

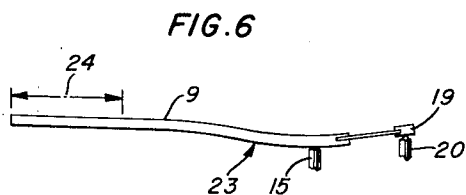
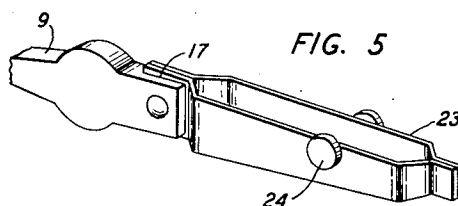
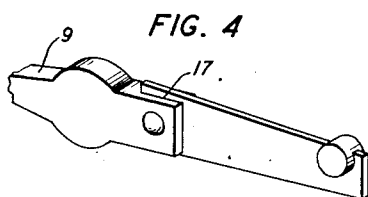
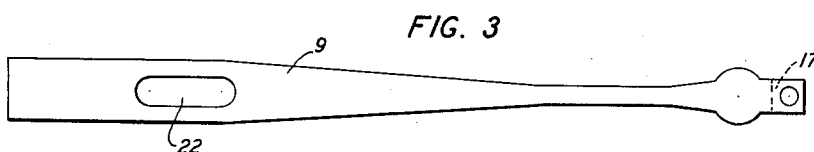
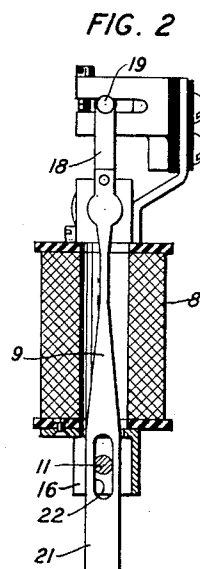
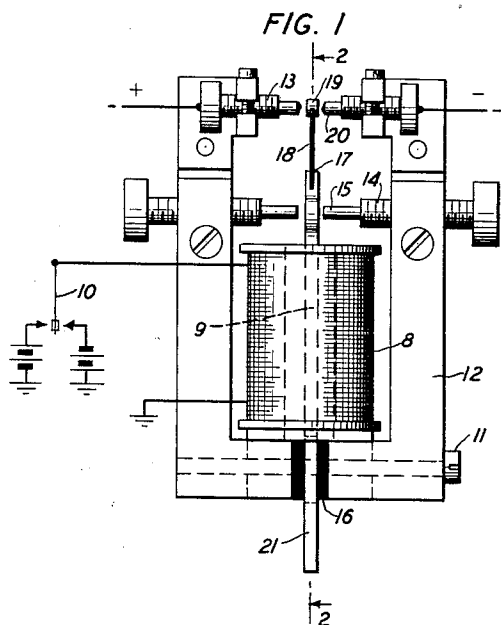
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2,580,123

RELAY

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2,580,123

RELAY

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This invention relates to high speed electro-magnetic relays of the polar type.

Telegraph apparatus has been so considerably improved and transmission channels having such effective transmission characteristics provided that the accuracy and speed of telegraph transmission is sometimes limited by the characteristics of available electromechanical relays.

Although several instrumentalities have been proposed as a substitute for electromechanical relays, the bulk of commercial practice in telegraphic impulse repetition or relaying is nevertheless accomplished at the present time by means of polarized electromechanical relays. It appears that they offer technical and economic advantages such that they have not been replaced by proposed substitutes. One of the objects of the present invention is to so improve electromechanical relays that they are capable of operating at higher speeds or with greater accuracy or both.

In speaking of defects or disadvantages of electromechanical relays, it is not to be assumed that these instruments are noteworthy imperfect or unsatisfactory at the present time; on the other hand, they serve their purposes quite effectively despite the fact that they have certain defects and insufficiencies.

Among the defects and insufficiencies of such relays are contact chatter; bias due to lack of mechanical or electrical symmetry; variation of bias due to previous history, such as a previous signal; contact wear; and erosion of contacts or deposition of material upon contacts resulting in undue maintenance expense in order to maintain the relay for signaling at required speeds with required accuracy.

The present invention has as an object to produce a relay in which one or more of the above conditions may be reduced or eliminated; even slight improvements in operation due to minor structural changes may be of considerable economic value; the cumulative result of various improvements set forth in the present application are quite considerable.

Several features of improvement disclosed in the present application all relate to improvements designed to increase the symmetry of operation of relays and may be incorporated in relays in combination with correspondingly beneficial results.

Among these features are:

(a) A special tapering of the armature to reduce maximum strain therein and to secure substantially uniform stress in the outer fiber of the armature;

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(b) Construction of the armature of high permeability iron-nickel alloy heat treated in a longitudinal magnetic field arranged symmetrically with respect to the longitudinal axis of the armature to create a magnetically symmetrical armature;

(c) Special machining to produce a bilateral symmetry of the armature;

(d) Use of a single contact spring accurately mounted and centered in the end of the armature;

(e) A rear end and extension of the armature to facilitate mounting or adjustment thereof in position without disturbing the armature, its working contacts, or the relation therebetween; and

(f) Symmetrical permanent magnet structure. The nature and details of these improvements may be more conveniently further described with reference to the accompanying drawings in which:

Fig. 1 is a top view of semidiagrammatic nature of a standard type of polar telegraph relay having the improvements of the present invention incorporated therein;

Fig. 2 is a cross-section through Fig. 1 taken on the line 2—2;

Fig. 3 is an enlarged side view of the armature designed to show its construction in greater detail;

Figs. 4 and 5 are perspective views, respectively, of single and double contact springs centrally mounted, these being modifications which may be employed with the features of Figs. 1 to 3, inclusive; and

Fig. 6 is a schematic view indicating whereat the point of inflection of the armature occurs; the curvature of the armature being indicated on an exaggerated scale.

In its fundamental features of construction, the improved relay disclosed in the present application is basically similar to that disclosed in the patent to Cummings 1,624,476, granted April 12, 1927 or Curtis 1,680,667, granted August 14, 1929; it may be considered as an improvement upon relays of the type disclosed in those patents; however, the features of the invention are not limited in application but may be applied to high speed polar relays of any suitable type.

The relay consists of an electromagnet comprising an energizing coil 3 through which armature 9 extends. The coil 3 may, and does in practice, consist of one or up to several windings connected to different sources, such as line current sources, polarizing current sources, etc., but is conventionally illustrated as being connected

to a source of positive and negative battery over a conductor which may be of any length to an armature 10 of an impulse originating relay or equivalent sending contacts of a transmitter which supplies impulses to vibrate the armature 9. The armature 9 is clamped by means of a screw 11 or any other suitable means between magnetic members of a completely symmetrical permanent magnet structure 12. To this end the opening for screw 11 may extend completely through the bar position and the screw may be made of brass or other non-ferrous material. The armature 9 vibrates between adjustable insulated conductive contacts 13 and is limited in motion by adjustable stop screws 14, which also are of magnetic construction, and terminate in pole-pieces 15 through which the flux to operate the armature flows into the armature structure. The armature is generally clamped between non-magnetic shims 16. In some relays the armature is kept from actual contact with the pole-piece 15 by a thin spacer of low permeability on either the armature or the pole-piece. This spacer is not shown. So far as described the construction is conventional and known.

A description will now be given of the novel features constituting the improvements to which this specification is primarily directed.

Prior practice in connection with high speed relays has been to construct the armature with a narrowed cross-section near the clamped end at which point most of the bending of the magnetic material takes place. This is shown in the two patents above identified and apparently was adopted as a standard construction in order that the relay armature might vibrate with the application of less force. Applicant has discovered that a standard type of armature of this kind may easily be strained enough to take on permanent deformation which is undesirable as the resulting lack of symmetry produces distortion or bias of telegraph signals.

According to this invention, the ideal shape of armature is one so tapered that bending in operation produces uniform stress in the outer fiber all along its length, thus using the material most efficiently. According to strict mathematical theory for producing uniform stress in the outer fiber all along its length, the height or cross-section at a point of inflection would be vanishingly small or zero. However, this ideal structure can only be approximated in practice because of the necessity of having sufficiently large pole faces and a structure capable of bearing the contact spring. Furthermore, the cross-section at the narrowed part must carry the magnetic flux required to operate the armature. However, it can be approximated rather closely in a practical armature. The armature is made of a width greater than that now in use for embodiment in a well-known relay of a standard type but the increase in width is limited by practical considerations. This limitation results in making the armature at the clamped end approximately one and one-half times the width of the narrow portion of armatures hitherto in use. Assuming an equal magnetic pulse in the two cases the stress is reduced by the factor of

$$\frac{1}{(1.5)^2}$$

and equals .444. If this width is not satisfactory, the width may be greater or smaller. The armature is tapered to an extent limited by the permeability of the material or the size of struc-

ture necessary to carry the pole faces and the contacts or both but it is made to approximate as nearly as possible, with a uniform thickness, a structure in which the maximum stress all along the outer fiber has a constant magnitude if the material is homogeneous.

In Fig. 6 is a view in which the curvature of the armature is exaggerated showing the armature in a position it assumes in engagement with one contact under the interaction of the magnetic field of an attracting pole-piece and the field resulting from a magnetic field set up in the armature by the operating winding. The pole-piece 15 is indicated as attracting the armature so that its contact rests against the fixed contact 20. The length of the rigidly fixed part of the armature is indicated by the dotted line 24 and the point of inflection is indicated at 23. It is seen that the point of inflection is between the fixed part of the armature and the pole-piece and occurs nearer the pole-piece than the fixed portion of the armature and in the region whereat the cross-section of the armature is a minimum. As previously stated, theoretical conditions for producing uniform stress in the outer fibre all along its length would call for a cross-section of the armature at the point of inflection vanishingly small; however, it is obvious from practical considerations that an armature whose cross-section becomes zero at an intermediate point would be without practical utility; consequently the mathematically ideal structure can only be approximated in practice.

Closely related to the tapering of the armature is the nature of the material of which it is constructed. In this connection two factors are important, first, the material must be of high permeability and low coercive force in the direction in which the field is applied and, second, its properties must be uniform. A material superior for this purpose is a composition of iron and nickel containing 65 per cent nickel and 35 per cent iron approximately, heat treated to produce the highest possible permeability and the lowest coercive force.

It has previously been discovered by others that nickel-iron alloys of this composition and other similar magnetic materials have a higher permeability in one direction than another when heat treated in a magnetic field. See patent to Kelsall 2,022,696, dated May 28, 1935. According to the present invention it has been discovered that heat treatment of the armature in a field in a direction parallel to its longitudinal axis may achieve not only the desirable result of producing an armature of high permeability in the direction in which the field is applied in use but also a structure which is far more nearly longitudinally symmetrical with respect to its magnetic properties than armatures manufactured as hitherto without regard to magnetic symmetry or the direction of any field which might accidentally or otherwise be applied to them during the heat treatment. Since the taper of the armature in accordance with the principles outlined above results in a cross-section at the thinnest portion, which is less than the smallest cross-section of prior standard armatures, the increase in permeability in the direction of the length of the armature is a factor of considerable importance.

This material thus prepared has a small coercive force which renders the relay relatively independent of the nature of previous signals which actuated it.

Another element of improvement is that the

armature is made bilaterally symmetrical. To achieve this result its opposite faces are ground to be planes parallel to each other within about 0.0001 of an inch.

Taper may be introduced by varying the dimensions of the armature with respect to a plane through the pole faces or a plane symmetrical with the pole faces. Only the former is considered practical in polar relays of the high speed type if the required symmetry with respect to a plane symmetrical to the pole faces is to result because any attempt to shape the armature by varying its thickness would present extremely difficult mechanical problems if in fact it can be done at all. The taper is then introduced by varying what we may term the height of the armature, keeping the thickness constant by accurately machining its sides as hereinafter stated. Minor departures from symmetry in a plane extending along the axis of the armature and through the pole faces are not consequential. If it is found to be mechanically achievable to produce a symmetrical armature having a taper in the thickness as well as in the width of the cross-section or by having a uniform width and tapered thickness or by having a taper in the width only, bilateral symmetry may be thereby achieved. The expense incident to production of sufficiently symmetrical armatures tapered in thickness is probably prohibitive.

Another feature of improvement with respect to symmetry consists of mounting the contacts upon a single contact spring. In a structure such as shown in the patent to Cummings referred to above, the contacts are mounted on two springs which rub together with frictional contact for the purpose of producing a frictional rubbing effect to reduce chatter. Although such a structure has been used to a considerable extent with beneficial results, it has been found that it is impossible except by occasional accident to select and mount two springs whose masses, flexibility and other physical properties are such that a symmetrical action will result. In accordance with a feature of the present invention, the end of the armature is prepared with an accurately machined slot 17 and in this slot is mounted a symmetrical contact-bearing spring 18 which may be bolted into place. Other methods of fastening the spring into a slot or slit, into which it exactly fits, may be used but bolting has the advantage that the contact spring may be readily removed. Furthermore, experience has shown that riveting is likely to result in non-symmetry, it being practically impossible to swage down the head of a rivet so that the two ends are symmetrical.

The contacts 19 on the spring are lined up with and arranged to make contact with adjustable fixed contacts 20 which are insulated from the body of the relay and are ordinarily connected to sources of potential or ground in an outgoing circuit, or to the outgoing circuits itself.

It has been found that a construction of this kind is more symmetrical in action than the double spring arrangement.

Tests have shown that relays made as above outlined do in fact as well as in theory repeat telegraphic impulses more accurately than the best relays previously known.

Another feature consists of an elongated tail-piece 21 by which removal, manipulation or adjustment of the armature is facilitated to avoid bending the narrower part of the armature when making adjustments. It may be desirable that

the slot 22 in the end of the armature be extended entirely to the end to permit inserting or removing the armature in the relay without removing the bolts which clamp the armature in place. In previous practice it has been considered that the narrowing of the cross-section of the armature near the clamped end produces a high reluctance portion so that a relatively large portion of the magnetic flux due to the windings is forced to pass through the pole-pieces. In prior relays this narrow portion also causes the armature to become saturated at the restricted portion and this limits the flux flowing between the armature and pole-piece so that the armature does not tend to stick so tightly to the pole-piece. The tapering of the armature in accordance with the present invention results generally in similar effects and if high reluctance at the clamped end is desired, it may be obtained by thicker non-magnetic shims and when these are used it has been found that the tapered armatures operate faster than armatures of the previous type which may be due in part to the reduced inertia of the armature. The reduced inertia is due to the new armature being thinner and lighter toward the moving end than prior armatures.

The features of the present invention are not inconsistent with and may be used in combination with any one or more of the features disclosed in applicant's Patent 2,303,952, granted December 1, 1942, that is, they may be used with electrical damping windings on the pole-pieces; or with offset contact points and springs as disclosed in Patent 2,291,410, granted July 28, 1942. They are not in all respects limited in use to high speed polar relays but may be employed, where appropriate, in other high speed relays. In so far as they relate to symmetry they are limited in applicability to polar type relays. Furthermore, the feature of a tapered armature may be used with a double spring armature as well as a single spring armature if one wishes to sacrifice the advantages attendant upon the use of a single spring.

This application is a substitute for application Serial No. 359,881, filed October 5, 1940, now abandoned, and is in part a continuation of Serial No. 444,838, filed May 28, 1942, now abandoned, and through it of one or more other of the applications enumerated above with respect to which all rights of priority permissible by law are claimed.

Single spring armatures are highly symmetrical but may require a reduction of spring vibration to reduce chatter. Fig. 5 shows a type of structure which may be made more symmetrical than the usual double contact spring relay armature and yet possesses the antichatter properties of the double spring. In the slot 9 two springs 23 are mounted; each bears a contact button 24 and at their free ends they are in frictional engagement. Lack of symmetry in the old type may proceed from dissimilarity in the rivet heads of the rivets holding the springs to the armature and that cause is removed in the present structure. By cutting off the upper edge of the springs or making them off center with respect to the contact buttons, a degree of sliding, twisting or frictional engagement of the movable with the fixed contact may be obtained, thus tending to reduce chatter in the manner more elaborately set forth and claimed in my copending specification.

Most mechanical and electrical or electrome-

chanical structures tend to vibrate or oscillate more freely at some frequencies than another. A telegraph relay, on the other hand, is required to respond accurately and equally to impulses occurring over a wide range of frequencies and the more accurately it does this without regard to its response to any previous impulse or condition the more effective it is for the intended purpose. It is for this reason that selective devices such as tuned reeds, which, although superficially similar to repeating relays, are required to have entirely different characteristics; the more effective a selective relay device and a telegraph relay are for the respective intended purposes the less effective they would be for the purposes of the other class of devices.

What is claimed is:

1. A polar electromagnetic relay having pole-pieces, a flexible armature fixed at one end, carrying movable contacts to cooperate with fixed contacts at the other end, actuated by pole-pieces intermediate said ends and nearer the other end than the fixed end, said armature being smoothly varied in cross-section from the fixed end to minimum cross-section at a point nearer the pole-pieces than the fixed end, and tapered to a greater cross-section from said point to the pole-pieces and being thick enough at the pole-pieces to provide a suitable magnetic flux path.

2. A polar electromagnetic relay having pole-pieces, a flexible armature fixed at one end, carrying movable contacts to cooperate with fixed contacts at the other end, actuated by pole-pieces intermediate said ends and nearer the other end than the fixed end, said armature being smoothly varied in cross-section from the fixed end to minimum cross-section at a point nearer the pole-pieces than the fixed end, and varied in cross-section to a greater cross-section from said point to the pole-pieces and being thick enough at the pole-pieces to provide a suitable magnetic flux path whereby in operation there is approximately uniform stress in the outer fiber of the armature all along the length of the flexing portion thereof.

3. A polar electromagnetic relay comprising a polarized U-shaped yoke structure having north and south poles at the respective arms of the U, an elongated armature of flat rectangular cross-section fixedly mounted in the base of the U and having its free end extending between the arms thereof, said armature being of higher permeability in its longitudinal direction than in any lateral direction, a winding structure connectable to positive and negative current supply means and associated with said armature to alternatively create north and south poles at the free end thereof, operating poles adjacent said armature at a point near the free end to flex the armature, said armature being of uniform thickness throughout but having its height tapered gradually to become lesser from the fixed end about two-thirds of the distance to the free end and then greater as it approaches the free end, a slot symmetrically located in the free end of the armature with respect to the thickness thereof, a spring member having its end fixedly mounted in the slot, contacts on the lateral sides of the free end of the spring, and stationary contacts with which said spring mounted contacts have selective contact when said armature has poles correspondingly selectively created at the free end thereof by said winding structure.

4. In a polar relay, an armature having a fixed end and a contact-carrying end, means

for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a uniform thickness and having a gradually tapered width from said fixed end to a minimum at a region intermediate said fixed end and said pole-pieces, said region being nearer to said pole-pieces than to said fixed end, and a gradually increasing width from said region to the portion of said armature adjacent said pole-pieces.

5. In a polar relay, an armature having a fixed end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a gradually tapered width from said fixed end to a minimum at a region intermediate said fixed end and said pole-pieces, a gradually increasing width from said region to the portion of said armature adjacent said pole-pieces, and a gradually decreasing width from said portion adjacent said pole-pieces to the contact-carrying end.

6. In a polar relay, an armature having a fixed end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a uniform thickness and having a gradually tapered width from said fixed end to a minimum at a region intermediate said fixed end and said pole-pieces, and a gradually increasing width from said region to the portion of said armature adjacent said pole-pieces, the said portion adjacent said pole-pieces being of substantially enlarged width to provide a suitable magnetic flux path.

7. In a polar relay, an armature having a fixed end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a gradually tapered width from said fixed end to a minimum at a region intermediate said fixed end and said pole-pieces, a gradually increasing width from said region to the portion of said armature adjacent said pole-pieces, and a gradually decreasing width from said portion adjacent said pole-pieces to the contact-carrying end, the said portion adjacent said pole-pieces being of substantially enlarged width to provide a suitable magnetic flux path.

8. In a polar relay, an armature having a fixed end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a region of constant cross-section intermediate said fixed end and said pole-pieces, a gradually decreasing width from said fixed end to said region, and a gradually increasing width from said region to the portion of said armature which is adjacent said pole-pieces.

9. In a polar relay, an armature having a fixed

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end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a region of constant cross-section intermediate said fixed end and said pole-pieces, a gradually decreasing width from said fixed end to said region, and a gradually increasing width from said region to the portion of said armature which is adjacent said pole-pieces, the portion of said armature adjacent said pole-pieces being substantially enlarged to provide a suitable magnetic flux path.

10. In a polar relay, an armature having a fixed end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces adjacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a region of constant cross-section intermediate said fixed end and said pole-pieces, a gradually decreasing width from said fixed end to said region, a gradually increasing width from said region to the portion of said armature which is adjacent said pole-pieces, and a gradually decreasing width from the portion of said armature which is adjacent said pole-pieces to the contact-carrying end.

11. In a polar relay, an armature having a fixed end and a contact-carrying end, means for clamping the fixed end of said armature, a stationary contact positioned adjacent the contact-carrying end of said armature, pole-pieces ad-

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jacent said armature and intermediate the fixed end and the contact-carrying end thereof, said armature having a region of constant cross-section intermediate said fixed end and said pole-pieces, a gradually decreasing width from said fixed end to said region, a gradually increasing width from said region to the portion of said armature which is adjacent said pole-pieces, and a gradually decreasing width from the portion of said armature which is adjacent said pole-pieces to the contact-carrying end, the portion of said armature adjacent said pole-pieces being substantially enlarged to provide a suitable magnetic flux path.

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