April 18, 1944. W. D. HAILES ET AL 2,346,751

RELAY

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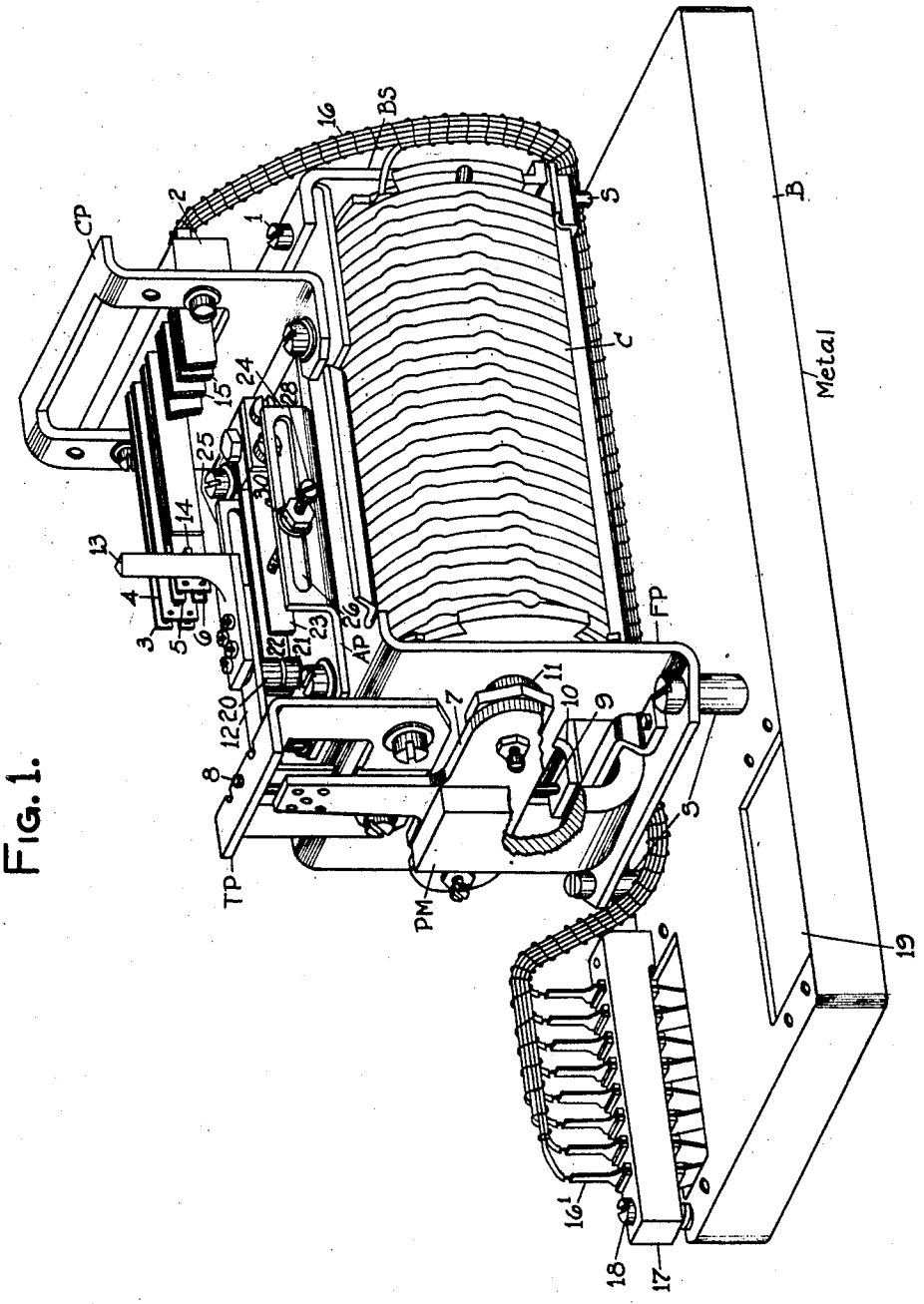


FIG. 1.

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FIG. 2.

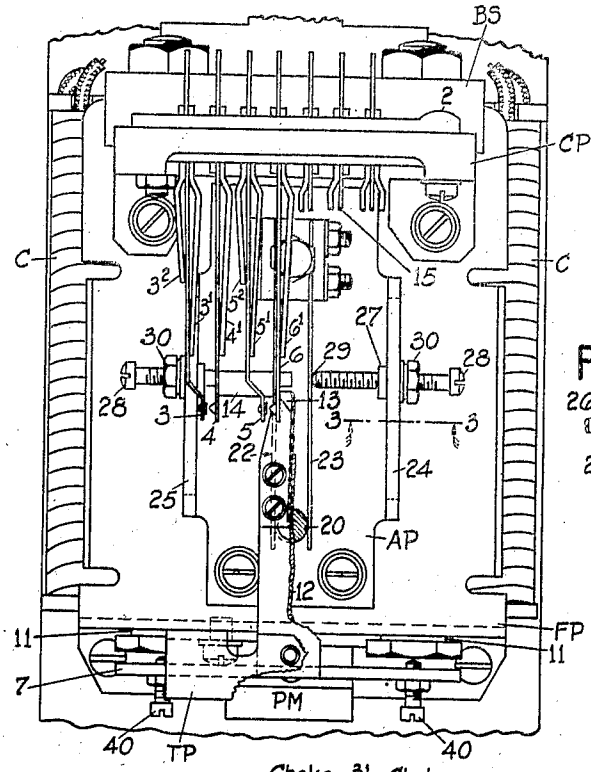


FIG. 3.

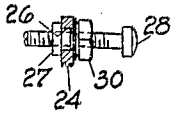


FIG. 4.

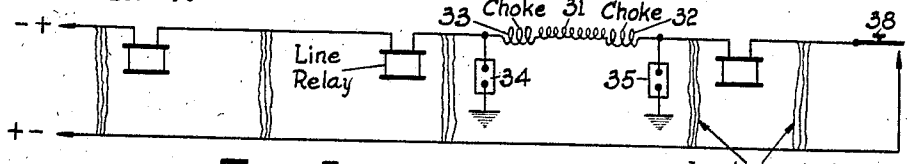
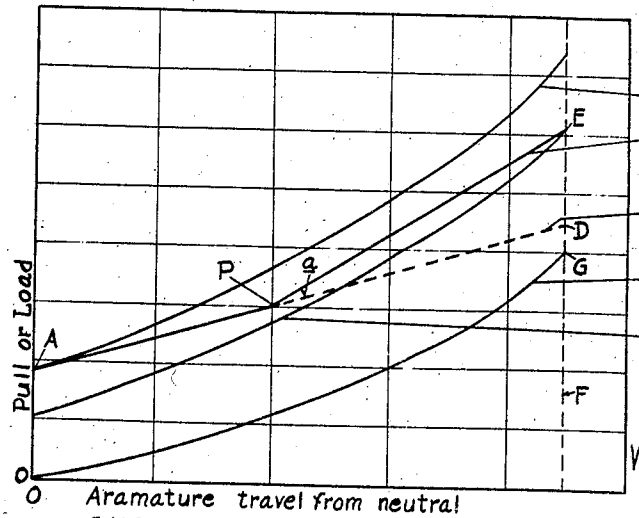


FIG. 5.



CHARACTERISTIC PULL & LOAD CURVES

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2,346,751

RELAY

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Application February 18, 1942, Serial No. 431,330

9 Claims. (Cl. 200—93)

This invention relates in general to electromagnetic relays and has more particular reference to such a relay of either the two-position or three-position polar type and one particularly adapted for use as a line relay in centralized traffic control systems and the like.

One purpose of the present invention is to provide a relay which is very rugged, is most dependable in its operation, and still is very efficient in energy consumption.

A further object of the invention is to provide novel and improved adjusting means for varying the mechanical load characteristics of the relay so as to accurately fit the magnetic pull characteristics of the relay.

A further object of the invention is to provide a relay which has substantially constant operating characteristics regardless of whether it be housed in cabinets made of magnetic or non-magnetic materials, and also to a limited extent irrespective of external magnetic fields.

Further objects, purposes and characteristic features of the invention will appear as the description thereof progresses, reference being made to the accompanying drawings, showing solely by way of example and in no way whatsoever in a limiting sense, one form which the invention can assume. In the drawings:

Fig. 1 is an isometrical view of one embodiment of this invention.

Fig. 2 is a plan view of the embodiment with parts broken away.

Fig. 3 is a sectional view on line 3—3 of Fig. 2, as viewed in the direction of the arrows.

Fig. 4 is a diagrammatic view of a control system employing relays constructed in accordance with this invention.

Fig. 5 is a graph illustrating the operating characteristics of relays constructed in accordance with this invention.

The relay, as referred to above, is of the polar three-position type with means for biasing it to its neutral position, or of the polar two-position type with means for biasing it to one extreme position. As readily appears from Figs. 1 and 2 of the drawings, the relay is mounted on a base B, made of steel or other magnetic material, for a purpose to be described below.

The relay proper is supported on the base by non-magnetic supports S, three in number, which supports are made of brass or other non-magnetic material. The core and coil structure C is carried in a frame which includes a front plate FP, which is L-shaped in form and extends the length of the relay to be connected at its rear end by screws or the like 1, to a back strap BS of magnetic material to which the two cores 11 are connected in a manner not shown. This front plate is made of non-magnetic material such as brass. Carried at the rear of the front plate is a contact carrying plate CP of non-magnetic material, to which is attached a block 2 of insulating material, holding various contact fingers as 3, 4, 5 and 6. At the front end of the front plate is a top plate TP of non-magnetic material, which aids in supporting a pivoted armature 7 which is pivoted at 8 and 9, on the top plate TP, and on a lug 10 of the front plate FP, respectively.

Extending beneath the core and coil structure is a permanent magnet PM which at its rear end is connected to the back strap BS of magnetic material which in turn magnetically connects the rear end of the two cores 11 together. This permanent magnet PM at its front end terminates very closely adjacent the central portion of the armature. This permanent magnet produces magnetic fields through the two air-gaps between the two ends of the armature 7 and the front ends of the two cores 11 of substantially equal intensity when the armature is in the neutral position and with the coils C deenergized.

The contact fingers 4 and 6 are operatively connected to the armature by means of an operator 12 extending toward the rear of the relay from its armature 7 and having an upstanding triangular finger 13 which operates contact finger 6 toward contact 5 and in turn through the medium of a pusher 14 moves the contact finger 4 toward the contact finger 3 so as to close circuits in the usual manner.

Although unnecessary for this disclosure, to show them in detail, to the right side of the relay as viewed in Fig. 2 are other contact fingers 15, etc.

The contact fingers project from the holding block 2 of insulating material and are connected to wires which can be conveniently formed into a cable 16 which passes beneath the relay and to the front thereof to be connected to the socket members 16^1 of a detachable plug connector member 17, fastened to base B as at 18. In this manner the entire relay and base, as well as its connecting wires, can be quickly connected to or disconnected from a supporting panel or other supporting means. The opening 19 in the base is to accommodate additional plug connector means if needed.

Depending from the rearwardly extending operating member 12 which is fixed to and moves

with the armature, is a pin 20 the sides of which are engaged by biasing spring fingers 22 and 23 which springs are carried by what may be conveniently termed an adjustment plate AP. Adjustment plate AP carries a pin 21 directly beneath, and concentric with, pin 20.

The adjustment plate AP has upturned sides 24 and 25 which are slotted longitudinally, as at 26. Slidable in these slots 26 are blocks 27 (see Fig. 3) each of which is threaded to receive an adjusting screw 28. Each screw 28 extends inwardly to bear at its inner end as at 29 against its associated biasing spring and is held in adjusted position by a lock nut 30 and an associated washer on the outer side and by the block 27 into which it is screwed on the inner side. Thus, by loosening the lock nut 30 each screw 28 can be slid to a different position in the slot 26 and can be turned into or out of the block 27 to bear with greater or lesser pressure on the biasing spring 22 or 23 which it controls. The arrangement is symmetrical on each side of the relay so as to render adjustable the spring (non-useful load) load upon the relay for each direction of movement of the armature 7 from its neutral position, to result in the desired non-useful load characteristics of the relay regardless of the polarity of the applied current and the corresponding direction of movement of the armature.

Referring now more particularly to the showing in Fig. 2 and assuming that the relay is energized with a polarity which causes the operator finger 13 to move to the left, it can be seen that the movable contact fingers 4 and 6 are moved to make up their front points 3 and 5, respectively. Upon the armature first moving it must move the contact fingers 4 and 6 against the spring load of these fingers and must also move the biasing spring 22. It should be understood that there is initial or trapped tension in spring 22 by reason of the tension having been trapped by the fixed stop pin 21. Similarly there may be initial or trapped tension in contact fingers 4 and 6 which was trapped by the fixed stops 4^1 and 6^1, respectively. After the contacts 4 and 6 have first made up with contacts 3 and 5 the movement continues to thus build up contact pressure and hence an added useful load above that of the non-useful load exerted by springs 22, 4 and 6 which must be carried by the relay armature and is added at this point (indicated at P in Fig. 5) in the movement of the armature. This added load or useful load is due to the spring exerted forces of the front contact fingers 3 and 5 carrying the front points and is called "useful" because it constitutes contact pressure.

It should be understood that although contact springs 4 and 6 may have initial or trapped tension no such spring tension is trapped in contact fingers 3 and 5 the stops 3^1 and 5^1 being barely in contact with springs 3 and 5 respectively.

The operating characteristics of the relay can be readily understood from a consideration of the curves shown in Fig. 5. Some of these curves show loads and others show various values of pull for different positions of the armature in its travel from its neutral to one of its operated positions. On the horizontal axis is represented from left to right the amount of movement of the armature in moving from its biased neutral position to one of its fully attracted positions, indicated by the dotted line F, where the residual pin 40 is in contact with the pole face of core 11. This distance in the particular example of one relay adjustment illustrated is measured at the residual pin. On the vertical axis measured from zero upwardly is indicated, the mechanical load and the magnetic pull at various positions of the armature.

In moving the armature from its neutral position toward one of the pole faces of the electromagnetic core structure a pull due to the redistribution of the fluxes from the permanent magnet PM develops as soon as it moves from its center position and the pull due to this redistribution of permanent magnet flux is represented by the curve PM, conveniently called the permanent magnet pull curve. In addition to this magnetic pull, there is the magnetic pull due to the electro-magnet when energized by energizing current of a particular value, and the sum of these two pulls is represented by the curve *PM+EM*, that is, permanent magnet pull plus electro-magnet pull. This pull due to magnetic forces *PM+EM* and plotted along the vertical axis, as stated above, in order that the relay will pick up when energized, must throughout the entire armature movement be greater than the total non-useful load due to the springs, such as springs 22, 4 and 6.

The load, due to moving the biasing spring such as spring 22 and due to moving the contact fingers, such as fingers 4 and 5, is represented by the curve NUL, or non-useful load, since it can be conveniently considered that moving this load produces no useful result. This curve NUL extends from point A to point D in Fig. 5. A really useful result is realized only after the contacts have touched and further movement has built up contact pressure enough to insure a proper flow of current through the circuits which have been closed by the relay contacts. The curve *NUL+UL* represents the total load TL and includes not only the above non-useful load but also the useful load which is encountered in building up contact pressure. From the diagram, it can be seen that after a movement of the armature to point P, the contacts close and the further movement includes building up contact pressure by flexing the front contact fingers 3 and 5, and this abruptly changes the slope of the total load curve TL as shown by the angle a at P in Fig. 5. The useful load is therefore the difference expressed by curves P to E and P to D.

It is thus apparent from Fig. 5 that the trapped tension, comprising the sum of the trapped tensions of springs 22, 4 and 6, in the particular example of relay adjustment illustrated in Fig. 5, is shown by curves A to D or NUL, and that the magnetic pull due to applying said predetermined operating current to the relay and represented by curve *PM+EM* amounts to slightly more than this trapped tension at zero armature movement. Consequently with this current applied movement of the armature in a counter-clockwise direction begins. As the armature travel increases the non-useful load builds up in straight line fashion until the armature travel has reached the position represented by point P. At this point P (see Fig. 5) in the armature travel the contacts 5—6 and 3—4 close and cause the total load TL to build up at a faster rate as shown by the solid line P to E beyond point P. The useful load (contact pressure) starts at this point P and is added to the non-useful load NUL. This same rate of build-up (straight line) of the total load continues after point P until the armature 7 strikes the residual pin 40 indicated by the dotted line F. It will be seen that the entire curve of total load

TL falls below the curve of total magnetic pull $PM+EM$ from which it is seen that the armature is actuated all the way and against the residual pins upon the application of this current of particular value. It is also seen that all of the total load curve TL is above all of the curve $PM+\frac{1}{2}EM$ which is an assurance that the relay will drop if the particular current conveniently called pick-up current is reduced to substantially one-half value. This also assumes that in the meantime the current has been increased way above the pick-up value to a point where saturation of the iron takes place, so that a certain amount of pull due to residual magnetism is included in the pull curve $PM+\frac{1}{2}EM$, and that the relay will drop away upon reduction of the current to one-half of the pick-up value in spite of this residual.

It is readily understood that when contact wear occurs the point P in the total load curve will be shifted farther to the right along the dotted line NUL and if continued to an appreciable extent will cause a portion of the total load curve to fall below the half-current magnetic pull curve $PM+\frac{1}{2}EM$. Under this condition the relay will not drop away if the current is reduced to one-half of its original value but will drop if the current is reduced to a somewhat lower value. This latter conclusion is apparent from the fact that with zero contact pressure, in which case the lines TL and NUL will be coincident and lie along the line NUL, all of the total load curve TL falls above all of the magnetic pull curve due to the permanent magnet as illustrated by line PM. Therefore even though appreciable contact wear takes place the relay will release when the current is reduced to a fraction of its minimum pick-up value, whereas if the load curve after appreciable loss of contact follow were to come lower than the pull curve PM due to the permanent magnet the relay would fail to drop even though all current were removed from the relay coils. In other words, the relay is constructed to allow contact wear until it fails to close its contacts upon being picked up and will still drop away upon deenergization thereof. The minimum load point of curve NUL is determined by the amount of trapped tension exerted by springs **4**, **6** and **22**, the portion contributed by spring **22** may be varied by turning the adjusting screw **28**. The slope of build-up of the load curve up to the point P is determined by the stiffness of springs **4** and **6** and also by the stiffness of spring **22** which may be varied by sliding the adjusting screws **28** in the slots **26**. The build-up or slope of the useful portion of the total load (the portion P to E beyond the point P) may be varied by properly selecting the material and cross-section of the contact springs **3** and **5** and by changing their bearing point by properly selecting the length of the stop members 3^2 and 5^2.

The relay of the present invention is thus constructed to cause the total load curve TL of the relay to approximate the curves of magnetic pull for both full energization $PM+EM$ and half energization $PM+\frac{1}{2}EM$ of the electro-magnet thereof and causes it to lie wholly between these two magnetic pull curves which assures both picking up of the relay at the pick-up value energization thereof and dropping away of the relay if the energizing current is reduced to one-half of the pick-up value when the relay is in normal adjustment. This construction assures that the relay armature will not begin to pick up until the current is increased to the pick-up value when it then moves to the fully picked-up position without further increase in current. Similarly, the relay armature will not begin to release until the current has been reduced to essentially one-half of the pick-up value when it then moves to the fully released position without further reduction in current.

This relay can be employed in any desired capacity but is of particular value in centralized traffic control systems such as diagrammatically shown in Fig. 4. In such systems, a large number of these relays are connected in series in a line circuit extending at times for many miles and for the functioning of the system in a proper manner, the opening of the line circuit must cause all the relays to release. However, it can be seen that, if the switch **38** at the end of the line circuit be intermittently opened, as is the case in a coded signalling system, the amount of leakage between the lines of the circuit and the flow of charging current due to the condenser effect produced by these long line circuits might permit enough current to flow through the relays near the battery end of the system to hold them up regardless of the intermittent opening of switch **38**.

With the above considerations held in mind it can be seen why the relay is so adjusted as represented by curve $PM+\frac{1}{2}EM$. that when the energizing current is decreased to anything less than one-half, the minimum pick-up value is insufficient to hold the relay up, and hence it will release as it should. It is of course understood that in practice the current applied to the line circuit is greater than this minimum pick-up value in order to provide ample operating margin considering leakage currents and the like.

It can also be seen from Fig. 5 that the relay, in adjustment, has such characteristics that the load curves, both the non-useful load NUL and the combined non-useful and useful load curves, constituting the total load curve TL, both lie above the permanent magnet magnetic pull curve PM. Thus, even though, due to wear, or accident, or otherwise, the contact pressure should completely disappear, the relay still could not hold up when deenergized, whereas, if the curve PM should lie in part above the non-useful load curve NUL the relay would not drop upon deenergization of its winding.

Referring again to Fig. 5 the area below curve PM is the uncontrollable portion of the pull characteristic of the relay. The area above curve PM is controllable by the excitation of the relay windings. The relay of this invention is constructed so that the load characteristics as represented by curves NUL and TL lie wholly within the controllable portion of pull characteristics of the relay.

In order to develop contact pressures of sufficient amounts to guarantee reliable contact operation and in order to develop sufficient non-useful load greater than the pull represented by curve PM, it is necessary to develop a total load in the fully picked up position of the relay as shown by curve TL at point E. The point E thus locates one point on the pull curve $PM+\frac{1}{2}EM$, namely, the pull curve of the relay when the windings are energized at a level at which the relay shall just release. When the armature begins to move, it is highly desirable that it shall move to the fully released position without a further reduction of the current in the relay coils. To accomplish this, it is necessary to adjust the load curve TL so that it lies above pull

curve $PM+\frac{1}{2}EM$ at all points. It is also highly desirable that when the excitation of the relay is increased to the pick-up value for which the pull curve $PM+EM$ starts at A, that the armature shall complete its pick-up movement without further increase in current. This means that the load curve TL should lie below the particular pull curve $PM+EM$ which is required to start the armature towards its pick-up position. The point A on the load curve TL must therefore be at or just below the point A on the pull curve $PM+EM$. It is also desirable that the relay shall respond to as small a change in excitation of its windings as is practicable. This means that if the load curve TL is made to approximate the slope and curvature of the pull curve $PM+\frac{1}{2}EM$, it will be unnecessary to employ a large increase in excitation to cause pick-up of the relay armature and therefore the relay will possess the desirable high release characteristic. That is, for a given pick-up only a small reduction in energy is required to cause the relay to release. Stated another way the more nearly the load characteristic of the relay is fitted to the pull characteristic of the relay the smaller the amount of increase required to pick the relay up above the value at which the relay releases.

From the foregoing it can be seen that it is highly desirable to be able to control the amounts of the various portions of the mechanical load of the relay and also the slope at which these mechanical loads increase with the movement of the relay armature. Stated broadly, it is desirable to be able to control the shape of the load curve TL and to this end the relay of the invention employs the following features namely a choice of contact springs of proper width and thickness plus a choice of the length of pressure members 3^2 and 5^2 plus the adjustable means for varying the intensity and slope of the centering spring **22**.

For example, the choice of contact spring material and proper width and thickness for fingers **3** and **5** plus the choice of pressure members 3^2 and 5^2 of the proper length produces the required contact pressure represented by the difference between the pressures and point E on curve TL, and the point D on curve NUL and also the correct slope with respect to curve NUL and represented by the angle a so as to intersect curve NUL at point P, the point of engagement of the contacts. Similarly, the choice of spring material and the proper width and thickness for fingers **4** and **6** and the choice of spring material and the proper width and thickness for centering spring **22** plus the adjustable feature provided by the adjusting screw **28** enables adjusting the non-useable portion of the load characteristic to exert a load as shown at D on curve NUL which is greater than the pull supplied by the permanent magnet as represented by the point G on curve PM and to fix the slope of this curve NUL so that the total load curve TL lies above pull curve at release value, i. e. $PM+\frac{1}{2}EM$, at all points.

The adjusting means for adjusting the load curve of the relay is provided so as to be enabled to fit this curve properly to the magnetic pull curve. By sliding the adjusting screws in the slots the effective length of the biasing springs and hence the slope of the load curve can be changed, the shorter the distance from the adjusting screw to the armature operated pin **26** the steeper the curve. To vary the initial point of the curve, that is, the point at substantially zero armature movement, the screw need merely be turned in or out so as to adjust, in effect, the trapped tension in the biasing spring **22** or **23** involved. The trapped tension in the centering springs **22** is exerted against fixed pin **21**, and holds the armature in its center, or neutral, position when the relay is not energized and upon application of current until the current has increased to the pick-up value. Upon movement of the armature from its normal position all of the force of one of the springs **22** or **23** is exerted against the fixed stop pin **21** whereas all of the force of the other spring **23** or **22** is exerted to oppose movement of the armature.

As stated above, the relay is mounted on a base of magnetic material such as steel. This is done to maintain substantially constant operating characteristics regardless of whether the relay be housed in a cabinet made of magnetic material such as steel, or in a cabinet made of non-magnetic material such as wood, or the like. By placing the relay close to a relatively large base of magnetic material the relay characteristics are stabilized and are not materially varied by being housed, for example, in a metal cabinet, or close to other devices of magnetic material. This construction offers the further advantage that it maintains substantially constant operating characteristics for the relay of this invention even though it is subjected to the stray magnetic fields set up by a group of relays with which it may be housed in a common cabinet. The magnetic metal base stabilizes the operating characteristics of the relay by providing a relatively low reluctance shunt or leakage path in parallel with the flux path which carries the relay operating fluxes so that when the relay is brought into juxtaposition with other magnetic material bodies or within stray fields set up by other devices the change in the flux condition in the operating flux path as a result of external bodies or fields is substantially negligible.

A relay of this type is of distinct advantage in centralized traffic control systems as referred to above. It is not merely a matter of economizing in energy that constitutes the problems, since, if the voltage at the battery end be increased too greatly, the leakage may increase to such an extent that if the relays pick up satisfactorily when the switch **28** is closed, they will not release when the switch is opened.

On the other hand, if the battery voltage be decreased too greatly so as to decrease leakage and hence prevent the relays holding up when the switch is open, the voltage may be too low to pick up relays at the switch end of the line when the switch is closed. Thus, a very sensitive and high drop-away relay such as described above is of particular value in connection with such systems as described above and similar systems.

One variation in the line circuit of these systems employs relays with high impedance windings connected in multiple between the line wires of the system. These relays must drop away when a shunt is momentarily applied between the line wires at a relay location irrespective of whether that relay location is near the battery end of the line circuit or near the open end of the line wires. A sensitive relay with a high drop-away is particularly valuable in this application of the relay of this invention. A sensitive relay avoids the necessity of transmitting relatively large amounts of energy over the line circuit and a reliable high drop-away characteristic of the relay insures that the relay will release without requiring that the line potential be reduced to a very

low value by the application of the controlling shunt. In other words, the high release characteristic of the relay avoids the need of reducing the line potential to substantially zero in order to guarantee release of the line relay. This is particularly advantageous where the line wires of the system are used jointly for centralized traffic control and telephone purposes.

The relay involves protection against lightning in that the first few turns of the winding at each end are either of larger wire than the rest or are of the same wire, but in either case, are more heavily insulated and are more widely spaced from each other, and from the remaining turns. This provides a choke winding and protects the main body of the winding by absorbing the voltages induced by lightning within a portion of the winding insulated to withstand these voltages.

As illustrated in Fig. 4, the main winding of a relay of this type is indicated at **31** with the first few turns at each end indicated as **32** and **33** spaced farther apart. If lightning surges occur the arresters as **34** and **35** will limit the voltages appearing at the relay winding to the order of the break-down voltage of the arresters which voltage is also low enough to be withstood by the insulation employed for the turns **32** and **33**.

Since lightning surges are characterized by a very steep wave front, that is, are of extremely high frequency, the voltage impressed by these surges upon windings is absorbed in a relatively few number of turns and therefore the voltage gradient is very steep for the first few turns of the winding. This means that the inter-turn voltage will be high for the first few turns and thus will require additional insulation or spacing or both in order to prevent damage from lightning surges. Therefore, the end turns are provided with extra insulation strength to a sufficient number of turns to absorb the maximum voltage, established by the lightning arresters, without damage.

Furthermore, by spacing a few turns on each end of the winding from each other and from other layers of the winding the distributed capacity of the end turns is reduced, and aids in distributing the surge voltage among a suitable number of turns.

Obviously if direct current of one polarity only is applied to the relay the relay becomes a two-position relay. Also, special adjustments of the relay may be made if it is to be used as a two-position relay only.

One of the difficulties encountered in relay construction employing permanent magnets is to prevent flux set up by the permanent magnet when the relay is in its actuated position, and represented by the pull G, from preventing release of the relay upon decreasing of the current a comparatively small amount below the pick-up value. In applicant's construction this difficulty has been removed by properly selecting the load of the relay for all points of armature position by selecting the trapped tension and pressure build-up of the springs **4**, **6** and **22** (line A to P) supplemented by further preselecting of contact pressure build-up (line P to E) determined by spring fingers **3** and **5**. Not only does this feature cause the load curve TL (P to E) to properly fit between the pull curves $PM+EM$ and $PM+\frac{1}{2}EM$ and thereby greatly improve the efficiency of the relay but it also at the same time affords a large amount of contact pressure (D to E) with a considerable amount of wipe of these contacts and a wide spacing of contacts when the relay is in its non-actuated position. In other words, the construction is such that almost every element of the current is used to do necessary work, that is, operate the armature and create contact pressure.

The above rather specific description of one form of the invention has been given solely by way of example and is not intended in any manner whatsoever in a limiting sense. It is to be understood that various modifications, adaptations and alterations may be applied to meet the requirements of practice without in any manner departing from the spirit or scope of the invention except as limited by the appended claims.

Having described our invention, we now claim:

1. In relays, in combination; a magnetic structure including a core, a coil on said core, a movably mounted armature and a permanent magnet so associated with said core and armature that the application of current to said coil causes magnetism from said permanent magnet to be redistributed in the working air gap between said core and said armature; two coaxial members of like diameter one fixedly supported with respect to said core and the other operatively connected to said armature in such manner as to cause said other member to move with respect to said one member so that their axes remain in parallel relation to each other but separate from each other as said armature moves from its normal position; two springs arranged on opposite sides of said coaxial members having one end fixed and having the other end engage both of said members; means to adjustably change both or either the effective lever arm of said springs and the initial force exerted thereby on opposite sides of said coaxial members when said armature assumes its normal position.

2. In relays, in combination; a magnetic structure including two cores, a coil on each core, a movably mounted armature and a permanent magnet so associated with said core and armature that the application of current to said coil causes magnetism from said permanent magnet to be redistributed in the working air gap between said cores and said armature; two coaxial members of like diameter one fixedly supported with respect to said core and the other operatively connected to said armature in such manner as to cause said other member to move with respect to said one member so that their axes remain in parallel relation to each other but separate from each other as said armature moves from its normal position; a spring arranged on one side of said coaxial members having one end fixed and having the other end engage both of said members; means to adjustably change both or either the effective lever arm of said spring and the initial force exerted thereby on the sides of said coaxial members when said armature assumes its normal position.

3. In relays, in combination; a magnetic structure including a core, a coil on said core, a movably mounted armature and a permanent magnet so associated with said core and armature that the application of current to said coil causes magnetism from said permanent magnet to be redistributed in the working air gap between said core and said armature; two coaxial members of like diameter one fixedly supported with respect to said core and the other operatively connected to said armature in such manner as to cause said other member to move with respect to said one

member so that their axes remain in parallel relation to each other but separate from each other as said armature moves from its normal position; a spring arranged on one side of said coaxial members having one end fixed and having the other end engage both of said members; means to adjustably change both or either the effective lever arm of said spring and the initial force exerted thereby on the sides of said coaxial members when said armature assumes its normal position; a front spring contact finger fixed at one end and having a stop touching it without initially tensioning it, so as to substantially prevent its movement in one direction only; and a movable spring contact finger operatively connected to and movable with, said armature, in a direction opposite to said one direction and into contact with said front spring contact finger, the movable finger having a stop member and being initially tensioned against its stop member to bias said movable spring finger away from said front spring contact finger, whereby said spring contact fingers are prevented by said stops from making unauthorized contact and these contact fingers do not impose additional trapped tension above that imposed by said spring and the movable contact fingers when contact is made during actuation of the relay from its normal position.

4. In relays, in combination; a magnetic structure including two cores, a coil on each core, a movably mounted armature and a permanent magnet so associated with said cores and armature that the application of current to said coils causes magnetism from said permanent magnet to be redistributed in the working air gap between said cores and said armature; two coaxial members of like diameter one fixedly supported with respect to said cores and the other operatively connected to said armature in such manner as to cause said other member to move with respect to said one member so that their axes remain in parallel relation to each other but separate from each other as said armature moves from its normal position; two springs arranged on opposite sides of said coaxial members having one end fixed and having the other end engage both of said members; means to adjustably change both or either the effective lever arm of said springs and the initial force exerted thereby on opposite sides of said coaxial members when said armature assumes its normal position; a front contact, a movable contact operable by said armature and exerting trapped tension when moved to engage the front contact; the front contact not exerting trapped tension when engaged by the movable contact, whereby the load curve imposed by said springs, said movable contact and said front contact starts at a point above zero and builds up at two different rates without an intervening off-set.

5. In relays, in combination; a magnetic structure including a core, a coil on said core, a movably mounted armature and a permanent magnet so associated with said core and armature that the application of current to said coil causes magnetism from said permanent magnet to be redistributed in the working air gap between said core and said armature in two different ways depending on the polarity of the applied current; two coaxial members of like diameter one fixedly supported with respect to said core and the other operatively connected to said armature in such manner as to cause said other member to move with respect to said one member so that their axes remain in parallel relation to each other but separate from each other as said armature moves from its normal position; springs arranged on opposite sides of said coaxial members having one end fixed and having the other end engage both of said members; and means to adjustably change both or either the effective lever arm of said springs and the initial force exerted thereby on the sides of said coaxial members with said armature assuming its normal position.

6. In relays, in combination; a magnetic structure including two cores, a coil on each core, a movably mounted armature and a permanent magnet so associated with said cores and armature that the application of current to said coils causes magnetism from said permanent magnet to be redistributed in the working air gaps between said cores and said armature in two different ways depending on the polarity of the current applied to said coils; two coaxial members of like diameter one fixedly supported with respect to said core and the other operatively connected to said armature in such manner as to cause said other member to move with respect to said one member so that their axes remain in parallel relation to each other but separate from each other as said armature moves from its normal position; springs arranged on opposite sides of said coaxial members having one end fixed and having the other end engage both of said members; means to adjustably change both or either the effective lever arm of said springs and the initial force exerted thereby on the sides of said coaxial members when said armature assumes its normal position; front spring contact fingers each having a stop member touching, but not biasing, it, so as to substantially prevent its movement in one direction; and movable spring contact fingers each operatively connected to said armature and movable in a direction opposite to said one direction and into contacting relationship with said front spring contact fingers and each having a stop member to prevent it from moving when said armature is moved in an opposite direction, whereby said front spring contact fingers are prevented by their associated stops from making unauthorized contact and do not impose additional trapped tension above that imposed by said springs and movable fingers when contact is made between said movable spring contacts and said front spring contacts during actuation of the armature from its normal position.

7. In a relay structure, the combination with a pair of cores connected by a back yoke, coils on said cores to magnetize the free ends of said cores so as to have magnetic poles of opposite polarity, an armature pivoted near the middle and having opposite ends in close proximity to the free ends of said cores, a permanent magnet for creating magnetic fields in multiple through said cores and passing through said armature, two members of substantially the same diameter one fixedly supported relatively to said cores and the other operatively connected with said armature and arranged coaxially when said armature assumes its normal non-actuated position and having their axes parallel but separated from each other when said armature assumes an actuated position, two flat springs having one end fixedly supported with respect to said cores and having their free ends bearing against opposite sides of both of said members when said armature is in its non-actuated position, a bias adjuster screw for each of said flat springs, means for mounting each adjuster screw in contacting relation with its flat spring, means for adjustably changing the con-

tacting relationship of each adjusting screw both transversely and longitudinally with respect to its associated flat spring, whereby to respectively adjust the initial trapped tension and the rate of pressure build-up of the force exerted by such spring upon said movable member as said armature is moved from its normal position.

8. In a relay structure, the combination with a pair of cores connected by a back yoke, coils on said cores to magnetize the free ends of said cores so as to have magnetic poles of opposite polarity, an armature pivoted near the middle and having opposite ends in close proximity to the free ends of said cores, a permanent magnet for creating magnetic fields in multiple through said cores and passing through said armature, two members of substantially the same diameter one fixedly supported relatively to said cores and the other operatively connected with said armature and arranged coaxially when said armature assumes its normal non-actuated position and having their axes parallel but separated from each other when said armature assumes an actuated position, two flat springs having one end fixedly supported with respect to said cores and having their free ends bearing against opposite sides of both of said members when said armature assumes its non-actuated position, a bias adjuster screw for each of said flat springs, means for mounting each adjuster screw in contacting relation with its flat spring, means for adjustably changing the contacting relationship of each adjuster screw both transversely and longitudinally with respect to its associated flat spring, whereby to respectively adjust the initial trapped tension and the rate of pressure build-up of the force exerted by such spring upon said movable member as said armature is moved from its normal position, spring contacts, other contacts operable by said armature and engageable with the spring contacts, pressure members, said spring contacts bearing against the pressure members, the pressure members being of such a length as to produce the proper build-up of contact pressure from the point at which the spring contacts are engaged by the other contacts to where the armature has been operated to its fully acuated position.

9. In a relay, a core and coil structure, a permanent magnet, and an armature magnetically associated with said permanent magnet and said core and coil structure, biasing means for urging said armature to a neutral position by trapped tension and producing a predetermined build-up when moved from such neutral position, and including, movable contact spring fingers moved upon initial movement of the armature, and a spring having trapped tension imposed against a stop when said armature is in its neutral position, the tension of said spring building up at a predetermined straight line rate upon movement of said armature from its neutral position, and other contact spring fingers engaged by said movable spring fingers to cause additional build-up of the load in addition to that imposed by said biasing means, whereby the load curve starts at an appreciable value upon initial movement of the armature, then builds up at one predetermined rate followed by a higher rate; said core, coil and permanent magnet structure being of a construction such that the torque curves due to energization of said coil with a current of a predetermined value and with current of one-half that value, respectively conform in shape to said load curve and fall respectively wholly above and wholly below said load curve, whereby said relay will pick up if energized by current of said one predetermined value, and will drop if the current be reduced to one half of that value.

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