

Oct. 16, 1945.

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2,386,904

ELECTROMAGNETIC DEVICE

Filed Jan. 10, 1942

2 Sheets-Sheet 1

Fig. 1

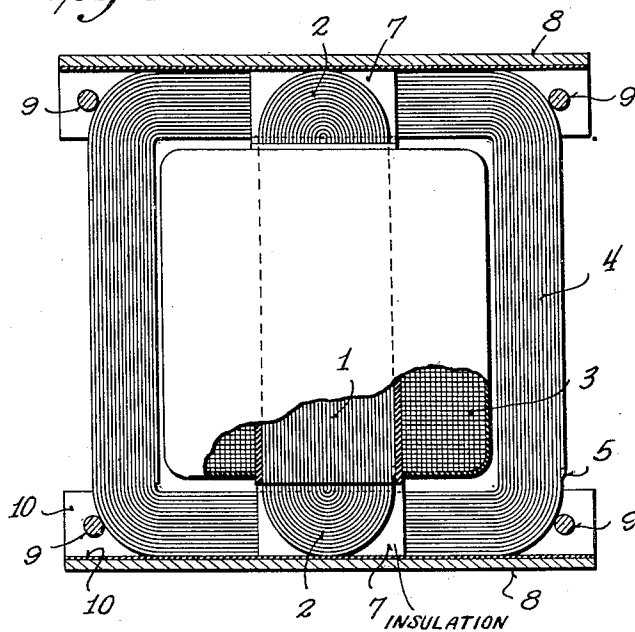


Fig. 2

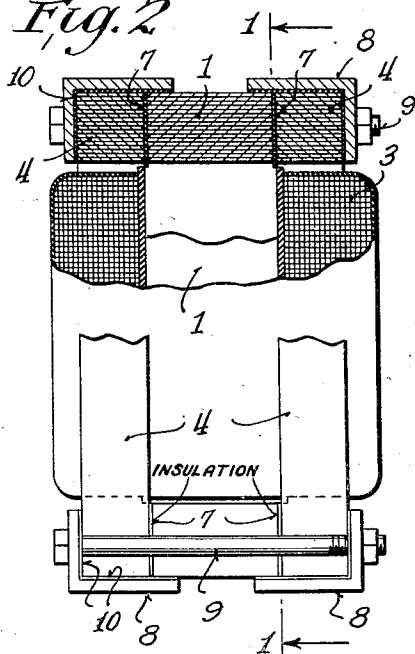
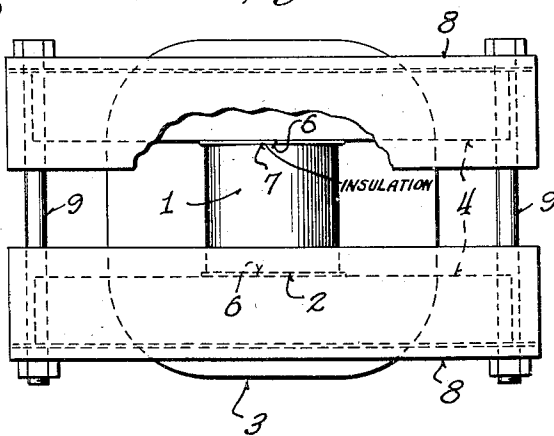


Fig. 3



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Fig. 4

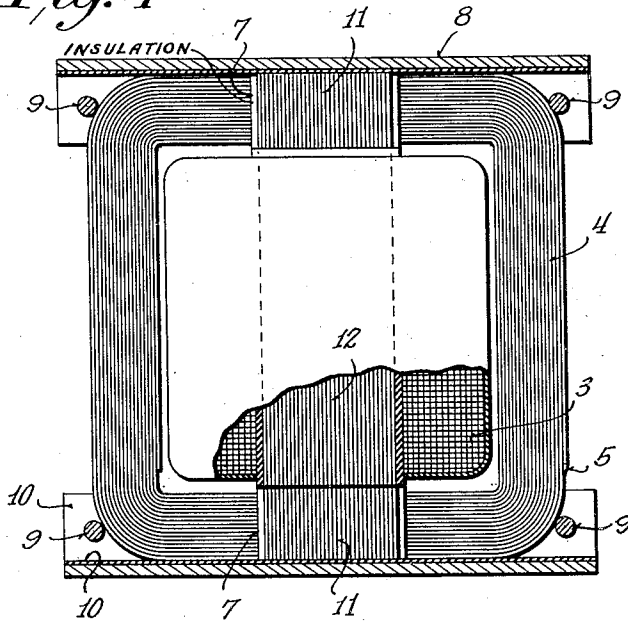


Fig. 6

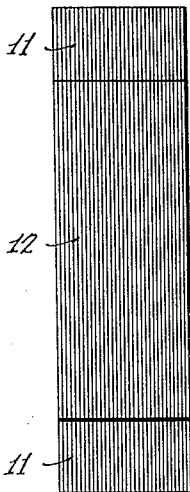
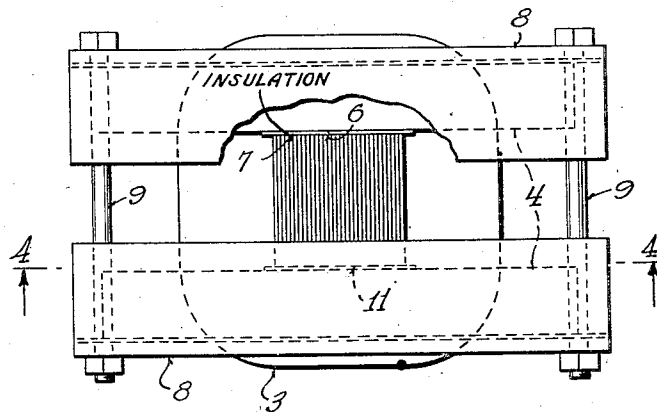


Fig. 5



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ELECTROMAGNETIC DEVICE

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Application January 10, 1942, Serial No. 426,344

1 Claim. (Cl. 175—356)

This invention relates to electromagnetic devices such as transformers, chokes, and other devices of this general nature.

Transformers have heretofore been made in which wound magnetic cores are employed. However, transformers having wound magnetic cores frequently require a considerable amount of assembly work and often require very great care in order to avoid the danger of imparting mechanical stresses to the magnetic core after the magnetic core has been annealed, as these mechanical stresses adversely affect the magnetic characteristics of the cores thereby resulting in a lowering of the efficiency of the transformer or other electromagnetic device.

This invention is designed to overcome the above noted defects, and objects of this invention are to provide a novel form of electromagnetic device having wound magnetic cores for all of the core structures or for the major portion of the core structures and in which the core structures are so made that no stresses are imparted to these core structures after they have been annealed and yet in which no unusual care is required in their assembly, in which no bending, machining or other working of the core structures is required after annealing, in which short-circuiting of the laminations is avoided, and in which either a preformed conducting winding or one wound on one of the core sections may be employed as desired, thereby allowing the utmost flexibility in the manufacture of the electromagnetic device.

Further objects are to provide a novel construction of electromagnetic device in which the losses are relatively small and in which a very good space factor is obtained for the conducting winding, and in which the air gap at the points of juxtaposition of adjacent core sections may be made relatively small and may be a predetermined quantity instead of an uncertain quantity as has heretofore been the case in transformers or other electromagnetic devices, thereby resulting in a more uniform product.

Further objects are to provide a novel form of transformer or other electromagnetic device which is extremely simple to manufacture and in which the number of operations required in its production is very greatly reduced.

Embodiments of the invention are shown in the accompanying drawings, in which:

Figure 1 is a view, partly in section, showing a transformer, such view corresponding approximately to a section on the line 1—1 of Figure 2.

Figure 2 is a view, partly in section, taken at right angles to Figure 1.

Figure 3 is a top plan view with a part broken away.

Figure 4 is a view, partly in section, showing a further form of transformer, such view corresponding approximately to a section on the line 4—4 of Figure 5.

Figure 5 is a top plan view with a part broken away.

Figure 6 is a view of the central core removed from the other portions of the apparatus.

The invention is applicable to electromagnetic devices and is not limited to transformers, though a transformer has been chosen for illustration. The transformer construction consists of three main magnetic sections, a central core, and two end or outside cores between which the central core section is positioned. All of these sections are formed of wound magnetic ribbon in the form of the invention shown in Figures 1, 2 and 3, each section being formed preferably of a continuous length of magnetic ribbon, though it could be formed of broken lengths if desired. This magnetic ribbon may be of any suitable material. Both cold rolled or hot rolled silicon steel has been found particularly suitable for this work.

In greater detail, the central magnetic core is formed by winding a strip of magnetic ribbon upon a mandrel to form a closed wound core, tacking the end convolution down by brazing or welding, and thereafter flattening the wound core to form an elongated structure as shown at 1 in Figure 1, and clamping the core in this flattened form. Thereafter the outer faces of the curved end portions are ground down slightly as indicated at the portions 2, as shown most clearly in Figure 1, so as to provide a uniform and accurate surface at the edge portions of these curved sections of the central core.

While it is preferable to wind the central core on a mandrel and thereafter flatten it, nevertheless the central core could be wound in a flat shape if so desired, though the first described method is much easier to follow. The central core while it is still clamped is then annealed and it has been found that during this annealing process any wire edges or burrs that may be left due to the grinding are usually burned off. If desired, a wire brush may be used to remove any burrs or wire edges, but, as stated, such burrs or wire edges are usually burned off during annealing or, if desired, the burrs or wire edges may be removed by a wire brush prior to annealing.

The conducting winding indicated at 3 is preferably preformed, though it may be wound on the central core if so desired. If a preformed con-

ducting winding is employed, the central core is merely slid into place within the conducting winding 3 with the curved end sections projecting from the ends of the conducting winding.

The outer magnetic core sections are formed by winding magnetic ribbon to form a pair of rectangular closed coils as indicated at 4. The end portions of these wound closed cores are tacked down by brazing, welding or otherwise as indicated at 5 in Figure 1. These closed magnetic sections 4 are adapted for assembly on opposite sides of the central core section, as shown in the drawings, and the portions of the outer closed core sections 4 are preferably ground down a slight amount at the portions indicated at 6 in Figure 3, that is to say, at the areas which are in juxtaposition to the curved end parts 2 of the central section 1 so as to have a uniform and accurate surface at these points. It is preferable to clamp the closed magnetic core sections 4 in shape upon the mandrel and anneal them while they are so clamped. As explained for the central section, this annealing will usually burn off all wire edges or burrs resulting from the grinding. However, they may be removed by means of a wire brush if desired, either before or after annealing.

After annealing, the closed magnetic outer core sections 4 are positioned on opposite sides of the central core section 2, as shown most clearly in Figure 2, and partially enclose the conducting winding 3. Means are provided to prevent short-circuiting of the laminations either by reliance on the oxide coating on the outer juxtaposed edges of the laminations of the central and outer core sections or by providing insulating paint at these points, or by providing a thin sheet of insulating material as indicated at 7 at these points. This insulating sheet has been very much exaggerated in thickness in Figures 2 and 3 for the purpose of illustration, but it is to be understood that the insulating sheet is in reality very thin.

Any suitable clamping means may be provided for holding the outer magnetic core sections clamped to the inner or central core section. For example, a very simple clamping means may consist of the four L-shaped clamping members 8 arranged in pairs at opposite sides of the transformer structure with the individual members of each pair drawn together by means of bolts 9 and with all of the clamping structure located externally of the closed outer core sections. Insulating sheet material as indicated at 10 is placed between each clamping member and the adjacent core section so as to prevent short-circuiting of the laminations. It is to be noted that the inwardly extending lip of each of the clamping members 8 extends over the central section 1 of the magnetic core, as shown in Figures 2 and 3.

When the nuts on the bolts 9 are tightened up, the parts of the transformer are drawn up very firmly and solidly, though a very simple clamping arrangement is employed.

It is to be noted particularly that the ground faces 2 and 6 of the central and outer cores respectively are very accurate and true faces and thereby a very thin insulating sheet 7 may be employed, or, as stated heretofore, insulating paint may be used or reliance may be placed upon the oxide coating, though the thin insulating sheet is the preferred form as the greatest security against shorting across the laminations is secured by using a thin sheet of insulating material.

The air gap at these portions is therefore of

a predetermined value and is not an uncertain quantity as has heretofore been the case. In addition to this, the accurately ground faces greatly aid in securing a very small and accurately defined air gap. If the irregular surface of the laminations alone were depended upon, the exact and predetermined spacing at the air gap would not be obtained, but by grinding these adjacent portions and by using an insulating sheet of a predetermined thickness or insulating paint, a very accurately predetermined air gap may be obtained and one which may be reduced to a minimum.

It is to be noted that the major portion of the flux travels lengthwise of the magnetic ribbon and it has been found that due to the orientation of the particles in the ribbon, the least magnetic reluctance is in the direction of the length of these ribbons. Almost all of the path of the flux travel is lengthwise of the ribbons forming the outer and central core sections. Only a very short path transversely of the length of the ribbons is necessitated, which occurs at the joint between the central section and the outer sections of the magnetic core. As stated, however, the flux path transversely of the magnetic ribbon of the core structure is relatively short and only at the juxtaposed portions of the central and outer core sections. In all other portions of the core sections the magnetic flux is lengthwise of the magnetic ribbon in the direction of minimum reluctance.

Transformers actually constructed in accordance with this invention have been found to have a relatively small loss and to be highly efficient.

It is immediately apparent from an examination of the drawings and from the above description that the manufacture of a transformer conforming to this invention is extremely simple. All that is required in the production of the magnetic core section is the winding of magnetic ribbon on mandrels of suitable shape, the flattening of the central core section, the grinding and annealing of the core sections and their subsequent quick assembly to produce the finished transformer. As stated, the central section may be slipped into a preformed conducting winding and this is the preferable manner in which the transformer is manufactured, or the conducting winding may be wound on the central core section, in all the cases, of course, suitable insulation being provided in accordance with the customary practice in winding conducting windings.

When it is considered that essentially there are only three members constituting the magnetic core sections of this transformer, and that only three of these sections therefore have to be handled in the assembly operations, it is at once apparent how much simplified the mechanical steps are in the production of this transformer.

Another point which is to be noted is that the rounded end portions of the central core section 1 facilitate the insertion of this central core section into a preformed conducting winding.

The central core may be formed of a set of stacked laminations which may be either punched or sheared, the remaining portion of the transformer being the same as that previously described. This form of the invention is shown in Figures 4, 5 and 6. Referring to these figures, it will be seen that the outer core sections 4 are identical with those previously described and are formed in the same manner. They preferably have the ground portions 6 and the insulating thin sheet 7 adjacent the ground portions 6 and

spacing such ground portions from the ground faces 11 of the central core 12. This central core 12 is formed of a set of stacked laminations which are held clamped together and are preferably ground adjacent their ends as indicated at 11, shown most clearly in Figures 4 and 6. These stacked laminations are annealed after grinding and any wire edges that may be left due to the grinding are usually burned off during annealing. If desired, however, a wire brush may be used to remove any burrs or wire edges but, as stated, such burrs or wire edges are usually burned off during annealing. If desired, the burrs or wire edges may be removed by a wire brush prior to annealing.

The annealing may be done for the central core while the laminations are all held clamped together, or they may be merely temporarily wired together during annealing or, if desired, they may be allowed to separate during annealing. It is, however, preferable to at least hold them in their stacked form during annealing so that no lamination will become turned end for end but instead the same ground ends of all the laminations will all be located at the same end of the central core.

As described in connection with the first form of the invention, the conducting winding 3 may be a preformed winding and the central core 12 may be slipped into this preformed winding or, if desired, the winding 3 may be formed directly on the central core, suitable insulation being provided in accordance with the usual practice.

While it is preferred to grind the ends of the central core and the adjacent faces of the closed cores, this invention comprehends a construction of the general nature heretofore described whether the cores are ground or not as the three main sections of the core structure can be assembled without grinding if desired. In the event grinding is dispensed with, the adjacent portions of the central and outer closed cores are preferably insulated from each other as previously described either by the use of an insulating paint or by using a thin sheet of insulation, it being understood, of course, that the oxide film alone may be relied upon if desired.

While this invention is described primarily as intended for a transformer construction, it is obvious that it is applicable to other types of elec-

tromagnetic devices. For example, chokes may be constructed in exactly the same manner. It is also clear that where the term "conducting winding" is employed, it is intended to cover either a single winding, as in a choke, or a combined primary and secondary winding, as in a transformer.

A further feature to be noted is that in the event a burned out transformer is to be replaced or remade, it is a very simple operation to remove the bolts 9, which immediately allows the removal of the outer core sections. Thereafter the central core section is merely slipped out of the burned out conducting winding and slipped into a new conducting winding and then the parts are reassembled, as previously described, with a minimum of effort. Thus the repair of transformers constructed in accordance with this invention is greatly simplified.

While the preferred form has the conducting winding on the central core section, it is to be understood that the conducting winding may be on the outer core sections if so desired, though this is not the preferred form.

Although it is preferred to use two outer cores, nevertheless the electromagnetic device could be made with a single outer core.

Although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

I claim:

A core construction for an electromagnetic device comprising two spaced, closed, wound cores formed of magnetic ribbon, a central wound core formed of magnetic ribbon wound into a closed figure and flattened to provide an elongated structure, said central core having rounded ends located between the closed cores and having its opposite faces at each end in close proximity to the opposed faces of the closed cores with the edges of the ribbon at the rounded ends of the central core extending transversely across the edges of the ribbon at the adjacent portions of the closed cores, and thin insulating means between the ends of the central core and the opposed faces of the closed cores.

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