No. 623,579. Patented Apr. 25, 1899.

J. S. STONE.

DIFFERENTIAL ELECTROMAGNET.

(Application filed Aug. 6, 1898.)

(No Model.)

Fig. 2.

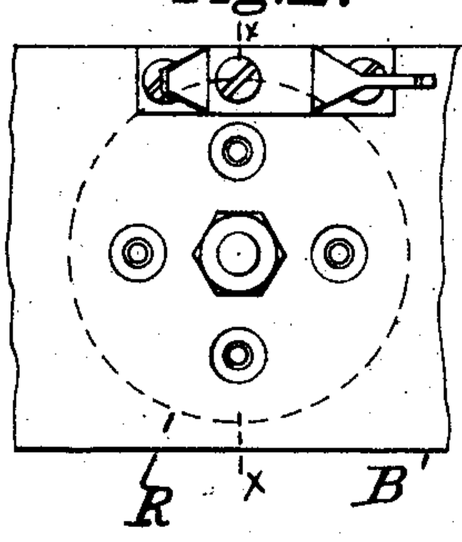


Fig. 1.

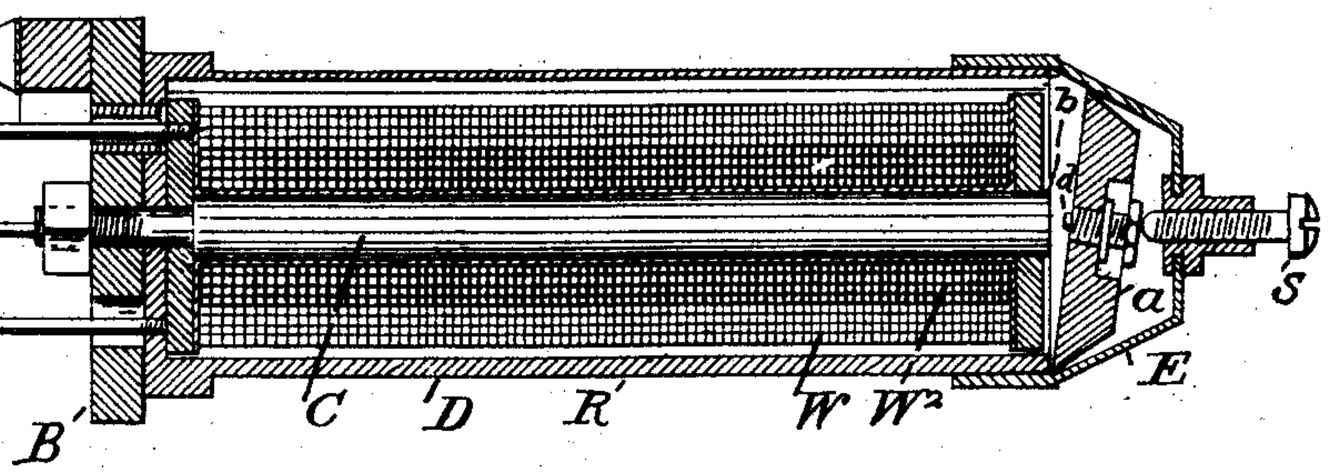


Fig. 3.

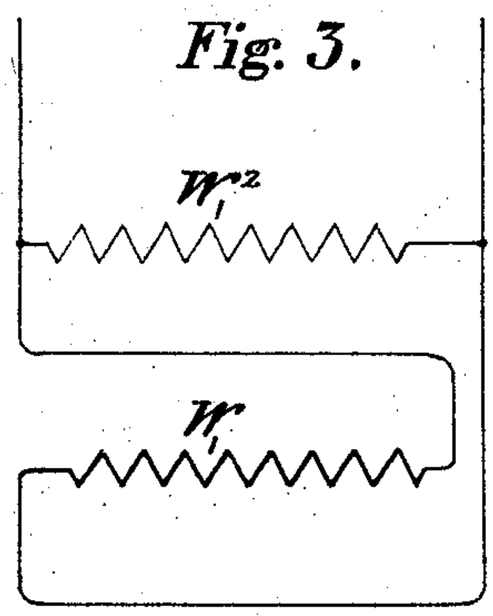
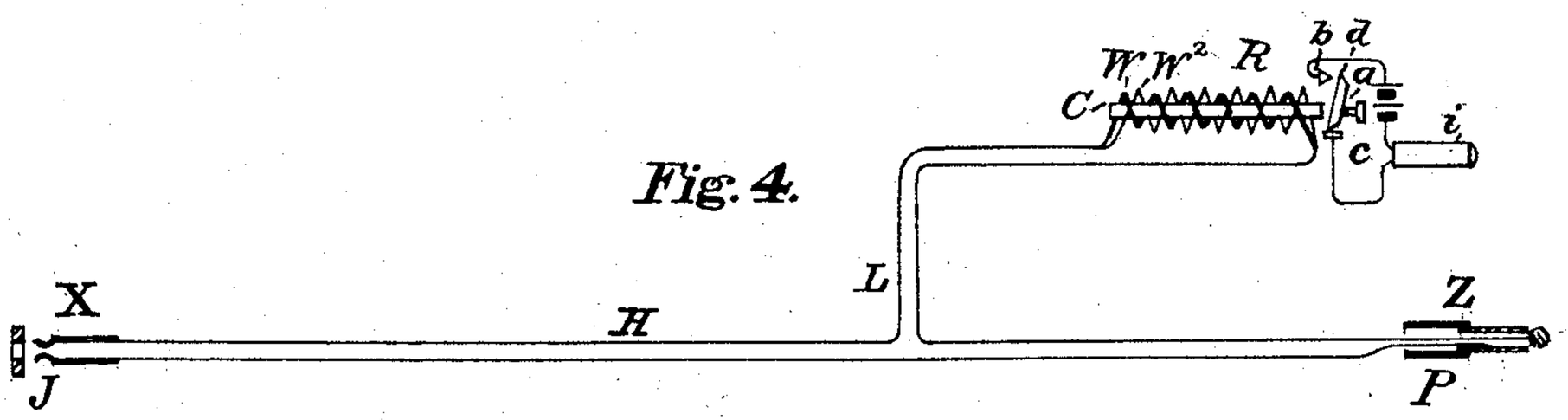


Fig. 4.



Attest.

Frank C. Lockwood,
Geo. Willis Cuce

Inventor.

John Stone Stone

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO THE AMERICAN BELL TELEPHONE COMPANY, OF SAME PLACE.

DIFFERENTIAL ELECTROMAGNET.

SPECIFICATION forming part of Letters Patent No. 623,579, dated April 25, 1899.

Application filed August 6, 1898. Serial No. 687,902. (No model.)

To all whom it may concern:

Be it known that I, JOHN STONE STONE, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Differential Electromagnets, of which the following is a specification.

In the operation of telephone-exchange or other telephonic installations it is frequently desirable to employ electromagnetic apparatus connected in circuits through which currents of diverse character—as, for instance, voice-currents and signaling-currents of possibly several kinds—may circulate, and when this is done it is obvious that for satisfactory results any such appliance must not only be perfectly responsive to the current intended for its operation, but also should be irresponsive to other currents, without impeding their flow through their appropriate conductors and without distorting such telephonic or voice currents as may be required to pass through its coils.

Where in telephonic practice signaling or other electromagnetic appliances are to be employed possessing the several requirements or characteristics of responsiveness to direct constant, direct intermittent, or pulsatory or slowly-alternating currents, irresponsiveness to rapidly-alternating currents, low impedance to rapidly-alternating currents, and little or no power of distorting or tending to distort the telephone-currents which pass through them, it is distinctly an advantage to provide that their electromagnets shall be double wound and shall have their two windings connected in parallel and differentially or in reciprocal magnetic opposition, the whole being constructed or arranged on a peculiar plan in conformity with principles to be stated herein. I have found that if the two windings of such an electromagnet are so relatively disposed upon the iron magnet-core that there is no appreciable "magnetic leakage" between the windings the said magnet-core will in general be excited by the passage through the windings of a direct current, either constant or pulsatory, or of a slowly-alternating current, whereas it will not be sensibly magnetized by the passage of a rapidly-alternating current through the windings. I have also discovered that by constructing such a double-wound differentially-connected electromagnet so that it shall have no appreciable magnetic leakage between the windings the core will in general be energized by the passage of either constant or pulsatory direct, or slowly-alternating currents, whereas the electromagnet will offer but a relatively slight impedance to the passage of rapidly-alternating currents. Moreover, I find that such impedance as is offered by the magnet when placed in a telephone-circuit to the passage of telephone-currents is the same for each of the simple components constituting the complex telephone-current, and for this reason such a coil will not, when placed in a telephone-circuit, distort the telephone-currents which may circulate through it. This essential condition of no magnetic leakage is to be obtained by so disposing the windings on the core that all, or substantially all, the induction developed by a current in either winding passes through, is included in, or is surrounded by the other winding, a condition which may be more precisely stated by saying that the mutual inductance between the two windings shall equal, or nearly equal, the square root of the product of the inductances of the windings.

In the foregoing statement that a double-wound electromagnet with its two windings connected or wound oppositely in parallel and so constructed as to have no appreciable magnetic leakage between the windings will "in general" have its core magnetized or excited by the passage of a direct current through the windings the qualification "in general" is made necessary by the fact that if the ratio between the number of turns and the resistance of the two windings, respectively, be the same for both then obviously no magnetization will result, even in the case of direct and constant currents, or we may say that if the two windings had each the same number of turns and also the same resistance, so that when conducting current the ampere-turns in each would be the same, the iron core obviously would remain unexcited. Its armature would therefore remain unattracted, and any electromagnetic apparatus or device depending for its operation on the attraction of such armature would thus be irresponsive even to

direct and constant currents. It follows from these considerations that besides the condition that the magnetic leakage of these double-wound and differentially-connected electromagnetic coils shall be zero it is necessary, in order that they shall be energized by or be responsive to constant or pulsatory direct currents or slowly-alternating currents, that the ratio of the number of turns to the resistance of each winding shall be different. This condition may be more precisely stated by saying that the time-constants of the two windings must be different. One practical way of carrying out these principles or conditions is to so construct the electromagnet that its two insulated conductor-windings shall have exactly the same number of turns, while the resistance of one shall be considerably greater than that of the other. The counter electromotive force of self-induction developed in an electromagnet so constructed on the passage of a rapidly-alternating current is small, and the impedance offered by it to such currents therefore is also small, and since the relatively weak magnetizing power of either winding produced by the passage through it of a rapidly-alternating current is checked and further minimized by the opposed magnetizing power of the other under the simultaneous passage through it of the same current the resultant effect is so small that the electromagnet is not sensibly excited and is to such a current irresponsive; but a constant or pulsatory direct or a slowly-alternating current will substantially divide between the two windings of diverse resistance inversely as their resistances, and as a consequence a resultant magnetizing effect upon the iron core will be produced, which with a current of appropriate strength will cause the attraction of the armature. This difference in resistance between the windings may be attained either by varying the size of the wires, by employing for the wires, respectively, metals of different resistivity, or by a combination of both expedients.

In the drawings which accompany and illustrate this specification, Figures 1 and 2 are respectively a longitudinal vertical section and a rear elevation of an electromagnetic relay embodying my invention. Fig. 3 is a diagram representing the parallel, but magnetically-opposed, connection of two windings of diverse resistance on the same magnetic core; and Fig. 4 represents the connection of the relay shown in Fig. 1 wound, as in Fig. 3, in a telephone trunk-circuit where the requirements are as hereinbefore set forth.

R indicates the electromagnetic signal or relay, secured to a suitable base B. C is its iron core; *a*, its armature; D, an iron casing within which it is secured, and E the cap-piece or armature-chamber, furnished with an insulated back-stop or limit-screw *s*.

W and W^2 are the two windings, each having the same number of turns, the resistances, however, being unlike, that of W^2 being considerably greater than that of W.

In an electromagnetic signaling-relay constructed to embody this invention and put in operation and wherewith good results have been attained one of the two windings, each having three thousand six hundred and sixty turns, was of wire of .0126 of an inch diameter, while the diameter of the other was .0100 of an inch.

In Fig. 4, H represents a trunk-circuit connection between two switchboards, which may be at different central stations X and Z, and is shown as being terminated at one of the said stations in a plug-socket or spring-jack J and at the other in a connecting-plug P. L is a loop extending from the said trunk and containing in one of its conductors the double-wound signaling-relay R. The relay has its two windings W and W^2 diagrammatically shown as surrounding its iron core C, and its armature *a* controls a local signaling-circuit *c*, which includes, in addition to its battery, any suitable visual signal *i*, as a self-setting annunciator or a glow-lamp. When the armature is attracted on the magnetic excitement of the core, it brings into contact the two terminals *b d* of the local circuit, and thus causes the same to operate the signal.

In constructing an electromagnetic appliance such as the double-wound relay described herein it is desirable to place that one of the two windings which has the lower resistance nearest to the iron core, in order that the difference in resistance of the windings may be made as great as possible by taking advantage of the fact that, other things being equal, the resistance per convolution of wire increases with the radius.

I claim as my invention—

1. An electromagnet or electromagnetic coil having two windings of different time-constants; connected in parallel; in opposition to each other; and substantially without magnetic leakage between them, as set forth.

2. The combination in an electromagnetic coil and with the iron core thereof; of two exciting-helices having substantially the same number of turns, but of unequal resistance, wound in parallel, and connected magnetically or inductively in opposition upon the said iron core; and substantially without magnetic leakage between them; as set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 1st day of August, 1898.

JOHN STONE STONE.

Witnesses:
GEO. WILLIS PIERCE,
FRANK C. LOCKWOOD.