

Feb. 18, 1958

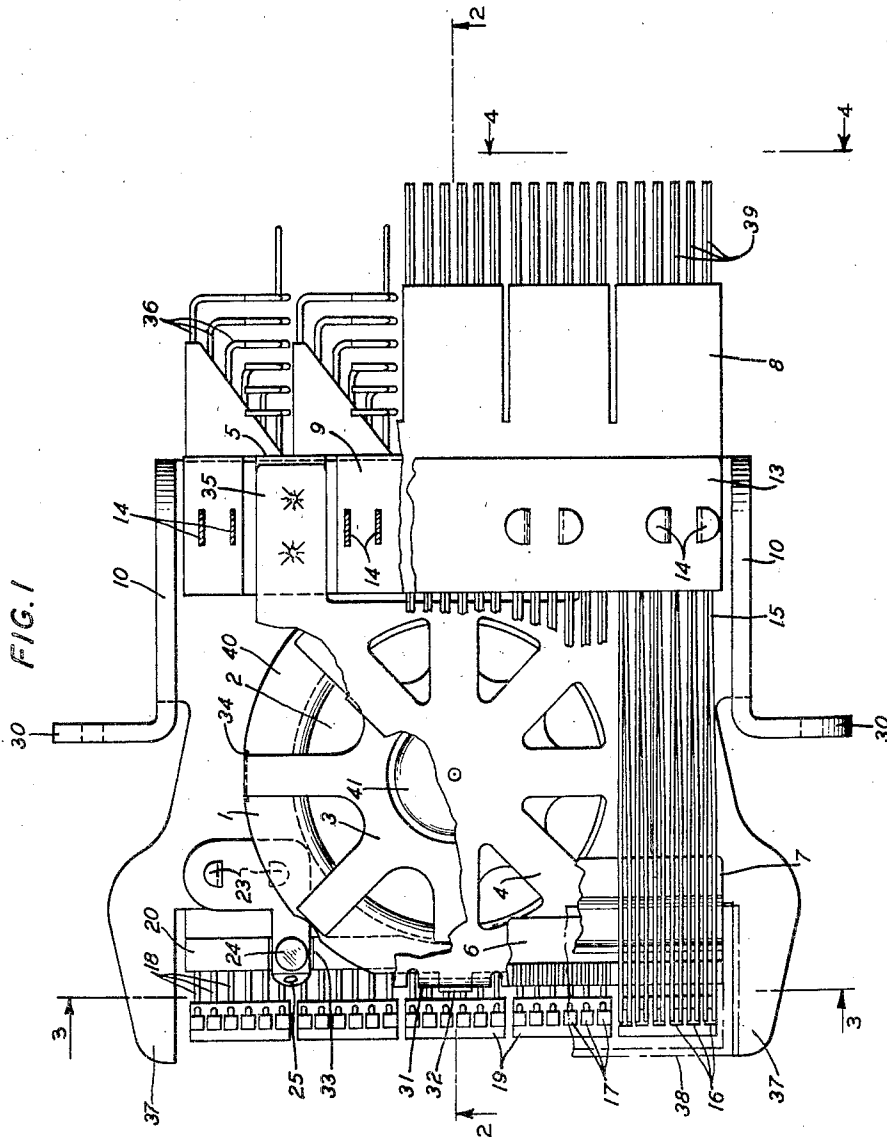
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2,824,266

RELAYS

Filed Feb. 25, 1955

5 Sheets-Sheet 1



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FIG. 2

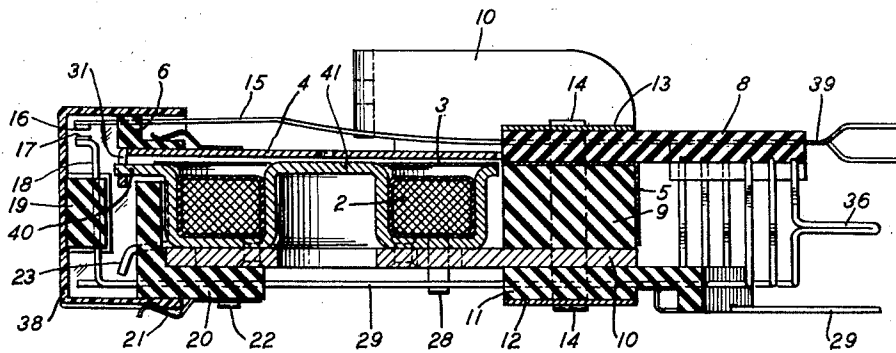


FIG. 3

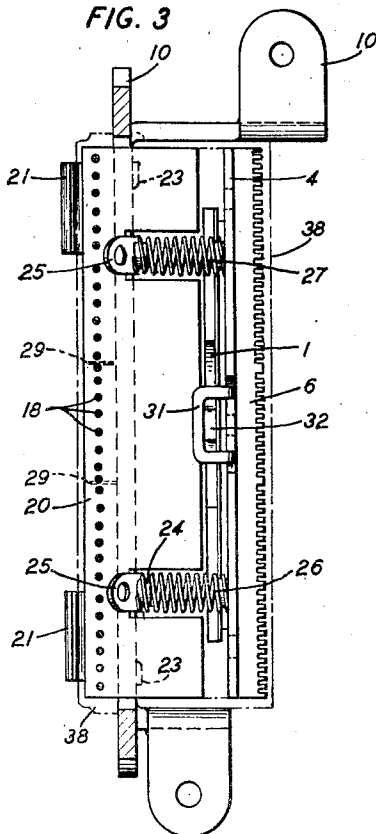
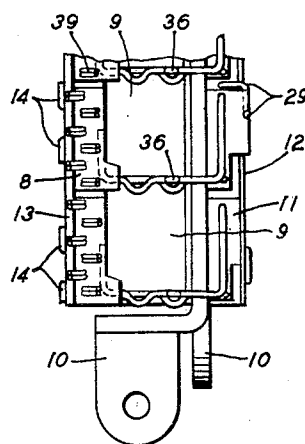


FIG. 4



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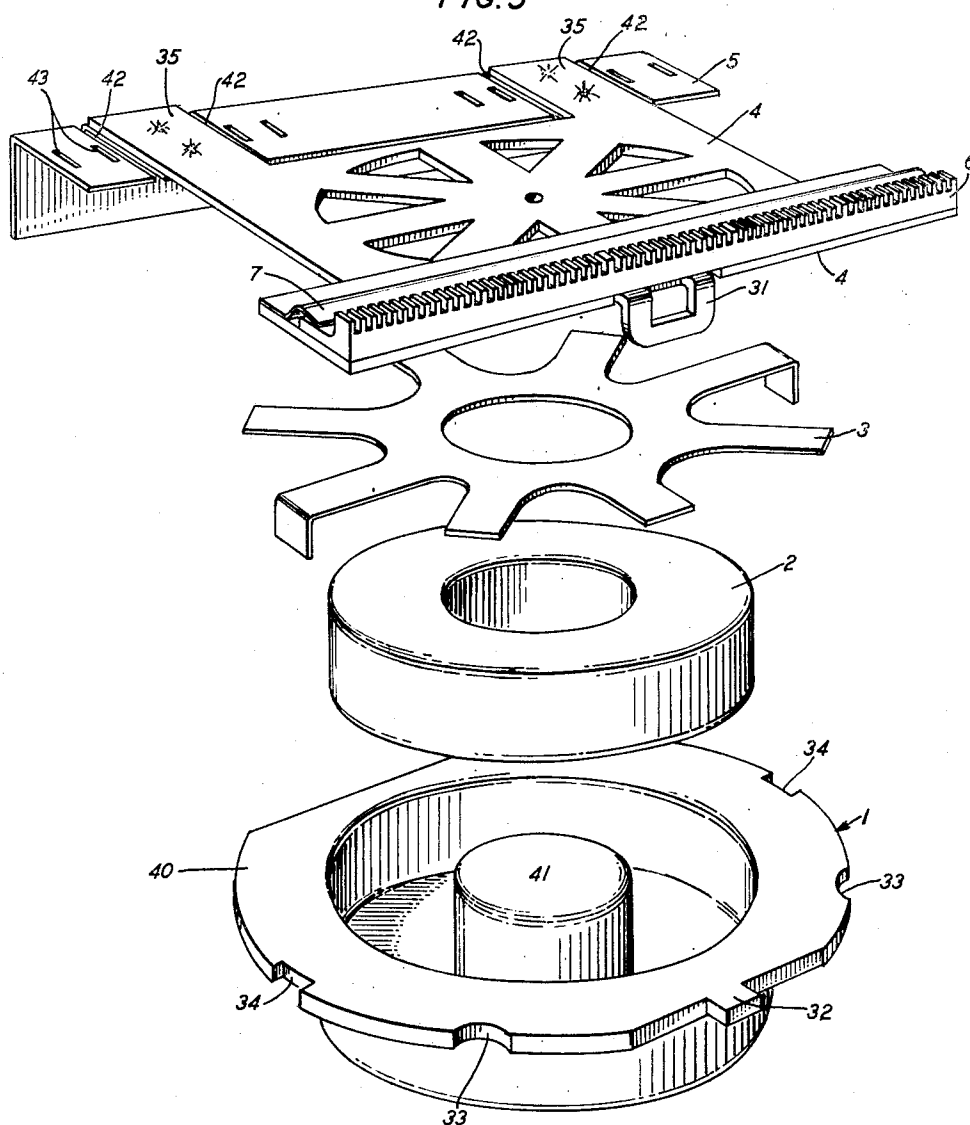
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FIG. 5



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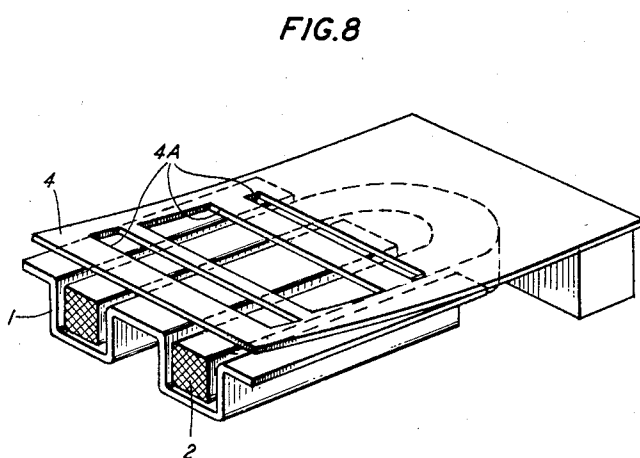
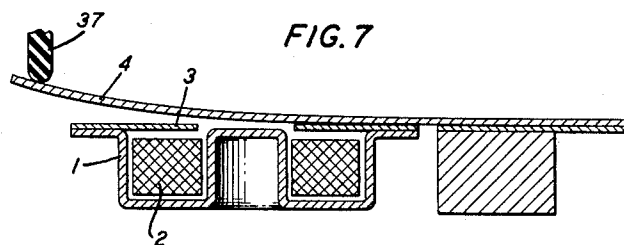
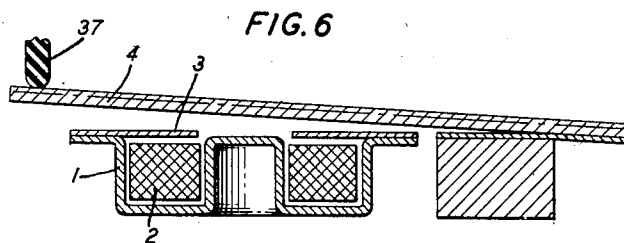
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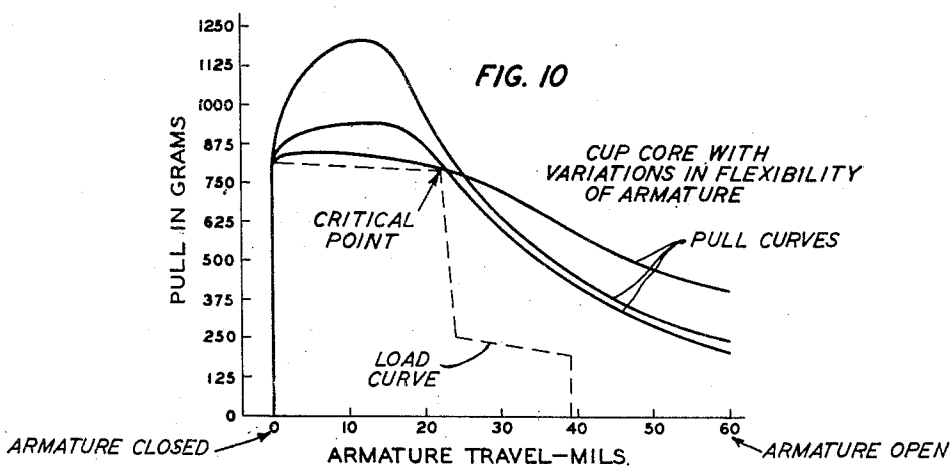
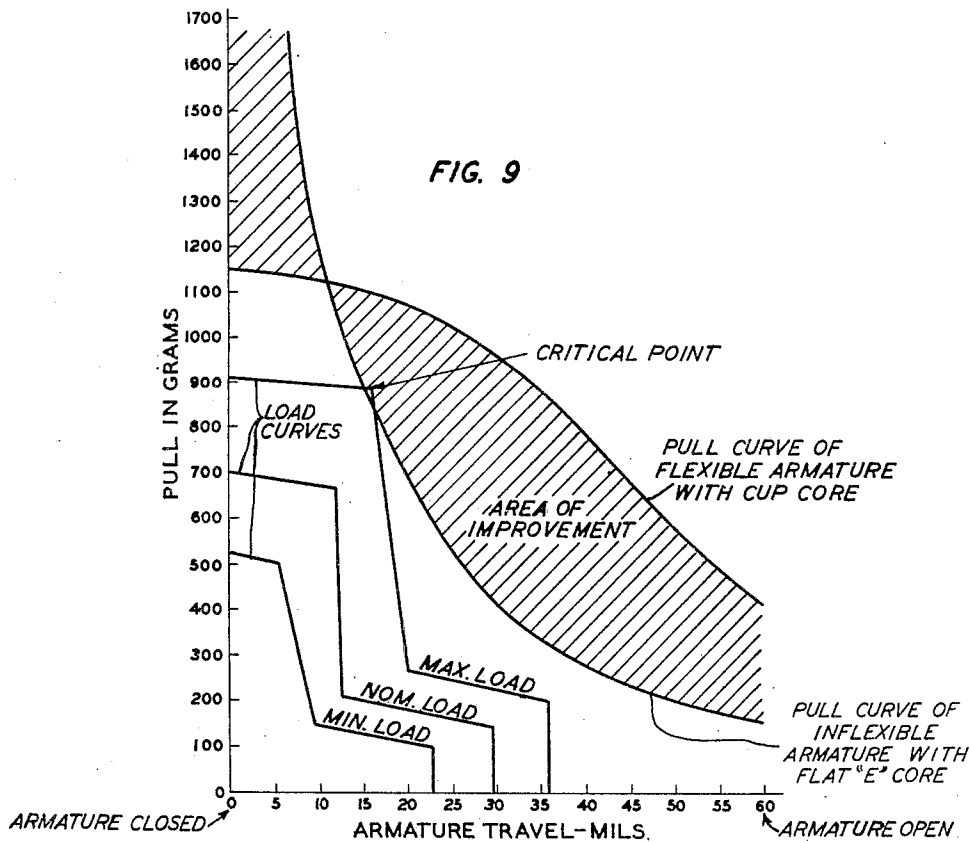
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2,824,266

RELAYS

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Application February 25, 1955, Serial No. 490,567

10 Claims. (Cl. 317—165)

This invention relates to electromagnetic devices and, more particularly, to magnetic systems for relays, especially for relays of the wire spring type such as disclosed, for example, in Patent 2,682,584, granted June 29, 1954, to H. M. Knapp.

In general, the magnetic system in relays of the type above mentioned comprises a core having a first leg or pole-piece and a second pole-piece having one or more legs spaced from the first pole-piece, the legs being substantially flat and parallel. A coil is coupled to the core and is effective when energized to magnetize the two pole-pieces to opposite polarities. Mounted for pivotal movement toward the pole-pieces in response to energization of the coil is a rigid armature which, in the operated position, substantially bridges the pole-pieces.

Among the operating characteristics of particular moment in the evaluation of a magnetic system of the character above mentioned are the pull characteristics, e. g. the relation between the load and the force effective upon the armature, the operate times, closing force and, concomitantly therewith, relay chatter, and, of course, efficiency.

In known constructions, the effective pole face area is substantially concentrated whereby a fixed lever ratio during movement of the armature obtains. As the armature approaches the pole-pieces, the pull thereon increases continually so that substantially maximum force is exerted upon the armature at the end of its travel. This is conducive to contact chatter and also to excessive wear. Further, in known constructions, the return flux path areas of the core contribute little, if at all, to the pull effective upon the armature so that the efficiency is relatively low. Moreover, in known constructions, efficiency is degraded by virtue of flux leakage.

One general object of this invention is to improve the performance characteristics of electromagnetic devices.

More specifically, objects of this invention are to realize improved pull characteristics in electromagnetic devices such as relays, to reduce chatter and wear in such devices, to decrease the operate and release times, to permit the use of thinner and lower grade magnetic materials and to increase the efficiency.

In accordance with one feature of this invention, in a magnetic system of the character discussed hereinabove, the pole-pieces and armature are constructed and arranged to provide a pull characteristic of prescribed configuration. More specifically, in accordance with one feature of this invention, the pole-pieces and armature are constructed and cooperatively associated to provide a pull characteristic conforming to or matching the load curve for the armature.

In one illustrative embodiment of this invention, the magnetic system of a wire spring relay comprises a core having a pair of coaxial, substantially coplanar pole faces and an armature mounted for rocking movement relative to the pole faces. The armature advantageously is flat, may be of polygonal configuration and is of transverse dimensions at least equal to those of the outer pole face. It

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is mounted normally inclined with respect to the pole faces by a support laterally beyond one side of the outer pole face. Thus, the armature forms an air gap with both pole faces, the gap between the armature and the outer pole face increasing in length away from the support. Upon energization of the coil, initially a large force or pull is exerted upon the armature adjacent the portion thereof for which the air gap aforementioned is relatively small, this force acting over a relatively short lever arm. As the armature moves toward the pole faces, the effective pole face area varies progressively so that as the armature approaches the end of its travel, the force or pull thereon increases only slightly at most and acts over a relatively long lever arm. Consequently, a comparatively low final armature velocity is achieved and, in the case of a relay, closing impact shock of the contacts is reduced. Further, it has been found, this construction enables enhancement of the operate and release times.

The pull characteristic above described approximates, generally, the load upon the armature. This characteristic can be tailored to match the load, particularly effectively through control of the stiffness of the armature. In especially advantageous constructions, the armature is made sufficiently flexible to bow concave upwardly relative to the pole faces upon initial energization of the coil. In such construction, in operation, the armature executes a rolling-like motion over or relative to the pole faces. By controlling the stiffness of the armature, the pull characteristic can be made such that the change in force effective upon the armature throughout the end portion of its travel is minimal.

All of the features of the invention will be readily understood from the following detailed description when read with reference to the accompanying drawings in which:

Fig. 1 is a plan view of a relay, a preferred embodiment of the invention, partially cut away to disclose the pole faces, terminal arrangements and other features of construction;

Fig. 2 is a longitudinal section of the relay shown in Fig. 1 taken along the line 2—2 and looking in the direction of the small arrows;

Fig. 3 is a transverse section of the relay shown in Fig. 1 taken along the line 3—3 and looking in the direction of the small arrows;

Fig. 4 is a back elevation of a part of the relay shown in Fig. 1 taken along the line 4—4 and looking in the direction of the small arrows;

Fig. 5 is an exploded view of the major components of the magnetic structure of the relay shown in Fig. 1;

Fig. 6 is a schematic cross section of some of the major components of the magnetic structure of a relay of the general type shown in Fig. 1 and illustrates particularly the configuration of a stiff armature at the instant after energization of the coil but prior to separation of the armature from its backstop;

Fig. 7 is a schematic cross section of some of the major components of the magnetic structure of a relay of the type shown in Fig. 1 and illustrates particularly the configuration of a flexible armature at the instant after energization of the coil but prior to separation of the armature from its backstop;

Fig. 8 is a schematic view of another embodiment of the invention employing a "deep W" type core structure with the armature transversely disposed with respect to the coil and core structure;

Fig. 9 is a graph of a family of load curves of a relay of the wire spring type together with the pull curve of a stiff or inflexible armature associated with a conventional E or flat core compared with the pull curve of a flexible armature operatively associated with a core arrangement constructed according to the invention; and

Fig. 10 is a graph of a wire spring relay load curve together with a family of flexible armature pull curves and illustrates particularly the flattening effect produced on the pull curve by increasing armature flexibility.

Referring now to Figs. 2 and 5, illustrating the magnetic structure of the relay of Fig. 1, it will be noted that the major elements include the armature 4, the armature spring 5, the non-magnetic spacer 3, the coil 2, and the core 1. The armature 4, when in the operated or closed position, bears against the non-magnetic spacer 3 which in turn separates the armature 4 from the outer pole face 40 and from the inner pole face 41. The coil 2 fits into the annular ring of the core 1. The core 1 can be manufactured advantageously from a single drawn or stamped piece. It will be noted further that except for the top surface of the coil 2, the coil is entirely contained within the core structure 1. This containment of the coil 2 by the core structure 1 results in a magnetic structure of small vertical dimension. Inasmuch as the dimension of the magnetic structure is the primary determining factor affecting the size of the relay, this feature is particularly desirable in relays employed in multiple banks where space considerations are of importance. Moreover, a further distinct advantage is gained by the association of the core and coil in the manner described. Containment of the coil by the core results in a large area magnetic circuit of low reluctance which reduces leakage flux to a minimum. As a result, fewer ampere turns are required for successful operation. Included among the advantages associated with reduced ampere turns is the fact that there is less heat to be dissipated, the core and armature can be manufactured of relatively low grade magnetic material such as cold rolled steel and also those components can be made thinner and lighter than is the case in a relay in which the core is essentially flat.

The manner in which the armature 4 is supported and pivoted may best be understood from Figs. 2 and 5. The pivoting side of the armature 4 is extended in two legs 35 which are spot-welded to the corresponding sections of the armature spring 5. It will be noted that the top portion of the armature spring 5 is divided into five sections by means of four slots 42 in order to attain a prescribed degree of flexibility. The top normally horizontal portion of the armature spring 5 rests against a phenolic supporting piece or spacer 9. The spring 5 and armature legs 35 are secured in position between the spacer 9 and a second phenolic piece, the twin wire block 8. The twin wire block 8 has recessed areas to accommodate the armature legs 35. The spacer 9 rests on the mounting bracket 10. The bottom member of the pileup or armature support structure is the rear single wire block 11. The pileup is secured in place by means of a top clamp plate 13, a bottom clamp plate 12 and four staples 14, each of which passes through the bottom clamp plate 12, the rear single wire block 11, the mounting bracket 10, the spacer 9, the armature spring 5, the twin wire block 8, and finally the top clamp plate 13. The eight holes 43 in the armature spring 5, which are designed to receive the four staples 14, are illustrated in Fig. 5. From the foregoing description of the armature support structure, it will be understood that the armature is pivoted at a point laterally beyond the outer pole face 40, thus forming an air gap with both the outer pole face 40 and the inner pole face 41. Further, it will now be apparent that in the unoperated position, the air gap between the armature and any given point on either pole face will vary directly with the distance of that point from the pivot or hinge axis of the armature.

Referring now to more of the details of the exemplary embodiment of the invention, illustrated in Figs. 1, 2, 3, 4 and 5, it will be noted that the contact end of the armature 4 is extended on each side so that the armature assumes a T configuration. Mounted across the end of the armature 4, on the cross of the T, is a non-magnetic twin wire guide comb bar 6 with slots provided to hold

the top twin wire leads in place. The guide comb bar 6 is held in place against the armature 4 by a metal spring clip 7 which is in turn spot-welded to the armature 4. The radial sectorial apertures in the armature 4 are designed to lighten the armature and to control its stiffness. Also, the apertures are spaced and proportioned to give the armature the desired magnetic flux conductivity.

The squared notches 34 in the outer pole face of the core 1 are designed to receive the two tongues of the separator 3 which are bent at right angles to the plane of the pole face and thus retain the separator 3 snugly against the pole faces 40 and 41 of the core 1. The rounded notches 33 in the outer pole face 40 of the core 1 are designed to permit insertion of the helical back tension springs 26, best viewed in Fig. 3. Operation of these springs will be explained later herein. The squared projection 32 from the outer pole face of the core 1 is the armature backstop and is designed to engage the armature backstop catch 31. Upon deenergization of the magnetic circuit, the armature pivots away from the pole faces, forced by the action of the armature spring 5 and the helical back tension springs 26, until the inner lower portion of the armature backstop catch 31 rides against the lower portion of the armature backstop 32.

As noted heretofore, the upper or movable set of relay contacts 16 are carried on the ends of pairs of conventional sets of wire spring leads 15. The paired spring leads are maintained in position at the back of the relay by the twin wire block 8 which is composed of laminated non-magnetic sections which enclose approximately one-third of the length of the twin wires 15.

Tracing the path of the movable sets of twin wire leads 15 from the terminal arrangements at the rear of the relay and passing through the twin wire block, it will be noted that the wires are bent slightly to pretension them to create a downward force to hold the wires in their respective slots in the twin wire guide comb bar 6. Continuing to trace the circuit, Fig. 2 illustrates the relay in the open or unoperated position with the open circuit gap appearing between the twin wire contacts 16 and the fixed single wire contacts 17. Each of the five groups of six single wire leads passes through a laminated phenolic contact adjustment and alignment block 19. Proper alignment of each of the five groups of single wire leads and contacts is attained by exerting a force against the appropriate alignment block 19 in order to impart the desired degree of bending stress against the group of single wire leads. After passing through the contact adjustment and alignment blocks 19, the single wire leads are bent at right angles to pass through the front single wire block 20, continuing back under the mounting bracket 10, through the rear single wire block 11 and on into the rear single wire terminal arrangement 36.

Returning now to the front single wire block 20, as illustrated in Fig. 2, it will be observed that two metal clips 21 are secured by staples 22 to the underside. The clips 21 are firmly tensioned against the underside of the front single wire block 20 in order to hold a rectangular box-like plastic contact cover 38 which may be fitted over the entire front or contact end of the relay in order to keep the contacts free from dust or other foreign matter. The plastic cover 38 has a groove on the outside of each side which accepts the inside edge of each of the two front projecting prongs or cover guides 37 of the mounting bracket 10. The plastic cover 38 has four plastic sections or divisional walls each of which fits into one of the four spaces between the contact adjustment and alignment blocks 19. The plastic divisions extend back to a depth which is approximately equal to the thickness of the contact adjustment and alignment blocks 19. The same staples 22 which secure the cover clips 21 to the front single wire block 20 pass through the mounting bracket 10 and through the two spring adjustment plates 23.

The spring adjustment plates 23 perform a dual function. They serve as lower bearing surfaces for the helical back tension springs 26 and also provide a means for adjusting the helical back tension springs 26 to the desired tension. Each back tension spring 26 is fitted over the small right cylindrical projection 24 or centering shoulder of the spring adjustment plate 23. The top of each back tension spring fits around and is centered by a small right cylindrical projection, not shown, on the bottom of the front section of the armature 4. The armature 4 thus operates against the tension of the armature spring 5 and also compresses the helical back tension springs 26. Adjustment of the tension of the helical back tension springs 26 is effected by bending the spring adjustment plates 23. This bending may best be accomplished by exerting force on any small pointed tool inserted in the hole provided in the bent over tip 25 of the spring adjustment plate 23.

Introduction of current into the coil 2 is effected by means of two coil supply contacts 28, one of which is visible in Fig. 2 extending below the core 1. Current to the contacts 28 is supplied by two coil supply leads 29, illustrated in Figs. 2 and 3. Each coil supply lead bears against the appropriate coil lead contact 28 and parallels the several single contact wires 18 running under the relay mounting bracket 10 and through the rear single wire block 11. The terminal end of a coil supply lead 29 is illustrated in both Figs. 2 and 4.

The foregoing descriptions of the armature 4 have not included discussions disclosing its unique flexibility or bending characteristics, noted above as a significant feature of the invention. Both the theoretical and practical aspects of this feature will be readily understood by reference to Figs. 6, 7, 9 and 10 in connection with the following discussion.

Traditional practice in the design of armatures for conventional relays calls for a rigid or stiff armature which remains substantially flat without bending while carrying a load during its period of travel. Fig. 6 schematically illustrates a conventional stiff armature 4 in combination with a cup-type magnetic core structure 1 integrally associated with concentric pole faces forming an essentially annular receptacle for the insertion of the coil 2. In Fig. 6, current has been introduced to the coil 2, flux has started to build up and exert a pull on the armature 4, but insufficient time has elapsed to overcome the opposing spring tension and hence the armature still rests against its backstop 37. It should be noted that with the type of relay illustrated in Fig. 6, the armature 4 will remain essentially flat and rigid throughout its entire arc of travel from its position of rest against its backstop 37 to its closed position in a plane essentially parallel to the pole faces.

In contrast to Fig. 6, Fig. 7 illustrates the action of a flexible or non-rigid armature 4. In other respects, the general construction of the relay is the same as that illustrated in Fig. 6 and the time elapsed since the coil was energized is the same as that illustrated in Fig. 6. The flexible armature in Fig. 7, however, has already been drawn toward the pole face in the area nearest to the armature axis. Nevertheless, the flux build-up has not been sufficient to draw the armature 4 away from its backstop 37. The result, as clearly illustrated, is a marked bowing or flexing of the armature as it is pulled against the spring load. It will now be understood that as the armature 4 in Fig. 7 moves through its arc of travel, the area of contact between the armature 4 and the pole face, or separator 3, will advance progressively from the point on the outer pole face nearest to the armature hinge axis to the point on the outer pole face furthest from the armature hinge axis. The armature 4 will thus close with a rolling like motion across the pole faces until it comes to rest in the closed or operated position at which point it will again become straight or flat as it was prior to the energizing of the coil. The effect of the bending action of the armature is to change the traditional

relationships between the armature gap and the armature travel, between the armature travel and the effective pull and between the pull and load lever arms. All of these effects may be utilized to provide a relay armature wherein the pull characteristics closely approximate the load characteristics.

It is well known that flux concentration in the air gap of a relay is inversely proportional to the length of the air gap. Thus, initially, the effective center of pull of the magnet will be relatively close to the armature hinge axis in the unoperated position whether the armature be rigid or flexible. With the flexible armature, however, the effective center of pull of the magnet moves rapidly away from the axis as the armature travels to its operated position. As a result thereof, advantage is taken, initially, of having a short lever arm from hinge point to pull center, permitting a high lever ratio to the load arm, while retaining the final advantage of a low lever ratio to the load arm.

The magnitude of these new relationship is readily apparent from Figs. 9 and 10. The family of load curves in Fig. 9 is fairly representative for any multicontact wire spring relay. The lower pull curve is that plotted from the operation of a 200-ampere turn wire spring relay with a flat E type core structure and a rigid armature. It will be noted that the curve is generally concave upward, that it intersects the maximum load curve approximately at the critical point, the break in the load curve nearest to the armature closed position, and that in approaching the closed position or point of zero armature travel, the pull in grams increases sharply to extremely high values. The essentially exponential characteristic of the curve results from the basic design characteristics of the conventional relay whereby a small force is exerted at large air gaps and a steadily increasing force is exerted as the armature approaches the core. The lever arm over which the force operates also remains substantially constant throughout the travel of the armature. Consequently, as may be readily seen from Fig. 9, the pull curve does not approximate the load curve.

The top curve in Fig. 9 has been plotted from values observed in the operation of a 200-ampere turn wire spring relay with a type of magnetic structure disclosed herein, i. e., a cup-type core with integral concentric pole faces and a flexible armature. It will be noted that the top curve is generally concave downward, that it clears the critical point of the load curve by a comfortable margin, and that in approaching the closed position or point of zero armature travel, there is no radical increase in the grams of pull. The areas partially enclosed by the two curves may be literally referred to as areas of improvement. The hatched area to the right of the intersection of the two curves illustrates the significant increase in pull force throughout the major part of armature travel that is attained in a relay which embodies features of the invention. The hatched area to the left of the intersection of the two pull curves illustrates the marked advantage of the improved relay in maintaining the pull force at a comparatively low level near the end of the armature travel. The distinct advantage gained thereby is that the application of the operating force to the load is more analogous to a rocking chair squeeze than to a hammer blow. This advantage is reflected in a lower final armature velocity and in the reduced shock of armature closing impact. Furthermore, these advantages are attained with faster operate and release times per ampere turn value. The area between the two curves to the right of their intersection illustrates the increased pull force which results in faster operate time for a relay embodying features of the invention. The area between the two curves to the left of their intersection illustrates the excessive magnetic flux which must decay upon deenergization of the conventional relay prior to armature release. Hence, the area to the left of the intersection of the two

curves is illustrative of the faster release time of a relay embodying features of the invention.

The pull curves of Fig. 9 illustrate clearly the broad area of improvement in pull curve characteristics attained in a relay embodying both the cup-type concentric pole face core and the flexible armature. Reference to Fig. 10 will be of assistance in pointing out the contribution of the flexible armature feature itself in improving pull curve characteristics. The dotted line represents a multiple contact wire spring relay load curve. The family of pull curves has been plotted from data observed from the operation of a relay embodying the features of the invention disclosed herein. The variation in the three pull curves represents the effect of varying the thickness and hence the flexibility of the armature. The curve which reaches a peak pull of approximately 1140 grams was plotted from the operation of a relay with an armature thickness of .040 inch. A peak pull of approximately 950 grams was reached with an armature of .036 inch thickness and a peak pull of approximately 850 grams was obtained with an armature of .028 inch thickness. In each case, the material of the armature was cold rolled steel. It is apparent that a primary contribution of the flexible armature is in limiting the excessive pull experienced toward the end of armature travel with a stiff or conventional armature, or, expressed in terms of the pull curve, the contribution of the flexible armature is in flattening the curve. Moreover, it is apparent that varying degrees of armature flexibility can be used in order to shape or tailor the pull curve to conform to the particular load curve resulting from any given relay design.

The type of novel core structure disclosed herein also lends itself to modifications by which, in particular design situations, the pull curve of a relay can be made to conform more closely to the load curve than is the case in relays known in the art heretofore. It has been found that varying the pole face area by changing the overall shape or size of the basic design, or by means of notches or pole face apertures, has a marked effect on the configuration of the pull curve. Further tailoring of the pull curve can be effected in a relay constructed according to features disclosed herein by varying the initial heel gap or space between the armature and that section of the pole face closest to the armature axis. This variation can be readily obtained by appropriate positioning of the level or plane of the armature hinge axis above the plane of the pole faces to the point at which the desired effect in shaping the pull curve is attained.

Still further tailoring or shaping of the pull curve is possible, for example, by controlling the stiffness of the armature linearly or transversely, or both, with ribs or bent over sections, and by choking or redistributing the useful flux paths in the armature or core through alteration of the cross sectional area of magnetic material in any of numerous places in the relay.

While the exemplary form of core structure 1, illustrated in Fig. 5, may be particularly well adapted to conform to the shape and space limitations and design requirements of a given relay installation, it is not to be interpreted as limiting the scope of the invention to the particular embodiment presented. For example, a number of common novel features are present in the magnetic relay structure illustrated in Fig. 8. There it will be observed that while a cross section of the structure presents essentially the same view as would a cross section of the type of core and coil illustrated in Fig. 5, the arrangement in Fig. 8 involves a core structure that is straight rather than annular, a design which may be described as a "deep W" type. While the greater part of the coil is substantially enclosed in the cup-type recesses of the core, the ends of the elliptical coil are outside the core.

Particular design requirements as to armature weight, flexibility, and flux conductivity, might result in the con-

figuration of the armature slots 4A as illustrated. Again it will be noted that the armature 4 is rotated about a pivot axis that is laterally spaced from the core 1. While differing substantially from the arrangement of the embodiment of the invention illustrated in Fig. 5, the device illustrated in Fig. 8 nevertheless retains the advantages of the features of the invention as discussed hereinabove.

Still further flexibility of mechanical design is possible in the cup-type core illustrated in Fig. 5. For example, the core need not necessarily be round but could be square, rectangular, elliptical, or of other convenient shape in order to match available space. Nor is it necessary that the core structure be drawn from a single piece. Within the same overall dimensions, greater winding space and a larger central pole face area may be obtained by using a central shouldered stud, or post, or other fabricated construction instead of an integral drawn center. The head of such a post could be enlarged or not depending upon the design requirements for the size of the center pole face.

All of the above embodiments of the features disclosed herein, and various modifications which may be suggested by the above discussions, may be used toward the end of exercising closer control over the electromagnetic behavior of a relay or similar magnetic device in order to achieve desired operating characteristics.

What is claimed is:

1. An electromagnetic device comprising a magnetic core having an inner pole-piece and an outer pole-piece encompassing and spaced from said inner pole-piece, an energizing coil for said core, an armature extending across and spaced from opposite portions of said outer pole-piece, said armature having an intermediate portion in juxtaposition to said inner pole-piece, and means mounting said armature adjacent one of said opposite portions for rocking movement relative to said pole-pieces, said armature being sufficiently flexible to bow concave upwardly with respect to said pole-pieces when said coil is energized, thereby causing contact between said armature and said pole-pieces to be effected progressively across said pole-pieces.

2. An electromagnetic device comprising a magnetic core having spaced inner and outer pole faces, an energizing coil for said core, an armature, and means mounting said armature for pivotal movement about an axis adjacent and outside of a portion of the outer pole face, said armature extending from said mounting means over said portion of said outer pole face and over said inner pole face to an opposite portion of said outer pole face, said armature being substantially flat but sufficiently flexible to bow concave upwardly with respect to said pole faces when said coil is energized, thereby causing contact between said armature and said pole faces to be effected progressively across said pole faces from a point on said outer pole face relatively near said mounting means to a point on said outer pole face relatively distant from said mounting means.

3. An electromagnetic device comprising a magnetic core having coaxial inner and outer pole faces, an energizing coil for said core, a support laterally beyond said outer pole face, and an armature mounted by said support, said armature extending over and in spaced relation to said inner pole face and diametrically opposite portions of said outer pole face, said armature being substantially flat but sufficiently flexible to bow concave upwardly with respect to said pole faces when said coil is energized, thereby causing contact between said armature and said pole faces to be effected progressively across said pole faces.

4. An electromagnetic device comprising a magnetic core having a cup-shaped outer pole-piece and an inner pole-piece coaxial with said outer pole-piece, an energizing coil for said core, said pole-pieces having substantially coplanar pole faces, a flat armature overlying

and spaced from said pole faces and of transverse dimensions at least as large as those of the outer pole face, and means mounting said armature for rocking movement about an axis laterally beyond said outer pole face, said armature being sufficiently flexible to enable the area of contact between said armature and said pole faces to increase progressively, after said coil is energized, from a point on said armature relatively close to said mounting means to a point on said armature relatively distant from said mounting means.

5. An electromagnetic device comprising a magnetic core having an inner pole-piece and an outer pole-piece encompassing and spaced from said inner pole-piece, an energizing coil for said core, an armature extending across and spaced from opposite portions of said outer pole-piece and having an intermediate portion in juxtaposition to said inner pole-piece, and means mounting said armature in normally inclined relation to said pole-pieces and for rocking movement about an axis laterally beyond said outer pole-piece, said armature being sufficiently flexible to bow concave upwardly with respect to said pole-pieces after said coil is energized, thereby causing contact between said armature and said pole-pieces to be effected progressively across said pole-pieces from a point on said outer pole-piece relatively near to said mounting means to a point on said outer pole-piece relatively distant from said mounting means.

6. An electromagnetic device comprising a magnetic core having a pair of pole-pieces terminating in spaced, coaxial, substantially coplanar pole faces, an energizing coil for said core, a flat, polygonal armature overlying said pole faces and extending beyond diametrically opposite areas of the outer pole face and in spaced relation thereto, and means mounting said armature adjacent one of its edges for rocking movement relative to said pole faces, said armature being normally inclined relative to the plane of said pole faces, said armature being sufficiently flexible to bow concave upwardly with respect to said pole-pieces after said coil is energized, thereby causing the area of contact between said armature and said pole-pieces to be increased progressively across said pole-pieces from a point on said outer pole-piece relatively near to said mounting means to a point on said outer pole-piece relatively distant from said mounting means.

7. An electromagnetic device comprising a magnetic core having a pair of pole faces, an energizing coil for said core, a substantially flat armature extending across said pole faces in spaced relation thereto, the spacing between said armature and one of said pole faces being greater than that between said armature and the other of said pole faces, and means mounting said armature adjacent one of said pole faces for rocking movement with respect to said pole faces, said armature being sufficiently flexible to bow concave upwardly relative to said faces when said coil is energized thereby causing the contact area between said armature and said pole faces to expand progressively across said pole faces starting at a point relatively near to said mounting means.

8. An electromagnetic device comprising a magnetic core having spaced inner and outer pole-pieces, an en-

ergizing coil for said core, a substantially flat armature having an intermediate portion in juxtaposition to said inner pole-piece and a pair of outer portions in juxtaposition to areas of said outer pole-piece on opposite sides of said inner pole-piece, the spacings between said outer portions and said areas respectively being different, and means mounting said armature for rocking movement about an axis laterally beyond one of said areas, said armature being sufficiently flexible to bow concave upward relative to said pole-pieces when said coil is energized thereby to cause contact between said armature and said pole-pieces to be effected progressively across said pole-pieces from a point on said outer pole-piece relatively near to said mounting means to a point on said outer pole-piece relatively distant from said mounting means.

9. An electromagnetic device comprising a magnetic core having a pair of coaxial, substantially coplanar pole faces, an energizing coil for said core, an armature having a substantially flat portion extending between opposite areas of the outer pole face and overlying the inner pole face, means mounting said armature for rocking movement about an axis laterally beyond said outer pole face, and normally in inclined relation to said pole faces, said armature being flexible whereby to bow concave upward relative to said pole faces when said coil is energized and thereby to cause the contact area between said armature and said pole faces to expand progressively across said pole faces starting at a point relatively near to said mounting means as said armature is being drawn toward said pole faces.

10. An electromagnetic device comprising a core having a cup-shaped outer pole-piece terminating in an annular outwardly extending flange defining an outer pole face, said core having also an integral inner pole-piece terminating in a circular pole face substantially coplanar with said outer pole face, an energizing coil for said core, a support to one side of said flange, and a substantially flat armature mounted by said support for rocking movement relative to said pole faces, said armature overlying said pole faces, extending across said outer pole face and being normally inclined with respect to said pole faces, and said armature being sufficiently flexible to bow concave upward relative to said pole faces when said coil is energized thereby to cause contact between said armature and said pole-pieces to be effected progressively across said pole-pieces from a point on said outer pole-piece relatively near to said mounting means, across the inner pole-piece and thence to a point on said outer pole-piece substantially diametrically placed from the point on said inner pole-piece where contact with said armature commenced.

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