Oct. 25, 1927. 1,646,956

J. ERICKSON

ELECTROMAGNETIC RELAY

Filed Oct. 25, 1920

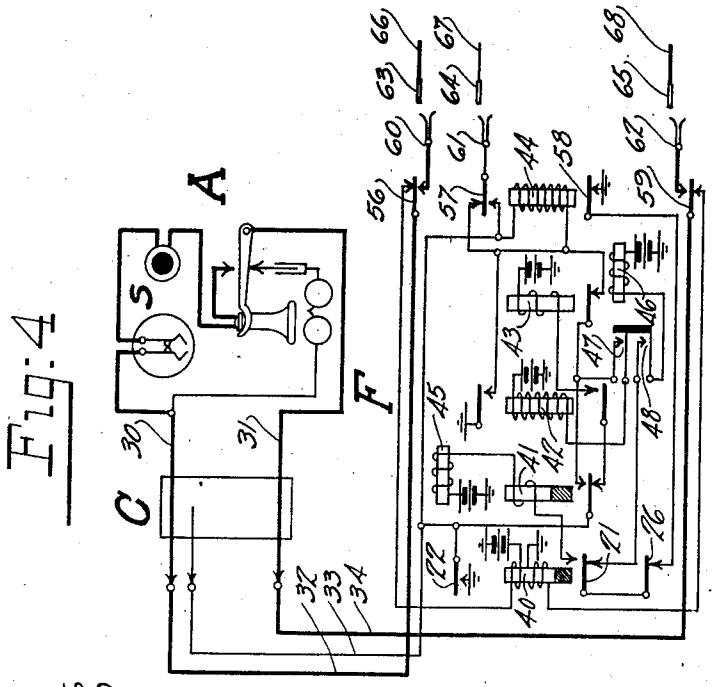


Fig: 4

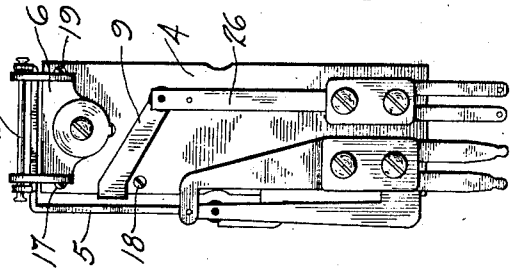


Fig: 2

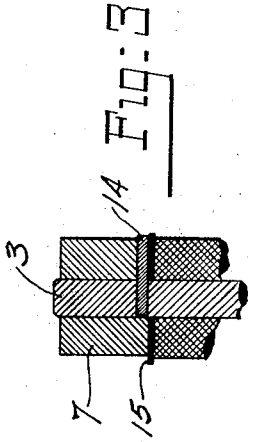


Fig: 3

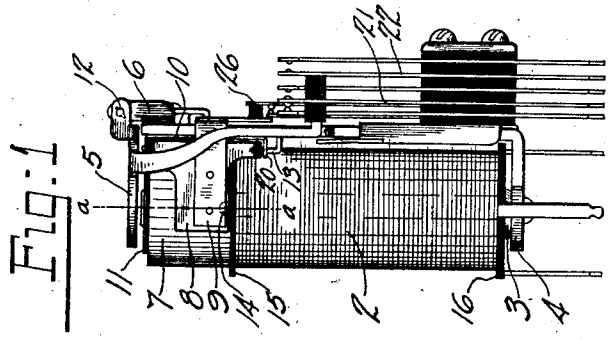


Fig: 1

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UNITED STATES PATENT OFFICE.

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ELECTROMAGNETIC RELAY.

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The present invention relates in general to electromagnetic relays, and the object of the invention is to provide a relay having two armatures, one of which will respond quickly when the relay circuit is opened or closed, while the other armature has a retarded characteristic and will respond slowly under the same circumstances.

Combination quick and slow relays have been made before this and especially for use in the circuit of the well known Strowger two wire switch which is employed in automatic telephone systems. The circuit of this switch uses a quick relay energized over the line, and a slow relay whose circuit is closed by the quick relay for controlling the release of the switch in its off normal position. The switch is operated by producing a series of rapidly recurring interruptions in the line circuit to which the quick acting relay responds by sending impulses to the operating magnet. The slow acting relay, however, does not fall back when its circuit is momentarily broken and thus the switch is prevented from releasing. If the line circuit is permanently opened then the slow relay falls back shortly after the line relay has deenergized and the switch is released.

Former attempts to combine the functions of these two relays in one structure have not been very successful, because the methods followed produced merely a combined quick and slow relay, that is, one which is more properly an aggregation, and in which the quick and slow acting armatures act independently and are made to operate by the same independent means, and in the same way as if they were parts of separate and distinct relay structures. The invention herein described provides a relay having quick and slow acting armatures and magnetic circuits so designed that a single copper ring effects the magnetic circuit of both armatures, and causes one armature to respond slowly when the relay circuit is opened or closed, while the other armature is caused to respond quickly.

The preferred construction of this new relay and its operation will be described fully hereinafter, reference being had to the accompanying drawing, in which Figs. 1 and 2 show side and rear views of the relays, respectively, Fig. 3 is a section through the core of the relay on the line *a*—*a*, Fig. 1, while Fig. 4 is a circuit diagram of the control circuit of an automatic switch in which the relay is employed.

Referring first to Figs. 1 and 2, the soft iron core 3 is secured to the heel piece 4 by means of a machine screw. The heel piece is bent at right angles as shown in the drawing and the vertical portion thereof carries at the upper end a bracket 6 to which the armature 5 is pivoted by means of the rod 12. The armature 5 is the slow acting armature and controls contact springs 21 and 22 in an obvious manner.

The winding space is indicated by the reference character 2. As shown in the drawing the relay has four terminals and there may be, therefore, two separate windings, both of which are inclosed within the insulating disks 15 and 16. The space above the disk 15 is occupied by the heavy copper ring or slug 7.

The quick acting armature is indicated by the reference character 8. The means for pivotally supporting this armature consists of a bracket 10 made of heavy sheet brass and secured to the heel piece 4 by means of screws 17, 18, and 19. On top the bracket 10 is the same width as the heel piece 4 and is bent at right angles, the extension 11 thus formed having a central hole through which the end of the core 3 projects. The bracket 10 thus serves to hold the end of the core 3 rigidly in position, without however shunting any of the magnetic flux away from the armature 5, for the said bracket is of non-magnetic material. That portion of the bracket 10 which lies against the heel piece 4 may be cut away diagonally so that at the lower end of the bracket the material is just wide enough to form a right angled extension 20. The rod 13 on which armature 8 is pivoted passes up through corresponding holes drilled in extensions 20 and 11. The arm 9 is attached to the armature 8 by means of rivets and is bent at right angles a short distance from the armature, passing to the rear of the heel piece 4 where it controls the contact spring 26. It may be stated that the armature 8 and the associated parts are of somewhat lighter material than is the armature 5 and its attachments.

In order to provide a magnetic circuit for the armature 8, the copper slug 7 and the core are drilled to receive the soft iron pin

14. The end of this pin lies beneath the armature 8 as shown in dotted lines in Fig. 1. The sectional view, Fig. 3, shows the relation between the pin 14, the core 3, and the copper slug 7 very clearly. It will be observed that the hole which is drilled through the copper slug 7 cuts the edge of the slug so that the pin 14 is in contact with the disk 15 and is not surrounded by copper.

The operation of the relay is best described by referring to circuit diagram, Fig. 4. In this figure the reference character A indicates an automatic telephone substation, of well known type, whose line conductors 30 and 31 terminate at a central exchange in an individual line or trunk selecting switch, indicated by the reference character C. The line switch C may be any well known type of trunk selector which is in common use and its function is to extend the line of substation A when the receiver is removed to a trunk line terminating in an idle first selector switch. One of the trunk lines to which the line switch C has access comprises conductors 32, 33, and 34 and extends to the first selector F. This latter switch is of the well known Strowger vertical and rotary type and is operable by the calling subscriber to select and connect with a trunk line extending to a desired main group of subscribers' lines. These arrangements may be readily understood by referring to the book entitled Automatic Telephony, by Smith and Campbell, published by the McGraw-Hill Book Company in 1914.

A selector switch of the type described is usually provided with a quick acting line relay and a slow acting release relay through the medium of which the operation and the release of the selector are controlled, but in the case of the selector F these two relays are replaced by a single combination quick and slow relay constructed as shown in Figs. 1 and 2. The operation of this relay may now be explained by describing the operations which take place when the selector F is operated by the calling subscriber to establish a connection.

For this purpose it will be assumed that the subscriber at sub-station A removes his receiver preparatory to making a call. When the receiver is removed the individual line switch C is operated to extend the calling line to an idle trunk line, and it will be assumed that the trunk line taken for use is the trunk line comprising conductors 32, 33, and 34. When the line conductors 30 and 31 are extended into connection with trunk line conductors 32 and 34, respectively, a circuit is completed for relay 40 of the selector switch, this being the combination quick and slow relay which is the subject matter of the invention. When the circuit is completed armatures 21, 22, and 26, corresponding to the same numbered contact springs in Fig. 1, are attracted and at armature 22 a holding circuit is established over the release trunk conductor 33 for the individual line switch C, whereby the line switch is maintained in operated position throughout the duration of the connection. At armature 21 a circuit is prepared for the vertical magnet 45, and it is to be noted that this circuit is opened at the break contact of armature 26 before it is closed at the make contact of armature 21.

The calling subscriber may now operate his calling device S in accordance with the first digit in the desired number. As a result, a series of short interruptions are produced in the line circuit over which the relay 40 is energized. In response to these interruptions relay 40 retracts its armature 26 a plurality of times, corresponding to the number of interruptions produced, but does not retract its armatures 21 and 22. At each retraction of armature 26 an impulse of current is transmitted through the vertical magnet 45 in series with the slow acting relay 41, and the vertical magnet is accordingly operated to raise the switch shaft step by step until wipers 60—62, inclusive, stand opposite the desired level of bank contacts. The slow acting relay 41 is energized in series with the vertical magnet and retains its armature in operated position throughout the vertical movement of the switch. At the first upward movement of the switch shaft the off normal springs are shifted into their closed position and since relay 41 is now operated a circuit is completed through the upper pair of off normal springs 47 for the stepping relay 42. Upon energizing, relay 42 establishes a locking circuit for itself at its upper armature and at its lower armature prepares a circuit for the rotary magnet 43. At the end of the vertical movement of the switch and after the impulses to the vertical magnet have ceased the slow acting relay 41 will fall back and the previously prepared circuit of the rotary magnet 43 is completed. The rotary magnet 43 is, therefore, operated and the switch wipers are rotated into engagement with the first set of bank contacts in the selected level. In operating the rotary magnet breaks the locking circuit of the stepping relay 42 and the said relay is accordingly deenergized and breaks the circuit of the rotary magnet, which then deenergizes also. The operation now depends upon whether or not the trunk line terminating in the first set of bank contacts is busy or idle. If this trunk line is busy there will be a ground potential on the test contact engaged by the test wiper 61, and a circuit will be completed by way of the said test wiper, armature 57 and its resting contact, interrupter contact of the rotary magnet 43, off normal springs 47, and the winding of the stepping relay 42 to bat-

tery. Relay 42 is, therefore, again operated, the circuit of the rotary magnet 43 is again completed, and the wipers are advanced into engagement with the next set of bank contacts. This operation is repeated as long as the test wiper 61 continues to engage grounded test contacts. As soon as an idle trunk line is found, which we will assume to be the trunk line terminating in bank contacts 63, 64, and 65, test wiper 61 will find no ground potential on the test contact 64, the stepping relay 42, therefore, will not again be energized, and the rotation of the switch will cease. The switching relay 44, which up to this time has been short circuited, is now energized in series with the stepping relay 42, and since the said switching relay is of very high resistance the stepping relay is not operated. Upon energizing, relay 44 connects the grounded release trunk conductor 33 to the test wiper 61 in order to make the selected trunk line busy, and at its armatures 56 and 59 extends the incoming trunk conductors 32 and 34 by way of the working contacts of the said armatures, wipers 60 and 62, bank contacts 63 and 65, and trunk line conductors 66 and 68 to the line relay of the next switch in the series, which may be another selector switch similar to the selector F, or a connector switch of the type which is adapted to complete the connection to the desired called line. In any case, the line relay of the succeeding switch is energized over the line circuit and ground is placed on the release trunk conductor 67, thereby establishing a holding circuit for the switching relay 44 of the selector F and for the line switch C.

When the trunk conductors 32 and 34 are extended to the next switch by the operation of the switching relay 44 the circuit of the combination quick and slow relay 40 is broken and the said relay retracts all its armatures, armatures 22 and 21, however, not being retracted until after the holding circuit is completed over conductor 67. Although the circuit of the release magnet 46 was prepared at off normal springs 48 when the selector was operated vertically, this circuit is not closed by the retraction of armatures 21 and 26 of relay 40 because switching relay 44 has opened the circuit at another point, at armature 58.

The calling subscriber will now operate his calling device in accordance with the remaining digits in the number and the connection is completed in the manner well known to persons familiar with automatic telephone systems. When the subscribers are through talking they will hang up their receivers, and the replacement of the receiver at the calling substation A causes certain relays to be deenergized in the final connector switch with the result that ground is removed from the release trunk conductor 67. The switching relay 44 now retracts its armature and at armature 58 completes the circuit of the release magnet 46, whereupon the selector F is returned to its normal position. The line switch C is also restored by the removal of ground from conductor 33 and all the apparatus will now be in its normal position.

The above describes the normal operation of the selector during the establishment and release of a complete connection. It is noted that during the time the selector F is operating and after the off normal springs 48 have closed the release is controlled by the continued retention of armatures 21 and 22. Should the line circuit be permanently opened before the switching relay 44 is operated, these armatures will be retracted after an instant and since the switching relay 44 has not yet been energized the circuit of release magnet 46 will be closed and the switch will be restored to normal position.

Having described the operation of the relay in certain particular circuits in which it may be used it will be well now to consider the operation of the relay itself a little more in detail, with particular reference to the magnetic circuits and the time constants of the quick and slow armatures. Referring to Fig. 1 now also, as well as to the circuit diagram, when the circuit of the relay is closed the resulting current flow tends to set up a flux in the magnetic circuit which includes the core 3, armature 5, and heel piece 4. As the magnetic lines in this circuit build up, currents are induced in the copper ring 7 and these currents oppose the building up of the field with the result that armature 5 is given a retarded characteristic and is slow to pull up. The magnetic circuit described above may be termed the main circuit and it will include most of the lines of force set up. There is another circuit, however, which includes the lower portion of the core 3, the pin 14, the quick acting armature 8, and the heel piece 4. This magnetic circuit may be termed the auxiliary circuit and since no portion of it is surrounded by a short circuited winding, like the copper ring 7, the lines of force will build up rapidly, and armature 8 will be instantly attracted when the relay circuit is closed. The pin 14, however, is small in cross section relative to the core 3 and can carry only a small percentage of the total lines of force set up, so that eventually the major part of the lines of force will follow the main magnetic circuit and armature 5 will be attracted. To sum up the operations so far, when the circuit of the relay is closed, the lines of force are built up rapidly in the auxiliary magnetic circuit and the armature 8 is quickly attracted, while building up of the lines of force in the main circuit is opposed by the currents induced in the copper ring 7 and the arma-

ture 5 is attracted only after a short interval. It should be stated at this point that the direction of the magnetic lines in the core 3 is assumed to be upward, and in the pin 14 outward from the core to the armature 8.

Assume now that the circuit of the relay is broken. When this occurs the lines of force in both the main and auxiliary magnetic circuits will begin to contract, and since as before stated there is no short circuited winding or copper slug inductively related to the auxiliary magnetic circuit, there is nothing to oppose the collapse of the magnetic field in this circuit, and armature 8 will be quickly retracted. This will evidently be true without considering the other magnetic circuit at all, but as will appear shortly the retraction of armature 8 is accelerated by currents generated in the copper ring 7. This may be explained by considering what occurs in the main magnetic circuit when the relay circuit is broken. As the field in the main magnetic circuit begins to collapse, currents are induced in the copper ring 7 which oppose the dying out of the field and which tend to maintain the lines of force in their original direction, which is upward through the core 3, through the armature 5, and back to the lower end of the core 3 by way of the heel piece 4. A second auxiliary magnetic circuit may now be traced through the upper portion of the core 3, through the armature 5, heel piece 4, armature 8, and through the pin 14, back to the core 3. The currents induced in the copper ring 7 tend to set up lines of force in this second auxiliary circuit and it will be evident that there is a tendency to reverse the direction of the lines of force in the armature 8 and in the pin 14. Before the relay circuit is broken the lines of force through the pin 14, and armature 8, pass from the core outward through the pin and through the armature to the heel piece, whereas when the circuit of the relay is broken the induced current in the copper ring 7 tends to set up lines of force passing from the heel piece through the armature and through the pin 14 to the core. In short, when the relay circuit is broken the current induced in the copper ring 7 tends to reverse the magnetism in the pin 14, the original field is caused to die out faster than would ordinarily be the case, and armature 8 is retracted quicker than would be the case with an ordinary relay armature. If the circuit of the relay is again closed before the effects of the copper ring 7 have died out armature 5 will be continuously held up, while armature 8 will again be attracted. Armature 5 will not respond to momentary interruptions of the circuit, if the relay circuit is interrupted momentarily a plurality of times, as by a substation calling device for example, but will remain continuously in operated position, while armature 8 will respond in accordance with the interruptions in the relay circuit. These are the operations which have been described in the case of relay 40 of the selector F.

It will be seen that this invention provides a combination quick and slow relay in which the same means which causes one armature to be slow acting also causes the other armature to be quick acting. A combination relay is thus produced in which the quick acting armature actually performs its functions better than it would if the two armatures of the relay were entirely separate, that is, the quick acting armature in the combination relay herein described responds quicker to the opening and closing of the relay circuit than will the armature of an ordinary quick acting relay. The advantage of using a relay of this type in a selector circuit such as the one herein shown will now be clear. There is not only a saving in first cost in the substitution of one relay for two, but the combination relay actually works better than the separate relays used heretofore.

Having fully described and ascertained the features and aspects of my invention, what I consider to be new and desire to have protected by Letters Patent will be pointed out in the appended claims.

What I claim is:

1. A relay having an electrical circuit, an armature for said relay, a magnetic circuit including said armature and effective to move said armature when said electrical circuit is closed, a second electrical circuit in which a current is induced when the relay circuit is broken, and an auxiliary magnetic circuit including said armature in which the induced current tends to set up a flux in opposition to the flux in said first magnetic circuit, for accelerating the release of said armature.

2. A relay having a circuit, two armatures for said relay, and a single means affecting both armatures when the relay circuit is broken to render one of said armatures quick acting and the other slow acting.

3. A relay having a circuit, two armatures for said relay, and a second circuit for said relay affecting both armatures when the first circuit is broken to render one of said armatures quick acting and the other slow acting.

4. A relay having a circuit, two armatures therefor, a conductive ring on the core of said relay so positioned relative to the magnetic circuits through said armatures that the current induced in said ring when the relay circuit is broken causes one of said armatures to respond quickly and the other slowly.

5. A relay having an electrical circuit, two armatures therefor, one quick acting and the other slow acting, magnetic circuits including said armatures, respectively, and a second closed electrical circuit for said relay effective when the first circuit is broken to

maintain the flux in the circuit of the slow acting armature and decrease the flux in the circuit of the quick acting armature.

6. A relay having a circuit, two armatures therefor, one quick acting and the other slow acting, magnetic circuits including said armatures, respectively, and a copper ring so positioned relative to the two magnetic circuits that when the relay circuit is broken the induced current in the said ring tends to maintain the flux in the circuit of the slow acting armature and tends to decrease the flux in the circuit of the quick acting armature.

7. A relay having a circuit, two armatures therefor, one quick acting and the other slow acting, magnetic circuits including said armatures, respectively, and means effective when the relay circuit is broken to oppose the decrease in flux in the circuit of the slow acting armature and to assist the decrease in the flux in the circuit of the quick acting armature.

8. A relay having a circuit, an armature therefor, a magnetic circuit for said armature, and means for accelerating the building up of the lines of force in said magnetic circuit when the relay circuit is closed.

9. A relay having a circuit, two armatures therefor, and means affecting both armatures when the relay circuit is closed to render one armature quick acting and the other armature slow acting.

10. In a relay, an electro-magnet having a winding, two armatures for said relay, means for causing said electro-magnet to excite said armatures and for permitting said armatures to restore, and means for delaying the restoring operation of one of said armatures for a definite period after the restoration of the other armature, said means also effective to accelerate the restoration of the other armature.

11. In a relay, a magnet having two armatures, a core for said magnet having a copper sleeve on one end thereof, a magnetic circuit for one of said armatures including said core and said copper sleeve and effective to move said armature with delay, a magnetic circuit for the other armature independent of said sleeve and effective to move said other armature without delay.

12. In a relay, a magnet having two armatures, a core for said magnet having a copper sleeve on one end thereof, a magnetic circuit for one of said armatures including said core and said copper sleeve and a magnetic circuit for the other armature independent of said sleeve, said magnetic circuits so related that said sleeve causes the magnetic flux to lag in said first circuit and accelerates changes in the flux in the other circuit.

13. In a relay, a magnet having two armatures, a magnetic circuit for the magnet having two parallel paths, means for causing magnetic flux to flow over said circuit, and means in one of said paths for setting up a counter magnetic flux in said path which opposes any change of flux in the main circuit and assists the changes of flux in the other path, to move one of said armatures quicker than the other armature.

14. In a relay, a magnet, a core for said magnet having two poles at one end and one at the other, a pair of armatures for said relay, each engaging one of the two poles at one end of the core, a copper slug on said core between said two poles, said slug acting on the magnetic flux in one pole to make one armature slow acting and to sharpen the changes of flux in the other pole to make the other armature quick acting.

15. A relay having two armatures, means for operating and releasing said armatures, and means comprising a copper slug for causing the release of one of said armatures to be accelerated and for causing the release of the other armature to be slightly delayed.

Signed by me at Chicago, Cook County, Illinois, this 22d day of October, 1920.

JOHN ERICKSON.