armature of the receiving instrument answered loudly to any pitch when it was placed in close contact with the face of its electro-magnet, but responded only to its proper pitch when it was placed about a quarter of an inch distant.

Damper attached (Nov. 1774).

A rubber band (d) attached to the armature served as a damper (Figs. 20, 21, and 22) so as to stop the vibration of the receiver immediately on the cessation of the electrical impulses.

Iron nail, &c., introduced into helix, emitted a loud musical note.

One form of receiving instrument constructed at this time is shown at R, Fig. 23. A wrought-iron nail (n) was placed between two cylindrical pieces of iron (i) inside a helix of wire. A note of similar pitch to that produced by the transmitting instrument proceeded from R. The instrument was not, however sensitive to one pitch alone, but reproduced very loudly the unison

Responded equally well to all pitches (Nov. 1874).

of whatever transmitter was employed. These experiments were made in November, 1874.

An attempt was also made by means of bar-magnets arranged around a cylinder as in Fig. 24 to induce current that would work the receiving instruments. The results were unsatisfactory.

Bar-magnets arranged on cylinder (Nov. 1874).

During the winter of 1874–75, it was attempted to use organ reeds (from the *vox humana* stop) as transmitting instruments. The mode of connection is shown in Fig. 25. The tongue (t) was insulated from the bed of the reed B by means of paper. The tongue (t) vibrated against a platinum plate P, making and breaking the circuit. The reeds soon got out of order, and were very liable to change in pitch, so that electro-magnetic transmitters were preferred.

"Vox Humana" reeds (winter of 1874–75).

In January, 1875, the thought occurred of rendering the pitch of the transmitting instrument independent of the strength of the battery, as well as of the resistance of the line, by causing the vibrating armature to strike alternately against two fixed points. One made contact for a local battery, the currents of which traversed the electro-magnet, and served to keep the armature in vibration. The other communicated with the main battery and the line wire, but not with the electro-magnet. The arrangement (see Fig. 26) proved so successful, that I felt that the instrument was near completion. I constructed armatures of various materials, but finally decided to use those made of clock-spring.

Electro-magnetic transmitter.

Double contact points for local and main battery. (Jan. 1875.)

Various kinds of armatures. Steel spring best (Jan. 1875).

Platinum connections could not be soldered on without spoiling the temper of the spring. Finally a small rivet of platinum was inserted in the spring where it came into contact with the fixed points. A sliding clamp was fastened to the armature of the receiving instrument for tuning it. The rubber damper was omitted, as the spring was allowed to strike the face of the magnet.

Platinum rivets (Jan. 1875).

It was next perceived that the armature of the receiving instrument would operate an ordinary Morse sounder, or any electro-magnetic machine, if it struck a body of slower vibration than itself, when the vibratory motion of the armature would be converted into permanent make or break of a local circuit. The first form of vibratory circuit-breaker is shown in Fig. 27. A light lever of straw S was hung vertically in front of the receiver R. When the armature vibrated the platinum plate P was brought into contact with the wires W W^1, completing a local circuit in which was placed a Morse sounder. The instrument was still further improved as in Fig. 28, in which form a patent was granted to me for it in February, 1875, No. 161,739. The oxidization of the mercury in the cups C C, Fig. 28, was prevented by covering it with glycerine.

First form of vibratory circuit-breaker. (Jan. or Feb. 1875).

Second form of vibratory circuit breaker. Mercury-cups (Feb. 1875).

The autograph telegraph described in the specification of the same letters-patent, was invented at the same time. See Fig. 29.

Application to autographic telegraphy Feb. 1875).

During the early part of February, friends in Salem tested the instruments by sending two messages simultaneously over the same wire, by an alphabet of numbers arranged for the occasion. The words "Multiple telegraph" were sent by one instrument and "Autograph telegraph" by another. Then the words "Katie Silsbee," "Valentine," and "Well done," and at the same time the words "Multiple," "Cat," "Lizzie," and "Lovely," only one wire being used in both experiments.

Simultaneous transmission of telegraphic despatches. Practical tests made in Salem Mass. (Feb. 1875).

On another occasion four stations, A, B, C, and D, were arranged on the same circuit; and among other messages the words "Bravo, bravo, bravo," were sent from A to D, while "Good tidings" were sent from B to C. These experiments were entirely successful.

During this month, February, 1875, I visited Washington, and retained Messrs. Pollok and Bailey as

solicitors for my patents; and left my models of the transmitting instrument, receiving instrument, and vibratory circuit-breaker, with them. I there met Mr. Orton, the President of the Western Union Telegraph Company, who was much interested in my instruments, and requested me to call upon him as I passed through New York on my way home, which I did. Applications made for patents in Washington (Feb. 1875).

In conclusion I would say, that the invention the subject matter of the first interference between my application dated Feb. 25, 1875, and the application of P. La Cour, filed March 3, 1875, and of Elisha Gray, filed Feb. 23, 1875, namely, —

"The method of transmitting two or more telegraphic signals or messages simultaneously along a single wire, and of receiving the same without confusion by the employment in an electric circuit of two or more transmitters, each transmitting per second impulses differing in number from the others, in combination with receivers, each tuned to a pitch at which it will be put in vibration to produce its fundamental tone by one only of the transmitters," — described by me in the first clause of my claim, and by Elisha Gray in his first, third, fifth, and seventh claims, was invented by me prior to August, 1870, and reduced to practice on or about the first day of November, 1872. (See the above statement, p. 2.) First interference.

The inventions, the subject matter of the second interference between my application and that of Elisha Gray, namely, —

"1st, The combination of a main line, an intermittent circuit-breaker adapted to throw upon the line a definite number of electrical impulses in a given time, and a key for controlling the throwing of such impulses upon the line" described in my second claim and Elisha Gray's second claim; Second interference.

"2d, The combination in one electric circuit of a series of such intermittent circuit-breakers, and a series of such keys, there being a key for each intermittent circuit-breaker," — were invented by me prior to August, 1870, and reduced to practice on or about the first day of November, 1872. (See the above statement, pp. 2 and 5.)

The invention the subject-matter of the interference between my patent, No. 161,739; and the application of Elisha Gray, filed Feb. 23, 1875; and that of P. LaCour, filed March 3, 1875; namely, —

Third interference.

"The combination with the portion of the receiver put into vibration by the musical impulses of a circuit controlling lever or bar, arranged and adapted to vibrate more slowly than the former" described in my second and Elisha Gray's fourth claim, was invented by me in January, 1875, and reduced to practice on or about the eighth day of February, 1875. (See the above statement, p. 16.)

A. GRAHAM BELL.

BOSTON UNIVERSITY, April 27, 1876.

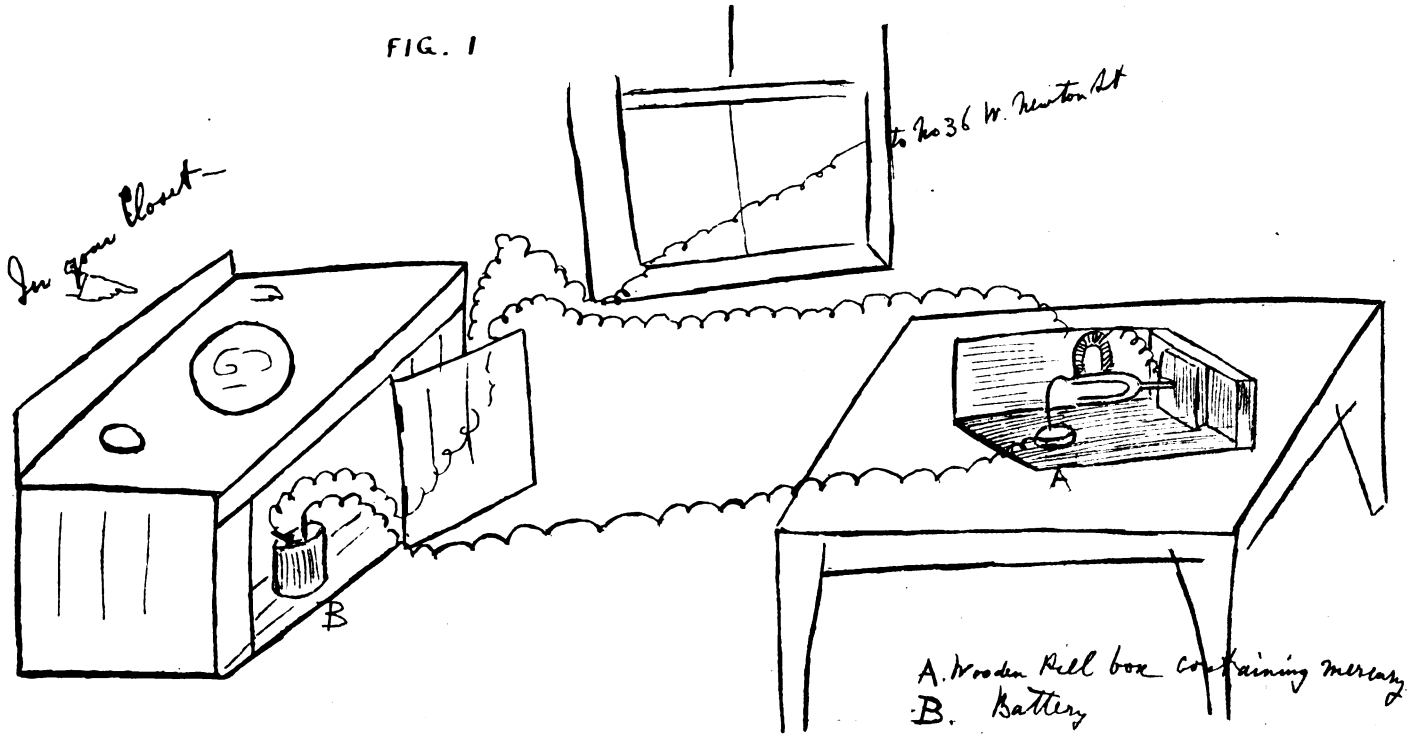
STATE OF MASSACHUSETTS, }
COUNTY OF SUFFOLK. }

MAY 8, 1876.

Before me, a notary public, personally appeared Alexander Graham Bell, who made solemn oath that the within statement by him subscribed is true to the best of his knowledge and belief.

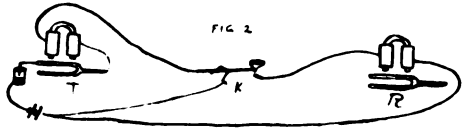
WILLIAM W. SWAN,
Notary Public.

FIG. 1

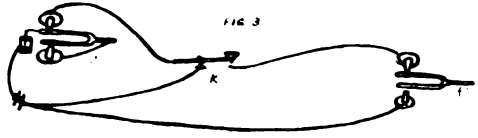


A. Wooden Bell box containing mercury
B. Battery

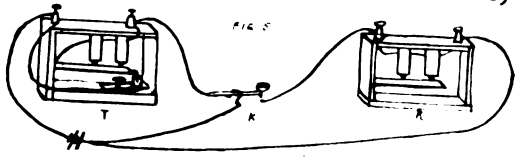
Apparatus constructed by A. Graham Bell during the winter of 1872-3.
Drawn from memory (Feb. 1876) by P. B. Richards (a witness of the experiments).



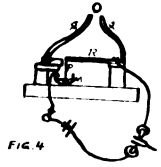
(WINTER OF 1872)



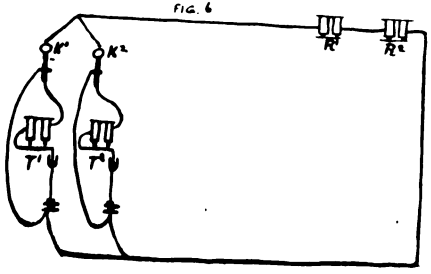
(SPRING OR AUTUMN 1873)



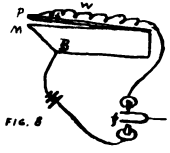
(NOV. 1873)



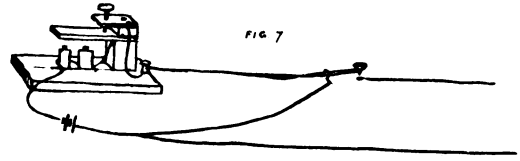
(OCT. 1873)



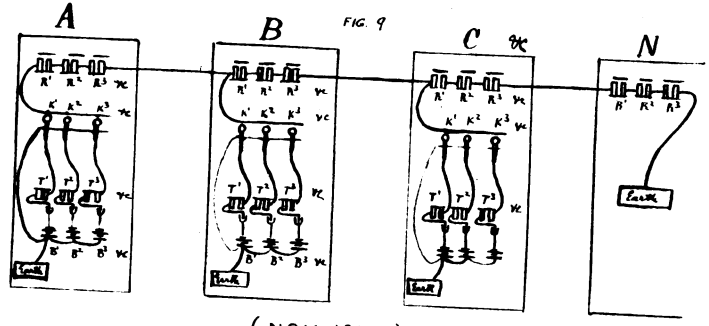
(NOV. 1873)



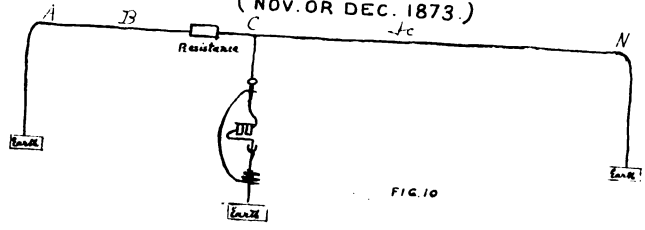
(WINTER OF 1873)



(WINTER OF 1873)

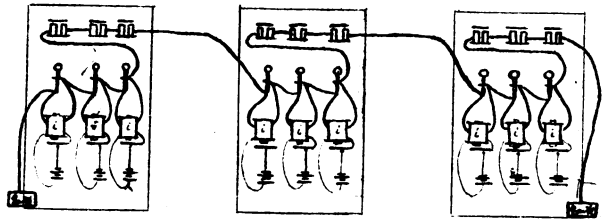


(NOV. 1873.)



(NOV. OR DEC. 1873.)

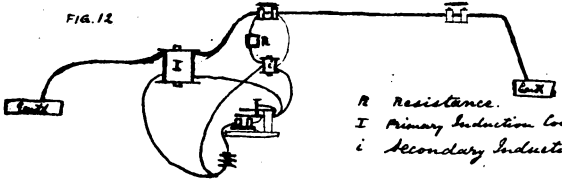
FIG. 11 (December 1873)



i, i, &c. Induction Coils

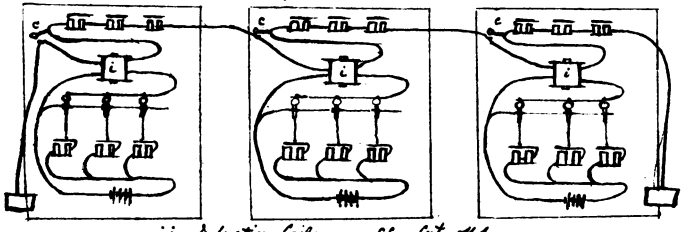
(December 1873)

FIG. 12



R Resistance.
I Primary Induction Coil.
i Secondary Induction Coil

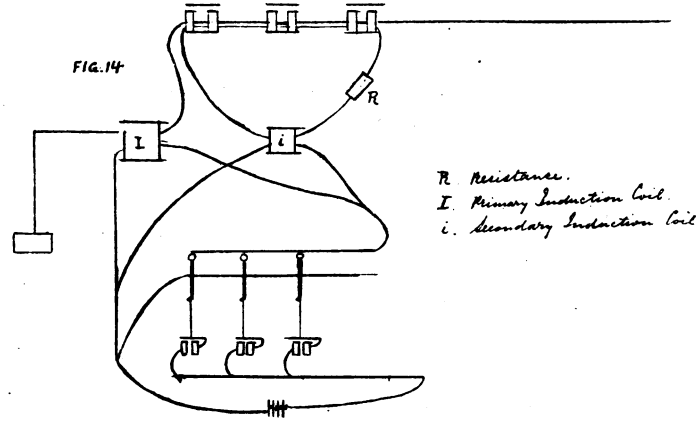
FIG. 13 (January or February 1874)



ii Induction Coils — cc Cut-offs

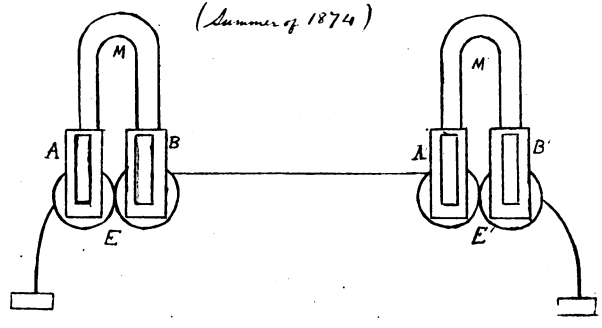
(January or February 1874)

FIG. 14



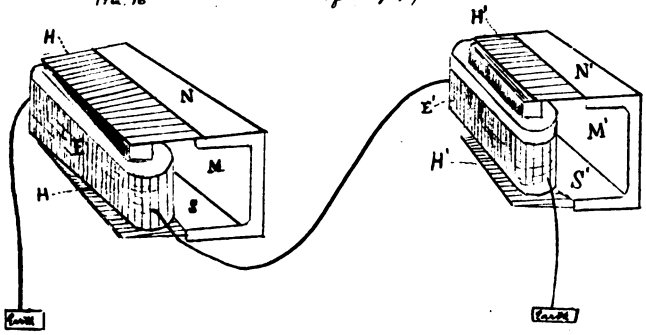
R Resistance.
I Primary Induction Coil
i. Secondary Induction Coil

FIG. 15 (Summer of 1874)



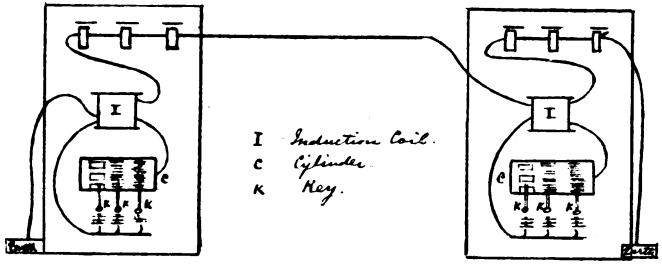
(Summer of 1874)

FIG. 16



(Summer of 1874)

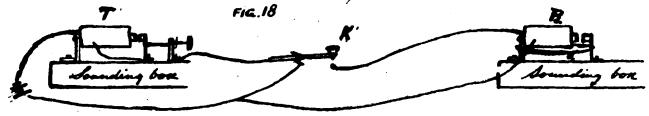
FIG. 17



I Induction Coil.
C Cylinder
K Key.

(October 1874)

FIG. 18



(October 1874)

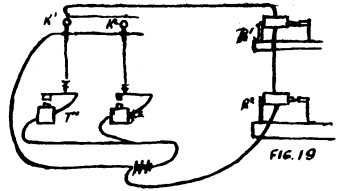


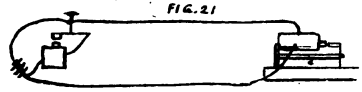
FIG. 19

(Oct. or Nov. 1874)

FIG. 20

(Oct. or Nov. 1874)

FIG. 21



(Oct. or Nov. 1874)

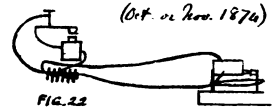
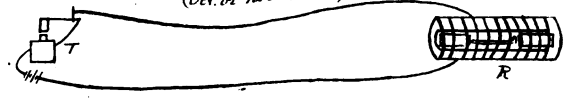


FIG. 22

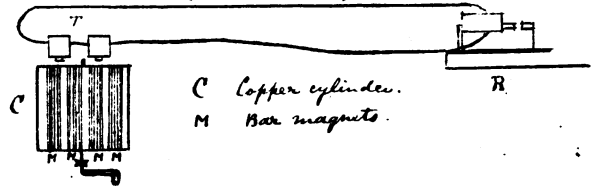
(Oct. or Nov. 1874)

FIG. 23



(Oct. or Nov. 1874)

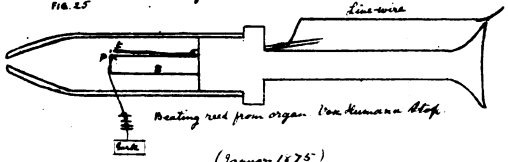
FIG. 24



C Copper cylinder.
M Bar magnets.

(Winter of 1874–5)

FIG. 25



Reading reed from organ Vox Humana Stop.

(January 1875)

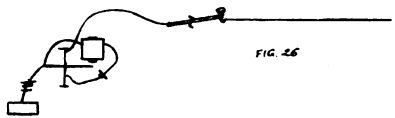


FIG. 26

(Jan. or Feb. 1875)

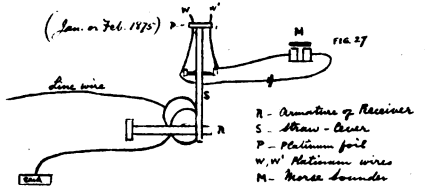
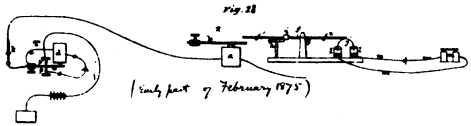


FIG. 27

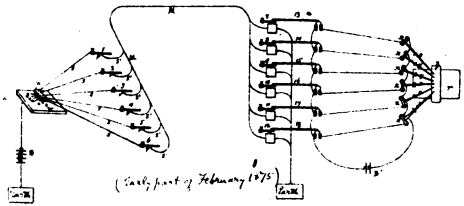
R - Armature of Receiver
S - Straw - Lever
P - Platinum foil
W, W' Platinum wires
M - Morse Sounder

Fig. 28

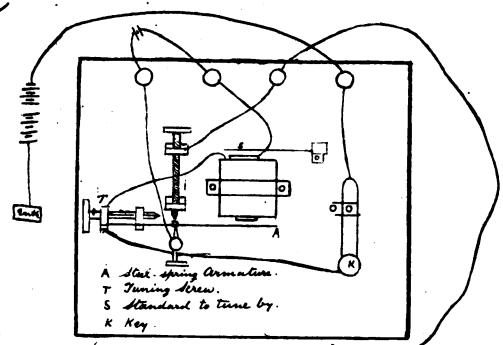


(Early part of February 1875)

Fig. 29



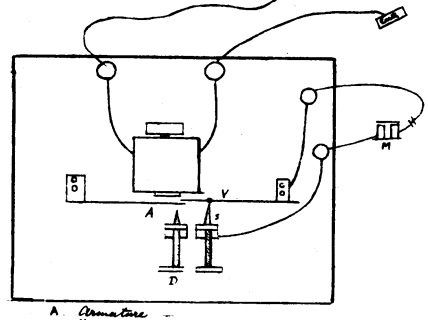
(Early part of February 1875)



A Steel-spring Armature.
T Turning Screw.
S Standard to tune by.
K Key.

(Transmitter and Receiver March 6 1875)

FIG. 30



A Armature
D Damper
V Vibratory Circuit-breaker
M Morse Sounder