C. H. THORDARSON.

COIL STRUCTURE FOR ELECTROMAGNETIC DEVICES.

APPLICATION FILED JUNE 30, 1913.

1,215,429. Patented Feb. 13, 1917.

Fig. 1.

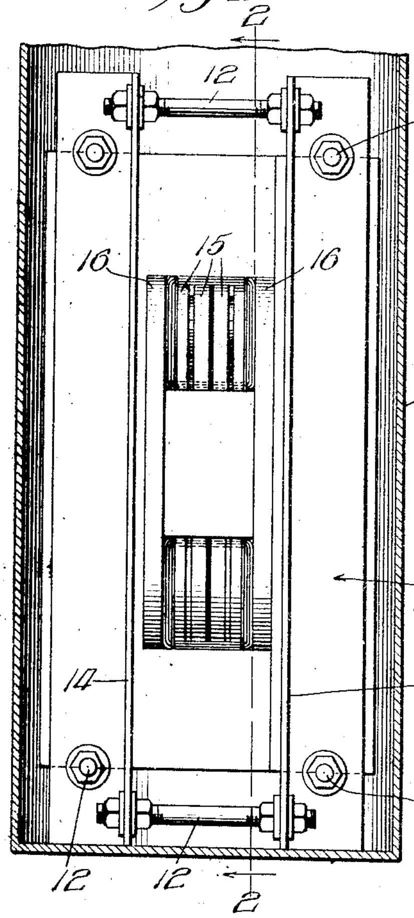


Fig. 2.

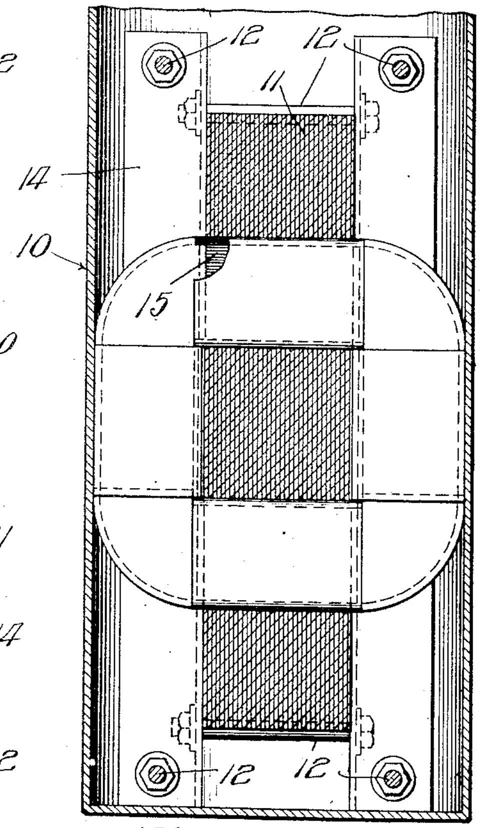


Fig. 4

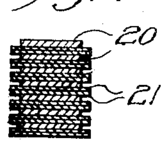
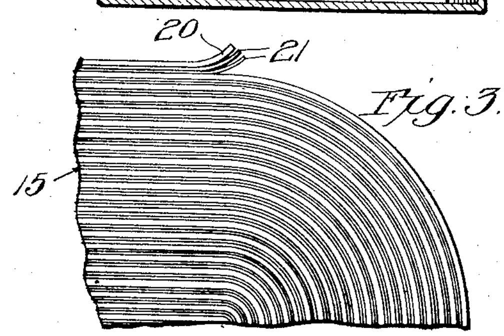


Fig. 3.



Witnesses:
Harry S. Gaither
G. E. Dowle.

Inventor:
Chester H. Thordarson
by William L. Hall,
Att'y

UNITED STATES PATENT OFFICE.

CHESTER H. THORDARSON, OF CHICAGO, ILLINOIS.

COIL STRUCTURE FOR ELECTROMAGNETIC DEVICES.

1,215,429. Specification of Letters Patent. Patented Feb. 13, 1917.

Original application filed January 24, 1913, Serial No. 744,001. Divided and this application filed June 30, 1913. Serial No. 776,521.

To all whom it may concern:

Be it known that I, CHESTER H. THORDARSON, a citizen of the United States, and a resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Coil Structures for Electromagnetic Devices; and I do hereby declare that the following is a clear, full, and exact description thereof, reference being had to the accompanying drawings, and to the characters of reference marked thereon, which form part of the specification.

This invention relates to improvements in coil structures for transformers or other electro-magnetic devices and the invention consists in the matters hereinafter set forth and more particularly pointed out in the appended claims.

Among the objects of the invention is to increase the efficiency of a coil structure when used in electro-magnetic devices to which it is adapted, as compared to the weight and size thereof, and to reduce the cost of construction.

A further object of the invention is to provide an improved means for insulating the several turns of the coil one from the other while at the same time increasing the compactness of the structure and its capacity as compared to known coil structures.

A further object of the invention is to provide a coil winding, made up of flat wire and interwound insulating strips in which the edge or edges of each turn of the winding is exposed to a cooling medium, as oil, in which the coil is submerged, so as to thereby enable the windings of a transformer or like structure to be maintained at a suitably low temperature to prevent charring of the insulation and a consequent breaking down of the coil, even when it is subjected to an excessive overload; and supplementing this phase of the invention the flat wires of which the winding is made are narrow so as to reduce the cross section thereof relatively to their exposed or side edges toward which the heat developed in the wire is driven, so as to thereby maintain the temperature of said exposed edges per unit of area, and in contact with the cooling medium, relatively low and thus facilitate maintenance of a suitably low temperature in the coil structure.

A further object of the invention is to provide a coil or winding of the character herein set forth, in which the current density is substantially directly proportionate to the cross section of the flat wire or conductor, thereby realizing maximum conductive efficiency of the wire.

The invention is herein shown as applied to a transformer construction, but it will be understood that it may be equally well and as efficiently applied to other electromagnetic devices.

In the drawings:—

Figure 1 is a side elevation of a transformer provided with a coil embodying my invention, with the casing of the transformer shown in section.

Fig. 2 is a vertical section on the line 2—2 of Fig. 1.

Fig. 3 is an enlarged side elevation of a portion of a coil embodying my invention.

Fig. 4 is a fragmentary transverse section of the coil.

The elements of the transformer in which my improved coil is herein shown as embodied may be of any preferred construction, and as herein shown is made like the transformer illustrated in my prior application for U. S. Letters Patent #744,001, filed January 24, 1913, of which this application is a division.

As shown in the drawings, 10 designates the inclosing casing; 11 the laminated magnetic circuit structure composed of superposed thin plates of good magnetic metal, the whole being held in place or clamped together by means of bolts 12, 12, which extend through corresponding members of angle bars 14, 14 arranged in the angles between the sides of the magnetic circuit structure and the windings wound upon the magnetic structure, as will hereinafter appear, certain of the bolts 12 having nuts thereon to constitute spacing means for the angle bar clamping members.

15, 15 designate the three units of the

primary winding and 16, 16 the two units of the secondary winding, as the transformer construction is herein shown as organized. The units of the primary winding may be connected in series or multiple, and the units of the secondary winding may be likewise connected. Suitable insulation is provided between the primary and secondary windings, the construction and arrangement of which is shown in my aforesaid application and need not be further herein described.

The said windings of both the high and low tension coils are composed of narrow flat or ribbon wire and are alike in both the high and low tension coils, except as to the dimensions of the wires forming the same. The present invention relates more particularly to the manner of insulating the turns of the windings from each other, in such a way that the several turns are efficiently insulated and the structure of the coil as a whole is rendered strong and durable, while at the same time making it possible to provide a coil of maximum efficiency as compared to its dimensions and weight and the cost of its production.

This feature of the invention is embraced in the following construction:

Between each turn 20 of each winding is interposed two or more thin sheets 21, 21 of thin insulating material, such as paper. These sheets of insulating material are usually made wider than the flat wires of the windings and, therefore, extend laterally beyond the margins of said wires or turns, as shown most clearly in Fig. 4, so as to thereby prevent short circuiting of one turn on the other around their lateral margins. In practice I have found that a projection of the sides of the insulating strips 21 beyond the wires or strips 20 of one-thirty-second to three-sixty-fourths of an inch is sufficient for transformers of the size most commonly used. These strips of insulating material are made as thin as the physical conditions will permit, having regard to the ordinary handling thereof, and the winding of the same in the winding unit or coil. For instance, I have used in high tension coils or windings insulating sheets of less than one-half of one-thousandth of an inch in thickness.

I have found that a single thickness of insulating strip, as for instance, paper, is unreliable by reason of the fact that flaws occur in the paper and impair the insulating efficiency thereof, and that, to avoid such defects with a single strip of paper or insulating material, it is necessary to provide a strip of such thickness as to render the coil structure excessively large and heavy. By using two or more thin strips of paper, or like material, (two being usually sufficient) the chances of flaws in the paper registering so as to produce a through opening in the superposed strips through which one turn may be short circuited on the other is so small as to be negligible.

As a result of this construction I am enabled to produce a highly efficient insulation between the turns of the windings, and at the same time reduce the thickness of the multiple sheet insulation as compared to a single strip heretofore used. I have found in practice that a coil or winding unit of a given capacity may be reduced in dimensions substantially one-half that of the prior construction where a single efficient insulating sheet or strip between the turns is employed. The construction is not only compact, but is also of less relative weight as compared to prior constructions of equal efficiency. This is partially due to the fact also that the reduction of the weight and dimensions of the coil permits of a corresponding reduction of the weight and size of the magnetic circuit structure. Moreover, a multi-sheet insulation is far superior in efficiency to any practical single sheet insulation heretofore used.

After the units are wound, they may be treated by a suitable insulating liquid, such as paraffin, to increase the insulating efficiency of the paper, and to stiffen the winding structure, by means not to impose a coating on the edges of the turns to materially modify the interchange of heat between the conductor and a cooling medium. In the claims, therefore, reference to bare edges of the turns does not exclude the presence of a thin film of such a stiffening substance. In order to brace or stiffen the first few or inner turns of the winding units, the insulating strip or strips for the first few turns may be made of relatively thick insulating material, applied by hand to the winding form, inasmuch as the pressure difference between the inner turns is not great.

It will be observed from an inspection of Fig. 1 that the flat wire conductors are quite narrow. In practice, these conductors do not exceed five-eighths of an inch in width and may be made as narrow as one-twelfth of an inch. I have found that a flat wire conductor decreases in its efficiency as a conductive medium after its width reaches to or increases beyond five-eighths of an inch. This is due, in a transformer of the character herein shown, partially to the fact that the pressure developed between adjacent windings tends to crowd the flow of current toward one edge of the flat conductor, or toward the edges presented toward the least pressure. Thus a portion of a wide flat conductor becomes, so to speak, an inactive conducting factor, and to the extent that it is inactive unnecessarily increases the size, weight and cost of the device as a whole. Moreover, there is set up in a wide conductor strip wound about a magnetic core or about one member of a magnetic circuit structure, eddying currents due to magnetic lines of force passing from one side to the other of the magnetic circuit, which has the effect of impairing the conductive efficiency of the flat conductor. This latter defect is particularly noticeable in devices used in an alternating current circuit, as a transformer, and in devices used in direct current circuits where the circuit is frequently opened and closed. By making the flat winding wires narrow, I am enabled to realize maximum efficiency with minimum weight, dimensions and cost.

It will be furthermore observed that by making the flat wire conductors narrow, as herein shown, the cross sectional area of the conductors is maintained low relatively to the area of the side edges thereof which, in a transformer or the like, are exposed to the cooling medium, so that thereby the heat developed in the conductor may be readily conducted away therefrom and thus avoid overheating of the structure and consequent breaking down of the insulation between the turns of the winding. Moreover, the coil structure is further adapted to be maintained at a suitably low temperature by reason of the fact that one or both edges of each turn of the winding is adapted to be exposed to a cooling agent, thus providing for a rapid and efficient interchange of heat from the turns of the winding to the cooling medium.

A further advantage of the construction shown is that, by reason of the possibility of reducing the dimension of the coil and the width of the wire composing the same, the coil or winding structure itself is relatively stiffer than a coil or winding structure of the same capacity constructed under the prior practice.

An advantage of reducing the weight of a transformer or other electromagnetic structure in which my improved coil is embodied is found where such transformer or like device is supported at considerable height, as, for instance, on a pole. The reduction in weight and dimensions enables the supporting structure to be made less massive, and also decreases the liability of the superweight impairing the foundation of the pole when subjected to excessive wind pressures.

Another advantage of employing winding units or coils made of flat bare wire, and insulated as described, is that the magnetic vibration of the winding has the effect to space the wire from the insulating strips and to allow the cooling oil to flow across and upon the flat faces of the bare wire, thereby contributing a further cooling effect of the oil or other cooling medium, and increasing the insulating efficiency between the turns of the flat wire due to the presence of the cooling medium between the turns of the flat wire of the winding.

It will be understood that the structural details of the coil may be somewhat varied within the spirit and scope of the invention, and that the invention is not limited to the details shown, except as hereinafter made the subject of specific claims.

I claim as my invention:—

1. An electro-magnetic coil composed of a plurality of turns of bare flat wire, with a plurality of thin flexible insulating strips between adjacent turns, the adjacent turns being separated only the distance due to the thickness of the multi-ply insulation between turns, each strip being so thin as not to afford in itself a reliable insulation between the turns and the total thickness of the strips between adjacent turns being less than that of a single strip of the same material of equal insulating efficiency.

2. In an electro-magnetic device, a winding composed of a plurality of turns of bare narrow flat wire, with two or more superimposed insulating strips between adjacent turns, said strips being of uniform thickness from edge to edge and extending at the edges thereof beyond the bare edges of the wire in a manner to expose the bare edge of each turn at the side of the winding and to insulate the bare edges of adjacent turns from each other, each insulating strip being so thin as not to afford in itself a reliable insulation between the turns and the combined thickness of the multi-ply insulation between adjacent turns being less than that of a single strip of the same material of equal insulating efficiency.

3. An electro-magnetic winding composed of a plurality of turns of narrow, flat thin bare wire, with two or more thin insulating strips between adjacent turns, each strip being so thin as not to afford in itself a reliable insulation between the turns and with the combined thickness of the strips between adjacent turns less than that of a single thickness strip of the same material of equal insulating efficiency, the bare edge of each turn of said wire being exposed at the side of the winding and insulated from adjacent edges by said strips, and the cross section of the flat wire being small relatively to the bare exposed area of the side edge thereof.

4. An electro-magnetic winding composed of a plurality of turns of flat, bare, transversely continuous wire, the edges of all of the turns of which are exposed at the side of the winding, an insulating medium separating the turns and lying against the bare faces thereof, the insulating medium being of uniform thickness from edge to edge and extending at the edge thereof laterally beyond the line of contact thereof with the flat wire to provide means for avoiding short-circuiting of adjacent turns upon each

other, and arranged to maintain the edges of the turns exposed to free access to an enveloping cooling medium, and to prevent obstruction or retardation in the free interchange of heat between said edges and such medium.

In testimony whereof I have affixed my signature in the presence of two witnesses, this 26th day of June, 1913

CHESTER H. THORDARSON.

Witnesses:
G. E. DOWLE,
W. L. HALL.