July 1, 1952 H. MULLER 2,602,097

VARIABLE ELECTRIC CHOKES, TRANSFORMERS OR THE LIKE

Filed Jan. 8, 1949 2 SHEETS—SHEET 1

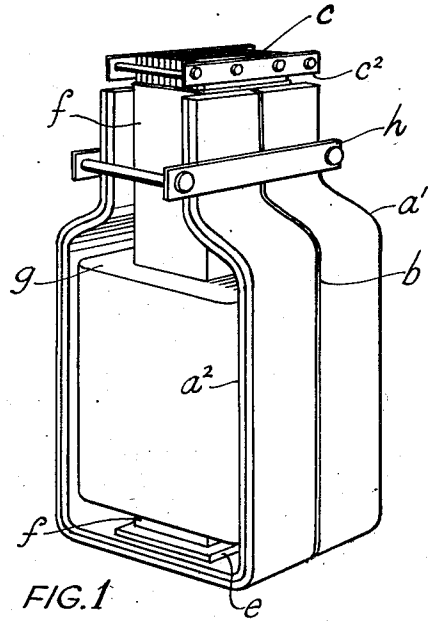


FIG. 1

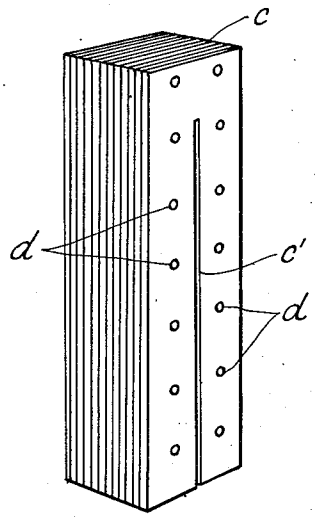


FIG. 2

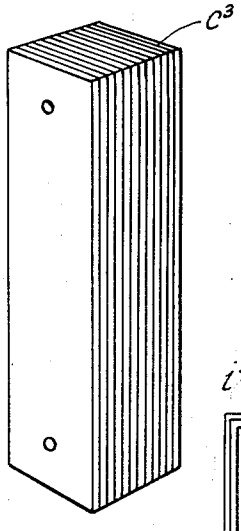


FIG. 3A

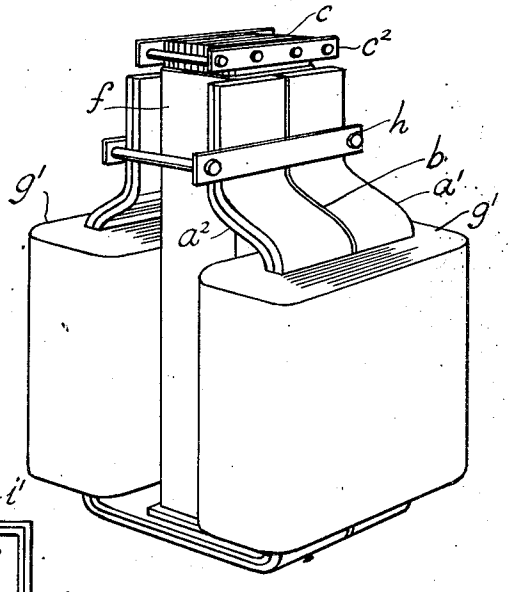


FIG. 4

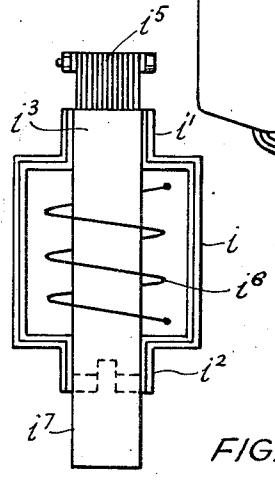


FIG. 5

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VARIABLE ELECTRIC CHOKES, TRANSFORMERS OR THE LIKE

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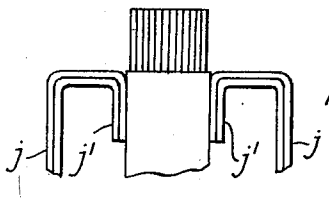


FIG. 6

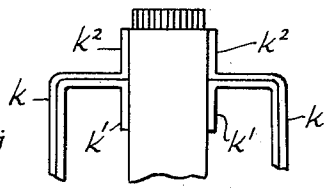


FIG. 7

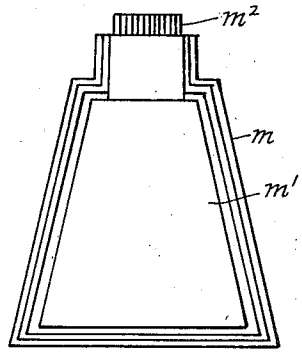


FIG. 8

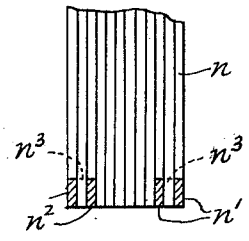


FIG. 9

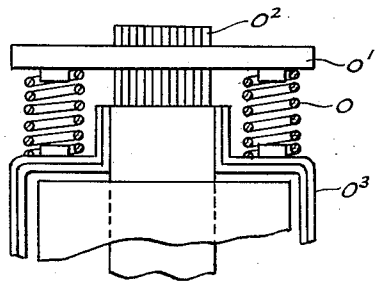


FIG. 10

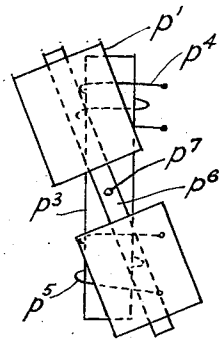


FIG. 12

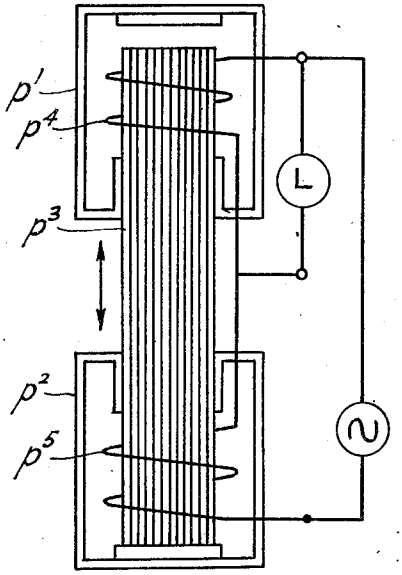


FIG. 11

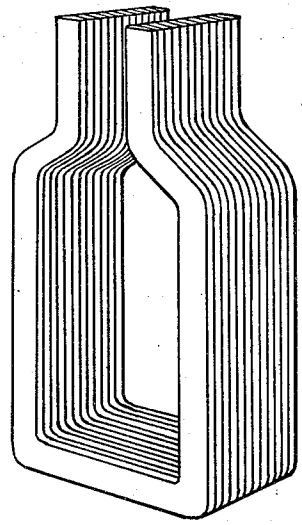


FIG. 3

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VARIABLE ELECTRIC CHOKES, TRANSFORMERS, OR THE LIKE

Heinrich Muller, Manchester, England

Application January 8, 1949, Serial No. 69,861
In Great Britain January 10, 1948

5 Claims. (Cl. 171—119)

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This invention relates to variable electric magnetic devices such as inductances, chokes, transformers or the like for A. C. or relays, solenoids etc. for A. C. or D. C., of the kind having a shell-shaped magnetic core, that is to say having a core which in its simplest form may be described as consisting of a closed outer frame across which is a centre limb. Various cores are also known, for example for multi-phase use, which are compounded forms of a plurality of simple shell-shaped cores and as such are included in the expression "shell-shaped core" as used herein whether used for single or multi-phase purposes or with D. C.

One of the objects of a designer of a variable electro-magnetic device is to obtain for a given amount of copper and iron, a maximum control range of current and/or flux variation. Another object is to make the variation within such range infinitely variable and this latter object, as is of course well known, is more easily obtainable by providing relative physical movement of the copper and iron rather than by the use of tappings.

The possible range of variation is determined by certain factors. For example, the minimum copper section of the conductor is determined by the maximum required amperage, and if there is to be no tapping then the copper section must be uniform throughout and sufficient to carry the said required maximum amperage.

On the other hand, if the number of turns is fixed (i. e. tappings are not used) the only possibility of varying the amperage is to provide means for varying the reluctance of the magnetic circuit. It is well known, on such basis, to provide a magnetic core with relatively movable parts, the movement being so arranged as to vary either the reluctance of the magnetic circuit, or the coupling between the copper and the iron.

An open-ended solenoid with relatively movable iron core and coil is an example of variation of coupling only, but such an arrangement is very limited in its range of current variation, though providing maximum efficiency for the higher currents. An open-ended solenoid also has low capacity for variation because the induction is low and therefore for a given amperage range of variation one would require more iron and copper than with a construction having a more closed iron path which would give greater inductance. Consequently, an open-ended solenoid becomes very large and expensive in material and electrical losses where large range of variation of amperage and/or flux is required.

On the other hand, a device having a relatively

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closed magnetic circuit with a movable part for variation of its reluctance, has a wider range of current variation but for the same weight of copper and iron it is not possible to obtain the same maximum amperage as with an open-ended solenoid, because the inherent impedance is higher. Consequently, the efficiency is also lower for the higher amperages. But, such construction has a higher efficiency than an open-ended solenoid for the lower amperages.

The object of the present invention is an improved construction of variable electro-magnetic device such as a choke, transformer or the like, combining the advantages of each of the aforesaid basic forms of open-ended solenoid or closed magnetic circuit.

According to the invention a variable electro-magnetic device such as a choke, transformer or the like comprising a shell-shaped magnetic core consisting of an outer frame and a central limb across the frame with at least one electric winding on the core arranged so as to produce therein a shell-shaped magnetic flux, is characterised in that the said central limb and frame are relatively movable so as to open or close the magnetic circuit at least between one end of the limb and the frame whereby greater current and flux variation may be obtained for the same amount of copper and iron.

The expression "shell-shaped magnetic flux" is used herein to describe that arrangement of magnetic flux in a shell-shaped core in which the flux in the centre limb is in one direction and is the sum of the flux from the two parts of the frame on each side of the said centre limb. Preferably the flux in each of the said two parts is substantially equal so that there is symmetry or balance.

In the accompanying drawings:

Fig. 1 is a perspective diagram showing one example of an electro-magnetic choke made in accordance with the invention;

Fig. 2 is a perspective diagrammatic view showing the centre limb of the choke shown in Fig. 1;

Fig. 3 shows an alternative construction of the outer frame;

Fig. 3A shows an alternative construction of centre limb;

Fig. 4 shows an alternative winding of the example shown in Fig. 1;

Fig. 5 is a diagram showing a modified construction for the frame;

Figs. 6 and 7 are fragmentary views showing further modified constructions for one end of a frame;

Fig. 8 shows a construction with the parts tapered;

Fig. 9 is a fragmentary diagram showing pole shadowing for the centre limb;

Fig. 10 is a fragmentary view showing mechanical counter-balancing of the magnetic forces;

Fig. 11 shows a potentiometer made in accordance with the invention;

Fig. 12 shows a modification of the construction shown in Fig. 11 for use as a twin choke.

In the example of the invention shown in Figs. 1 and 2 a choke for 230 volts 10 amps. 50 cycles comprises a bottle-shaped outer frame consisting of 15 laminations (shown diagrammatically as 2 laminations) of standard gauge and usual material, divided longitudinally at *b* to reduce eddy current losses and for that purpose made of two parallel sets of laminations *a'*, a^2. The overall inside dimensions of such frame are substantially 3½ inches between the sides of the frame, which sides are 3 inches wide. From the base to the neck of the bottle the frame is about 6 inches and the neck is about 2 inches long. The parts forming the neck are therefore of such length that the area of the air gap between such parts and the centre limb is greater than the cross sectional area of the said centre limb as described below.

Slidably located in the neck of the bottle is a centre limb *c* shown separately in Fig. 2, consisting of a group of about 80 to 90 laminations (shown diagrammatically as 12 laminations) collectively forming a core of about 1¾ inch square cross section. The laminations are divided from the bottom by a cut at *c'*, and are secured together by a series of rivets *d* in the centre of each limb thus formed. The cut at *c'* reduces eddy and other currents which might otherwise be induced in circuits formed by the rivets and thus cause heating and losses. Such core, when the inner end is against a thin interposed insulator *e* at the base of the bottle-shaped frame projects at its other or outer end about ½ inch beyond the neck of the frame. This insulator provides the usual basic air gap and also prevents magnetic adhesion. A thin insulating guide tube *f* of rectangular cross section is provided within the frame extending substantially from the base to the end of the neck constituting a former for the electric winding *g* and a guide for the sliding core *c* as well as providing something against which the laminations of the frame at the neck may be clamped by a clamp *h*. The upper end of the centre limb laminations *c* are secured by a clamp c^2 and movement of the sliding centre limb may be effected by cam, lever, screw or other suitable mechanism connected to such clamp and either manually or power operated. The winding *g* occupies substantially the whole of the space between the sides of the frame and the centre core. The relatively long neck provides a sufficiently large area of air gap or gaps to reduce the reluctance at such position to compensate for the unavoidable thickness of the insulating tube *f*. It also provides stability for the sliding tube and noiseless location for the sliding centre core or limb.

As shown in Fig. 3A, the laminations c^3 of the centre limb are arranged in the plane at right angles to those shown in Fig. 2 and this is found to increase the efficiency and the laminations can be made as stampings.

In operation, as the centre limb *c* is withdrawn through the neck of the bottle-shaped frame the basic air gap between the inner end of the centre

limb and the base of the bottle-shaped frame, as determined by the thickness of the interposed insulator *e*, is progressively increased and thereby quickly reduces the impedance of the apparatus. When the centre limb is fully "in" the device has all the characteristics of a choke having a shell-shaped core whilst when the centre limb is fully withdrawn so that its inner end is within the neck of the frame, the choke will have substantially the same characteristics as an open-ended solenoid without any iron core. Intermediate characteristics are provided by intermediate positions of the sliding centre limb and thus in one device it is possible to obtain the full range of variation hitherto obtainable only by the use of the two comparable separate types of chokes or relatively inefficiently by much larger chokes of either type. Instead of the winding being on the centre limb, a balanced pair or pairs of windings *g'* are provided as shown in Fig. 4 on the sides of the frame, with the result that the flux of the two windings come into opposition progressively as the centre limb is withdrawn.

As shown diagrammatically in Fig. 5 the choke comprises an outer frame *i* formed with necks *i'* and i^2 one at each end between which is an insulating guide tube i^3 in which is located a sliding centre limb i^5. The choke is shown with a winding i^6 around the insulating guide tube. The centre limb has an extension i^7 of non-magnetic material secured thereto at the lower end as a guide member.

In operation, the provision of the neck at the lower end as well as at the upper end of the frame provides a better mechanical construction for guiding the centre limb and also enables one to have a greater area at the air gap for the passage of the flux.

As shown in Fig. 6, the neck may be formed by inward bending at *j'* of the laminations *j* of the frame or as shown in Fig. 7 some of the laminations of the frame *k* may be bent outwardly at *k'* while others are bent inwardly at k^2. The arrangement of Fig. 6 reduces the overall length and is therefore of advantage if it is desired to arrange several chokes in line, as for example for a multi-phase or multi-circuit use. These modified formations for the neck may be used at either or both ends of the frame. A neck is essential at least at one end in order to provide minimum reluctance to get characteristics as near as possible to a normal shell-shaped core and so that the effect of variation of the air gap at the other end shall be the main or as near as possible the only variable.

Of course, the device may have a plurality of windings or tappings to provide additional characteristics and uses for example as an auto-transformer.

As shown in Fig. 8, the frame *m* is tapered to have inclined sides and there is a correspondingly shaped winding *m'* to provide modification of its characteristic. Thus, by providing a winding which is wider at the base than at the neck, there will be an increase in the available range of variation as well as increase of the variation effect at the initial stages of movement of the centre limb m^2 as its end approaches or recedes from the insulation m^3 at the base of the frame. By reversing the taper, the available range of variation will still be increased but with reduction of the variation effect at the initial stages of movement.

As shown in Fig. 9, the inner end of the centre limb *n* may be "pole shadowed" in known man-

ner by means of short-circuit rings n', n^2 to reduce physical vibration. Alternatively a single short-circuit winding as shown dotted at n^3 may be sunk in the laminations facing the end of the centre limb. In this alternative the losses due to such winding decrease as the centre limb is withdrawn. As a mechanical modification shown in Fig. 10, in order to reduce the relatively high physical force required to produce initial outward movement of the centre limb from its "in" position, return springs o may be incorporated in the construction of the device as compression springs between a clamp o' for the laminations of the centre limb o^2 and the upper shoulder of the frame o^3.

The device made in accordance with the invention has characteristics particularly suitable for use as a dimmer or as a choke for a welding transformer. An inductive potentiometer as shown in Fig. 11 may be provided by arranging two frame parts p', p^2 similar to that of the example first described with their necks modified as shown in Fig. 6 adjacent and in alignment, and with a common slidable centre limb p^3. The two windings p^4, p^5 on the centre limb are in series with the load L across one of them. Displacement of the centre limb p^3 will vary the relative reluctance of the two coils and consequently alter the potential gradient.

As a further physical modification, the centre limb, instead of being axially slidable through the bottle neck of the frame it may be laterally movable in any desired manner, as by pivoting. Such an arrangement is shown in Fig. 12 as applied to the construction of Fig. 11 for providing a twin choke in which the frames p' and p^2 are connected by side members p^6 and are pivoted at p^7 to the centre limb so that they can be displaced angularly as shown, so that the impedance of each choke varies simultaneously and equally.

What I claim is:

1. A variable electromagnetic device comprising a shell-shaped magnetic core having an outer frame, a central limb within said frame and at least one winding on said core to produce a shell-shaped magnetic flux, said frame consisting of a plurality of laminations bent to provide substantially parallel flat sides and defining a relatively wide space, the end portions of said sides being bent to form restricted neck portions, the latter being substantially parallel, said frame being slit in a plane transversely of said laminations, said central limb consisting of a plurality of laminations slidably fitting between said neck portions and extending into said space, the direction of movement of said limb being substantially parallel to said sides.

2. A variable electromagnetic device comprising a shell-shaped magnetic core having an outer frame, a central limb within said frame and at least one winding on said core to produce a shell-shaped magnetic flux, said frame consisting of a plurality of laminations bent to provide substantially parallel flat sides and defining a relatively wide space, the end portions of said sides being bent to form restricted neck portions, the latter being substantially parallel, said central limb consisting of a plurality of laminations slidably fitting between said neck portions and extending into said space, said limb being slit in a plane transversely of said laminations, the direction of movement of said limb being substantially parallel to said sides.

3. A variable electromagnetic device comprising a shell-shaped magnetic core having an outer frame, a central limb within said frame and at least one winding on said core to produce a shell-shaped magnetic flux, said frame consisting of a plurality of laminations bent to provide substantially parallel flat sides and defining a relatively wide space, the end portions of said sides being bent to form restricted neck portions, the latter being substantially parallel, said central limb consisting of a plurality of laminations slidably fitting between said neck portions and extending into said space, the direction of movement of said limb being substantially parallel to said sides, and an insulating tube within said frame, said limb being mounted within said tube.

4. A variable electromagnetic device comprising a shell-shaped magnetic core having an outer frame, a central limb within said frame and at least one winding on said core to produce a shell-shaped magnetic flux, said frame consisting of a plurality of laminations bent to provide substantially parallel flat sides and defining a relatively wide space, the end portions of said sides being bent to form restricted neck portions, the latter being substantially parallel, said central limb consisting of a plurality of laminations slidably fitting between said neck portions and extending into said space, the direction of movement of said limb being substantially parallel to said sides, and an insulating tube within said frame, said limb being mounted within said tube, said neck portions being clamped to said tube.

5. A variable electromagnetic device comprising a shell-shaped magnetic core having an outer frame, a central limb within said frame and at least one winding on said core to produce a shell-shaped magnetic flux, said frame consisting of a plurality of laminations bent to provide substantially parallel flat sides and defining a relatively wide space, the end portions of said sides being bent to form restricted neck portions, the latter being substantially parallel, said central limb consisting of a plurality of laminations slidably fitting between said neck portions and extending into said space, the direction of movement of said limb being substantially parallel to said sides, a second similar frame the neck portions thereof facing the neck portions of said first frame and in alinement therewith, said limb extending into and slidable in both of said frames.

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