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(72) Inventors:
• **Ishizuki, Junichi**
Tokyo 100-8220 (JP)
• **Kurata, Takashi**
Tokyo 100-8220 (JP)
• **Ito, Yoshimitsu**
Tokyo 100-8220 (JP)

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(71) Applicant: **Hitachi Industrial Equipment Systems Co., Ltd.**
Chiyoda-ku
Tokyo (JP)

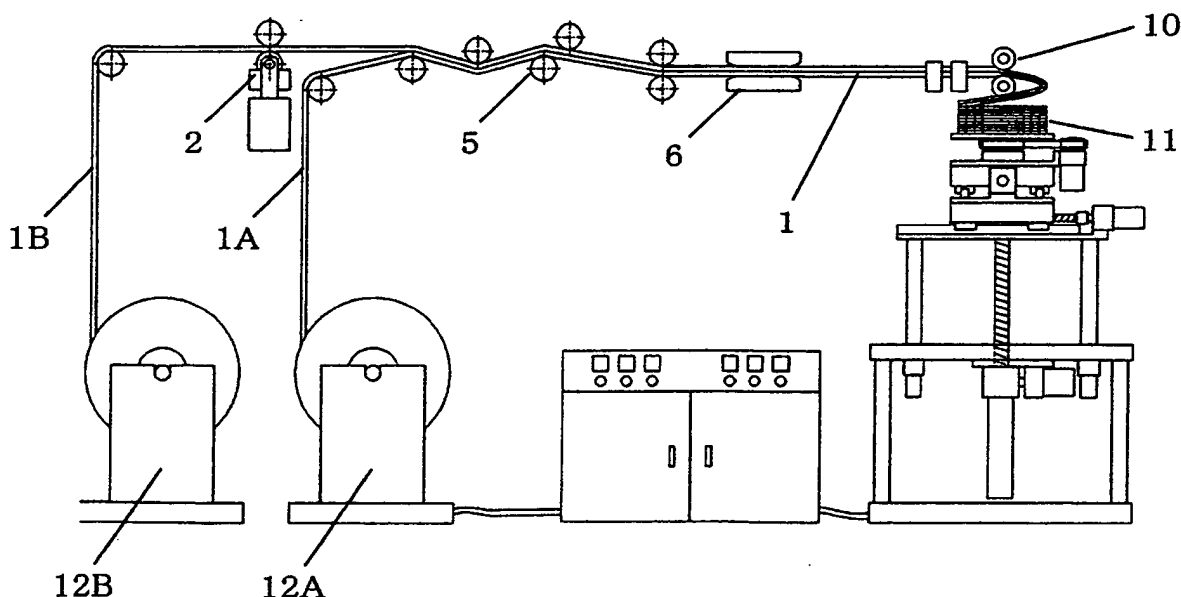
(74) Representative: **Strehl Schübel-Hopf & Partner**
Maximilianstrasse 54
80538 München (DE)

(54) **Multi-layer coil of plural electric wires for transformer and its winding machine**

(57) A plurality of flat-type electric wires (1A, 1B) fed individually are coated with a bonding agent by a bonding agent coating mechanism (2) so as to be held in overlapped constraint condition, thus impersonating a single flat-type electric wire (1) which in turn is molded by a molding unit 10 and piled up in laminated disk-like form by use of a stacking unit (11) to provide a multi-layer coil

using plural flat-type electric wires. The multi-layer coil can attain the effect equivalent to an increase in cross-sectional area of the single flat-type electric wire and a molded transformer of a large capacity can be realized. Thus, by additionally providing a mechanism for keeping the flat-type electric wires (1A, 1B) in overlapped condition in a winding machine, a multi-layer coil using plural electric wires can be manufactured at low costs.

FIG.2



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a multi-layer coil for transformer having two or more flat-type electric wires coiled in laminated form for use in a molded transformer and a winding machine adapted to manufacture the multi-layer coil as well.

[0002] There have hitherto been offered a winding machine for coiling two or more flat-type electric wires in laminated form to provide a multi-layer coil for transformer used in a molded transformer and a multi-layer coil of plural wires for transformer manufactured by use of the winding machine. When piling up a plurality of flat-type electric wires in disk-like form and in laminated form so as to be stacked in a cylindrical shape, the plural flat-type electric wires supplied individually or independently from feeders are molded through rolling by means of a molding unit while placing wire portions, which constitute curved portions when the flat-type electric wires will be coiled in disk-like form, in overlapped condition. The flat-type electric wires leaving the molding unit are fed to a stacking unit, in which the plural flat-type electric wires conveyed while being kept in overlapped condition are freed from each other, especially, in their longitudinal direction.

[0003] In general, the flat-type electric wires coiled in disk-like form eventually take the form of a rectangle or circle in plan view. In the case of a coil having a rectangular coiling form, the coil can be constrained relatively easily in the longitudinal direction of the flat-type electric wires at its individual corners of rectangle but in the case of a coil having a circular coiling form, corners do not exist unlike the rectangular coil and nothing to constrain the individual flat-type electric wires in the longitudinal direction exists. Accordingly, the product quality management will sometimes face a problem in confirming whether or not register of the overlapped flat-type electric wires are undisturbed in the longitudinal direction or in confirming whether or not laminated lengths of the overlapped flat-type electric wires are sufficiently uniform.

[0004] In order to deal with an increase in capacity of the molded transformer, the multi-layer coil using a plurality of flat-type electric wires (coiling electric wires) to be coiled has been proposed as described above but with the plural flat-type electric wires used, even when the plural electric wires are molded identically at the molding unit, the molded plural flat-type electric wires are disassembled during subsequent lamination in the stacking unit and the flat-type electric wires in this condition are very difficult to pile up in laminated form and much time is consumed for this kind of work, giving rise to expensiveness of a resultant multi-layer coil.

[0005] A multi-layer coil manufacture apparatus, as proposed by the present applicant to manufacture a multi-layer coil by coiling flat-type electric wires in rectangular form, is disclosed in Japanese Patent No. 3996005. The multi-layer coil manufacture apparatus has a paired roll-

ing rollers opposing to each other in a direction of the thickness of flat-type electric wires so as to clamp and roll the flat-type electric wires, a stock unit for receiving the rolled flat-type electric wires and a rolling roller controller for controlling the angle of clamping of the rolling rollers, wherein a curved portion constituting a corner and a linear portion constituting a side of the flat-type electric wires are formed reiteratively, the radius of curvature is gradually increased as coiling proceeds from inner peripheral side to outer peripheral side while the radius of curvature is gradually decreased as coiling proceeds from outer peripheral side to inner peripheral side and the linear portion is molded through parallel rolling by paralleling the rolling rollers at an instant that the curved portion shifts to the linear portion, thus making the cross-sectional area of the linear portion substantially equal to that of the innermost peripheral curved portion, whereby the rectangular multi-layer coil can be manufactured efficiently and automatically.

SUMMARY OF THE INVENTION

[0006] In order to manufacture a multi-layer coil more cheaply and efficiently from a plurality of flat-type electric wires which are fed individually, mated with each other on the midway and subsequently supplied in unconstrained condition, during molding and lamination of the plural flat-type electric wires to be set, the flat-type electric wires need to be constrained mutually in such a way that the laminated individual flat-type electric wires will not be disassembled and they do not disturb coiling operation in the same winding machine.

[0007] Then, when piling up the plural flat-type electric wires while coiling them in disk-like form, there arises a problem to be solved as to how to permit electric wire portions, which constitute curved portions during disk-like coiling, to be kept in overlapped condition after completion of molding of the flat-type electric wires by rolling and to be handled as if they were a single flat-type electric wire.

[0008] The present invention aims at providing a multi-layer coil of plural wires for transformer in which a plurality of flat-type electric wires are fed individually in unconstrained condition but the flat-type electric wires are molded in somewhat mutually constrained condition to ensure easy lamination of the flat-type electric wires, whereby even for a molded transformer of large capacity, the multi-layer coil of plural wires for transformer can be manufactured more inexpensively and also aims at providing its winding machine.

[0009] According to one aspect of the present invention, to solve the above problem, a winding machine for a multi-layer coil of plural wires for transformer comprises feeders for supplying a plurality of flat-type electric wires individually, a molding unit for molding, through rolling, electric wire portions which constitute curved portions when the flat-type electric wires will be coiled in disk-like form and a stacking unit for piling up in laminated form

the flat-type electric wires molded through the molding unit while coiling them in disk-like form, **characterized in that** the molding unit operates to simultaneously mold the overlapped plural overlying and underlying flat-type electric wires while keeping the overlapped condition constrained and the stacking unit piles up the thus molded plural flat-type electric wires in laminated form by coiling them in disk-like form.

[0010] According to another aspect of the invention, in the multi-layer coil of plural wires for transformer, the overlapped plural overlying and underlying flat-type electric wires are piled up in laminated form while being coiled in disk-like form and the flat-type electric wires in overlapped condition are constrained such that a positional shift possibly occurring therebetween does not disturb the lamination.

[0011] According to still another aspect of the invention, in the multi-layer coil of plural wires for transformer and its winding machine, during coiling in disk-like form and pile-up in laminated form, at least two flat-type electric wires are so constrained as to keep the overlapped condition and impersonate a single flat-type electric wire in handling and they are coiled in disk-like form and piled up in laminated form while being kept in constrained condition to ensure that lamination and coiling can be accomplished easily. As a result, the plural flat-type electric wires do not displace mutually in their longitudinal direction.

[0012] According to yet still another aspect of the invention, in the multi-layer coil of plural wires for transformer and its winding machine, the plural flat-type electric wires can be constrained mutually to overlapped condition by taping applied in the longitudinal direction at intervals of predetermined distances, mutual bonding by a bonding agent applied in the longitudinal direction at intervals of predetermined distances or mechanical coupling such as a raise/recess fitting applied in the longitudinal direction at intervals of predetermined distances.

[0013] It is possible to distribute differently the constraint positions, where the overlapped condition is constrained, in the peripheral direction of the multi-layer coil coiled in disk-like form. By distributing differently the constraint positions in the peripheral direction of the multi-layer coil across respective turns of disk-like coiling, an increase in coil height due to overlapping of many constraint positions in the same coiling phase can be avoided. The distribution of the constraint positions in the peripheral direction is effected to such an extent that almost coiling phases across respective turns of disk-like coiling do not overlap at the same position in peripheral direction with the exception that overlapping at the same position in the peripheral direction across every several respective turns of coiling can be permissible.

[0014] Further, the plural flat-type electric wires can be piled up in laminated form to provide a circular multi-layer coil or a rectangular multi-layer coil through coiling in disk-like form.

[0015] According to yet still another aspect of the in-

vention, in the multi-layer coil of plural wires for transformer and its winding machine, when piling up the plural flat-type electric wires in overlapped condition while coiling them in disk-like form, the flat-type electric wires do not displace mutually, especially, in their longitudinal direction and therefore, high-quality molding and lamination of plural flat-type electric wires can be facilitated through a process similar to molding and lamination of an impersonated single flat-type electric wire and a high-quality multi-layer coil of overlapped plural flat-type wires can be realized at low costs. In addition, the capacity of the winding coil for transformer can be increased, giving rise to development into large-sized transformers. The number of wires can be developed in excess of two, leading to applications to further enlarged type of transformers. Furthermore, according to further yet still another aspect of the invention, by performing the process for constraining the plural flat-type electric wires in-line process, winding can be accomplished with time and labor similar to that for winding of the single wire and therefore, the multi-layer coil of plural wires can be manufactured and offered more inexpensively.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a schematic plan view diagram illustrating the whole of an embodiment of a winding machine of a multi-layer coil for transformer according to the present invention.

Fig. 2 is a front view diagram illustrating the whole of the winding machine of a multi-layer coil for transformer shown in Fig. 1.

Fig. 3 is a schematic plan view diagram illustrating the whole of another embodiment of the winding machine of a multi-layer coil for transformer according to the invention.

Fig. 4 is a schematic front view diagram illustrating the whole of the winding machine of a multi-layer coil for transformer shown in Fig. 3.

Fig. 5 is a diagram for explaining essential part of still another embodiment of the winding machine of a multi-layer coil for transformer according to the invention.

Figs. 6A and 6B are diagrams illustrating embodiments of the multi-layer coil for transformer in perspective view form.

Figs. 7A and 7B are diagrams illustrating different embodiments of the multi-layer coil for transformer in perspective view form.

Figs. 8A and 8B are diagrams illustrating still different embodiments of the multi-layer coil for transformer in perspective view form.

DESCRIPTION OF THE EMBODIMENTS

[0017] Embodiments of a multi-layer coil for transform-

er and its winding machine according to the present invention will be described hereunder with reference to the accompanying drawings.

[Embodiment 1]

[0018] The whole of a winding machine of a multi-layer coil for transformer according to embodiment 1 is schematically illustrated in plan view form in Fig. 1 and its front view is illustrated in Fig. 2. In the winding machine of embodiment 1, a plurality of flat-type electric wires are molded in constrained condition by use of a bonding agent so as not to be displaced mutually and are piled up in laminated form, producing a multi-layer coil of plural electric wires.

[0019] As shown in Figs. 1 and 2, a plurality of flat-type electric wires 1A and 1B are set in feeders 12A and 12B, respectively, and they are independently or individually paid out of the feeders 12A and 12B. A mechanism 2 for coating an adhesive or bonding agent to the bottom of the flat-type electric wire 1B is disposed and before the paid-out flat-type electric wires 1A and 1B are mated with each other in the machine, surfaces through which the flat-type electric wires 1A and 1B are mutually overlapped are coated with the bonding agent (or adhesive). The flat-type electric wire 1B having its bottom surface coated with the bonding agent or adhesive is passed through a leveler 5 while being overlapped on the flat-type electric wire 1A. The leveler 5 functions to eliminate a tendency toward curling each of the flat-type electric wires 1A and 1B has and also to stick the flat-type electric wires 1A and 1B together. Thereafter, an assemblage 1 of the overlapped plural flat-type electric wires is sent to a molding unit 10 by means of a conveyance unit 6. Through rolling, the molding unit 10 operates to mold wire portions which constitute curved portions when the flat-type electric wire 1 will be coiled in disk-like form. The thus rolled and molded flat-type electric wire 1 is piled up while being coiled in laminated disk-like form by use of a stacking unit 11.

[0020] The bonding agent provides an expedient for constraining the overlapped condition of the plural flat-type electric wires 1A and 1B and the coating mechanism 2 acts as a constraint expedient application unit which applies the bonding agent to the flat-type electric wires. The molding unit 10 and stacking unit 11 can be materialized with the molding unit and stacking unit disclosed in the aforementioned Patent Document 1, respectively, and will not be detailed herein. The molding unit 10 simultaneously molds the flat-type electric wires 1A and 1B of the same shape and same size, so that the flat-type electric wires 1A and 1B can be piled up in laminated form while being coiled in disk-like form by means of the stacking unit 11 as if they were a single flat-type electric wire while keeping the electric wires 1A and 1B conditioned in mutual overlap to permit them to impersonate a single flat-type electric wire.

[Embodiment 2]

[0021] The whole of a winding machine of a multi-layer coil for transformer according to embodiment 2 is schematically illustrated in plan view form in Fig. 3 and its front view is illustrated in Fig. 4. In the winding machine shown in embodiment 2, overlapped plural flat-type electric wires are applied with taping so as not to be displaced mutually and then piled up in laminated form to fabricate a multi-layer coil of plural wires.

[0022] As shown in Figs. 3 and 4, a plurality of flat-type electric wires 1A and 1B are set in feeders 12A and 12B, respectively, and they are independently paid out of the feeders 12A and 12B. The flat-type electric wires 1A and 1B are passed through a leveler 5 so that a tendency toward curling each of the flat-type electric wires 1A and 1B has may be eliminated and thereafter, they are put together in the machine to provide an assemblage 1 of the overlapped plural flat-type electric wires. A tape supply and apply unit 3 instantaneously attaches a tape 7 for flat-type electric wire constraint to the bottom of the lowermost flat-type electric wire 1A. The flat-type electric wire constraint tape 7 is wound around the flat-type electric wire 1 by use of a unit 4 for attachment of the side and top surfaces of the tape, thereby constraining the overlapped condition of flat-type electric wires 1A and 1B. Thereafter, an assemblage 1 of the flat-type electric wires is sent to a molding unit 10 by means of a conveyance unit 6. Through rolling, the molding unit 10 operates to mold wire portions which constitute curved portions when the flat-type electric wire 1 will be coiled in disk-like form. The thus rolled and molded flat-type electric wire 1 is piled up in laminated form while being coiled in disk-like form by means of a stacking unit 11. It will be appreciated that the flat-type electric wire constrain tape 7 can be made of the same material as the paper which has already been used for fixing the coil for transformer and it of course meets a test of characteristics required for molding.

[0023] In embodiment 2 as above, the flat-type wire constraint tape 7 provides an expedient for constraining the overlapped condition of the plural flat-type electric wires 1A and 1B and the tape supply and apply unit 3 acts as a constraint expedient application unit. The molding unit 10 and stacking unit 11 can be materialized with those disclosed in the aforementioned Patent Document 1, respectively. The molding unit 10 and the stacking unit 11 operate cooperatively with each other to simultaneously mold the flat-type electric wires 1A and 1B of the same shape and same size as if they were a single flat-type electric wire and to pile them up in laminated form while coiling them in disk-like form.

[Embodiment 3]

[0024] Turning to Fig. 5, essential part of a winding machine of multi-layer coil for transformer according to embodiment 3 is illustrated, particularly showing a unit

for constraining plural flat-type electric wires to overlapped condition. As shown in Fig. 5, a flat-type electric wire 1A paid out of the feeder 12A (see Fig. 1) and a flat-type electric wire 1B paid out of the feeder 12B (see Fig. 1) are underlying and overlying, respectively, in overlapped condition and are mechanically coupled with each other by use of a caulking unit 20. More particularly, the caulking unit 20 has a lower die 21 with a raised part 23 and an upper die 22 with a flat surface 24 confronting the raised part 23. The overlapped flat-type electric wires 1A and 1B are clamped together and pressed by the lower and upper dies 21 and 22 so that a raised portion 25 on the top of flat-type electric wire 1A may be fitted in a recessed portion 26 on the bottom of flat-type electric wire 1B, thus fixing both the flat-type electric wires 1A and 1B in a caulk fashion. In embodiment 3, a fitting 27 of raised portion 25 of flat-type wire 1A and recessed portion 26 of flat-type wire 1B in the overlapped condition of flat-type electric wires 1A and 1B provides a constraint expedient for preventing the flat-type electric wires 1A and 1B from displacing mutually, especially, in their longitudinal direction and the caulk unit 20 acts as a unit for applying the constraint expedient.

[0025] Referring now to Figs. 6A and 6B, examples of the multi-layer coil of plural wires for transformer are illustrated in perspective view form. Shown in Fig. 6A is a multi-layer coil coiled in disk-like form to provide a rectangular coil in plan view and shown in Fig. 6B is a multi-layer coil coiled in disk-like form to provide a circular coil in plan view. In these examples, a flat-type electric wire 1 is shown as having overlapped flat-type electric wires 1A and 1B which are mutually bonded by a bonding agent or which are constrained by means of a mechanical raise/recess fitting such as caulking. Both the electric wires 1A and 1B are constrained as if they were a single flat-type electric wire and can be coiled in disk-like form as in the case of disk-like coiling of the single flat-type electric wire without taking care of possible disassembling. In the figures, the height of the multi-layer coil of flat-type electric wire 1 is indicated by reference numeral 8 or 9.

[0026] Turning to Figs. 7A and 7B, there are illustrated, in perspective view, examples of a multi-layer coil of plural wires for transformer having overlapped flat-type electric wires which are constrained by use of the flat-type electric wire constraint tape 7 and are piled up in laminated form. Preferably, the flat-type electric wire constraint tape 7 is as thin as possible because it is responsible for increasing height 8A or 9A of the flat-type wire to be piled up in laminated form. But if application of the flat-type electric wire constraint tapes 7 is concentrated to the same coiling phase position (in the figure, 4 coiling phase positions), the pile-up height 8A or 9A of the flat-type electric wire 1 increases, raising a problem that the coil height increases.

[0027] Then, in order to suppress the coil height as low as permissible, it is preferable that fabrication proceeds while controlling the position where the flat-type electric wire constraint tape 7 is attached by means of the tape

supply and apply unit 3 in such a manner that when the flat-type electric wire 1 is piled up in laminated form by the stacking unit 11, the flat-type electric wire constraint tapes 7 are not concentrated to the same coiling phase position across respective turns of disk-like coiling as shown in Figs. 8A and 8B. In this manner, the pile-up height 8B or 9B of flat-type electric wire 1 can be suppressed as small as permissible.

[0028] According to the present invention, since at least two flat-type electric wires can be kept in overlapped condition by means of the constraint expedient during coiling them in laminated disk-like form, the flat-type electric wires will not be disassembled in the stacking unit but are molded as if they were a single flat-type electric wire and then are coiled in disk-like form and piled up in laminated form. Due to the fact that the plural flat-type wires are mutually constrained inside the winding machine, the present invention is advantageous over the prior art when taking preparatory arrangements into account and besides, operation disturbance, for example, stoppage of normal winding operation as required in case the plural flat-type electric wires are desired to be constrained in the course of operation of the winding machine will not occur.

[0029] In the molded transformer according to the foregoing embodiments of the invention, since the flat-type electric wires do not displace mutually when two or more electric wires in combination are molded and piled up in laminated form, a multi-layer coil meeting a transformer of large capacity can be manufactured and besides, by performing constraint of the plural flat-type wires in-line process, coiling can be achieved with time and labor similar to that for a single wire and so a multi-layer coil of plural electric wires and a transformer using the same can be manufactured more inexpensively.

Claims

1. A winding machine of a multi-layer coil of plural electric wires for transformer comprising feeders (12A, 12B) for feeding plural flat-type electric wires (1A, 1B), respectively, a molding unit (10) for molding, through rolling, wire portions which constitute curved portions when the flat-type electric wires will be coiled in disk-like form and a stacking unit (11) for piling up said flat-type electric wires molded by said molding unit while coiling them in laminated disk-like form, **characterized in that** said molding unit (10) molds simultaneously the overlapped plural overlying and underlying flat-type electric wires while constraining them to the overlapped condition and that said stacking unit (11) piles up said molded plural flat-type electric wires in laminated form while coiling them in disk-like form.
2. The winding machine of a multi-layer coil of plural electric wires for transformer according to claim 1,

- characterized in that** said plural flat-type electric wires (1A, 1B) are mutually constrained to the overlapped condition by a tape (7) applied to be wound around them at intervals of predetermined distances in the longitudinal direction. 5
3. The winding machine of a multi-layer coil of plural electric wires according to claim 1, **characterized in that** said plural flat-type electric wires (1A, 1B) are mutually constrained to the overlapped condition by a bonding agent applied from a bonding agent coating mechanism (2) at intervals of predetermined distances in the longitudinal direction. 10
4. The winding machine of a multi-layer coil of plural electric wires according to claim 1, **characterized in that** said plural flat-type electric wires (1A, 1B) are mutually constrained to the overlapped condition by mechanical coupling such as a raise/recess fitting (27) applied at intervals of predetermined distances in the longitudinal direction. 15 20
5. The winding machine of a multi-layer coil of plural electric wires according to any one of claims 1 to 4, **characterized in that** the constraint positions where the overlapped condition is constrained are distributed differently in the peripheral direction across respective turns of disk-like coiling. 25
6. The winding machine of a multi-layer coil of plural electric wires according to any one of claims 1 to 5, **characterized in that** the plural flat-type electric wires (1A, 1B) are piled up in laminated form while being coiled in disk-like form to provide a circular multi-layer coil or a rectangular multi-layer coil. 30 35
7. A multi-layer coil of plural wires for transformer, **characterized in that** mutually overlapped plural overlying and underlying flat-type electric wires are piled up in laminated form while being coiled in disk-like form and that said flat-type electric wires in overlapped condition are constrained such that a positional displacement possibly occurring therebetween does not disturb the lamination. 40 45
8. The multi-layer coil of plural wires for transformer according to claim 7, **characterized in that** said plural flat-type electric wires are mutually constrained to the overlapped condition by a tape (7) applied to be wound around them at predetermined intervals of distances in the longitudinal direction. 50
9. The multi-layer coil of plural wires for transformer according to claim 7, **characterized in that** said plural flat-type electric wires are mutually constrained to the overlapped condition by a bonding agent applied from a bonding agent coating mechanism (2) at predetermined intervals of distances in the longitudinal direction. 55
10. The multi-layer coil of plural wires for transformer according to claim 7, **characterized in that** said plural flat-type electric wires are mutually constrained to the overlapped condition by mechanical coupling such as a raise/recess fitting (27) applied at predetermined intervals of distances in the longitudinal direction.
11. The multi-layer coil of plural wires for transformer according to any one of claims 7 to 10, **characterized in that** the constraint positions where the overlapped condition is constrained are distributed differently in the peripheral direction across respective turns of disk-like coiling.
12. The multi-layer coil of plural wires for transformer according to any one of claims 7 to 11, **characterized in that** said multi-layer coil is a circular multi-layer coil or a rectangular multi-layer coil.

FIG.1

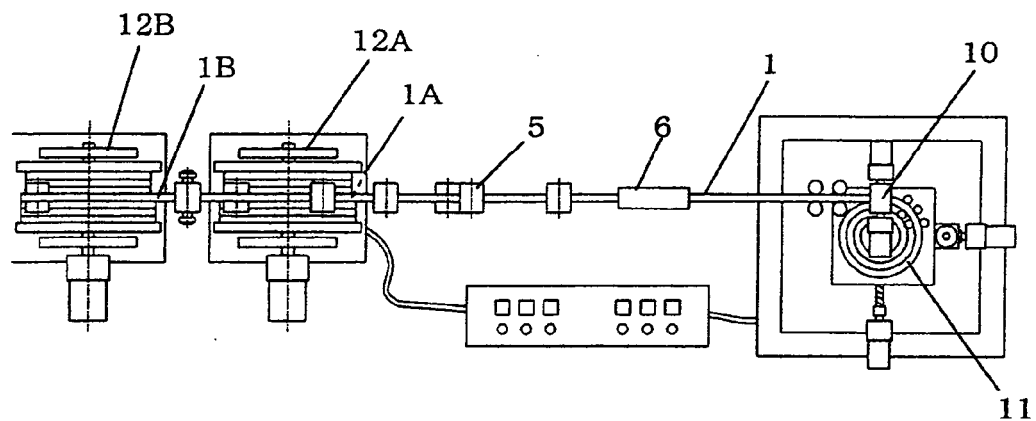


FIG.2

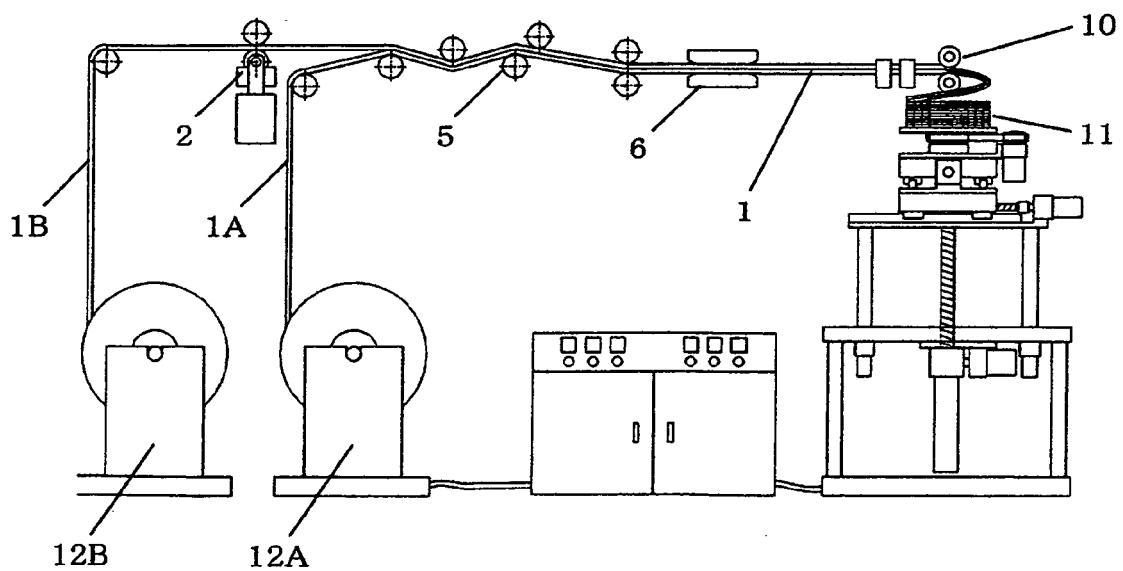


FIG.3

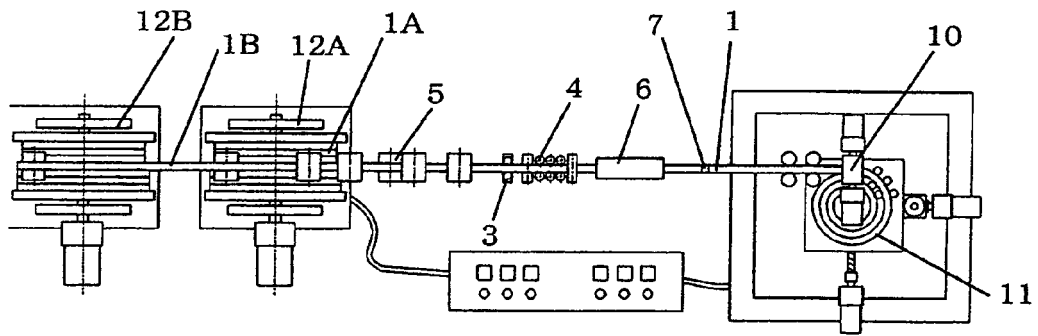


FIG.4

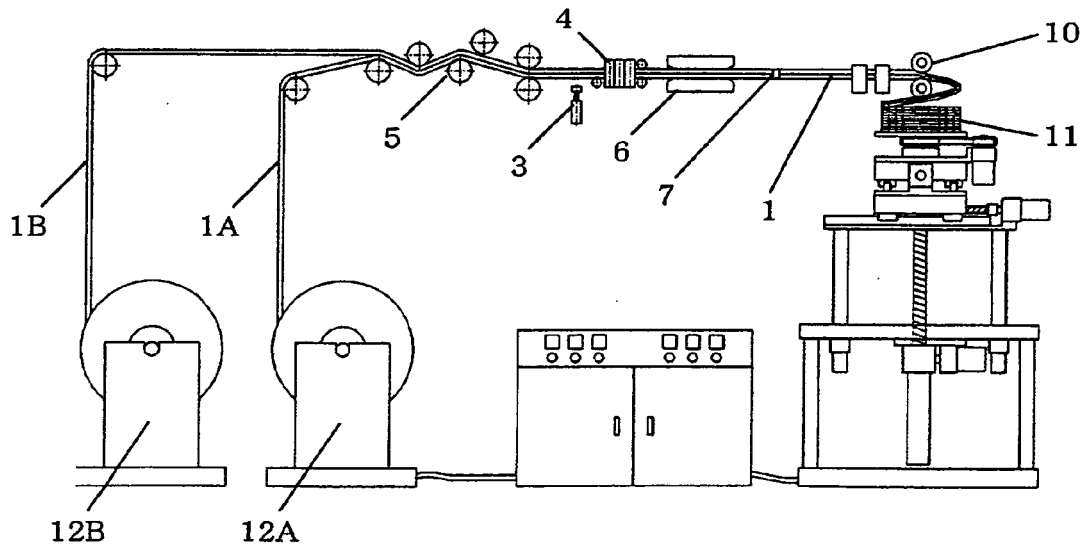


FIG.5

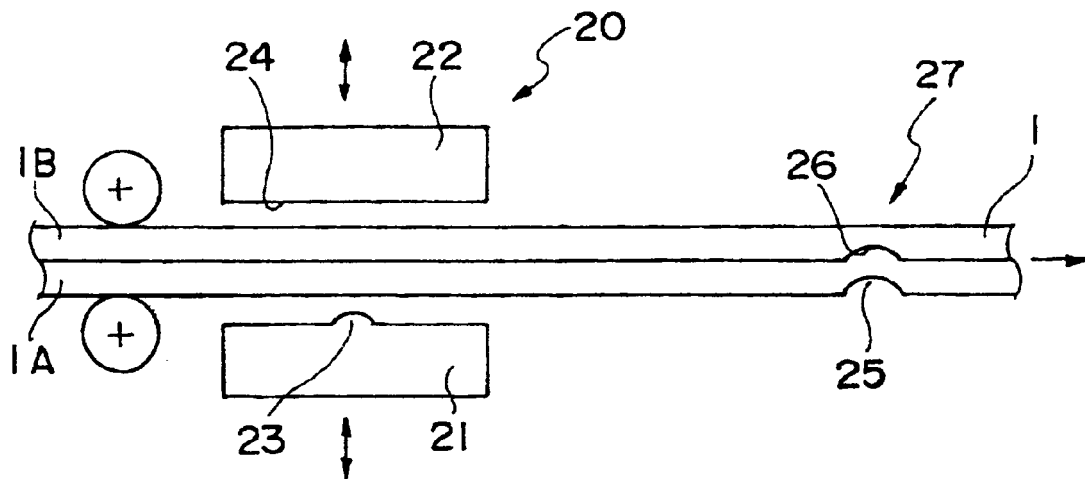


FIG.6A

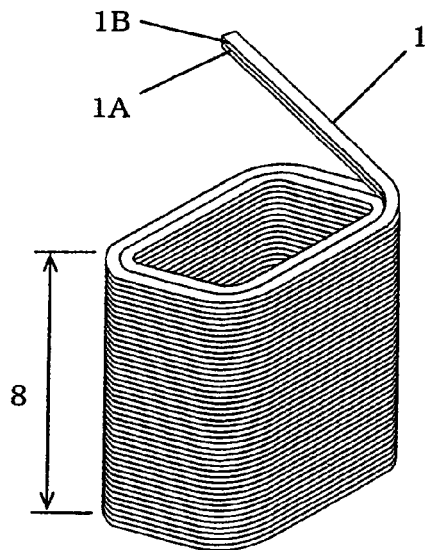


FIG.6B

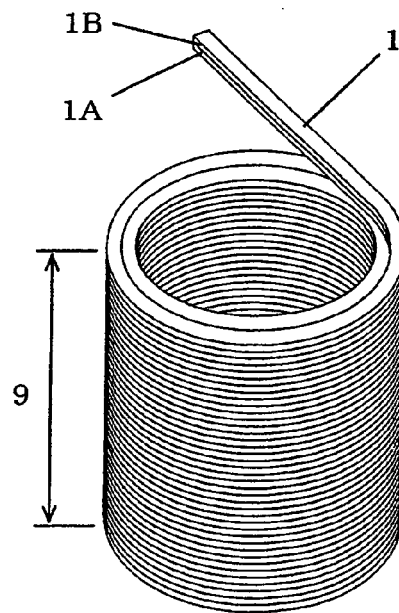


FIG.7A

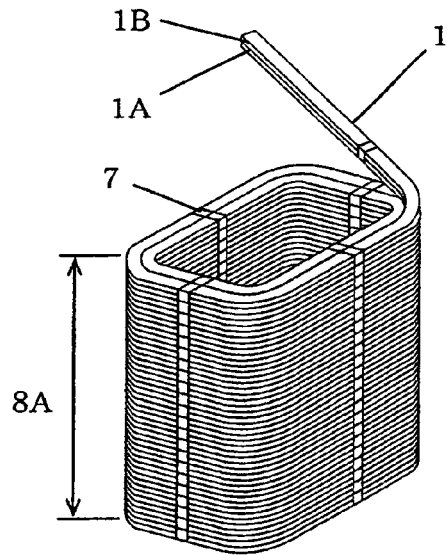


FIG.7B

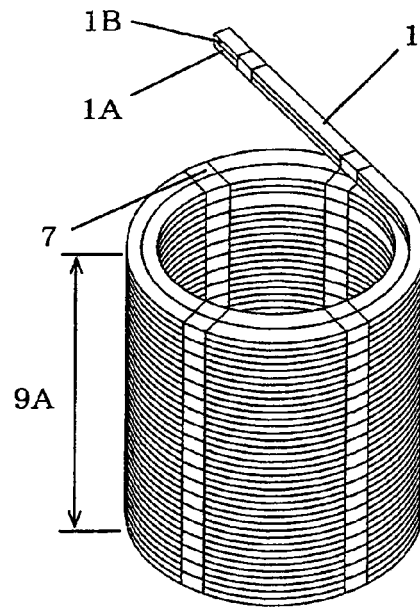


FIG.8A

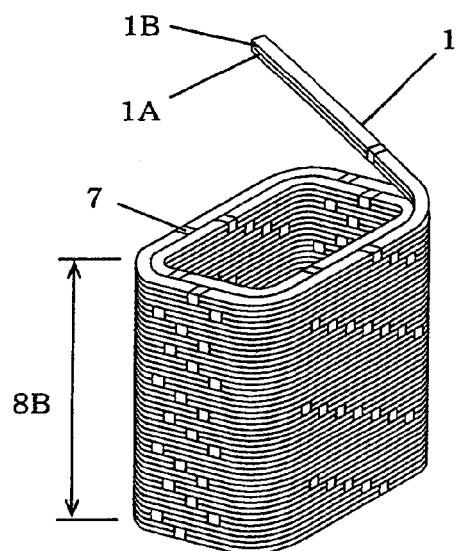
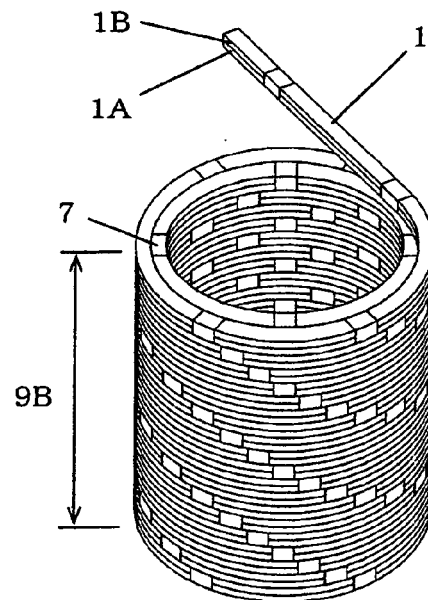


FIG.8B



REFERENCES CITED IN THE DESCRIPTION

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