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2,253,314

TIME DELAY RELAY

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FIG. 1

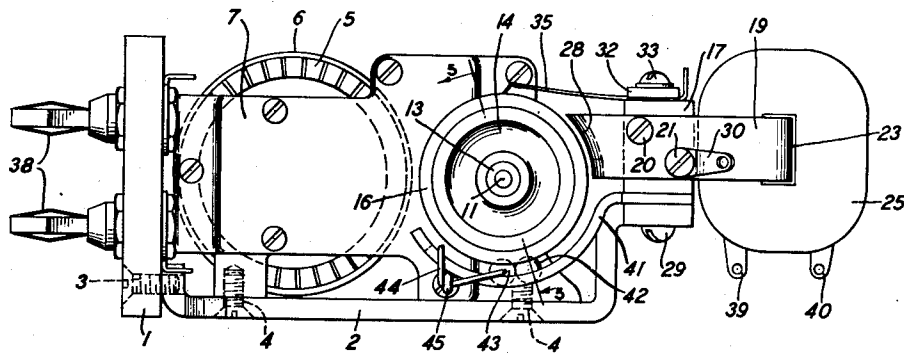


FIG. 2

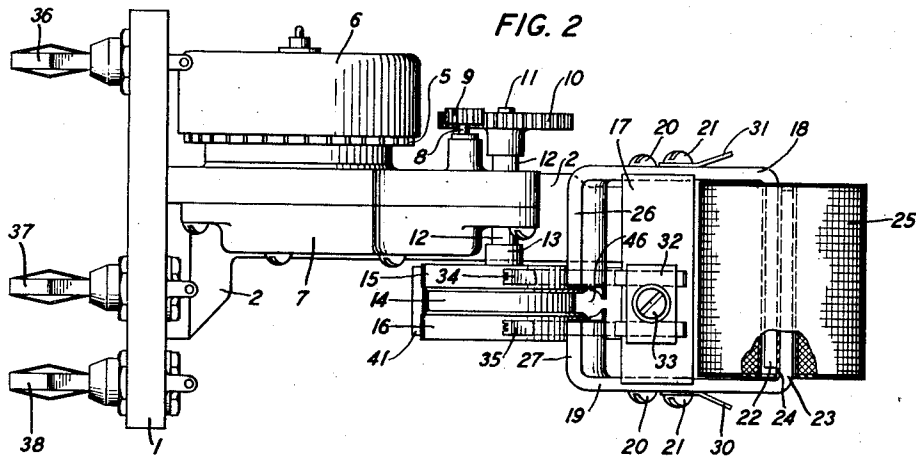


FIG. 3

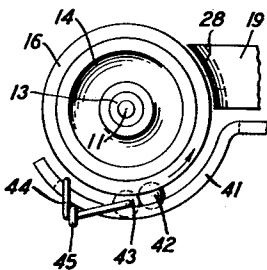


FIG. 4

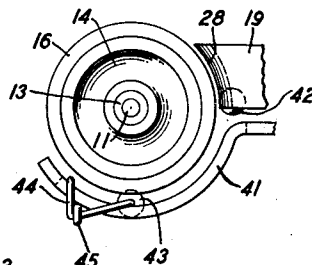
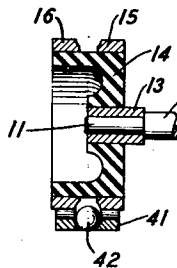


FIG. 5



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## UNITED STATES PATENT OFFICE

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## TIME DELAY RELAY

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This invention relates to a relay and more particularly to a relay of the type which closes its work circuit a predetermined interval after its energizing circuit is closed.

It is a well-known expedient to render a relay 5 slow to operate by providing a short-circuited winding on its core whereby the relay armature is delayed in its attracted movement, thereby delaying the closure of the work circuit over the armature operated contact springs. For the measurement of short delay intervals which do not require accurate limitation, this type of relay structure has been found to be very satisfactory. When, however, longer delay intervals are to be measured and a more accurate timing of the intervals is required, this type of relay is not adequate. Other types of delay relays have heretofore been devised which permit longer delay intervals to be attained with a measure of accuracy but they have been complex in structure and, therefore, expensive to manufacture and have required comparatively large operating currents.

It is, therefore, the object of the present invention to provide a delay relay which is simple and compact in structure, which will operate accurately under changes in temperature, humidity and under fluctuations in operating voltage, which is easily adjustable with respect to the delay interval desired and which, because of its simplicity, is inexpensive to manufacture and to maintain in efficient service.

In accordance with the invention, the aforesaid object is attained by providing a relay structure which comprises an operating electromagnet having two fixed pole-pieces electrically insulated from each other and two rotatable annular pole-pieces mounted on a hub of insulating material and thereby electrically insulated from each other. The rotatable pole-piece assembly is mounted on a shaft which is rotated at a slow speed through reduction gearing by a small synchronous alternating current motor. The peripheries of the rotatable pole-pieces are positioned adjacent to the ends of the fixed pole-pieces and separated therefrom by narrow air-gaps which electrically insulate them from the fixed pole-pieces. Positioned concentrically beneath the rotatable pole-pieces is an arcuate runway, one end of which is supported beneath the fixed pole-pieces and on which a movable armature is positioned normally out of engagement with the rotatable pole-pieces. An adjustable back stop is provided on the runway for determining the normal position of the armature. 55

Brushes are also provided which engage the rotatable pole-pieces.

The relay functions in the following manner: When the magnet coil is energized, the fixed pole-pieces become magnetized, in turn magnetizing the rotatable pole-pieces associated therewith, whereupon the movable armature is attracted off the runway into engagement with the rotatable pole-pieces, thereby closing a circuit from a source of commercial alternating current through the motor over the brushes and rotatable pole-pieces. With the circuit of the motor closed, the pole-pieces are rotated at a slow speed carrying the armature upwardly toward the fixed pole-pieces. When thereafter the rotatable pole-pieces have rotated sufficiently to carry the armature to a position adjacent to the air-gap between the fixed pole-pieces, between which the flux density is greater than the flux density between the rotating pole-pieces, the attracting force holding the armature in engagement with the rotating pole-pieces is overcome and the armature is attracted from them into engagement with the fixed pole-pieces. The fixed pole-pieces are now conductively bridged by the armature, thereby closing the work circuit of the relay. As soon as the armature is disengaged from the rotating pole-pieces, the motor circuit is opened and the rotation of the pole-pieces is arrested. The work circuit now remains closed so long as the magnet coil is maintained energized. As soon, however, as the magnet coil becomes deenergized, the armature is released and returns along the runway until it again engages the back stop.

By selecting the reduction ratio of the motor gearing and by adjusting the position of the back stop, the delay interval between the time the magnet coil is energized and the time the work circuit is closed may be altered between wide limits, it being possible, for example, to obtain a maximum delay of sixty seconds and a minimum delay of seven seconds with one choice of gearing and a maximum delay of three seconds and a minimum delay of four-tenths of a second with a second choice of gearing.

The invention having been described in a general manner, reference may now be had for a more comprehensive understanding thereof to the following detailed description taken in connection with the accompanying drawing in which:

Fig. 1 is a side elevational view of a relay embodying the invention;

Fig. 2 is a top plan view of the relay;

Fig. 3 is a detail view showing the rotating and fixed pole-pieces, the runway and back stop and the armature in its normal position on the runway;

Fig. 4 is a detail view similar to Fig. 3 showing the armature in the position to which it has been moved by the rotation of the pole-pieces and attracted into engagement with the fixed pole-pieces; and

Fig. 5 is a cross-sectional view of the rotating pole-piece assembly, runway and armature taken along section lines 5—5 of Fig. 1.

The relay is provided with a base member 1 of insulating material having a supporting bracket 2 secured thereto by screws, such as 3. Secured to the horizontal arm of bracket 2 by screws 4 and to the base member 1 by screws (not shown) is a motor assembly which comprises a synchronous alternating current motor 5 which may, for example, be of the type employed for driving electric clocks, mounted within the cylindrical housing 6 and a speed reduction gearing (not shown) positioned within the divided housing 7 whereby the motor drives the shaft 8. Positioned on the shaft 8 is a pinion gear 9 which meshes with gear 10 which in turn is secured to one end of a shaft 11, journaled in bearings 12 secured to the two halves of the housing 7. Thus through the reduction gearing within the housing 7 and through the reduction gears 9 and 10, the motor is enabled to drive the shaft 11 at a slow speed.

Secured to the other end of the shaft 11 is a rotatable pole-piece assembly which comprises the metal hub portion 13, a web portion 14 of insulating material and two rings 15 and 16 of magnetic material supported in parallel spaced relationship on the periphery of the web portion 14. The rings 15 and 16 and the hub 13 may, if desired, be assembled in a suitable die and the insulating material then molded into the die to form the web 14 or the rings, hub and web portion may be separately made, machined and assembled together.

The free end of the bracket 2 is extended upwardly and then outwardly as a support for the magnet assembly. This assembly comprises a rectangular block 17 of suitable insulating material to the opposite ends of which two U-shaped fixed pole-pieces 18 and 19 are secured by screws 20 and 21. The outer arms 22 and 23 of these pole-pieces overlap each other as disclosed in Fig. 2 and are electrically insulated from each other by the interposed strip 24 of insulating material. Supported on these overlapping pole arms and surrounding them is an energizing coil 25 having terminal lugs 39 and 40. The other arms 26 and 27 of the pole-pieces extend in alignment toward each other with their inner ends separated by the air-gap 46. These arms are shaped to provide cylindrical surfaces which are concentric with the outer peripheries of the rotatable pole-piece rings 15 and 16 and are electrically separated therefrom by the narrow air-gaps 28. The magnet assembly is secured to the out-turned end of the bracket 2 by screws 29 which extend through holes in the bracket into threaded holes in the block 17.

Secured beneath the heads of screws 21 and in conductive engagement with the fixed pole-pieces 18 and 19 are two terminal lugs 30 and 31 which serve as terminals for the work circuit controlled by the relay. Since the pole-pieces 18 and 19 are insulated from each other by the block 17 and by the insulating strip 24, there

is normally no circuit path between the terminal lugs 30 and 31.

Mounted on the upper face of the block 17 and secured thereto by the insulating clamping plate 32 and by the screw 33 are two brush springs 34 and 35 which engage respectively with the rotatable pole-piece rings 15 and 16.

The base 1 is provided with three pairs of plug terminals 36, 37 and 38 which are insertable into a jack block (not shown) mounted on a relay rack, by means of which the relay is supported on the rack and which afford connection terminals for the relay. One of the pair of plug terminals 36 is connected to one terminal of the motor, the other terminal of which is connected to the brush spring 34 and the other plug terminal of the pair is connected to the brush spring 35. The two plug terminals 37 are connected to the terminal lugs 30 and 31 of the work circuit and the two terminal plugs 38 are connected to the terminal lugs 39 and 40 of the coil 25. To avoid confusion, the wiring conductors have been omitted from the drawing.

Clamped between the end of bracket 2 and the lower face of block 17 by the screws 29 and extending beneath the rotatable pole-piece assembly is an arcuate runway 41, the arcuate portion of which is concentric with the peripheries of the rings 15 and 16 and spaced therefrom. The portion of the runway beneath the pole-piece assembly and extending to a point beneath the inner ends of the arms 26 and 27 of the fixed pole-pieces 18 and 19 is slotted as disclosed more clearly in Fig. 5, in which slot a spherical armature 42 of magnetic material is supported out of normal engagement with the pole-piece rings 15 and 16. In its normal position on the runway, the armature rests against the roller 43 of insulating material which serves as a back stop. The roller 43 is supported on the end arms of a substantially C-shaped wire clip 44, the base of which overlies the upper surface of the runway 41 and the bent side arms of which are united by a cross-wire 45 which underlies the outer surface of the runway. The base of the clip and the roller 43 engaging the upper surface of the runway and the cross-wire 45 pressing firmly against the under surface of the runway, the roller, clip and cross-wire constitute a back stop structure which may be adjusted to any desired position along the runway and be retained thereon in its adjusted position.

As disclosed in Figs. 2 and 5, the inner peripheral edges of the pole-piece rings 15 and 16 are beveled to conform to the spherical surface of the armature 42 when the armature is attracted thereto and these beveled surfaces are normally separated from the spherical surface of the armature by a narrow air-gap. As disclosed in Fig. 2, the lower edges of the arms 26 and 27 of the fixed pole-pieces 18 and 19 are formed to provide an arcuate-shaped air-gap 46. Since, as hereinafter described, conductive paths are established during the operation of the relay between the brushes 34 and 35 and the rings 15 and 16, between the rings and the armature 42 and between the armature 42 and the arms 26 and 27 of the fixed pole-pieces 18 and 19, the peripheral surfaces of the rings, the surface of the armature and the arcuate-shaped ends of the fixed pole-piece arms 26 and 27 may be plated with a metal having good conductivity, such, for example, as gold, silver or rhodium.

The structure of the relay having been described, the operation thereof will now be dis-

cussed. When the circuit from the terminal plugs 38, through the coil 25 is closed, the fixed pole-pieces 18 and 19 become oppositely magnetized and, since the arms 26 and 27 thereof are separated from the rotatable pole-piece rings 15 and 16 by only narrow air-gaps 28, the rings 15 and 16 also become oppositely magnetized and attract the spherical armature 42 off the runway 41 from the position illustrated in Figs. 1 and 3, into engagement with such rings. Since the armature now conductively bridges the rings, the circuit of the motor is closed from one terminal of a source of alternating current, which may be, for example, a source of 60-cycle, 110-volt commercial current, over one of the plug terminals 36 through the field winding of the motor to the brush 34, through the ring 15 engaged thereby, the armature 42, the ring 16, brush 35 engaged therewith to the other plug terminal 36 and thence to the other terminal of the source of alternating current. The motor is thereupon energized and through the reduction gearing rotates the rotatable pole-piece assembly at a slow speed in the direction indicated by the arrow in Fig. 3.

By the rotation of the pole-piece assembly, the armature 42 is moved until it enters the magnetic field between the arcuate surfaces of the ends of the fixed pole-piece arms 26 and 27 and, since the flux density across the ends of these arms through the armature is now greater than the flux density between the rings 15 and 16 through the armature, the armature is snapped into engagement with the fixed pole-piece arms and out of engagement with the rings 15 and 16, thereby opening the circuit of the motor to arrest the further rotation of the rotatable pole-piece assembly. The position assumed by the armature at this time is illustrated in Fig. 4. Since now the ends of the arms of the fixed pole-pieces 18 and 19 are conductively bridged by the armature 42, the work circuit of the relay is established from one of the terminal plugs 37 to the terminal lug 31 through the pole-piece 18, armature 42, pole-piece 19, terminal lug 30 and thence to the other terminal plug 37.

This work circuit will now remain closed so long as the coil 25 remains energized. When the coil is deenergized the flux ceases to flow through the fixed pole-pieces 18 and 19 and the armature and the armature is released and rolls along the runway 41 guided by the slot thereof until it comes to rest in its normal position against the back stop roller 43 in which position the relay is conditioned for reoperation. Since the armature rolls down the runway quickly, the relay is susceptible of quick recycling, unaffected by previous operation or the non-completion of the delay interval.

Since the delay interval measured between the time of energization of the coil 25 and the closure of the work circuit by the engagement of the armature with the ends of the fixed pole-pieces is a function of the speed of rotation of the rotatable pole-piece assembly and a function of the adjusted position of the back stop, this delay interval may be varied either by the adjustment of the back stop or by changing the speed of rotation of the pole-piece assembly. For example, with one reduction ratio between the gears 9 and 10, the back stop structure, if adjusted to the extreme left end of the runway 41 as viewed in Fig. 1, will produce a maximum delay interval of sixty seconds or, if adjusted to the extreme right end of the runway, will produce a

minimum delay interval of seven seconds. If gears 9 and 10 are provided with a smaller reduction ratio, the time delay interval may be changed by the adjustment of the back stop, for example, from a maximum of three seconds to a minimum of four-tenths of a second. It is thus apparent that the relay is easily adaptable for securing a wide range of delay intervals. Furthermore, since the driving motor always operates at a substantially invariable speed, it is possible to adjust the back stop to accurately secure a delay interval which will also be substantially invariable. Furthermore, since the mass of the armature is small and the reluctance of the magnetic circuit is low, the relay requires a small current to insure its positive operation.

Although a spherical armature has been illustrated, it will be obvious that it might be in the form of a roller, the runway in that case being so constructed as to guide it in its return movement towards the back stop. If a back contact for the relay should be desirable, the runway could be constructed as two parallel sections insulated from each other which would be bridged by the armature so long as it rested upon them.

What is claimed is:

1. In a time delay relay, an electromagnet having an energizing coil, a pair of electrically insulated fixed pole-pieces associated with said coil, a pair of electrically insulated rotatable pole-pieces the peripheries of which are separated from said fixed pole-pieces by narrow air-gaps, an arcuate runway concentrically positioned beneath said rotatable pole-pieces, an adjustable back stop on said runway and a spherical armature normally positioned on said runway in engagement with said back stop and attractable to said rotatable pole-pieces by the energization of said coil, whereby said armature is carried by said rotatable pole-pieces to a position adjacent to the ends of said fixed pole-pieces and is thereby attracted into engagement with said fixed pole-pieces to conductively connect them.

2. A time delay relay having an energizing coil and pairs of electrically insulated fixed and rotatable pole-pieces, a motor for rotating said rotatable pole-pieces, a runway positioned concentrically beneath said rotatable pole-pieces and having an adjustable back stop thereon, and a spherical armature positioned on said runway and attractable to the rotatable pole-pieces by the energization of said coil for closing the motor circuit whereby said armature is carried by the rotation of said rotatable pole-pieces to a position adjacent to the ends of said fixed pole-pieces whereupon it is attracted out of engagement with said rotatable pole-pieces to open said motor circuit and into engagement with said fixed pole-pieces to close a work circuit, said armature rolling back along said runway to said back stop upon the deenergization of said coil.

3. A time delay relay having an energizing coil and pairs of electrically insulated fixed and rotatable pole-pieces, brushes engaging with said rotatable pole-pieces, a motor for rotating said rotatable pole-pieces, a runway positioned concentrically beneath said rotatable pole-pieces and having an adjustable back stop thereon, and a rolling armature positioned on said runway and attractable to said rotatable pole-pieces by the energization of said coil for closing the motor circuit over said rotatable pole-pieces and said brushes, whereby said armature is carried by the rotation of said rotatable pole-pieces to a position adjacent to the ends of said fixed pole-pieces

whereupon it is attracted out of engagement with said rotatable pole-pieces to open said motor circuit and into engagement with said fixed pole-pieces to close a work circuit, said armature rolling back along said runway to said back stop upon the deenergization of said coil.

4. A time delay relay having an energizing coil and pairs of electrically insulated fixed and rotatable pole-pieces, a motor for rotating said rotatable pole-pieces, a slotted runway positioned concentrically beneath said rotatable pole-pieces and having an adjustable back stop thereon, a spherical armature positioned on said runway and attractable to said rotatable pole-pieces by the energization of said coil for closing the circuit of said motor whereby said armature is carried by the rotation of said rotatable pole-pieces to a position adjacent to the ends of said fixed pole-pieces whereupon it is attracted out of engagement with said rotatable pole-pieces to open said motor circuit and into engagement with said fixed pole-pieces to close a work circuit, said armature being released by the deenergization of said coil to roll back along said runway guided by said slot into engagement with said back stop.

5. In a time delay relay, an electromagnet having an energizing coil, a pair of electrically in-

5 insulated fixed pole-pieces the ends of which are separated by a narrow air-gap and which serve as the terminals of a work circuit, and a pair of electrically insulated rotatable pole-pieces the peripheries of which are separated from said fixed pole-pieces by narrow air-gaps, a motor for rotating said rotatable pole-pieces, an arcuate runway concentrically positioned beneath said rotatable pole-pieces and having an adjustable back stop thereon, a spherical armature positioned on said runway in engagement with said back stop out of engagement with said rotatable pole-pieces and attractable into engagement therewith by the energization of said coil, and a circuit for said motor closed upon the engagement of said armature with said rotatable pole-pieces whereby said pole-pieces are rotated to carry said armature to a position adjacent the air-gap between said fixed pole-pieces, said armature thereupon being attracted into engagement with said fixed pole-pieces to close said work circuit and out of engagement with said rotatable pole-pieces to open said motor circuit, said armature returning along said runway to its normal position upon the subsequent deenergization of said coil.

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