March 27, 1951 L. J. GOLDBERG 2,546,740

ALTERNATING CURRENT ELECTROMAGNET WITH ARMATURE

Filed July 26, 1949

Fig 1

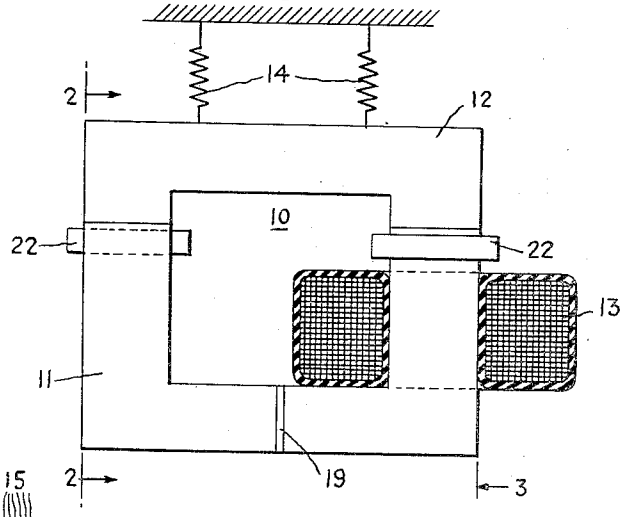


Fig. 2.

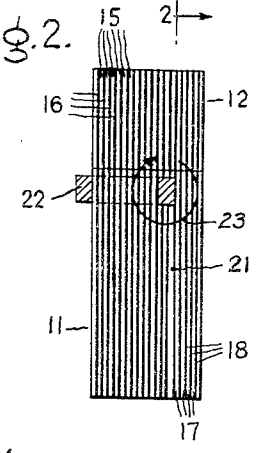


Fig. 3.

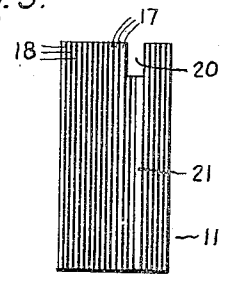
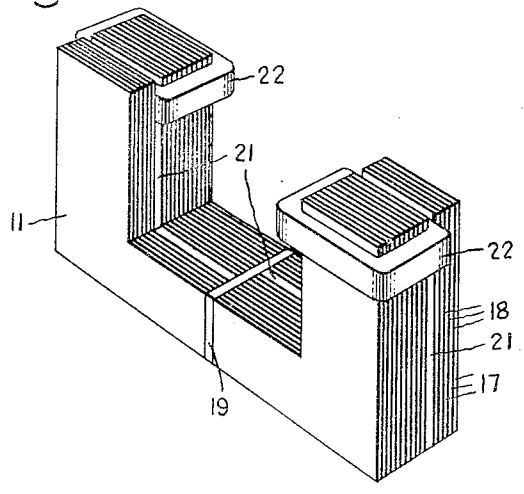


Fig. 4.



Inventor:
Leon J Goldberg,
by Claude A. Mott
His Attorney.

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ALTERNATING-CURRENT ELECTRO-MAGNET WITH ARMATURE

Leon J. Goldberg, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

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1 Claim. (Cl. 175—338)

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This invention relates to alternating current electromagnets, and more particularly to alternating current electromagnets of the shaded pole type. The principal object of the invention is to provide an improved type of construction for such electromagnets.

Shading coils commonly are used in the pole faces of alternating current electromagnets to provide a shift in time phase of a portion of the magnetic flux in order to produce a continuous pull for attracting and holding an armature. In order to provide such a shading coil, the magnetic path is split and one part of the magnetic path is surrounded with a conducting loop. The presence of such a loop, because of the current which is induced in it, produces an additional component of magnetic flux in the core of the electromagnet which results in a time delay in the main flux in the portion of the magnetic circuit which the shading coil encircles, thus causing the magnetic flux in this portion to pass through zero at a later point in the cycle than the flux in the other portion. When the pull due to the magnetic flux outside the loop is zero, there is a finite pull by the flux within the loop, and when the pull due to the magnetic flux within the loop is zero, there is a finite pull by the flux outside the loop; thus, a continuous magnetic pull is provided whereby chattering or vibration of the armature is minimized.

The magnetic cores of alternating current electromagnets are usually laminated to prevent excessive eddy currents in the cores. Heretofore, in the construction of a magnetic core having a shading coil in a pole face thereon, it has been customary to provide a recess in the pole face perpendicular to the plane of the laminations. In this recess is located a portion of the conductive loop which encircles a part of the magnetic path to form the shading coil. This construction is entirely satisfactory for holding an armature or other member once it has been attracted to the core; however, it has been found that such construction may cause the armature to stick, or not to retract immediately when excitation is removed from the electromagnet, particularly if there is good magnetic contact between the core and the armature, this effect being due to the remanent or residual flux caused by the shading coil within the coil and completing its loop around the embedded portion of the conductor which forms the loop.

It is an object of my invention to reduce the remanence caused by the shading coil and thereby to prevent the armature from sticking because of this remanence.

In carrying out my invention in one form, I provide an electromagnet having a U-shaped laminated core. An armature, which bridges the ends of the core in the closed position, is operated by the magnetic attraction of the electromagnet. The end surface on each leg of the core has a recess across it parallel to the plane of the laminations. A single loop shading coil, which encircles a portion of the magnetic path in that leg of the core, is positioned in each such recess. In order to minimize the residual magnetic flux encircling the part of the shading coil embedded in the recess, during the time immediately following the de-energizing of the electromagnet, a separator of non-magnetic material is provided between two of the laminations abutting on each such recess. This introduces into the path of the magnetic flux component around the conductor forming the shading coil, reluctance of sufficient magnitude to reduce the remanent value of this flux sufficiently to prevent the armature from sticking due to such remanent flux, but not sufficient to prevent flux around the shading coil during energization of the electromagnet from reducing the chatter of the armature.

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For a clearer and more complete understanding of my invention, reference should be had to the accompanying drawing, Fig. 1 of which is a side view in elevation of one embodiment of the invention; Fig. 2 is a sectional view along the line 2—2 of Fig. 1; Fig. 3 is a partial end view of the core of the device shown in Fig. 1 along the line 3, with the excitation coil and shading coil removed; while Fig. 4 is a perspective view of the core of Fig. 1 with the excitation coil removed but with the shading coils in position.

Referring to Fig. 1 of the drawing, a typical device embodying my invention is designated generally by the numeral 10. The device 10 has a U-shaped stationary core, or frame portion 11 and a movable armature 12. On one leg of core 11 is positioned a multi-turn alternating current excitation coil 13. Together, core 11 and excitation coil 13 comprise an electromagnet which attracts armature 12 when coil 13 is energized, and thereafter holds the armature in the closed position illustrated in Fig. 1 as long as the electromagnet remains energized. Armature 12 is biased by springs 14 or other suitable means which pull armature 12 away from core 11 when the electromagnet is de-energized. The pull of the electromagnet is strong enough to overcome the pull of springs 14 when coil 13 is energized.

Armature 12, as best seen in Fig. 2, is composed of a plurality of flat laminations 15 of magnetic material, preferably steel, separated by layers 16 of electrical insulating material in order to minimize eddy currents in the armature due to alternating magnetic flux. Core 11 is composed principally of similar flat laminations 17 of magnetic material separated by layers 18 of electrical insulating material. In the bight portion of core 11 is a separator, or spacer 19 of non-mag-

netic material. Spacer 19 is perpendicular to the plane of laminations 17 and covers the entire cross sectional area of core 11, completely separating the core into two laminated portions. Each upper horizontal surface of the legs of core 11 is provided with a slot or recess 20, one of which is clearly shown in Fig. 3. Each recess 20 extends entirely across the end surface, or pole face of the core leg in which it is located parallel to the laminations 17. The legs of frame 11 may be termed polar projections inasmuch as these legs contain the magnetic poles of the electromagnet formed jointly by frame 11 and exciting coil 13; likewise, the end surfaces of the legs of frame 11 may be called pole faces.

Each leg of core 11 is provided with a nonmagnetic separator 21 of suitable thickness which abuts on recess 20, thus providing a magnetic separation between the portions of each leg of the core which lie on opposite sides of the separator 21. Positioned in recesses 20, as seen best in Fig. 4, are shading coils 22 which are composed of a single closed loop of electrically conductive material such as copper. Each coil 22 encircles a portion of the core leg adjacent the end, or pole face against which armature 12 abuts, thus providing an additional component of magnetic flux due to the current induced in the shading coil, which has the effect of retarding the portion of the main flux encircled by coil 22, thereby reducing the tendency of the armature to chatter.

When coil 13 is energized, the restraining force of springs 14 is overcome and armature 12 is attracted and held in engagement with core 11, in the position illustrated in Fig. 1. This forms a magnetic circuit around the loop formed by members 11 and 12 in which oscillating magnetic flux is present, the oscillations being at the frequency of the alternating current in coil 13. When coil 13 is deenergized, the flux in the loop formed by core 11 and armature 12 decays gradually in accordance with the hysteresis characteristic of the loop. If spacer 19 were not present in the bight portion of frame 11, the hysteresis characteristic might, under some circumstances permit an amount of residual flux sufficient to cause the armature 12 to stick closed against the pull of springs 14 even after the removal of coil excitation. Spacer 19 increases the reluctance of the loop formed by members 11 and 12 sufficiently that the magnetic flux in this loop always decays to a low enough value when coil 13 is de-energized that the pull exerted this residual flux is insufficient to cause sticking of the armature.

Shading coils 22 also tend to cause armature 12 to stick when coil 13 is de-energized. The principal function of coils 22 is to produce a component of flux in a separate path in order to change the time phase of a portion of the main magnetic flux and thereby to prevent chatter or vibration of the armature. The effect of this addition flux component may be to cause sticking of the armature under some conditions, these conditions depending on where on the voltage wave the circuit is opened. In order substantially to counteract this effect, I provide nonmagnetic laminations or separators 21 which create relatively high reluctance paths for the components of magnetic flux surrounding the portions of coils 22 which are embedded in recesses 20. This is illustrated by the arrow 23, which is shown in Fig. 2 encircling the embedded portion of one coil 22, it being understood that the direction of the flux is reversed during half of each cycle. Nonmagnetic separator 21 is substantially perpendicular to the path of the flux below coil 22, so that the reluctance of this path is increased. This causes the component of flux around coil 22 to decay to a lower value when the electromagnet is de-energized, thereby preventing sticking or delayed opening of the armature due to such flux.

The essential feature of my invention is the introduction of additional reluctance in the circuit of the component of magnetic flux resulting from the shading coil, in order to prevent the sticking of the armature because of the residual flux in this circuit. It will be understood, however, that the use of a nonmagnetic separator 21 is not the only manner in which sufficient reluctance may be introduced into this circuit. For example, the presence of layers 16 and 18 of insulating material between laminations 15 and 17, respectively, may provide sufficient reluctance, thus making separator 21 unnecessary. It will be noted from arrow 23 in Fig. 2 that the path of this component of magnetic flux is substantially normal to the layers 16 and 18 above and below conductor 22; therefore, one or more layers 16 and one or more layers 18 are always present in this path, even in the shortest possible path for this component of flux, providing recess 20 in wider than the thickness of laminations 15 and 17. Consequently, if layers 16 and 18 are provided with sufficient reluctance, they alone may supply the reluctance that is required.

It will be noted in Figs. 1 and 4 that shading coils 22 in this typical apparatus embodying my invention are disposed on the two legs of core 11 so that they are symmetrical with respect to a pull axis extending vertically through the geometrical center of the upper surface of armature 12. The effect of this is to prevent unbalance of the force necessary to pull armature 12 away from core 11 when coil 13 is de-energized. The unbalancing effects of the two shading coils counteract each other, both laterally and longitudinally, when the electromagnet is constructed in the manner illustrated, causing the pull axis to remain substantially centralized with respect to the upper surface of armature 12.

While I have illustrated and described one preferred embodiment of my invention, together with one modification thereof, additional modifications will occur to those skilled in the art. Therefore, it should be understood that I intend to cover, by the appended claim, all such modifications as fall within the true spirit and scope of my invention.

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

An electromagnet device comprising a U-shaped frame of laminated magnetic material in which the laminations lie parallel to a plane coinciding with the center lines of the legs of said U, a first nonmagnetic separator in one leg of said U parallel to said laminations separating said leg into two laminated portions, said first separator being a predetermined distance from one side of said U-shaped frame, a second nonmagnetic separator in the other leg of said U parallel to said laminations separating said other leg into two laminated portions, said second separator being an equal distance from the other side of said frame, a first recess in the end surface of said one leg parallel to said laminations, said first separator abutting the bottom of said first recess, a first shading coil positioned in said first recess surrounding the portion of said one leg

lying between said recess and said first side, a second recess in the end surface of said other leg parallel to said laminations, said second separator abutting the bottom of said second recess, a second shading coil positioned in said second recess surrounding the portion of said other leg between said second recess and said second side, an exciting coil positioned on said frame, a symmetrical U-shaped laminated armature operatively positioned adjacent the end surfaces of said legs, the end surfaces of the legs of said armature arranged to abut respectively said end surfaces of the legs of said frame when said exciting coil is energized, and means biasing said armature away from said frame.

LEON J. GOLDBERG.

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