

Feb. 23, 1937.

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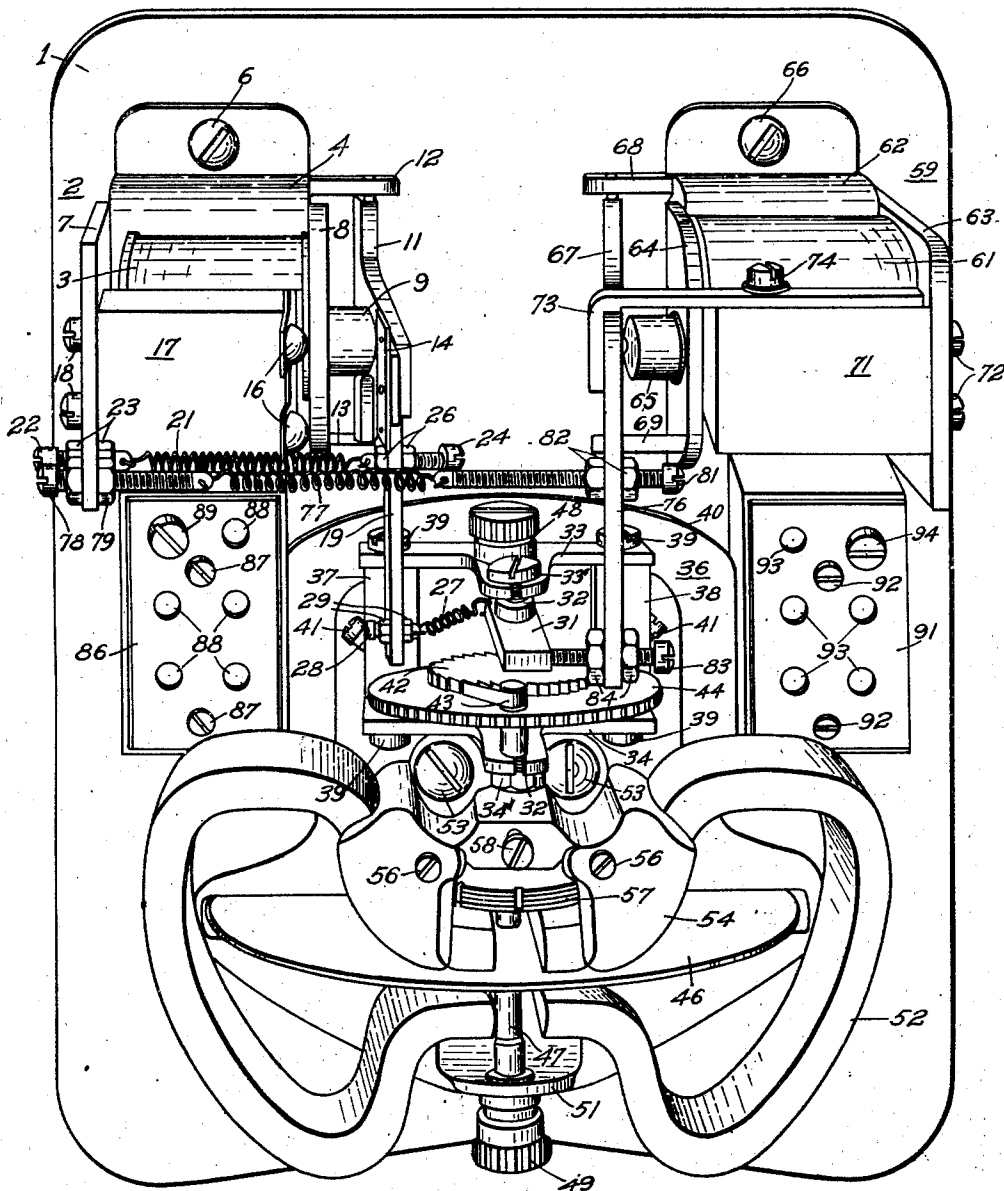
2,071,857

BROAD RANGE TIME LIMIT RELAY

Filed Oct. 13, 1931

2 Sheets-Sheet 1

Fig. 1.



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2 Sheets-Sheet 2

Fig. 2.

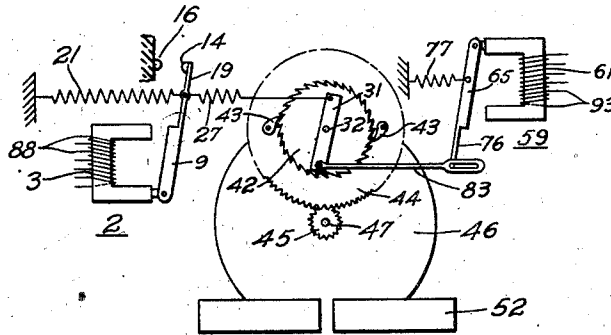


Fig. 3.

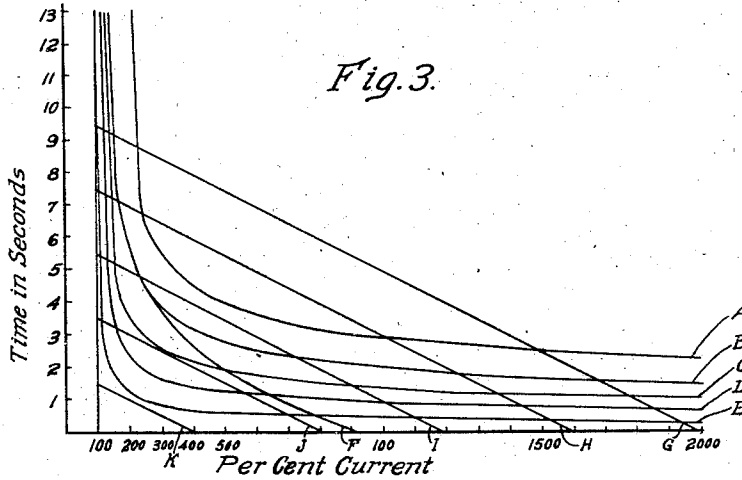
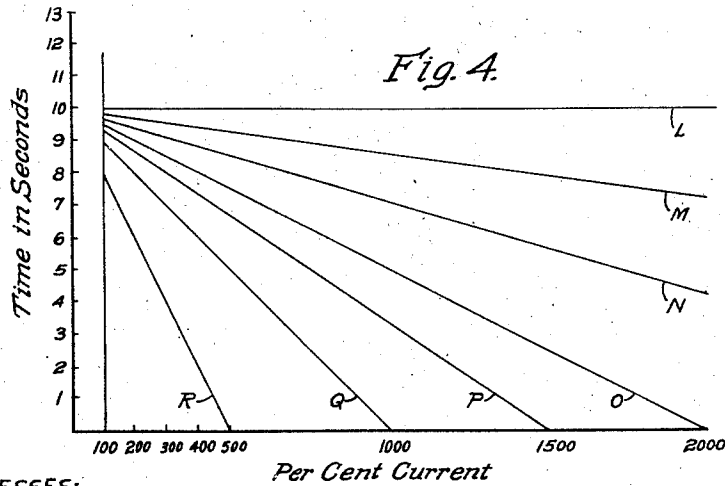


Fig. 4.



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2,071,857

BROAD RANGE TIME LIMIT RELAY

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Application October 13, 1931, Serial No. 568,627

7 Claims. (Cl. 200—97)

The present invention relates to protective re-
lays and more particularly to relays having an
inverse time element of operation over the entire
operating range thereof. The present disclosure
is directed more specifically to a broad range cur-
rent relay having a time-current characteristic
such that the ratio between the current increment
and the time decrement may be made substan-
tially constant.

Most over-current protection for transmission
lines and distribution networks has been provided
by induction-disc type current-responsive re-
lays, and such relays have been designed to oper-
ate either with a definite time characteristic or
with a modified or partially inverse form of such
time characteristic. This preference for induc-
tion-disc type relays is due mainly to the superior
accuracy and permanence of calibration made
possible by the induction principle, and any relay
which departs from this principle of operation
must necessarily effect a superior protection and
incorporate additional novel and advantageous
characteristics.

Referring to the known types of induction re-
lays, it may be noted that the usual preference
has been for a flat time-current-characteristic
curve, whereby the operating time of the relay
is made to be independent of the magnitude of the
short-circuit current. The main reason for this
preference was due to the fact that relatively little
was known concerning an accurate method of
calculating short-circuit currents, and this diffi-
culty has only been surmounted in very recent
years. The introduction and popularization of
symmetrical component methods of calculating
unbalanced fault currents has made it possible to
determine quite accurately the conditions obtain-
ing during fault conditions.

In accordance with the introduction of a suit-
able method for calculating short-circuit currents,
attempts have been made to use the inverse
portion of existing time-current-characteristic
curves, but the general adoption of such relay
characteristics has been difficult in view of the
fact that all possible time-current-characteristic
curves of induction type relays have an inverse
portion of quite restricted range.

The use of definite time, or over-current relays
having a definite time-current-characteristic
curve, results in a very serious disadvantage in
that the application of such relays to a section-
alized power system requires that the timing of
the relays must be properly cascaded with the re-
sult that those relays nearest to the generating
source or sources have to be set for a prohibitively

long definite time of operation. This disadvan-
tage has resulted in an increased demand for an
inverse time-current-characteristic curve in a
relay.

Furthermore, the tendency in the relaying of all
electric systems is toward quicker clearing times,
as is evidenced by the recent development of ex-
tremely high speed protective relays, and the ob-
jection to cascaded relay settings is at once
apparent.

It is an object of the present invention, there-
fore, to provide a protective relay incorporating
a time-current-characteristic curve which may be
made inverse over substantially the entire operat-
ing range.

Another object of the present invention is to
provide a reliable relay which may be utilized
either as a definite time relay or an inverse time
relay, as desired.

Another object of the present invention is to
provide a relay having a suitable actuating means
therefor, and means for imparting an inverse
time characteristic to the relay through substan-
tially the entire operating range thereof.

A further object of the present invention is to
provide a relay having a time-current-character-
istic curve such that the ratio of the current in-
crement and the time decrement may be made
substantially constant throughout the entire
operating range of the relay.

A further object of the present invention is to
provide an accurately responsive relay of a
flexible character such that any desired inverse
time-current-characteristic curves may be ob-
tained in accordance with any particular system
conditions.

Further objects and advantages of the present
invention will become readily apparent to those
skilled in the art by reference to the following
description of one embodiment of the present
invention.

In the drawings:

Figure 1 is a perspective view of a relay de-
signed in accordance with the principles of the
present invention.

Fig. 2 is an equivalent schematic diagram of
the relay shown in Fig. 1.

Fig. 3 illustrates typical time-current-charac-
teristic curves of known induction relays and pos-
sible inverse curves obtainable in a relay designed
in accordance with the present invention, and

Fig. 4 illustrates other possible characteristics
of the present invention.

Referring more particularly to Figs. 1 and 2,
a base or panelboard 1 is provided for effecting

the proper mounting of the relay elements. The main operating element 2, of the relay, comprises an operating winding 3 mounted on a suitable bracket member 4, the bracket member 4 being held in fixed position with reference to the base 1 by means of a screw 6. The operating winding 3 is adapted to be held in position by means of vertical plate member portions 7 and 8 associated with the bracket member 4.

A suitable iron core 9 is associated with the winding 3 and is adapted to be moved laterally with respect to the winding 3 in accordance with the degree of energization of such winding. The core 9 is secured to a pivotal contact member 11, which is pivotally mounted between horizontal plate members 12 and 13 associated with the bracket member 4.

The pivotal contact member 11 is provided with a suitable contact 14, which is adapted to coast with, and bridge, stationary contact members 16 which are secured to an insulating block 17 and the block 17 is secured to the vertical plate member 7 by means of screws 18.

The pivotal contact member 11 is provided with a downwardly extending arm 19 which is also adapted to be moved laterally with the solenoid coil 3 in accordance with the degree of energization of such coil.

A spring 21 has one end thereof fastened to the vertical plate member 7 by means of an adjustable screw 22 and lock nuts 23, and the other end thereof associated with the downwardly extending arm portion 19 by means of an adjustable screw 24 and lock nuts 26. The spring 21 is, practically, as long as possible in order to provide a substantially constant spring force through the entire travel required of the pivotal contact member 11 before the contact 14 effects the bridging of stationary contacts 16.

A second spring 27 is adapted to be connected to the lower end of the downwardly extending arm portion 19 by means of an adjustable screw 28 and lock nuts 29. The other end of the spring 27 is connected to one end of a rotatably mounted bar member 31, and the spring 27 is made relatively short and strong in order to effect an appreciable normal tension. The bar member 31 is positioned on a rotatably adjustable shaft 32, which is mounted for rotation between horizontal bracket members 33 and 34 of a bracket assembly 36 comprising the bracket members 33, 34 and vertical aligning members 37 and 38. The horizontal and vertical bracket members are secured together by means of cap screws 39. The rotatable shaft 32 is adjustably positioned with respect to the bracket members 33 and 34 by means of adjustable screw bearings 33' and 34', respectively, and the bracket assembly 36 is secured to a base mounting 40 by means of screws 41. The base mounting 40 is adapted to be secured to the base 1 by any suitable means, not shown.

A ratchet-wheel 42 is mounted on the shaft 32 and is adapted to be rotated in accordance with the rotation of the shaft 32. Associated with the ratchet-wheel 42 are two diametrically opposed pawls 43 which are secured to a gear 44 included in a suitable reduction gear train, shown schematically in Fig. 2 as including gear 45. The pawl and ratchet-wheel assembly is so arranged that the gear 44 is adapted to be moved in accordance with the rotation of the shaft 32 only when the pivotal contact member 11 is being actuated in a direction to effect the bridging of

stationary contacts 16 by means of the contact 14.

When the shaft 32 and associated bar member 31 are rotated in a clockwise direction, or in a direction to separate the contacts 14 and 16, the pawl and ratchet assembly is ineffective to move the gear 44 and its associated gear train.

A non-magnetic disc element 46 is mounted securely on a spindle 47, and the spindle 47 is mounted for rotation between upper and lower bearing structures 48 and 49, respectively. The upper bearing structure 48 is associated with the horizontal bracket member 33, included in the bracket assembly 36, and the lower bearing structure 49 is adapted to be associated with a raised portion 51 of the base mounting 40.

The disc member 46 and the spindle 47 are associated with the gear train, including the gear 44, and are adapted to be rotated in accordance with the counter-clockwise movement of the shaft 32. A permanent magnet assembly 52 is associated with the disc member 46 and is secured to the base mounting 40 by means of screws 53. The permanent magnet assembly 52 may be of any usual construction, and is shown as including two ordinary C-magnet structures rigidly secured together by means of clamp 54 and screws 56. A usual means for varying the damping flux of the permanent magnet assembly 52 is also provided, and is represented as including a laminated nut 57 and set screw 58.

When the shaft 32 is rotated in a counter-clockwise direction, the pawls 43 engage the ratchet 42, and the resultant movement of the gear train, including the gear 44, effects the movement of the disc element 46 between the poles of the permanent magnet assembly 52. The provision of the disc element 46 and the permanent magnet assembly effects a damping of the movement of the shaft 32, and such damping may be varied by changing the position of the permanent magnet assembly 52 with respect to the disc element 46 and/or by moving the laminated nut 57 in a vertical direction.

However, when the shaft 32 is rotated in a clockwise direction, the pawls 43 are disengaged from the ratchet 42 with the result that the gear 44 is not moved in accordance with the rotation of the shaft 32 and ratchet 42. It follows, therefore, that the disc member 46 is not rotated between the poles of the permanent magnet assembly 52, and no damping of the movement of the shaft 32 results.

An initiating element 59, comprising a solenoid winding 61 and a solenoid core 65, is adapted to be securely positioned with respect to the base 1. The winding element 61 is mounted on a suitable bracket member 62 and is adapted to be secured in proper position by means of vertical bracket members 63 and 64 associated with the bracket member 62. The bracket member 62 is secured to the base 1 by means of screw 66 in a similar manner to the position of the bracket member 4 associated with the main operating element 2.

A pivotal member 67 is pivoted between horizontal bracket members 68 and 69 associated with the bracket member 62, and is secured to the solenoid core for horizontal movement therewith. A block member 71 is secured to the vertical bracket member 63 by means of suitable screws 72 and is made similar to the insulating block 17 associated with the main operating element 2 in order to provide substantial symmetry in the appearance of the elements 2 and 59. A

stop member 73 is secured to the block member 71 by means of screw 74 and is adapted to limit the position of the pivotal member 67 when the winding 61 of the initiating element 59 is de-energized.

The pivotal member 67 is provided with a downwardly extending portion or arm 76, and the member 67 is adapted to be normally held against the stop member 73 by means of a spring member 77. One end of the spring member 77 is adapted to be adjustably secured to the vertical bracket member 7 of the main operating element 2 by means of screw member 78 and lock nuts 79. The other end of the spring member 77 is adapted to be adjustably secured to the downwardly extending portion 76 of the pivotal member 67 by means of screw 81 and lock nuts 82. The spring member 77 is made relatively short, in comparison with the spring member 21, and spring member 77 is also provided with a very high initial tension.

An adjustable screw 83 and lock nuts 84 are associated with the lower extremity of the downwardly extending arm portion 76 of the pivotal member 67, and the end of the screw is adapted to coact with the pivotal bar member 31. By adjusting the position of the screw 83, the initial position of the bar member 31 and pivotal contact member 11 may be predetermined, and such screw 83, associated with the pivotal member 67, and the spring member 77 effectively limits the counter-clockwise rotation of the bar member 31 when the energizing winding 61 of the initiating element 59 is deenergized.

A terminal block 86 is secured to the base 1 by means of screws 87, and is provided with a plurality of taps 88 associated with the energizing winding 3, such that the position of the contact screw 89 predetermines the number of effective turns included in the energizing winding 3 and/or the degree of energization of the winding 3. A second terminal block 91 is secured to the base 1 by means of screws 92, and is adapted to be associated with the energizing winding 61 of the initiating element 59. This terminal block 91 is provided with suitable taps 93, associated with the winding 61, and the contact screw 94 is adapted to be associated with any such taps in order to effect a predetermined effective energization of the winding 61 of the initiating element 59.

Assuming the main operating element 2 of the present relay to be energized in accordance with the current flowing in a transmission or distribution system, and the initiating element 59 to be made responsive to a predetermined magnitude of current existing in such line or system, under normal current conditions, the position of the respective relay elements is as follows.

The energizing winding 3 of the operating element 2 is energized and acts to effect the movement of the solenoid core 9 and associated pivotal contact member 11 in a direction to effect the bridging of stationary contacts 16 by means of contact member 14. The movement of the pivotal contact member 11 in the direction to effect the bridging of the stationary contacts 16 is added to by the action of the substantially constant force exerted by the spring 21. These two forces are normally balanced by the restraining force exerted by the spring member 77 in maintaining the screw 83 in engagement with the bar member 31, and thereby effectively preventing any movement of the pivotal contact member 11, which is secured to the bar member 31 by means

of the downwardly extending arm portion 19 and the spring 27.

Assuming that a definite predetermined magnitude of over-current exists, such that the energizing winding 61 of the initiating element 59 is effectively energized to move the solenoid core 65 and associated pivotal member 67 against the normal tension of the spring 77, the screw 83 is moved out of engagement with the rotatable bar 31, and the pivotal contact member 11 is adapted to be moved in a direction to bridge the stationary contacts 16 by means of contact member 14. The forces effective to control the movement of the pivotal contact member 11 and associated contact 14 comprise the force acting on the solenoid core 9, which may be made proportional to a desired exponential function of the energizing current for the energizing winding 3, the constant force effected by the spring member 21 and the damping force effected by the rotation of the disc member 46 between the poles of the permanent magnet assembly 52. The tension of the spring 27 is substantially unchanged for low and medium values of current in the energizing winding 3, and this spring is only provided for the purpose of permitting an added displacement between the contact member 11 and the rotatable bar member 31 under conditions of high current energization of the winding 3.

Assuming that the over-current condition no longer exists, or that the contacts 16 have been bridged by the contact 14 to effect the deenergization of the relay elements, the energizing winding 61, of the initiating element 59, is effectively deenergized with the result that the spring 77 effects the movement of the pivotal member 67 and associated downwardly extending arm 76 to the normal position thereof. This action of the spring 77 forces the screw 83 against the rotatable bar 31, and effects the rotation thereof in a clockwise direction, thereby effecting a quick reset of the pivotal contact member 11. During the reset operation of the relay elements, the rotatable bar 31 is being rotated in a clockwise direction with the result that the pawls 43 are disengaged from the ratchet 42, and the gear 44 is not rotated in accordance with the rotation of the bar 31 and shaft 32, and no damping by means of the disc member 46 and permanent magnet assembly 52 is provided in the reset operation of the relay.

From the foregoing description of one embodiment of the present invention as depicted in Figs. 1 and 2, it should be noted that the stationary contacts 16 are adapted to be bridged by the contact 14 by a torque equal to an exponential function of the energizing current plus the constant force exerted by the spring 21 minus the damping force exerted by the movement of the disc member 46 between the poles of the permanent magnet assembly 52.

In Fig. 3, curves A, B, C, D and E are illustrative of the time-current curves of the usual induction type current-responsive relay, and it may be noted that these curves have an inverse portion of quite restricted range. These curves are plotted, having as abscissa per cent current, and having as ordinate time in seconds. All of the curves are also plotted on the basis of the relay being set for tripping only on values of current above 100% load. The various curves A, B, C, D and E are obtained, in the usual-type induction relay, by changing the timing or amount of

damping effective to restrain actuation of the relay contacts.

With this type of curve, it will be noted that for low values of over-current, namely up to 200% current, the timing of the relay may not be determined with any degree of accuracy, in view of the asymptotic nature of the curves with respect to the time ordinate. For such low values of over current, the time required for the relay contacts to close becomes prohibitively long and, in practice, it has been found impracticable to utilize such low settings of these relays. It may also be noticed that these curves become asymptotic with respect to the current abscissa, thereby providing a substantially definite time characteristic in the actuation of the relay contacts, with the result that such relays are not capable of distinguishing between heavy over-currents.

As referred to hereinbefore, attempts have been made to utilize the inverse portion of the existing time-current curves of the usual induction relay, and such attempts have met with partial success, but only for very limited ranges of over current. The relay of the present invention is very flexible in character and, as will be explained hereinafter, the various constants and adjustments of the relay may be varied to effect a time-current characteristic curve of almost any desired inverse form.

Referring to the curve B of a usual induction-type relay, the relay of the present invention is assumed to effect a time-current curve, similar to curve B, for values below 250% current, and is shown as extending down to the current abscissa at substantially 925% current. This new curve F may be obtained from the relay of the present invention, assuming the constant force spring 21 to be removed.

The main operating element or driving element 2, of the relay, is of the solenoid type, and this electro-magnet is designed to have characteristics such that the pull thereof will not increase materially as the plunger, or armature, is permitted to move by the timing mechanism or damping element. Much of the design of electro-magnet solenoids is of an empirical nature, although much design data is available relating to solenoid type electromagnets. It follows, therefore, that the electromagnet 2 may be so designed as to effect a time-current curve, which is similar to curve B for currents up to 250%, and the slope of this curve may be varied within a broad range by changing the characteristics of the solenoid. This characteristic curve portion is obtained by means of the driving element 2, and the timing or damping mechanism, effected by the disk 46 and permanent magnet assembly 52 together with the constant force spring 21, are not utilized.

For higher values of current energization of the driving element 2, the pull of the solenoid element effects a stretching of the spring 27, and the time required for the contacts 14 and 16 to close will be materially shortened, inasmuch as the full time of the time element is not utilized. If the proportions are correctly made between the pull of the electromagnet 2, spring 27 and the timing mechanism, including the disk 46 and the permanent magnet assembly 52, it will be possible to definitely fix a point where the contacts will close substantially instantaneously without waiting for the time element to move or be effective. This feature constitutes the essence of the present invention, inasmuch as the straightening out of

the lower part of the curve, and effecting an instantaneous time of operation, as indicated by curve F, is not possible in any present type of over-current induction relay.

The use of the spring 27 obviates the necessity for increasing the operating force of the driving element 2 beyond values which are easily obtainable, and the stretching of the spring 27 permits the closing of the contacts 14 and 16 without waiting for the full time of the timing mechanism or damping element.

The provision of the substantially constant force spring 21 serves to bend the upper part of the curve in such manner as to effect the closing of the contacts 14 and 16 after a definite time, assuming the driving element 2 to be deenergized and the actuating element 59 to be ineffective to restrict the movement of the contact 14. It follows, therefore, that by employing both the substantially constant force spring 21 and the spring 27, the upper part of the curve B may be straightened out in such manner to intersect the time ordinate, while the lower part of the curve B is made to intersect the current abscissa, by virtue of the action of the spring 27. The various constants of the present relay may be varied in such manner to effect a straight line time-current characteristic, and examples of such characteristic curves are indicated by the curves G, H, I, J and K.

The curves G, H, I, J and K are illustrated as being parallel, and they are shown as originating at the 100% current point. Obviously, however, these curves extend to the zero current point, thereby permitting the use of the relay on values of current below 100%, without altering the slope of the curve in any manner. These different straight line curves are obtained by varying the position of the screw 83 and/or by changing the adjustment of the substantially constant-force spring 21, and by adjusting the actuating element 59, such that the contact 14 and associated timing mechanism are permitted to be actuated in accordance with the combined pull of the spring 21 and the solenoid electromagnet 2.

The slope of the time-current characteristic curve may also be varied, as illustrated in Fig. 4, by changing the amount of pull or force exerted by the electromagnet driving element 2. The curves L, M, N, O, P, Q and R, illustrated in this figure, are obtained by adjusting the substantially constant force spring 21 in such manner that the contacts 14 and 16 will be permitted to close in 10 seconds, when the main operating element 2 is deenergized and when the actuating element 59 is adjusted for 100% current. The curve L is obtained in this manner and, obviously, since the spring 21 exerts a substantially constant force, the curve L defines an absolute definite time of operation of the relay. The remaining curves M, N, O, P, Q and R are obtained by increasing the energization of the main operating element 2 and by maintaining the same initial tension of the spring 21. This increased energization of the energizing winding is effected by changing the tap setting thereof, for example, curve O is obtained by providing only half the number of turns as are required to effect the characteristic curve Q.

From the illustrated curves in Figs. 3 and 4, it may be concluded that the relay of the present invention may be employed as a definite time relay, merely by adjusting the screw 83 and/or the tension of the substantially constant force spring 21 for the particular time desired, and

the relay may be actuated in accordance with any predetermined value of current by means of the actuating element 59. When the relay is used as a definite time relay, the main operating element or driving element 2 is completely deenergized. The slope of the time-current-characteristic curve may be altered, if desired, by maintaining a constant setting of the screw 83 and spring 21 and by varying the energization of the main operating element 2. Here again, the relay may be actuated for any predetermined value of current by means of the actuating element 59. The parallel straight line curves, as shown in Fig. 3, may be obtained by imparting a predetermined energization to the main operating element 2 and by changing the setting of the screw 83 and/or the amount of tension or force exerted by the spring 21.

The relay of the present invention is, therefore, capable of effecting a very broad range of characteristics and may be adjusted for either straight line or modified inverse time-current characteristics. This relay effects a substantially constant ratio of current increment to time decrement and may be admirably adapted for any protection application where current protection is required. The time-current characteristic may be made to intersect the time ordinate and to become asymptotic with respect to the current abscissa, if desired, by eliminating the spring 27 and effecting a non-resilient connection between the driving element and the timing mechanism, or time-current-characteristic curves similar to curve F may be obtained by utilizing the spring 27 and eliminating the use of the substantially constant force spring 21. Obviously, any desired modified form of inverse time characteristic may be obtained in the present relay with a minimum of trouble.

The advantages of this relay, incorporating the straight line or modified inverse time current characteristics, should be obvious to one skilled in the protective relaying art, and it is deemed unnecessary to point out in detail wherein the application of such relay is far superior to the application of any existing relays, induction or otherwise.

The actuating element 59 of the present relay may also be of any desired type, and may be made responsive to voltage, impedance of an associated system, etc. Broadly speaking, the present invention relates to a broad range relay wherein the time characteristic may be made to be either a straight line curve, or modified inverse form of such curve. This relay may also be utilized as a definite time relay, as desired, and the simple schematic illustration of the component parts of the relay, as shown in Fig. 2 of the drawings, should provide a complete and accurate description of the theory of operation of the relay and, obviously, the various desired characteristic curves may easily be obtained by balancing the characteristics of the springs 21, 27, the characteristics of the operating element 2 and any suitable timing mechanism.

In view of the basic improvement in relay characteristics made possible by a relay designed in accordance with the foregoing description, in conjunction with the drawings, it is desired that no limitations be imposed on the present invention other than those required by the prior art and indicated in the appended claims.

I claim as my invention:

1. In an overcurrent relay, contact members, a

timing device having a movable element operable with a displacement dependent upon time, a contact operating member movable toward a contact operating position and resiliently restrained by said element, current-responsive electromagnetic means for exerting an operating force dependent upon current upon said contact operating member, and biasing means tending to move said contact operating member toward said position and effective to accelerate operation of said contact members at low current values.

2. In an overcurrent relay, contact members, a timing device having a movable element operable from an initial position with a displacement dependent upon time, a contact operating member movable toward a contact operating position and resiliently restrained by said element, current-responsive electromagnetic means for exerting an operating force dependent upon current upon said contact operating member, biasing means tending to move said contact operating member toward said position and effective to accelerate operation of said contact members at low current values, and means effective upon deenergization of said relay for returning said movable element to said initial position without time delay.

3. In a relay, the combination including contact means, energizing means associated therewith for effecting the actuation thereof, damping means, means resiliently coupling said damping means to said energizing means, and actuating means including means associated with said damping means for rendering said damping means ineffective for one direction of movement of said contact means.

4. In combination in a relay, contacts, actuating means therefor, means for applying a substantially constant force for biasing said actuating means to contact closing position, means for applying thereto, in aiding relation, a second force which is substantially an exponential function of the energizing current, means for applying a damping force opposing said first and second forces, and starting means for preventing operation of said actuating means under normal conditions and for initiating operation of said actuating means in response to said forces under predetermined abnormal conditions.

5. In combination in a relay, contacts, actuating means therefor, means for applying a substantially constant force for biasing said actuating means to contact closing position, means for applying thereto, in aiding relation, a second force which is substantially an exponential function of the energizing current, starting means for preventing operation of said actuating means under normal conditions and for initiating operation of said actuating means in response to said forces under predetermined abnormal conditions, and timing means connected with said actuating means for maintaining a substantially constant time-current derivative over substantially the entire range of currents by which said relay may be operated.

6. In combination in a relay, contacts, actuating means therefor, means for applying a substantially constant force for biasing said actuating means to contact closing position, electromagnetic means for applying thereto, in aiding relation, a second force which is a function of the energizing current in said electromagnetic means, damping means and resilient coupling means between said actuating means and said damping means arranged to permit substantially instantaneous operation of said actuating means in re-

sponse to a predetermined value of said second force and to introduce the timing action of said damping means for lesser values of said second force.

- 5 7. In combination in a relay, contacts, actuating means therefor, means for applying a substantially constant force for biasing said actuating means to contact closing position, electromagnetic means for applying thereto, in aiding relation, a second force which is a function of the
10 energizing current in said electromagnetic means,

damping means, resilient coupling means between said actuating means and said damping means arranged to permit substantially instantaneous operation of said actuating means in response to a predetermined value of said second force, and to
5 introduce the timing action of said damping means for lesser values of said second force, and initiating means for holding the damping means until the energizing current exceeds a predetermined
10 value.

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