

July 3, 1951

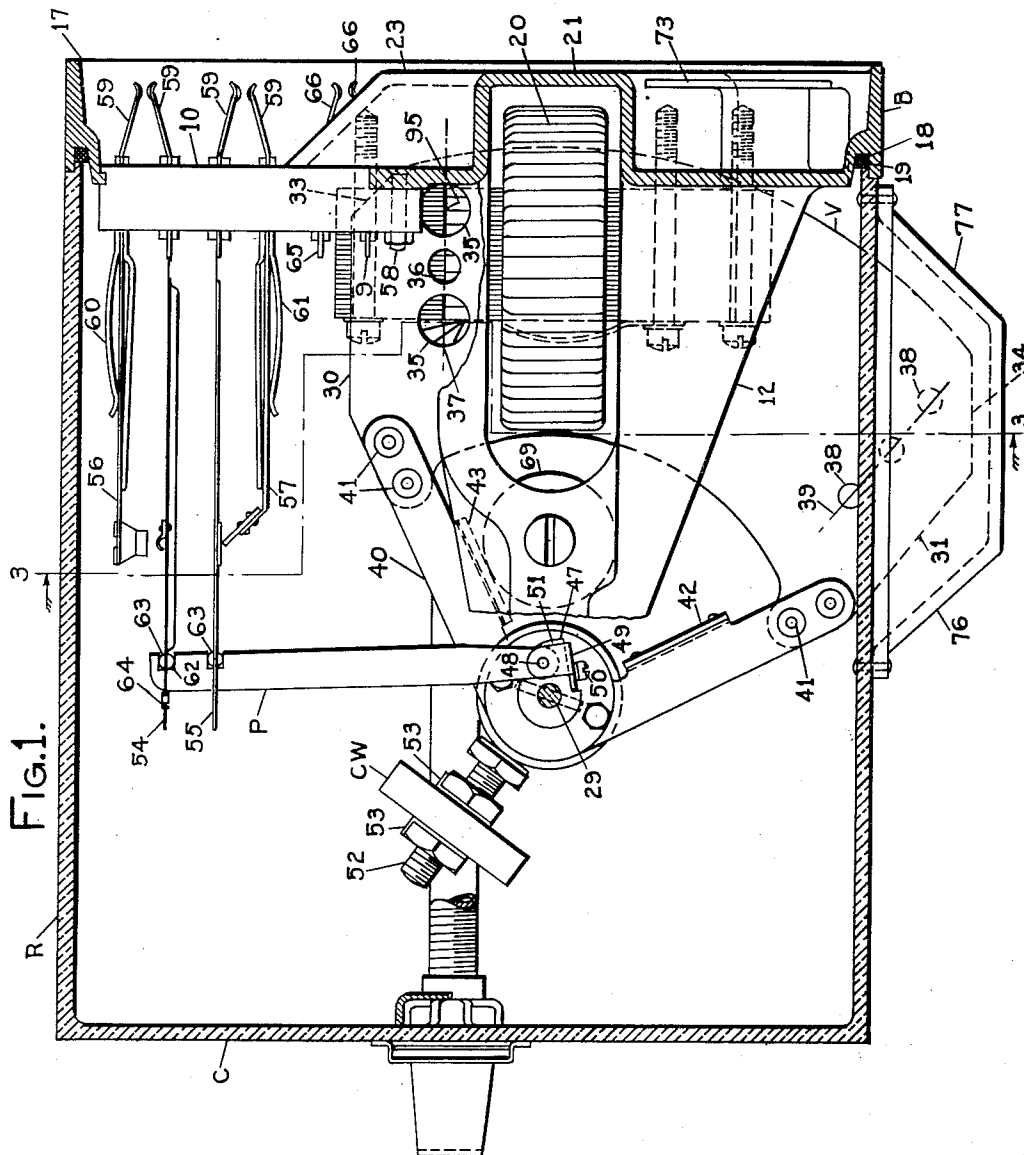
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2,559,448

ALTERNATING CURRENT VANE RELAY

Filed May 24, 1947

3 Sheets-Sheet 1



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FIG. 3.

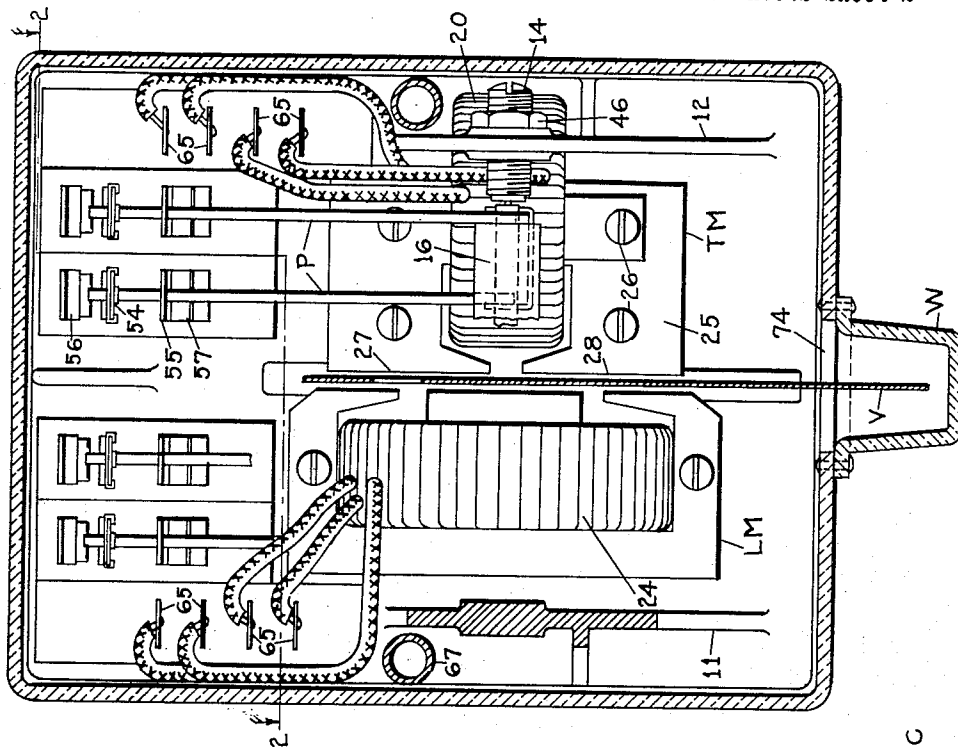
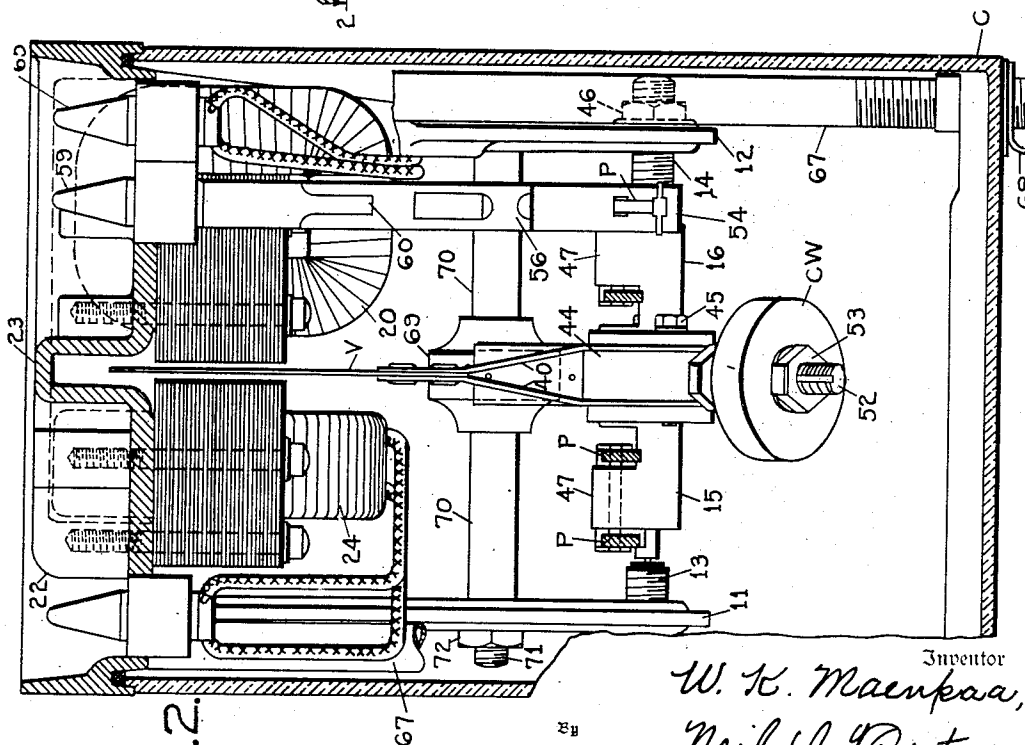


FIG. 2.



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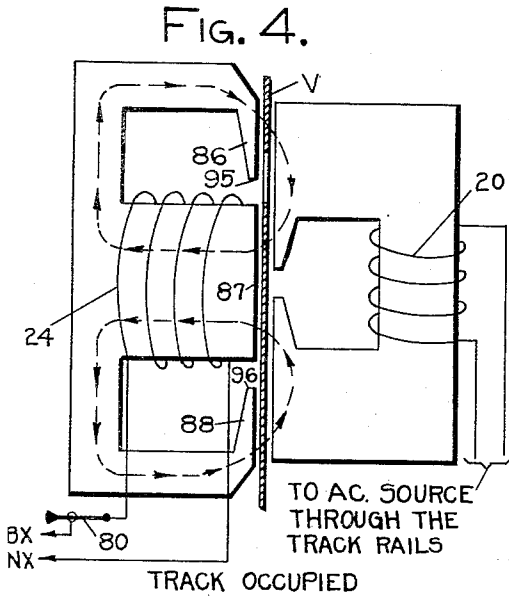
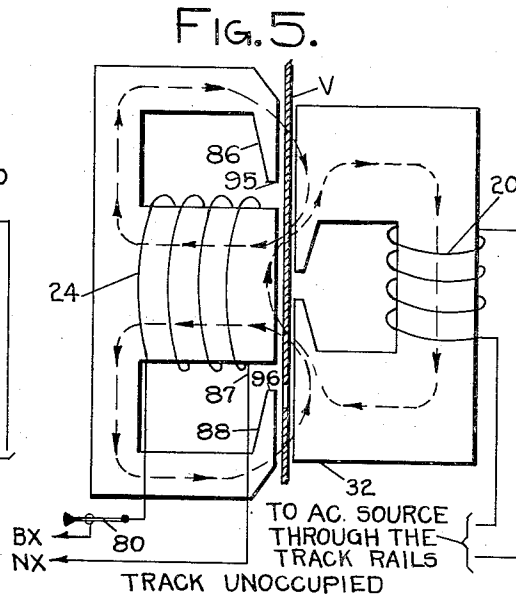
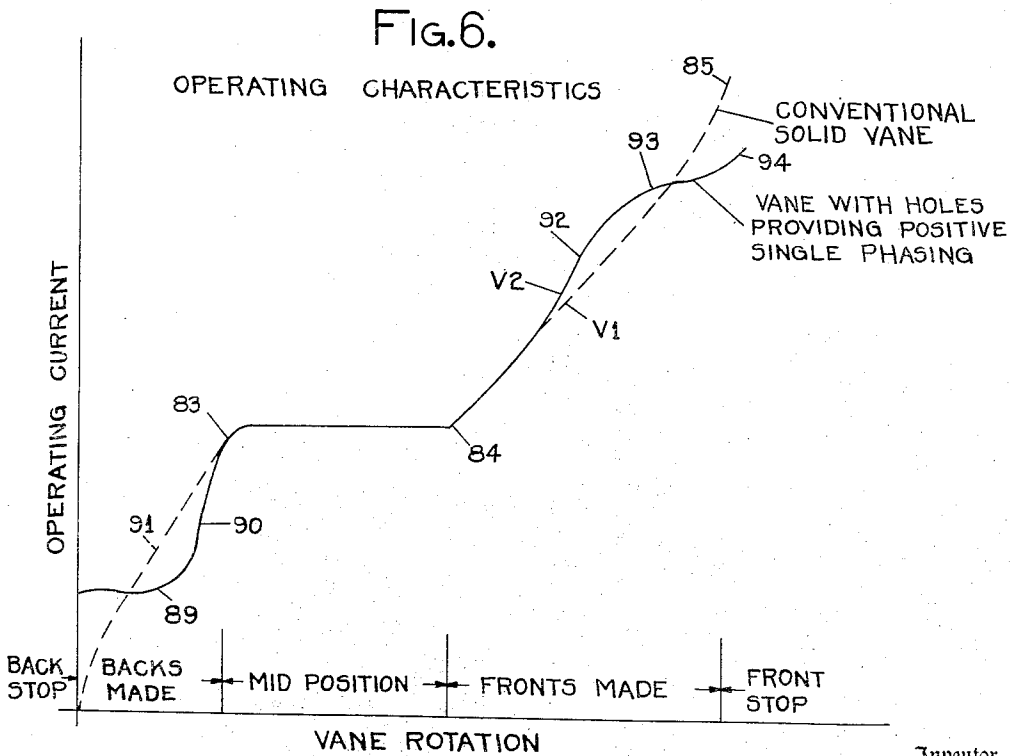
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ALTERNATING CURRENT VANE RELAY

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,559,448

ALTERNATING CURRENT VANE RELAY

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Application May 24, 1947, Serial No. 750,339

2 Claims. (Cl. 175—338)

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This invention relates to alternating current relays, and it more particularly pertains to alternating current relays of the vane type.

Alternating current vane relays are generally of the two-phase, or split-phase, type in which a continuously energized local winding at a relatively high potential provides the main power for relay operation, and the vane of the relay is selectively picked up or dropped away in accordance with the respective energization at a relatively low potential, or deenergization, of an operating winding, sometimes called a track winding, with a potential substantially 90° displaced from the potential of the local winding. Such relays are used to a considerable extent in alternating current track circuits in which the relays are normally picked up and are dropped away by the shunting of the track rails upon the approach of a train. Inasmuch as the shunting of the track rails is effective to reduce the potential across the track winding of a vane relay only to a limited extent, the relay must operate dependably within certain margins of energization. It is therefore desirable that a vane relay be capable of applying full front and back contact pressures well within the margins of track circuit non-shunt and shunt potentials.

It is an object of the present invention, in view of the above considerations, to provide a means including a novel vane structure for causing the local winding to be increasingly effective, after the front contacts of the relay are closed upon energization of the track winding, to compress the relatively stiff contact springs and thus allow full compression of the front contact springs at a reduced required working current for the track winding.

Another object of the present invention is to cause the local winding to be increasingly effective, after the back contacts have been closed upon the deenergization of the track winding of the relay, to compress the springs of the back contacts and thus allow full compression of the back contact springs at a higher current value in the track winding.

Another object of the present invention is to render the local winding increasingly effective to a lesser degree for compressing the front contact springs than for compressing the back contact springs to provide an additional margin of safety when the relay is picked up against it being held in that position after the deenergization of the operating winding in case of extreme over-energization of the local winding.

Another object of the present invention is

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accomplished by the positive single phasing action of the local winding with the vane in the picked-up or dropped-away position to render the vane relay safely operable when tilted at a greater angle than in the conventional vane relay.

Another object of the present invention is to shorten the length of the vane for the required number of degrees travel, without sacrifice of desired operating characteristics, by the use of holes spaced from the top and bottom edges of the vane, and located on a center line substantially parallel to such edges, to counteract single phasing action because of such edges coming within the magnetic field of the electro-magnetic structure.

Another object of the present invention is to provide a rugged and dependable vane relay of a structure particularly adapted to occupy a minimum amount of space when plug coupled to a suitable vertical plug board.

Other objects, purposes, and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description progresses.

In describing the invention in detail, reference is made to the accompanying drawings in which like reference characters designate corresponding parts throughout the several views, and in which:

Fig. 1 is a side elevational sectional view of a vane relay constructed according to the present invention;

Fig. 2 is a sectional plan view of the relay of Fig. 1 taken along the line 2—2 of Fig. 3;

Fig. 3 is a sectional end elevational view of the relay of Fig. 1 taken along the line 3—3 of that figure;

Fig. 4 is a diagram showing schematically an instantaneous condition of energization of the local winding when it is assumed that the track winding is shunted by the presence of a train;

Fig. 5 illustrates a corresponding instantaneous condition of energization of the local winding of the vane relay, together with the condition of energization of the track winding when the track is unoccupied; and

Fig. 6 illustrates graphically the improved operating characteristics of the vane relay providing according to this embodiment of the present invention as compared to a vane relay of similar structure but employing a conventional solid vane such as is generally employed in practice.

A base B, preferably of non-magnetic material, is of an irregular configuration as illustrated to

have the general utility of providing a support for a contact block 10, a housing for enclosing the contact tips when they are coupled to cooperating plug contacts (not shown) of a suitable plug board, a support to which respective local and track electro-magnetic structures LM and TM respectively are secured, and providing oppositely disposed brackets 11 and 12 (see Fig. 2) carrying jeweled bearings 13 and 14 respectively for journaling respective trunnions 15 and 16 used in supporting a vane V.

More specifically, with reference to Fig. 1, the vertically disposed base B has its upper and lower edges and its sides formed outwardly to the right so that the edge 17 becomes a bearing point for clamping the relay R to a suitable vertical plug board of the general character disclosed, for example, in the patent to J. F. Merkel, No. 2,258,122, dated October 7, 1941. A suitable slot 18 is formed in the left-hand edge of the base B, and about its periphery, for seating the preferably transparent cover C, the slot containing suitable resilient packing 19 for providing a substantial tight joint between the cover C and the base B.

The oppositely disposed longitudinal side brackets 11 and 12 extend to the left from the base B as viewed in Fig. 1 on the outside of the electro-magnetic structures, except that the winding 20 of the track electro-magnetic structure TM extends through the center of the bracket 12.

The vertical portion of the base B has recesses 21, 22, and 23 formed to the right as viewed in Fig. 1 of configuration to allow clearance for the track winding 20 of the track electro-magnetic structure TM, for local winding 24 of the local electro-magnetic structure LM (see Fig. 2), and for the vane V respectively.

The U-shaped track electro-magnet TM (see Fig. 3) has a track winding 25 disposed about the center of its core structure 25 and such electro-magnet is secured in a vertical position to the base B by the screws 26.

Oppositely disposed from the pole pieces 27 and 28 of the U-shaped track electro-magnet TM is an E-shaped local electro-magnet LM which is spaced sufficiently from the pole pieces of the track electro-magnet TM to allow adequate clearance for free passage of the vane V between the pole pieces of the respective oppositely disposed electro-magnetic structures LM and TM.

The vane V is of a sector configuration as shown so as to be operative through the space between the two electro-magnetic structures in an arc of approximately 40° about the pivot point 29. The upper edge 30 of the vane V is formed so as to be substantially transverse to the electro-magnetic structures when the relay R has its track winding deenergized, and the vane V assumes its dropped-away position as illustrated in the drawings. Similarly the lower edge 31 of the vane V is formed to be substantially transverse of the electro-magnetic structures and nearly even with the lower edge 32 (see Fig. 5) of the core 25 of the track electro-magnetic structure TM when such vane is fully operated to its picked-up position in a manner to be hereinafter described. The upper and lower corners of the vane V are cut at points 33 and 34 respectively to permit a minimum size for the structure of the relay R and yet maintain the above described substantially 40° operation at a relatively large radius from the pivot point for providing maxi-

imum mechanical advantage in the actuation of the contact pushers P.

The vane V has two relatively large holes 35 and one smaller hole 36 formed therein along a center line 37 substantially parallel to the upper edge 30 of the vane V and spaced from that edge a distance to be hereinafter considered when considering the mode of operation and operating characteristics of the relay R. Similarly the three small holes 38 are formed along a center line 39 substantially parallel to the lower edge 31 of the vane V and spaced from such edge a distance to be hereinafter specified in considering the mode of operation of the relay R. Although various materials may be employed for the structure of the vane V, aluminum has been found to be preferable for obtaining relatively quick operation, but copper can be satisfactorily employed if a longer operating time is tolerable.

With reference to Fig. 1, two laterally disposed 90° brackets 40 are illustrated as being suitably connected as by the rivets 41 near their ends to the opposite sides of the vane V near its upper and lower inside corners. A back stop plate 42 is secured to suitable ears formed at the inside edges of the legs of the brackets 40, and similarly the front stop plate 43 is suitably secured to the inside edges of the legs of the brackets 40.

With reference to Fig. 2, it is illustrated that the brackets 40 are laterally spaced by a suitable spacer 44 and that respective left and right trunnions 15 and 16 are suitably secured as by the bolts 45 through the brackets 40 and the spacer 44. Such trunnions are journaled in suitable jeweled bearings 13 and 14 respectively which are oppositely disposed along a center line transverse to the vane V, the bearings 13 and 14 being adjustably secured within the respective bracket arms 11 and 12 of the base B. The jeweled bearing stud 14, for example, is threaded into the bracket 12 so as to allow adjustment for endplay and for properly centering the vane V laterally within the airgap between the poles of the electro-magnetic structures LM and TM. When suitable adjustment of the jeweled studs 13 and 14 is effected, such studs are locked in their properly adjusted position by lock nuts 46.

The respective left and right trunnions 15 and 16 also serve as lever arms to which are pivoted respective pushers P for operating the various relay contacts. Thus it is illustrated in Fig. 2 that each of the trunnions 15 and 16 has a short lever arm at each side of which is pivoted a pusher P for operating a particular pair of relay contacts. With reference to Fig. 1, one of the pushers is illustrated as being pivoted by the pin 48 which is journaled in a clip 49 as well as a lever arm 47. The clip 49 is suitably secured to the lower portion of the pusher operating crank 47 by the screw 50. Such clip has ears 51 formed upwardly over the outside of the pushers P to maintain such pusher in position on the pin 48.

The vane V and the brackets 40 are counter-balanced to a considerable extent by the adjustable counterweight CW which is adjustable along the threaded stud 52. The stud 52 is suitably secured within the spacer 44, and the counterweight CW is locked in its adjusted position by the lock nuts 53. It will be noted with reference to Fig. 1 that the stud 52 for the counterweight CW extends at an angle to the center line of the vane V and bracket 40 assembly so that maximum counterweight is applied at a time when the weight of the vane and bracket provides maximum torque about the pivot point 29. Thus it

is desirable that the center line of the counter-weight stud 52 be substantially 17° above the center line of the bracket 40 and vane V assembly in order that a substantially constant torque may be maintained throughout the mid-position operation of the relay.

Each of the pushers P is illustrated as being effective to actuate movable contact fingers 54 and 55 to selectively open and close contact with the respective front and back fixed contact fingers 56 and 57 in accordance with the picking up and dropping away of the relay R.

The contact fingers 54, 55, 56, and 57 are suitably secured within the contact block 10 which is formed of insulating material, such block 10 being suitably secured to the base B as by the bolts 58. The contact tips 59 extend from the contact fingers 54, 55, 56, and 57 through the back of the block (to the right as viewed in Fig. 1), and thus provide electrical connection of the respective contact fingers to suitably plug board contacts (not shown) when the relay is coupled to a plug board. In addition to the resiliency of the respective contact fingers, additional spring pressure is applied to the front and back contact fingers 56 and 57 by the springs 60 and 61 respectively in order to maintain a relatively high contact pressure when the contacts are closed to insure good electrical contact and to provide a desired amount of wipe for keeping the contacts clean.

The pushers P extend upwardly through the respective movable contact fingers 54 and 55, and by the jaws 62 engage operating knobs 63 which are secured to the respective contact fingers, the pushers P actuate the movable contacts 54 and 55 up and down in accordance with the rotation of the vane V about its pivot point. The jaws 62 of each of the pushers P are maintained in engagement with their respective knobs 63 by the spacer fingers 64 which are suitably secured back of the pushers P after the insertion of the pushers P through suitable slots in the movable contact fingers 54 and 55.

The wires connecting the respective local and track windings of the electro-magnetic structures are suitably secured to respective wire terminals 65 (see Fig. 3) imbedded in the contact block 10, which terminals have contact tips 66 (see Fig. 1) for the coupling of the respective windings 20 and 24 of the relay R to plug contacts of the plug board (not shown) to which the relay R is to be coupled. It is thus illustrated in Fig. 3 that the wires connecting the local winding 24 are connected to respective wire terminals 65 at the left of the relay contacts, and the winding connections for the track winding 20 are shown as being secured to respective wire terminals 65 at the right of the relay contacts. Four terminals 65 are illustrated as being provided by each of the windings because each of the windings is assumed to be double wound in order to provide a number of different combinations under which the energization of the relay R can be effected in accordance with the requirements of practice and the potential available for its energization.

Respective left and right longitudinal sleeves 67 (as viewed in Fig. 2) are suitably secured to the base B so that such sleeves extend through the cover C and thus provide a means by which the cover C can be secured in place by suitable brackets 68 which are threaded on to the sleeves 67 on the outside of the cover C and to which a seal (not shown) can be applied in accordance

with the requirements of practice. The sleeves 67 fit over suitable mounting rods (not shown) of a plug board of the character disclosed in the above mentioned patent to J. F. Merkel, and by use of suitable means (not shown) threaded on to the ends of the rods against the ends of the sleeves 67 of the relay R, the relay R is secured to the plug board.

The extent of rotation of the vane V about its pivot point 29 is limited by the bumper 69 against which the respective back stop and front stop plates 43 and 42 are actuated. The bumper 69 is preferably of resilient material such as rubber to absorb the shock when the vane picks up or drops away against the respective front or back stop, and such bumper is centered by suitable spacers 70 and a stud 71 extending transverse to the vane V and between the legs of the brackets 40. The stud 71 is threaded through holes in the brackets 11 and 12, and the entire assembly of bumper 69 and spacers 70 is rigidly locked in position by the tightening of the nut 72 on to the threaded left-hand end of the stud 71.

In accordance with general practice where different types of relays, and relays having different contact combinations are plug coupled to a single plug board, it is desired that registration means be employed whereby the respective types of relays can be coupled to the plug board only in their particular allocated positions. Such registration can be conveniently accomplished by providing each relay with a registration plate having holes formed therein in locations characteristic of the location of registration pins on the portion of the plug board to which the relay is to be assembled. It is thus provided that the relay R of the present invention has a registration plate 73 suitably secured to the base B and so disposed as to cooperate with registration pins of a suitable plug board (not shown) to which the relay is to be coupled.

Inasmuch as the relay R is contemplated for use in a row along with other types of relays which do not ordinarily require as much space as that required by the operation of the vane of the relay R through its 40° of movement, it is desired that the size of the base mounting of the relay R be maintained of a standard dimension adapted to cooperate in a plug coupled manner with standard plug board sections (not shown). It is thus provided that the base B is of an elevational dimension (see Fig. 1) corresponding to the standard elevational dimension of other types of relays to be used on the same plugged board organization, but in order to allow for the full operation of the vane V throughout its 40° movement, a well is formed in the lower side of the cover C to allow the extension of the vane outside of the substantially rectangular outline of the relay R, which outline dimensions is standard to the other types of relays as mentioned above.

According to this arrangement a slot 74 (see Figs. 1 and 3) is formed in the lower side of the substantially rectangular cover C to allow the vane V to extend through the lower side of the cover C and within the auxiliary well cover W which is particularly formed to accommodate the general configuration of the portion of the vane V which extends through the lower side of the case C. The well W as illustrated in Fig. 1 has its ends 76 and 77 formed at angles such as to provide proper clearance for the vane in its dropped away position, and such as to act with a camming action upon the vane upon the removal and insertion of the cover. It will be readily

apparent that the cover is removable only by longitudinal movement (see Fig. 1) to the left of the position in which it is normally seated against the base B, and in removing the cover in this manner when the vane V is dropped away, the inclined surface 77 of the well W, by acting against the outer edge of the vane V raises the vane V sufficiently to allow the complete removal of the cover. It is general practice that the cover C is sealed closed, and there is little occasion to remove the cover from the relay R. In case there is work to be done on the relay R, it is general practice to remove the relay from the plug board and replace it so as to cause a minimum amount of interruption in the operation of the signaling system. After the relay has been removed from the plug board, an authorized person may break the seal of the relay and remove the cover to clean or adjust relay contacts or perform other maintenance operations which may be required.

Having thus described specifically the structure of the relay R providing according to this embodiment of the present invention, consideration will now be given as to the mode of the operation of the relay and a theory by which such mode of operation is believed to be accomplished.

The local and track electro-magnetic structures LM and TM respectively have windings 24 and 29 which are energized by respective local and track sources of energization as is indicated, for example, in Figs. 4 and 5. In Fig. 4, alternating current energy is indicated as being applied through the control switch 33 to the local winding 24 from a suitable source of alternating current, while the track winding 29 is illustrated as being connected to an alternating current source through the track rails of a track section. Because of the character of the windings, including their relative resistances, a substantially 90° phase displacement is accomplished between the local and track windings 24 and 29 so as to set up effectively a rotating field within the electro-magnetic structures when both windings are energized so as to attract the vane V to its upper operated position, generally known as its picked-up position, such vane being dropped away when energy is applied to only one winding of the electro-magnetic structure. By this arrangement a substantial amount of power for operating the relay is furnished by the relatively high voltage local electro-magnetic structure LM, but the cooperative energization of the track winding 29 is required to cause vane rotation to its picked up position.

The general principle of operation of a vane relay of the character described is well known to those familiar with the art and for a consideration of the present invention, it is believed sufficient to assume that the energization of both windings having currents displaced substantially 90° is effective to produce magnetic fields in the electro-magnetic structures extending through the vane V in a manner to effectively shift maximum flux density from the lower to the upper portion of the electro-magnetic structures as viewed in Fig. 4, and thus provide a so called rotating field to cause the vane V to be rotated about its pivot point in a direction corresponding to the direction of movement of the magnetic field density cutting the vane V. It is well known that the rotation of the vane V is caused by the action of magnetic fields set up in the vane because of eddy currents caused in the vane by

magnetic fields linking electro-magnetic structures.

The mode of operation of a relay as has just been described will be readily recognized as that of any conventional vane relay, rather than being particularly characteristic of the relay R according to the present invention. The rotation of the vane V about its pivot point when it is attracted from a dropped away position is effective in the first portion of its operation to move away from the back stop 43 as indicated according to the chart of Fig. 6. After a certain amount of rotation has been accomplished, the back contacts are opened, and there is a mid-position operation of several degrees before the closing of the front contacts of the relay is rendered effective. After the front contacts are closed, the continued rotation of the vane V compresses the springs 69 associated with the front contact fingers 56 for providing the required amount of spring pressure to insure low resistance continuity of circuits through the contacts, and for providing a desired amount of contact wipe to keep the contacts clean. The vane V continues to rotate until the compression of the front contacts 56 is fully established to the desired pressure, and at such time the rotation of the vane V is stopped when it is limited by the front stop 42.

Upon considering the movement of a vane as has been described, it will be readily apparent that the initial operation of the vane is aided by the back contact pressure to the point where the opening of the back contacts is rendered effective, and inversely, subsequent to the closure of the front contacts, the front contact spring pressure is increasingly effective to retard the motion of the vane, and thus increased current is required progressively for the rotation of the vane subsequent to the closure of its front contacts.

It is a well known principle in alternating current magnetism that there is a tendency for a homogenous piece of non-magnetic sheet metal having edges coming within the limits of an alternating electro-magnetic field to assume a position in which the losses are the least, or in other words to assume a position centered within the alternating current electro-magnetic field.

With reference to Fig. 1, therefore, applying these fundamental principles, if it were not for the holes near the upper edge of the vane V, there would be a tendency for the vane to be driven upwardly by the flux at the upper hole of the local electro-magnetic structure because of the upper edge 30 of the vane V being within the magnetic field of such pole. This effect upon the vane by the local electro-magnetic structure LM, when the track winding 29 is deenergized, is conventionally called a single phasing action upon the vane. Such single phasing action is obviously undesirable in that the allowable counterweighting of the vane is required to be reduced in order that gravity of the vane acting in opposition to that single phasing action may apply a particular specific amount of pressure against the back stop when the track winding is deenergized. If less counterweight is provided, it is thus inherent in the organization that a higher working current is essential for the operation of the relay.

The solution generally applied to a problem of this character in a vane relay would be to increase the length of the vane sector to an amount whereby the upper and lower edges of the vane never materially enter the electro-magnetic fields of the local electro-magnetic structure. By such

organization, there would be no unbalancing of the losses within the electro-magnetic field associated with either of the poles of the local electro-magnetic structure, and therefore there would be no objectionable single phasing action with the vane in its dropped-away or picked-up position.

In accordance with the requirements that the dimensions of the vane relay be kept within a particular standard size as has been heretofore set forth, there is no room available for the extension of edges of the vane sector in this embodiment of the present invention to an extent whereby single phasing action due to the upper and lower edges of the vane would be ineffective. To overcome this undesirable single phasing action (conveniently called negative single phasing action) with respect to the upper edge of the vane V according to Fig. 1, the vane V has holes 35 and 36 formed therein along a center line 37 space from and substantially parallel to the upper edge 30, the amount of spacing of the center line 37 from the edge 30 being determined in a manner to be hereinafter more specifically described.

It will be readily apparent from the curves V1 and V2 of Fig. 6 and from the description as it is hereinafter set forth that the size of the holes determines the degree to which the negative single phasing action of the upper edge of the vane is counteracted, and it is further provided that if the holes are made large enough, a positive single phasing action is rendered effective which is strong enough not only to counteract the opposing and undesirable negative single phasing action of the upper edge 30 of the vane V but also to develop a certain amount of torque to aid in overcoming the pressure of the back contact springs 61 as required to urge the vane V back stop plate 43 against the bumper 69.

Although other combinations of sizes of holes can be used to accomplish similar results, according to the present embodiment, the outside holes 35 are made relatively larger than the smaller center hole 36 so as to provide the desired effect and yet maintain sufficient mechanical structure to prevent warpage of the vane V. A slot formed parallel to the upper edge 30 of the vane could obviously accomplish a similar result if properly spaced from such edge, but slotted vanes have been found to be more subject to warpage, and furthermore more desired operating characteristics of the relay R have been found to be obtained by the use of the holes in the vane V rather than by the use of a slot.

A similar structure will be found as applied to the holes 38 located along a center line 39 parallel to and spaced from the lower edge 31 of the vane V except that the holes 38 associated with the lower edge 31 of the vane V are of a uniform size and a smaller diameter than the holes 35 and 36 that are associated with the upper edge 30. The center line 39 of the holes 38 associated with the lower edge 31 of the vane V is spaced slightly closer to the associated lower edge 31 than the spacing of the center line 37 of the holes 35 and 36 from their associated upper edge 30 for purposes to be more apparent as the description progresses.

Having thus considered reasons for the specific structure of the vane V in a general manner, consideration will now be given with reference to Fig. 6 as to the improving operating characteristics which are obtained by the above described vane structure. The curves of Fig. 6 illustrate comparative curves of operating characteristics of two vane relays of similar structure except

that the curve V1 shown dotted is the operating characteristic of a relay having a vane of the size and configuration as illustrated in Fig. 1 but having a solid vane (without holes), and the curve V2 shown as a solid line represents the operating characteristics of the vane relay R according to the structure specifically shown and described in this embodiment of the present invention.

Considering first the operating characteristics obtained by a similar vane to the vane V but without holes, energy will be assumed to be applied in varying degrees to the track winding for the building up of operating current. Such operating current is plotted as ordinate of the characteristic curve V1 to produce vane rotation which is plotted as abscissa.

It is thus illustrated in Fig. 6 that if the operating current in the track winding 20 is increased, the vane rotation progresses so as to move the vane from its back stop position to the point 83 of the curve at which the back contacts are opened. The vane rotates through the mid-position with little increase in current required, and upon the closure of the front contacts of the relay R at the point 84 in the characteristic curve, the operating current required to provide further rotary motion of the vane is materially increased because such current is required in order to overcome the compression of the contact springs 80 of the front contacts 56. Thus the slope of the characteristic curve becomes steeper at the point 84 where the front contacts are made, and considerable current is required to drive the vane to its fully picked-up front stop position. This amount of current required to drive the vane front stop 42 against the bumper 69, conveniently called the working current of the relay, is represented by the point 85 of the characteristic curve V1 for the relay having a solid vane as has been described. It will be noted that the upper end of the curve has an upward slope because of the negative single phasing action of the lower edge of the vane. A similar negative single phasing action is illustrated at the lower end of the curve V1.

Although the characteristic curves V2 and V1 shown are for only the pick-up operating characteristic of the vane under consideration, it will be readily apparent to those skilled in the art that similar characteristic curves are obtained for the dropping away of the vanes, except that the drop away characteristic curves fall slightly below the pick-up characteristic curves due, for example, to a certain small amount of gravity action of the vanes required to overcome the friction of the jeweled bearings as compared to the overcoming of such friction by operating current when taking the pick-up operating characteristic values of the vane.

The improved operating characteristics of the relay R with the vane V provided according to the present invention over the operating characteristics of a similar relay having a conventional solid vane is readily apparent upon comparing the curves V1 and V2 of Fig. 6. The curve V2 for the vane V (with holes) is illustrated as providing desirable characteristics allowing use of a lower track working current, the desirability of which will be hereinafter discussed, and it is also illustrated that the vane V is completely dropped away with its back stop 43 against the bumper 69 at a higher operating current value than would be effective if it were not for the holes formed therein.

It is believed that the operating characteristic of the vane V according to curve V2 can best be understood by first considering specific conditions illustrated in Figs. 4 and 5. Considering first the conditions effective when the track rails are shunted by the presence of a train as illustrated in Fig. 4, potential applied to the track winding 20 is reduced to its minimum point of energization which is determined by the resistance of the track shunt applied by the presence of a train. Under such conditions the action upon the vane V is principally that of the magnetic field of the local electro-magnet LM which cuts the vane V particularly in portions opposite the three respective pole pieces 86, 87, and 88 of the local electro-magnetic structure LM.

It is thus apparent in Fig. 4 that the center of the upper pole piece 86 of the structure LM is approximately the center of a magnetic field cutting the vane V at that pole piece, and the action of such field in cutting the vane V at the top edge 30 would have a tendency were it not for the holes 35 and 36 to operate the vane away from its back stop position, the amount of single phasing action in this direction (conveniently called negative single phasing) being determined to a considerable extent by the relative distance of the upper edge of the vane V from the center of the electro-magnetic field cutting the vane at the upper pole piece 86 of the local electro-magnetic structure LM.

Similarly the holes 35 and 36 in the vane V along the center line 37 parallel to the upper edge 30 act to cause a countersingle phasing action (conveniently called positive single phasing) of the vane in a direction to counteract the negative single phasing action due to the upper edge 30 of the vane that would be present if it were not for the holes 35 and 36. The positive single phasing action tends to drive the back stop 43 of the vane V with greater pressure against the bumper 69. This is true because the center line 37 of the holes 35 and 36 is below the magnetic center of the upper pole piece 86 of the electro-magnetic structure LM, and therefore the tendency of the vane V is to equalize the opposing positive and negative single phasing effects. It will be readily apparent that the single phasing effects are opposing because the upper edge 30 and the holes 35 and 36 parallel to such edge are on opposite sides of the center of the electro-magnetic field set up through the vane V at the upper pole 86 of the electro-magnetic structure LM. In other words, negative single phasing is exerted to push the upper edge 30 of the vane upward out of the electro-magnetic field and positive single phasing is exerted to push the portion of the vane having the holes 35 and 36 downward out of the electro-magnetic field at the upper pole 86 of the electro-magnetic structure LM.

The degree to which the respective opposing positive and negative single phasing is effective is dependent upon the relative proximity of the top edge 30 of the vane and the holes 35 and 36 to the center of the electro-magnetic field cutting the vane V at the upper pole 86 of the local electro-magnetic structure LM, together with the size of the holes 35 and 36 employed. Inasmuch as the holes are closer to the center of such electro-magnetic field and of a substantial diameter, a resultant positive single phasing action is effective to drive the vane V downward in a direction to increase the back stop 43 pressure against the bumper 69. By this arrangement it is possible to maintain a specified pressure against the back

stop with a greater balancing of the operating mechanism of the relay R by the counterweight CW, thus providing that less gravity action of the vane V is required to be overcome upon operation of the vane V to its picked up position.

Because of the positive single phasing action urging the back stop 43 against the bumper 69, it is provided as illustrated according to the curve of Fig. 6 that a higher operating current is required to move the vane V (with holes) from its back stop than would be required for the operation of a conventional solid vane of the same size. The vane without the holes would necessarily reduce the contact pressure applied to the back contacts 57 to a considerable degree because of the rotation of the vane through several degrees for the same value of operating current that is required to initiate motion of the vane V away from its back stop position according to the present invention.

Assuming the operating current of the track winding 20 of the relay R to be gradually increased from the point at which vane rotation is initiated, it is apparent from the curve of Fig. 6 that considerable vane rotation is accomplished with a small increase in operating current until the knee 89 of the curve is reached, at which point the holes 35 and 36 in the vane V are shifted beyond the center point of the flux cutting the vane at the upper pole 86 of the local electro-magnetic structure LM, and thus the single phasing action is effective to aid in driving the vane in its assumed direction of the rotation toward a picked up rather than a dropped away position. The resulting single phasing diminishes as the holes move farther away from the center of the electro-magnetic field. Thus, although the current required for a given degree of rotation of the vane V is less when the vane is operating beyond the knee 89 than would be required if there were no holes in the vane, the slope of the curve along the line 90 is greater than along the dotted line 91 representing the characteristics of a solid vane actuated through corresponding degrees of rotation. This is true because of the diminishing effect of the single phasing action of the hole 35 and 36 in the electro-magnetic field.

When the vane V has been rotated to a position to open the back contacts, the holes 35 and 36 are moved out of the electro-magnetic field of the upper field of the electro-magnet LM, and the operating current required for the rotation of the vane through the mid-position is substantially the same as would be required for a vane having no holes formed therein as illustrated by the coincidence of the curves of Fig. 6 through the mid-position.

Assuming the vane V to be rotated to a position at which the front contacts become made, the front contact pressures acting to retard rotation calls for an increase in operating current in the track winding 20, and as rotation of the vane V further progresses, the holes 38 along the center line 39 parallel to the lower edge 31 of the vane enter the magnetic field set up through the vane V at the lower pole 88 of the electro-magnetic structure LM, and the action of the field under such conditions is to attempt to repel the entry of the holes 38 into the magnetic field to an extent dependent upon the proximity of the holes 38 to the center of such electro-magnetic field. It is thus illustrated in Fig. 6 that the portion 92 of the curve V2 increases in slope as compared to the slope of the curve V1 of the conven-

tional solid vane because of the so called negative single phasing effect of the holes 38 until the center of the electro-magnetic field is reached at the knee 93 of the curve V2 at which point there is no single phasing action because of the holes being on center with the electro-magnetic field cutting the vane V at the lower pole 88 of the electro-magnetic structure LM.

As current is increased to carry the vane V beyond its degree of rotation at the knee 93 of the curve V2, relatively little increase in operating current of the track winding 20 is required to overcome the negative effect of the front contact springs 60 because the pressure of such springs is overcome to a considerable extent by the single phasing action of the holes 38 which becomes a positive action when such holes have passed the center of the electro-magnetic field at the lower pole 88 of the local electro-magnetic structure LM. It will therefore be apparent that the holes 38 are effective to provide a positive single phasing effect aiding the track operating current to overcome the front contact spring pressure required to be overcome before the rotation of the vane V can be completed to a point where its rotation is limited by the front stop 42.

It is therefore provided that a lower track operating current is required for a working current by use of the holes 38 along the center line 39 parallel to the lower edge 31 of the vane V than would be required to actuate the front stop 42 of the vane against the bumper 69 without the aid of the positive single phasing action provided by such holes as is indicated by the difference in operating current of the curves V1 and V2 at points 85 and 94 respectively where the vane rotation is completed to its picked up position as limited by the bumper 69. In other words, the working current required from the track circuit for operation of the relay R by use of the vane V with holes 38 parallel to its lower edge 31 is materially less than the working current that would be required if the vane were formed without holes.

Because of the center lines 37 and 39 of the holes being substantially parallel to the respective upper and lower edges 30 and 31 of the vane V, maximum positive single phasing action is accomplished acting to hold the stop 42 or 43 of the vane V against the bumper 69 when the vane V is fully operated to its respective picked-up or dropped-away position. This is true because such center lines extending slightly beyond the center of the magnetic fields of the respective poles 86 and 88, without being materially acted upon by the magnetic fields set up up the center pole 87 of the local electro-magnetic structure LM.

If the center lines 37 and 39 of such holes were radial with respect to the pivot point 29, the holes would be differently spaced from the centers of the magnetic fields with which they cooperate, and thus in order to position the center line of the holes so that one hole would provide optimum operating characteristics, the other holes would be improperly spaced from the center of the electro-magnetic field, and such improper spacing could well cause a negative single phasing action because of the extension of such holes into the magnetic field cutting the vane at the center pole 87 of the E-shaped electro-magnetic structure LM. It has been found in practice that the desired location of the center line 37 of the holes 35 and 36 in the vane V is at a point substantially opposite the inside edge 95 of the pole

of the local electro-magnetic structure LM with which such holes cooperate.

It has been found with respect to the location of the center line 39 of the holes 38 that it is desirable to locate such center line relatively closer to the edge 31 of the vane V than the location of the center line 37 with respect to the upper edge 30. Thus, rather than locating the center line 39 of the holes 38 directly opposite the edge 96 of the local electro-magnetic structure LM when the relay is fully picked up, the center line 39 of such holes is located slightly below the edge 96 of the pole piece 88, with the relay R in its fully picked up position, in order that the holes 38 may not enter to any great extent the relatively strong magnetic field set up through the center pole 87 of the local electro-magnetic structure LM, particularly by the field established in the track electro-magnetic structure TM as is illustrated by the dotted lines of Fig. 5. Thus, in order to prevent a negative single phasing action to be effective because of the entrance of the holes 38 into the field at the center pole 87 of the electro-magnetic structure LM, it is desirable that such holes be spaced farther away from the center pole 87 when the relay is fully picked up, than the spacing of the center line 37 of the holes 35 and 36 from the upper side of the pole piece 87 when the relay is fully dropped away.

The general nature of signaling circuits associated with track circuits is such that circuits involving safety are selected through front contacts of normally energized track relays, thus providing that any failure of the track relays to pick up, or any failure causing the track relays to be dropped away is on the side of safety in that a more restrictive signal indication is rendered effective according to such failure. It is thus highly desirable that the dropping away of each track relay to provide a more restrictive signal indication be definitely effected in response to a train shunt, irrespective of any abnormal conditions which may exist as to the energization of the local windings of the relays involved.

More specifically, if the possibility of line wires becoming crossed, or other extraneous conditions which could materially increase the potential applied to the local winding of the local electro-magnetic structure LM of a track relay becomes a consideration, it is desirable that such increased energization can in no manner hold up the track relay by means of the positive single phasing action which has been described when the track winding of that relay is shunted by the presence of a train in its associated track section. It is therefore desirable to limit the amount of positive single phasing effect of the local electro-magnetic structure LM which acts to aid in actuating the front stop 42 of the vane V against the bumper 69 in order that the dropping away of the relay R is insured to provide the desirable signal indications in response to a train shunt, irrespective of any abnormal condition of over-energization that may occur with respect to the energization of the winding 24 of the local electro-magnetic structure LM.

Inasmuch as the maintaining closed of the back contacts 57 of the relay R because of an abnormal energization of the local electro-magnetic structure would be on the side of safety, a greater positive single phasing action of the local electro-magnetic structure can be tolerated in order to provide improved operating characteristics without affecting the safety of operation

of the signaling system. It is thus in accordance with these conditions that it has been found desirable to use larger holes in the vane V along the center line 37 associated with the upper edge 30 of that vane, as compared to the size of the holes 33 along the center line 39 associated with the lower edging 34 of the vane V.

Because of the principle of restoration of vane relays by gravity, it is obvious that the tilting of a relay of this character from its predetermined operating position is effective to change the operating characteristics of that relay, and tilting the relay to any considerable extent results in failure of the relay to properly close its contacts.

The relay R according to the present invention can be dependably operating when tilted to a considerably greater extent from its described operating position than vane relays of the conventional type because of the positive single phasing action which is effective to aid in maintaining the vane V in its respective picked-up or dropped-away position, irrespective of a considerable change in the force of gravity of the vane because of the relay being tilted.

Having thus considered specifically the operating characteristics of the relay R having a vane V provided according to the present invention, it is believed expedient to consider to some extent the advantages of the operating characteristics obtained as applied to the use of such relay in alternating current track circuits. It is well known to those familiar with the signaling art that a track relay which is normally energized when no trains are present in its associated track circuit, must be dropped away upon entrance of the train into that track section because of a reduction in potential applied to the relay effected by the train shunting the track rails. The resistance of the train shunt varies from time to time in accordance with various conditions, and the track relay must be sufficiently sensitive to be dropped away to apply full back contact pressure within the reduced margin of potential applied thereto in accordance with the maximum track shunt resistance to be encountered in practice. Thus, inasmuch as the relay must be responsive to a reduction of potential between that required for providing working current of the relay and that at which the back contacts have full contact pressure applied thereto, it is desirable that the required difference in potential between these conditions be maintained as small as possible.

Another way of considering the problem as described above is that the track shunt may be effective to reduce the potential applied across the track relay by a certain percentage, and as the potential normally applied to the relay is required to be high, the reduction of such potential by a percentage upon applying a train shunt to the track rails would still maintain a particular potential across the relay which would have a tendency to retard the application of full back contact pressure.

It is therefore of considerable utility according to the present invention that the margin between the working current, and the current at which the back contact pressure is fully applied is lowered to a considerable degree under the margin which is generally inherent in vane relays having conventional solid vanes. Such margin has obviously been accomplished at both ends of the operation of the vane relay in that the holes 35 and 36 associated with the upper edge 30 of

the vane V effectively reduce the working current required to be applied to the track winding when the associated track section is unoccupied, and the holes 33 associated with the lower edge 34 of the vane V are effective to increase the operating current of the track winding at which full back contact pressure is applied and the back stop 43 of the vane V is actuated against the bumper 69. It is therefore provided that a vane relay constructed according to this embodiment of the present invention will provide dependable operation under poor track circuit shunt conditions that lower the margin of potential difference between shunt and non-shunt conditions of the track circuit.

Having thus described a specific vane type relay as one embodiment of the present invention, it is desired to be understood that this form is selected particularly to facilitate the disclosure of the invention rather than to limit the number of forms which the invention may assume, and it is to be further understood that various adaptations, alterations and modifications may be applied to the specific form shown to meet the requirements of practice.

What I claim is:

1. A vane relay comprising in combination, two elevationally disposed electromagnetic structures opposite each other, one of said electromagnetic structures having three poles elevationally disposed one above the other, and the other of said electromagnetic structures having two larger poles, one of the larger poles being disposed opposite a first pole and a portion of a second pole of the three pole electromagnetic structure, and the other of the larger poles being disposed opposite the third pole and a portion of the second pole of the three pole electromagnetic structure, a vane elevationally disposed to be rotated between said electromagnetic structures about a fixed pivot point, said vane being restored by gravity to a particular limit position upon the de-energization of but one of said electromagnetic structures subsequent to a time when both electromagnetic structures have been energized, said vane when in said particular position having a top edge which falls within a magnetic field extending through said one large pole and through said first pole, said top edge extending substantially parallel to but spaced about a horizontal center line extending across said first pole, and said vane when in said particular position having a plurality of openings formed therein along a center line within said magnetic field through said first pole, but spaced below and substantially parallel to said horizontal center line of said first pole to an extent comparable to the spacing of said upper edge above that horizontal center line, and said vane when in said particular position having an integral portion with no openings formed therein extending opposite the other two poles of said three pole electromagnetic structure, whereby the flux of either electromagnet alone has no effect upon movement of the vane at said second and third poles, but the flux at said first pole tends to maintain said vane in said particular position.

2. A vane relay comprising in combination, two oppositely disposed electromagnetic structures, one of said electromagnetic structures having three poles respectively disposed one above the other, and the other of said electromagnetic structures having two larger poles, one of the larger poles being disposed opposite a first pole and a portion of a second pole of the three pole

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electromagnetic structure, and the other of the larger poles being disposed opposite the third pole and a portion of the second pole of the three pole electromagnetic structure, a vane elevationally disposed to be rotated upwardly to a particular energized position between said electromagnetic structures about a fixed point by a rotating field set up upon energization simultaneously of both of said electromagnetic structures, said vane being restored by gravity upon the deenergization of one of said electromagnetic structures when both electromagnetic structures have been energized, said vane when operated upwardly to said particular position having a bottom edge which falls within the magnetic field extending through said other large pole and through said third pole of said three pole electromagnetic structure, said edge being substantially parallel to but spaced below a horizontal center line extending across said third pole, and said vane when in said particular position having a plurality of openings formed therein along a center line within said magnetic field through said third pole but spaced above said horizontal center line of said third pole to an extent substantially comparable to the spacing of said lower edge below that hori-

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zontal center line, and said vane when in said particular energized position having an integral portion with no openings formed therein extending opposite the other two poles of said three pole electromagnetic structures, whereby the flux of either electromagnetic structure alone has no effect upon the movement of the vane at said first and second poles, but the flux at said first pole tends to maintain said vane in said particular energized position.

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