Dec. 6, 1927.

1,651,684

J. ERICKSON

ELECTROMAGNETIC RELAY

Filed May 6, 1920

2 Sheets-Sheet 1

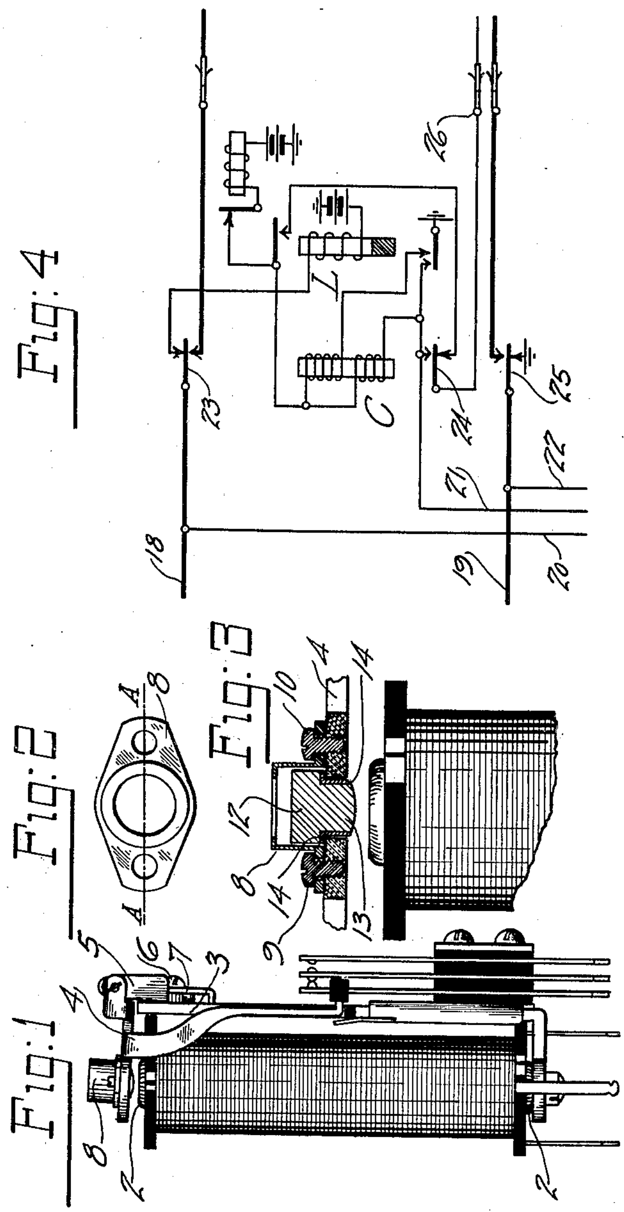

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Fig. 7

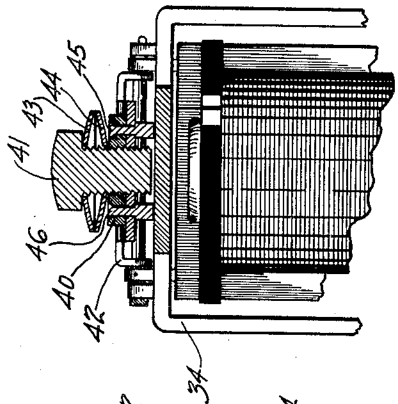


Fig. 6

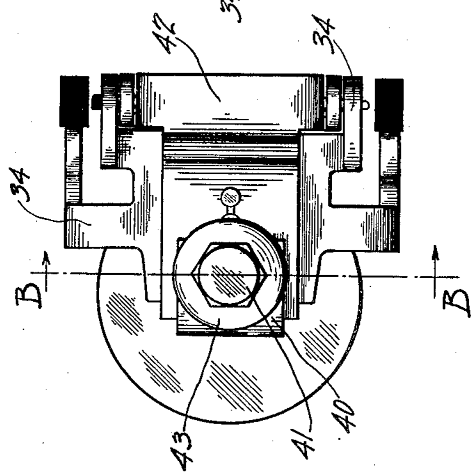
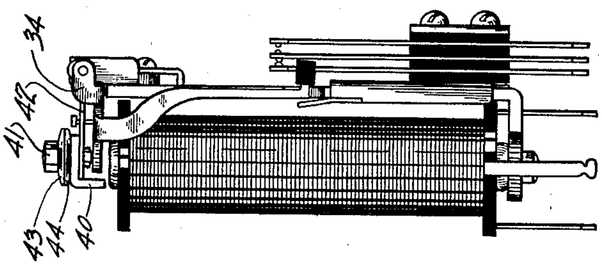


Fig. 5



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Patented Dec. 6, 1927. **1,651,684**

UNITED STATES PATENT OFFICE.

JOHN ERICKSON, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE.

ELECTROMAGNETIC RELAY.

Application filed May 6, 1920. Serial No. 379,236.

My invention relates in general to electromagnetic relays but more particularly to such relays as are commonly known as marginal relays; and the object of the invention may be stated to be, specifically, the provision of a marginal relay having definite and permanent operating characteristics, the preferred embodiment of the invention comprising a relay operable in two stages responsive to two different current values which, because of the sharply defined operating characteristics of the relay, may fluctuate within rather wide limits without causing failure or wrong operation of the relay.

The construction and operation of my improved relay will be described fully hereinafter, reference being had to the accompanying drawings, in which Figs. 1, 2 and 3 show a simple form of the relay; Fig. 4 shows the circuit of a well known type of rotary line switch in which the new relay is used as a combination cut-off and switching relay; while Figs. 5, 6, and 7 show an improved form of the relay which is adjustable to operate on different current values.

Referring to Fig. 1 the relay may be for the most part of any preferred construction and as shown here it comprises a pair of windings which are wound on the core 2 which is supported by the heel piece 3. To the heel piece is also attached any desired combination of contact springs and also the principal armature 4. The latter is secured to the heel piece by means of a bracket 5 to which the armature is pivoted, the bracket being fastened to the heel piece by means of the machine screw 6 and washer 7. So far there is nothing new. I have provided, however, an auxiliary armature which is mounted on the principal armature and is retained in place by the cap or housing 8. A top view of this housing is shown in Fig. 2. The construction and function of the auxiliary armature can best be understood by an inspection of Fig. 3 which is a cross section on the line A—A, Fig. 2. Referring to Fig. 3, the housing 8 is made of brass or other non-magnetic metal and is secured to the principal armature 4 by means of screws 9 and 10. The auxiliary armature is a rivet shaped plug of soft iron and comprises an enlarged head portion 12 and a short body or shank 13. The shank of the auxiliary armature passes through an opening in the principal armature and extends a short distance below it as shown. A brass sleeve which is indicated by reference character 14 prevents sticking between the sides of the shank and the hole in the principal armature and also forms a small secondary gap in the magnetic circuit between the head portion 12 of the auxiliary armature and the upper surface of the principal armature.

Having described the mechanical features of the relay, I will now explain the operation thereof, and for this purpose it will be assumed that the relay is provided with a winding designed to give a maximum magnetization, being, however, connected in a circuit at the outset which contains a very high resistance. This resistance should be in the form of a rheostat in order to demonstrate the operation to advantage. When the circuit is first closed the relay is not operated on account of the high resistance. The magnetic flux set up passes for the most part through the principal armature and the auxiliary armature in series and as the resistance is gradually cut out of circuit the magnetization will gradually increase, approaching a critical point at which the attraction for the armature is sufficient to overcome the tension of the contact springs. When this critical point is reached the principal armature and the auxiliary armature are operated as a unit and are pulled down until the end of the latter armature touches the core. This closes the air gap normally existing between the auxiliary armature and the core and brings about a condition of stable equilibrium. The magnetic circuit through both armatures in series, however, is of relatively high reluctance, due to the presence of a small gap in the magnetic circuit between the armatures (brass sleeve 14) and if more resistance is cut out the leakage of magnetic flux from the principal armature direct to the core will begin to assume noticeable proportions. It will be seen that this leakage path constitutes a second magnetic circuit excluding the auxiliary armature. As more and more resistance is cut out the flux in this second magnetic circuit will continue to accumulate until eventually a second critical point is reached. When this occurs the principal armature breaks away from the head of the auxiliary armature and is pulled clear down onto the core, the auxiliary armature being pushed up into the housing until the lower end is flush with the lower surface of the principal armature. The relay is now completely operated.

It has been assumed in the above example, that the relay is provided with only one winding designed to give a maximum magnetization, being, however, connected in a circuit at the outset which contains a very high resistance. The example was chosen for the purpose of conveniently demonstrating the properties of the relay, and the effect of increased magnetization upon its operating qualities. It will be understood, of course, that the relay may be provided in practice with a plurality of windings, that is to say, with a plurality of coils, each designed to produce a certain magnetization of the relay. As a matter of fact, the relay being a two-stage relay, I have provided two windings upon the core of the relay, one winding operating initially in the low stage, and the other in the high stage of the relay. A detailed explanation of this condition will be given later on.

It will be seen that a relay constructed on the above described principles is very positive in its operation, and it is believed that such relays will be found very useful in the telephone and other arts. One of the applications which I have made of the same is shown in Fig. 4. This is a circuit diagram of a well known type of rotary line switch such as is shown and described in chapter 15 of Automatic Telephone Practice, by Harry E. Hershey. In this line switch as it is ordinarily built, there is only a single winding on the cut off relay C, connected as shown in the case of the lower winding on relay C, Fig. 4, and there is also a mechanical interlocking arrangement between the armature of the cut-off relay C and the armature of the line relay L such that if the cut off relay is energized while the line relay is at normal the armature of the cut off relay will operate only about half way, due to the aforesaid interlocking device, but if the cut-off relay is energized while the line relay is energized also, its armature will be completely operated. The mechanical connection between the two relays requires a special construction in which both relays are necessarily mounted together as a unit. This is objectionable sometimes, and I have, therefore, found it very convenient to use a relay of the type herein described as a cut-off relay, thus doing away with the mechanical locking device. In the circuit drawing, Fig. 4, the relay C may be of the type shown in Fig. 1, or of the type shown in Fig. 5 and yet to be described, and has two windings which are so wound as to give a cumulative magnetizing effect. When the line comprising conductors 18 and 19 is called, the connector switch in use connects with the normal conductors 20, 21, and 22 and places ground on the private normal conductor 21. This operation closes a circuit through the lower winding of the cut-off relay C and the said relay is operated about half way, or until the end of the auxiliary armature touches the core. In this position the contact springs 23–25, inclusive, have broken away from their normal or resting contacts but have not engaged their working contacts. In this case the relay only operates through one stage. When the line is calling, however, the line relay L is first energized over the line circuit and closes a circuit through both windings of the cut-off relay in parallel. At the same time the test wiper 26 is connected to the circuit between the cut off relay and the stepping magnet and the trunk selecting movement is initiated, both windings of the cut off relay being short circuited until an idle trunk is found. When this occurs, the cut off relay at once operates and now, since the magnetization is greatly increased by the addition of the magnetizing effect of the upper winding, the relay is completely operated and the contact springs 23–25, inclusive, are brought into engagement with their working contacts. After the line relay L falls back the armature of relay C is maintained in its final operated position by means of a holding circuit through the lower winding alone, established by way of the test wiper 26 in the usual manner. Since the relay is very positive in its operation it will work with almost any kind of windings connected as shown, but the best arrangement is to make the lower winding partly of copper and partly of German silver with a total resistance of about 1300 ohms. This results in an inefficient winding which if the relay is properly adjusted will give somewhat more than enough magnetization to operate it through the first stage but not nearly enough to operate it through the second stage. The upper winding, on the contrary, is preferably wound entirely with copper and is an efficient winding which gives perhaps twice the magnetizing effect of the lower winding. The above remarks relating to the windings of the relay apply, of course, equally to the relay shown in Fig. 1 and to that shown in Fig. 5. That is to say, each of the two relays may be provided with two windings as intimated above, the relay shown in Fig. 5 offering the additional advantage of permitting an adjustment of the magnetic circuit, as is more clearly pointed out below.

While the relay described is simple and is very satisfactory in most cases, it is desirable under certain circumstances to have a relay which is more readily adjustable to different current values. Referring to the detailed explanation of the operation herebefore given, the adjustment consists obviously in changing one or both of the "critical points." The first critical point is changed by merely changing the tension of the contact springs and is readily accomplished, but the second critical point depends on the auxiliary gap in the magnetic circuit, which in the case of the relay first described is fixed. In order to permit the adjustment of this auxiliary gap, I have designed an improved form of relay which operates according to the same principles as does the relay shown in Fig. 1, but which is considerably modified in mechanical construction in order to take care of the adjustment feature. This improved relay is shown in Figs. 5, 6, and 7. Fig. 5 is a side view showing the new construction of the auxiliary armature, Fig. 6 is an enlarged top view, while Fig. 7 is a cross section on the line B—B, Fig. 6.

The relay itself may be the same as the relay shown in Fig. 1. The principal armature 34 is the same also and is mounted in the same manner. It is not however, perforated in the center above the core, as is armature 4 of the relay shown in Fig. 1, but is cut away a trifle at the front so that it does not extend clear over the core. The auxiliary armature is of entirely new construction, and comprises a member 42 which is made of brass and is pivoted on the same rod with the principal armature, as shown clearly in Figs. 6 and 7. To the pivoted member 42 is secured an L shaped piece of soft iron 40, the two being fastened together by means of brass rivets 45 and 46. These rivets project downward as shown most clearly in Fig. 7 and rest on top of the principal armature 34. A hole is drilled clear through the iron piece 40 and the member 42, which hole is tapped to receive the hexagonal headed iron machine screw 41. This screw 41 is turned down until it almost touches the principal armature 34, and is prevented from working loose by means of spring washers 43 and 44.

Assuming now that the relay is connected in the theoretical test circuit hereinbefore described, when the current is increased and the magnetization reaches the first critical point. the armature 34 is operated and is pulled down far enough so that the soft iron piece 40 touches the core of the relay. This cuts out the main air gap leaving only the small auxiliary gap between the end of the iron screw 41 and the armature 34. The current may now be increased and nothing happens until the magnetization reaches the second critical point, when the principal armature will break away and close down on the core. It will be seen that the principle of operation is precisely the same as in the case of the relay shown in Fig. 1, the relay now being described differing from that relay, however, in that the second critical point can be readily changed as desired. This is accomplished simply by turning the screw 41 in or out, which decreases or increases the auxiliary gap to any desired extent. Thus the relay can easily be adjusted for a considerable range of current values.

Having described 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. In an electromagnetic relay, main and auxiliary armatures, said armatures being spaced apart from each other and from the core of said relay to form a gap between the said main armature and the said core, a second gap between the auxiliary armature and the said core and a third gap between the said armatures, means for magnetizing said relay, both armatures being responsive to said magnetization to close the said second gap and shorten the said first gap without altering the third, means for increasing the magnetization, the main armature being then alone responsive to close the said first gap and increase the said third gap, and means for adjusting the length of the third gap to vary the amount of increased magnetization required to fully operate said main armature.

2. In an electromagnetic relay, main and auxiliary armatures, means for energizing said relay to operate both armatures, a high reluctance magnetic circuit including both of said armatures, a leakage path including only the main armature, means for increasing the magnetization of said relay beyond the saturation point of said high reluctance circuit, the main armature being responsive to the resulting magnetic flux in said leakage path, and adjusting means for varying the reluctivity of said high reluctance magnetic circuit.

3. In an electromagnetic relay, main and auxiliary armatures, a magnetic circuit including both of said armatures, a second magnetic circuit including the main armature but excluding the auxiliary armature, means for initiallly magnetizing said relay, the resulting magnetic flux being effective to fully operate said auxiliary armature and to partially operate said main armature, means for increasing the magnetization beyond the saturation point of said first magnetic circuit to produce a magnetic flux in said second circuit effective to said main armature, and adjusting means for altering the saturation point of said first magnet circuit.

4. In a relay, a heel-piece having a core mounted thereon, main and auxiliary armatures hinged to said heel-piece, said main and auxiliary armatures included in the

magnetic circuit of the relay in series with the core and heel-piece, their armatures being spaced apart and completely separated by non-magnetic means to introduce a relatively high reluctance in the circuit, and means for varying said reluctance.

5. In a relay, a heel-piece having a core mounted thereon, main and auxiliary armatures hinged to said heel piece, said main and auxiliary armatures included in the magnetic circuit of the relay in series with said core and heel piece, said armatures being spaced apart and completely separated by a medium of high reluctivity to introduce a high reluctance gap in the circuit, and an adjusting device for bridging more or less of said gap as desired.

6. In a two-stage relay, a plurality of contact sets on said relay, a magnetic circuit closed at the end of the first stage of operation, a second magnetic circuit closed at the end of the second stage of operation, said first circuit having a lower initial reluctance than the second circuit but a higher reluctance when said circuits are closed, means controlled by said armature for operating certain of said contact sets at the end of the first stage of operation and for operating other of said contact sets at the end of said second stage of operation, an armature included in both of said circuits, and means for adjusting the closed circuit reluctance value of said first circuit.

7. In a relay, long and short stroke armatures subject to mutual magnetic attraction and operating as a unit responsive to a low degree of magnetization without altering their positions relative to each other, the long stroke armature being brought to rest in partially operated position when the short stroke armature completes its stroke, and magnetic circuits for operating said armatures as set forth and for causing the long stroke armature to complete its stroke responsive to a high degree of magnetization.

8. In a relay, long and short stroke armatures, a magnetic circuit causing mutual attraction between said armatures and between the short stroke armature and the relay core, both armatures operating simultaneously throughout the stroke of the short stroke armature, and a second magnetic circuit causing a mutual attraction between the relay core and said long stroke armature sufficient to overcome the mutual attraction between said armatures and operate the long stroke armature to complete its stroke.

9. In an electromagnetic relay, a pair of windings and a magnetic circuit with three separate gaps, and a movable armature included in said magnetic circuit responsive to the energization of one of said coils to close the said first gap and shorten the said second gap without altering the reluctance of the third gap, said armature also responsive to the energization of the other of said coils to close the said second gap and widen the said third gap without opening the said first gap.

10. In a relay, long and short stroke armatures subject to mutual magnetic attraction and operating as a unit responsive to a low degree of magnetization, the long stroke armature being brought to rest in partially operated position when the short stroke armature completes its stroke, and magnetic circuits for operating said armatures as set forth and for causing the long stroke armature to complete its stroke responsive to an increased magnetization, and means for adjusting the amount of increase in magnetization required to operate said armature to complete its stroke.

11. In a relay, long and short stroke armatures, a magnetic circuit causing mutual attraction between said armatures and between the short stroke armature and the relay core, both of said armatures operating simultaneously until the short stroke armature completes its stroke, and a second magnetic circuit for causing mutual attraction between the relay core and said long stroke armature sufficient to overcome the mutual attraction between said armature and operate the long stroke armature to complete its stroke, and means for adjusting said second magnetic circuit to control said mutual attraction between said armatures.

12. In a relay provided with a core carrying a coil, a magnetic circuit, an armature for said relay having a main and an auxiliary element, the auxiliary element being mounted close to the core and the main element at a greater distance therefrom, said armatures being responsive as a unit to normal magnetization of said core to advance the auxiliary element into engagement with said core without altering their positions with respect to each other, and the main armature alone being responsive to an increase in the magnetization of said core to displace the main and auxiliary elements relative to each other and to advance the main element into engagement with said core.

Signed by me at Chicago, Illinois, county of Cook, this 30th day of April, 1920.

JOHN ERICKSON.