Sept. 2, 1947. A. HUFNAGEL 2,426,970

ELECTRICAL RELAY

Filed June 28, 1944 3 Sheets-Sheet 1

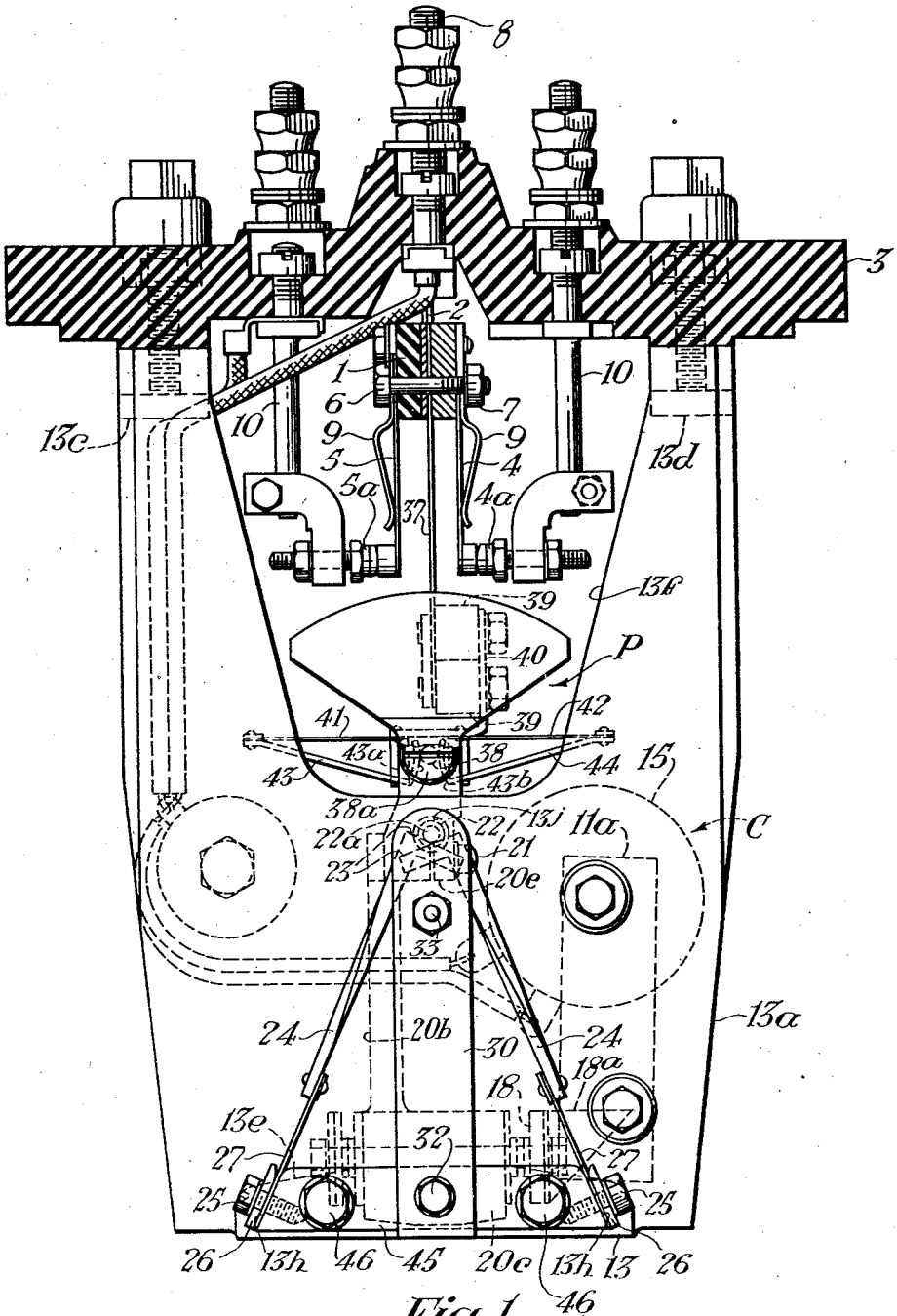


Fig. 1.

INVENTOR
Andrew Hufnagel.

BY

HIS ATTORNEY

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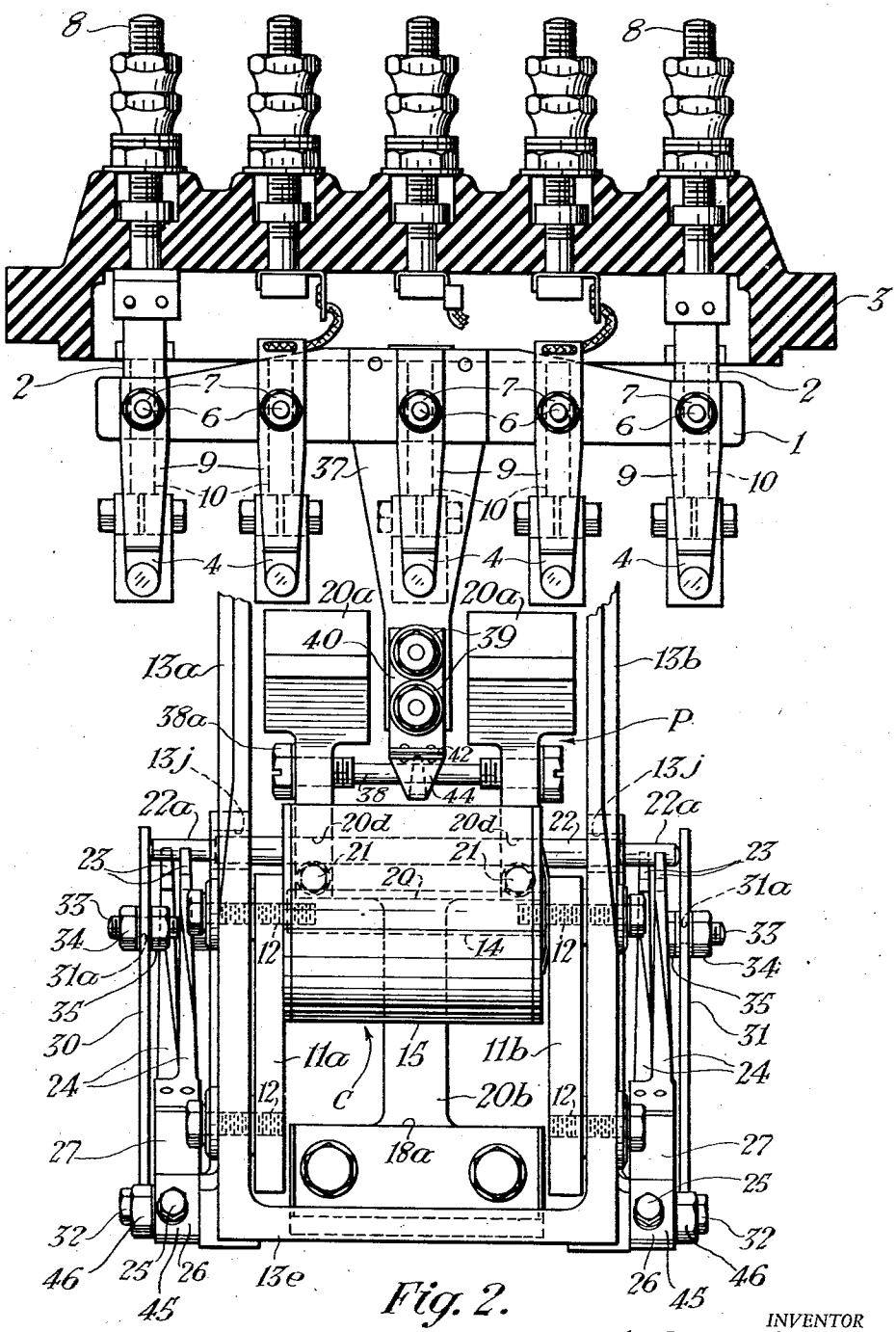


Fig. 2.

INVENTOR
Andrew Hufnagel

BY

HIS ATTORNEY

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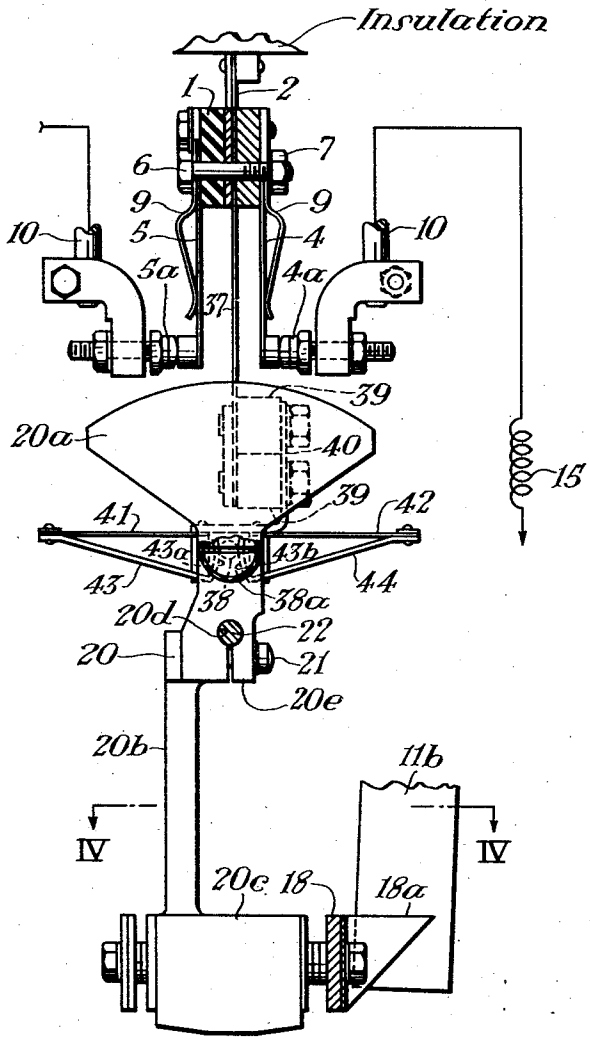


Fig. 3.

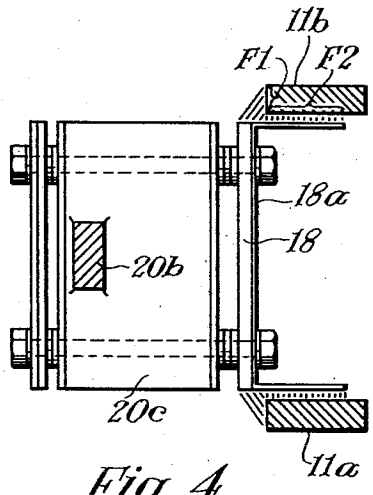


Fig. 4.

INVENTOR
Andrew Hufnagel.

BY

HIS ATTORNEY

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UNITED STATES PATENT OFFICE

2,426,970

ELECTRICAL RELAY

Andrew Hufnagel, Penn Township, Allegheny County, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application June 28, 1944, Serial No. 542,561

4 Claims. (Cl. 172—126)

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My invention relates to electrical relays, and particularly to electrical relays which are suitable for use in railway signaling systems employing for the control of signaling devices current which is periodically interrupted or coded at different frequencies in accordance with traffic conditions.

More particularly, my present invention relates to relays of the type described in Letters Patent of the United States No. 2,300,790, granted to Robert M. Laurenson on November 3, 1942, in which the rate of operation of the relay when the relay is energized is determined by the period of oscillation of a relatively massive compound pendulum, and one object of my present invention is to provide an improved bearing for supporting the pendulum in relays of the type disclosed in said patent, which bearing shall have negligible friction and extremely long life.

Another object of my invention is to provide a bearing for supporting the pendulum in relays of the type described, which bearing will be inexpensive to manufacture and install, and which will not require any maintenance throughout the life of the relay.

Another object of my invention is to provide improved means for operatively connecting the pendulum of relays of the type described with the contact carrying rocker of the relay.

A further object of my invention is to provide means to limit the amplitude of the pendulum while oscillating, and at the same time enable the pendulum to start oscillating at a relatively low energization of the relay.

According to my invention the bearing comprises a horizontal shaft which is secured intermediate its ends to the pendulum and which is provided at each end with a trunnion supported on bearing tracks formed on the upper ends of bearing arms the lower ends of which arms each include a flexible supporting strip. The bearing arms are inclined toward the shaft so that the planes of the arms intersect substantially at the axis of the associated trunnion, and the bearing tracks are so disposed that they are substantially normal with respect to the plane of the arms. When the pendulum is moved in either direction from its gravity biased position, frictional adhesion between the trunnions and bearing tracks causes the tracks to move with the trunnions in

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such manner that substantially pure rolling motion results, the necessary motion of the tracks being permitted by the flexing of the flexible strips of the bearing arms. End play of the pendulum is limited by adjustable positioning members which cooperate with the ends of the trunnions, while excessive vertical displacement of the pendulum is prevented by holes in the frame which serves as a support for the relay parts and which holes receive the shaft between the trunnions with some clearance.

The pendulum is operatively connected with a rocker which carries the contacts of the relay through the medium of a semi-flexible arm which is secured to and depends from the rocker. An angle bracket is mounted on the lower end of this arm by means of insulating supports and has attached to the horizontal portion thereof two flexible supporting strips which extend transversely of the relay directly above a circular driving rod secured to the pendulum some distance above the pivotal axis of the pendulum. Each of these strips carries a rigid finger which extends downwardly from the free end of the strip at a slight angle toward the other finger and which is provided at its free end with a curved surface which cooperates with the driving rod. The parts are so proportioned that the two curved surfaces are held in frictional engagement with the opposite sides of the driving rod by a slight flexing of the supporting strips and that as the pendulum oscillates the movement of the pendulum will cause the rod to roll around the curved surfaces of the fingers and thus transmit the motion of the pendulum through the fingers to the flexible supporting strips, and thence through the angle bracket and the depending arm to the rocker whereby the rocker is caused to oscillate in synchronism with the oscillations of the pendulum.

The pendulum is caused to oscillate by an electromagnet energized over certain ones of the relay contacts, and provided with pole pieces which cooperate with an armature attached to the pendulum. Associated with the armature is a U-shaped extension of soft steel which is thin enough to saturate under starting conditions, and which acts to change the inductance of the electromagnet with changes in amplitude of the pendulum in a manner which tends to limit the pendulum amplitude.

Other objects and characteristic features of my invention will become apparent as the description proceeds.

I shall describe one form of electrical relay embodying my invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a view partly in side elevation and partly in section showing one form of relay embodying my invention. Fig. 2 is a side elevational view of the relay shown in Fig. 1 taken at right angles to Fig. 1. Fig. 3 is a view partly in elevation, partly in section and partly diagrammatic of certain parts of the relay shown in Figs. 1 and 2. Fig. 4 is a sectional view taken on the line IV—IV of Fig. 3.

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

Referring to the drawings, the relay here shown is generally similar to the relay described and claimed in the aforementioned Laurenson Patent No. 2,300,790 except for the bearing means presently to be described for supporting the compound pendulum of the relay, and certain other improvements which will also be described presently.

The relay as shown comprises a contact carrying rocker 1 of suitable insulating material, such as a phenol condensation product, suspended by means of flexible strips 2 from a top plate 3, also of suitable insulating material. The rocker 1 is provided with a plurality of flexible contact fingers 4 and 5, each of which cooperates with a fixed contact member 4*a* or 5*a* to close a contact 4—4*a* or 5—5*a* according as the rocker is swung to one or the other of its extreme positions. The contacts are disposed in pairs and are secured to the opposite sides of the rocker within vertical grooves which maintain the fingers in the desired vertical positions by means of bolts 6 which extend through suitable holes in the rocker and the fingers and are secured in place by nuts 7. The bolts 6 also serve to secure the lower ends of the strips 2 to the rocker thereby electrically connecting the fingers with the strips. The upper ends of the strips are secured to the heads of terminal posts 8 mounted on the top plate 1. The positions of the flexible fingers when the fingers are out of engagement with the associated fixed contact members are determined by means of stops 9 which are clamped against the outer faces of the fingers by means of the associated bolts 6 and which are so adjusted by bending them that the fingers will break the contacts in the desired positions in response to the swinging movement of the contact carrying rocker 1.

The fixed contact members 4*a* and 5*a* are similar to the fixed contact members 18*a* and 19*a* described and claimed in Letters Patent of the United States No. 2,285,890, granted to Herman G. Blosser on June 9, 1942, for Electrical relays, and are adjustably secured to the lower ends of terminal studs 10 mounted on the top plate on opposite sides of the terminal post 8 in a manner which is similar to that described in the said patent. It is believed to be unnecessary, therefore, to describe the construction and arrangement of these fixed contact members any further herein. It should be noted, however, that due to the fact that these fixed contact members are adjustable, the contacts can be readily adjusted to be either open or closed when the rocker is at rest and to close or open at any point in the stroke of the rocker 1.

The relay also comprises motor means for oscillating the rocker between its two extreme positions to alternately operate the contacts at a constant relatively low preselected frequency. As here shown these motor means comprise an electromagnet C having pole pieces 11*a* and 11*b* secured by means of studs 12 to the plate portions 13*a* and 13*b* of a frame 13 in parallel spaced relation and connected together at one end by a core 14 surrounded by a winding 15.

The frame 13 is in the form of a one piece rectangular casting provided at its upper end with spaced parallel arms 13*c* and 13*d* which support the top plate 1, and at its lower end with a connecting portion 13*e*. Substantially V-shaped openings 13*f* are formed in the plate portions below and between the arms to provide access to certain of the operating parts of the relay for inspection or repair.

The pole pieces 11*a* and 11*b* of electromagnet C cooperate at their lower or free ends with a magnetizable armature 18 which is secured to one side of the lower portion or foot of a compound pendulum P, and with a saturable armature extension 18*a* of soft steel which is clamped against the outer face of the armature 18 for a purpose which will be made clear presently.

The compound pendulum P may have any suitable form possessing within the limited space available the necessary mass to cause it to have a natural period equal to the desired code frequency, which may for example be 75 cycles per minute. In the form here illustrated this pendulum comprises a casting consisting of a central horizontal portion 20 provided at its opposite ends with upstanding weight arms 20*a*, and provided intermediate its ends at one side of said horizontal portion with a central depending leg 20*b* terminating at its lower end in a foot 20*c* to which the armature 18 and armature extension 18*a* referred to hereinbefore are secured.

Provided in the arms 20*a* adjacent their lower ends at one side of the central horizontal portion 20 are aligned holes 20*d*, and secured within these holes by means of screws 21 which draw split portions 20*e* of the arms together is a bearing shaft 22 provided at its ends with trunnions 22*a*. The shaft 22 is disposed substantially at the center of gravity of the pendulum, and the trunnions 22*a* each rest on a pair of crossed bearing tracks 23 provided on the upper ends of laterally offset bearing arms 24. The bearing arms are inclined toward the shaft so that the planes of the arms intersect substantially at the axis of the shaft, and are each provided at their lower ends with a flexible supporting strip 27 which is secured at its lower end by means of an associated stud 25 and clamping block 26 to an inclined surface 13*h* formed on a bearing mounting block 45. The blocks 45 are clamped by means of studs 46 against flat surfaces ground on the connecting portion 13*e* of the casting 13. The upper edge of each clamping block 26 is rounded into a gradual curve and the opposite portion of the surface 13*h* is similarly rounded to cause the supporting strip 27 to flex in the form of a gradual curve in response to movement of the bearing arms due to operation of the pendulum. The bearing tracks are so disposed that they are substantially normal to the plane of the arms, and the angles at which the arms are disposed are such and the parts are so proportioned that when the pendulum is moved in either direction from its gravity biased position, the frictional adhesion between the trunnions and bearing tracks will cause the tracks to move with the trunnions in such manner that substantially pure rolling motion results, the necessary

motion of the tracks being permitted by the flexing of the flexible supporting strips. It will be seen, therefore, that oscillation of the pendulum will cause a new line of contact to be formed between each trunnion and each track in each different angular position of the pendulum throughout its entire angular movement.

The pendulum is maintained in the desired longitudinal and lateral position relative to the bearing tracks and to the pole pieces 11*a* and 11*b* by means of adjustable positioning members 30 and 31. These members are secured at their lower ends to the bearing mounting blocks 45 by means of studs 32, and extend upwardly past the trunnions 22*a* to positions a slight distance above the trunnions. Each positioning member is provided intermediate its ends with a hole 31*a* through which a stud 33 secured to the adjacent plate portion 13*a* or 13*b* of the frame extends with some clearance, and mounted on this stud on opposite sides of the positioning member are adjusting nuts 34 and 35. It will be obvious that by adjusting these nuts the upper ends of the positioning members can be moved toward or away from the associated plate portions 13*a* and 13*b* of the frame 13, and these nuts are intended to be so adjusted that when the pendulum is in the proper longitudinal position, the positioning members will just clear the ends of the shaft. To reduce friction and wear the ends of the shaft are rounded and chromium plated, and the upper ends of the positioning members are likewise chromium plated.

Excessive vertical and lateral displacement of the pendulum P from its normal position is prevented by passing the shaft 22 adjacent the inner ends of the trunnions 22*a* through clearance holes 13*j* provided in the plate portions 13*a* and 13*b* of the frame 13. The studs 46 which securing the bearing mounting blocks 45 in place pass through clearance holes in the bearing mounting blocks, and these clearance holes are made sufficiently large so that each bearing assembly may be moved about as a unit before being secured in place an amount which will permit the pendulum shaft to be centered in the holes 13*j*. It will be obvious that the holes 13*j* do not interfere in any way with the normal operation of the pendulum, but that, if due to handling or the like abnormal forces are exerted on the pendulum, the shaft will engage the frame at the edges of the holes and will thus act to limit the displacement of the pendulum to an amount which is insufficient to cause damage to the parts.

The pendulum P is operatively connected with the rocker 1 through the medium of an arm 37 the upper end of which is clamped to the center of the rocker by means of one of the bolts 6. An angle bracket 40 is mounted on the lower end of the arm 37 by means of insulating supports 39, and has attached to the horizontal portion thereof two flexible supporting strips 41 and 42 which extend transversely of the relay above and on opposite sides of a circular drive rod 38 mounted at its ends in aligned sleeves 38*a* screwed through the sides of the arms 20*a* of the pendulum directly above the shaft 22. The supporting strips 41 and 42 support two driving fingers 43 and 44. These fingers are secured to the outer ends of the strips as by riveting, and are inclined downwardly away from the strips and are provided at their free ends with confronting curved surfaces 43*a* and 43*b* disposed on opposite sides of the driving rod 38. The parts are so proportioned that when the pendulum is at rest, the

supporting strips will be bowed just enough to hold the curved surfaces of the driving fingers in frictional engagement with the driving rod, and that when the pendulum is in motion the resulting movement of the driving rod will cause it to move along the curved surfaces of the fingers with a pure rolling motion and thus transmit the motion of the pendulum from the rod through the fingers to the flexible supporting strips and thence through the angle bracket and the depending arm 37 to the rocker, whereby the rocker is caused to oscillate in synchronism with the oscillations of the pendulum. It should be noted that the movement of the driving fingers necessary to permit the driving rod to roll along the curved surfaces results in a flexing of the supporting strips, which strips are made sufficiently flexible to permit the necessary flexing to take place without causing slippage between the driving rod and the driving fingers.

With the pendulum operatively connected with the rocker in the manner just described it will be apparent that rotation of the pendulum in one direction will cause swinging movement of the rocker in the opposite direction, and the parts are further so proportioned that oscillation of the pendulum through its normal amplitude will cause movement of the rocker between its two extreme positions. The length of the pendulum P is such that the armature 18 and armature extension 18*a* are free to swing between the pole pieces 11*a* and 11*b*, and it will be seen, therefore, that energization of the winding 15 will tend to pull the armature 18 between the pole pieces and hence will swing the rocker in a clockwise direction as viewed in Figs. 1 and 3. The energization of the winding 15 may be controlled by one set of the contacts 4—4*a* and 5—5*a* connected in series with the winding, as shown diagrammatically in Fig. 3. The contacts of this particular set are so adjusted that both contacts 4—4*a* and 5—5*a* are closed when the pendulum occupies its gravity biased position but that when the pendulum is swung away from this position, one or the other of these contacts will become opened at a predetermined intermediate point in the stroke of the pendulum depending upon which direction the pendulum is swung.

When the pendulum is at rest and energy is initially applied to the winding 15 magnetic flux will traverse the air gap at each end of the armature. Due to the pole piece extension 18*a* this flux will divide into two parts designated F1 and F2, respectively, in Fig. 4. It is obvious that the flux lines designated F1 will tend to cause the armature to swing between the pole pieces, and if the voltage applied to the winding 15 is above a certain critical value the armature will swing far enough to open the contact 4—4*a*, whereupon the pendulum will start to oscillate. The flux lines designated F2 will not be effective to cause any movement of the armature, and the polar extension 18*a* is so proportioned that it will become saturated at a flux density sufficiently low to prevent the ineffective flux lines from appreciably reducing the value of the effective flux F1.

Once the pendulum has started to oscillate energy will be applied to the winding 15 during each oscillation for the relatively short period of time during which the contacts 4*a* and 5*a* are both closed, and under these conditions the armature extension 18*a* will act to limit the amplitude of the oscillations. The reasons why the extension 18*a* acts to limit the pendulum amplitude are thought to be as follows:

a. The effective pole face area is increased making the electromagnet more inductive, so that its current and the magnetic flux build up more slowly. This is particularly true at the point in the armature stroke in which the contact 4—4*a* just becomes closed since in this position the pole piece extension 18*a* will then be disposed between the pole pieces, whereas if the pole piece extension were omitted the air gap between the armature and the pole pieces would be large and the rise in flux would be correspondingly rapid.

b. When the pendulum is oscillating the flux levels are lower than on starting, and with the lower flux levels, saturation of the armature extension ceases to be a factor. Consequently, a large part of the total flux is diverted through the extension where it is ineffective to exert a torque on the armature. That is to say, the ratio of torque producing to non-torque producing flux is decreased.

It should be noted that while the armature extension as shown is substantially U-shaped with triangular arms or projections the actual shape of the arms is not important provided the arms are kept thin enough to saturate at the proper flux densities.

It will be obvious that oscillation of the pendulum will cause the contacts 4—4*a* and 5—5*a* which are not used to control the energization of the winding 15 to be alternately opened and closed at the frequency of oscillation of the pendulum. These contacts may be used for coding purposes or for any other desired purpose as will be readily understood.

One advantage of a relay embodying my invention is that the bearing structure does not require any oiling and shows almost no detectable wear after long periods of operation.

Another advantage of a relay embodying my invention is that the bearing structure provides accurate centering of the pendulum with respect to the electromagnet and contacts. This prevents variations in the voltage required to start the pendulum oscillating.

A further advantage of a relay embodying my invention is that due to the small amount of friction in the oscillating parts it is highly efficient.

A still further advantage of a relay embodying my invention is that in spite of the small amount of friction in the oscillating parts any tendency of the pendulum to overswing is effectively eliminated, and the pendulum amplitude remains substantially constant over a wide degree of energization of the parts.

Although I have herein shown and described only one form of electrical relay 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 combination, a frame provided with two spaced parallel plate portions connected at their lower end with a connecting portion and provided with aligned holes, a compound pendulum comprising a central horizontal portion provided at its opposite ends with upstanding arms and provided intermediate its ends with a central depending leg terminating at its lower end in a foot, a shaft extending through said arms and through the aligned holes in said plate portions and provided at its ends with trunnions, a pair of bearing arms extending toward each of said trunnions on opposite sides thereof, each said arm being secured at its lower end to the connecting portion of said frame by means of a flexible supporting strip and being provided at its upper end with a bearing track extending normal to the plane of the arm in supporting relation to the associated trunnion, the two tracks on the arms of each pair being laterally offset, the parts being so proportioned that said shaft is normally held clear of said holes by engagement of said trunnions with the associated track but that said shaft will engage said holes and limit vertical displacement of said pendulum in the event of the application of abnormal forces to said pendulum, means for positioning said pendulum endwise comprising two adjusting members secured at their lower ends to said frame and provided intermediate their ends with means for moving said members toward and away from said frame.

2. In an electrical relay, the combination with a rocker mounted for swinging movement between two extreme positions, a pendulum, and motor means for causing said pendulum to oscillate, of means for operatively connecting said rocker with said pendulum comprising a rod secured to said pendulum above its axis of oscillation, an arm secured to said rocker, and two fingers each provided at one end with a curved surface and secured at the other end to the free end of said arm by flexible means in such manner that said curved surfaces are disposed on opposite sides of said rod and are held in frictional engagement with said rod by said flexible means, whereby when said pendlulum is oscillating said rod will move along said curved surfaces with a rolling motion and will act to transmit the oscillations of said pendulum to said rocker.

3. In an electrical relay, the combination with a rocker mounted for swinging movement between two extreme positions, a pendulum, and means for causing said pendulum to oscillate, of a depending arm secured to said rocker, a bracket secured to but insulated from the lower end of said arm, a drive rod secured to said pendulum above its axis of oscillation, two flexible supporting strips secured to said bracket and extending transversely of the relay above and on opposite sides of said drive rod, two driving fingers secured at one end to the free ends of said supporting strips, said strips being inclined downwardly from said supporting strips and being provided at their free ends with confronting surfaces disposed on opposite sides of said driving rod, the parts being so proportioned that when said pendulum is at rest said strips will act to hold the curved surfaces of the driving fingers in frictional engagement with the driving rod and that when the pendulum is in motion the resulting movement of the driving rod will cause it to move along the curved surfaces of said fingers with a pure rolling motion to thereby cause said rocker to oscillate in synchronism with the oscillations of said pendulum.

4. In an electrical relay including an electromagnet provided with spaced pole pieces, a pendulum armature disposed to swing between said pole pieces, contacts controlled by said armature, and means controlled by said contacts for energizing said electromagnet to cause said pendulum to oscillate at its natural period, the combination of an armature extension secured to said armature and extending between said pole pieces, said extension being proportioned to become sat-

urated in response to energization of said electromagnet when said armature is at rest but not when said armature is oscillating.

ANDREW HUFNAGEL.

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