March 13, 1928.

1,662,060

J. HERMAN

RELAY AND CIRCUITS THEREFOR

Filed Dec. 31, 1925

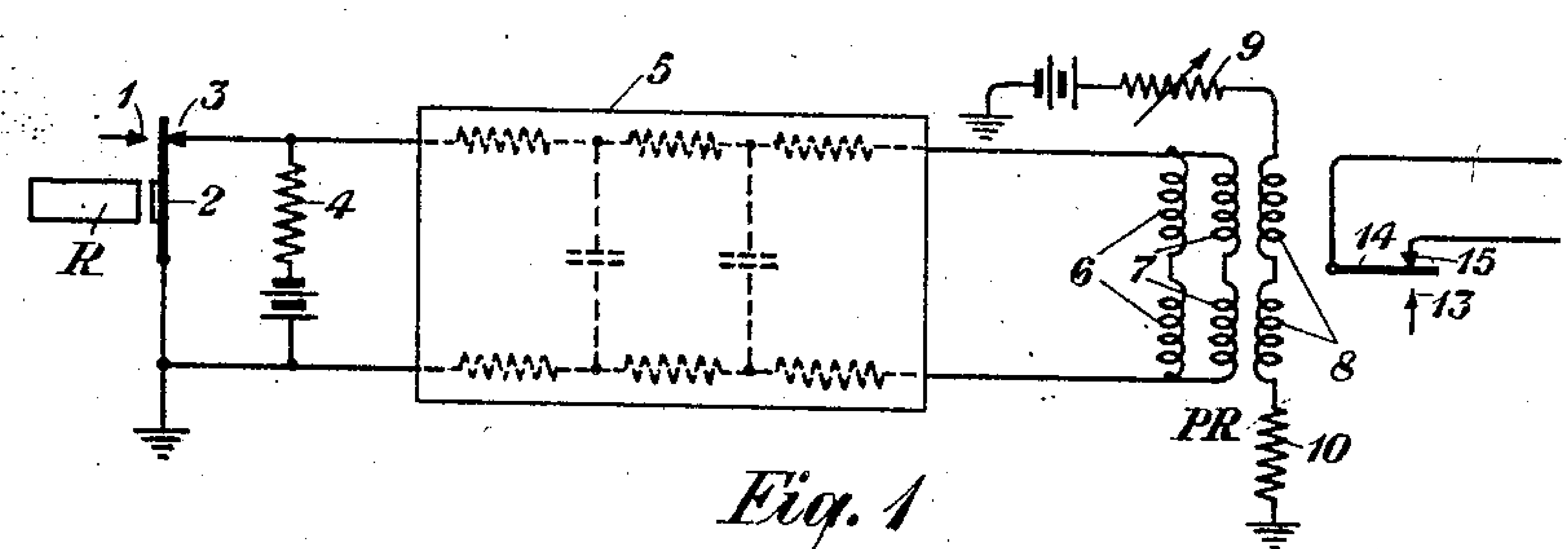

Fig. 1

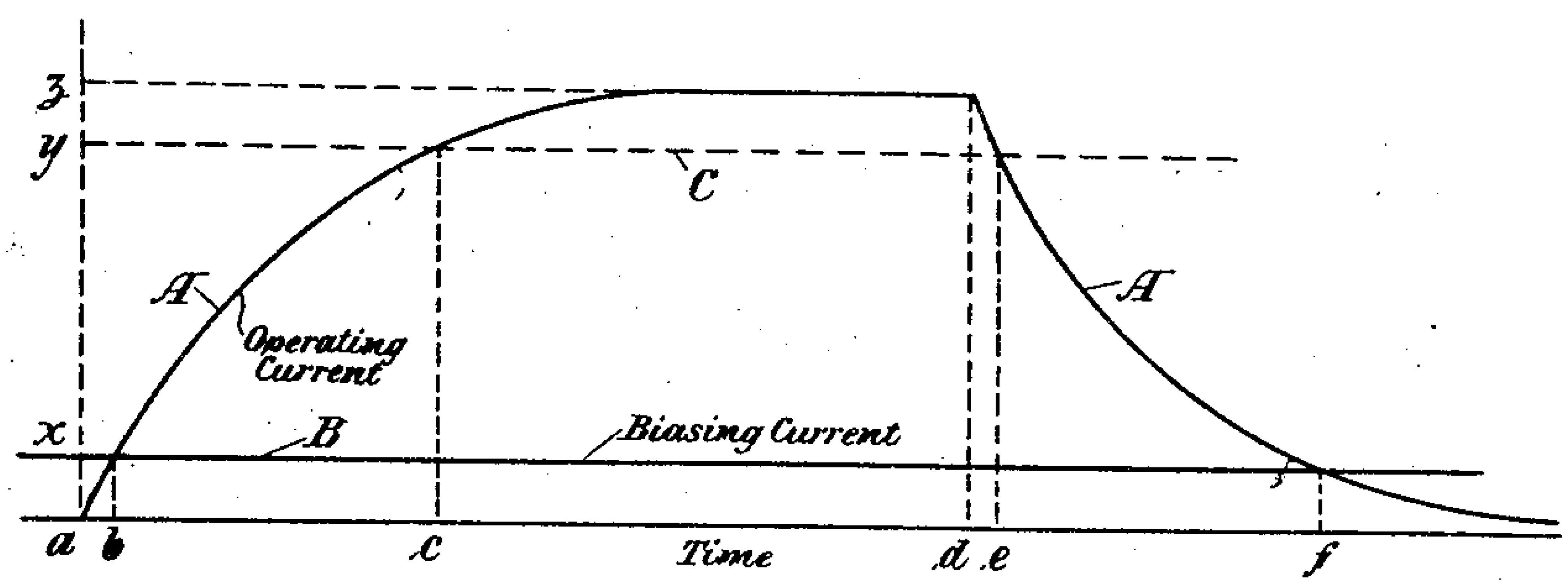

Fig. 2

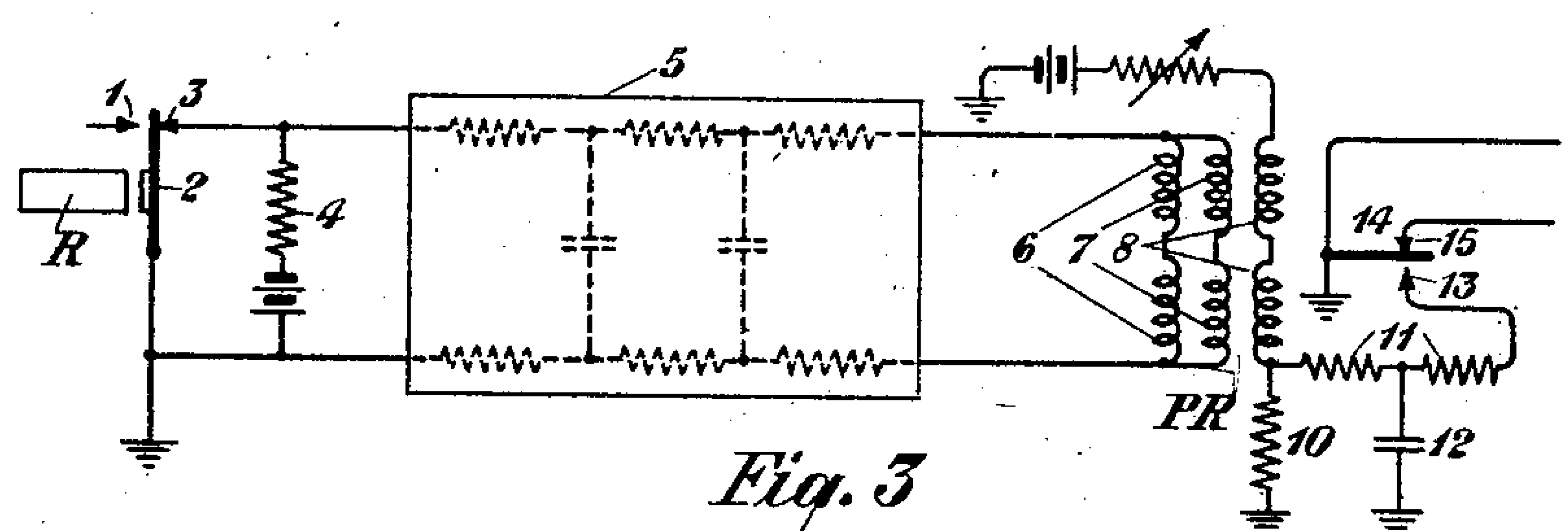

Fig. 3

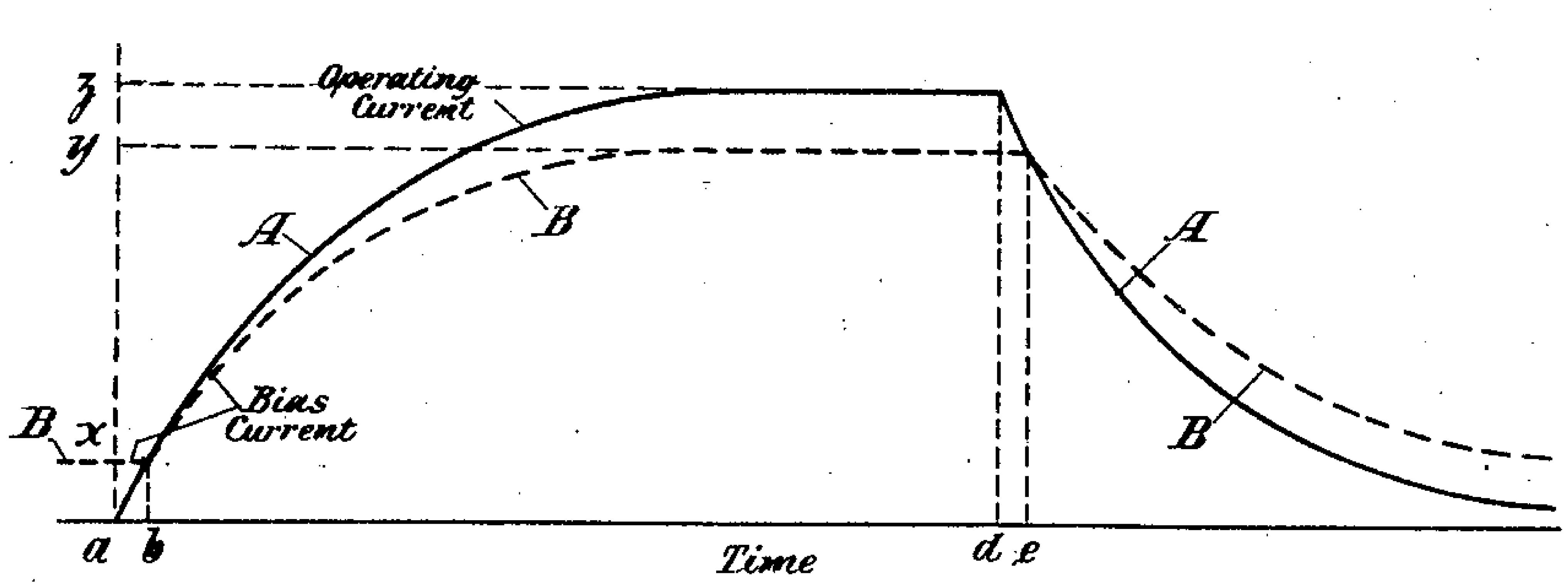

Fig. 4

INVENTOR

J. Herman

BY

ATTORNEY

Patented Mar. 13, 1928. **1,662,060**

UNITED STATES PATENT OFFICE.

JOSEPH HERMAN, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

RELAY AND CIRCUITS THEREFOR.

Application filed December 31, 1925. Serial No. 78,657.

This invention relates to relays, and more particularly to circuit arrangements for decreasing the operating time of polar relays.

Cases frequently arise in which a polar relay located at one point and controlling a piece of apparatus at that point must be operated over a circuit from a distant point. For example, where a telephone line is connected to a radio transmitter, an echo suppressor may be associated with the line at a point distant from the radio transmitter. If the echo suppressor is to control the operative condition of the distant radio transmitter, it is highly desirable that the local polar relay at the transmitter station shall be able to pull up and release its armature as soon as possible after the echo suppressor relay has opened and closed the circuit at the distant point. The present invention has for one of its objects to provide a polar relay circuit in which a minimum time lag will occur both in attracting and releasing its armature in response to a distant control operation.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing, Figure 1 of which is a circuit diagram illustrating the type of polar relay circuit heretofore employed; Fig. 2 is a series of curves illustrating the operation of the relay of Fig. 1; Fig. 3 is a circuit arrangement embodying the principles of the present invention; and Fig. 4 is a series of curves showing the operation of the circuit of Fig. 3.

Referring to Fig. 1, a polar relay is shown comprising sets of windings 6, 7 and 8. The sets of windings 6 and 7 are connected in parallel across an operating circuit and comprises the operating winding of the relay. The set of windings 8 constitutes the biasing windings and are connected in series with the battery through an adjustable resistance 9 by means of which the value of the biasing current may be controlled. The biasing winding is so arranged, either by having its windings reversed with respect to the operating windings or by having the direction of the current reversed with respect to the operating current, that it produces a pull on the armature 14 of the relay in a direction opposite to that produced by the operating winding. At some distant point, a controlling relay R may be arranged, the controlling relay having an armature 2. A line conventionally indicated at 5 is connected between the polar relay PR and the controlling relay R. At the point where relay R is located, the potential of the battery is applied to the line terminals through a resistance 4, and when the armature of the relay R rests upon its back contact 3, the terminals of this battery supply circuit are short-circuited.

When the circuit is in the condition illustrated with the terminals of the resistance 4 and battery short-circuited, no current flows through the operating windings of the polar relay PR. The current flowing through the biasing winding 8 holds the armature 14 of the polar relay against its contact 15. When the armature of the relay 2 is moved in a direction away from the back contact 3, the short-circuit of the terminals of the resistance 4 and operating battery is opened, and current flows over the line 5 through the operating windings of the polar relay. The operating current produces a pull of greater magnitude and in a direction opposite that of the biasing winding so that the armature 14 is shifted away from its contact 15 to the back contact 13. When the relay R again releases its armature so that the short-circuit is once more closed, the operating current ceases, and the biasing current flowing through the biasing winding restores the armature 14 to its contact 15.

Now, when the armature 2 is withdrawn from the back contact 3, it takes an appreciable interval for the polar relay PR to shift its armature 14 away from the contact 15. This is called the "break" time of the relay and arises principally through the fact that the line 5 is, in effect, a series of resistances with shunted capacities, which capacities are gradually charged up when the current begins to flow over the line so that the operating windings of the polar relay PR do not receive their full current at once. If the biasing current through the winding 8 be made small, the break time will be small. This results, however, in increasing the "make" time, the make time being the interval intervening between the instant at which the armature 2 again contacts with the back contact 3 and the instant at which the armature 14 again makes contact with the contact 15.

In order to understand how the make and

break intervals occur, attention is called to the curves of Fig. 2. In this figure time is plotted as abscissæ and the current values as ordinates. Suppose a steady current of a value *ax* is flowing through the biasing winding as indicated by the curve B, and that no current is flowing in the operating winding. If, at an instant of time *a*, the armature 2 leaves the contact 3 so that current flows into the line, it will take an appreciable time for the current flowing through the operating windings of the relay PR to build up to its full value, because the capacity of the line must gradually be charged to its full extent before the current through the relay windings reaches a steady state value, as indicated at the top of the curve A. Now, since the biasing current indicated by the curve B produces a pull in a direction opposite to that produced by the operating current, the operating current represented by the curve A must be built up at least to the value of the biasing current before the armature 14 can be shifted from its contact, so that it takes at least an interval of time *ab* for the relay PR to shift its armature away from the contact 15 after the armature 2 opens the short-circuit. If the biasing current was much larger, so that it had a value, for example, *ay*, the operating current would have to build up to at least this same value, which would require a time of at least *ac* as the break time of the relay PR. It is therefore evident that, to make the break time short, it is necessary to keep the biasing current low in value.

If, now, we suppose that after the operating current through the operating windings of the polar relay PR has reached its steady state value, the armature 2 is again brought into contact with the back contact 3 at an instant of time *d*, the operating current represented by the curve A gradually decays owing to the capacity of the line and does not immediately fall to zero. If a small biasing current, as represented by B, is used, the operating current must drop to a value lower than *ax* before the biasing curent can become effective to restore the armature 14 to the contact 15, so that it will take an interval of time at least equal to *df* to effect the make operation. If, of course, the biasing current had a value *ay*, as shown by the curve C, the make time would only be *de*. This, as already pointed out, would result in an increase in the break time, which would be undesirable.

It will be clear from the above discussion that, in order to effect a quick break time, the biasing current should be of small value, and, to effect a quick make time, the biasing current should be of large value. The circuit arrangement shown in Fig. 3 is designed to accomplish this result. As will be seen, the armature 14 of the polar relay PR is so arranged that when it rests on its back contact 13 it will connect a resistance 11 to ground in parallel with the resistance 10. When, however, the armature 14 is on its make contact 15, only the resistance 10 is in series with the battery supplying the biasing current. Consequently, the resistance in series with the biasing winding is of much greater when the armature 14 is on its contact 15 than when it is on its back contact 13. By properly proportioning the resistances 10 and 11, the two effective values of current may be brought within any desired limits. This arrangement results in increasing the biasing current for the make operation. Since the larger biasing current would fall to the smaller value the instant the armature left the contact 13, a condenser 12 is connected as shown, so that it will become charged when the circuit is opened at contact 13, thereby continuing the flow of current for an appreciable length of time so that the biasing current does not immediately drop to its original value.

The operation of this circuit will be clear from the curve shown in Fig. 4. If at an instant of time *a* the armature 2 leaves the contact 3, the operating current begins to build from zero up to its steady state value gradually as indicated by the curve A, this part of the operation being the same as in Fig. 1. If the biasing current have the value *ax*, as indicated by curve B, the biasing current will remain at this value until the operating current builds up to an equal or greater value, so that it may shift the armature 14 from the contact 15. This would require a break time represented substantially by the interval *ab*. As soon as the armature 14 reaches the contact 13, the condenser 12 begins to discharge through the right-hand member of resistance 11 and the biasing current begins to gradually build up, as indicated by the curve B, to a final value represented by *ay*. This final value is less than the steady state value of the operating current, so that the armature 14 will be held against its back contact 13 by the operating current.

If, now, at an instant *d* the armature 2 is again brought into cotnact with the contact 3, the operating current begins to decay as shown by the curve A, and as soon as it falls to a value *ay*, the biasing current becomes greater than the operating current, so that the armature 14 is shifted to its make contact 15. The make operation, therefore, will only require a time substantially equivalent to the interval *de*. If we assume that at the instant *e* the armature 14 leaves the contact 13, the biasing current begins to decay as indicated by the right-hand portion of the curve B until it drops to its steady state value *ax*. This gradual decay of the biasing current is due to the action of the condenser

12, and if this condenser were not provided, the biasing current would drop immediately at the instant e to the value ax with the result that the biasing current would again be less than the operating current, so that the operating current might tend to shift the armature back to the contact 13 thus producing a chattering effect.

It will be apparent that by properly proportioning the resistances 10 and 11 and the condenser 12 with respect to the other circuit elements, both the make time and the break time may be brought within any desired limits, and the make time may be made substantially as short as the break time. In actual practice, it has been found that when the circuit 5 is 19-gauge cable of twenty miles in length and the circuit of Fig. 1 is employed, it requires substantially .0018 seconds to open the contact 15 and .02 seconds to close it. With the special type of biasing circuit illustrated in Fig. 3, however, the break time is about .002 seconds (which it will be noted is substantially the same as in the case of the circuit of Fig. 1), and the make time is reduced to .005 seconds. Thus, without increasing the break value, the circuit of Fig. 3 enables the make time to be cut down to one-quarter its original value. The make and break times are nearly independent of each other in the circuit arrangement of Fig. 3 and may be adjusted independently by means of the resistances 10 and 11. It is not possible, however, to obtain as small a make time as break time due to the fact that the time required for the armature 14 to travel from one contact to the other must be added to the make time. This is the reason why, in actual practice, using the circuit of Fig. 3, the break time is .002 seconds as compared with a make time of .005 seconds.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. A polar relay comprising an operating winding, a biasing winding, and an armature, and means controlled by said relay whereby when the armature is on one of its contacts the biasing current of small but definite value will flow through the biasing winding to produce a pull on the armature opposite to that of the operating winding, and means whereby when the armature is on the other of its contacts the biasing current will be increased.

2. A polar relay comprising an operating winding, a biasing winding, and an armature, a make contact for said armature, and a break contact for said armature, means to determine that a small but definite amount of current will flow through the biasing winding when said armature rests upon its make contact, and means to increase the amount of said current when the armature rests upon its break contact.

3. A polar relay comprising an operating winding, a biasing winding, and an armature, a make contact and a break contact for said armature, a resistance in circuit with said biasing winding to determine that a small but definite amount of current will flow therethrough when said armature is on its make contact, and means to shunt said resistance when said armature is on its break contact to thereby increase the flow of current through the biasing winding.

4. A polar relay comprising an operating winding, a biasing winding, and an armature, a make contact and a break contact for said armature, a resistance in circuit with said biasing winding to determine the amount of current flowing therethrough when said armature is on its make contact, means to shunt said resistance when said armature is on its break contact to thereby increase the flow of current through the biasing winding, and a condenser so connected as to prevent the biasing current from immediately dropping to its make value when the armature leaves the break contact.

In testimony whereof, I have signed my name to this specification this 30th day of December, 1925.

JOSEPH HERMAN.