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ELECTRIC CONTROL MAGNETS

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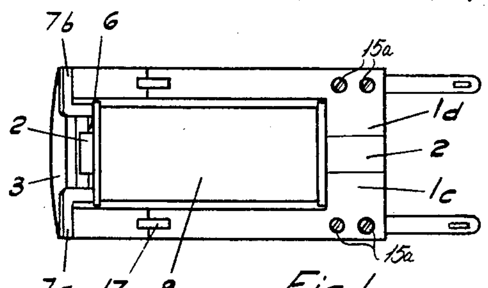
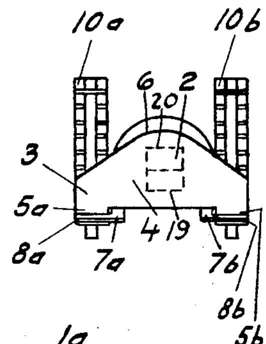


Fig. 1

Fig. 3



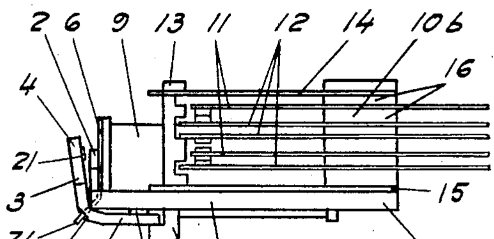


Fig. 2

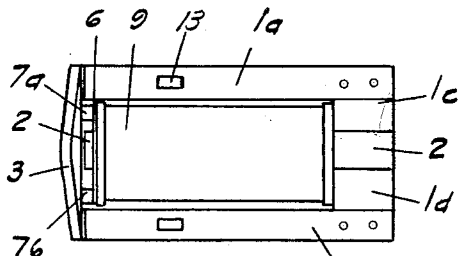


Fig. 4

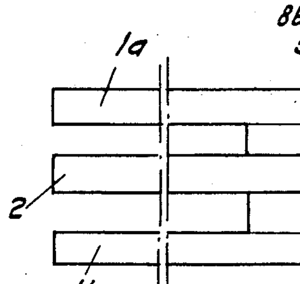


Fig. 5

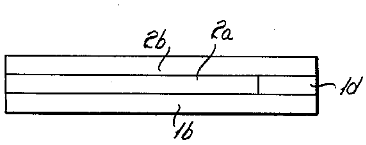


Fig. 7

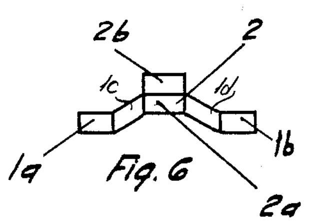


Fig. 6

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ELECTRIC CONTROL MAGNETS

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5 Claims. (Cl. 200—104)

This application is a continuation-in-part of our co-pending application for United States Letters Patent Serial No. 311,582 (abandoned June 6, 1958 in favor of the present application) filed September 26, 1952 which is a continuation-in-part of our co-pending application for United States Letters Patent Serial No. 143,016 filed February 8, 1950 for improvements in Electric Control Magnets. Application Serial No. 143,016 is now abandoned but the subject matter thereof was continued in a co-pending application Serial No. 335,006 filed on February 4, 1953 and now Patent No. 2,693,554.

This invention relates to electrical control magnets, e.g., for use in electromagnetic switching devices such as relays or the like, and is particularly related to an improved electrical control magnet utilizing an angle-bent type armature.

A type of angle-bent armature relay very frequently used in telephone equipment is the so-called Kellog relay. The main parts of the magnetic circuit of such a relay consist of a bridge, a core with a winding coil and an armature. The bridge consists of a comparatively broad piece of sheet-metal of ferro-magnetic material, angle-bent into L-shape, the core, which usually is circular in cross-section, extending from the shorter shank of the bridge so as to project parallel with the longer shank of the bridge. Accordingly, the latter has one broad side facing the core. The armature is angle-bent and pivoted at the apex of its angle profile along one edge of the end of the bridge, so that its pivotal axis extends perpendicularly to the longitudinal axis of the core. The pole face of the armature coacts with the end surface of the core and accordingly the plane of the armature pole face is substantially perpendicular to the longitudinal axis of the core in the operated position of the armature. The portion of the armature situated on the other side of the pivotal axis is connected to, or shaped as one or more arms, or the like, adapted to actuate operating studs in contact spring assemblies mounted on the longitudinal shanks of the bridge on the side opposite the core.

This previously known construction, however, has rather considerable drawbacks. Due to the fact that the prior art L-shaped bridge has its flat side facing the core, the magnetic leakage between bridge and core will be very great and this causes the sensitivity of the relay to be very unsatisfactory.

Applicants have determined that it is possible to effect an appreciable increase in the sensitivity of relays by arranging the armature and the portion of the core attracting the armature in such a way, that the boundary line of the pole face on the armature situated next to the pivtoal axis undergoes a considerably less length of travel than the corresponding armature pole face boundary line situated farthest away from said pivotal axis. In other words, this may be said to mean that the armature is made short in radial direction or that the dimension of the armature pole face in a radial direction constitutes a comparably great part of the total length of the armature from its pivotal axis.

However, such an armature arrangement in a conventional angle-bent relay cannot effect any appreciable improvement unless the magnetic leakage between bridge and core is kept at a low value. An increase of sensitivity by decreasing the armature length is not obtainable in relays of the above-mentioned Kellog angle-bent armature type, since a structure permitting the short-armature arrangement involves locating the core, at least at its pole end, near to the plane parallel with the core through the swinging axis; and when this is done in previously known angle-bent armature relays the core must inherently be disposed closer to the bridge resulting in increased magnetic leakage between core and bridge which decreases sensitivity, rather than increasing sensitivity.

Furthermore, the space between the bridge and the core and hence the length of the armature tongue will be dependent on the diameter of the winding coil, which of course interferes with and unduly restricts the possibility of dimensioning the Kellog type magnetic circuit in an optional manner.

The control magnet according to the present invention is characterized by the fact that the bridge is so arranged relative to the core that its projection in a plane parallel to the main longitudinal direction of the core and to the swinging axis of the armature, at least to an essential extent, falls outside the projection of the core in the same plane. To overcome the physical interference of the coil between the bridge and core, which in previously known angle-bent armature relays limits the shift of the bridge toward the core and also results in inherent increase of magnetic leakage between them, the aforementioned essential extent to which the bridge is disposed outside the projection of the core is such that the bridge projection will also be disposed outside of the projection of the winding coil, as apparent from the drawings and a geometrical consideration of the preferred ratios of travel of inner and outer radial boundaries of the armature pole face as hereinafter set forth.

In a preferred embodiment of the invention, these parts are, in addition, so arranged in relation to each other, that the projection of the bridge in a plane parallel to the main longitudinal direction of the core and perpendicular to the swinging axis of the armature, at least to an essential extent, falls outside the projection of the core on the same plane. As will be apparent from discussion hereinafter, the "essential extent" in this side elevation projection is that distance necessary to dispose the armature pivot axis at least a minimum distance below the closest edge portion of the core pole face. Thus, an overlap condition of bridge and core in side elevation projection is within the contemplation (e.g., for the 1:4 armature boundary travel ratio hereinafter described), of this invention and it necessarily follows that the spacing between parallel bridge and core members in a plan projection must be sufficient so that the plan projection of bridge members falls outside of the coil winding.

Accordingly, it is a principal object of this invention to produce an improved magnet structure, similar to the above-mentioned relay-type having an angle-bent armature, the pole face of which is substantially perpendicular to the longitudinal axis of the core in the operated position of the armature, in which the drawbacks above referred to such as excessive magnetic leakage due to closely positioned bridge and core members and physical interference between coil and bridge are entirely eliminated, and in which it is possible to obtain very great sensitivity by arranging the armature and the pole face coacting therewith in the manner outlined above without causing thereby the leakage between the core and the bridge to reach too high a value.

It is another principal object of this invention to provide an angle-bent armature type electromagnet in which the armature pivot axis can be located with respect to and very close to the core pole face without eliminating the requisite air gap spacing between the bridge members and the core even when the core and side bridge members are substantially coplanar (i.e. the lateral spacing between core and bridge members in plan projection is maintained and is sufficient to prevent appreciable magnetic leakage between them regardless of the desired positioning of the armature axis). It is a related object to provide such an electromagnet in which the bridge shanks, seen in plan projection on a plane parallel to bridge shanks, core and pivot axis, are disposed outside the projections of the winding coil around the core in the same plane, thus enabling the maintaining of a sufficient spacing between bridge shanks and magnet core to prevent magnetic leakage even when the armature pivot axis approaches contiguity with the nearest edge portion of the pole face.

A further object of this invention resides in providing an improved type of control magnet structure of the angle-bent armature type in which the armature apex pivots on end edges of the magnet bridge and in which the distance between the armature pivot axis and the nearest edge of the core pole face is no greater than the distance between the edge of the core pole closest to the pivot axis and the edge of the core pole face furthest from the pivot axis and, in which said distance can be so small as to provide a 1:4 ratio of travel of armature edge portions.

Still another object of this invention resides in the provision of a contact spring switch assembly on a bridge shank and linkage interconnecting the armature and an operating stud of the contact spring switch assembly so the operating stud is pulled downwards instead of being pushed upward in relation to the base of the contact spring assembly when the relay is energized whereby an essentially flat space-saving angle-bent relay with contact switch assembly is achieved.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings showing preferred structures and embodiments, in which:

On the drawings:

Figure 1 is a plan view as seen from below illustrating a relay incorporating the inventive concepts of this invention;

Figure 2 is an elevation view of the same relay;

Figure 3 is an end view of the same relay looking at the armature end;

Figure 4 is a top plan view of the same relay with the spring stacks omitted;

Figure 5 is a plan view of the bridge and core of the relay shown in Figures 1–4;

Figure 6 is an end view of the bridge and core shown in Figure 5 looking at the pole face end; and

Figure 7 is a side view of the bridge and core shown in Figure 5.

In the figures, which illustrate a preferred structure embodying the invention, the bridge is designated **1**, the core **2** and the armature **3**. As appears most clearly in Figure 5, the bridge **1** and the core **2** form together an E-shaped unit having a middle shank and two side shanks designated **1***a* and **1***b*, respectively, the middle shank forming the core and the side shanks being interconnected with the core at one end by means of transverse pieces **1***c* and **1***d*. As is shown in Figures 6 and 7, the portions **1***c* and **1***d* are bent in such a way, that the middle shank or core is situated on a higher level than the shanks **1***a* and **1***b*. In order that the core shall get a satisfactory cross-sectional area, it includes not only a lower part **2***a*, preferably made integral with the bridge shanks **1***a* and **1***b* but, in addition, an upper portion or rod **2***b*. In the exemplary construction, all parts just described are made of magnetic material.

The relay armature **3** comprises an armature tongue **4** and two spaced apart shanks or arms **5***a* and **5***b* bent to form an angle to the armature tongue **4**. Armature **3** is disposed so the apex of the armature profile abuts against the edges of the end surfaces on the bridge shanks **1***a* and **1***b*. The pole face of the armature, situated on the armature tongue **4**, will be determined by the end surface of the core **2**, as is illustrated in Figure 3. The armature is kept in position by means of a forkshaped holding member **6** having projections **7***a* and **7***b* directed outwards and engaging recesses **8***a* and **8***b* in the shanks **5***a* and **5***b* of the armature. The holding member is, in any suitable way, attached close to one gable piece of a winding bobbin for the winding coil **9**, which in a conventional manner is arranged on the core of the relay.

On the side shanks **1***a* and **1***b* of the bridge are mounted two contact spring switch assemblies **10***a* and **10***b* comprising fixed and movable contact springs **11** and **12**, respectively. The movable contact springs **12** are operated by means of a toothed operating stud **13** being slidable up and down and normally kept in elevated position by a holding spring **14**, which is pretensioned in an upward direction. Each contact spring assembly is mounted on a base plate **15**. The contact springs **11** and **12** and the holding spring **14** are separated from each other by insulating spacers **16** or the like, and these parts are attached to the base plate **15**, for example in a usual way by means of insulated screws or the like passing through them. The base plate **15** is attached to the respective shank of the bridge in any suitable manner, for instance by means of screws **15***a* or lugs bent down around the shanks or the like.

The lower portion of operating stud **13** is provided with a projection **17** engaging the ends of arms **5***a* or **5***b*, respectively, of the armature **3**. In order to effect a suitable limitation of the upward movement of the armature, there is a distance stud **18** beneath each armature shank **5***a* and **5***b*.

As is evident, this arrangement differs from corresponding conventional arrangements by the operating stud **13** moving downwards instead of upwards in relation to the base of the contact spring assembly when the relay is energized. This arrangement has been used in order to obtain as great a saving of space as possible, which in this case is considerable if the contact spring assemblies are placed on the top side of the shanks of the bridge as shown in the drawing.

It will be appreciated through a study of the disclosed embodiment that the relative positioning of the core and the shanks of the bridge is very advantageous from a magnetic viewpoint due to the fact that the core and the bridge have no large and neighboring surfaces facing each other. This is true also in a particularly advantageous embodiment of the invention, in which the pole face on the armature tongue **4** is situated so near to the swinging axis of the armature that the boundary line of the armature pole face extending next to the swinging axis shows a materially shorter length of travel than the corresponding boundary line extending farthest away from the swinging axis. The above-mentioned boundary lines are designated **19** and **20**, respectively, in Figure 3. Tests have shown that such an arrangement results in a surprising increase of sensitivity of th relay. For comparison, it may be mentioned that if this principle should be applied to a relay of Kellog-type, the boundary line **19** on the core pole face would run close to the relay bridge, which in a Kellog-type relay structure extends over the whole width of the armature, and the great magnetic leakage it would cause would result in that no increase of sensitivity would be obtained. As shown in the accompanying drawings, and more especially Figures 3 and 6 thereof, in the above-described electromagnet construction, the distance from the armature pivot axis to the edge **19** of the core pole face nearer said axis is less than the distance between the sides of the core **2** and the sides of the bridge elements **1a** and **1b** closest to the core, a construction which is impossible in Kellog-type angle-bent armature relays.

Theoretical calculations verified by practical tests have shown that an appreciable increase of sensitivity of the relay of this invention as compared with, e.g., known Kellog relays, is achieved even by choosing a relation between the above-mentioned lengths of travel of about 1:1.25, and the relay will be very sensitive if the said relation is chosen to be equal with or less than 1:2, for instance 1:2–1:4. To obtain a ratio of 1:2 between length of travel of the edge of the armature pole closest to the pivot axis and length of travel of the armature pole face furthest from the pivot axis, the distance from the pivot axis to the closest edge of the armature pole face must be equal to the dimension of the armature pole face radially with respect to the pivot axis. To obtain a ratio of 1:4, the distance from the pivot axis to the nearest edge of the armature pole face is one-third of the dimension of the armature pole face radially with respect to the pivot axis; since in the described embodiment (Figure 6) the thickness of the bridge side members **1a** and **1b** is one-half the thickness of the core members **2a** and **2b**, the projected bridge side member in side elevation will overlap the core when such a 1:4 ratio is employed. This is possible because the sideways dispostion of the bridge shanks relative to the core a distance is sufficient so that the plane projection of the bridge shanks lies outside the plan projection of the coil; and a sufficient magnetic gap between bridge and core is thereby maintained regardless of the chosen aforementioned ratios. If a material increase of sensitivity is to be obtained, it is important that the pivotal axis of the armature substantially coincides with the line of intersection between the planes of the pole face on the armature and the pole face on the core.

The length of travel at that boundary line of the pole face which extends next to the swinging axis of the armature must not be chosen too small if the desired improved results are to be obtained. If, for instance, the device were so constructed that the armature is in contact with the core adjacent to its swinging axis, a short-circuit for the magnetic flux would arise at the place of contact and this would cause a considerable reduction of sensitivity. Though less marked, a similar disadvantageous effect will arise if this length of travel is chosen very small, so that it is very close to zero.

It is advantageous to construct the device in such a manner that the pole face of the armature forms an angle to the pole face of the core of at least 1.5°, preferably 2.5° or more, in the non-operated position of the armature.

A control magnet according to the invention may be so constructed and arranged that the armature and/or the core becomes saturated in a portion close to the boundary line **20** as the armature moves towards the core. The saturation may for instance appear in and close to the pole face of the armature and/or the core. In order that this effect shall be obtained, it may be advantageous that there is a relatively great angle between the pole faces of the armature and core respectively in non-operated position of the armature. It may also be possible to make the armature so thin that this saturation arises in substantially transversal flux paths in the same.

Such a "wandering" saturation may be desirable due to the fact that the resultant of the attracting force is caused thereby to be displaced in a direction from the swinging axis of the armature during the operating movement, which displacement effects a successive elongation of the lever arm of the attracting force, in turn resulting in an advantageous characteristic of the derived force. In relays the armature loads usually rise rapidly at the end of the operation movement of the armature, and in view of this fact and the necessity of obtaining a sufficient force for holding the relay in operated position with a satisfactory safety margin such a growth of the derived force may be desirable.

In order to prevent the armature sticking on the breaking of the energizing current, it is provided with a pole stud or strip **21** preferably situated on about the same level or somewhat below the upper boundary line **20** of the pole face.

Though the control magnet according to the invention has been used in an electromagnet relay in the described embodiment, it may, of course, also be used in other electromagnetic switching devices and also for many other purposes.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. An electromagnet comprising an elongate magnetic core, one end thereof forming a substantially flat pole face substantially perpendicular to the core axis; a winding coil on said core; two elongate bridge elements parallel with and spaced from each side of the core member and said winding coil; means structurally joining said bridge elements adjacent one of their ends to the core at the end of said core opposite said pole face; at least one of said bridge elements and its associated joining means being magnetic material; a bent angle armature; support means, including the other end portions of said bridge elements and an armature support structure disposed on said electromagnet to support said armature; said other end portions having substantially flat end surfaces with aligned straight line edges disposed parallel to said core pole face; said bent angle armature pivotally supported by said support means with the interior apex of the armature angle abutting said aligned straight edges on said other end portions of said bridge elements and forming with said edges an armature pivot axis extending parallel to the plane of the core pole face, said pivot axis being spaced a distance away from the edge of the core pole face nearest the pivot axis which is less than the distance between the nearest surfaces of said core and of said bridge elements; the spacing between said bridge elements being of a sufficient dimension so that a theoretical projection of said bridge elements on a plane parallel to said bridge elements and parallel to said pivot axis will fall outside of the theoretical projection of the winding coil on said plane; said armature being supported in operable disposition adjacent said core pole face so there is at least a minimum air gap spacing between the core pole and armature sufficient to avoid substantial short-circuiting of the magnetic flux from the core member to the bridge members through the armature at least when the armature is in non-operated position.

2. An electromagnet comprising: a bridge and core unit having one central elongate core member of magnetic material and two side elongate bridge members of magnetic material and of rectangular cross section, all said members being of substantially equal length and spaced apart in substantially parallel side by side relation; a winding coil disposed on said core; transverse bars of magnetic material interconnecting one end of each side member to the corresponding end of the central member; a corresponding surface on each of the two bridge members lying in a first common plane, said first common plane being substantially parallel to the longitudinal axis of said core member; the side by side spac-

ing between each side member and said core consisting of a sufficient dimension that a theoretical projection of said side members on said common plane will be outside the theoretical projection of said winding coil on said common plane; each of said members having free ends with essentially flat surfaces thereon substantially perpendicular to the longitudinal axes of said members, said free end surfaces being substantially coplanar; said free end surface of the core member comprising a core pole face; the free ends of said side bridge members having a first set of edges in a first common straight line lying in said first common plane; an armature comprising a tongue and two substantially coplanar arms bent to form an angle to said tongue; means disposed on the electromagnet supporting the armature with the internal apex of the bend in said armature pivotally abutting said first set of edges of the ends of said side bridge members to thereby establish a pivot axis for said armature on said first straight line with the bent arms of said armature in the non-operated position disposed adjacent the surfaces of the side members lying in said first common plane; said armature tongue having a planar pole face on the inner surface thereof opposing said core pole face, lying substantially in a plane containing said armature pivot axis and disposed at an acute angle to the plane containing the free ends of the said bridge members, said armature being so bent and supported about said pivot axis in operable disposition adjacent said core pole face that in the non-operated position the distance between the armature and core pole faces at the edge of the core pole faces at the edge of the core pole face nearest the armature pivot axis is at least a minimum effective air gap spacing and the distance between the armature and the core pole faces at the edge of the core pole face furthest from said pivot axis is greater

than said air gap spacing; said minimum effective air gap being sufficient to avoid substantial short-circuiting of the magnetic flux from the core member to the bridge members through the armature.

3. An electromagnet as defined in claim 2, wherein said corresponding surfaces on each of the two bridge members are so disposed relative to said core member that said first common plane is spaced a distance from the nearest surface portion of said core member not greater than the side by side spacing between the core and bridge members.

4. An electromagnet as defined in claim 2, wherein said armature arms are spaced apart a distance substantially equal to the spacing between said side members.

5. An electromagnet as defined in claim 2, further comprising a switch stack disposed longitudinally on a side surface opposite to the surfaces lying in said first common plane, said stack comprising a set of contacts; contact operating means engaging said contacts and engaging with at least one of said armature arms whereby pivotal movement of said armature to an operated position operates said contacts.

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