No. 668,554. Patented Feb. 19, 1901.

A. M. BULLARD & L. A. FALK.

ELECTRICAL RELAY AND CIRCUIT.

(No Model.) (Application filed Dec. 3, 1900.)

Fig. 1

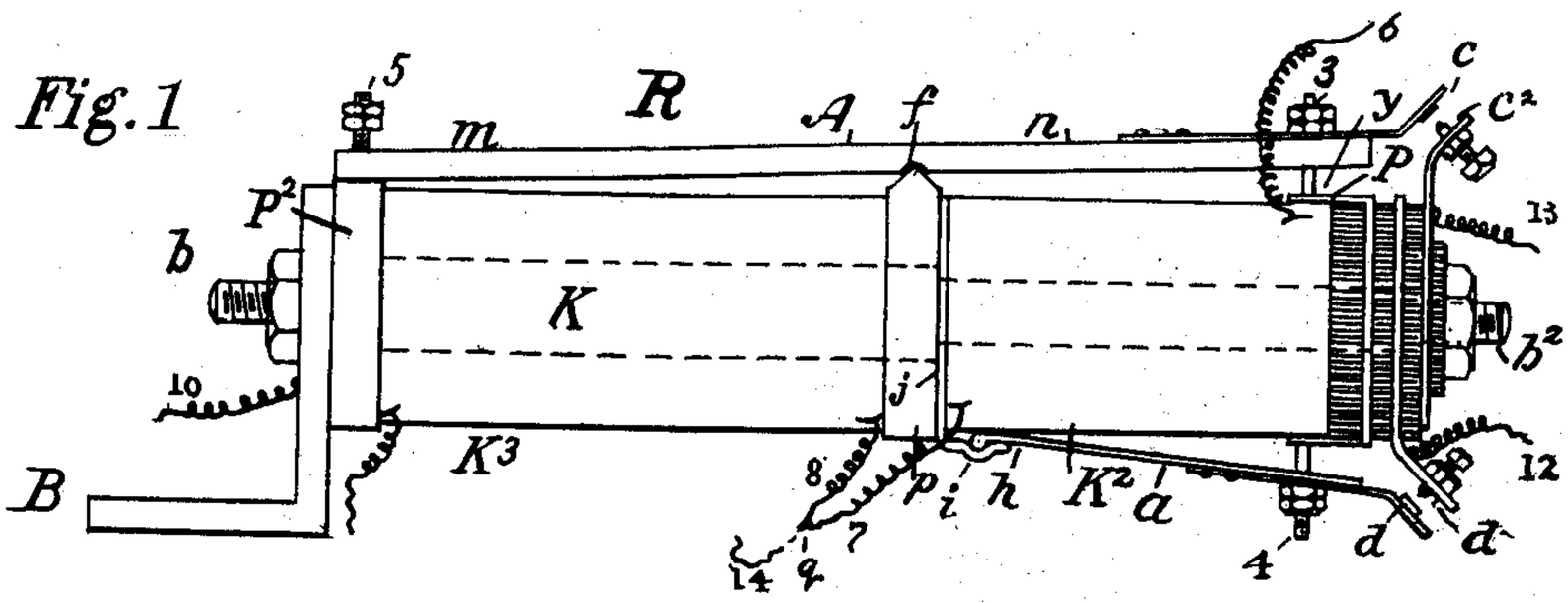


Fig. 2.

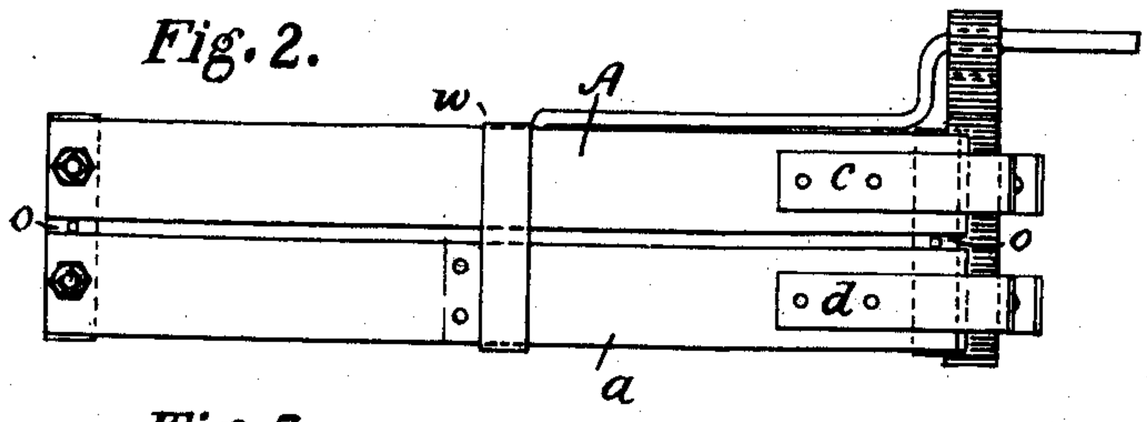


Fig. 5.

Fig. 3.

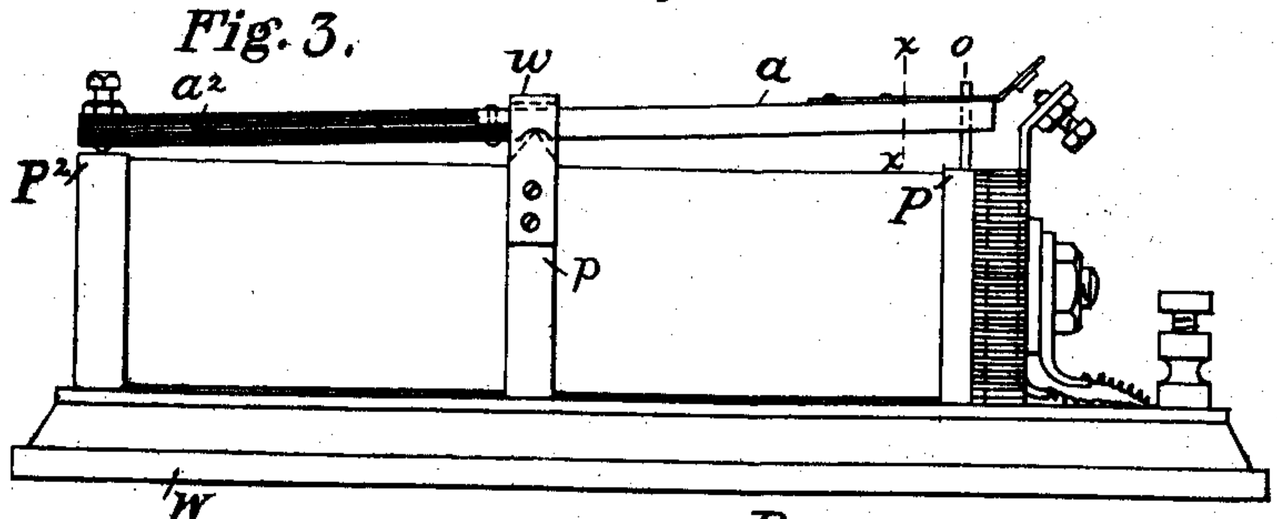


Fig. 4.

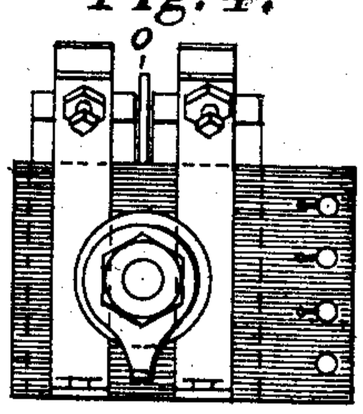
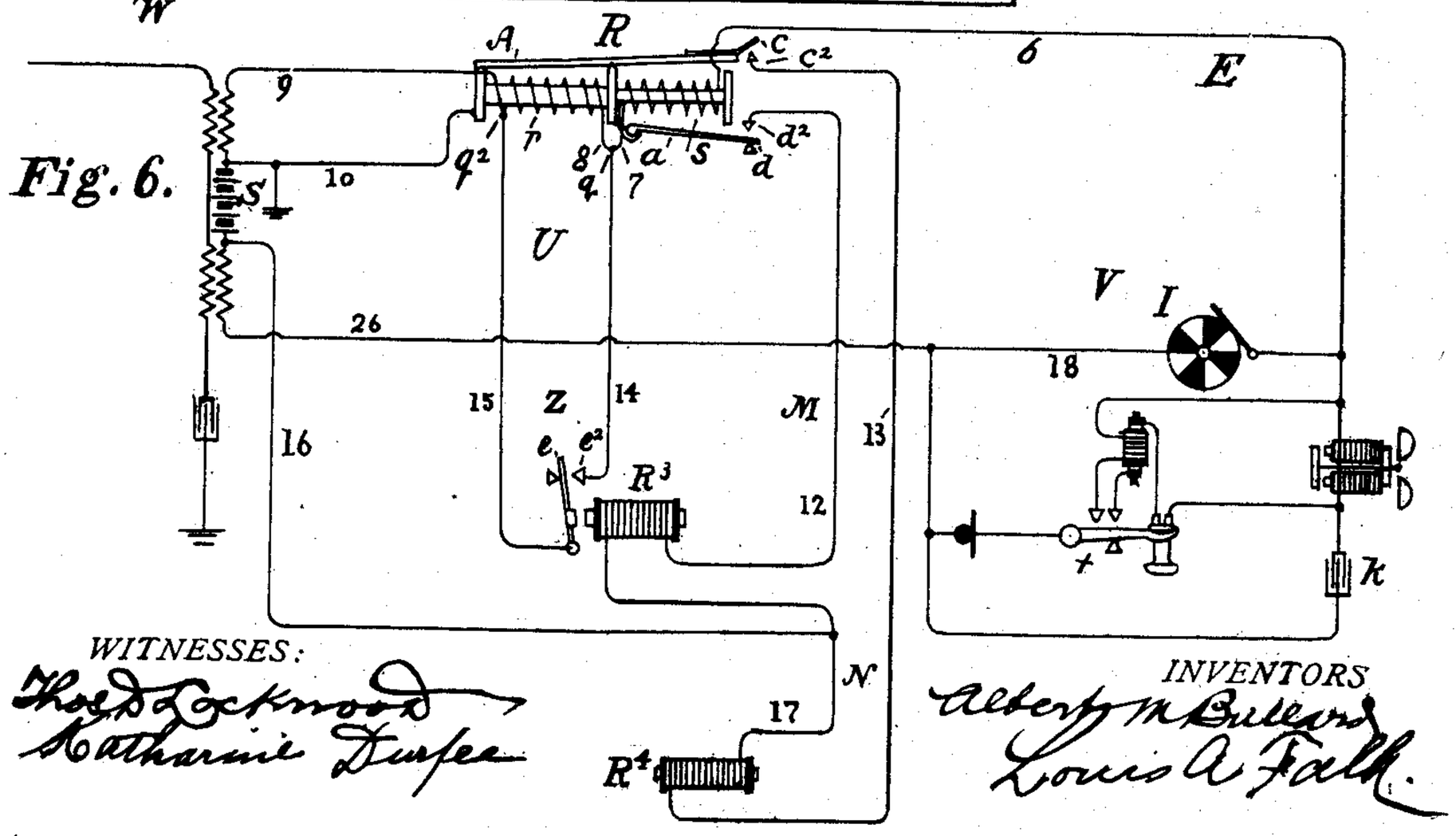


Fig. 6.



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ELECTRICAL RELAY AND CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 668,554, dated February 19, 1901.

Application filed December 3, 1900. Serial No. 38,477. (No model.)

To all whom it may concern:

Be it known that we, ALBERT M. BULLARD, residing at Somerville, in the county of Middlesex, and LOUIS A. FALK, residing at Boston, in the county of Suffolk, State of Massachusetts, have invented certain Improvements in Electrical Relays and Circuits, of which the following is a specification.

This invention relates to electromagnetic apparatus, and particularly to relays and circuits controlling and controlled by them. Its object is to provide a single relay capable of responding to either intermittent or continuous electric currents traversing a main circuit with which it may be connected and which under the influence of the said currents is capable of selectively controlling either or both of two independent local circuits for the operation of the apparatus associated therewith or contained therein.

The relay of this invention has two independent armatures of diverse inertia. One of these (the heavier) is irresponsive to interrupted or intermittent currents, which indeed, so far as they affect it at all, tend to maintain its quiescence or normal or resting position, but responds to the passage through the main circuit of a continuous or steady current or to a current impulse which is so far protracted that its following currents and intermissions do not in any sense follow one another with such rapidity that they can properly be said to be rhythmical. The lighter armature is arranged to be responsive either to a steady or continuous current or to a rhythmically-interrupted current. To act upon these armatures, the relay is provided with an iron core having forward and rearward terminal poles or polar ends and an intermediate pole or pole-piece, the said core being wound with two magnetizing-coils surrounding the forward and rearward sections, respectively formed between the intermediate and the two end poles. The said coils are in series with one another and are adapted for connection in a main circuit. The heavier armature is poised or fulcrumed at or near its middle at the intermediate pole, and its ends extend in opposite directions to points in front of and within the field of the two end poles, respectively; but by making the rearward arm a little longer or heavier than the other a normal inclination is imparted to it, so that the armature is overbalanced rearwardly, and while its hinder end is in close juxtaposition to the approximate pole, the forward end is as far away from the forward pole as is permitted by the range of armature oscillation. Thus when a current impulse passes through both coils the attraction exerted by the core upon the rearward end of the armature is, by reason of its closer proximity to the pole, much greater than the opposing attraction exercised upon its forward end by the forward pole, and the armature consequently remains at rest, being practically "locked" or retained in its normal position by the preponderating influence of the rear pole. The lighter armature is suspended or fulcrumed also at or near the intermediate pole, but extends therefrom in one direction only—viz., to the forward end pole, and is therefore subject to the action of the forward exciting-coil only. Since this armature is not controlled by the rear coil, it is responsive to any current sufficiently strong traversing the front coil and is consequently responsive not only to a steady current passing therein, but, having little inertia, to a rhythmically-interrupted current also, moving to its forward limit on the passage of the impulse and falling back promptly on the intermission.

Referring to the functions of the two exciting-coils, we term the front coil the "actuating-coil" and that on the rear section of the core a "locking-coil."

Both armatures are provided with local-circuit contacts which are controlled by their oscillations, the said contacts being united by the forward motion of the corresponding armature and separating on the recession of the armature. By this means our relay is enabled to do work heretofore requiring the employment of two separate relays—that is, it independently controls two separate local circuits or connections—closing one of said local circuits with each successive impulse of an intermittent current and closing the other

whenever the interruptions cease and the current remains continuous or steady.

To bring about the requisite motion of the main or heavy armature in its proper time, we provide means controlled by the oscillations of the lighter armature for withdrawing the locking-coil from the circuit when a continuous current passes. The said locking-coil is, indeed, so withdrawn during the latter portion of each impulse of the intermittent current; but the transient withdrawal of the locking-coil under these conditions is so immediately followed by an intermission of current that the excitement of the front coil also at once ceases and the main armature does not move. Thus to bring about the operation of said armature our invention requires that the locking-coil shall first be withdrawn from the working circuit or deprived of current and that during such condition of the retaining-coil a current shall continue to flow through the actuating-coil. This occurs during the passage of a continuous current. In the main circuit which contains the said coils we provide a source of current, means for interrupting the current rhythmically, and means for withdrawing the said interrupting apparatus to permit the steady flow of current.

Our invention is primarily designed for use in automatic telephone-exchanges, wherein heretofore the practice has been to employ two relays to close independent local circuits at the central station, including, respectively, a selecting-magnet and a connecting-magnet. When so employed to produce the intermittent current necessary for the exclusive operation of the lighter relay-armature, a rhythmical interrupter or circuit-breaker at the substation is introduced into the main circuit, which also includes the central battery, and the requisite succession of current impulses is thus created. These in due season are followed by the establishment in the circuit of a steady current, and this is brought about when the substation-telephone is removed from its switch-hook, the circuit being thereby closed through the said telephone, and pursuant to the said continuous current the heavy relay-armature is operated.

In the drawings which accompany this specification, Figure 1 is an elevation of one form of our relay. Figs. 2 and 3 are respectively a top and side view of another and in some respects preferable form of the said relay. Fig. 4 is an end view of the form illustrated by Figs. 2 and 3. Fig. 5 shows cross-sections of the two armatures on the line $x\,x$ of Fig. 3. Fig. 6 is a diagram showing the connections of the relay as associated with a substation-circuit of an automatic exchange system.

Referring for the present to Figs. 1 and 6, R is the relay, shown as being mounted horizontally and secured at the rear end by the bolt b to a bracket B. K is the iron core, having polar ends P P^2 and an intermediate pole or pole-piece p, which may also serve as a partition, dividing the core into front and rear sections K^2 K^3, and likewise by giving its upper side a knife-edge may be utilized as an armature-fulcrum f. The core may be in one piece from end to end or, if desired, the front and back sections may be separate, but secured end to end, the front section, however, in either case being preferably smaller in cross-section than the rear, since it is desired that the latter shall be sluggish and the former relatively rapid in operation. The front polar end is shown as being formed of an iron strip y, bolted to the core and turned at a right angle at the top and bottom ends to overlap the coil-spool; but any preferred construction, such as the plate form of the rearward polar end, may readily be adopted.

A is an armature of considerable inertia fulcrumed at f and extending by arms m and n to the rear and front polar ends, respectively. It is made heavier at the rear end either by making that arm longer than the other or of greater cross-section than the other or, as indicated in Fig. 5, by making holes or recesses in the front arm n or otherwise lightening the same. Guide-pins 3 and 5 are secured to the polar ends and pass loosely through holes in the armature, the requisite range being determined for the oscillations of said armature by threading the ends of said pins and fitting them with adjustable nuts, so that the said nuts serve as limit-stops. The lower armature a is much lighter and smaller, and its inertia is therefore much less. It is fulcrumed at one end h in a support i, attached to an arm j, secured at or near to the intermediate pole p, and extends by its free end to a point in front of the front pole P. This armature has a guide-pin and limit-stop 4.

The heavy armature A controls local-circuit contacts c and c^2, the latter being fixed and the former carried by the armature itself, and the light armature a in like manner controls movable and fixed local contacts d and d^2. The said fixed contacts c^2 and d^2 are mounted in metal strips or plates insulated from one another and from the core by suitable insulating-layers, but mechanically secured to said core by the bolt b^2.

The exciting-helices r and s of the relay are adapted for connection in a main circuit E and are in series with each other in said main circuit, which, entering by conductor 6, passes through the actuating helix or coil s, the connecting-conductors 7 and 8, and the retaining-coil r in succession, leaving the latter by conductor 9 and leading thence to the source of current S, the other conductor 26 of said main circuit being extended from the other pole of said source. The battery S may also supply current for a local circuit M, controlled by the local points d d^2 of the lighter armature a and including a relay R^3. This circuit, starting from the battery, passes by

conductor 16, through relay R^3, to conductor 12, contacts d^2 and d, armature a, and through the support therefor, the core, and the framework generally to the common return-conductor 10. It is normally open, but is closed when by the forward motion of armature a the points d d^2 are united.

N is another local circuit, which may contain a relay R^4 or, in fact, any desired appliance, such as an indicator or a lamp, and which also may be supplied with current by the battery S. This circuit, starting from said battery, passes, by way of conductor 16, conductor 17, relay R^4, conductor 13, contact-points c^2 c, and armature A, to the metallic core and framework, and thus to common return 10. This circuit also is normally open and is controlled by armature A, being closed when the points c c^2 are brought into contact by the forward movement thereof.

Z is a shunt-circuit constituting means for the control of the locking-coil r of the relay. It is normally open, and the coil r is therefore in the main circuit; but its continuity is controlled by the relay-points e e^2 of relay R^3, and when these are brought into contact the shunt-circuit is closed and the coil r practically withdrawn from the main circuit, so that currents passing through said main circuit and the forward coil s no longer pass through the coil r also, but through the shunt-conductors 14 and 15, which short-circuit the said coil r by passing from the point q on one side of coil r to the point q^2 on the other through the contacts e e^2 of relay R^3. It is manifest that, if desired, the lighter armature a of the relay R of our invention could be made to control the shunt-circuit Z directly by its local contacts d d^2 instead of employing these contacts to close an intervening circuit acting upon the shunt by means of a second relay. If an intermittent current or an appropriate series of current impulses be transmitted through the relay of our invention, the light armature a will respond to each impulse and will be attracted forward, bringing the contacts d d^2 together and closing the local circuit M; but the heavy armature A will not respond, for the said current impulses traverse coil r as well as coil s, and though undoubtedly attraction is thereupon exercised on said armature by both poles P and P^2 that exerted by the rear pole P^2 is the stronger, since the end m of the armature is close to that pole and since, therefore, all that the said pole P^2 has to do is to maintain the armature in the resting position it normally occupies. Consequently during the transient impulses of current through both coils armature a responds, but armature A does not; but when armature a closes its contacts d d^2 the operation of relay R^3 (if such relay be employed) or the operation of said contacts directly closes the shunt-circuit transiently around the retaining-coil r. When this occurs, the heavy armature A becomes acted upon, like the armature a, by the front coil s alone, and would operate were it not that, the intermission of current closely following the impulse thereof, the attraction due to the said front coil has ceased, and this, together with the mechanical inertia of the armature and the electrical inertia of the core-section K^3, prevents the said armature from being moved during the brief periods wherein the shunt Z is closed while an intermittent current is passing through the circuit. The succeeding current impulse thus finds the shunt again opened and the winding r in the main circuit, and again the armature A is retained; but if instead of such intermittent current a continuous current flows in the main circuit, so that the light armature a once attracted into its forward position stays there for an interval of time at all protracted, the points d and d^2 remain in contact, and the shunt-circuit consequently remains closed, practically withdrawing the relay-coil r from the main circuit. The heavy armature A no longer held by the forces combining to maintain its quiescence and now acted upon by the coil s alone oscillates into its operative position, the end n approaching more closely to pole P, and thus bringing the points c c^2 into contact and closing the local circuit N. Apparatus for producing this cycle of operations is indicated in the diagram Fig. 6, the central-station portion U of which, comprising the relay of our invention, the central source of current, the auxiliary relays R^3 and R^4, and the local and shunt circuits, has already been described.

V is a substation of the main circuit E. Normally the telephone t is on its switch-hook, as shown, the circuit in that case being conductively open in the condenser k.

I is a rhythmical interrupter of any well-known construction connected in a branch 18 of the circuit. To send recurrent impulses, the said interrupter is operated and causes a succession of alternate current impulses and intermissions in the circuit, which affect our relay and the apparatus controlled thereby in the manner described. When the appropriate number of pulsations for any particular occasion has been sent, the operation of the interrupter ceases and the telephone t is removed from the hook, closing the main circuit and permitting a continuous or steady current to flow therein from the source S. When our relay is operated in association with such a central-battery automatic exchange apparatus as has been indicated and generally described herein, it is found advantageous to so adjust or arrange the substation-circuit-interrupting device as to produce the intermittent current impulses at a rate of about ten per second.

The form of relay illustrated by Figs. 2 and 3 does not differ in principle from that already described. Its construction, however, provides that the lighter armature a as well as the heavier, A, shall be fulcrumed on the knife-edge at the intermediate pole p, a cap w being placed over both to prevent displace-

ment. The said armature *a*, though still extending from its fulcrum to the forward pole-piece P, is fitted with a rearward extension-piece a^2, of brass or like non-magnetic metal or alloy, to aid in maintaining its poise. The weight of the heavier armature is distributed as in the former case, the fulcrum preferably being slightly nearer to the front pole P than to the rear pole P^2. This gives the armature the required normal bias toward the said rear pole-piece and aids in providing a longer coil-space for the helix *r*, this being found generally desirable. Both armatures being above the coil, the contact-points *c* and *d* are likewise both above, a separating-pin *o* being placed between the armature ends. The whole is mounted on a base-board W.

We claim—

1. A relay comprising an iron core; an exciting-coil therefor consisting of front and rear sections in series; an armature of slight inertia in the field of the front coil-section responsive to currents passing through said front coil-section regardless of the condition of the other; and a second armature of greater inertia in the field of both coil-sections, adapted to be held in its normal position when currents are passing through both coil-sections, but to be responsive by attraction into its working position, on the passage of current through the front coil-section only; substantially as set forth.

2. In a relay, the combination of an iron core having terminal poles, and divided by an intermediate pole into two sections; two magnetizing-coils in series wound over the said two core-sections respectively; an armature extending between the said terminal poles, fulcrumed intermediately, and biased or inclined toward the rear terminal pole, the same being held in its normal position by the preponderating influence of the said rear pole when an exciting-current is passed through both coils, but adapted to move toward the front pole and into its operative position on the passage of a steady current through the coil of the front coil-section only; a lighter armature extending from a fulcrum at the said intermediate pole to the front terminal pole only, and made to be responsive to the passage of an exciting-current through the coil of the front core-section, regardless of the condition of the other; and independent sets of local-circuit contacts controlled by the said armatures respectively; substantially as described.

3. In a relay, the combination of a single magnetic core with polar extremities, and divided into front and rear sections by an intermediate polar partition; a main armature poised intermediately and adapted to oscillate between said polar extremities, but normally approximating toward that of the rear section; a lighter armature suspended by one end at the said intermediate pole and having its other end extended to the front polar extremity of said core; a magnetizing-coil surrounding the said front section of said core, and adapted when traversed by an exciting-current to cause said core to exercise attraction on both armatures; a second exciting-coil in series with the first, surrounding the rear section of said core, and adapted when traversed by an exciting-current to cause said core to exercise attraction on the main armature alone, tending to maintain the quiescence thereof; circuit-closing relay-points controlled by the said lighter armature; and means controlled by said relay-points for withdrawing the second or rear section-coil from the circuit; substantially as and for the purposes specified.

4. The combination in a relay, of an electromagnetic core adapted to have end poles and an intermediate pole; a main armature therefor poised near its middle and extended between said end poles, but unbalanced and normally inclining toward the rearward, and away from the forward end pole, but capable of oscillating into a reversed or forward position; local contacts normally separated but adapted to be united by said armature when attracted to its forward position; an actuating-coil for the forward pole of said core and a retaining or locking coil for the rearward pole thereof, in serial circuit with each other, the former operating to swing the said armature into said forward position, and the latter acting to retain said armature in its normal position; with a lighter armature acted upon by the said forward pole and actuating-coil only; and means controlled by said lighter armature for short-circuiting said retaining-coil, and for maintaining said short circuit as long as the current actuating said lighter armature persists; whereby the main armature is made irresponsive to an interrupted current, and responsive to a continuous or steady current passing in the circuit of the actuating-coil; substantially as specified.

5. The combination in a relay, of an iron core having terminal poles, and an intermediate pole; an armature fulcrumed at the intermediate pole and extending between the terminal poles, the same gravitating normally toward one of the said terminal poles; a second and lighter armature also fulcrumed at said intermediate pole, and extending therefrom to one only of said terminal poles; two sets of local contacts controlled by the said armatures respectively; an exciting-coil comprising two serially-connected sections wound over said core between the intermediate and the terminal poles respectively; and a shunt-circuit for one of said coil-sections controlled by the local contacts of said lighter armature; substantially as and for the purposes set forth.

6. The combination of a main circuit; a source of current contained therein; and means for establishing in said circuit either a continuous or a rhythmically-intermittent current from said source; with a relay comprising a sluggish armature, an actuating and a

retaining coil in series in said circuit the former acting to move said armature, and the latter acting in opposition and operating to prevent the movement of said armature during the passage of intermittent current in said main circuit, an auxiliary armature of lesser inertia under the influence of the actuating-coil only and hence responsive to all currents in said main circuit, and two sets of relay-contacts controlled by the said armatures respectively the members of each being united when the controlling-armature has been moved by said actuating-coil; a local circuit including the said relay-contacts of the sluggish armature; and a shunt-circuit of the relay retaining-coil, controlled directly or indirectly by the relay-contacts of the lighter armature, and adapted to be closed thereby, and to free the sluggish armature of said relay on the passage of continuous or steady current in the main circuit substantially as set forth.

7. The combination of a main circuit; a source of current; and a device for rhythmically interrupting the current of said source included therein; and means at a station of said circuit for withdrawing the said interrupter therefrom, and thus leaving the current steady; with a relay comprising a core; two armatures, one placed in operative relation to both terminal poles of said core, and the first in operative relation to one only of said poles; a retaining-helix in said circuit acting on said core in such manner as to prevent the movement of the first-named armature; a second helix serially connected with the said retaining-coil in said circuit acting on said core in such manner as to operate the second armature, and to operate the first when freed from the influence of said retaining-coil; independent local contacts for each of said armatures; and a normally open shunt-circuit around the retaining-helix controlled by the local points of said second armature; whereby the first armature is prevented from operating during the passage of interrupted or intermittent currents, but enabled to operate on the passage of a steady current; substantially as set forth.

In testimony whereof we have signed our names to this specification, in the presence of two subscribing witnesses, this 1st day of December, 1900.

ALBERT M. BULLARD.
LOUIS A. FALK.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.