Dec. 25, 1928. 1,696,615

P. TROMBETTA

ELECTROMAGNET

Filed May 9, 1927

Fig. 1.

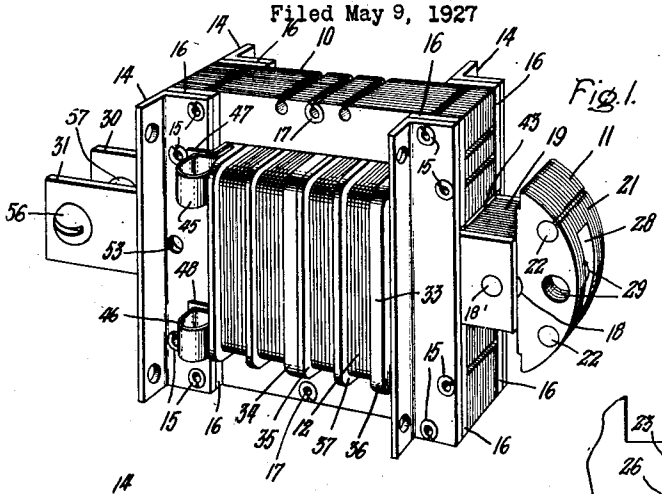


Fig. 3.

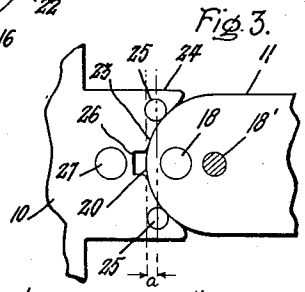


Fig. 2.

Fig. 4.

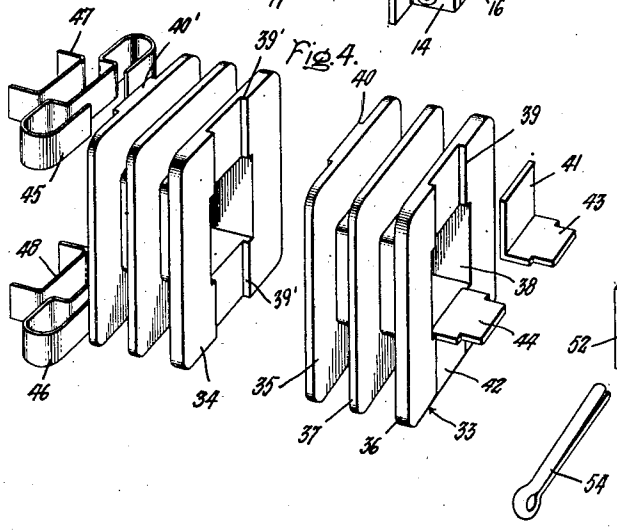
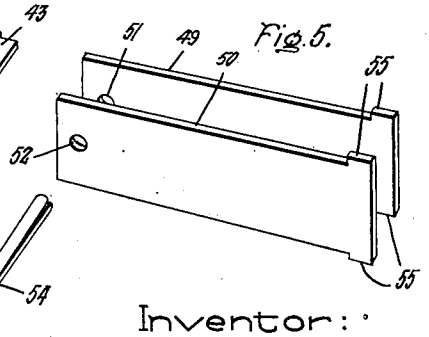


Fig. 5.



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by Alexander S. Lent.
His Attorney.

Patented Dec. 25, 1928. 1,696,615

UNITED STATES PATENT OFFICE.

PANFILO TROMBETTA, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTROMAGNET.

Application filed May 9, 1927. Serial No. 189,878.

The present invention provides an improved form of electromagnet particularly suitable for alternating current service, although certain features of the invention are equally advantageous in direct current service.

One of the principal objects of the invention is to provide an improved construction and arrangement of the magnetic circuits and windings of the electromagnet whereby the power and efficiency of the electromagnet in both alternating and direct current service may be materially increased over that ordinarily obtained.

A further object of the invention is to construct the electromagnet so that it readily may be mounted or supported in many different ways and connection made with the movable magnetic member to either pull or push a switch, valve, or other device to be operated thereby.

Another object of the invention is to provide an improved mounting for the magnetizing windings of the electromagnet arranged so that the windings are firmly secured in the proper operating position and still may be easily and readily assembled and disassembled without the use of any clamping screws, bolts, or the like.

A still further object of the invention is to render the operation of the electromagnet in alternating current service as quiet and free from vibration as possible with the minimum consumption of energy in the pole shading windings.

Other objects and advantages of my invention will appear from the following description of the accompanying drawing showing a preferred form of electromagnet embodying the several improvements of the invention set forth in the appended claims.

In the drawing, Fig. 1 is a perspective view of my improved electromagnet with the various parts assembled in cooperating relation; Fig. 2 is a perspective view of the electromagnet with the magnetizing windings removed to show the constructional details of the frame and the movable plunger forming the magnetic circuits of the electromagnet, as well as the pole shading winding which is associated therewith for alternating current service; Fig. 3 is an enlarged fragmentary view showing more clearly the relative location of the pole shading winding with reference to the cooperating magnetic members of the electromagnet; Fig. 4 is a perspective view of the magnetizing windings of the electromagnet and the mounting elements therefor; while Fig. 5 shows certain guide elements that may be employed in a modified construction of the electromagnet shown in Fig. 1.

Referring to Fig. 1, the electromagnet comprises essentially the magnetic frame 10, the movable magnetic plunger 11, and the magnetizing windings 12. In order to permit efficient operation with alternating current, the frame 10 and the plunger 11 are built up of a multiplicity of thin laminations of magnetic material as indicated in the drawing. As more clearly shown in Fig. 2, each of the superimposed laminations constituting the frame 10 is formed in substantially the shape of a rectangle so as to closely encircle the magnetizing winding 12 except for the cut-away portion in one side of each lamination forming the opening 13 through which the plunger 11 operates within the magnetizing windings 12.

The rectangular frame laminations are clamped in alignment between the opposing pairs of angle supporting pieces 14 which are held securely together by the rivets 15 with the spacing members 16 interposed between the angle supports and the laminations. The two opposing angle supports 14 at the end of the magnetic frame having the opening 13 therein bridge across on either side of this opening and serve to maintain the frame laminations on the opposite sides of the opening in alignment. These angle supports also serve as guides to confine the plunger 11 in proper operating relation in the opening 13. The opposing pair of angle supports 14 at the opposite end of the frame 10 are spaced apart from the frame 10 as pointed out hereinafter to form guideways for the arms 30 and 31

extending from the plunger 11. Moreover, these angle supports are arranged with the outstanding flanges thereof substantially flush with the outer edge of the laminations. This provides a broad substantial base upon which the electromagnet may be mounted. The angle supports at the other end of the frame are disposed with the outstanding flanges thereof in substantial alignment with the inner edge of the laminated frame instead of the outer edge. It will be observed that each of the angle supporting pieces is provided with suitable spaced apart holes to permit mounting of the electromagnet upon any one or more of these angle supports. The rivets 17 serve to hold the frame laminations firmly together intermediate the angle supports 14. Preferably, the rivets 15 and 17 are hollow and slotted along one side and are located in open slots formed in the outer edge of the laminations constituting the frame 10, as this construction effectively prevents the production of eddy currents in the rivets in alternating current service, thereby increasing the efficiency of the electromagnet.

In the preferred form illustrated in Fig. 2 the laminations forming the movable magnetic member or plunger 11 are rounded at one end and are provided with opposing lateral extensions at the other end in the form of a sector. Thus when superimposed and secured together by the rivets 18, these laminations form a plunger having a body portion 19 of rectangular cross section adapted to reciprocate freely but without possibility of rotation in the opening 13 in the frame 10 and presenting a convex cylindrical surface at the end 20 with the lateral projections of the laminations forming an enlarged head 21 at the other end. The rivets 18 preferably are located along the axis of the plunger 11 while at the enlarged head of the plunger the laminations are secured together by rivets 22 located in open slots in the outer edge of the head in substantially the same manner as the rivets 15 and 17 of the frame 10.

To cooperate with the convex end of the plunger 11, the side of the frame 10 opposite the opening 13 is provided with an oppositely rounded or concave surface 23. As shown, the surface 23 is formed at the end of the polar projection 24 located on the inside of the frame 10 opposite the opening 13 so as to extend a short distance within the core space of the magnetizing windings 12. The convexly rounded end of the plunger 11 and the concavely rounded surface 23 of the frame 10 thus constitute complementary engaging surfaces when the plunger 11 is operated to the attracted position within the core space of the windings 2.

These complementary engaging surfaces are considered an important feature of the present invention and although the cooperating magnetic plunger and frame are shown as provided with cylindrically shaped convex and concave engaging surfaces in the preferred form of the electromagnet illustrated, it should be understood that the complementary surfaces may if desired be made of other shapes, such as semi-spherical, conicoidal, wedge shape, or in fact, any shape in which the surface of one of the magnetic members readily nests within, and is enveloped by the complementary surface of the cooperating magnetic member.

Furthermore, for alternating current service a pole shading winding is located adjacent the engaging surface of one of the cooperating magnetic members in order to render the electromagnet quiet and as free from vibration as possible. In accordance with the present invention the pole shading winding is mounted on the magnetic member presenting the surface which envelopes the complementary engaging surface of the cooperating magnetic member and located closely adjacent to this surface. Thus in the preferred form of electromagnet illustrated the pole shading winding 25 is located in slots formed in the concave cylindrical surface 23. As shown in Fig. 3, this location of the pole shading winding 25 permits a portion of the end of the plunger 11 to pass within, and be encircled by, the pole shading winding by the amount indicated as a, when the plunger is in the attracted position. As a result of the complementary enveloping and enveloped shapes of the engaging surfaces of the plunger and frame and the location of the pole shading winding on the enveloping surface, the operation of the electromagnet with alternating current is rendered quiet and practically vibrationless with a minimum expenditure of energy in the pole shading winding.

As clearly shown in Fig. 2, the pole shading winding is formed by the two rivets 25, preferably of iron or other resistance material, which are located in open slots in the surface 23 and electrically connected together at their ends through the outer laminations forming the frame 10. In order to complete the electrical circuit, the ends of the rivets 25 are welded to the outer laminations, thus providing a reliable conducting junction between the ends of the rivets and the outer laminations. Moreover, the pole shading winding formed by the rivets 25 is symmetrically located with reference to the engaging surfaces of the projection 24 and of the plunger 11 so as to balance the out of phase magnetic forces set up by the pole shading winding. This materially aids in maintaining the plunger 11 in magnetic equilibrium and thereby avoids noise and vibration in the electromagnet.

When it is desired to further increase the

balance of the magnetic forces acting to hold the end of the plunger 11 in stable equilibrium in alternating current service, the slot 26 is located in the concave surface 23 midway between the rivets 25 forming the pole shading winding. With the slot construction, the magnetic forces tending to bring the curved end of the plunger 11 into nesting alignment with the enveloping surface 23 are augmented and thereby insure that the plunger is held in both magnetic and mechanical equilibrium. It will be understood, however, that the slot 26 serves simply to amplify the magnetic and mechanical balancing forces inherently obtained with the magnetic structure as previously described and hence may be omitted if desired.

The centrally located rivet 27 serves to hold the laminations in the projection 24 firmly together against the hammering action resulting from the repeated engagement of the rounded end of the plunger 11 with the complementary rounded surface 23, while the pole shading winding rivets 25 having their ends welded to the outer laminations serve effectively to hold the laminations together at the extremities of the convex surface 23.

The length of the body portion 19 of the plunger 11 is made such that when the rounded end 20 engages with the complementary curved surface 23 of the frame 10, the opposing projections forming the enlarged head 21 of the plunger are brought just short of abutting engagement with the opposing legs of the rectangular frame 10 defining the opening 13. This provides two practically closed circuits of laminated magnetic material in multiple relation for the flux of the operating windings 12 when the plunger 11 bridges the gap between the polar projection 24 and the legs of the rectangular frame on either side of the opening 13. Consequently, practically all of the magnetizing flux is localized in the multiple paths of the laminated magnetic structure formed by the plunger and frame of the electromagnet, and there is no appreciable amount of flux passing betweeen the frame 10 and the plunger 11 through the solid angle pieces 14. This construction permits of a relatively large clearance between the body of the plunger 11 and the ends of the frame laminations defining the opening 13. Hence, rugged and substantial bearing guides for the plunger 11 may be placed in the opening 13, as later described, without appreciably increasing the reluctance of the substantially closed magnetic circuit formed by the enlarged head 21 of the plunger or adversely affecting the efficiency of the electromagnet, or the magnetic and mechanical balance of the plunger 11.

To permit ready attachment of a link, lever, or other connection to be operated by the plunger 11, the laminations constituting the plunger head 22 are formed to provide a central slot 28 with the hole 29 arranged to transversly intersect the slot 28. Thus, by forming a corresponding hole in the link, or other connection to be operated by the plunger, a good connection readily may be made by means of a cotter pin, bolt or other suitable fastening. In addition, the two arms 30 and 31 are secured on opposite sides of the body of the plunger 11, preferably by means of separate rivets 18′ in order that the operating force of the plunger may be transmitted through the ends of the arms extending beyond and straddling the opposite side of the frame 10, as shown in Fig. 1. The spacers 16 serve to maintain the angle pieces 14 a sufficient distance away from the sides of the magnetic frame 10 to permit the arms 30 and 31 to freely slide between the angle supports and the frame. In this way the angle supports 14, the spacers 16, and the frame 10, form guideways of large bearing surface for maintaining the plunger 11 and the arms 30 and 31 in proper operating alignment with the device to be operated by the electromagnet.

With the construction illustrated in Figs. 1 and 2, the entire electromagnet readily may be mounted or supported by attachment to any one or more of the angle pieces 14. Moreover, the link, lever, or other connection to be operated by the plunger of the electromagnet may be either pulled by connection with the plunger head 22 or pushed by connection with the outer ends of the arms 30 and 31. The connection with the outer ends of the arms 30 and 31 may be made by any suitable means such as the bolt 56 passing through the holes 32 with the spacing collar 57 interposed between the ends of the arms as illustrated in Fig. 1. It will be evident that this construction adapts the electromagnet for a wide variety of applications with a minimum of restrictions in the manner of mounting and establishing the operating connections.

While any suitable form of magnetizing winding may be employed with the improved magnetic structure of the electromagnet previously described, the magnetizing winding construction and mounting illustrated in Fig. 4 is particularly adapted for use therewith. In this construction the magnetizing windings preferably are placed on two cooperating spools 33 and 34, each of which may be formed of moulded insulating material.

It will be observed that the spool 33 is of substantially rectangular form with space for receiving the layers of the windings 12 between the end flanges 35 and 36 and a centrally located winding barrier 37. Thus the body of the spool provides a core space 38 of the precise shape required to permit the

rectangular body 19 of the plunger 11 with the pusher arms 30 and 31 attached thereto to operate loosely and freely in relatively close proximity to the magnetizing windings 12.

The end flange 36 has a slot 39 formed in the outer face thereof, while the end flange 35 is provided with a corresponding projection 40 extending from the outer face thereof.

The construction of the winding spool 34 is identical with that of the spool 33 and the arrangement is such that the projection 40 on the spool 33 snugly nests within the groove 39′ of the winding spool 34 when the spools are properly brought together. The outside groove 39 of the spool 33 and the outside projection 40′ of the spool 34 are arranged to be used in the following manner in mounting the magnetizing windings within the magnetic frame 10 of the electromagnet as shown in Fig. 1.

Two guide pieces 41 and 42 of angular shape and of suitable bearing material, such as bronze or bakelite, are arranged to fit into the groove 39 on opposite sides of the core space 38 with the upstanding portions 43 and 44 of the guides extending over the ends of the laminations of the frame 10 defining the opening 13 to serve as guides for the plunger 11. The spring members 45 and 46 and the channel members 47 and 48, which latter are of insulating material, cooperate with the outside projection 40′ on the spool 34 in the mounting of the magnetizing windings in the electromagnet frame 10, in the manner indicated in Fig. 1.

In assembling the spools 33 and 34 with the magnetizing windings 12 located thereon in the frame 10, the insulating channels 47 and 48 first are placed adjacent to the polar projection 24 so as to extend over the opposing angle supports 14 and the frame laminations secured therebetween. The springs 45 and 46, having an offset at their central portions to form a yoke fitting snugly over the insulating channels 47 and 48, then are placed in position. In this way each spring is maintained out of electrical contact with both the laminations and the angle supports and thus avoids forming a short circuited turn encircling the flux passing through the polar projection 24.

The ends of the springs 45 and 46 when thus assembled over the channels as shown in Fig. 1 are spaced so as to engage firmly with the sides of the projection 40′ as the winding spool 34 is inserted over the polar projection 24 of the frame 10 with the plunger 11 withdrawn. The guide pieces 41 and 42 are then placed with the portions 43 and 44 lying over the ends of the laminations of the core 10 at the opening 13. By compressing the springs 45 and 46 the winding spool 33 then may be inserted between the right hand end of the spool 34 and the inside of the right hand angle supports 14 and moved into position to engage the projection 40 with the slot 39′ and the slot 39 with the guides 41 and 42. Thereupon the winding spools 33 and 34 are held firmly pressed against the right hand end of the electromagnet frame 10 and the right hand angle supports 14 by the springs 47 and 48. The guide members 41 and 42 interlocking with the slot 39 positively prevent lateral displacement of the right hand end of the winding while the ends of the springs 45 and 46 engaging with the projection 40′ likewise lock the left hand end of the windings against lateral displacement. In this way the windings are mounted in the proper operating position with practically no possibility of chaffing or displacement of the windings due to extraneous shock or vibration during service, all without the use of clamping screws or bolts which might loosen during operation.

The plunger 11 with the pusher arms 30 and 31 attached then may be inserted through the opening 13 in the core 10 to reciprocate within the openings 38 and 38′ in the magnetizing windings. The pusher arms 30 and 31 straddle the core laminations of the polar extension 24 and pass freely between the angle supports 14 as previously described. With the arms 30 and 31 secured together at their ends by the bolt 56 as shown in Fig. 1, it will be evident that the spools carrying the magnetizing windings 12 are effectively locked in place.

While I have illustrated and described the magnetizing winding as carried on two separate interlocking spools, it should be understood that the winding may be carried on a single spool if desired and the other spool used simply to interlock the winding spool in position in the frame. Moreover, in case the concave surface 23 is located flush with the frame laminations opposite the opening 13 only a single winding spool is required. In this case the single spool may be provided with a slot in the outer face of one end flange and a corresponding projection on the outer face of the opposite end flange which serve to lock the single spool in position in the frame in exactly the same manner as described in connection with the two spool mounting for the winding.

Whenever the application of the electromagnet is such that it is not desired to employ the arms 30 and 31, these members may be entirely omitted. It will be noted that the body of the plunger has two sets of rivet holes. One set is used for the rivets 18 which hold the laminations firmly together, while the other set is left available for the rivets 18′ used in mounting the arms 30 and 31. Hence upon removing the rivets 18′ and the arms 30 and 31, the plunger lamina-

tions remain firmly secured together by the rivets 18. With the arms 30 and 31 removed the operative connection then is made with the plunger 11 solely through the slot 28 and the hole 29 formed in the laminations of the head 22. In this case the space reserved for the arms 30 and 31 is occupied by the guides 49 and 50 in order to maintain the plunger 11 in proper operating alignment with the frame 10. The guides 49 and 50 may be formed of a suitable bearing material such as bronze, or a tough material such as bakelite, as desired. With the pusher arms 30 and 31 eliminated, the guides 49 and 50 are inserted through the opening 13 on either side of the polar projection 24 after the magnetizing winding spools 33 and 34 are assembled in the manner previously set forth. The holes 51 and 52 in the guides 49 and 50 are arranged to register with the holes 53 located in the angle supports 14 so that a suitable securing pin, such as the cotter 54, may be inserted to lock the guides in position. The upstanding shoulders 55 formed at the right hand ends of the guides 49 and 50 are arranged to fit in the recess formed on either side of the projecting portions 43 and 44 of the guide pieces 41 and 42. Thus with the guides 49 and 50 secured in place, the magnetizing windings again are effectively locked in their proper operating positions.

Although not shown in the drawing, it will be evident that the magnetizing windings 12 may be energized and controlled in any desired way; for example, the portions of the windings on the two spools 33 and 34 may be connected either in series or in multiple as desired. Furthermore, the magnetizing winding 12 may be divided into different portions, one arranged to operate the plunger 11 from the unattracted to the attracted position, and the other solely for holding the plunger 11 in the attracted position. The particular manner in which the magnetizing windings may be energized and controlled is described and claimed in my copending application, Serial No. 206,466, filed July 18, 1927, and hence no further description thereof is deemed necessary.

While I have illustrated and described the improvements of the present invention in a preferred form of electromagnet, it will be understood that various changes and modifications therein may be made by those skilled in the art without departing from the spirit and scope of the invention. Furthermore, while the construction and arrangement of the magnetic circuits and the magnetizing and pole shading windings of the electromagnet described heretofore are particularly advantageous and efficient when the electromagnet is energized with alternating current, still the identical construction and arrangement may be used in direct current service with materially increased power and efficiency of the electromagnet.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An alternating current electromagnet comprising magnetizing windings, relatively movable magnetic members operable into engagement under the influence of said windings, said members having engaging surfaces of such shape that the engaging surface of one member is enveloped within the engaging surface of the other member, and a pole shading winding located on one of said members so as to encircle the enveloped and enveloping engaging surfaces of said members.

2. An alternating current electromagnet comprising magnetizing windings, relatively movable magnetic members operable into engagement under the influence of said windings, said members having complementary enveloping and enveloped engaging surfaces, and a pole shading winding mounted on the member having the enveloping engaging surface so as to encircle an enveloped portion of the other member.

3. An alternating current electromagnet comprising magnetizing windings, relatively movable magnetic members operable into engagement under the influence of said windings, one of said members having a concave engaging surface and the other of said members having a complementary convex engaging surface, and a pole shading winding mounted on said one member adjacent the concave engaging surface thereof.

4. An alternating current electromagnet comprising magnetizing windings, a magnetic structure therefor including a frame and a relatively movable magnetic member operable into engagement with the frame under the influence of said windings, said frame and magnetic member having complementary enveloping and enveloped engaging surfaces with the enveloping surface on the frame, and a pole shading winding mounted on the frame in symmetrical alignment with said enveloping surface.

5. An alternating current electromagnet comprising magnetizing windings, a movable magnetic plunger having a convex surface at the end thereof operable within said magnetizing windings, and a magnetic frame cooperating with said plunger to provide a substantially closed magnetic flux path when the plunger is operated into engagement therewith, said frame having a concave complementary surface engaging with the convex end of the plunger, and a pole shading winding mounted on said frame adjacent said complementary concave surface so as to encircle a portion of the convex end of said plunger when the plunger is in engagement with the frame.

6. An alternating current electromagnet

comprising a laminated frame having an opening at one side and a concave surface formed opposite the opening, magnetizing windings mounted within the frame with the core space of the windings in alignment with the said opening and the said concave surface, a laminated plunger having a convex surface at the end thereof operable within said core space into engagement with the concave surface of the frame and having an enlarged head cooperating with the sides of the frame adjacent to said opening to form two substantially closed magnetic flux paths in parallel relation, and a pole shading winding mounted on the frame adjacent the said concave engaging surface thereof to encircle a portion of the convex end of the plunger enveloped by the concave surface of the frame.

7. An electromagnet comprising magnetizing windings and a magnetic structure therefor including a magnetic frame substantially encircling the windings and having an opening at one side and a polar projection extending within said windings opposite said opening and a magnetic plunger adapted to operate through said opening into engagement with the said polar projection, the engaging ends of the plunger and the polar projection having complementary enveloping and enveloped surfaces, and a pole shading winding symmetrically located with respect to said surfaces for insuring magnetic and mechanical balance of the plunger in the attracted position.

8. An electromagnet comprising magnetizing windings, a movable magnetic plunger having a convex surface at the end thereof operable within said magnetizing windings and having lateral projections at the other end thereof, and a magnetic frame substantially encircling the coil and having a concave surface for engaging with the curved end of said plunger, said frame providing a substantially closed multiple return flux path through said lateral projections of the plunger when the said plunger is in the attracted position.

9. An electromagnet comprising a magnetic frame having an opening at one side and a polar projection opposite the opening formed with a concave end surface, magnetizing windings mounted within the frame with the core space of the windings in alignment with the said opening and the said concave surface of the polar projection, and a movable magnetic member having a body portion operable through said aligned openings in the frame and windings with one end presenting a convex surface complementary to the concave surface of the polar projection and the other end provided with lateral extensions overlapping the frame on opposite sides of the said opening therein when the said complementary surfaces of the magnetic movable member and polar projection are in engagement.

10. An electromagnet comprising magnetizing windings and a magnetic strutcure therefor including a magnetic frame having at one side an opening therein and a magnetic plunger operable through said opening into engagement with the opposite side of the frame, the end of said plunger and the opposite side of the frame having complementary cylindrical engaging surfaces for insuring magnetic and mechanical balance of the plunger in the attracted position, and the said plunger and the opening in the frame having non-circular cross sectional shapes for maintaining the said cylindrical engaging surfaces of the plunger and the frame in substantial alignment during operation of the plunger.

11. An alternating current electromagnet comprising magnetizing windings, relatively movable magnetic members operable into engagement under the influence of said windings, a pole shading winding mounted on one of said members in symmetrical alignment with the surface thereof engaged by the other member, one of said members having a slot formed therein intersecting the axis of said pole shading winding to maintain the members in magnetic equilibrium.

12. An electromagnet comprising magnetizing windings, relatively movable magnetic members operable into engagement under the influence of said windings, said members having complementary concave-convex engaging surfaces, and a pole shading winding mounted on one of said members in symmetrical alignment with the engaging surface thereof, said member having a slot formed therein intersecting and in symmetrical alignment with the axis of said pole shading winding for balancing the magnetic action thereof.

13. An electromagnet comprising magnetizing windings, a laminated magnetic structure therefor including a frame and a relatively movable member, and a pole shading winding formed of a plurality of spaced apart rivets extending across the laminations of said structure and having their ends welded to the outer laminations thereof.

14. An electromagnet comprising magnetizing windings, a laminated magnetic structure including a movable magnetic core member operable within said magnetizing windings and a substantially rectangular magnetic frame encircling said windings and having an opening in one end thereof for receiving said core member, and a pair of angle supports for the electromagnet disposed in opposing relation at the said one end of said frame and secured together for maintaining the frame laminations adjacent said opening in alignment, and a second pair of angle supports for the electromag-

net secured together in opposing relation at the opposite end of said frame, the outstanding leg of each of said pairs of angle supports being provided with fastening means for permitting mounting of the electromagnet on any one of the said supports.

15. An electromagnet comprising magnetizing windings, a magnetic frame substantially encircling said windings and having an opening in one side thereof, a magnetic plunger operable through said opening into engagement with the opposite side of the frame, and arms secured on said plunger in spaced relation to straddle the side of the frame opposite the opening for transmitting the operating force of the plunger.

16. An electromagnet comprising magnetizing windings, a magnetic frame encircling said windings and having an opening in one side thereof, a magnetic plunger operable through said opening into engagement with the opposite side of the frame, arms secured on said plunger in spaced relation to straddle the opposite side of the frame, and means at the outer ends of said arms and said plunger for establishing connections for transmitting the operating force of the plunger.

17. An electromagnet comprising magnetizing windings and a movable magnetic member operable under the influence of said windings, said member being laminated with the laminations formed to provide a slot and a hole transversely intersecting the slot at one end of the magnetic member.

18. In an electromagnet, a magnetic frame, a magnetizing winding therefor having a winding spool provided with opposite end flanges formed with a slot in the outer face of one end flange and a corresponding projection on the outer face of the other end flange, and means cooperating with said slot and said projection for securing the winding spool in operating position in the magnetic frame.

19. In an electromagnet, a magnetic frame, a magnetizing winding therefor comprising a plurality of spools each provided with opposing end flanges for supporting the winding therebetween, said spools having means associated with the outer face of each end flange for interlocking the spools together in operating relation in the magnetic frame.

20. An electromagnet comprising a magnetic frame, magnetizing windings carried on a plurality of spools for mounting in alignment within said frame, said spools having mechanical interlocking means on their adjacent sides and on their outer sides, and resilient means cooperating with said interlocking means for holding the winding spools in alignment within said frame.

21. An electromagnet comprising a substantially rectangular laminated magnetic frame having a core opening in one side thereof, a magnetizing winding located within said frame in alignment with said opening, a core member operable through said opening into said magnetizing winding, arms secured on said core member in spaced relation to straddle the side of the frame opposite said opening for transmitting the operating force of the core member, a pair of members secured in opposing relation at the end of the frame having the opening therein and serving as guides to maintain said core member in said opening, a second pair of members secured in opposing spaced relation at the opposite end of the frame to provide guideways through which said arms on the core member operate.

22. An electromagnet comprising a substantially rectangular magnetic frame having a substantially rectangular opening in one side thereof, magnetizing windings located within said frame in axial alignment with said opening, a plunger of rectangular cross section operable through said opening into said magnetizing windings, arms secured on opposite sides of said plunger in spaced relation to straddle the side of the frame opposite said opening, and two pairs of angle supports for the electromagnet, one pair secured in opposing spaced relation at the end of the magnetic frame having said opening therein and serving as guides to prevent lateral displacement of said plunger, the other pair of angle supports being secured in spaced relation with the opposite end of the magnetic frame to provide sliding guideways for said arms on the plunger, the outstanding leg of each of said angle supports being provided with fastening means for permitting mounting of the electromagnet on any one or more of said supports.

23. An electromagnet comprising a substantially rectangular magnetic frame having a core opening in one side thereof, a magnetizing winding therefor carried on a spool provided with opposing end flanges of substantially rectangular shape with a slot formed in the outer face of one end flange and a projection located on the outer face of the other end flange, and means for securing said winding spool in operating alignment in said frame comprising locking members registering with said slot and said core opening and resilient spring members interlocking with the opposite end of the frame and said projection.

24. An electromagnet comprising a substantially rectangular laminated magnetic frame having a core opening of substantially rectangular shape in one side thereof, a magnetizing winding carried on a plurality of spools having a substantially rectangular core space for mounting in alignment with said rectangular core opening, each of said

spools having opposing end flanges with a slot formed in the outer face of one end flange and a corresponding projection located on the outer face of the opposite end flange for interlocking the adjacent end flanges of the spools together with the spools end to end, and means for securing the spools in said frame comprising locking members one portion of which is arranged to interlock the slot in the outer end flange of one of the spools with the core opening in said frame and another portion of which is arranged to interlock the projection on the outer end flange of the other spool with the opposite end of the magnetic frame.

In witness whereof I have hereunto set my hand this 6th day of May, 1927.

PANFILO TROMBETTA.

CERTIFICATE OF CORRECTION.

Patent No. 1,696,615. **Granted December 25, 1928, to**

PANFILO TROMBETTA.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 7, line 38, claim 18, for the word "opposite" read "opposing"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of February, A. D. 1929.

M. J. Moore,
Acting Commissioner of Patents.

(Seal)