March 16, 1943. A. J. SORENSEN 2,313,973

ELECTRICAL RELAY

Filed May 31, 1941

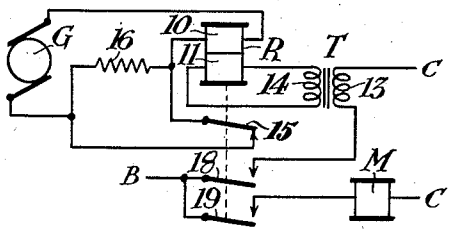


Fig. 1.

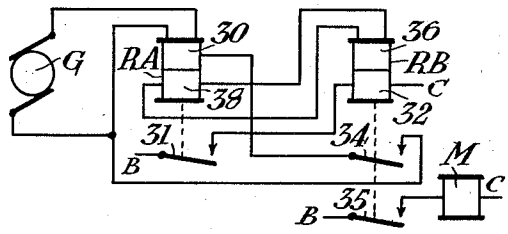


Fig. 3.

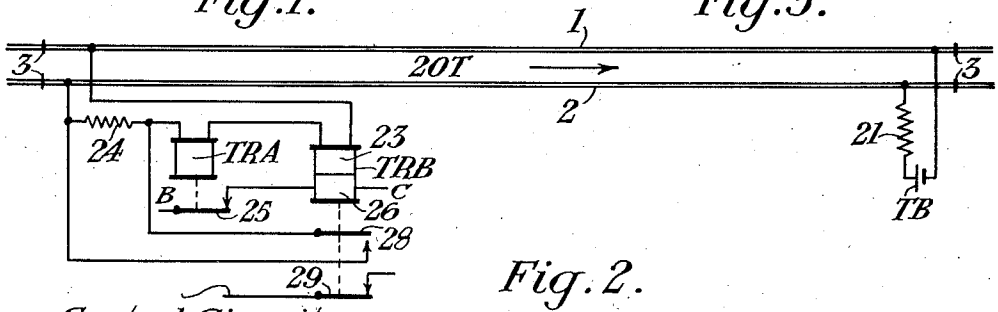


Fig. 2.

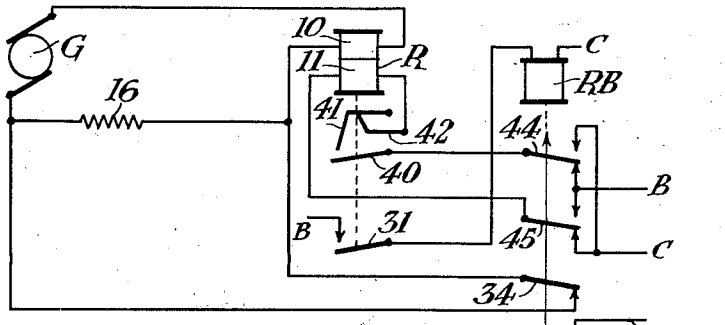
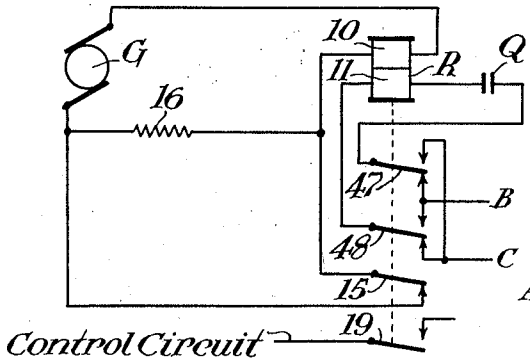


Fig. 4.

Fig. 5.



INVENTOR
Andrew J. Sorensen.
BY
HIS ATTORNEY

Patented Mar. 16, 1943

2,313,973

UNITED STATES PATENT OFFICE

2,313,973

ELECTRICAL RELAY

Andrew J. Sorensen, Edgewood, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application May 31, 1941, Serial No. 395,907

15 Claims. (Cl. 175—320)

My invention relates to a relay system and particularly to means for rendering the operation of a relay more positive than has heretofore been possible.

This application is a continuation-in-part of my application Serial No. 361,929, filed October 19, 1940.

As usually constructed a relay has a core, a winding mounted on the core, and a movable armature which is attracted to the core on energization of the relay winding. In addition, the armature has mounted thereon, or otherwise associated therewith, movable contacts which engage stationary contacts on movement of the relay armature to its picked-up position. Normally either or both the movable and stationary contacts are mounted on springs, while these contacts are arranged so that they engage when the relay armature moves part of the way to its picked-up position, and so that on further movement of the relay armature towards its picked-up position the contact springs are deflected and the contacts are held firmly in engagement.

The force exerted to move the relay armature from its released to its picked-up position on energization of the relay winding varies inversely as the square of the distance between the core and the armature. Accordingly, when the armature is in its released position, at which time there is considerable space between the relay core and armature, the force exerted by the flux in the core on the armature is relatively small, and current of relatively high value must be supplied to the relay winding before the flux in the core is built up to a value high enough to attract the relay armature to the core, that is to move the relay armature from its released to its picked-up position.

Similarly, when the relay armature is in its picked-up position, there is relatively little space between the relay armature and core and the flux in the core exerts relatively great force on the armature to maintain it in the picked-up position. Accordingly, when the relay armature is in its picked-up position, it will remain in that position until the current in the relay winding is reduced to a much lower value than was necessary to effect picking up of the relay armature.

This difference between the pick-up and release values of a relay is objectionable in some situations, and it has been suggested heretofore that these values can be made more nearly equal by arranging the circuit of the relay winding so that on movement of the relay armature from its released position to its picked-up position the degree of effective energization of the relay winding is reduced to a value slightly in excess of that necessary to maintain the relay armature picked up. This reduction in the degree of energization of the relay winding on picking up of the relay armature may be accomplished by connecting a resistance in series with the relay winding, by short circuiting some of the turns of the relay winding, or by any other suitable means.

Accordingly, with this arrangement on a subsequent small reduction in the value of the current supplied to the circuit of the relay winding the armature of the relay becomes released. On release of the relay armature the degree of effective energization of the relay winding is increased and the relay armature is thereafter picked up on a small increase in the value of the current supplied to the circuit of the relay winding.

The arrangement described above operates to greatly reduce the difference between the pick-up and release values of a relay, but even with the best possible arrangement of the equipment a considerable difference between these values must be maintained to insure proper operation of the relay.

A complicating factor in the operation of a relay of this type is the effect of the contact springs. On movement of the relay armature far enough towards its picked-up position to cause engagement of the movable and fixed contacts further movement of the relay armature is resisted by the contact springs. If when the relay armature moves far enough towards its picked-up position to cause the movable contacts to engage the stationary contacts the effective energization of the relay winding is reduced by inserting a resistance in series with the winding, or otherwise, the flux density may be reduced to such a low level that insufficient force is exerted on the relay armature to move it to its picked-up position against the opposition of the contact springs. Accordingly, the relay armature may not complete its movement to its picked-up position but will remain in the position in which the movable and fixed contacts lightly engage.

In like manner when the relay armature moves from its picked-up position towards its released position, initial movement of the armature is assisted by the contact springs so that the armature will move towards its released position when the flux in the relay core is reduced to a predetermined value. As the relay armature moves towards its released position, the force exerted by the contact springs decreases, while when the armature moves to the position in which the movable and fixed contacts barely engage, or are disengaged, the contact springs cease to exert force on the relay armature to move it to its released position and the relay armature may remain in this position and

not complete its movement to the released position. This is particularly true if when the relay armature moves to the position at which the fixed and movable contacts disengage the degree of energization of the relay winding is increased so that there is an increase in the flux in the relay core.

It has been found that when relays of the type described are energized with current of an intermediate value, the contacts will chatter or vibrate, that is, the movable contacts of the relay intermittently engage and become disengaged from the relay stationary contacts. This condition is objectionable because as the voltage of the current supplied to the relay is gradually increased or decreased, there is a range during which operation of the relay is uncertain.

It is an object of my invention to provide a relay incorporating means to insure that on movement of the relay contacts towards their released or picked-up positions they will complete their movement to such positions.

A further object of my invention is to provide a relay having little difference between the pick-up and release values and incorporating means to insure that the relay armature will always move all of the way to its picked-up and released positions.

Another object of my invention is to provide an improved relay.

Other objects of my invention and features of novelty will be apparent from the following description taken in connection with the accompanying drawing.

I shall describe five forms of equipment embodying my invention, and shall then point out the novel features thereof in claims.

In the drawing

Fig. 1 is a diagram showing speed responsive apparatus employing a relay provided by this invention,

Fig. 2 is a diagram of a section of railway track provided with track circuit apparatus employing a relay embodying my invention,

Figs. 3, 4, and 5 are diagrams of modifications which may be employed in place of the equipment shown in Fig. 1.

Similar reference characters refer to similar parts in each of the several views.

Referring to Fig. 1 of the drawing, there is shown therein a direct current generator G of a type which is adapted to supply current at a voltage which is substantially proportional to the speed at which the generator armature is rotated. The generator armature may be driven from a suitable member, such as the axle of a railway vehicle, which is operated at varying speeds, while the equipment of which the generator forms a part may be employed to control the brakes on the vehicle or to indicate when the vehicle is exceeding a predetermined speed.

A complete brake control system of the type in which the relay provided by this invention may be employed is shown in my application Serial No. 342,941, filed June 28, 1940, for Brake control means (Westinghouse Air Brake Company Case 4745).

The equipment shown in Fig. 1 of the drawing includes in addition to the generator G, a relay R, a transformer T, and an electroresponsive device M. The device M may be a magnet valve device for controlling the supply of fluid under pressure to brake cylinders, not shown, or it may be a lamp or any other device which it is desired to govern in response to the vehicle speed.

The relay R is provided with a first winding 10 and a second winding 11, while the transformer T has a primary winding 13 and a secondary winding 14.

The equipment is shown in the condition which it assumes when the vehicle is standing still or is moving at a slow speed. When the vehicle is idle, the generator G does not supply any energy, while when the vehicle is moving at a slow speed, the voltage of the energy supplied by the generator is so low that too little energy flows in the circuit of the winding 10 of the relay R to pick up the relay contacts. Accordingly, at this time the contacts of the relay R are released and contact 15 establishes a circuit shunting the resistor 16, while contact 18 interrupts the circuit of the primary winding 14 of the transformer T, and contact 19 interrupts the circuit of the device M.

On an increase in the speed of the vehicle there is an increase in the voltage of the current supplied from the generator G to the winding 10 of the relay R, and a corresponding increase in the current flowing through the winding of the relay R. When the speed of the vehicle increases to a predetermined value, such as 50 miles an hour, the current in the winding 10 is increased to a value high enough to cause sufficient flux to be developed in the relay core to attract the relay armature to the core.

As usually constructed, the relay armature and contacts are arranged so that the movable contacts do not become disengaged from their back points of contact until the armature has moved a substantial part of the way towards its picked-up position.

Accordingly, on picking up of the relay armature the circuit shunting the resistor 16 is not interrupted until after the relay armature moves a substantial part of the distance towards its picked-up position, while before the contact 15 interrupts the circuit which it controls the air gap separating the relay core and armature will have been substantially reduced so that the force acting on the armature to move it towards the picked-up position is materially increased. As a result, even though on interruption of the circuit shunting the resistor 16 there is a reduction in the current in the winding 10, sufficient force is exerted on the relay armature to insure that it will continue to move towards its picked-up position far enough for the movable contacts to engage their front contacts.

When contact 18 engages its front contact, the circuit is established for supplying energy from a local source of direct current, such as a battery, not shown, to the transformer primary winding 13. As a result of the supply of energy to the winding 13, an impulse of energy is induced in the transformer secondary winding 14 and is supplied therefrom to the winding 11 of the relay R. The impulse of energy supplied to the relay winding 11 is of such polarity that the flux developed in the relay core by this energy is of the same polarity as the flux developed by the energy in winding 10. Accordingly, on the supply of the impulse of energy to the winding 11 there is an increase in the flux in the relay core and an increase in the force tending to move the relay armature to its picked-up position.

The various parts of the equipment are arranged and proportioned so that the force developed on the supply of the impulse of energy to the winding 11 is great enough to move the relay armature all of the way to its picked-up

position against the biasing means and against the contact springs.

The impulse of energy induced in the transformer secondary winding 14 is of momentary duration only and terminates as soon as the current in the transformer primary winding builds up to the full value of the current supplied from the current source.

On termination of the impulse of energy in the winding 11 of relay R the flux density of the relay core decreases. However, before this decrease occurs the relay armature will have been moved all of the way to its picked-up position and the air gap between the relay core and armature will have been reduced to the minimum with the result that the maximum force is exerted on the relay armature to maintain it in its picked-up position.

The various parts of the equipment are arranged so that, when the relay armature is in its picked-up position, the flux developed in the relay core by the energy supplied to the winding 10 through the resistance 16 is effective to maintain the relay armature picked up as long as the current supplied to winding 10 is equal to or greater than the value present when the vehicle speed exceeds the predetermined speed.

As long as the armature of the relay R is picked up, contact 19 establishes the circuit of the electro-responsive device M, while contact 18 maintains the circuit of the transformer primary winding.

As long as the speed of the train exceeds the predetermined rate, the value of the current supplied by the generator G is high enough to maintain the relay armature picked up. However, when the speed of the train is reduced, the voltage of the current supplied by the generator is reduced, and when this falls to a predetermined amount, the energy supplied through the resistor 16 to the winding 10 of the relay R does not develop sufficient flux in the relay core to maintain the relay armature picked up, and the armature moves towards its released position. Initial movement of the armature is assisted by the contact springs, but as the armature moves from its picked-up position, the effect of these springs is reduced, while, when the armature moves far enough towards the released position for the movable contacts to become disengaged from the front contacts, the contact springs cease to exert force on the armature.

As the armature moves towards its released position, the air gap between the relay armature and core is increased so that the force exerted on the armature by the flux in the relay core is reduced. As soon as the armature moves far enough towards its released position for contact 18 to be disengaged from the associated stationary contact, the circuit of the transformer primary winding is interrupted and the flux in the transformer core collapses with the result that an impulse of energy is induced in the transformer secondary winding and is supplied therefrom to the relay winding 11. The polarity of this impulse of energy is such that it tends to develop in the relay core flux of the polarity opposite to that developed by the energy supplied to the winding 10.

Accordingly, on the supply of the impulse of energy to the winding 11 there is a decrease in the flux in the core of the relay and a corresponding decrease in the force opposing movement of the relay armature towards its released position and the armature quickly moves all of the way to its released position.

When the relay armature moves far enough towards its released position for contact 15 to engage its back point of contact, the circuit shunting the resistor 16 is established and there is an increase in the energy supplied to the winding 10 of the relay R and a corresponding increase in the flux in the relay core.

The impulse of energy supplied to the winding 11 is of momentary duration, and after its termination the flux in the relay core is built up by the energy in the winding 10. However, before this increase in the flux in the relay core occurs the relay armature will have moved all of the way to its released position and the air gap between the armature and core will have been increased to the maximum so that the force exerted on the armature by the flux in the relay core is at the minimum. Accordingly, even though the flux in the relay core increases, the armature will remain in its released position until the current supplied from the generator G to the winding 10 is increased to a predetermined value.

It will be seen that with the relay provided by this invention, on picking up of the relay armature a resistance is inserted in the circuit of the relay winding to render the release value of the relay nearly the same as the pick-up value. In addition, as soon as the relay armature picks up far enough for its front contacts to engage, an impuse of energy is supplied to the relay to insure that the armature will complete its movement to its picked-up position.

Similarly, on release of the relay armature the resistance is removed from the circuit of the relay winding, while an impulse of energy is supplied to the relay to insure that the relay armature will complete its movement to its released position.

It will be seen, therefore, that operation of the relay is definite and positive, and that once the relay armature starts to move to either position it will complete its movement to that position. This eliminates chattering and fluttering of the relay contacts and thereby makes it possible to arrange the relay and associated apparatus so that there is little difference between the pick-up and release values of the relay.

Referring to Fig. 2 of the drawing, there is shown therein a stretch of railway track having track rails 1 and 2 over which traffic normally moves in the direction indicated by the arrow, that is, from left to right. The track rails have insulated rail joints 3 therein to divide the track stretch into track sections. One such section is shown and is designated section 20T.

The track section has at the exit end thereof a source of track circuit energy in the form of a track battery TB which is connected across the section rails, while a suitable resistor 21 is connected in series with the track battery.

A primary track relay TRA and a secondary track relay TRB are connected across the section rails at the entrance end of the section. The relay TRB may be employed to control a signal, not shown, for the track section, or it may be employed to control any other apparatus which it is desired to govern in accordance with occupancy of the track section.

The equipment is shown in the condition which it assumes when the track section is vacant. At this time energy from the track battery TB feeds over the track rails to the windings of relays TRA

and TRB and maintains the contacts of the relay TRA picked up. The circuit for energizing these relays is traced from one terminal of the track battery TB over track rail 1, winding 23 of relay TRB, winding of relay TRA, resistance 24, track rail 2, and resistance 21 to the other terminal of the track battery.

As the winding of relay TRA is energized, its contact 25 is picked up and establishes a circuit to supply energy from a local source of direct current, not shown, to the winding 26 of relay TRB. The windings 23 and 26 of relay TRB when energized assist each other in maintaining the relay contacts picked up, and at this time the contacts 28 and 29 are picked up. As contact 28 is picked up, the circuit which it controls for shunting the resistance 24 is interrupted, while as contact 29 is picked up, the control circuit is established.

When a train enters the track section, the wheels and axles of the vehicles comprising the train shunt the track relays TRA and TRB and reduce the energy in the winding of the relay TRA to such a low value that the relay armature releases. When the armature moves far enough towards its released position for contact 25 to become disengaged from the associated stationary contact, the circuit of the winding 26 is interrupted.

On deenergization of the winding 26 of relay TRB there is a collapse of the flux in the relay core. As the flux in the relay core reduces, energy is induced in the winding 23, and is supplied therefrom to the winding of relay TRA. The polarity of the impulse of energy supplied to the relay TRA from the winding 23 is opposite to that supplied to the winding of relay TRA over the track rails, and therefore this impulse of energy operates to create in the core of relay TRA flux of the polarity opposite to that present in the core. Accordingly, any flux in the core of relay TRA produced by energization of the relay winding by current supplied from the track battery is quickly dissipated and the armature of the relay is certain to complete its movement to its released position.

On the collapse of the flux in the core of the relay TRB there is a reduction in the force tending to hold the relay armature in its picked-up position, and, when the flux density reduces to a predetermined value, the relay armature moves towards its released position and contact 28 establishes the circuit shunting the resistor 24 with the result that there is an increase in the current supplied from the track battery TB to the relay TRA.

However, before the flux in the core of the relay TRB reduces far enough for the armature of this relay to become released and establish the circuit shunting the resistor 24, an impulse of energy of substantial value will have been supplied to the relay TRA and the armature of this relay will have completed or substantially completed its movement to its released position, and the air gap between the relay core and armature will be substantially at the maximum so that the flux in the relay core exerts the minimum force on the relay armature. Accordingly, on the increase in the current in the winding of relay TRA which takes place on shunting of the resistance 24 the relay armature remains released.

As a result of the release of the armature of the relay TRB, contact 29 opens the control circuit.

When the train vacates the track section, the shunt provided by the vehicles of the train is removed and energy from the track battery feeds to the relays TRA and TRB. At this time the resistor 24 is shunted by the circuit controlled by contact 28 of relay TRB so sufficient energy is supplied to the winding of relay TRA to pick up the armature of this relay. When the armature moves far enough towards its picked-up position for contact 25 to engage the associated stationary contact, energy is supplied to the winding 26 of relay TRB.

On the supply of energy to the winding 26 of relay TRB the flux in the relay core builds up and an impulse of energy is induced in the winding 23 and is supplied therefrom to the winding of relay TRA. This impulse of energy is of the same polarity as that of the energy supplied to the relay TRA from the track battery so that there is a momentary increase in the flux in the core of relay TRA, and a corresponding increase in the force tending to move the armature of relay TRA all of the way to its picked-up position against the resistance of the contact springs.

When the flux in the core of relay TRB builds up a predetermined amount, the armature of this relay picks up and contact 28 interrupts the circuit shunting the resistor 24 so that there is a reduction in the current supplied to the relay TRA. On this reduction in the current in the winding of relay TRA there is a reduction in the flux in the relay core and a corresponding reduction in the force tending to hold the relay armature picked up. However, before this reduction in the force acting on the relay armature takes place the relay armature will have been moved all of the way to its picked-up position, or substantially all of the way thereto, and the space between the relay armature and core will have been reduced to the minimum so that the maximum force is exerted on the relay armature to maintain it picked up.

Accordingly, on the reduction in the current in the winding of relay TRA, which occurs on termination of the impulse of energy from winding 23 of relay TRB and on inclusion of the resistor 24 in the circuit of the relay winding, the relay armature will remain in its picked-up position and contact 25 will maintain the circuit of the winding 26 of relay TRB so that contact 29 establishes the control circuit. In addition, contact 28 interrupts the circuit shunting the resistor 24 and the relay TRA will release on a small reduction in the energy supplied thereto.

From the foregoing it will be seen that the arrangement shown in Fig. 2 is especially efficient since on picking up of the armature of relay TRA far enough for its front contacts to engage, a portion at least of the impulse of energy from the winding 23 of relay TRB is supplied to the relay TRA before the resistance 24 is included in the circuit of the relay TRA. Accordingly, current of the maximum value is present in the relay winding and insures movement of the relay armature substantially all of the way to its picked-up position before the current in the relay winding is reduced by the resistance 24.

Similarly, when the relay armature moves far enough towards its released position for contact 25 to be disengaged from the associated stationary contact, a portion at least of the impulse of energy from the winding 23 of relay TRB is supplied to the relay TRA before the resistance 24 is shunted. Accordingly, the flux in the core of relay TRA is reduced to insure movement of the relay armature substantially all of the way to its released position before the current in the relay

winding is increased by shunting of the resistor 24.

Referring to Fig. 3 of the drawing, there is shown therein a modified form of apparatus which may be employed in place of that shown in Fig. 1. The system shown in Fig. 3 includes a generator G of the type employed in the equipment shown in Fig. 1, while the equipment shown in Fig. 3 includes relays RA and RB each of which is provided with two windings. The winding 30 of relay RA is energized by current supplied by the generator G, while this winding is provided with a tap or connection at an intermediate point in the winding so that a portion of the turns of the winding may be short circuited at times to thereby decrease the effectiveness of the winding.

The equipment of Fig. 3 is shown in the condition which it assumes when the vehicle is idle or is moving at slow speed. At this time the voltage of the energy, if any, supplied by the generator G is so low that too little energy is supplied to the winding 30 of relay RA to pick up the contact 31. Accordingly, the circuit of the winding 32 of relay RB is interrupted and its contacts 34 and 35 are released. As contact 34 is released, the circuit for short circuiting a portion of the winding 30 of relay RA is interrupted and the entire winding is energized, while as the contact 35 is released, the device M is deenergized.

When the vehicle speed is increased to a predetermined rate, such as 50 miles an hour, the energy supplied from the generator G to the winding 30 of relay RA picks up the contact 31 so that energy is supplied from a local source of direct current, not shown, to the winding 32 of relay RB. As a result of the supply of energy to the winding 32 of relay RB, an impulse of energy is induced in winding 36 of the relay and is supplied therefrom to the winding 38 of relay RA and assists the winding 30 in moving the relay armature to its pick-up position so that the armature is certain to complete its movement.

In addition, as a result of the supply of energy to the winding 32 of relay RB, the armature of this relay picks up and contact 35 completes the circuit of the device M, while contact 34 establishes the circuit for short circuiting a portion of the winding 39 of relay RA so that thereafter a portion only of this winding is energized and there is a reduction in the force tending to hold the armature of relay RA picked up.

The various parts of the equipment are arranged so that the portion of the winding 30 which continues to be energized after picking up of contact 34 develops sufficient flux in the relay core to maintain the relay armature picked up as long as the vehicle speed exceeds the predetermined rate.

On a subsequent predetermined reduction in the speed of the vehicle the current supplied from the generator G to the winding 30 of relay RA is unable to maintain the relay armature picked up and the armature releases and contact 31 interrupts the supply of energy to the winding 32 of relay RB. On deenergization of winding 32 an impulse of energy is induced in the winding 36 and is supplied therefrom to winding 38 of relay RA. The impulse of energy supplied to the winding 38 at this time is of such polarity that it decreases the flux in the relay core and thereby insures that the armature of relay RA will complete its movement to its released position.

On deenergization of the winding 32 of relay RB the armature of this relay releases and contact 35 interrupts the circuit of the device M, while contact 34 interrupts the circuit short circuiting a portion of the winding 30 of relay RA.

It will be seen that the modification shown in Fig. 3, like those shown in Figs. 1 and 2, incorporates means to render operation of a relay positive and definite. In the modification shown in Fig. 3 impulses of energy are supplied to the winding 38 of the relay RA to insure that the relay armature will complete its movement to its picked-up and released positions, while means is provided for at times short circuiting a portion of the winding 30 of the relay RA to thereby render the release and pick-up values of the relay more nearly equal than they would otherwise be.

In Fig. 4 of the drawing there is shown another form of apparatus which may be employed in place of that shown in Figs. 1 and 3.

The relay R of the modification shown in Fig. 4 is provided with a make-before-break contact which controls a circuit for supplying impulses of energy to the winding 11 of the relay, while the polarity of the energy supplied over this circuit is controlled by contacts of the auxiliary relay RB.

The equipment is shown in the condition which it assumes when the vehicle is idle or is moving at slow speed. At this time the voltage of the energy, if any, supplied by generator G is so low that too little energy is supplied to the winding 10 of relay R to pick up the contacts of this relay. Accordingly, contact 31 of relay R interrupts the circuit of relay RB so that the contacts of relay RB are released and contact 34 establishes the circuit shunting the resistance 16. Accordingly, the full voltage of any energy supplied by the generator G is supplied to winding 10 of relay R.

When the vehicle speed is increased to a predetermined rate, such as 50 miles an hour, the energy supplied by the generator G to winding 10 of relay R is effective to pick up the contacts of this relay. On picking up of the relay contacts its movable contact 40 engages contact 41 so that a circuit is established to supply energy of one polarity to the winding 11 and is traced from terminal B of a source of direct current through back contact 44 of relay RB, contacts 40—41—42 of relay R, winding 11 of relay R, and back contact 45 of relay RB to terminal C of the source. The various parts of the equipment are arranged so that the energy supplied to winding 11 of relay R at this time aids the energy in winding 10 to move the relay contacts to their picked-up positions. Accordingly, after the contacts of relay R have moved far enough towards their picked-up positions to cause contact 40 to engage contact 41 additional force is exerted on the relay contacts tending to move them to their picked-up position.

On further movement of the armature of the relay R subsequent to engagement of contact 40 with contact 41 the contact 41 is moved out of engagement with contact 42 to thereby interrupt the circuit for supplying energy to winding 11. Before this occurs, however, the relay armature will have been moved relatively close to the core of the relay so that the winding 10 exerts great force on the armature to cause the armature to complete its movement to its picked-up position, while the inertia of the armature assists in caus-

ing the armature to complete its movement to the picked-up position.

On picking up of the contacts of the relay R its contact 31 establishes the circuit for supplying energy to the winding of relay RB, but this relay has a slow pick-up characteristic so that its contacts do not pick up until after the contacts of relay R are picked up so that its contacts 41—42 interrupt the circuit of winding 11 of relay R. Accordingly, on picking up of the contacts 44 and 45 of relay RB there is no possibility that energy of reverse polarity will be supplied to the winding 11 of relay R.

In addition, on picking up of the contacts of relay RB its contact 34 interrupts the circuit shunting the resistor 16 so that this resistance is included in series with the circuit for supplying energy from the generator G to the winding 10 of relay R with the result that there is a reduction in the current in this winding. Before this reduction occurs, however, the armature of relay R has completed its movement to its picked-up position, and the reduced current in the winding 10 is effective to maintain the relay contacts picked up assuming that the train speed has not been reduced.

On picking up of the contacts of relay RB its contact 35 completes the control circuit which may be employed to perform any desired function.

On a subsequent slight reduction in the speed of the train the current supplied from the generator G through the resistance 16 to the winding 10 of relay R is ineffective to maintain the relay contacts picked up. Accordingly, the contacts of the relay release, and when they move a part of the distance towards their released position, contact 41 engages contact 42 and a circuit is established to supply energy to winding 11 of relay R. The energy supplied to this winding at this time is of the opposite polarity from that supplied to the winding on picking up of the relay contacts since at this time the contacts of relay RB are picked up. The circuit for supplying energy to the winding 11 is traced from terminal B through front contact 45 of relay RB, winding 11 of relay R, contacts 42—41—40 of relay R, and front contact 44 of relay RB to terminal C of the source.

The energy supplied to the winding 11 at this time is of such polarity that the force exerted by winding 11 opposes that exerted by winding 10 so that on energization of winding 11 there is a substantial reduction in the force exerted on the armature to hold it picked up and the biasing means causes the armature to move all of the way to its released position.

On further movement of the relay armature towards its released position subsequent to engagement of contact 41 with contact 42, contact 40 becomes disengaged from contact 41 and interrupts the circuit of the winding 11. Before this occurs, however, the relay armature will have moved substantially all of the way to its released position so that the air gap between the armature and core is increased to such an extent that the winding 10 exerts reduced force on the armature, while the inertia of the armature assists in causing the armature to complete its movement to its released position.

On release of the contacts of relay R its contact 31 interrupts the circuit of relay RB so that the contacts of this relay release. This relay is of a type the contacts of which are slow to release so that its contacts remain picked up until the contacts of relay R have moved far enough towards their released position for contact 40 to become disengaged from contact 41 and thereby interrupt the circuit of winding 11 of relay R.

On release of the contacts of relay RB contact 34 establishes the circuit shunting the resistor 16 so that there is an increase in the current supplied to winding 10 of relay R, but this is insufficient to pick up the relay contacts assuming the train speed to have remained constant.

In addition, on release of the contacts of relay RB contact 35 interrupts the control circuit.

From the foregoing it will be seen that this modification provides means effective on movement of the contacts of the principal relay R towards either position to supply to the winding 11 of the relay a momentary impulse of energy of such polarity as to assist movement of the armature. This energy overcomes the effect of the changes in the force exerted on the armature by the contact springs and insures that the relay armature will complete its movement to either position.

In Fig. 5 of the drawing there is shown another modification which I may employ. This modification employs a condenser Q which is connected in series with the winding 11 of the relay R.

When the vehicle is standing still or is traveling at a low speed, the energy supplied from the generator G to the winding 10 of relay R is ineffective to pick up the relay contacts. Accordingly, the contacts of relay R are released and contact 15 establishes the circuit shunting the resistor R, while contact 19 interrupts the control circuit.

At this time condenser Q is charged over the circuit which is traced from terminal B of a source of direct current through back contact 47 of relay R to one element of the condenser, and from the other element of the condenser through the winding 11 of relay R and back contact 48 of relay R to terminal C. The condenser Q prevents flow of direct current in this circuit so that winding 11 does not exert any force on the relay armature.

On a predetermined increase in the train speed the energy supplied from the generator G to the winding 10 is increased to a value effective to pick up the relay contacts. On this movement of the relay contacts the circuit traced above for charging the condenser Q is interrupted and a circuit is established to supply energy of the opposite polarity to the condenser. This circuit is traced from terminal B through front contact 48 of relay R, and winding 11 of the relay to one element of the condenser, and from the other element of the condenser through front contact 47 of relay R to terminal C.

On establishment of this circuit energy flows through the winding 11 of relay R as a result of the discharge of the energy previously stored in the condenser and as a result of charging up of the condenser with energy of the opposite polarity. This flow of energy is of momentary duration only and ceases when the condenser is charged.

The various parts of the equipment are arranged so that the energy which flows in the winding 11 at this time flows in such direction that the force exerted by winding 11 on the relay armature assists that exerted by winding 10 to pick up the relay armature. Accordingly, the relay armature moves all of the way to its picked-up position, and thereafter remains in that position although contact 15 interrupts the

circuit shunting the resistor 16 so that less energy is supplied to the winding 10.

When the contacts of relay R are picked up, contact 19 establishes the control circuit.

On a subsequent reduction in train speed the energy supplied to winding 10 through the resistance 16 is too low in value to maintain the relay contacts picked up. On release of the contacts 47 and 48 the circuit traced above for supplying energy to the condenser Q is interrupted and a circuit including back contacts 47 and 48 is established to supply energy of the opposite polarity to the condenser. Accordingly, energy flows through the winding 11 of relay R both as a result of discharge of the condenser and of charging of the condenser with energy of the opposite polarity. The energy flowing through the winding 11 of relay R is of such polarity that the force exerted by the winding on the relay armature opposes that exerted by winding 13 and the armature completes its movement to its released position even though contact 15 establishes the circuit shunting the resistor 16 so that there is an increase in the current supplied to the winding 10.

It will be seen, therefore, that the modification shown in Fig. 5, like the other modifications, operates so that on movement of the relay contacts towards either of their positions there is supplied to a winding of the relay a momentary impulse of energy of such polarity as to insure movement of the relay armature all of the way to that position.

While the invention has been illustrated and described in connection with speed responsive means and with a track circuit, the invention is not limited to use in these fields and may be employed wherever it is desired to have a relay operate positively when energized with current of variable voltage.

Although I have herein shown and described only five forms of relay systems embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a relay, means for supplying to a winding of said relay energy which at one time is of a value high enough to effect movement of the relay contacts from their released to their picked-up positions and at another time is of a value too low to maintain the relay contacts picked up, a first and a second winding inductively coupled together, means for supplying energy from said second winding to a winding of said relay, a source of direct current, and a circuit controlled by a contact of said relay for supplying energy from said source to said first winding, whereby on movement of the relay contacts from one of their positions to the other there is a change in energization of said first winding and an impulse of energy is induced in said second winding and is supplied therefrom to said relay winding, the equipment being arranged so that on movement of the relay contacts towards either of their two positions the impulse of energy supplied to the relay winding from said second winding is of such polarity as to assist movement of the relay contacts to such position.

2. In combination, a relay having a winding and having an armature which when in its released position is moved to its picked-up position when said winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, means operative when said relay armature is in its picked-up position to modify the circuit of the relay winding so that when energy of said first value is supplied to said supply circuit energization of the relay winding is reduced to a degree slightly higher than that necessary to maintain the relay armature in its picked-up position, whereby when said armature is in its picked-up position it becomes released on a small reduction in the value of the current supplied to said supply circuit, a first and a second winding inductively coupled together, means for supplying energy from said second winding to a winding of said relay, a source of direct current, a circuit governed by said relay armature for supplying energy from said source to said first winding, whereby on movement of the relay armature from either of its positions to the other of its positions there is a change in energization of said first winding and an impulse of energy is induced in said second winding and is supplied therefrom to said relay winding, the equipment being arranged so that on movement of said relay armature towards either of its two positions the impulse of energy supplied to the relay winding from said second winding is of such polarity as to assist movement of the relay armature to such position to thereby insure that the relay armature will complete its movement to such position.

3. In combination, a principal relay having a winding and having an armature which when in its released position is moved to its picked-up position when said winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, an auxiliary relay having a first and a second winding, means for supplying energy from said auxiliary relay second winding to a winding of said principal relay, means operative in one position of the armature of said auxiliary relay to modify the circuit of the winding of the principal relay so that when energy of said first value is supplied to said supply circuit energization of said winding is reduced to a degree slightly higher than that necessary to maintain the relay armature picked up, whereby when said relay armature is picked up it becomes released on a small reduction in the value of the current supplied to said supply circuit, a source of direct current, and a circuit controlled by the armature of said principal relay for supplying energy from said source to said auxiliary relay first winding, whereby on a change in the position of the armature of the principal relay the armature of the auxiliary relay also changes its position, and whereby in addition on a change in the position of the armature of the principal relay an impulse of energy is induced in the auxiliary relay second winding and is supplied therefrom to a winding

of the principal relay, the equipment being arranged so that on movement of the armature of the principal relay towards either of its positions the impulse of energy supplied to the principal relay winding from said auxiliary relay second winding is of such polarity as to assist movement of the armature of said principal relay.

4. In combination, a principal relay having a first and a second winding and having an armature which when in its released position is moved to its picked-up position when said first winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay first winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, an auxiliary relay having a first and a second winding, means for supplying energy from said auxiliary relay second winding to said principal relay second winding, means operative in the first position of the armature of said auxiliary relay to modify the circuit of the first winding of the principal relay so that when energy of said first value is supplied to said supply circuit energization of said principal relay first winding is reduced to a degree slightly higher than that necessary to maintain the relay armature picked up, whereby when said auxiliary relay armature is in its first position and the principal relay armature is picked up the principal relay armature becomes released on a small reduction in the value of the current supplied to said supply circuit, a source of direct current, and a circuit controlled by said principal relay armature for supplying energy from said source to said auxiliary relay first winding, whereby on a change in the position of the armature of the principal relay the armature of the auxiliary relay also changes its position, and whereby in addition on a change in the position of the armature of the principal relay an impulse of energy is induced in the auxiliary relay second winding and is supplied therefrom to the principal relay second winding, the equipment being arranged so that on movement of the armature of the principal relay towards either of its positions the impulse of energy supplied to the principal relay second winding from said auxiliary relay second winding is of such polarity as to assist movement of the armature of said principal relay, the circuit for supplying energy to the auxiliary first winding being arranged so that when the principal relay armature is picked up the auxiliary relay armature occupies its first position.

5. In combination, a principal relay having a first and a second winding and having an armature which when in its released position is moved to its picked-up position when said first winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay first winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, an auxiliary relay having a first and a second winding, means for supplying energy from said auxiliary relay second winding to said principal relay second winding, a source of direct current, a circuit established by the principal relay armature when picked up to supply energy from said source to the first winding of the auxiliary relay, whereby on picking up of the principal relay armature the auxiliary relay armature is picked up and an impulse of energy of one polarity is induced in the auxiliary relay second winding and is supplied therefrom to the principal relay second winding and whereby on release of the principal relay armature the auxiliary relay armature releases and an impulse of energy of the opposite polarity is induced in the auxiliary relay second winding and is supplied therefrom to the principal relay second winding, the equipment being arranged so that on movement of the principal relay armature towards either of its two positions the impulse of energy supplied to the principal relay second winding from said auxiliary relay second winding is of such polarity as to assist movement of the principal relay armature to such position, and means operative when said auxiliary relay armature is picked up to modify the circuit of the principal relay first winding so that when energy of said first value is supplied to said supply circuit energization of said principal relay first winding is reduced to a degree slightly higher than is necessary to maintain the relay armature picked up, whereby said principal relay armature when picked up becomes released on a small reduction in the value of the current supplied to said supply circuit.

6. In combination, a relay having a first and a second winding and having an armature which when in its released position is moved to its picked-up position when said first winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay first winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, a device having a primary and a second winding inductively coupled together, means for supplying energy from said secondary winding to said relay second winding, a source of direct current, a circuit established by the relay armature when picked up to supply energy from said source to said device primary winding, whereby on picking up of said relay armature energy is supplied to said device primary winding and an impulse of energy of one polarity is induced in the device secondary winding and is supplied therefrom to the relay second winding, and whereby on release of said relay armature the supply of energy to the device primary winding is interrupted and an impulse of energy of the opposite polarity is induced in said secondary winding and is supplied therefrom to the relay second winding, the equipment being arranged so that on movement of the relay armature towards either of its two positions the impulse of energy supplied to the relay second winding from said device secondary winding is of such polarity as to assist movement of the relay armature to such position, and means operative when said relay armature is picked up to modify the circuit of the relay first winding so that when energy of said first value is supplied to said supply circuit energization of said relay first winding is reduced to a degree slightly higher than is necessary to maintain the relay armature picked up, whereby said relay armature when picked up becomes released on a

small reduction in the value of the current supplied to said supply circuit.

7. In combination, a relay having a first and a second winding and having an armature which when in its released position is moved to its picked-up position when said first winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay first winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, a device having a primary and a secondary winding inductively coupled together, means for supplying energy from said device secondary winding to said relay second winding, a source of direct current, a circuit established in one position of the relay armature for supplying energy from said source to said device primary winding, whereby on a change in the position of said relay armature energization of said device primary winding is varied and an impulse of energy is induced in said device secondary winding and is supplied therefrom to the relay second winding, the equipment being arranged so that on movement of the relay armature towards either of its two positions the impulse of energy supplied to the relay second winding from said device secondary winding is of such polarity as to assist movement of the relay armature to such position, and means operative when said relay armature is picked up to modify the circuit of the relay first winding so that when energy of said first value is supplied to said supply circuit energization of said relay first winding is reduced to a degree slightly higher than is necessary to maintain the relay armature picked up, whereby said relay armature when picked up becomes released on a small reduction in the value of the current supplied to said supply circuit.

8. In combination, a principal relay having a core and having a first and a second winding mounted on said core, said relay also having an armature which is moved from its released to its picked-up position when the flux density in the relay core is increased to the value present when energy of a predetermined value is supplied to the relay first winding, a supply circuit over which energy may be supplied to said relay first winding, means for supplying to said supply circuit energy which at one time is of said predetermined value and at other times is of a second or lower value, an auxiliary relay having a first and a second winding, means for supplying energy from said auxiliary relay second winding to the principal relay second winding, a source of direct current, a circuit established in the picked-up position of the armature of the principal relay for supplying energy from said source to the auxiliary relay first winding, whereby on picking up of the principal relay armature energy is supplied to the auxiliary relay first winding and the armature of said relay picks up and in addition an impulse of energy is induced in the auxiliary relay second winding and is supplied therefrom to the principal relay second winding, and whereby on release of the armature of the principal relay the supply of energy to the auxiliary relay first winding is interrupted and the auxiliary relay armature releases while an impulse of energy is induced in the auxiliary relay second winding and is supplied therefrom to the principal relay second winding, the equipment being arranged so that the impulse of energy supplied to the principal relay second winding on picking up of the principal relay armature increases the flux in the relay core and so that the impulse of energy supplied to the principal relay second winding decreases the flux in the relay core, whereby movement of the relay armature to each of its positions is rendered positive, and means operative when the armature of said auxiliary relay is picked up to modify the circuit of the principal relay first winding so that when energy of said first value is supplied to said supply circuit energization of said relay first winding is reduced to a degree slightly higher than is necessary to maintain the relay armature picked up, whereby said relay armature when picked up becomes released on a small reduction in the value of the current supplied to said supply circuit.

9. In combination, a relay, means for supplying to a winding of said relay energy which at one time is of a value high enough to effect movement of the relay contacts from their released to their picked-up positions and at another time is of a value too low to maintain the relay contacts picked up, a first and a second winding inductively coupled together, means for supplying energy from said second winding to a winding of said relay, a source of direct current, and a circuit established on picking up of the contacts of said relay for supplying energy from said source to said first winding, whereby on picking up or releasing of said relay contacts there is a change in energization of said first winding and an impulse of energy is induced in said second winding and is supplied therefrom to a winding of said relay, the equipment being arranged so that the impulse of energy supplied to the relay winding on movement of the relay contacts towards either of their positions is of such polarity as to assist movement of the relay contacts to such position.

10. In combination, a relay having a first and a second winding, means for supplying to said relay first winding energy which at one time is of a value high enough to effect movement of the relay contacts from their released to their picked-up positions and at another time is of a value too low to maintain the relay contacts picked up, a device having a primary and a secondary winding inductively coupled together, means for supplying energy from said device secondary winding to the relay second winding, a source of direct current, and a circuit established on picking up of said relay contacts for supplying energy from said source to said device primary winding, whereby on picking up or releasing of said relay contacts there is a change in energization of said device primary winding and an impulse of energy is induced in the secondary winding of said device and is supplied therefrom to the second winding of said relay, the equipment being arranged so that the impulse of energy supplied to the relay second winding on movement of the relay contacts towards either of their positions is of such polarity as to assist movement of the relay contacts to such position.

11. In combination, a principal relay having a first and a second winding, an auxiliary relay having a first and a second winding, means for supplying to said principal relay first winding energy which at one time is of a value high enough to effect movement of the relay contacts from their released to their picked-up po-

sitions and at another time is of a value too low to maintain the relay contacts picked up, means for supplying energy from the auxiliary relay second winding to the principal relay second winding, a source of direct current, a circuit established on picking up of the contacts of the principal relay for supplying energy from said source to the first winding of the auxiliary relay, whereby on picking up or releasing of the contacts of the principal relay there is a change in energization of the first winding of the auxiliary relay and an impulse of energy is induced in the second winding of said auxiliary relay and is supplied therefrom to the second winding of the principal relay, and whereby on a change in the position of the contacts of the principal relay there is a corresponding change in the position of the contacts of the auxiliary relay, the equipment being arranged so that the impulse of energy supplied to the principal relay second winding on movement of the contacts of said relay towards either of their positions is of such polarity as to assist movement of the relay contacts to such position, and a control circuit governed by a contact of said auxiliary relay.

12. In combination, a principal relay having a first and a second winding, an auxiliary relay having a first and a second winding, means for supplying to said principal relay first winding energy which at one time is of a value high enough to effect movement of the relay contacts from their released to their picked-up positions and at another time is of a value too low to maintain the relay contacts picked up, means for supplying energy from the auxiliary relay second winding to the principal relay second winding, a source of direct current, a circuit established in one position of the contacts of said principal relay for supplying energy from said source to the first winding of said auxiliary relay, whereby a change in the position of the principal relay contacts is accompanied by a change in the position of the auxiliary relay contacts, and whereby on a change in the position of the contacts of the principal relay an impulse of energy is induced in the auxiliary relay second winding and is supplied therefrom to the principal relay second winding, the equipment being arranged so that the impulse of energy supplied to the principal relay second winding on movement of the contacts of said relay towards either of their positions is of such polarity as to assist movement of the relay contacts to such position, and a control circuit governed by a contact of said auxiliary relay.

13. In combination, a relay having a winding and having an armature which when in its released position is moved to its picked-up position when said winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, means operative when the relay armature is in its picked-up position to modify the circuit of the relay winding so that when energy of the first value is supplied to said supply circuit energization of the relay winding is reduced to a degree slightly higher than that necessary to maintain the relay armature in its picked-up position, whereby when said armature is in its picked-up position it becomes released on a small reduction in the value of the current supplied to said supply circuit, and means responsive to movement of said relay armature towards either of its positions for momentarily supplying energy to a winding of said relay, said means being arranged so that on movement of the relay armature towards its picked-up position the energy supplied to the relay winding is of a polarity effective to assist movement of the relay armature to its picked-up position and so that on movement of the relay armature towards its released position the energy supplied to the relay winding is of a polarity effective to assist movement of the relay armature to its released position.

14. In combination, a relay having a first and a second winding and having an armature which when in its released position is moved to its picked-up position when said relay first winding is energized to a predetermined degree, a supply circuit over which energy may be supplied to said relay first winding, means for supplying to said supply circuit energy which at one time is of a first value and is effective to energize said relay winding to said predetermined degree and which at other times is of a second or lower value and is ineffective to energize said relay winding to said predetermined degree, means operative when the relay armature is in its picked-up position to modify the circuit of the relay first winding so that when energy of the first value is supplied to said supply circuit energization of the relay first winding is reduced to a degree slightly higher than that necessary to maintain the relay armature in its picked-up position, whereby when said relay armature is in its picked-up position it becomes released on a small reduction in the value of the current supplied to said supply circuit, and means responsive to movement of said relay armature towards either of its positions for momentarily supplying energy to the relay second winding, said means being arranged so that on movement of the relay armature towards its picked-up position the energy supplied to the relay second winding is of a polarity effective to assist movement of the relay armature to its picked-up position and so that on movement of the relay armature towards its released position the energy supplied to the relay second winding is of a polarity effective to assist movement of the relay armature to its released position.

15. In combination, a circuit having a variable voltage impressed thereon, a relay having a first winding on which the voltage of said circuit is impressed, a second winding, and an armature, said first winding being effective in response to an increase in the voltage of said circuit above a certain value for causing the actuation of the armature from its dropped-out position toward its picked-up position; means effective in response to the actuation of the armature to its picked-up position to reduce the effectiveness of the first winding whereby to cause the armature to be dropped-out at substantially the same circuit voltage as that at which it is picked-up; and means for stabilizing the operation of the armature including means for momentarily energizing the said second winding of the relay when the armature is actuated to its picked-up position or restored to its dropped-out position in a manner to insure the retention of the armature in the position into which it is last moved.

ANDREW J. SORENSEN.