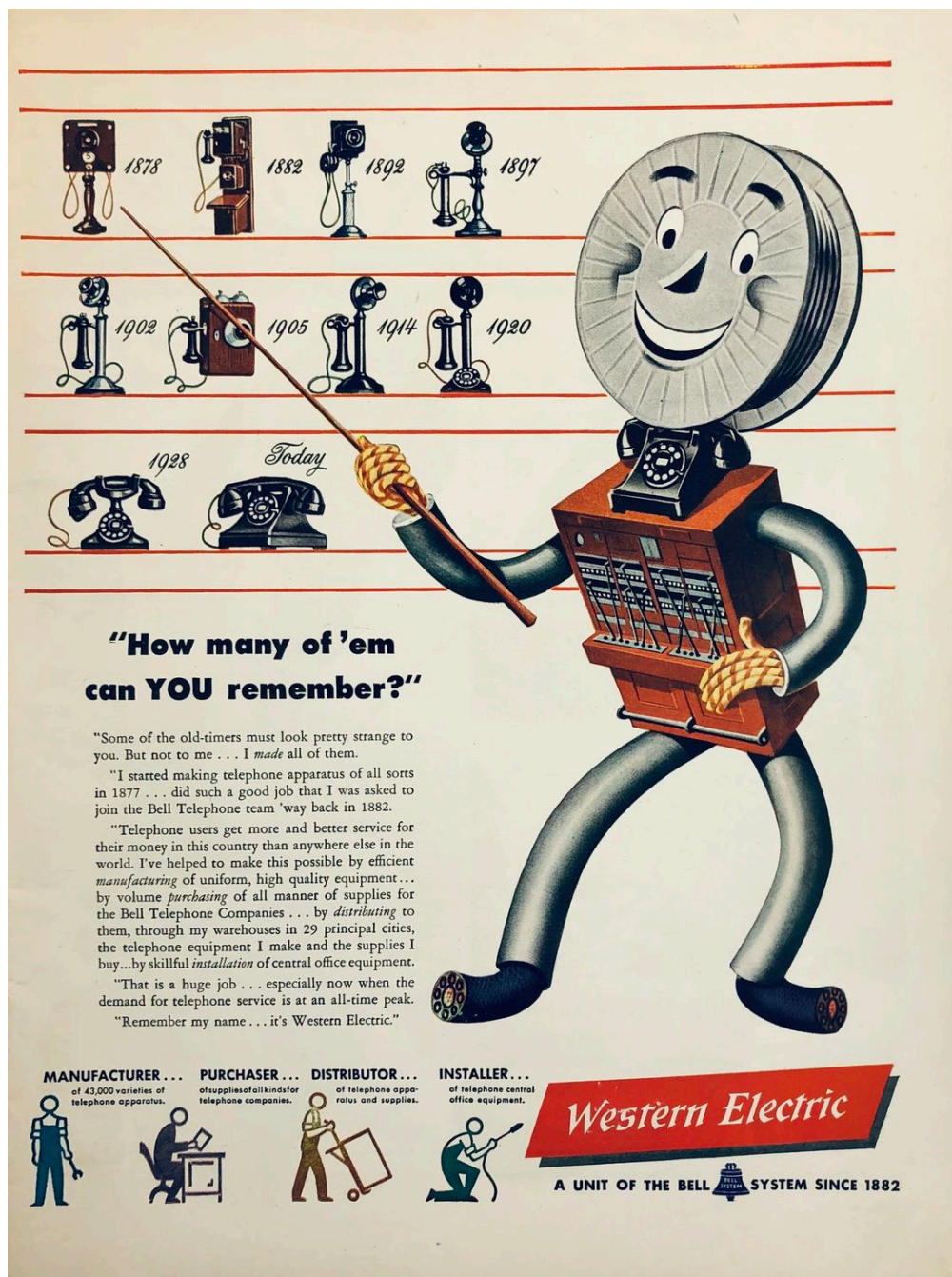


Bell Telephone patent



**"How many of 'em
can YOU remember?"**

"Some of the old-timers must look pretty strange to you. But not to me . . . I *made* all of them.

"I started making telephone apparatus of all sorts in 1877 . . . did such a good job that I was asked to join the Bell Telephone team 'way back in 1882.

"Telephone users get more and better service for their money in this country than anywhere else in the world. I've helped to make this possible by efficient *manufacturing* of uniform, high quality equipment . . . by volume *purchasing* of all manner of supplies for the Bell Telephone Companies . . . by *distributing* to them, through my warehouses in 29 principal cities, the telephone equipment I make and the supplies I buy . . . by skillful *installation* of central office equipment.

"That is a huge job . . . especially now when the demand for telephone service is at an all-time peak.

"Remember my name . . . it's Western Electric."

MANUFACTURER . . . of 43,000 varieties of telephone apparatus.

PURCHASER . . . of supplies of all kinds for telephone companies.

DISTRIBUTOR . . . of telephone apparatus and supplies.

INSTALLER . . . of telephone central office equipment.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

([click to enlarge](#))

Alexander Graham BELL.

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

UNITED STATES PATENT OFFICE.

ALEXANDER GRAHAM BELL,

OF SALEM, MASSACHUSETTS.

IMPROVEMENT in TELEGRAPHY.

Specification forming part of Letters Patent No. 171,465, dated March 7, 1876; application filed February 14, 1876.-

To all whom it may concern:

Be it known that I, ALEXANDER GRAHAM BELL, of Salem, Massachusetts, have invented certain new and useful improvements in Telegraphy, of which the following is a specification In-Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for, transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving instruments,

each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting instruments; and of [vibratory circuit](#) breakers operating to convert the vibratory movement of the receiving instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed, a Morse sounder, [register](#), or other telegraphic apparatus. I have also therein described a form of [ant'ograph] telegraph based upon the action of the above-mentioned instruments.

In illustration of my method of multiple telegraphy I have shown in the patent aforesaid, as one form of transmitting instrument, an electro-magnet having a steel-spring armature, which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for, when [[a fro m]] gradual changes of intensity exactly analogous to the changes in the [density](#) of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a [sinusoidal curve](#) or by the [resultant](#) of several sinusoidal curves.

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

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction coils; fourth, that cable dispatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use; for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable signals is prevented; fifth, [audthatas] the circuit is never broken a spark-arrester becomes unnecessary. It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electromagnet an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and, in intensity to the amplitude of its vibration.

That the difference between an [undulatory](#) and an intermittent current may be more clearly understood I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously - first upon the one plan and then upon the other. Let the [interval](#) between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. Now, when the intermittent current is used, the circuit is made and broken four times by one transmitting instrument in the same time that five makes and breaks are caused by the other. A and B, Figs. 1, 2, and 3, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. c c c, [810.], show where and for how long time the circuit is made, and d d d, [&c.], indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Fig. 1 the ratio is as 1 to 4; in Fig. 2, as 1 to 2; and in Fig. 3 the makes and breaks are of equal duration. The combined effect, A and B, Fig. 3, is very nearly equivalent to a continuous current.

When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same circuit the [current](#) upon the main line becomes for all practical purposes continuous.

Next, consider the effect when an undulatory current is employed.

Electrical undulations, induced by the [vibration](#) of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated,- the rate of [oscillation](#) in the electrical current corresponds to the rate of vibration of the inducing body - that is, to the [pitch](#) of the [sound](#) produced. The [intensity](#) of the current varies with the [amplitude](#) of the vibration - that is, with the loudness of the sound; and

the a **polarity** of the current corresponds to the direction of the vibrating body - that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinusoidal curve A or B, Fig. 4, represents, graphically, the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line a d [of, &c.,] represents the zero of on[rrcn t]. The elevations b b b,[&c.], indicate impulses of **positive electricity**. The depressions c c c,[&c.,] show impulses of **negative electricity**. The vertical distance [6 d or cf] of any portion of the curve from the zero line expresses the **intensity** of the positive or negative impulse at the part observed, and the horizontal distance a a indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, [of 4 to 5] - that is, four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A+B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A+B also indicates the actual **motion** of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence, the coexistence upon a telegraphic circuit of electrical vibrations of different **pitch** is manifested, not by the obliteration of the vibratory character of the **current**, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

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

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

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet, A, Fig. 5, having a coil upon only one of its legs b. A steel-spring armature, c, is firmly clamped by one extremity to the uncovered leg [(l of the magnet, audits free Gld)] is allowed to project above the pole of the covered leg. The armature 0 can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, [9 b e f g,] the armature 0 becomes magnetic, and the **polarity** of its free end is opposed to that of the magnet underneath. So long as the armature 0 remains at rest, no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note a powerful inductive action takes place, and electrical undulations traverse the circuit [9 b c f g.] The vibratory current passing through the coil of the electromagnet f causes vibration in its armature h when the armatures [c h] of the two instruments [A I] are normally in **unison** with one another; ['bnt'] the armature h is unaffected by the passage of the undulatory current when the pitches of the two instruments are different. [A.] number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the

instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus, if A, Fig. 6, is set in vibration, the armatures of A and A will vibrate also, but all the others [ou'the] circuit will remain still. So if B is caused to emit its musical note the instruments B B respond. They continue sounding so long as the mechanical vibration of B is continued, but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound when two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison. Thus the signals of A, Fig. [(hare] repeated by A and A, but by no other instrument upon the circuit; the signals of B by B and B; and the signals of C [by G and C whether A, B, and G] are successively or simultaneously caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

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

When the armature c, Fig. 5, is set in vibration the armature h responds not only in pitch, but in loudness. Thus, when 0 vibrates with little amplitude, at very soft musical note proceeds fro m h, and when 0 vibrates forcibly the amplitude of the vibration [of his] 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 and A repeat loudly the signals of A, and B B repeat softly those of B.

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

The armature c, Fig. 7, is fastened loosely by one extremity to the uncovered leg d of the electro-magnet b, and its other extremity is attached to the center 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 4 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 [fro m] L.

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

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

1. A system of telegraphy in which the **receiver** is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.
2. The combination, substantially as set forth, of a permanent magnet or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim, whether the permanent magnet beset in vibration in the neighborhood of the conducting wire form simultaneously be set in vibration in each other's neighborhood.
3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting [wim] itself, in the neighborhood of such bodies, as set forth.
4. 'Iiie method of producing undulations in a continuous voltaic circuit by gradually increasing and diminishing

the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.
5. The method of, and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound, substantially as set forth.

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

ALEX. GRAHAM BELL.

Witnesses:

Tonus E. BARRY

P. D. Rcnans.