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G. W. PICKARD.

ALTERNATING CURRENT RELAY.

APPLICATION FILED AUG. 21, 1903.

NO MODEL.

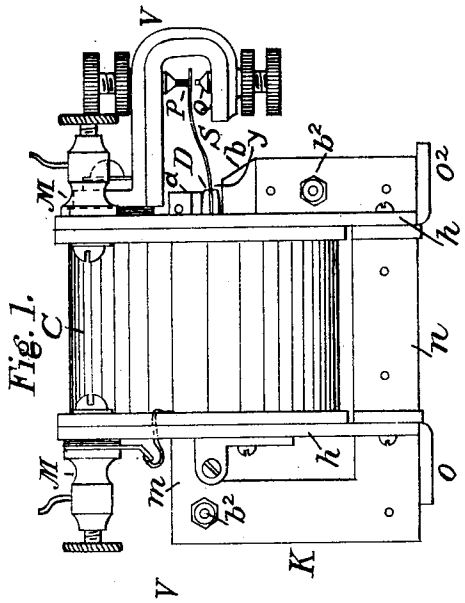


Fig. 1.

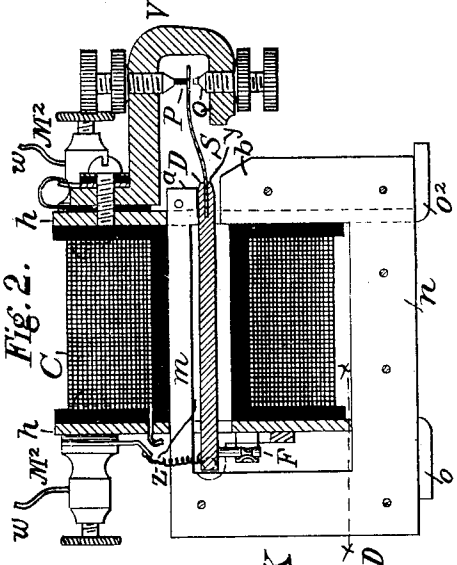


Fig. 2.

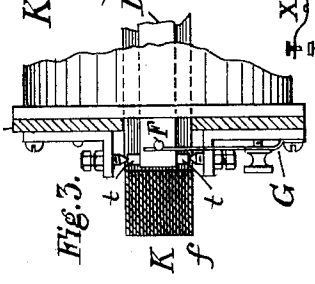


Fig. 3.

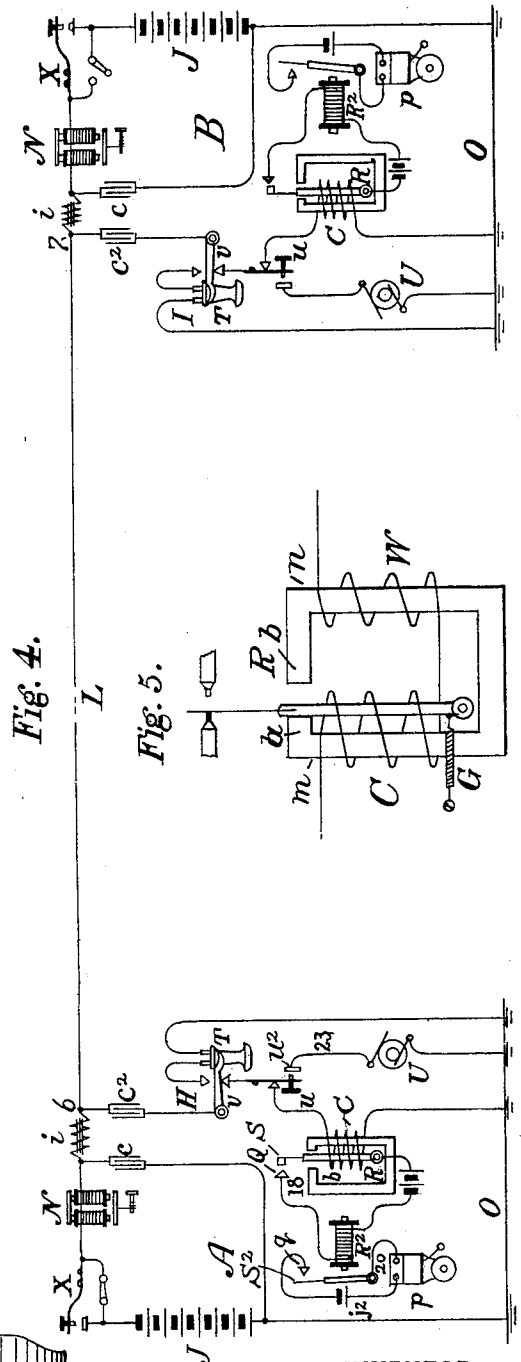


Fig. 4.



Fig. 5.

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# UNITED STATES PATENT OFFICE.

GREENLEAF W. PICKARD, OF AMESBURY, MASSACHUSETTS, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

## ALTERNATING-CURRENT RELAY.

SPECIFICATION forming part of Letters Patent No. 749,399, dated January 12, 1904.

Application filed August 21, 1903. Serial No. 170,368. (No model.)

*To all whom it may concern:*

Be it known that I, GREENLEAF W. PICKARD, residing at Amesbury, in the county of Essex and State of Massachusetts, have invented certain Improvements in Alternating-Current Relays, of which the following is a specification.

The present invention relates to composite systems for the electrical transmission of intelligence, wherein telegraphic and telephonic communications may be simultaneously transmitted over the same main-line conductor or conductors, and has particular reference to the efficient and satisfactory transmission of call-signals as an auxiliary to the telephonic part of the system, such call-signals virtually constituting a third class of electrical communications, which also at any time may occupy the line conductor simultaneously with its use in telegraphic transmission. The employment of alternating currents for such signaling is in practice highly desirable; but the provision of a call-receiving relay perfectly responsive to an alternating current of frequency sufficiently high to avoid interference with the telegraphic part of the system and satisfactory in all respects has been difficult of attainment. The call-receiving device heretofore most generally employed in this association has depended upon the partial opening of or the establishment of a high resistance in a normally closed circuit, including a battery, by the vibration of contacts placed in the conductor of the said closed-battery circuit. This arrangement is, however, not altogether free from objectionable features, since it is liable under certain conditions of practice to give false signals due to the concurrent transmission of the telegraphic current impulses and, moreover, involves the employment of a closed-circuit battery at each station.

To provide a call-receiving apparatus promptly and effectually responsive to the transmission of an alternating current of the desired high frequency equally responsive reversely to the cessation of such alternating-current transmission and generally free from the above-mentioned disadvantages is the object of this invention.

The invention, generically described, consists in a relay whose characteristic feature is an electromagnetic movement comprising a pivoted iron armature whose free end, adapted to form a movable pole, extends between the two polar ends or pole-pieces of a core system, such ends being adapted to form fixed poles of a nearly-closed magnetic circuit of iron, and an electromagnetic helix or exciting-coil surrounding the said armature and one limb of said core system, so that when energized by the passage through it of a current the said coil operates to temporarily magnetize the said movable and fixed poles thus associated in its bore, (which is sufficiently wide for the free lateral movement of the former therein,) with like polarity, thus making them reciprocally repellant, while the other limb of said core system being outside of said coil has its polar end, which forms the said other fixed pole, at the same time temporarily magnetized with opposite polarity, produced either by magnetic propagation through the substance of the core or in any appropriate way, mutual attraction being thereby developed between said other fixed pole and the movable pole, which latter being repelled by the fixed pole of the limb associated therewith within the exciting-coil and attracted by the said other fixed pole moves away from the former and nearer to the latter.

Limit-stops are mounted above the poles of the core system and armature, one of them, that on the side of the fixed pole associated with the armature-pole, being non-conducting, while the other on the outer fixed-pole side is conducting and serves as one of the contact-terminals of a controlled circuit, and a flat conducting-spring forming a continuation of the armature and constituting the complementary contact-terminal of said controlled circuit extends between said stops, resting against the non-conducting stop when the relay is unoperated and against the conducting-stop to close the said controlled circuit when the said relay is excited and in operation. The re-

siliency of the said spring extension acts to slightly prolong the contact when the armature is retracted to its normal position.

A maintaining and retracting spring is provided for the armature to hold the same normally against the non-conducting or back stop and to restore the same thereto, when having been oscillated into contact with the conducting or forward stop by the passage of an operating-current through the exciting-coil such current ceases to flow.

The relay thus constructed is of course operative with a steady current of single direction, but has been devised with special reference to use in connection with an alternating current, and since with every alternation or reversal of direction of such current the two fixed poles and the movable pole all have their polarity simultaneously reversed it follows that there is no change of relation between them and that the armature-pole having been oscillated in the direction of the fixed pole of the outer portion of the core system by the first pulsation of current regardless of the direction will retain its deflected position and maintain the union of the contacts of the controlled circuit as long as the alternating current in the main circuit and exciting-coil continues and will only move back to its normal position nearer to the associated fixed pole, separating such contacts, on the cessation of such alternating energizing-current.

In the drawings which accompany this specification, Figure 1 is a side elevation of the relay of this invention. Fig. 2 is a vertical central cross-section thereof. Fig. 3 is a section of a detail on the line $x$ $x$ of Fig. 2 looking toward the pivots and retracting-spring of the armature and showing the arrangement of the latter and the lamination of the core system. Fig. 4 is a diagram of a composite system, wherein the relay of this invention is connected for operation as the principal factor of the call-signal-receiving apparatus of the telephonic portion of the system; and Fig. 5 illustrates a modification of the relay construction, wherein the necessary magnetic polarity of the attracting fixed pole of the core system is imparted thereto by an individual magnetizing-coil.

R is the alternating-current relay.

K is the iron-core system.

C is the electromagnetic helix or exciting-coil.

D is the iron armature.

S is the flat extension or continuation spring thereof.

P is the non-conducting limit-stop against which the said spring extension rests when the armature is in its normal or resting position.

Q is the conducting limit-stop on which the said spring extension rests when the armature is in its operative position.

M M are the main-circuit binding-screws and are terminals of the exciting-coil.

F is a pin extending laterally from the armature at a point near the pivots thereof, and G a spring pressing upon the under side thereof and tending to hold the said armature steadily toward the non-conducting limit-stop P and acting to return the same thereto when it has been deflected toward the conducting limit-stop Q.

The iron-core system K is preferably formed of laminated iron, as indicated at $f$ in Fig. 3, the plates thereof being held together in any preferred way, as by bolts $b^2$, and may be mounted in slotted portions of brass base-plates $h$, whose faces overlap and support the ends of the electromagnetic exciting-coil C and whose ends turned at a right angle, as shown, may serve as feet $o$ $o^2$ for the relay.

One limb $m$ of the core system K passes through the bore $z$ of the exciting-coil and the other limb $n$ passes outside or over the exterior of said coil and then at an angle across the end thereof, so that the two polar ends $a$ and $b$ of the said limbs respectively are brought near to one another, the two limbs being united at their other ends to form a continuous core. The entire core is conveniently formed substantially as a parallelogram, discontinuous at one corner, and constitutes a nearly-closed magnetic circuit, with closely-adjacent confronting polar ends $a$ $b$, having a narrow magnetic-field space between them.

The magnetizing or exciting coil is adapted for connection in the main circuit by means of the binding-screws M and has a wide central bore $z$ for a purpose presently to be described.

The iron armature D is pivoted or poised at one end by its trunnions $t$, with adjustable screws mounted in suitable brackets near the heel end of the core K, and extends through the bore of the coil C parallel to and side by side with the core-limb $m$, being of such length as to bring its free end $y$ into the space provided between the polar ends $a$ and $b$ of the core. The purpose of having the bore $z$ of the coil C wide, as is now manifest, is to provide for the admission therein of the core-limb $m$ and the armature D, which are thus both surrounded by said coil, and to afford sufficient space for the oscillation of the armature.

The limiting-stops P and Q are mounted upon adjustable screws in opposite sides of the arched bracket V, and the armature extension-spring S, attached to the free end of said armature, passes between them and is capable of oscillating from each to the other.

Main-circuit conductors are represented by the wire ends shown as being attached to the binding-screws M, and the wires $w$ of the controlled alarm-circuit leading from the conducting limit-stop Q and the armature D, respectively, are attached to the binding-screws $M^2$.

If the coil C of this relay be connected in a circuit and a current of appropriate strength

passed through it, the polar end *a* of the core-limb *m* and the free end *y* of the armature D, associated with said limb and both encircled by said coil, will be temporarily magnetized with definite and like and therefore mutually-repellant polarity, and the polar end *b* of the outer limb *n* of the core will at the same time be magnetized with an opposite polarity adapted to attract the armature. Under these conditions the said polar ends become fixed poles of the core system, while the free end of the armature is a movable pole sustaining a certain relation to said core system. The armature or movable pole *y*, repelled by fixed pole *a* and attracted by fixed pole *b*, will swing toward the latter and will cause the spring-tongue S to separate from the resting-stop P and to establish contact with the conducting-stop Q, thus closing the circuit of the conductors *w*. If now the direction of the main circuit be reversed, it is obvious that the polarities of the said fixed and movable poles will all also be reversed, so that if the armature and its associated fixed pole were in the former case magnetized with N polarity and the other fixed pole with S polarity the said associated poles *a* and *y* now both become S poles, while the fixed pole *b* becomes an N pole. The reciprocal repulsion of the two former and the reciprocal attraction of poles *b* and *y* thus continues and the change in the direction of the current does not alter the attractions and repulsions of the armature, which continues to hold the spring-tongue S in contact with the conducting-stop Q. It is therefore manifest that the relay of this invention is perfectly responsive to an alternating current by the movement of its armature into operative position with the first pulsation of said current and by maintaining the same steadily in such operative position as long as the said alternating current continues to flow and without regard to the frequent reversals thereof.

In the composite system of simultaneous telegraphy and telephony represented by Fig. 4, L is the common line conductor, A and B the telegraph-stations, and H and I the telephonic stations. J J are the telegraphic batteries; N N, the telegraphic receivers; X X, the telegraphic keys, X being supposed to be transmitting; *i i*, the standard impedance-coils, placed in the telegraphic branches of the main line to smooth the telegraphic transmission and to effectively oppose the passage in any undersired direction of the talking and ringing currents; *c c*, the standard grounded condensers branched from the conductor L at points between the telegraphic instruments and impedance-coils, and O O the terminal earth connections.

The apparatus at the telephonic stations comprises the transmitting and receiving telephones symbolized by the receivers T, the call-receiving appliances, the call-transmitting appliances, condensers $c^2$ $c^2$, interposed between the telephone-station instruments and the line conductor, suspension-switches *v v*, controlling the alternative connection of the talking and signaling instruments, and keys or switches *u u*, controlling the alternative connection of signal-sending and signal-receiving instruments. At both telephone-stations the telephone is shown at an unemployed moment, the receivers being on their hooks, and the circuits of the telephone instruments branch from the main conductor at points 6 and 7 at stations H and I.

The apparatus is of the same kind at both telephone-stations and works at each in the same way. It is therefore generally sufficient to describe that at but one of them. Referring to station H, the telephone extension leading inward from point 6 passes through the condenser $c^2$ to the telephone switch-hook *v*, and thence when the receiver is removed to ground through the station-telephones. When the telephone is in its place on the hook, the said circuit continues from the lower hook-switch contact to the signaling-key *u*, and normally by way of the back contact thereof to the coil C of the call-receiving or alternating-current relay R and to ground or return O. The said relay is thus in the normal calling-circuit and controls the call-bell *p*, connected in the local circuit 20 of the battery $j^2$. In practice the alternating-current relay R does not directly close and open the local circuit 20 of said bell, but controls the same through the medium of an interposed local circuit 18 and an intermediate relay $R^2$, included therein. This is a well-known expedient, and its object is to prevent false signals due to momentary contacts which may occasionally be established between the points Q S of the relay due to undesired impulses or "kicks" from the telegraphic side of the circuit.

The call-sending apparatus U is connected between the forward contact $u^2$ of the key *u* and the earth in conductor 23.

It is necessary in such composite transmission as is described herein in order to operate through the condensers $c^2$ to employ an alternating call-current, and it is also necessary for the avoidance of interference with the telegraphic relays to provide that the said current shall be of frequency as high as from one hundred and sixty to two hundred periods per second. The key being, as shown, in its normal position, such a call-current transmitted from station I will traverse the coil C of relay R, and the armature D of said relay will swing toward the fixed pole *b*, establishing contact between its spring extension S and contact-stop Q, which, as shown, are terminals of the local circuit 18, and will retain such position as long as the said alternating current continues to flow. The intermediate relay $R^2$ is thus energized and in turn brings its arma-

ture-contact $S^2$ into engagement with contact-stop $q$, thus closing the second local circuit 20 and operating the call-signal bell $p$, which will continue to ring as long as the distant key is depressed.

To send the call-signal from station H, the key $u$ is operated, temporarily disconnecting the relay branch and substituting the alternating-current generator U.

Alternating currents of the frequency required may readily be developed by any convenient and suitable source or apparatus, and although a dynamo-electric generator is indicated any such recognized equivalent, as a battery associated with an induction-coil and vibratory circuit-breaker, may of course, if desired, be employed.

The modification illustrated by Fig. 5 concerns merely the mode of effecting the magnetization of the outer fixed pole $b$ of the relay R and shows the limb $n$ of said core as being provided with an exciting-coil W of its own connected in series with the principal coil C and in such manner as to insure the opposed polarity of the fixed pole $b$. In cases where this modified construction is adopted it is of course not essential that the core shall be continuous from one pole to the other, and, if desired, the uniting-heel of the core may without change in the character of the operation be dispensed with, so that the two limbs are quite separate. The only requisite is that their active poles $a$ and $b$ shall be of opposite character or sign.

Having thus fully described the invention, its mode of operation, and one application thereof, I claim—

1. The hereinbefore-described electromagnetic movement, consisting in an iron-core system having two fixed and confronting pole-pieces; a pivoted iron armature with its free end extending between the said fixed pole-pieces, and itself constituting a movable pole-piece; and a magnetizing-helix surrounding the said movable pole-piece and one of the said fixed pole-pieces, and adapted when energized by the passage of an electric current therethrough to develop temporary magnetism of like polarity and consequent mutual repulsion between the said coil-surrounded fixed and movable poles, and opposite temporary polarity in the other fixed pole-piece, and consequent attraction between the same and the said movable pole-piece as long as the said passage of current continues, and without regard to its direction.

2. A relay adapted to respond by the steady attraction of its armature to its operative position to a high-frequency alternating-current, comprising a magnetizing or exciting helix; a soft-iron-core system having fixed and movable pole-pieces surrounded by said coil, and a second fixed pole-piece extraneous to said coil; and means for establishing temporary magnetic polarity in said second fixed pole-piece opposite in sign to that established by said coil in the said fixed and movable pole-pieces surrounded thereby; the said movable pole-piece being mounted between the two fixed pole-pieces, and the bore of said coil being sufficiently large to permit of the lateral movement therein of said movable pole-piece; whereby when the said coil is excited by an alternating current, like temporary polarity is developed in said coil-surrounded fixed and movable pole-pieces, and opposite temporary polarity in the said other fixed pole-piece; and whereby the polarity of all of the said pole-pieces is simultaneously reversed at each reversal of said current; substantially as described.

3. A relay, comprising a soft-iron-core system having two fixed and confronting pole-pieces; a soft-iron armature pivoted or poised at one end and having its free end extending into the space between said pole-pieces, and constituting a movable pole-piece organized to oscillate between said fixed poles; an exciting-helix surrounding the said movable pole-piece and one of the said fixed pole-pieces, in electromagnetic inductive relation to all of the said pole-pieces, and adapted when energized to develop like magnetic polarity in the fixed and movable pole-pieces thus associated therein, and opposite polarity in the other fixed pole-piece; a maintaining and retracting spring for the said armature; and electrical contacts controlled by said armature; substantially as and for the purposes set forth.

4. A relay comprising an exciting or magnetizing coil; an iron core extending through the bore and back over the exterior of said coil and forming a nearly-complete magnetic circuit, with closely-confronting poles at one end of said coil; a soft-iron armature extending through said coil, pivoted or poised at one end to oscillate laterally therein and having its free end between said poles; a counter-spring for the said armature; a contact-spring carried by the free end of said armature; and limiting-stops for said contact-spring, one of said stops being an electrical contact-point; substantially as set forth.

5. An alternating-current relay operating by magnetic repulsion and attraction and consisting of an iron-core system composed of two limbs united at one end and having their other ends approximated to constitute a nearly-closed magnetic circuit with closely-adjacent confronting polar ends; an iron armature pivoted or poised near the heel ends of said core-limbs, extending forward in close association with one of them, and having its free end in the field-space between the polar ends of both; an electromagnetic coil or helix surrounding the said armature and its associated core-limb and adapted when energized by the passage of an alternating current therethrough to develop the ends thereof into like and mutually-repellent movable and fixed poles respectively,

and to form of the end of the other or non-associated core-limb an opposed fixed pole attractive of said movable pole, the bore of said coil being of sufficient width to admit of lateral oscillatory movement of the said armature therein; non-conducting and conducting limit-stops for the said armature corresponding to its normal and operated positions respectively; a conducting spring extension for said armature adapted to move therewith between said stops, and constituting a complementary contact for the latter; and a counter-spring for said armature tending to hold the same in its normal position with the said contacts separated, and adapted to restore it thereto on the cessation of the said energizing-current; substantially as set forth.

6. In an alternating-current relay the combination with the magnetizing or exciting coil C adapted for inclusion in a main circuit; and the parallelogrammic soft-iron core K forming a nearly-completed magnetic circuit, and constituted of limbs *m* and *n* passing respectively through and outside of said coil, united at one end and provided at the other with confronting polar ends *a* and *b;* of the soft-iron armature *d* pivoted at one end of said coil, passing through the bore thereof conjunctively with the said core-limb *m*, and having its free end between the polar ends *a* and *b* of said core; limit-stops P and Q mounted above the polar ends *a* and *b* respectively, the latter forming a contact-point for a controlled circuit; the spring extension S of said armature extending between said limit-stops, and constituting the complementary contact of said controlled circuit; the heel-pin F of said armature and the counter-spring G therefor pressing said armature constantly toward the said polar end *a* and the non-conducting limit-stop P; substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 19th day of August, 1903.

GREENLEAF W. PICKARD.

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