E. E. CLEMENT.

METHOD OF RELAYING ELECTRICAL CURRENTS.

APPLICATION FILED JUNE 9, 1906.

1,003,337. Patented Sept. 12, 1911.

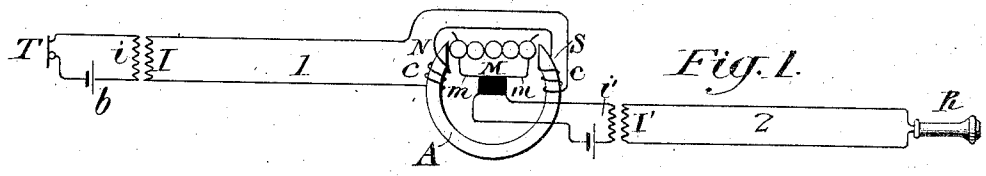


Fig. 1.

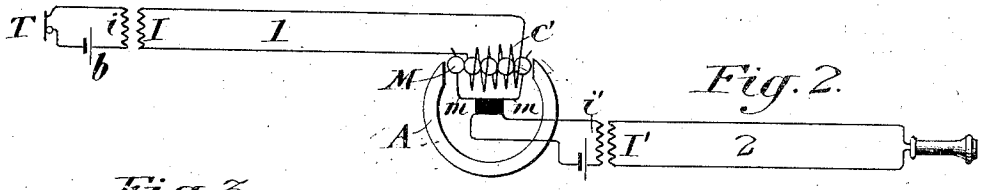


Fig. 2.

Fig. 3.

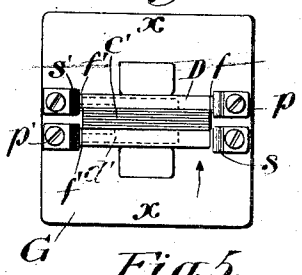


Fig. 4.

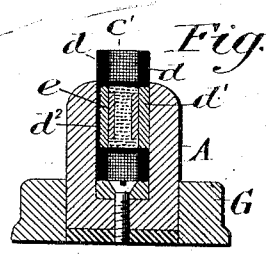


Fig. 9.

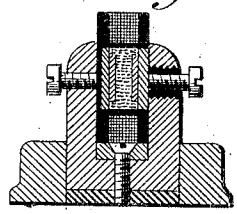


Fig. 5.

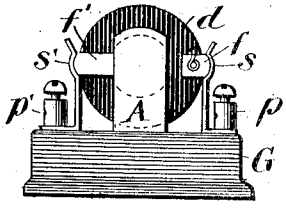


Fig. 6.

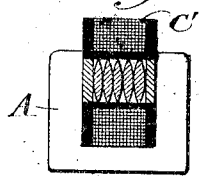


Fig. 7.

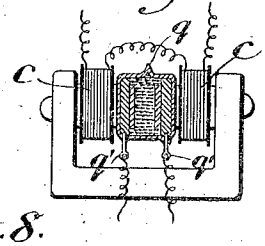
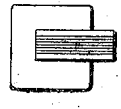


Fig. 8.



Witnesses:
Jos. L. Wright.
James H. Marr.

Inventor:
Edward E. Clement

UNITED STATES PATENT OFFICE.

EDWARD E. CLEMENT, OF WASHINGTON, DISTRICT OF COLUMBIA.

METHOD OF RELAYING ELECTRICAL CURRENTS.

1,003,337. Specification of Letters Patent. Patented Sept. 12, 1911.

Original application filed June 16, 1898, Serial No. 683,651. Divided and this application filed June 9, 1906. Serial No. 321,044.

To all whom it may concern:

Be it known that I, EDWARD E. CLEMENT, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Methods of Relaying Electrical Currents, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to the method of relaying electrical currents wherein a translating device, included in one circuit, in which current is being periodically varied to correspond to sound undulations, reacts upon a second translating device to reproduce said variations in a second and independent circuit.

This case is a division of a co-pending case filed June 16, 1898, Serial No. 683,651, allowed April 2, 1906, patented June 19, 1906, Serial No. 823,763.

My object is to eliminate what is known as the "time constant," or at least to so reduce the same as to permit of the production of electrical undulations in the second circuit corresponding to the original sound waves, without appreciable distortion.

So far as I know all telephonic relays at present in use, are dependent for their operation upon the translation of electrical changes into mechanical changes, which are by a second operation translated again into electrical changes. I have achieved the end of effecting the same result by a single change. That is, I translate the current variations in one circuit directly into current variations in a second circuit by a single operation. To effect this I employ a coil included in the first circuit and a resistance varying medium in the second, the latter directly acted on by the former, without any intermediate mechanism.

It will be seen that while my invention is particularly useful in telephonic work, *i. e.* in the relaying of "voice currents," it is equally applicable to telegraphic work, the changes in resistance produced in the second circuit being prompt and sharp, and the relay as a whole being simple, cheap, and easily cared for, its liability to get out of order, moreover, being very small, as there are no adjustments to undergo change, no springs to deteriorate, and no parts that can be injured by exposure to moisture or dust.

My invention includes various details of construction, and is fully set forth in the specification and claims hereto appended, and illustrated in the accompanying drawings, wherein the same letters refer to the same parts throughout.

In the drawings, Figures 1 and 2 are diagrams illustrating the broad principle of my invention. Fig. 3 is a plan view of a relay constructed in accordance with this principle. Fig. 4 is a section on the line x—x of Fig. 3. Fig. 5 is a side view looking in the direction in which the arrow points in Fig. 3. Figs. 6, 7, 8 and 9 represent modifications.

Many forms of relay have been suggested and tried in the endeavor to increase the distance through which good clear transmission of speech can be had. In all of these, so far as I know, an electromagnet is employed, whose coil is included in the circuit to be relayed. This magnet exerts a varying pull, due to the variations in the current on its circuit, on a diaphragm or armature. The diaphragm or armature in its turn, varies the pressure or intimacy of contact between solid electrodes or granules of carbon or other semi-conductor, connected into the second circuit. A single impulse coming over the first circuit, such as would be caused by tapping a telegraph key, energizes the magnet, which pulls the armature, which decreases (or increases, as the case may be,) the tension on the electrodes in the second circuit, and thus changes the current flowing in the second circuit. This last change will lag behind the original change in the first circuit, however, by reason of the mechanical inertia of the armature and the electrodes, and the magnet inertia of the iron forming the core and armature. The time elapsing, or the amount of lag, will be of no moment, however, even though comparatively large, because there is only one impulse. A musical note causing corresponding current undulations in this first circuit will be accurately reproduced by a telephone receiver in the second circuit, unless the armature and spring have a widely different rate of vibration of their own, because, although the changes are periodic, they are also simple, and whether one commences on the first or the tenth or the hundredth wave crest the rate of change is always the same, and consequently the resulting note is the same. With speech undulations it is different, however. Here

we have a complex change, consisting of a series of fundamental simple periodic changes, upon which are superimposed harmonics or overtones *ad infinitum*. Obviously the lag is a serious detriment, if not a total deterrent. At the best the undulations reproduced in the second circuit will be distorted. They will have had some of the little sharp superimposed wave crests smoothed off, and perhaps, even the rapidly changing fundamentals will have lost their perfect characteristics. In order to get rid of this lag I employ no armature. I use a coil or coils connected in the first circuit. I make my resistance varying medium or electrodes of magnetic material, or of non-magnetic material rendered susceptible to magnetic influence for the time, as will be explained, or mix magnetic material therewith, and I place this medium directly within the field of the coil or coils. In order to get the best results, I polarize the medium by bringing it into a permanent magnetic field, so that the actual mechanical changes in the medium are due to the resultant effect of the initial changes in the coil, and of the supplemental permanent magnetic field. It is possible to get fair results without the permanent magnet, but I have found that enhanced results, even as to the mechanical movements, are produced with it. Whether with or without the supplemental magnet, the gist of my method is to make the resistance varying medium of the second circuit act as a portion of the magnet circuit or core of the magnet in the first, and thus the entire translation is directly performed in one operation, and there are no heavy mechanical moving parts at all to deal with, and very little or no magnetic inertia.

In the claims hereunto appended I shall refer to the effect of the current changes on the magnetic core in the presence of the auxiliary magnetic field, as "resultant product undulations." It is thought the meaning of this will be clear without further explanation.

Referring to Fig. 1, A is a permanent magnet, carrying coils *c*—*c*, which are included in the circuit numbered 1. There is also included in this circuit, the secondary winding of an induction coil I, the primary *i*, of which, is in circuit with a battery *b*, and microphone transmitter, T. Between the poles of the magnet A, is included a resistance varying medium, M; connected through contacts *m*—*m*, to the primary *i'* of the coil I': the secondary of which is connected into a second circuit, numbered 2. There is included in this second circuit a telephone receiver, R.

In Fig. 2, A is a permanent magnet, the circuit 1, and the circuit 2 are the same, and include the same parts, as in Fig. 1. and the resistance varying medium M is similarly included between the poles of the magnet A; but in this case the single coil *c'* is included in the first circuit, and directly surrounds the medium M.

The principle illustrated in these two figures is the same. Undulations caused by the microphone T are propagated into the circuit 1 through the medium of the induction coil I. The coils *c*—*c*, or *c'*, respond to these undulations to alternately strengthen and weaken the field of magnet A. The resistance varying medium M, being included in the magnetic circuit, responds directly to these changes by corresponding changes in the mutual pressure or intimacy of contact of its component parts, and resultant changes in the resistance in circuit with the primary *i'* of coil I'. The variations are finally reproduced in the circuit 2, and affect the receiver R. I prefer to use for the resistance varying medium M, granular material, which I may prepare in several ways, hereafter described, but which may be simply carbon.

A practical embodiment of my invention is shown in Figs. 3, 4 and 5. Referring to these figures, D is a hollow spool turned out of hard rubber or fiber. Between the flanges *d*—*d* of the spool I wind the coil *c'*. Fitted to the ends of the spool are conducting disks *d'*, provided on their inner faces with polished carbon electrodes, *e*—*e*. The disks *d'* fit the bore of the spool, but the electrodes, are preferably of somewhat smaller diameter. The disks I find are best made of very soft iron, and the electrodes are brazed or soldered to them. On one side of each flange of the spool is a contact *f*, to which the end of the coil *c'* is attached. Radially opposite, on each flange is a contact *f'* connected to one of the disks *d'*. The contacts *f*—*f'* extend slightly beyond the edge of the flanges, for a purpose to be presently noticed. Suitably mounted in a base G, is the magnet A, its poles extending upwardly and parallel. Upon the base at opposite sides of the magnet are mounted two pairs of contact springs, S—S, and S'—S'. The springs are bent at their upper ends to form slight curvatures approximately hook shaped; and at their lower ends are provided with connecting means, shown as binding posts *p*—*p*, *p'*—*p'*. I insulate, as at d^2, one or both disks, *d'*.

In assembling the instrument, one disk *d'* is removed, and a quantity of granular material I shall describe is poured into the bore of the spool until it is almost or quite full. The disk is then replaced, and the entire spool slipped between the poles of magnet A, as shown in Figs. 3, 4 and 5. The springs *s*—*s*, *s'* *s'* come into contact with the contacts *f*—*f*, *f'*—*f'*, and automatically complete both circuits, while their slightly hooked portions retain the spool in place.

I make the granular material in several ways, and have attained good results with each. According to one method I coat irregularly shaped granules of very soft Swedish iron, with shellac, and bake, then coat again and again bake. I then mix these granules with about an equal bulk of fine carbon, granulated. The carbon granules may be either spherical or irregular; but the magnetic particles should be irregular. In using the granulated material so composed the greater specific gravity of the iron tends to make it sink below the carbon, separating from it. This tendency is counteracted, however, by the lifting effect of the poles of magnet A. As the tendency is always to shorten the magnetic circuit, there is a balance of forces; and one result of this is that this microphone never "packs." According to a second method I make the granules all of magnetic material, and prepare them, either by preliminary coating with carbonaceous material and backing, or by a system of flashing such as incandescent light filaments are subjected to. I may use also for the granular material, carbon of a sufficient hardness and high enough quality, to carry a considerable current without deterioration. In this case, the effect is to render the granules carrying the current, susceptible to magnetic influence.

Fig. 6 shows the same form of coil and magnet as Figs. 3, 4 and 5, but separate buttons of magnetic material coated with carbon or a similar semi-conductor, substituted for the granular material.

In Fig. 7 I show a double coil on the poles of the magnet A, and an exhausted glass capsule, between the poles, containing the electrodes and the granular material. q is the nipple where the capsule is sealed, and q'—q' are the terminals of the electrodes, sealed into the glass. I may likewise seal the magnet poles directly into the glass.

Fig. 8 shows an alternative position of the relay, where the magnet poles and the spool are arranged horizontally.

Fig. 9 shows a further modification of the construction shown in Fig. 4, in which adjusting screws are threaded into the magnet poles from opposite sides so as to enable an initial pressure to be exerted and the tension regulated between the granules and the electrodes. In order to prevent short circuiting one of the tension screws passes through an insulating bushing, and the other bears against an insulating facing on its electrode. These specific features are of course subject to modification at will.

I am aware that it is not broadly new to use magnetic material for the resistance varying medium in a microphone, but I believe I am the first to so place such a resistance varying medium as to make it part of a magnetic circuit or a core and then to vary the strength of the circuit or effect of the core proportionately to the variations in an electric circuit, whereby the resistance of the resistance varying medium is varied to reproduce the variations in a second electric circuit.

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

1. The method of relaying electrical currents consisting in causing undulations of varying intensities, causing a magnetic device to be influenced thereby, producing mechanical changes in said device corresponding to the changes caused in the magnetic circuit, and finally directly translating the mechanical into electrical changes within the body of the device and transmitting them to a receiving device.

2. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a medium within a constant magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations, whereby an enhanced mechanical result is obtained, and causing the energy thus manifested in mechanical form to be transformed directly into secondary electrical undulations in said medium.

3. The method of transmitting messages electrically which consists in transforming electrical undulations into magnetic changes or undulations in a resistance medium under the influence of an auxiliary magnetic field, causing the resultant magnetic forces thus developed to produce mechanical movements of said resistance medium, and thereby to produce secondary electrical undulations qualitatively corresponding to the original undulations but quantitatively enhanced in value.

4. The method of repeating messages electrically which consists in producing a normal magnetic flux through variable resistance contact members of magnetic material, altering the permeability of said members in accordance with electrical undulations corresponding to the message to be repeated, and producing thereby changes of resistance qualitatively corresponding to the original message undulations but adapted to produce in turn secondary electrical undulations of enhanced quantitative value.

5. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a medium within a supplemental magnetic field, producing thereby qualitatively corresponding magnetic product undulations, and causing qualitatively corresponding mechanical vibrations in said medium quantitatively pro-

portionate to the resultant magnetic product undulations, thereby quantitatively enhancing the mechanical result while preserving therein the characteristic quality of the original electrical undulations.

6. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a medium within a supplemental magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations, establishing and maintaining a symmetrical relation between the forces of the supplemental field and the electrically induced magnetism respectively, and transforming the resultant magnetic product undulations into qualitatively corresponding mechanical vibrations in said medium.

7. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a supplemental magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations and producing in said medium by means of the said product undulations mechanical vibrations quantitatively proportionate to the resultant magnetic product and qualitatively corresponding to the original electrical undulations.

8. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a supplemental magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations, and causing qualitatively corresponding mechanical vibrations quantitatively proportionate to the resultant magnetic product undulations, thereby quantitatively enhancing the mechanical results while preserving therein the characteristic quality of the original electrical undulations, and causing qualitatively corresponding electrical undulations by means of said mechanical vibrations.

9. The method of transmitting telephonic messages consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a supplemental magnetic field, and producing by means of the said resultant magnetic product undulations mechanical vibrations, quantitatively proportionate and qualitatively corresponding to the resultant magnetic product undulations and causing qualitatively corresponding electrical undulations therewith.

10. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a supplemental substantially constant magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations, and causing qualitatively corresponding mechanical vibrations qualitatively proportionate to the resultant magnetic product undulations, thereby quantitatively enhancing the mechanical result while preserving therein the characteristic quality of the original electrical undulations.

11. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a substantially constant supplemental magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations and producing by means of the said product undulations mechanical vibrations quantitatively proportionate to the resultant magnetic product and qualitatively corresponding to the original electrical undulations.

12. The method of transmitting messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a substantially constant supplemental magnetic field, producing thereby qualitatively corresponding resultant magnetic product undulations, and causing qualitatively corresponding mechanical vibrations quantitatively proportionate to the resultant magnetic product undulations, thereby quantitatively enhancing the mechanical result by preserving therein the characteristic quality of the original electrical undulations, and causing qualitatively corresponding electrical undulations by means of said mechanical vibrations.

13. The method of transmitting telephonic messages which consists in transforming electrical undulations into qualitatively corresponding magnetic undulations in a resistance medium within a supplemental substantially constant magnetic field, and producing by means of the said resultant magnetic product undulations mechanical vibrations quantitatively proportionate and qualitatively corresponding to the resultant magnetic product undulations, and causing qualitatively corresponding electrical undulations therewith.

14. The method of relaying telephonic and other undulatory currents which consists in causing the currents which are to be relayed to produce undulatory magnetic effects in a resistance medium, translating the same into quantitatively corresponding mechanical effects within said medium, and causing said mechanical effects to re-act directly in the medium upon a source of constant potential, whereby qualitatively

corresponding but quantitatively enhanced current changes will be produced.

15. The method of relaying telephonic and other undulatory currents, which consists in translating the original electrical undulations into magnetic undulations in a resistance medium and said magnetic undulations into corresponding mechanical vibrations in said medium, and causing said mechanical vibrations to directly produce electrical undulations qualitatively corresponding to the original undulations.

In testimony whereof I affix my signature in presence of two witnesses.

EDWARD E. CLEMENT.

Witnesses:

ALEXANDER S. STEUART,

H. R. WHITING.