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(54) Transposed cable for making windings in electric machines, manufacturing process of the same, and method of making a winding by said transposed cable

(57) A transposed cable (1) is disclosed comprising a core (2) consisting of a plurality of flattened wires (3) disposed in mutually superposed relationship to form two stacks (4a, 4b) arranged parallelly and side by side, the flattened wires (3) located at the base and on top of said stacks (4a, 4b) being cyclically transposed from one stack to the other. One or more thread-like elements (6a, 6b) of polyester or any other appropriate material are helically wound around the core (2), optionally in opposite winding directions. At least one ribbon-like element (7) of paper or other material is wound over the thread-like elements (6a, 6b) and superposed thereon, said ribbon-like element being tearable by means of a tear thread (8) longitudinally interposed between the paper ribbon (7) and the thread-like elements (6a, 6b) wound over the core (2). The tear thread (8) is used to remove the paper ribbon (7) when the cable (1) is wound around a winding core (23) to make an electric winding.

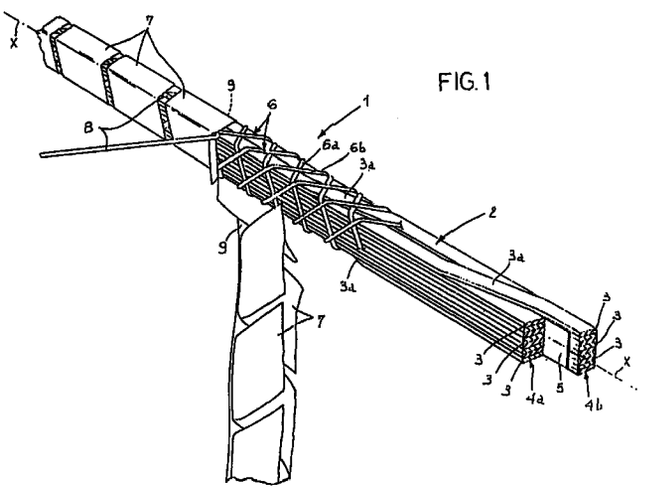

FIG. 1

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Description

The present invention relates to a transposed cable for making windings in electric machines, of the type comprising a core consisting of a plurality of electric conductors of a substantially rectangular or flattened section, disposed in at least two side by side stacks and individually transposed, sequentially in the longitudinal extension of the cable, from one to the other of said stacks, and wrapping means disposed around the core to hold said conductors so as to structurally stabilize the cable.

It is also an object of the invention a process for manufacturing said transposed cable.

In accordance with the present invention, a new method of making electric windings by using the cable in reference is also provided.

More particularly, the invention relates to transposed cables to be employed in low-voltage windings of electric transformers or, more generally, in making windings in electric machines submitted to high intensity but relatively low voltage currents, so that, to dispose them in the winding, a high electric insulation between the coils forming the winding itself is not required.

It is known that transposed cables, usually employed in making electric windings in transformers and the like, essentially comprise a core consisting of a plurality of conductors of a substantially rectangular section, usually referred to as "flattened wires", currently made of copper and individually coated with one or more layers of electrically insulating paint. These flattened wires are currently disposed in mutually superposed relationship so as to form two stacks arranged side by side relative to each other. In the longitudinal cable extension, each flattened wire has a slightly inclined path so that it will progressively take up all positions between the base and the top of the stack to which it belongs. Close to the top or the base of the respective stack, each flattened wire is diverted onto the adjacent stack so as to successively take all positions included between the base and the top of the latter. Consequently, in the longitudinal cable extension, each flattened wire progressively takes all positions within the section of said cable.

The sequential transposition of the flattened wires in the above described manner gives the cable a satisfactory structural flexibility on the whole, the individual flattened wires being allowed to mutually slide lengthwise so that, upon winding the cable on the core of the electric machine, they can compensate for the differences in winding diameters of the closest and the farthest flattened wires with respect to core axis.

However, the mutual sliding between the flattened wires must be conveniently held and controlled in order to ensure a sufficient structural stability.

This holding action is provided by wrapping means usually consisting of one or more paper ribbons helically wound around the core itself so as to form partly overlapped turns. One example of such a winding by paper ribbon is described in US Patent No. 4,431,860.

Different alternative solutions are provided in the art which do not involve the use of paper ribbons as wrapping means.

For example, in US Patent No. 4,276,102 cable wrapping is carried out by a heat-shrinkable tape either superimposed on or in place of the usual paper covering. After the cable has been wound around a winding core to make a winding for a transformer, the winding itself is submitted to heating means to obtain heat shrinkage of the heat-shrinkable covering so as to cause a mutual approaching of the individual flattened wires thereby compacting the structure of the cable wound around the winding core.

In US Patent No. 4,639,282, electric insulation of the surfaces of electric components in a transformer, including the conductors used in windings, is obtained by wrapping them with tapes made of flexible and porous material. The material may consist of cotton, fibreglass, wood or different cellulose or plastic fibres, which may be knitted or woven on a loom, but it may also consist of a non-woven felt material such as for example porous paper.

To obtain a sufficient permeability of oil or other fluids through the wrapping layer, along with a sufficient degree of electric insulation and good heat dissipation, pores in the covering material are provided with a size of from 0.2 to 10 mm^2, the area occupied by the pores being from 20 to 80% of the overall area of the covering material.

International Patent Application WO 95/30991 discloses a transposed cable whose core is covered with a ribbon-like element made of insulating material helically wound in partially overlapping turns, which element has a selvedged net-like structure with a mesh width of at least two mm^2, wherein the warp and/or the weft yarns are made of fibreglass, polyester or a mixed yarn of glass and polyester filaments.

In accordance with the present invention it has been found that, for the purpose of manufacturing a transposed cable, the core wrapping can be advantageously carried out either by helical winding, around the core itself, of a continuous thread-like element or by a plurality of continuous thread-like elements helically wound in the same direction or in opposite directions, but not interlaced with each other.

More particularly, it is an object of the present invention a transposed cable for making windings for electric machines, characterized in that said wrapping means comprise at least one or more thread-like elements helically wound around the core, substantially in the absence of points of mutual interlacing.

Depending on requirements, two or more thread-like elements can be provided which are disposed parallel to each other and wound in sequentially alternated turns, or helically wound in respectively opposite directions.

Preferably, each thread-like element can be made in the form of a single thread of a diameter of from 0.1 to 0.8 mm, or in a flattened form of the same strength, with a width of from 0.30 to 0.60 mm.

Alternatively, each of said thread-like elements is formed of a polyester yarn of a size of from 1000 to 3000 dtex.

Preferably, each thread-like element has a tensile strength at break between 50 and 250 N, and an elongation at break between 5 and 20%.

In accordance with another preferred embodiment of the present invention, each thread-like element is wound with a tension of from 5 to 25 N, with a winding pitch between 0.5 and 3 times the cable width, and/or in such a manner that the turns formed by said one or more thread-like elements on the core are mutually spaced by an amount, measured perpendicularly to the thread-like element direction of extension, equal to the pitch divided by the number of thread-like elements, or, alternatively, at least equal to six times the dimension of the thread-like element measurable in the same direction.

Independently of whether said thread-like elements are present or not, at least one tearable ribbon-like element, preferably of paper material, may be advantageously arranged on the cable in reference, said ribbon-like element being helically wound around said conductors and said at least one thread-like element.

At least one tear thread may also be provided, extending longitudinally along the cable between the paper ribbon and said at least one thread-like element, said tear thread being arranged to be pulled along away from the cable to cause tearing and removal of the tearable ribbon-like element.

At least one adhesive tape may be applied longitudinally along the cable on the outside of the tearable ribbon-like element, to keep turns joined together when said ribbon-like element is torn and removed from the cable.

It is a further object of the invention a process for manufacturing a transposed cable to be employed for making windings in electric machines, comprising the following steps: making a core formed of electric conductors of flattened section disposed in at least two side by side stacks and individually transposed from each other of said stacks, sequentially in the longitudinal cable extension; covering said core with wrapping means disposed around the core for holding the individual conductors, so as to cause a structural stabilization of the core, characterized in that said covering step is carried out by helically winding one or more thread-like elements substantially in the absence of mutual interlacing points.

Preferably, the covering step comprises winding of a continuous thread-like element; alternatively, it can be carried out by helically winding at least two continuous thread-like elements disposed either parallelly or in opposite winding directions.

Preferably, during the helical winding a tension of from 5 N to 25 N is applied to each thread-like element, and winding of said one or more thread-like elements is carried out in such a manner that turns are spaced apart from each other by the same distance according to a value included between 0.5 and three times the cable width.

Also in accordance with the present invention, a step involving helical winding of at least one tearable ribbon-like element around the core carrying said at least one thread-like element may be also carried out.

Advantageously, provision may be also made for insertion of a tear thread extending longitudinally between said at least one tearable ribbon-like element and the core carrying said at least one thread-like element.

Insertion of said tear thread is preferably carried out by pulling the thread itself by means of the cable moving forward to a winding station conveniently arranged for carrying out winding of the tearable ribbon-like element.

The process according to the invention preferably also provides for application of at least one adhesive tape externally of the tearable ribbon-like insert wound over the cable.

The invention further proposes a new method of making an electric winding by means of a transposed cable, said cable comprising a core made up of a plurality of electric conductors of flattened section disposed in at least two side by side stacks and individually transposed from each other of said stacks, sequentially in the longitudinal cable extension, at least one tearable ribbon-like element helically wound around said core, said method being characterized in that during winding of the cable around the core, removal of the tearable ribbon-like element is carried out by pulling at least one tear thread laterally of the core, said tear thread being arranged longitudinally along the cable between said tearable ribbon-like element and said core.

Preferably, the tear thread is pulled in correspondence with an extension length of the cable comprised between the winding core and the braking means acting on the cable to give it a desired tensioning.

Further features and advantages will become more apparent from the detailed description of a preferred, but non-exclusive, embodiment of a transposed cable in particular for making windings in electric machines, in accordance with the present invention, as well as of a manufacturing process of same and a method of making a winding by said transposed cable.

This description will be given hereinafter with reference to the accompanying drawings given as non-limiting examples, in which:

- Fig. 1 is a perspective view of a transposed cable made in accordance with the present invention, with an auxiliary paper covering partly removed;
- Fig. 2 is a diagrammatic plan view of a production line of the transposed cable in accordance with Fig.

1;

- Fig. 3 is a diagrammatic top view of a winding step of the transposed cable in accordance with the invention with simultaneous removal of the auxiliary paper covering in order to make a winding for an electric machine.

With reference to the drawings, a transposed cable in particular for making windings in electric machines in accordance with the present invention has been generally identified by reference numeral 1.

The transposed cable 1 has a core 2 comprising a plurality of flattened wires 3, i.e. conductors made of copper or another electrically-conductive appropriate material, of a substantially rectangular flattened section and individually coated with an electrically insulating paint, not shown in the accompanying drawings.

As shown in Fig. 1, the flattened wires are disposed in mutual superposed relationship in a first and a second stack 4a, 4b respectively arranged side by side, optionally alternated with a partition insert 5 made of paper or another appropriate material.

Each flattened wire 3 substantially lies in a plane perpendicular to the separation plane between the two stacks 4a, 4b and extends following a slightly inclined path so as to occupy, progressively along the cable extension 1, all the positions within the corresponding stack 4a, 4b. At one end of a respective stack (the first stack 4a for example) the path of each flattened wire 3 is diverted onto the adjacent stack 4b by a transposed length 3a intersecting the separation plan between the stacks 4a, 4b.

In the extension of the cable, the flattened wire 3 which is transposed from the first stack 4a to the second stack 4b extends obliquely until it reaches the opposite end of the new stack 4b, to be again diverted onto the adjacent stack 4a.

Cable 1 further comprises wrapping means 6 disposed around the core 2 to hold the flattened wires 3 so as to obtain a certain structural stabilization of cable 1, thereby conveniently inhibiting undesired movements of flattened wires 3 in a radial direction relative to the geometric axis "X" of the cable.

This wrapping means 6 comprises one or more thread-like elements 6a, 6b helically wound around core 2.

In a preferred embodiment, each thread-like element 6a, 6b consists of a single thread made of polyester, rayon, polypropylene, PPS (polyphenylene sulfide), PCDA (polycyclohexanedimethyleneterephthalate), having approximately a diameter of from 0.1 to 0.8 mm and preferably from 0.3 to 0.6 mm.

Microtapes may also be used, namely thread-like elements of flattened section and equivalent strength, of a width preferably between 0.2 and 1 mm, made of the above materials; microtapes of polyester, polypropylene, PPS, PCDA may be for example used, which have sections of from 0.2 mm x 0.4 mm to 0.4 mm x 0.6 mm, depending on the desired strength features.

Other materials have been successfully tested which enable good holding of flattened wires 3, for instance a polyester yarn having a size of from 1000 to 3000 dtex.

It is also preferably provided that each thread-like element 6a, 6b should have a tensile strength at break of from 50 to 250 Newton and an elongation at break between 5 and 20%.

The number of thread-like elements 6a, 6b to be used may vary depending on requirements, and basically the greater is the number of flattened wires 3 forming core 2, the greater is the number of these thread-like elements.

For example, with a number of flattened wires 3 lower than or equal to 31 a single thread-like element 6a can be used, which is wound with a winding pitch of from 0.5 to 3 times the cable width, to obtain a sufficient holding for flattened wires 3. To obtain a better holding, two thread-like elements 6a, 6b may be advantageously applied. These thread-like elements can be disposed parallel to each other, or wound in respectively opposite directions, as shown in the example of Fig. 1.

For cables with a core 2 having a number of flattened wires 3 equal to or higher than 31, two or more pairs of thread-like elements 6a and 6b can be arranged which are wound respectively in opposite directions.

An advantageous aspect to achieve construction simplicity is that the thread-like element or elements 6a, 6b should be devoid of points of mutual interlacing at the relevant crossing points. This can be easily viewed from Fig. 1 where the second thread-like element 6b is merely superposed on the first thread-like element 6a at their crossing point.

The presence of several thread-like elements wound in opposite directions reduces the risk of wrapping means 6 being undone due to an accidental breaking of one of the thread-like elements.

Actually, an accidentally broken thread-like element 6a would remain firmly linked to core 2 by effect of the "belting" action exerted by the thread-like element or elements wound over it.

The winding pitch of the individual thread-like elements preferably ranges from 0.5 to 3 times the cable width and each of the turns they form is spaced apart from the immediately adjacent turns by a distance equal to the pitch divided by the number of the thread-like elements.

It is also provided that the distance between two adjacent turns measured perpendicularly to the extension of the thread-like element 6a, 6b should be at least equal to 6 times the diameter or size of the thread-like element itself measured in the same direction.

In accordance with a preferred embodiment of the present invention, the transposed cable 1 is further provided with at least one tearable ribbon-like element 7 helically wound around core 2 and thread-like elements 6a and 6b constituting the wrapping means 6, said rib-

bon-like element being superposed to said wrapping means. In more detail, the ribbon-like element is preferably made of a paper of "clupack" or "kraft" type with a thickness included approximately between 0.05 and 1.15 mm.

Extending longitudinally relative to cable 1, between the tearable ribbon-like element 7 and the thread-like element or elements 6a, 6b wound over core 2, is at least one tear thread 8, made for example of nylon or another suitable material.

The tear thread 8 can be pulled laterally away from the cable core 2 to cause tearing and removal of the tearable ribbon-like element 7, as better clarified in the following, during the step of winding the cable 1 over a relevant winding core.

Advantageously, at least one adhesive tape 9 is also provided, applied longitudinally to the cable 1 externally of the tearable ribbon-like element 7. The presence of this adhesive tape 9 enables turns formed by the tearable ribbon-like element 7 to be maintained together, so as to avoid an uncontrolled dispersion of said turns when the tape is torn and removed from the cable by means of the tear thread 8.

Particularly referring to Fig. 2, to manufacture cable 1, flattened wires 3 and the partition insert 5, if any, are continuously drawn out from respective feeding reels 10 mounted by means of respective oscillating supports 11 on a carrousel 12 rotating on a horizontal axis. The oscillating supports 11 support reels 10 in such a manner that, in spite of the movement imparted to them around the rotation axis of carrousel 12, said reels and therefore the individual flattened wires 3 keep a constant orientation, so that said flattened wires are constantly disposed in respective substantially horizontal planes.

Flattened wires coming from reels are caused to mutually converge through guide means 13, until they join together to form core 2 of cable 1. In the zone where flattened wires 3 join together to form core 2, a transposition unit 14 operates, cyclically intervening on the individual flattened wires 3 located at the base and on top of columns or stacks 4a, 4b to cause transposition from each other of said columns.

Core 2 coming from the transposition unit 14 is moved longitudinally through a series of winding stations by which application of the wrapping means 6 and the tearable ribbon-like element takes place.

In more detail a first winding station 15 is contemplated where winding of the first thread-like element or elements 6a is provided, preferably according to a winding tension included between 5 N and 25 N.

Operating downstream of the first winding station 15 is a second winding station 16 carrying out application of the second thread-like element or elements 6b, in the same direction as the first thread-like elements 6a or in the opposite direction, the latter being in superposition relationship with the former at the respective crossing points.

A third winding station 17 may be utilized, if necessary, for application of further thread-like elements.

A fourth winding station 18 is finally provided to carry out winding of the tearable ribbon-like element 7 superposed on the wrapping means 6 consisting of the thread-like elements 6a and 6b.

Between the third and fourth winding stations 17, 18, a feed and guide unit 19 is disposed for the tear thread 8, said thread being guided in correspondence to the cable entering the fourth winding station 18, so that the tear thread is laid down lengthwise on the cable externally of the wrapping means 6, to be engaged between the latter and the tearable ribbon-like element 7 wound in the fourth winding station 18.

The pulling action exerted by cable 1 moving forward along the production line takes up the tear thread 8 from the feed and guide unit 19.

Also disposed downstream of the series of winding stations 15, 16, 17, 18 is a unit 20 to apply an adhesive tape which, by means of suitable guide means, applies the adhesive tape 9, continuously supplied from a roll 9a, to the exterior of the tearable ribbon-like element 7.

A dragging unit 21 located also downstream of the winding stations 15, 16, 17, 18, operates on the finished cable 1 to cause dragging of the latter in a longitudinal direction along the whole production line, and feeding of the cable itself to a collecting reel 22 located at the end of the production line.

When cable 1 is to be utilized for making a winding 26 of a transformer or another electric machine, the cable itself is unwound from reel 22 to be conveniently wound around a relevant winding core 23, as diagrammatically shown in Fig. 3. Usually, this operation is carried out by driving in rotation the winding core 23, having its axis disposed vertically or horizontally, and submitting cable 1 in its portion extending between the winding core itself and reel 22, to braking means 24 known per se, adapted to ensure an appropriate winding tension of the cable. Under this circumstance, the presence of the tearable ribbon-like element 7 appears to be advantageous for the purpose of preventing the thread-like elements 6a, 6b and/or core 2 from being damaged or broken due to stresses transmitted to them by the braking means 24.

Advantageously, in an area included between the braking means 24 and winding core 23 over which cable 1 is wound, the tear thread 8 is pulled laterally of the cable 1 and optionally collected on a spool 25, concurrently with moving forward of the cable to the winding core 23. Consequently, the tearable ribbon-like element 7 is torn lengthwise of cable 1.

Turns formed by the tearable ribbon 7 remain consecutively linked together, due to the presence of the adhesive tape 9, in such a manner that the tearable ribbon-like element 7 and adhesive tape 9 removed together with the latter can be easily moved away from cable 1, possibly with the aid of further means for collecting them on rotating drums or the like.

Cable 1 wound around winding core 23 is therefore devoid of any paper ribbon.

The presence of the thread-like elements 6a, 6b wound around core 2 ensures an excellent structural stability of cable 1, keeping the individual flattened wires 3 conveniently guided in their mutual slidings, such slidings being required so that the different radii of curvature according to which the radially outermost flattened wires are wound relative to the radially innermost flattened wires 3 may be followed, without any risks of undesired deformations and/or displacements of the individual flattened wires 3 away from the cable 1 axis.

With reference to known cables in which the holding action of the turns relies on paper ribbons, the invention enables a better cooling of the winding core consisting of the cable itself. Actually, the presence of paper represents a hindrance to dissipation of the heat inevitably produced because of current passage. This situation is particularly disadvantageous and undesired, for example, in cables for low-voltage windings of electric transformers or in any case in cables to be employed in windings passed through by high-intensity current of a relatively limited voltage.

Under these circumstances, the paper covering in accordance with the known art will substantially perform the only function of structurally holding the cable core and mechanically protecting the same while it is being unwound, without practically performing any function of electric insulation, differently from that which happens, on the contrary, in high-voltage windings or windings of different typology.

Conversely, in the cable in accordance with the present invention the presence of the thread-like wrapping element or elements 6a, 6b does not at all hinder passage of oil or other cooling fluid in intimate contact with the individual flattened wires 3, thereby enabling an efficient heat removal.

The core wrapping made in accordance with the present invention further enables a better dimensional definition of winding 26 with respect to wrappings made of paper or net-like ribbons. Actually, ribbons of paper material or net-like ribbons leave empty spaces between the ribbons and flattened wires, above all at transposed segments. In these circumstances, the cable wrapping paper or ribbons cause dimensional unreliability, because, firstly, dimensions of the empty spaces depend on different variable factors such as ribbon-winding modalities, ribbon tensioning during winding, and geometric features of the cable. Moreover, these empty spaces can be eliminated or in any case reduced in an unspecified manner only by pressing winding 26 before or during heat treatments performed during production phase of the latter. Therefore, it is impossible to know in advance the exact dimensional features of the finished winding 26.

The cable wrapped with thread-like elements 6a, 6b, on the contrary, supplies repeatable and easily verifiable dimensions, thereby avoiding dimensional correction measures a posteriori.

Moreover, the higher dimensional accuracy of the cable allows a remarkable size reduction of the finished winding 26, namely a better filling factor expressed as ratio between the volume occupied by copper or other material forming flattened wires 3 and the overall volume of winding 26. In this connection, it has been found that the use of the cable in accordance with the invention enables the filling factor to be improved by more than 40% relative to cables wrapped, for example, with paper ribbons.

This result is due not only to the elimination of the volume occupied by paper wrapping in accordance with the known art, but also to the possibility of greatly reducing width of the channels left between each winding turn and the following one to allow oil circulation, such reduction being achieved in consequence of the improved heat exchange offered by the present invention.

It is also to point out that elimination of paper, usually arranged in several superposed layers in traditional wrappings, involves an important reduction in the cable production costs.

The invention appears to be an improvement also with reference to known cables wrapped with net-like ribbons, which have higher production costs as compared with the thread-like elements employed in accordance with the present invention.

Wrapping with net-like ribbons further causes the use of a greater amount of material to perform wrapping, and consequently a reduction of heat removal from flattened wires.

Obviously, many modifications and variations may be made to the invention as conceived, all of them falling within the scope of the inventive concept characterizing it.

In particular, while described with reference to the realization of a low-voltage winding for electric transformers, the cable in accordance with the present invention can be used in any other circumstances when current values for which the cable is designed do not make it necessary the presence of an electric insulating layer of paper material.

It is also to be pointed out that application of the tearable ribbon-like insert may be advantageously used also in cables having a wrapping consisting of net-like ribbons or completely devoid of wrapping, as well as in any circumstances when it is desirable to protect the cable from mechanical stresses or weathering agents or from the attack of other substances present in the environment with which the cable may be brought into contact during transportation and/or storage, as well as during the step involving manufacturing of winding 26.

Claims

1. A transposed cable for making windings in electric machines, comprising:

- a core (2) consisting of a plurality of electric conductors having flattened section (3), disposed in at least two side by side stacks (4a, 4b) and individually transposed from each other of said stacks (4a, 4b), sequentially along the longitudinal extension of the cable,
- wrapping means (5) disposed around the core (2) to hold said conductors (3) so as to cause structural stabilization of the cable (1),

characterized in that said wrapping means (5) comprise at least one thread-like element (6a, 6b) helically wound around the core (2) in the form of turns, said turns being substantially devoid of points of mutual interlacing.

2. The transposed cable according to claim 1, characterized in that said wrapping means (5) consist of one helically wound thread-like element (6a).

3. The transposed cable according to claim 1, characterized in that said wrapping means (5) consist of at least two thread-like elements (6a, 6b) helically wound in respectively opposite directions.

4. The cable according to claim 1, characterized in that said wrapping means (5) consist of at least two thread-like elements (6a, 6b) disposed parallel to each other and wound in sequentially alternated turns.

5. The transposed cable according to claim 1, characterized in that said thread-like elements (6a, 6b) comprise a polyester yarn.

6. The transposed cable according to claim 5, characterized in that said yarn has a size of from 1000 to 3000 dtex.

7. The transposed cable according to claim 1, characterized in that said thread-like element (6a, 6b) has a diameter of from 0.1 to 0.8 mm.

8. The transposed cable according to claim 7, characterized in that said thread-like element (6a, 6b) is a single thread of polyester, rayon, polypropylene, PPS (polyphenylene sulfide), PCDA (polycyclohexanedimethyleneterephthalate).

9. The transposed cable according to claim 1, characterized in that said thread-like element (6a, 6b) has a flattened section having a width of from 0.3 to 0.6 mm.

10. The transposed cable according to claim 1, characterized in that said thread-like element (6a, 6b) has a tensile strength at break of from 50 to 250 N.

11. The transposed cable according to claim 1, characterized in that said thread-like element (6a, 6b) has an elongation at break of from 5 to 20%.

12. The transposed cable according to claim 1, characterized in that said thread-like element (6a, 6b) is wound with a tension of from 5 to 25 N.

13. The transposed cable according to claim 1, characterized in that said thread-like element (6a, 6b) is wound with a winding pitch between 0.5 and three times the cable width.

14. The transposed cable according to claim 13, characterized in that turns formed by said one or more thread-like elements (6a, 6b) on the core (2) are mutually spaced by an amount, measured perpendicularly to the thread-like element (6a, 6b), equal to the pitch divided by the number of thread-like elements.

15. The transposed cable according to claim 1, characterized in that turns formed by said one or more thread-like elements (6a, 6b) on the core (2) are mutually spaced by an amount, measured perpendicularly to the thread-like element, at least equal to six times the size of the thread-like element (6a, 6b) measured in the same direction.

16. The transposed cable according to claim 1, characterized in that it further comprises at least one tearable ribbon-like element (7) helically wound around said conductors (3) and said at least one thread-like element (6a, 6b).

17. The transposed cable according to claim 16, characterized in that said tearable ribbon-like element (7) is made of paper material.

18. The transposed cable according to claim 15, characterized in that it further comprises at least one tear thread (8) extending longitudinally along the cable between the tearable ribbon-like element (7) and said at least one thread-like element (6a, 6b), said tear thread (8) being arranged to be pulled along away from the cable (2) to cause tearing and removal of the tearable ribbon-like element (7).

19. A transposed cable according to claim 15, characterized in that it further comprises at least one adhesive tape (9) applied longitudinally along the cable (1) to the outside of the tearable ribbon-like element (7) to keep turns joined together when said ribbon-like element is torn and removed from the cable (1).

20. A process for manufacturing a transposed cable to be employed for making windings in electric

machines, comprising the following steps:

- making a core (2) formed of electric conductors of flattened section (3) disposed in at least two side by side stacks (4a, 4b) and individually transposed from each other of said stacks (4a, 4b), sequentially in the longitudinal cable (1) extension;
- covering said core (2) with wrapping means (5) disposed around the core (2) to obtain a structural stabilization of the core (2),

characterized in that said covering step is carried out by helically winding one or more thread-like elements (6a, 6b) around the core (3), substantially in the absence of mutual interlacing points.

21. The process according to claim 20, characterized in that said covering step is carried out by helically winding at least two continuous thread-like elements (6a, 6b) in opposite winding directions.

22. The process according to claim 20, characterized in that said covering step is carried out by helically winding at least two continuous thread-like elements (6a, 6b) disposed parallelly.

23. The process according to claim 20, characterized in that during the helical winding a tension of from 5 to 25 N is applied to each thread-like element (6a, 6b).

24. The process according to claim 20, characterized in that winding of said one or more thread-like elements (6a, 6b) is carried out so that turns are spaced from each other by the same distance according to an amount equal to the pitch divided by the number of the thread-like elements.

25. The process according to claim 20, characterized in that it further comprises a step of helically winding at least one tearable ribbon-like element (7) around the core (2) carrying said at least one thread-like element (6a, 6b).

26. The process according to claim 20, characterized in that it further comprises a step of inserting at least one tear thread (8) extending lengthwise between said at least one tearable ribbon-like element (7) and the core (2) carrying said at least one thread-like element (6a, 6b).

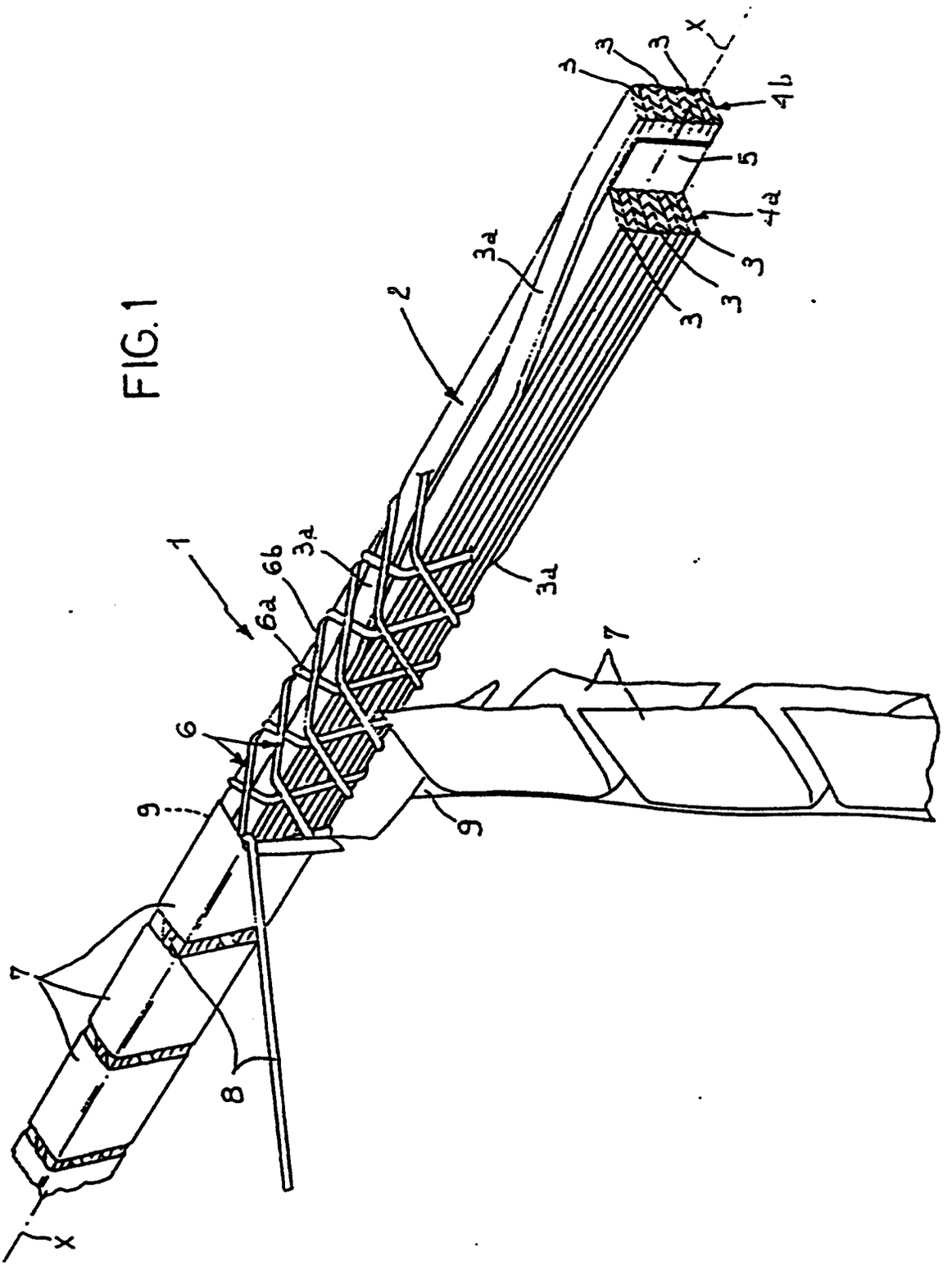
27. The process according to claim 26, characterized in that insertion of said tear thread (8) is carried out by pulling along of the thread itself by the cable (1) moving forward to a winding station conveniently arranged to wind up the tearable ribbon-like element (7).

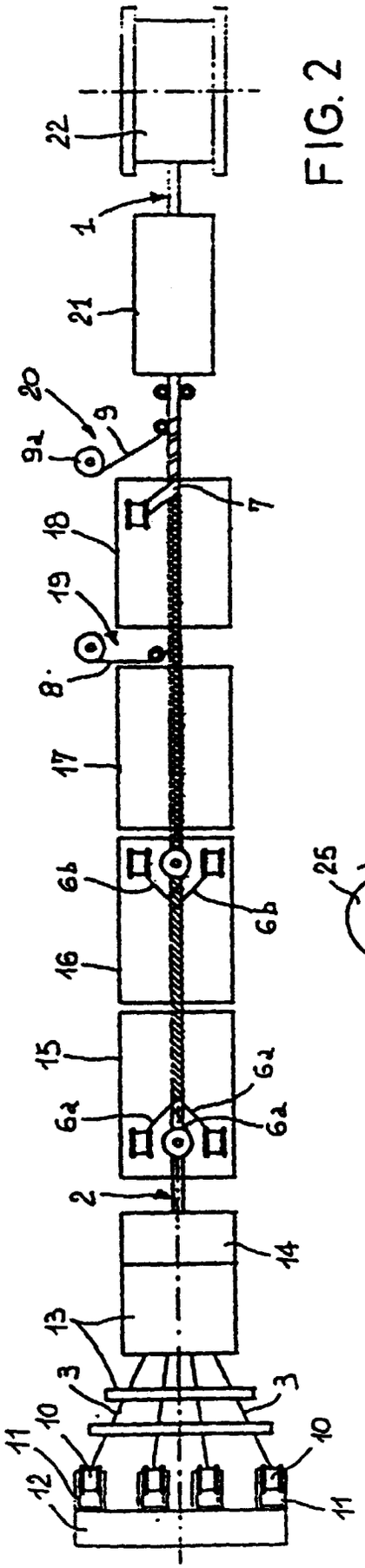
28. The process according to claim 25, characterized in that it further comprises applying at least one adhesive tape (9) externally of the tearable ribbon-like element wound over the cable (1).

29. A method of making an electric winding by a transposed cable, said cable (1) comprising a core (2) made up of a plurality of electric conductors of flattened section (3) disposed in at least two side by side stacks (4a, 4B) and individually transposed from each other of said stacks (4A, 4B), sequentially in the longitudinal cable extension, at least one tearable ribbon-like element (7) helically wound around said core (2), said method being characterized in that during winding of the cable (1) on a relevant core (23), removal of the tearable ribbon-like element (7) is carried out by pulling at least one tear thread (8) laterally of the core (2), said tear thread being arranged longitudinally along the cable, between said tearable ribbon-like element (7) and core (2).

30. The method according to claim 29, characterized in that the tear thread (8) is pulled in correspondence of a segment of the cable comprised between the winding core (23) and braking means (24) acting on the cable to give it a desired tensioning.

FIG.1




22
1
21
20
9a
9
7
18
19
8
17
6a
6b
16
15
6a
6a
6a
2
14
13
3
3
10
11
12
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11

FIG. 2

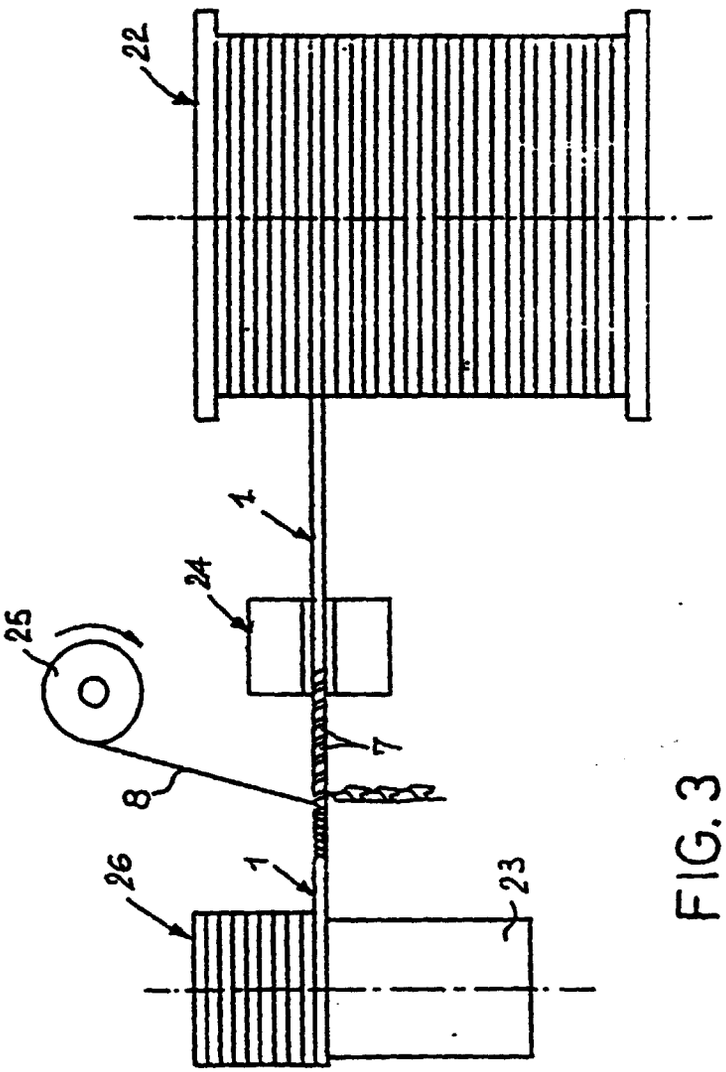
22
1
24
25
7
8
26
1
23

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 2034

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	DE 24 02 149 A (TRANSFORMATOREN UNION AG) 24 July 1975 * page 3, line 8 - page 4, last line; figure *	1,20,29	H01F27/28 H01B13/26 H01F41/06
A	US 4 644 098 A (NORRIS DANIEL A ET AL) 17 February 1987 * column 2, line 62 - column 3, line 10; figures 1,2 *	1,2,20	
A	US 4 041 237 A (STINE CLIFFORD R ET AL) 9 August 1977 * column 2, line 39 - line 51; figures *	29	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01F
H02K
H01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 May 1998	Marti Almeda, R

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