

March 22, 1938.

B. LAZICH

2,111,635

ELECTRICAL RELAY

Filed April 15, 1936

2 Sheets-Sheet 1

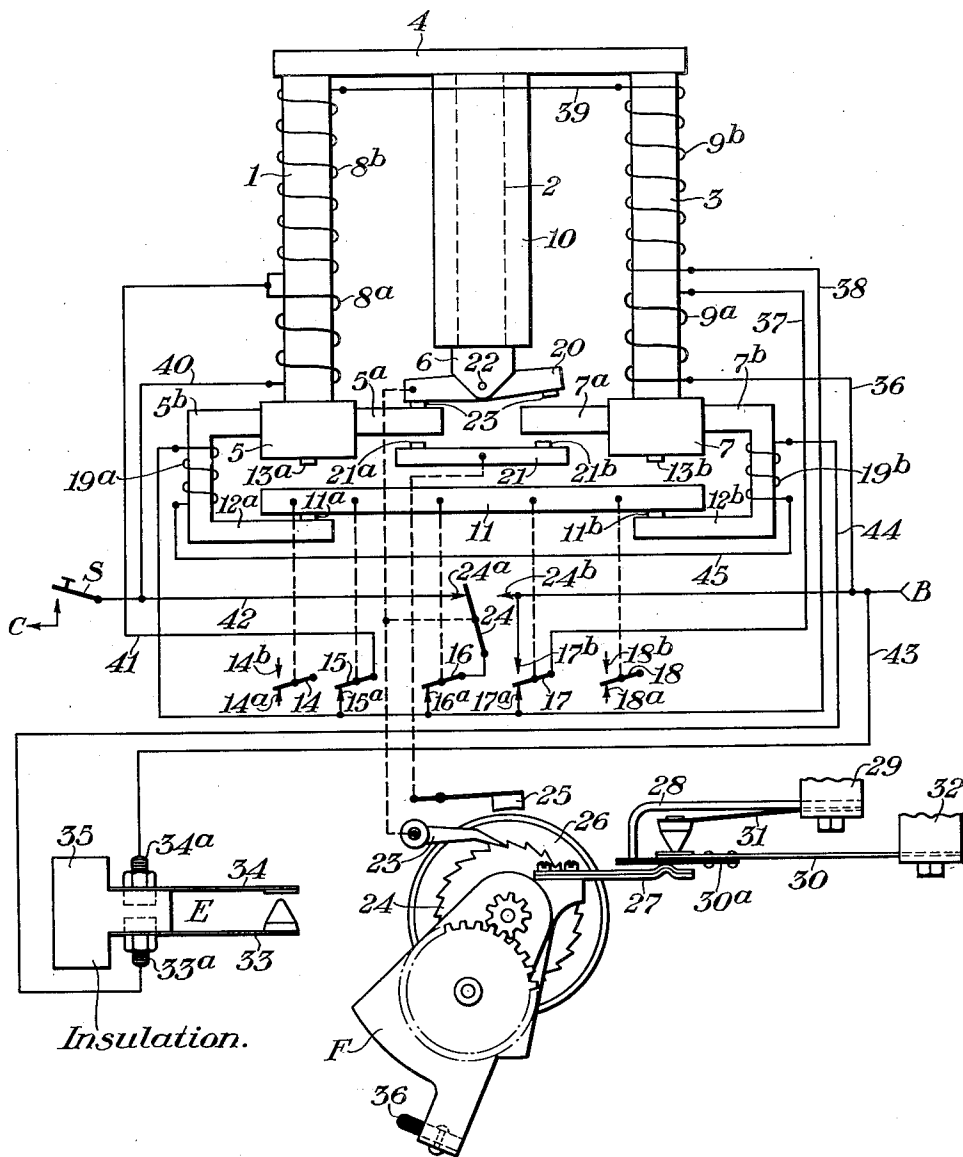


Fig. 1.

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2 Sheets-Sheet 2

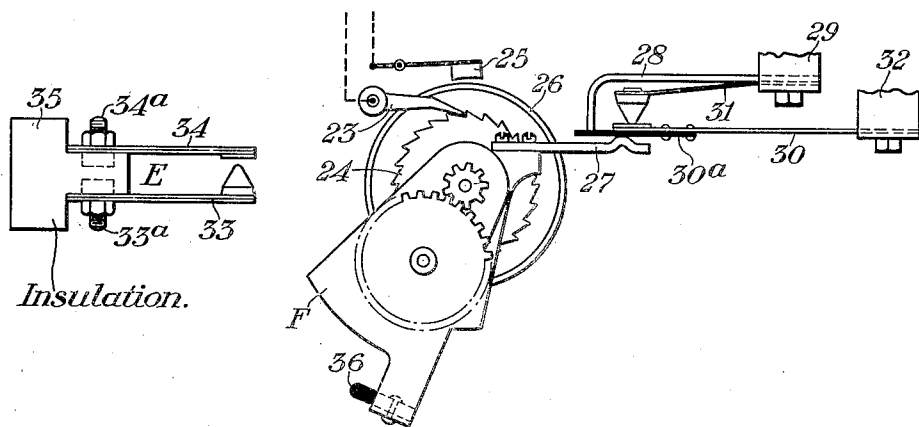


Fig. 2.

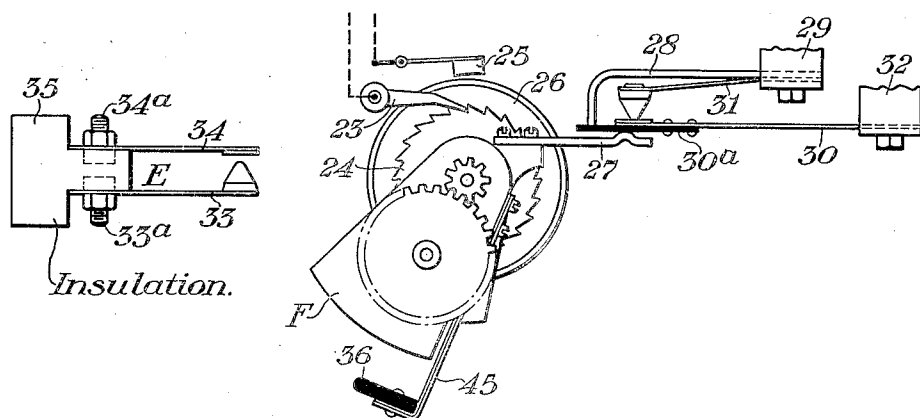


Fig. 3.

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UNITED STATES PATENT OFFICE

2,111,635

ELECTRICAL RELAY

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Application April 15, 1936, Serial No. 74,448

9 Claims. (Cl. 200—97)

My invention relates to electrical relays, and particularly to relays of the type comprising a contact which becomes closed at the expiration of a time interval of relatively long duration after the relay becomes energized.

One object of my invention is the provision in a relay of the type described of novel means for maintaining constant the time required to close the time contact irrespective of variations in the operating characteristics of the relay caused by changes in the ambient temperature.

I will describe three forms of relays embodying my invention, and will then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a view, partly diagrammatic and partly in elevation, showing one form of relay embodying my invention. Figs. 2 and 3 are views showing modifications of my invention.

Similar reference characters refer to similar parts in all three views.

Referring first to Fig. 1, I have here shown my invention applied to a time element relay of the type which is described and claimed in Letters Patent of the United States No. 1,966,965, granted to me and H. E. Ashworth, on July 17, 1934, but it should be distinctly understood that my present invention is not limited to relays of this particular type. The relay is illustrated diagrammatically in the drawings, and since a full description of the relay may be had by reference to the above identified patent, it is believed that for purposes of the present application the following brief description of the relay will be sufficient.

As will be seen from an inspection of the drawings, the relay comprises a core structure consisting of three parallel legs 1, 2, and 3 connected together at one end by a backstrap 4, and provided at the other end with pole pieces 5, 6, and 7, respectively. The leg 1 is provided with an operating winding 8^a and a holding winding 8^b, which windings in actual practice are wound into a single coil, and the leg 2 is similarly provided with an operating winding 9^a and a holding winding 9^b, which windings in actual practice are also wound into a single coil. The middle leg 2 is surrounded by a sleeve 10, the function of which will become apparent as the description proceeds. The pole piece 5 is provided with two extensions 5^a and 5^b, and the pole piece 7 is likewise provided with two extensions 7^a and 7^b. The extensions 5^a and 7^a, as shown in the drawings, extend laterally toward each other, but in actual practice these extensions project rearwardly from the pole pieces to a point opposite the middle leg 2, which

latter leg is offset rearwardly from the legs 1 and 3. The extensions 5^b and 7^b are made U-shaped for a purpose which will appear presently, and are provided with bucking windings 19^a and 19^b, the purpose of which will also appear presently.

The relay also comprises a main tractive armature 11, an auxiliary armature 20, and a clutch armature 21. The main tractive armature 11 is biased by gravity to a released position in which non-magnetizable stops 11^a and 11^b that are secured to the underside of the armature rest against pole faces 12^a and 12^b formed on the extensions 5^b and 7^b, respectively, but is adapted to be at times moved against the action of gravity to an attracted position in which the armature engages non-magnetic stops 13^a and 13^b provided on the underside of the pole pieces 5^a and 5^b, respectively. The armature 20 is pivotally supported by means of a pivot pin 22 between bifurcations which are formed in the pole piece 6, and is arranged to swing toward one or the other of the pole piece extensions 5^a and 7^a, non-magnetic stops 23 being attached to the armature to prevent the armature from coming into actual contact with the pole piece extensions. The clutch armature 21 is biased by gravity to a position in which it is separated from the pole piece extensions 5^a and 7^a by means of air gaps, but is adapted to be moved, when the relay becomes energized, to a position in which non-magnetic stops 21^a and 21^b secured to this armature engage the pole piece extensions 5^a and 7^a.

The main armature 11 actuates a plurality of contact fingers 14, 15, 16, 17, and 18 which, when the armature occupies its released position in which it is shown in the drawings, engage fixed back contact members 14^a, 15^a, 16^a, 17^a, and 18^a, respectively, to close back contacts 14—14^a, 15—15^a, 16—16^a, 17—17^a, and 18—18^a. When, however, the armature 11 occupies its attracted position, the fingers 14, 17, and 18 then engage fixed front contact members 14^b, 17^b, and 18^b to close front contacts 14—14^b, 17—17^b, and 18—18^b. The back contacts 15—15^a, 16—16^a, and 17—17^a and the front contact 17—17^b control the energization of the various windings of the relay in a manner which will be described more fully hereinafter.

The auxiliary armature 20 actuates a contact finger 24 to close a contact 24—24^a or 24—24^b according as the armature occupies the extreme position in which it is shown in the drawings, or its opposite extreme position. The contacts 24—24^a and 24—24^b control the supply of energy

to the windings 8^a and 9^a in such manner that when a manually operable switch S is closed to energize the relay, and the armature 11 occupies the position shown, the armature 20 will be made to oscillate as will appear more fully hereinafter.

The armature 20 also actuates a pawl 23 which cooperates with a ratchet wheel 24 in such manner that oscillation of the armature 20 will cause a step-by-step rotation of the ratchet wheel in a clockwise direction. The ratchet wheel 24 is operatively connected with a planetary arm F in such manner that when a clutch 25, which is operatively connected with the clutch armature 21, is engaging a clutch wheel 26, rotation of the ratchet wheel will cause the arm F to rotate in a clockwise direction, but that, when the clutch 25 is out of engagement with the clutch wheel, the arm F is then free to rotate in a counter-clockwise direction, due to the bias of gravity, to a position in which a strip 27, which is secured to the arm F, engages an insulating member 30^a secured to a contact finger 30, and moves the insulating member into engagement with a fixed stop 28 and the finger 30 into engagement with another contact finger 31. The stop 28 and finger 31 are secured to a suitable supporting bracket 29, while the finger 30 is secured to a similar bracket 32. The two fingers 30 and 31 together form a checking contact, the function of which is to indicate when the arm F occupies the position to which it is biased.

The contact arm F controls a contact E comprising two spaced contact fingers 33 and 34 attached by means of studs 33^a and 34^a to a block 35 of insulating material. The contact E is arranged to be closed, in response to clockwise rotation of the arm F, by means of an insulating piece 36 which is secured to the arm F.

The operation of the portion of the apparatus thus far described is as follows: As shown in the drawings, switch S is open and the windings 8^a, 8^b, 9^a, 9^b, 19^a and 19^b are all deenergized. The neutral armature 11 therefore occupies its retracted position so that contacts 14—14^a, 15—15^a, 16—16^a, 17—17^a, and 18—18^a are all closed, and contacts 14—14^b, 17—17^b, and 18—18^b are all open. Auxiliary armature 20 is swung toward extension 5^a of pole piece 5, and normal contact 24—24^a is therefore closed, while reverse contact 24—24^b is open. The contact arm F is held by gravity in its normal position, so that contact 30—31 is closed and contact E is open.

I will now assume that with the parts in the positions just described, switch S becomes closed. The closing of this switch completes a circuit for the windings 9^a, 9^b, 8^a, and 8^b in series passing from terminal B of a suitable source of current not shown in the drawings through wire 36, winding 9^a, wire 37, contact 17—17^a, wire 38, winding 9^b, wire 39, windings 8^b and 8^a, wire 40, and switch S to terminal C, but only winding 9^a becomes energized because windings 8^b and 9^b are short circuited over a circuit which may be traced from the lower terminal of winding 8^b through wire 41, contact 15—15^a, wire 38, winding 9^b, and wire 39 to the upper terminal of winding 8^b, and winding 8^a is short circuited over a circuit which may be traced from the lower terminal of winding 8^a through wires 40 and 42, contacts 24—24^a, 16—16^a, and 15—15^a, and wire 41 back to the other terminal of windings 8^a. As a result, auxiliary armature 20 is swung toward extension 7^a of pole piece 7, and the clutch armature 21 is attracted to extensions 5^a and 7^a of the pole pieces 5 and 7. The neutral armature 11, however, is

held away from the pole pieces 5 and 7 under these conditions because the windings 19^a and 19^b on the pole piece extensions 5^b and 7^b are deenergized, and the reluctance of the path to the neutral armature through the magnetic structures of the pole piece extensions 5^b and 7^b for the flux set up by winding 9^a is lower than the reluctance of the path to the neutral armature through the air gaps between the pole pieces 5 and 7 and the neutral armature, and more flux therefore reaches the neutral armature through the pole piece extensions than through the air gap between the pole pieces 5 and 7 and the neutral armature. It follows that the tractive force exerted to lift the armature 11 toward the pole pieces 5 and 7 is less than the combined force of gravity and the effect of the flux through the pole piece extensions 5^b and 7^b. The contacts 14—14^a, 15—15^a, 16—16^a, 17—17^a, and 18—18^a controlled by the neutral armature therefore remain closed even though winding 9^a of coil 9 is now energized.

When the auxiliary armature 20 is swung toward extension 7^a of pole piece 7, normal contact 24—24^a becomes opened and reverse contact 24—24^b becomes closed. Since contacts 16—16^a and 17—17^a are still closed, the closing of contact 24—24^b completes a short circuit for winding 9^a which will be obvious from an inspection of the drawings, and the field set up by this winding commences to decay. Due, however, to the snubbing effect of the circuit for winding 9^a, and to the sleeve 10, this decay is comparatively slow. The opening of contact 24—24^a in the meantime has removed the short circuit from winding 8^a, thus allowing this winding to become energized. The growth of the flux set up by this latter winding is comparatively slow, however, due to the sleeve 10 on leg 2 but, after an interval of time, the torque exerted on armature 20 by this flux overbalances the torque exerted on armature 20 by the decaying flux in winding 9^a, and armature 20 then swings back toward extension 5^a of pole piece 5. This motion first opens contact 24—24^b and then closes contact 24—24^a. The neutral armature 11 is still held away from the pole pieces 5 and 7 during this movement of the armature 20 for the reasons pointed out hereinbefore so that contacts 14—14^a, 15—15^a, 16—16^a, 17—17^a, and 18—18^a controlled by armature 11 are still closed, and winding 9^a therefore again becomes energized and winding 8^a again becomes short circuited. The field of winding 9^a then slowly builds up, and the field of winding 8^a slowly decays, this decay being retarded by the self inductance of winding 8^a and by the sleeve 10. It will therefore be seen that auxiliary armature 20 is positively swung to and fro as long as switch S is closed and the windings 19^a and 19^b remain deenergized, and it will also be clear that a considerable interval of time elapses between armature movements. It should be pointed out that this time interval is substantially independent of fluctuations of the electromotive force in the energy supply because the auxiliary armature is acted upon by two opposing forces both of which increase or decrease as the electromotive force of the energy supply increases or decreases.

Each time the auxiliary armature 20 is swung toward pole piece extension 7^a, the pawl 23 rotates the ratchet wheel 24 through a small arc, and since the clutch 25 is now held in engagement with the clutch wheel 26 by the clutch armature 21, the rotation of the ratchet wheel is trans-

mitted through the gearing of the planetary arm F to this arm, thus causing the arm to be rotated in a clockwise direction in response to the rotation of the ratchet wheel. As soon as the contact arm has been rotated through a small arc, the resultant movement of the strip 27 permits contact finger 30 to move out of engagement with contact finger 31, thereby opening the contact 30—31, and when the arm has been rotated through a sufficiently large arc, the insulating piece 36 attached to the arm engages contact finger 33 and moves into engagement with contact finger 34, thereby closing contact E.

When contact E becomes closed, if contact 24—24^a is then closed, or as soon thereafter as contact 24—24^a becomes closed, current is supplied to the windings 19^a and 19^b over a circuit which may be traced from terminal B through wire 43, contact E, wire 44, winding 19^b, wire 45, winding 19^a, contacts 16—16^a and 24—24^a, wire 42, and switch S to terminal C. The windings 19^a and 19^b are connected in this circuit in such manner that the fluxes created in the extensions 5^b and 7^b of the pole pieces 5 and 7 thread these extensions in the opposite direction from the fluxes which thread these extensions due to current in either of the windings 8^a or 9^a, and the parts are so proportioned that the magnitude of the flux in the extensions 5^b and 7^b due to the current in the windings 19^a and 19^b is sufficiently great that the flux which threads the armature 11 through the air gaps between the armature 11 and the pole pieces 5 and 7 under these conditions will exert a torque on the armature which causes the armature to swing toward the pole pieces 5 and 7. Shortly after the armature 11 starts to swing toward the pole pieces 5 and 7, contacts 14—14^a, 16—16^a, 17—17^a, and 18—18^a are opened but contact 15—15^a is adjusted to remain closed until the armature has moved a short distance beyond the point in its upward travel at which the other contacts open. When contacts 16—16^a and 17—17^a are open, winding 9^a which is normally energized when these contacts are closed and contact 24—24^a is closed, becomes deenergized and, at the same time the short circuit which is normally completed for winding 8^a at contact 16—16^a when contact 24—24^a is closed is opened. Winding 8^a is then supplied with current in series with the windings 19^a and 19^b over contact 15—15^a, the circuit being from terminal B through wire 43, contact E, wire 44, winding 19^b, wire 45, winding 19^a, contact 15—15^a, wire 41, winding 8^a, wire 40, and switch S to terminal C. Winding 8^a, therefore, becomes energized and supplies flux to the armature 11 in place of winding 9^a. The reactance of the windings 19^a and 19^b will usually be considerably less than the reactance of the winding 8^a, so that the magnitude of the flux which is supplied to armature 11 due to the current in winding 8^a under these conditions will be only slightly less than the magnitude of the flux which was supplied to armature 11 due to current in winding 9^a, and it will be apparent, therefore, that the opening of contacts 16—16^a and 17—17^a has very little effect on the torque exerted on the armature 11 tending to move the armature toward the pole pieces 5 and 7. As soon as winding 9^a becomes deenergized and winding 8^a becomes energized in the manner just described, auxiliary armature 20 stops oscillating, and this armature is then held in the position in which its normal contact 24—24^a is closed. When contact 15—15^a opens, the short circuit which was previously closed for windings 8^b and 9^b at this

contact is opened, and the windings 8^a, 8^b, 9^b, 19^a, and 19^b in series are then all supplied with current from the terminals B and C of the source over contact E and switch S so that these windings are all energized. The windings 8^b and 9^b are preferably constructed to have a comparatively high resistance in order to limit to a low value the current supplied to the relay after these windings become energized. When armature 11 has completed its upward stroke, contacts 14—14^b, 17—17^b, and 18—18^b become closed. As long as switch S now remains closed, the windings 8^a, 8^b, 9^b, 19^a, and 19^b will continue to be energized because the clutch 25 is held in engagement with clutch wheel 26 by armature 21, so that contact arm F is held in the position in which contact E is closed. It will be apparent, therefore, that after the neutral armature has once been attracted to the pole pieces 5 and 7, this armature will be held in the position which it then occupies until switch S is opened to deenergize the relay. When this is done, the neutral armature 11 drops away from the pole pieces 5 and 7, thereby opening contacts 14—14^b, 17—17^b, 18—18^b and closing contacts 14—14^a, 15—15^a, 16—16^a, 17—17^a, and 18—18^a. Furthermore, the clutch armature 21 drops away from the extensions 5^a and 7^a of the pole pieces 5 and 7, respectively, thereby permitting the contact arm F to return by gravity to its normal position. When the contact arm returns to its normal position, contact E is opened and contact 30—31 becomes closed. When contact 30—31 becomes closed, the parts of the relay are then restored to their normal positions in which they are illustrated in the drawings.

With a relay constructed in the manner just described, if the ambient temperature changes, the resistance of the windings 8^a and 9^a and the resistance of the sleeve 10 will all change, and this change in the resistance of the windings 8^a and 9^a and the sleeve 10 will cause the rate of oscillation of the armature 20 to increase with increases in the ambient temperature and decrease with decreases in the ambient temperature. The time required to close the time contact E is, of course, inversely proportional to the armature speed, and it follows, therefore, that the time required to close the time contact will decrease or increase according as the ambient temperature increases or decreases. Under some conditions of operation, it is desirable to maintain the time required to close the contact E constant irrespective of changes in the ambient temperature, and in accordance with my present invention, I accomplish this result by providing temperature responsive means for automatically increasing or decreasing the arc through which the arm F has to be rotated to close the time contact an amount which is just enough to counteract the effect of the changes in armature speed caused by the changes in the ambient temperature. Referring now again to Fig. 1, the temperature responsive means here shown comprises the strip 27, which strip is constructed of bimetallic material arranged in such manner that if the ambient temperature increases, the free end of this strip will deflect downwardly an amount which is proportional to the temperature increase, and will thus allow the contact arm F to rotate, due to its bias, to a position in which the total arc through which this arm F has to be rotated to close the contact E will be increased just enough to offset the decrease in the time required to close the contact E that would take place due to the increased armature speed if the bimetallic strip

were not employed. It will be obvious that a decrease in the ambient temperature will cause the strip 27 to deflect in a manner to shorten the arc through which the arm F has to be rotated to close the time contact an amount which is proportional to the temperature change, and it follows, therefore, that with the relay constructed as shown in Fig. 1, the bimetallic strip 27 will act to automatically compensate for the changes in the operating characteristics of the relay caused by changes in ambient temperature in such manner as to maintain the time required to close the time contact E substantially constant.

Referring now to Fig. 2, in the modified form of my invention here shown, instead of making the strip 27 out of bimetallic material, I make the contact fingers 33 and 34 out of bimetallic material, and I arrange these fingers in such manner that as the ambient temperature increases, the free ends of these fingers will deflect upwardly an amount which maintains a uniform spacing between the fingers, but which is sufficient to increase the arc through which the arm F has to be rotated to close the contact E just enough to compensate for the increased armature speed caused by the increase in ambient temperature. With the apparatus arranged in this manner, it is obvious that the relay will compensate for changes in ambient temperature just as effectively as when the apparatus is constructed in the manner shown in Fig. 1.

Referring now to Fig. 3, in the modified form of my invention here illustrated, the arm 27 and the contact fingers 33 and 34 are both made out of the same materials that have commonly been used for this purpose prior to my present invention. The insulating piece 36, however, instead of being attached directly to the arm F, is attached to the lower end of a bimetallic strip 45, the upper end of which is secured to the strip 45. The length of the arm F is such and the parts are so proportioned that as the ambient temperature increases, the strip will deflect toward the right and will thus increase the arc through which the arm F has to be rotated to close the time contact E just enough to compensate for the increase in armature speed caused by the increase in ambient temperature. It will be apparent, therefore, that the apparatus shown in Fig. 3 will likewise compensate for changes in the operating characteristics of the relay caused by changes in the ambient temperature in such manner that the time required to close the time contact will be unaffected by temperature changes.

It should be pointed out that if for any reasons the desired temperature compensation cannot be obtained by using only one of the compensating means shown in Figs. 1, 2, and 3, any two or all of these means may be combined to secure the desired compensation.

It should also be pointed out that if under or over compensation is desired for any reason, such compensation can be secured by the means embodying my invention by merely changing the proportioning of the parts.

It should further be pointed out that if the arm F instead of being actuated by means which increases its speed of operation with increases in the ambient temperature, is operated by means which decreases its speed with increases in the ambient temperature, the proper temperature compensation to maintain the operating time of the contact E constant can be obtained with any one of the forms of my invention or with any

combination of them by merely reversing the bimetallic strip or strips which are employed for the purpose of securing the compensation.

It should still further be pointed out that apparatus embodying my invention may also be used to produce known changes in the time required to close the time contact with changes in ambient temperature, it being necessary in this case to operate the contact arm F by means which are unaffected by changes in the ambient temperature.

Although I have herein shown and described only three forms of apparatus 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 a time element relay, in combination, a contact arm biased to rotate in one direction, means for rotating said arm in opposition to its bias, a contact which becomes operated when said arm is rotated to one position by said rotating means, a fixed stop, and temperature responsive means secured to said arm and cooperating with said stop to arrest the movement of said arm due to its bias, whereby the arc through which said arm has to be rotated to operate said contact is automatically varied in response to variations in the ambient temperature.

2. In a time element relay, in combination, a contact arm biased to rotate in one direction, a fixed stop, a bimetallic strip secured to said arm and cooperating with said stop to arrest the rotation of said arm due to its bias in a first position which depends upon the ambient temperature, means for rotating said arm in opposition to its bias from said first position to a second position, and a contact which becomes operated by said arm when said arm is rotated to said second position.

3. In a time element relay, in combination, a contact arm biased to a first position, means effective when the relay is energized for rotating said arm away from said first position at a rate of speed which depends upon the ambient temperature, a contact arranged to be operated by said arm when said arm has been rotated through an angular distance from said one position, and means for varying the angular distance through which said arm has to be rotated to operate said contact in response to variations in the ambient temperature in such manner that the time required to operate said contact will remain constant.

4. In a time element relay, in combination, a contact arm biased to a first position, means effective when the relay is energized for rotating said arm away from said first position at a rate of speed which depends upon the ambient temperature, a contact arranged to be operated by said arm when said arm has been rotated through an angular distance from said one position, and means for varying the angular distance through which said arm has to be rotated to operate said contact in response to variations in the ambient temperature in such manner that the time required to operate said contact will be unaffected by changes in the ambient temperature.

5. In a time element relay, in combination, a contact comprising two bimetallic contact fingers one of which is adapted to be moved into engagement with the other to close the contact,

said fingers being so arranged that changes in the ambient temperature will cause both fingers to deflect in the same directions by equal amounts, a contact arm rotatable to different positions to close said contact, and means effective when the relay is energized for rotating said arm.

6. In a time element relay, in combination, a contact comprising two bimetallic contact fingers one of which is adapted to be moved into engagement with the other to close the contact, said fingers being so arranged that changes in the ambient temperature will cause both fingers to deflect in the same directions by equal amounts, a contact arm biased to one position, and means effective when the relay is energized for rotating said arm from said one position to a position to close said contact.

7. In combination, a rotatable contact arm biased to one position, means for at times rotating said arm away from said one position at a rate of speed which varies in response to variations in the ambient temperature, a fixed contact, and a bimetallic strip secured to said arm and cooperating with said contact to close said contact in response to rotation of said arm away from said one position in such manner that the time required to close said contact will be unaffected by changes in the ambient temperature.

8. In combination, a rotatable contact arm

biased to one position, means for at times rotating said arm away from said one position at a rate of speed which varies in response to variations in the ambient temperature, a fixed contact, and a bimetallic strip secured to said arm and cooperating with said contact to close said contact in response to rotation of said arm away from said one position in such manner that the arc through which said arm has to be rotated will vary with the ambient temperature an amount which maintains the time required to close said contact constant.

9. In combination, a rotatable contact arm biased to one position, means for at times rotating said arm away from said one position at a rate of speed which varies with the ambient temperature, a contact comprising two bimetallic contact fingers one of which is adapted to be moved into engagement with the other to close the contact in response to rotation of said arm away from said one position, said finger being so arranged and so designed that changes in the ambient temperature will cause both fingers to deflect equal amounts in the same directions in such manner that the time required to close said contact in response to movement of said arm away from said one position will be unaffected by temperature changes.

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