ELECTROMAGNETIC DEVICE AND METHOD OF MAKING

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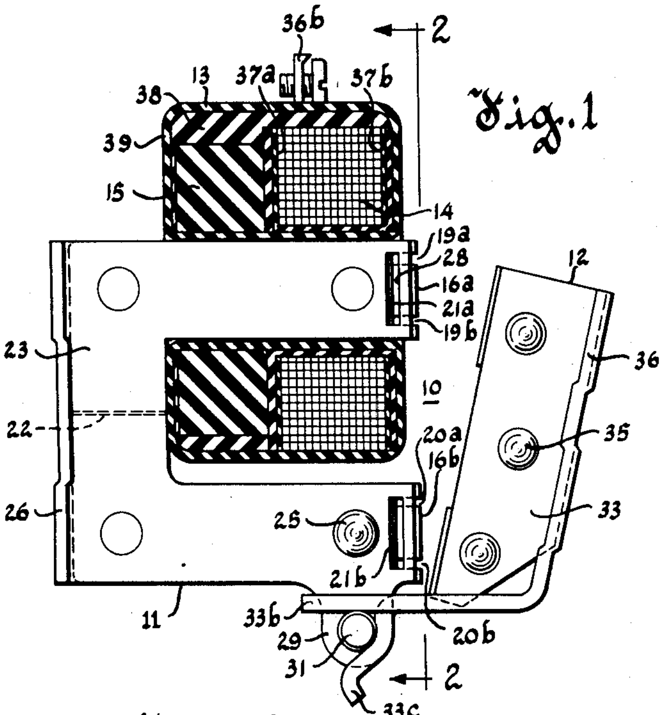

Fig. 1

Fig. 2

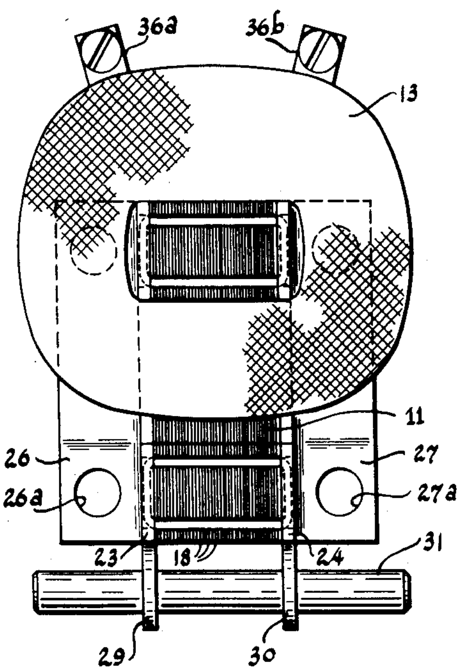

Fig. 3

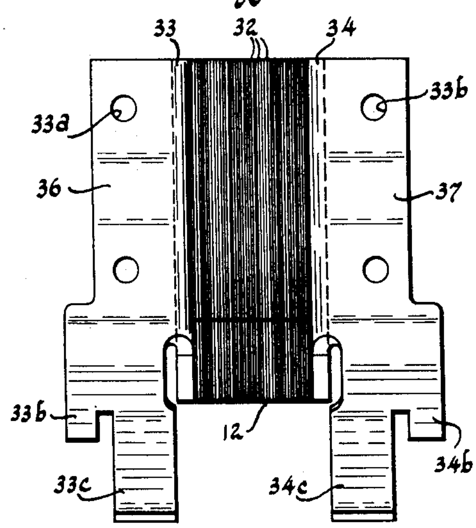

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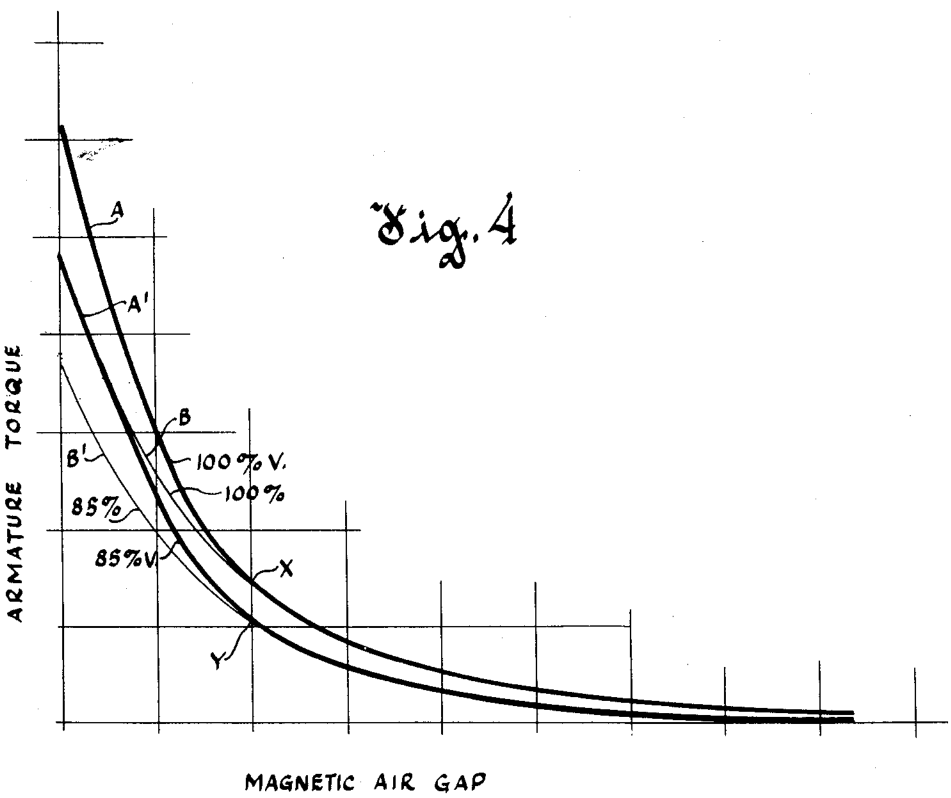
Fig. 4



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ELECTROMAGNETIC DEVICE AND METHOD OF MAKING

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9 Claims. (Cl. 317—165)

This invention relates to improvements in and methods of making electromagnetic devices.

While not limited thereto, the invention is especially applicable to alternating current electromagnetic contactors of the shading coil type employed in electrical control systems and the like.

It has heretofore been proposed to fill the window area of an electromagnet with a coil, that is, to construct the core and energizing coil so that the coil winding fills the interior space between the bottom of the core and the armature air gap and thus surrounds and extends throughout substantially the entire length of a pole piece. Providing a core having a window area only large enough to accommodate the required size of coil and then using a coil that occupies this full space has heretofore been thought to be necessary to afford an electromagnet having optimum electrical characteristics. The pull curve of the aforementioned type of electromagnet has been known to be alterable by winding the coil with more than one size of wire to provide a greater number of turns adjacent the air gap.

It has been found desirable to devise an electromagnetic device capable of selectively accommodating any one of a number of different sizes of alternating current energizing coils. For some applications it is desirable to employ direct current coils which inherently require a greater amount of copper in the coil for a given magnetic pull. It has been discovered that a common size of the core constructed to receive the maximum size of coil can be effectively employed to accommodate any one of a plurality of different sizes of coils by properly positioning the latter thereon. Spacing such coil into the area adjacent the air gap results in a structure having optimum electrical characteristics. Concentration of the coil winding in the area adjacent the air gap as in the present invention not only permits use of selectively different sizes of coils on a single size of core but also results in decrease of the leakage flux with a consequently higher percentage of the total flux bridging the air gap to an extent that the total flux can be reduced without decreasing the open gap pull. This reduction in total required magnetic flux affords pull characteristics which are more desirable for most applications and permits a significant reduction in the magnetizing volt-amperes resulting in a substantial decrease in the power consumption. Consequently, the improved device operates at a lower temperature although it has less heat radiating surface area than devices heretofore known.

Accordingly, a primary object of the invention is to provide improved means affording the aforementioned and other new results.

A more specific object of the invention is to provide an improved electromagnetic device capable of accommodating any one of a plurality of selectively different sizes of energizing coils at optimum efficiency.

A still more specific object of the invention is to provide improved means for reducing the leakage flux in an

electromagnetic device to an extent that the total flux can be reduced without decreasing the open gap pull.

Another specific object of the invention is to provide an improved energizing coil for such electromagnetic device which is simple in construction and economical to manufacture.

Another primary object of the invention is to provide a method of improving the efficiency and operating characteristics of an electromagnetic device.

A further specific object of the invention is to provide a method of making improved alternating current electromagnetic devices having maximum uniformity in their constituent parts.

Other objects and advantages of the invention will hereinafter appear.

While the device hereinafter described is effectively adapted to fulfill the objects stated, it is to be understood that I do not intend to confine my invention to the particular preferred embodiment of electromagnetic device disclosed, inasmuch as it is susceptible of various modifications without departing from the scope of the appended claims.

In the accompanying drawings:

Figure 1 is a side view in elevation and partly in section of an electromagnetic device constructed in accordance with the present invention;

Fig. 2 is a top view of the core assembly of the device taken along the line **2—2** of Fig. 1;

Fig. 3 is a top view of the armature of the device shown in Fig. 1; and

Fig. 4 graphically depicts operating characteristics of the device shown in Fig. 1.

Referring to Figs. 1 and 2 of the drawings, an electromagnetic device embodying the invention is designated generally by the numeral **10**. The device **10** has a U-shaped stationary frame portion or core **11** and a movable armature **12** shown in its normally open position. Surrounding one leg of core **11** is a unitary coil structure **13** having a multiple-turn alternating current energizing winding **14** and a spacer **15** of non-magnetic material. Core **11** and energizing winding **14** in combination comprise an electromagnetic which attracts armature **12** when winding **14** is energized, and thereafter holds the armature in the closed position as long as the electromagnet remains energized. Armature **12** is mechanically biased by one or more springs (not shown) or other suitable means which pull armature **12** away from pole faces **16*a*** and **16*b*** of core **11** when the electromagnet is de-energized. The pull of the electromagnet is of sufficient strength to overcome the opposing forces of the aforesaid springs and any load driven by the armature upon energization of winding **14**.

Core **11** as shown in Figs. 1 and 2 is constructed of a plurality of flat laminations **18** of magnetic material such as silicon steel or the like separated by thin coatings or layers of electrical insulating material (not shown) in order to minimize eddy current losses in the core caused by the alternating magnetic flux. Pairs of recesses or slots **19*a***, **19*b*** and **20*a***, **20*b*** are provided on pole faces **16*a*** and **16*b***, respectively, each slot extending completely across the pole face in which it is located perpendicular to the laminations and the slots of each pair being located symmetrically on opposite sides of the center of each pole face. Positioned in the respective pairs of slots **19*a***, **19*b*** and **20*a***, **20*b*** are shading coils **21*a*** and **21*b*** each of which is comprised of a single closed loop of electrically conducting material such as copper or the like. Each coil **21*a*** and **21*b*** surrounds the portion of the core leg adjacent to and associated with the portion of the pole face between the pair of slots. The primary function of the shading coils is to afford an additional component of magnetic flux developed by the current induced in the shading coils which is displaced in phase relative to the phase of the flux developed by energizing winding **14** to maintain the total of the absolute values of the fluxes above zero value at all times, thereby maintaining the armature pull above zero value at all times to reduce the tendency of the armature to chatter due to the cyclic variations of the alternating current. In the intermediate bottom portion of core **11** is an air gap **22** which may be filled, if desired, with a separator or spacer (not shown) of non-magnetic material affording a permanent gap in the magnetic path. Air gap **22** is perpendicular to the planes of laminations **18** and completely divides the core into two laminated portions. The laminations of core **11** are held together by generally U-shaped brackets **23** and **24** of non-magnetic material on opposite sides of the core and a plurality of rivets **25** or the like extending through alined holes in the brackets and laminations to form a unitary rigid structure. Brackets **23** and **24** comprise flanges **26** and **27** laterally extending in opposite directions from the bottom of each respective U-shaped bracket forming a mounting structure for the core assembly. Holes **26*a*** and **27*a*** are provided at spaced points in the respective flanges to facilitate securing the electromagnetic device to a stationary base. In addition each bracket has a longitudinal opening such as **28** shown in Fig. 1 adjacent each pole face and overlying each pair of shading coil slots for accommodating the ends of the shading coils and retaining the latter in their respective pairs of slots. Ears **29** and **30** are integrally formed on corresponding legs of brackets **23** and **24** having alined holes therethrough for receiving an armature pivot pin **31**.

Armature **12** shown in Figs. 1 and 3 is similarly constructed of a plurality of flat laminations **32** of magnetic material such as silicon steel or the like separated by thin coatings or layers of electrical insulating material in order to minimize eddy current losses therein caused by the alternating magnetic flux. The laminations of armature **12** are held together by members **33** and **34** of magnetic material on opposite sides of the armature and a plurality of rivets **35** or the like extending through alined holes in the members and laminations to form a unitary rigid structure. Flanges **36** and **37** formed integrally with and extending laterally in opposite directions from the respective members **33** and **34** are provided with one or more holes **33*a*** and **33*b*** for attaching force transmitting members such as contact actuators or the like (not shown) to the armature. Members **33** and **34** further comprise integrally formed pivot structures at corresponding ends thereof having linear portions **33*b***, **34*b*** and offset bent portions **33*c***, **34*c*** for removably receiving the opposite end portions of pivot pin **31**. Portions **33*c*** and **34*c*** are formed to extend away from linear portions **33*b*** and **34*b*** at a suitable angle and to provide seats for pivot pin **31** such that members **33** and **34** are free to move away from pivot pin **31** when the armature closes to afford self-alining positive engagement between the respective sealing surfaces.

Coil structure **13** having screw-threaded terminals **36*a*** and **36*b*** shown in Figs. 1 and 2 is comprised principally of the winding **14** and spacer **15**. Washers **37*a*** and **37*b*** of electrical insulating material such as pressed board or the like are assembled on respectively opposite ends of winding **14**, washer **37*a*** separating winding **14** from spacer **15**. Spacer **15** has a dimension perpendicular to its axis equal to that of the smallest size of coil employed. Thus, when spacer **15** is assembled to a coil having a larger dimension, an additional insulating member **38** may be employed if desired to provide a structure of uniform width. The aforementioned assembled parts including spacer **15** are then wrapped with a partially overlapping winding of tape **39** of electrically insulating material such as cotton or the like to provide a unitary coil structure. Coil structure **13** encircles one leg of core **11** and the spacer end of the coil structure abuts the intermediate bottom portion of the core. Spacer **15** serves to maintain winding **14** in the area immediately adjacent the air gap defined by pole face **16*a*** and armature **12**. The primary function of spacer **15** is to concentrate the coil winding closer to the air gap to reduce the leakage flux which results in a higher percentage of the total flux bridging the working air gap. As a result the total flux can be reduced without decreasing the open gap pull with a consequent saving in weight and cost of the coil. Such reduction in the total required flux permits a significant reduction in the sealed volt-amperes required for a given pull resulting in a substantial decrease in the sealed watts consumed. Therefore, although the heat dissipating surface area of the coil is reduced, the device operates at a lower temperature because less heat is produced. In addition, the single size of core accommodates a variety of selectively different sizes of coil windings with their complementary spacer elements resulting in substantial savings in manufacturing costs.

When coil winding **14** is energized, a magnetic field is developed in the air gaps between core **11** and armature **12** which acts to attract the latter and overcome the restraining forces of the aforementioned biasing springs. Currents induced in shading coils **21*a*** and **21*b*** develop phase displaced magnetic fluxes in the air gaps adjacent pole faces **16*a*** and **16*b***, respectively, to maintain the total of the absolute values of the fluxes always above zero value. Armature **12** is held in engagement with core **11** as long as winding **14** is energized. Thus, a magnetic circuit is formed around the loop comprising core **11** and armature **12** having an alternating magnetic flux oscillating at the frequency of the alternating current in winding **14**. Magnetic circuits are also formed in loops through each respective shading coil and portions of the corresponding core leg and armature sealing surface having a phase displaced alternating magnetic flux oscillating at the frequency of the alternating current in winding **14**. When coil winding **14** is de-energized, the armature returns to its normally open position.

Fig. 4, wherein successive values of armature torque or pull are plotted against lengths of armature air gap or armature stroke to provide pull curves for the electromagnetic device, graphically depicts the advantageous results afforded by the present invention. Curves A and A′ show pull characteristics of prior electromagnetic devices at approximately 100 percent and 85 percent normal alternating current coil voltage, respectively, while curves B and B′ show pull characteristics of the novel electromagnetic device employing a coil winding filling approximately 60 percent of the window area at approximately 100 percent and 85 percent normal alternating current coil voltage, respectively. While the aforementioned curves depict approximate values of armature pull throughout the armature stroke, it should be noted that at 100 percent normal coil voltage the open air gap pull of the novel electromagnetic device of the present invention shown by curve B is equal to the open gap pull of prior devices shown by curve A down to approximately point X. The present invention affords a reduction in the magnetizing volt-amperes of approximately 40 percent and a reduction in the wattage of approximately 30 percent with 60 cycle alternating current energization. Likewise, at 85 percent normal coil voltage the open gap pull of the improved device shown by curve B′ is equal to the open gap pull of heretofore known devices shown by curve A′ down to approximately point Y.

In electromagnet devices heretofore known the sealed pull is inherently too great and more than that which is required to maintain the armature closed even under severe shock conditions. This is brought about by the large value of leakage flux rapidly decreasing as the armature approaches a sealed condition. The optimum pull curve for most applications is that which closely follows the load curve of the device. The load curve (not shown) of driven devices such as contactors and the like falls below the pull curve A of prior electromagnetic devices as the armature air gap approaches zero and more nearly follows curve B of the invention. Therefore, the excess energy provided by heretofore known devices and represented diagrammatically by the separation of curves A and B from approximately point X toward zero air gap must be dissipated as the armature strikes the core leg resulting in contact bounce and undesirable wear and noise.

On the other hand, electromagnetic devices constructed in accordance with the present invention afford pull curves B and B′ having a more desirable shape such that they follow the load curve of the driven device more closely in the region wherein the air gap approaches zero value. Therefore, correspondingly less excess energy is required to be dissipated as the armature seals with the consequent advantageous results of less contact bounce, noise, wear and waste of energy.

I claim:

1. In an electromagnetic device having a core for receiving any one of a plurality of selectively different sizes of energizing coils and an armature mounted for movement relative to the core and normally biased away from the core to form an air gap therebetween, in combination, an energizing coil surrounding at least a portion of the core, means for spacing said coil into the area adjacent the air gap, said means comprising a spacer member of non-magnetic material having a configuration substantially corresponding to the configuration of said coil, and means for securing said spacer member to one end of said coil to form a unitary structure.

2. In a device as claimed in claim 1, the last mentioned means comprising a partially overlapping winding of electrically insulating tape surrounding said coil and said spacer member.

3. In an electromagnetic device having a generally U-shaped core for receiving any one of a plurality of selectively different sizes of energizing coils and an armature pivoted for movement relative to the core and normally biased away from the core to form an air gap therebetween, in combination, a selected size of energizing coil surrounding at least one leg of the core immediately adjacent the air gap, and non-magnetic means of complementary thickness filling the space between the coil and the bottom of the U-shaped core to space and maintain the coil in the aforementioned position.

4. In an alternating current electromagnetic device having a laminated U-shaped core for accommodating any one of a plurality of selectively different sizes of energizing coils, a permanent non-magnetic gap between portions of the core and a laminated armature arranged for movement relative to the core and normally biased away from the latter to provide an air gap therebetween, in combination, means subjecting the armature to an attractive force varying in the closing region of the armature stroke substantially in proportion to the variation in

the opposing load force which must be overcome to close the air gap, said means comprising energizing coil means surrounding at least one leg of the U-shaped core and means for spacing said coil means from the intermediate portion of the core to concentrate said coil means adjacent the air gap thereby to reduce the leakage flux.

5. In an alternating current electromagnetic device having a laminated U-shaped core with a permanent non-magnetic gap between portions of the latter, a laminated armature normally biased away from the core to provide an air gap therebetween, and an operating coil surrounding at least one leg of the U-shaped core, the improvement comprising means for positioning said coil adjacent the air gap and away from the bottom of the U-shaped core to introduce a greater percentage of the total flux into the air gap thereby to permit a reduction in the total flux without a decrease in the open gap pull.

6. In a device as claimed in claim 5, the last mentioned means comprising a non-magnetic spacer member between the coil and the bottom of the U-shaped core and secured to the coil to form a unitary structure therewith.

7. In combination, an energizing coil for an electromagnetic device for introducing alternating magnetic flux into an air gap of the device and means for reducing the leakage flux so that a greater percentage of the total flux traverses the air gap, said means comprising a member of substantial thickness for maintaining said coil immediately adjacent the air gap.

8. In an alternating current electromagnetic device having a core, an armature normally biased away from the core to provide an air gap therebetween, and a shading coil around at least a portion of the core immediately adjacent the air gap, in combination, an energizing coil surrounding a portion of the core for developing an alternating magnetic flux, and means for confining substantially all of the flux developed by said energizing coil to penetrate the air gap, said means comprising non-magnetic means spacing said energizing coil into an area immediately adjacent the shading coil.

9. A method of reducing the power consumption and operating temperature of an alternating current electromagnetic device to the type having an energizing coil extending over substantially the whole length of a pole piece without decreasing a given open gap attractive force on its armature, which method comprises the steps of substituting an energizing coil productive of a smaller value of magnetic flux, and positioning said energizing coil adjacent the end of the pole piece defining the air gap to concentrate a greater percentage of the total flux in the air gap.

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