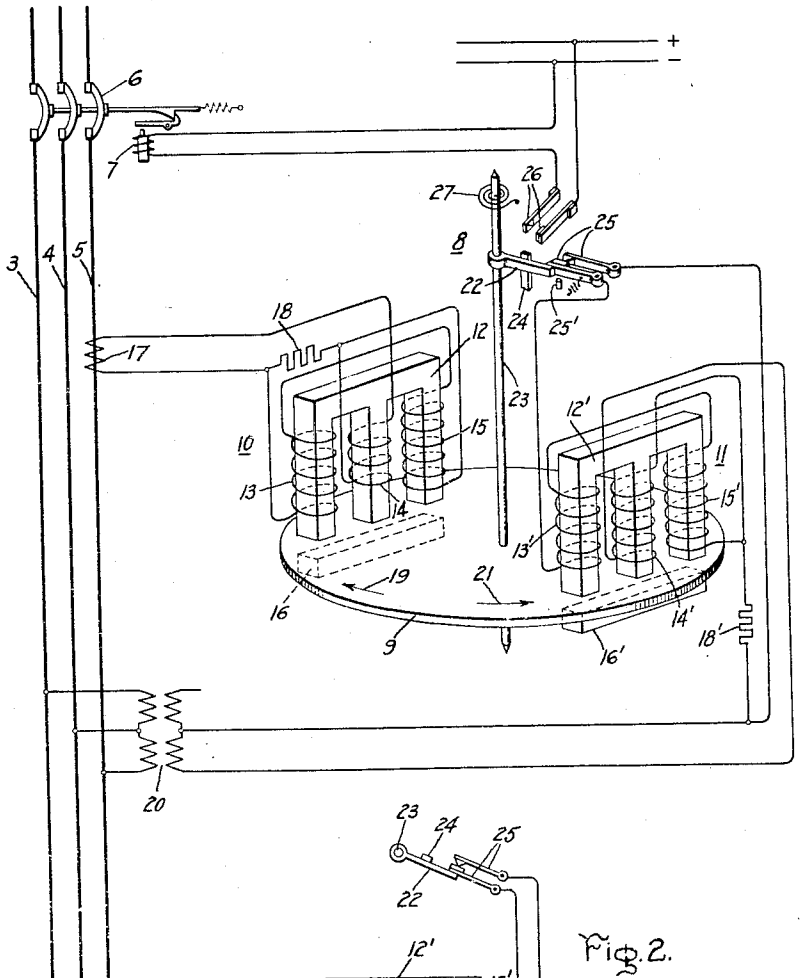
May 28, 1929. J. BIERMANNS 1,714,940

PROTECTIVE APPARATUS

Filed Feb. 28, 1928

Fig. 1.



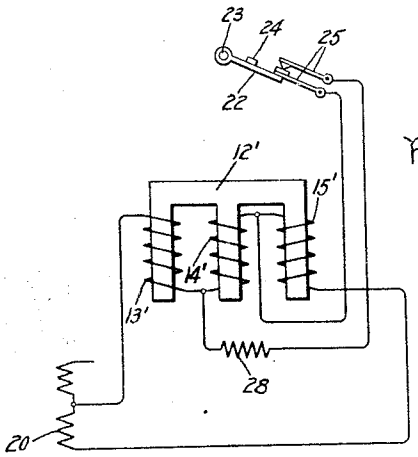


Fig. 2.

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UNITED STATES PATENT OFFICE.

JOSEF BIERMANNS, OF KARLSHORST, GERMANY, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

PROTECTIVE APPARATUS.

Application filed February 28, 1928, Serial No. 257,731, and in Germany April 4, 1927.

My invention relates to improvements in protective apparatus, and more particularly to improvements in protective relays for electric circuits and especially relays of the type whose time of operation is dependent on the distance between the relay and the fault point. An object of my invention is to provide improved protective apparatus whereby on the occurrence of abnormal circuit conditions so to change the mode of operation as to obtain an improved time characteristic.

My invention will be better understood from the following description when considered in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Fig. 1 illustrates partly in diagram and partly in perspective an embodiment of my invention, and Fig. 2 illustrates diagrammatically a modification of a part of my invention.

Relays whose time of operation or release is dependent on the circuit current and voltage to get operation in such a manner that with a reduction in voltage operation may take place in a shorter time and/or at a lower current, are known. Apparatus embodying my invention, however, operates in accordance with the following principles. If a force or a torque dependent on the current of a circuit is exerted on a movable member such as a Ferraris disk and is opposed by a torque dependent on the voltage so as to be at rest normally, then the current necessary to move the disk against the voltage torque is dependent on the ratio of the current to the voltage. If the disk, when actuated by the current torque, is damped by eddy currents produced in it and dependent on the voltage, then the speed of the disk is also dependent on this condition. On the movement of the disk the direct torque exerted by the voltage should be negligible in comparison with the damping torque and the direct torque may be made entirely ineffective at the moment motion begins.

If the forces exerted by the current and voltage vary proportionally therewith, then proportionality is also obtained between a current to which the device responds and the time of operation on the one hand and the distance on the other, that is to say, the time is directly proportional to the current and inversely proportional to the voltage. This, however, is not always desirable and the characteristic can be in accordance with other functions than the first power, for example, the second power.

Relays in which a Ferraris disk is controlled by a current magnet and a voltage magnet are known. Since, however, in these the effect of the voltage magnet is based on the constant production of the opposing direct torque, the time of operation is dependent on the difference between the torques produced by the current and the voltage. A characteristic dependent on the ratio of the current and the voltage is, however, not obtained with such an arrangement.

In the embodiment of my invention shown in Fig. 1 an electric circuit having conductors 3, 4 and 5 is arranged to be controlled by a circuit breaker 6 herein shown as of the latch closed type and provided with a trip coil 7. The circuit of the trip coil is arranged to be controlled in accordance with my invention by protective apparatus such as a relay 8 whose mode of operation is subject to change on the occurrence of abnoral circuit conditions.

The relay 8 as shown comprises a movable element, such as a rotatable electric current conducting member or Ferraris disk 9, the movement of which is arranged to be controlled by a plurality of electromagnetic means such as motor elements 10 and 11 which as shown are inductively related to the member. The motor element 10 is responsive to a current of the circuit 3, 4, 5 and includes, as shown, a magnetic core 12 provided with windings 13, 14 and 15 and a cooperating magnetic member 16. The windings 13, 14 and 15 are connected to be energized in accordance with the current in a conductor 5 of the circuit by any suitable means such as the current transformer 17, suitable phase displacing means such as the resistor 18 being connected in circuit with the windings such as 13, 14, 15. This motor element 10 may be constructed as set forth in German Patent 316,599 so as to provide a torque which is substantially proportional to the first power of the current. As pointed out in this patent, this may be done by having the magnetic circuit of one of the windings such as 14 arranged to become saturated at some predetermined current, for example, normal line current. The motor element 10 exerts a torque which tends to turn the disk 9 in the direction indicated by the arrow 19.

The motor element 11 as shown may be similar in construction to motor element 10, that is comprising a magnetic member 12′ whose branches are provided with windings 13′, 14′, 15′ and a cooperating magnetic member 16′. Windings 13′, 14′ and 15′ are connected to be energized in accordance with a voltage of the circuit 3, 4, 5, such as the voltage between phase conductors 4 and 5 by any suitable means herein shown as a potential transformer 20. Suitable phase displacing means such as a resistance 18′ may be placed in circuit with the windings 13′, 14′, 15′. The motor element 11 normally exerts a direct torque which opposes the torque of the current element 10 and tends to turn the disk in the direction indicated by the arrow 21. Motion in this direction is limited by suitable means such as an extension 22 on the shaft 23 which supports the disk, this extension coming to rest against a stop 24.

In accordance with my invention, the movement of the disk is arranged to control the circuit of one of the windings 13′—15′ of the voltage element 11 so as to change the action thereof from a direct torque to a damping torque, when the current element 10 in response to current of a predetermined value exerts a torque which is sufficient to overcome or predominate the direct torque of the voltage element. For this purpose I may provide in the circuit of the winding 13′—15′ contacts 25 which are arranged to be actuated by the extension 22 so that they are normally closed and are arranged to be opened on the movement of the disk. The extension 22 may also be arranged to control contacts 26 in the circuit of the trip coil 7 after a predetermined movement of the disk in the direction indicated by the arrow 19.

Under normal circuit conditions, the direct torque of the voltage element 11 predominates over the opposing direct torque of the current element 10 to hold the extension 22 in the position shown in Fig. 1 whereby to maintain the circuit of the winding 13′—15′ closed. On the occurrence of a fault, involving, for example, the conductor 5 of the circuit 3, 4, 5 and causing the current to rise and usually the voltage to fall, the direct torque of the current element 10 predominates to overcome the direct torque of the voltage element 11 and thereby effects movement of the disk in the direction indicated by the arrow 19. On the initial movement of the disk, the extension 22 releases one of the contacts 25 and thereby open circuits the winding 13′—15′, circuit opening movement being limited by a stop 25′. In this way the motor element 11 is changed from a direct torque device to a damping torque device whose torque can be made proportional to the voltage by any suitable means. Consequently the disk 9 is turned at a speed which is directly proportional to the torque exerted by the current, that is, proportional to the current and inversely proportional to the damping force or torque exerted by the voltage that is inversely proportional to the voltage. If the disk 9 moves sufficiently for the extension 22 to engage the contacts 26, then the energization of the trip coil 7 and the release of the circuit breaker 6 is effected. In order to restore the disk 9 from the tripping to the normal or rest position a small counter-force or torque means such as a spring 27 may be provided.

The contacts 25 may be used to change the operation of the voltage element from a direct torque device to a damping torque device in a manner different from that shown in Fig. 1. For example, as shown in Fig. 2, the circuit of suitable phase displacing devices such as an impedance 28 may be controlled in any suitable manner to effect a change from a direct torque to a damping torque so as to obtain the desired characteristic. Thus in Fig. 2 it will be noted that when the contacts 25 are opened all three of the windings 13′, 14′, 15′ are effective to produce damping flux as compared with only one winding in Fig. 1.

While I have shown and described my invention in considerable detail, I do not desire to be limited to the exact arrangements shown, but seek to cover in the appended claims all those modifications that fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. In a protective relay for an electric circuit, a movable electric current conducting member, electroresponsive means for moving the member in one direction, electromagnetic means inductively associated with the member and arranged normally to exert thereon a direct opposing action tending to prevent movement of the member in said direction by said electroresponsive means, and means arranged to be operated on movement of the member in said direction to change the action of said electromagnetic means from a direct opposing action to an action dependent on the speed of the member.

2. In a protective relay for an electric circuit, a rotatable electric current conducting member, electroresponsive means for turning the member in one direction, electromagnetic means inductively associated with the member and arranged normally to exert thereon a direct torque tending to prevent movement of the member in said direction by said electroresponsive means, and means arranged to be operated on rotation of the member in said direction to change the action of said electromagnetic means from a direct torque to a damping torque.

3. A relay including a rotatable electric current conducting member and means for controlling the movement thereof, including

a plurality of electromagnetic means arranged to exert opposing torques on the member, one of said means being inductively related to the member, and means operative in response to the movement of the member when the torque of the other means is predominant for changing the action of said one of said means from a direct torque to a damping torque.

4. A relay including a rotatable electric current conducting member and means for controlling the movement thereof, including a plurality of electromagnetic motor elements inductively associated with the member and arranged to exert thereon opposing direct torques, and means operative in response to the movement of said member when the torque of one of said elements predominates over the torque of the other for changing the action of the other element from a direct torque to a damping torque.

5. A relay including a rotatable electric current conducting member and means for controlling the movement thereof including a plurality of electromagnetic motor elements inductively associated with the member and arranged to exert thereon opposing direct torques, and means operative in response to the movement of the member when the torque of one of said elements predominates over the torque of the other to control the circuit of a winding of said other element whereby to cause said other element to operate as a damping magnet.

6. In combination with an electric circuit, circuit controlling means including a protective relay having a rotatable electric current conducting member, and means for controlling the movement thereof including a plurality of electromagnetic means inductively associated with the member, one being arranged to be energized in accordance with the current of the circuit and to tend to move the member in one direction and another being arranged to be energized in accordance with the voltage of the circuit normally to exert a direct torque on the member whereby to prevent movement thereof until overcome by said current energized means on the occurrence of an over-current condition, and means responsive to the movement of the member for changing the action of said electromagnetic means from a direct torque to a damping torque.

7. In a protective relay for an electric circuit, a rotatable electric current conducting disk and means for controlling the movement thereof including a plurality of electromagnetic motor elements inductively associated with the disk, one of said elements being arranged when energized to exert a torque tending to move the member in one direction and the other of said elements being arranged when energized normally to exert a direct torque on the disk for preventing movement thereof in said direction, and means arranged to be operated on movement of the member in said direction to change the action of said other element from a direct torque to a damping torque.

8. In combination, an electric circuit and circuit controlling means including a protective relay having a rotatable electric current conducting member and electroresponsive means for controlling the movement thereof, including a plurality of electromagnetic means arranged to exert on the member opposing torques respectively dependent on the current and the voltage of the circuit, said voltage responsive means being inductively related to the member, and means operative in response to the movement of the member when the torque of the current responsive means predominates for changing the action of the voltage responsive means from a direct torque to a damping torque.

In witness whereof, I have hereunto set my hand this 10 day of February, 1928.

JOSEF BIERMANNS.