April 4, 1961

F. BRAECKMAN

2,978,530

CONDUCTOR FOR TRANSFORMER WINDINGS

Filed May 28, 1959

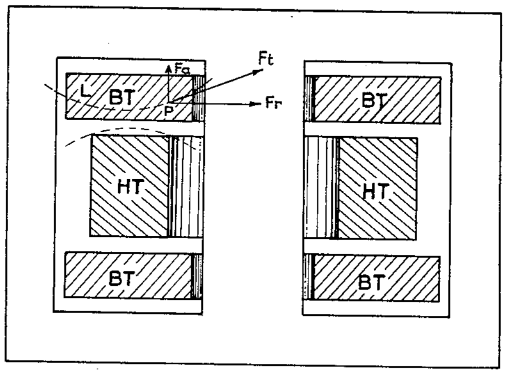

Fig.1

PRIOR ART

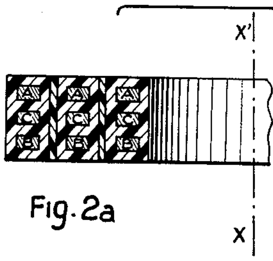

Fig.2a

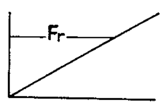

Fig.2b

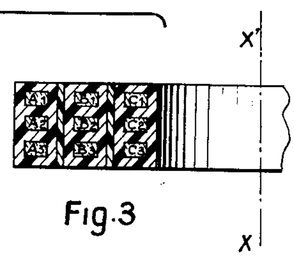

Fig.3

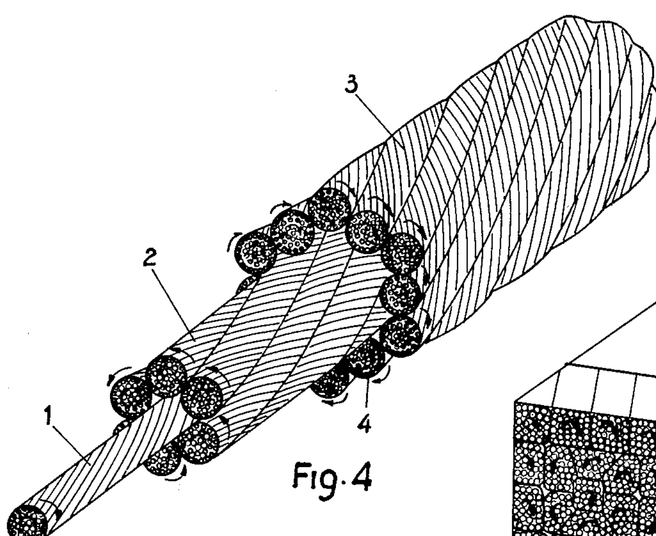

Fig.4

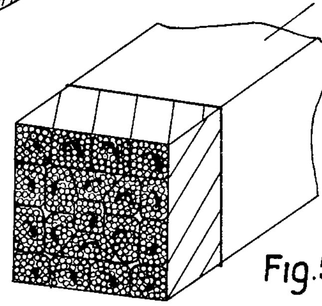

Fig.5

United States Patent Office

2,978,530

Patented Apr. 4, 1961

2,978,530

CONDUCTOR FOR TRANSFORMER WINDINGS

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Filed May 28, 1959, Ser. No. 816,463

Claims priority, application France June 2, 1958

1 Claim. (Cl. 174—34)

The invention relates to a special type of conductor for windings of transformers and similar apparatus.

It is shown that, in power transformers, and apparatuses comprising similar arrangements, the conductors forming the windings, being submitted to the stray field, give rise to extra losses.

Figure 1 shows, as an example, an horizontal cut through a classic interleaved transformer made up from disc coils, showing a high voltage winding HT between two low voltage windings BT.

If one considers, for example, a flux line L of the stray field passing through the low voltage winding BT, the field F_t at any point may be split up into an axial component F_a and a radial component F_r. The extra losses developed in the conductors by these two components are proportional to the square of the field strength and to the square of the conductor dimensions.

The tendency to increase continuously the rating of the power transformers, leads to an ever increasing space filling factor, resulting in always higher flux densities.

Hence the reduction of the extra losses is of paramount importance. Several solutions to this problem are known.

Among these, one is currently used in transformer manufacture, and consists in winding up coils from subdivided insulated conductors which are interleaved during the winding operation.

Figure 2*a* presents, for example, a half cut through a turn of a disc coil, the axis of which is shown as XX′.

This turn is built up from three bundles comprising each three strands A, B, C, all being connected in parallel.

At a conveniently situated place of the coil, generally towards the middle, strands A and B interchange their position so that, on the average, these conductors will be submitted to a radial field corresponding to the one encountered at half thickness of the coil (it may be assumed that the radial field component varies linearly across the coil as shown in Figure 2*b*). In this way the electromotive force induced in the various individual strands by the radial component of the flux, is roughly the same and they may be connected in parallel without any undue circulating current.

A further step is to compensate not only for the effect of the radial flux F_r, but as well for the axial component of the flux F_a. For example, Figure 3 presents a half cut through a turn, the axis of which is shown as XX′, and incorporating nine strands A_1, A_2, A_3; B_1, B_2, B_3; C_1, C_2, C_3 operated in parallel. Crossovers are applied not only in the coil itself among the strands from the same bundle, but as well among the bundles themselves. This set up is used principally for low voltage windings and tapping coils.

If one wishes to reduce even more the eddy losses, it is necessary to reduce the dimensions of the conductors to the minimum possible size but there is a limit to this due to taping and winding difficulties.

A solution to this is brought by our invention where the conductor is constituted in such a way that a marked reduction in extra losses is achieved. This conductor is made up from a cable comprising concentrically disposed strands twisted all in the same direction; said strands being formed by wires of small circular section insulated by enamel or any other suitable thin insulating material; strands from even layers are twisted in one way while those from odd layers are twisted the other; the cable so formed is then shaped to a rectangular cross section by pressing.

Figure 4 shows as a non-limitative example, a conductor incorporating the embodiments of the invention. It is made up from strands such as **1**, **2** and **3**, set in concentric layers. All these strands are twisted in the same direction and are formed by round wires **4**; said wires being of small cross section, enamel insulated and twisted in the way shown by arrows. Direction of twisting is alternated in each successive layer.

Figure 5 shows, diagrammatically, how the cable appears after having been formed into a rectangular cross section. Direction of twisting of the wires within the strands, is shown by arrows as in Figure 4. The conductor so formed may then be insulated, as commonly known in the art, by a material **5**.

In a winding turn made up from a conductor as described in the invention, each of the wires **4** occupies all possible positions radially and axially and hence they are all submitted to the same average stray field.

I hereinafter claim as my invention:

An electrical conductor of rectangular cross-section comprising a plurality of strands arranged in a plurality of concentric, successive layers, said strands comprising electrically conductive wires helically twisted together in a common direction within respective strands in a given layer and twisted in opposite directions in alternate layers, insulation on each of said wires comprising a thin insulative coating, all of the strands in said conductor being helically twisted together in the same direction with the pitch of the helical twist being so chosen that the wires of two successive layers do not cross each other thereby to avoid damaging said thin insulative coating and preclude formation of short-circuited loops in the conductor.

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