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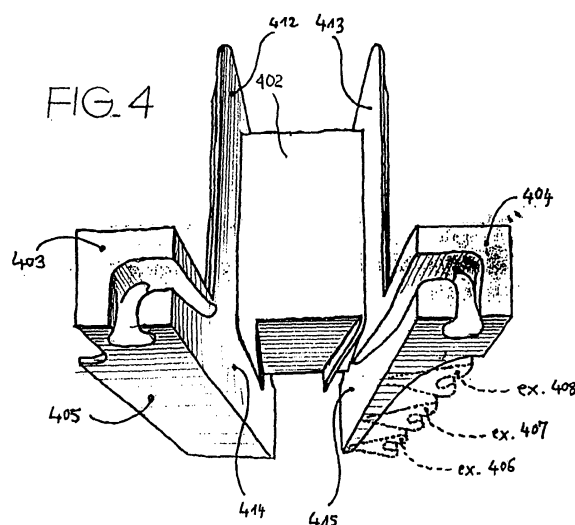
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(54) **A multi-chamber transformer**

(57) A transformer includes a plurality of windings (290, 390, 490) wound on an insulating bobbin, which in turn includes a plurality of coil formers (200, 300; 200, 300, 400) each having at least one respective winding (290, 390) wound thereon. Each coil former (200, 300; 200, 300, 400) includes two separating end walls (212... 215, 312...315, 412...415) providing insulation of the respective winding, and at least one of the end walls (214, 215; 314, 315; 414, 415) of the coil formers has a protruding portion (204, 225, 306, 309, 403, 405) extending in correspondence with a neighbouring coil former. The protruding portion in question may include a wall extension (225, 305, 405) at least partly covering the respective winding provided in the neighbouring coil former, and/or a pin stand (204; 306, 309; 403).



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Description

Field of the invention

[0001] The present invention relates to (electrical) transformers.

Description of the related art

[0002] Transformers are used in several areas e.g. in power supply units for halogen lamps, wherein an input line voltage (e. g. the typical 220-240 volt mains voltage of most European countries, while 100 - 120 volts are typical values for many American countries) is transformed into an output voltage of 6, 12 or 24 volts. Transformers are also frequently used as output isolating transformers in electronic converters for halogen lamps to produce a 12 volt output voltage.

[0003] Symmetric three-chamber winding structures offer a number of distinct advantages over conventional two-chamber windings. These advantages include, e.g., a significant reduction of proximity losses within the windings, a flux equilibrium within the core (which nulls the magnetic field in the outer leg(s) of the core and thus reduces the core losses), a higher quality factor of the leakage inductance (up to 70) due to the symmetrical field distribution which enables such a transformer to be used as real resonance inductor for soft-switching circuits, and finally a reduced electromagnetic noise emission. Thus, when using three windings i.e. three coils, the same power can be transferred by using a core of smaller size.

[0004] In the case of two-part cores of the types currently referred to as E, EF, EFD, EP, EV (EVD, EFS), E-I, U, UR and U-I to be assembled from outside as the last assembly step of the transformer, plastic moulded coil formers are available with three or more insulated chambers available, in a layered structure. This leads to having thin coils coaxially nested within each other arranged around the centre leg of the core, single coils being sometimes one-layer coils. Transformer arrangements including three windings (or more) are not exempt from problems such as, e.g. high cross-winding capacitance, weak creep age at the end of the cylindrical coils, wire outlets and pin stands quite exposed to creep age, and complicated wiring arrangements especially for the interleaved coil. In the case of high insulation classes (e.g. SELV) the plastic material ends up to be largely prevailing over the copper (i.e. the winding wire) within the winding windows. In the case of a two coils arrangement, but with three windings, the coil that has been "halved" to form the inner and outer windings does not become a fully symmetric couple having the second coil arranged in between. This is because the wire of the outer "half" every times is much longer than that of the inner "half". A good deal of the problems outlined in the foregoing also arise in connection with standard two winding transformers, especially in the case of high-insulation transformers us-

ing the cores types described above, with high power density, low cross capacitance, and high leakage inductance.

[0005] The transformer structures disclosed e.g. in EP-0 793 243-B1 or in European patent applications No. EP04425783.0 and No. EP04425853.1 in the name of the same applicant. These two applications being included in the state of the art only under the provisions of Art. 54(3) EPC, bear witness to earlier attempts to solve these problems. Essentially, in these prior art arrangements, two coils are placed as multi-layered yet short, compact blocks located side-by-side onto the same leg of the core somehow like beads on a shackle.

Object and summary of the invention

[0006] While the arrangements disclosed in the last-cited documents effectively tackle the various problems outlined in the foregoing, the need is still felt for further improved arrangements.

[0007] The object of the present invention is thus to provide a transformer adapted to fully satisfactorily meet the requirements set forth in the foregoing. According to the present invention, that object is achieved by means of a transformer having the features set forth in the claims that follow. The claims form an integral part of the disclosure of the invention provided herein.

[0008] A preferred embodiment of the invention is thus a transformer including a plurality of windings wound on an insulating bobbin, characterized in that:

- the bobbin includes a plurality of coil formers each having at least one winding wound thereon, and
- each coil former includes two separating end walls providing insulation of said at least one respective winding, and
- at least one of said end walls has a protruding portion extending in correspondence with (i.e. over) a neighbouring coil former.

[0009] A particularly preferred embodiment of the invention enables the economical, reliable, modular, and reproducible mass production of transformers with more than two hermetically insulated winding chambers by the combination of a "disc-like" structure with the multi-winding concept. A symmetrical three-chamber transformer can thus be realized which is symmetrical even in respect of parasitics: the winding resistances of the two "halves" of one coil are equal, and the cross-winding capacitances between each "half" of the first winding/coil and the second coil are similarly equal. This is primarily due to the same winding diameter and thus the same length and sorting of the wires within each "half" coil.

[0010] The basic advantages related to the presently preferred embodiment of the invention are as follows:

- the traditional, single coil former with a plurality of flanges and H-shaped separating walls is substituted

- by a plurality of individual, smaller coil formers with only one winding chamber and two flange walls,
- the pins of each individual coil former may be "moved" from the flange side to the edge side of the coil former (thus shifting the pin in-line by 90°),
 - locating the pin stands on both flange walls of each coil former allows using a cover cap adapted to cover all the individual coil formers and to insulate them sufficiently from each other and from the outer free space above the substrate or bench (printed circuit board or PCB),
 - each coil can be wound onto the corresponding, individual coil former prior to the final assembly of the whole transformer, and
 - the possibility exists of providing below the winding room of a coil former at least one pin stand and/or bench insulation consisting of wall extensions coming from a neighbouring coil former; resorting to this bench insulation arrangement makes it possible to reduce the transformer height: that portion of the height corresponding to the portion of the coils extending below the core (which portion is in fact wasted for getting enough creep age in traditional arrangements) is used to accommodate the height or thickness of the pin stands.

Brief description of the annexed drawings

[0011] The invention will now be described, by way of example only, by referring to the enclosed figures of drawing, wherein:

- figure 1 is a general cross-sectional view of a two winding transformer of the type described herein,
- figure 2 is a perspective view of a component adapted to be included in a transformer as shown in figure 1,
- figure 3 is a perspective view exemplary of the possibility of assembling a plurality of elements as shown in figure 2,
- figure 4 is a bottom-up perspective view of an element as shown in either of figures 2 or 3,
- figure 5 and figure 6 are two generally opposed perspective views of a cover cap adapted to be included in a transformer as described herein,
- figure 7 and figure 8 are magnified views of two possible variant embodiments similar to the portion indicated by arrow VI in figure 1,
- figures 9 to 11 are enlarged partial views of coil formers as shown in figures 2 to 4, and
- figure 12 is partial perspective view exemplary of a method of forming connection pins in a transformer as described herein.

Detailed description of exemplary embodiment of the invention

[0012] The exemplary embodiments of a transformer

described herein have in common the basic feature of including a plurality of coil formers generally indicated 200, 300, and 400 in figures 2 to 4. The designation "coil former" is primarily intended to highlight the role these elements play both in providing winding chambers for respective windings ("coils") and in jointly forming the winding of the transformer.

[0013] It will thus be appreciated that the coil former 400 of figures 2 and 4 is shown without the respective winding wound thereon. Conversely, the three coil formers 200, 300, and 400 of figure 3 are shown after being provided with respective windings. While assemblies comprised of two and three coil formers are described herein by way of example, those of skill in the art will promptly appreciate that the arrangement described herein may be extended to include also four coil formers or more, i.e. any number in a plurality of coil formers.

[0014] Each coil former is essentially comprised of a ring-shaped body of an electrically insulating material (of any type currently used to produce bobbins for transformers) having wound thereon a winding (or "coil") of electrically conductive wire such as e.g. copper wire.

[0015] In the final transformer assembly (see e.g. figure 1) a plurality of coil formers are arranged side-by-side on a common core. This is typically comprised of one of the legs (usually the main, central leg) of a ferromagnetic (e.g. ferrite) core of any of the types listed in the introductory portion of the description.

[0016] In the following the concepts of "winding room", "winding chamber" and "winding space" will be repeatedly referred to in order to describe the various exemplary arrangements disclosed and the advantages associated therewith.

[0017] The "winding room" describes the space within one individual coil former 200, 300, and 400 that is actually filled up by its coil 290, 390, 490.

[0018] The "winding chamber" 298, 398, 498 is the assembly remaining free of any metal, ferrite, or plastic portion after mounting the corresponding coil former into the complete insulation arrangement, and must be larger than or at least equal to the corresponding winding room.

[0019] The "winding space" finally is the notionally infinite disc, starting from the tubular wall portions (see e.g. the portions indicated as 202, 302, 402 in several of the figures of the attached drawing) of the coil formers 200, 300, and 400 as seen from the unmounted individual coil formers between its two flange walls (see e.g. the flange walls 412, 413 of the coil former 400 shown in figure 2). The winding space is thus a space notionally heading to infinity in each direction orthogonally to the winding axis, thus having a "thickness" of the distance between its two flange walls. The winding space essentially defines the space required for winding the coil onto the individual unmounted coil former.

[0020] The "bobbin" portion of each coil former 200, 300 and 400 provides an insulation arrangement consisting of plastic moulded material (such as e.g. Polyamide, Polycarbonate, or Polybutylene-Terephthalate) with a re-

sistivity of at least $3 \cdot 10^9$ Ohm*cm for transformers with two-part E, EF*, EP, EFD, EV*, E-I, U, UR, or U-I cores.

[0021] The bobbin portion also includes a cover cap designated 100 as a whole. The cover cap 100 includes a partial (i.e. apertured) top wall or a closed top wall of the same sufficient thickness or of an even smaller thickness (see e.g. the elements 24 and 25 of figure 5). The cap 100 is thus adapted to contain a plurality of coil former elements 200, 300, and 400 matching perfectly to each other as better detailed in the following.

[0022] The cover cap provides lateral walls (see walls 5, 6, 7, and 8 of figures 5, 6, and 9) of sufficient extension above the circuit supporting substrate or "bench" (such as the PCB shown in figure 1) reaching closely down to this substrate and thus covering the pins of the arrangement.

[0023] After the final assembly of the transformer, the various coil former elements will form sufficient thickness through insulation, creep age, and clearance distances between their winding chambers 298, 398, 498 and between each individual winding chamber and the lateral (and - if necessary - the top) surrounding free space by means of adequate labyrinth shapes at the border surfaces between the insulating elements.

[0024] These will consist of at least two individual coil formers (the number of the coil formers 200, 300, and 400 will be one less than the total number of all insulating elements) with substantially the form of hollow spindles. These provide the insulation between the individual coils and the core by completely covering one leg of the ferromagnetic (e.g. ferrite) core 3, 4. As indicated, this will generally be the central leg or the most compact leg of a core of e.g. any of the core types indicated in the introductory portion of the description. Specifically, insulation with respect the core is provided by the central tubular portions 202, 302, and 402.

[0025] The assembly process of the transformer described herein thus provides for at least two coil formers 200, 300 and 400 being arranged directly side by side onto the same leg of the core 3, 4. Each individual coil former can thus be provided with its coil before the insulation arrangement is assembled in order to build the complete transformer.

[0026] At least one of the coil formers 200, 300, and 400 has at least one horizontal or three-dimensional portion associated with its flange walls extending outwardly of its winding space. These protruding portions are configured in such a way as to extend into the winding space of at least one of the neighbouring coil formers.

[0027] These protruding portions can be in the form of pin stands 203, 204, 306, 309, 403, 404. As better detailed in the following, these pin stands may be configured in such a way that the winding wires itself build the corresponding terminal pins (see figure 12).

[0028] In order to minimize the overall dimensions of the transformer, and especially the height thereof, the lower side of the coils near the common circuit supporting substrate (PCB) - in other words the bench side of the

coils - stands significantly closer to the circuit substrate than e.g. half the maximum required creep age (in the lower portion of figure 1) without protruding completely to and through the circuit support. This is thanks to the provision of lower flange walls such as e.g. 215, 314, 414 that have extensions 225, 305, 405 that are configured as protruding portions that extend into the winding space of at least one of the neighbouring coil formers to build parts of the insulation barriers between any neighbouring winding chambers.

[0029] Specifically, the extensions in question are in the form of bench walls that extend essentially in the directions of the "bench" or PCB to provide the sufficient creep age and clearance distances between two neighbouring winding chambers. Stated otherwise, these bench walls correspond to lower flange walls such as e.g. 215, 314, or 414 being "bent" at the lower edge of the insulation barrier outwardly from the corresponding coil former by 90°. These bench walls extend horizontally with a sufficient thickness below the winding rooms of the neighbouring coil former, i.e. between the bench side of the neighbouring coil and the circuit substrate (PCB), and the at least one neighbouring unbent flange wall has been shortened by that thickness necessary for passing through of the bench wall(s).

[0030] This arrangement substitutes the conventional solution of heading vertically the side and/or flange and/or H-separating walls against the circuit supporting substrate. In that way the possibility exists of avoiding that the transformer should stand "higher" than necessary, while also avoiding the need of forming a cut through the circuit substrate exactly at the position(s) of the lower flange and/or H-separating wall(s) of the coil formers.

[0031] The coil former portions (be these pin stands and the bench walls just described) that protrude into the winding space of the neighbouring coil former are preferably formed as a single moulded piece with the relative coil former.

[0032] More generally, if a core (such as a two-part core 3, 4) is used that is considered as a part of the free space above the circuit supporting substrate (i.e. the PCB) from the point of view of insulation, all the surfaces where the insulating arrangement touches the core or comes into close proximity to it are provided with a sufficient wall thickness - see references 19 to 21, 202, 302, 402, and partially 212, 213, 312, 313, 412, 413. Additionally, between any of the at least two separate winding chambers 298, 398, 498 and the core there exist sufficient creep age and clearance distances.

[0033] In the exemplary arrangement described, the cover cap 100 covers all the individual coil formers together at their outer lateral sides closely down to the circuit supporting substrate PCB and at their top sides (at least partially or - if necessary - completely). The cover cap 100, which is preferably comprised of a single moulded piece of insulating (e.g. plastics) material, has continuous side walls and a - possibly apertured - top wall 24,

25. A part of these walls, named side walls in the following (see e.g. the walls designated 5, 6, 20, 21), extend parallel to the centre leg or the most compact leg of the core 3, 4, while other of these walls named face walls are orthogonal to that leg (see e.g. lower face walls designated 7, 8) and are in fact traversed by that leg of the core (see e.g. the upper face walls designated 260, 270, 24, 25).

[0034] Specifically, the cap 100 has a central horizontal, ring-shaped shoulder wall 19 with outer dimensions at least equal or even bigger than the outer dimensions of the core, which carries the shoulders and the outer legs of the core. The shoulder wall extends parallel to the mounting substrate (PCB) and surrounds the whole area where the windings are located. The shoulder wall 19 has a hole with dimensions roughly defined by the four outer corners of the two winding windows of the core 3, 4, which provides the protrusion of the coils and the portions of the coil formers inside and above the core through said shoulder wall 19. These dimensions of this hole have to be reduced exactly by the thickness of the upper side walls 20, 21, and traversed upper face walls 260, 270, 24, 25, to enable them to be connected closely and stable with the shoulder wall 19; all these wall parts complete the winding chambers 298, 398, 498 of the coil formers inside the winding windows and above the core.

[0035] The ring-shaped shoulder wall 19 supports the downwardly extending lower side walls 5, 6 and lower face walls 7, 8. These skirt walls 5, 6, 7, 8 extend in the space between the core and the circuit substrate covering the pin stands and the bench walls if present. The walls 5, 6, 7, 8 can thus be positioned at the same locations as the upper side and upper face walls of the cap 100 or at any other outer locations up to the outer dimensions of the central shoulder wall 19.

[0036] This is the case of the exemplary preferred embodiment shown, where the shoulder wall 19 supports the downwardly extending skirt walls 5, 6, 7, 8 at its periphery.

[0037] The cover cap 100 provides the required insulation both between any of the winding chambers 298, 398, 498 at their adjacent inner sides and between these chambers and the core and the free space above the circuit substrate on its outer side (see especially figures 5 and 6).

[0038] More specifically, the insulation between the at least two separate winding chambers 298, 398, 498 is provided by the joint action of the flange walls 212, 213; 312, 313; and 412, 413 (including the lower flange walls 214, 215, 314, 315, 414, 415 together with the possible extensions represented by the "bench walls" 225, 305, 405) of the coil formers 200, 300, 400 plus complementary walls extending from the inner side of the cover cap 100.

[0039] These include walls 15, 16, 17, 18, 26, 27, 28, 29, 30 and 31 that, as best shown in figures 7 and 8, penetratingly engage (in a labyrinth-like fashion) corresponding receiving grooves formed between adjacent

flange walls of the coil formers. To advantage, the walls in question may have an outwardly directed taper (see especially figure 8) mirrored by a complementary flare of the receiving grooves. Such a flare is typically produced as a result of the flange walls of the adjacent coil formers (200 and 300 in figure 7, 300 and 400 in figure 8) having a distal chamfer.

[0040] Other walls designated 260, 270, 24 and 25, located at the longitudinal ends of the "narrow" upper portion of the cover cap 100, in other words the traversed upper face walls located at the narrow sides of the winding windows, cooperate with the flange walls (e.g. 212 and 413) of the coil formers located at the outer extremities of the coil former pack. To advantage, the walls in question also may have an outwardly directed taper (see especially figure 8), mirrored by a complementary taper/chamfer of the flange walls of the coil formers, thus leading to a sort of scissors like, tight mutual engagement.

[0041] Again as best shown in figures 7 and 8, the insulating arrangement thus created between each of the at least two separate winding chambers and the free space above the circuit supporting substrate (thus including the core) may be comprised of one element or of the combination of at least two different elements.

[0042] Specifically, as shown in the centre portions of Figures 7 and 8, the insulation barriers may comprise three elements: one flange wall (312, 213), another flange wall of the neighbouring coil former (412, 313), and a wall portion 26, 27 of the cover cup 100 - acting as an intermediate wall.

[0043] As shown, the intermediate walls in question are parts of the cap 100 extending inside and above the winding windows of the core or are parts (see e.g. 30, 31) of its at least partial top walls, protruding orthogonally into the inner space of the cap 100.

[0044] Preferably, the intermediate walls 26, 27, 28 and 29 have downward extensions (designated 9 to 18), moulded as a one-piece part together with the central ring shoulder wall 19, that complete the insulation between the winding chambers not only in the space of the winding windows of the core and above, but even in the space between the circuit support (PCB) and the core, especially in the area of the wire outlets.

[0045] The extensions 15 to 18 are simple prolongations of the intermediate walls 26 to 29, located at exactly their positions in parallel to the face walls, eventually with smaller thickness, due to the fact that the pin stands protruding below the central shoulder wall 19 build additional insulation which is missing above that shoulder wall 19. These prolongations may protrude down to the adjacent bench wall.

[0046] The single-, two- or three-part portions building one specific insulation barrier (e.g. between the chambers, or between one chamber and the core) may have parts that do not have constant thickness. Typically, thicker (e.g. 0.8 mm or more) insulation-forming portions are used in proximity of the basic structure of the insulating element, e.g. near the tube-shaped walls 202, 302,

402 of the coil formers and near the side and top walls of the cap 100. Conversely thinner (e.g. 0.2 mm) insulation-forming portions are used in the peripheral areas of the insulating elements. This may be exploited by way of sum to produce a constant thickness through the insulation of a specific insulation barrier (see, for instance, figure 8).

[0047] The downward extensions (designated 9, 10, 11) of the upper side walls of the cap 100 below the shoulder wall 19 protruding down to a bench wall, if present, or down to the circuit supporting substrate PCB, double the lower side walls 5, 6 in each area where the adjacent coil former has no requirement for wire outlets heading for the corresponding pin stands and where a pin stand 204, 309, 306, 403 of a neighbouring coil former protrudes into the winding space of the adjacent coil former.

[0048] Typically, these downward extensions 9 to 11 are located at the positions of the upper side walls (e.g. 20, 21) or at positions placed at least slightly outward of said upper side walls. In both cases, the extensions involved are moulded together with at least one of the lower intermediate walls 15 to 18 by forming an adjoining section bent at an angle of almost 90° (see figure 6).

[0049] At least some of the inner walls of the cap 100 (e.g. 12, 13, 14) act as connecting walls between the inner side walls 9, 10, 11 and the skirt walls 5, 6, 7, 8, below the central shoulder wall 19. At each location where they build the required insulation between neighbouring pin stands which belong to different coil formers, they protrude down to the common circuit substrate and have sufficient thickness. At any other location where no significant insulation (e.g. only 24V) is required between neighbouring pin stands of different coil formers, these extensions 12, 13, 14 provide useful stabilization (i.e. mechanical strengthening) between these inner side walls and skirt walls, if necessary, and may but need not protrude down to the circuit supporting substrate.

[0050] It will be appreciated that in the exemplary arrangement described, at least one of the individual coil formers (e.g. the coil former designated 300 - see e.g. Figure 9) has a pin stand 309 combined with a bench wall 305 protruding into the winding space of a neighbouring coil former 200, while the neighbouring coil former 200 has a single pin stand 204 protruding into the winding space of the coil former 300 first considered. The round corners of both neighbouring winding rooms 297, 397 can be used to complete the requested creep age in the region of bench insulation skipping. The role of bench insulation is thus shifted from the one coil former 300 - taking over the bench insulation within all the length of its combined protruding portions - to the neighbouring coil former 200 almost in line to the inner surface of the inner side wall 9 that separates the single protruding pin stand 204 of the coil former 200 from the combined protruding portions of the coil former 300 (see figure 9). In this figure, one single coil former link is displaced in bottom view, with solid lines and numbers describing the really visible portions, and with dotted lines and dotted

encircled numbers depicting the hidden portions.

[0051] By using the inner surfaces of all the inner side walls 9, 10, 11 in the same manner, the transformer insulation arrangement described may in fact contain more than one of these coil former links in any orientation.

[0052] As shown in figure 10 for the case of the bench wall 305, the bench walls such as 225 or 305, or 405 may include a plastic moulded "fill-up" (i.e. a pad-like formation) 323, 329 with outer dimensions less or equal to the corresponding bench wall which is preferably placed onto the bench wall at the opposite side of an adjoining pin stand and which fits exactly into the free space produced by the round corner of the neighbouring coil in the region of the bench insulation skipping.

[0053] As shown in figure 11, the fill-ups in questions may also arranged in pairs 323, 329 while retaining outer dimensions less or equal to the corresponding bench wall which fit exactly into the free spaces caused by the round corners of the neighbouring coil at its lower side.

[0054] Preferably at least one group of at least two coil formers (200, 400) out of said plurality of coil formers (200, 300; 300, 400) may include bench-side protruding portions, like pin stands (204, 403) and/or wall extensions (225, 405) and/or pad-like formations (226, 429) which are directed towards each other, respectively, and surrounds at least one other coil former (300) out of said plurality.

[0055] One of the bench-side protruding portions like the pin stands (204, 403) and/or the wall extensions (225, 405) and/or the pad-like formations (226, 429) may touch each other in the situation of the completely assembled transformer.

[0056] Additionally a horizontal meander link is approached between that wall extensions (225, 405) and pad-like formations (226, 429) which are touching each other in the case of assembly of the transformer and being in parallel to sections of the outer shape of the surrounded windings.

[0057] Further at least one of the bench-side protruding portions which are touching each other in the situation of the completely assembled transformer may be moulded together. It is also possible that all the bench-side protruding portions which are touching each other in the situation of the completely assembled transformer may be moulded together forming a unique part.

[0058] Preferably the pin stands (204, 403) may be augmented by a horizontal tunnel for providing a direct series connection between windings arranged on adjacent coil formers (200, 400).

[0059] At least two coil formers out of that plurality of coil formers may be surrounded by other coil formers of that plurality of coil formers while the adjacent separating end walls of these at least two surrounded coil formers have chamfered end portions on their bench sides, providing a groove and having distally tapered wall portion extending upwards from the unique bench isolation, matching that groove between the bench sides of the facing end walls of that at least two coil formers.

[0060] In the specific embodiment to which figures 3 to 6 refer, the arrangement described herein includes three individual coil formers 200, 300, 400. Typically, the outer coil formers 200, 400 provide the same winding room, while the middle coil former 300 provides a winding room that is almost the sum of the winding rooms of the both outer coil formers.

[0061] Preferably, the two outer coil formers 200, 400 have almost the same shape, but mirrored along that plane which would be represented by the notional intermediate plane of a core consisting of two equal halves. Similarly, the middle coil former 300 has a shape that is almost symmetrical along that plane which would be represented by the notional intermediate plane of a core consisting of two equal halves.

[0062] It will be appreciated that each individual coil former has only two pin stands 203+204; 306+309; 403+404, on both sides of its winding chamber and both pin stands are preferably located directly opposite to each other on at least the middle coil former 300.

[0063] At least one of the outer coil formers (see e.g. the coil former 400 of Figure 4) uses the free space left by the not-used single-in-lined pin stands (406 ... 408) along its outer lower flange wall 415 to produce a very smooth wire outlet between the inner side of the corresponding coil and the outer pin stand 404. In another version of that arrangement, at least one of these single-in-line pin stands is used in the place of or together with other pin stands 203+204, 403+404, to achieve an optimal fitting of the wire outlets to the traces layout on the circuit supporting substrate (PCB) and/or to provide the wire outlets necessary for a winding system comprising more than one coil.

[0064] In the exemplary three-coil arrangement considered here, two bench walls are typically present. They are preferably both carried by the middle coil former 300, protruding outwards; alternatively they are carried each by one of the outer coil formers, protruding inwardly of the transformer.

[0065] In the exemplary three-coil arrangement considered here, both outer coil formers 200, 400 carry identical coils belonging to the same winding system, and the middle coil former 300 carries the opposite winding system.

[0066] The coils of the outer coil formers can be connected in parallel, e.g. via conductive strips on a common circuit supporting substrate (PCB), using these paralleled coils for example as output of an extreme step-down transformer or as input of an extreme step-up transformer: "extreme" is a current designation for transformers having a transforming ratio of about ten or higher.

[0067] Alternatively, the coils of the outer coil formers are connected in series, again e.g. via conductive strips on a common circuit supporting substrate (PCB), using that series of coils for example as output of a moderate step-down transformer or as input of a moderate step-up transformer: "moderate" is a current designation for transformers having a transforming ratio of less than ten,

typically about four.

[0068] In practical experiments carried out by the Applicant the leakage inductance of a transformer as described herein has been fixed in a desired region (e.g. 13...17 mH * VA) by acting - in a manner known per se - on the winding directions and orientations, by adjusting the insulation barriers, and by judicious sorting of the windings and the pins, respectively. Similarly, these experiments have involved optimising the transformer for minimum radiated and/or conducted electromagnetic noise emission. This again was achieved by acting - in manner known per se - on the winding directions and orientations and by sorting of the windings and the pins, respectively, thus reducing the RFI of the whole circuit and/or the effort necessary for the RFI filtering, e.g. the filtering between secondary and primary side of the whole circuit.

[0069] The arrangement described herein enables the economical, reliable, modular, and reproducible mass production of transformers with more than two hermetically insulated winding chambers.

[0070] The advantages of a disc structure - a lower cross-winding capacitance and a higher leakage inductance - have been combined in such a transformer. The presently preferred embodiment in the form of a symmetric three-chamber winding structure leads to a number of significant advantages. These include i.a. a significant reduction of the proximity losses within the coils, the flux equilibrium within the core which nulls the magnetic field in the outer leg(s) of the core and thus reduces the core losses, and the higher quality factor of the leakage inductance (up to 70) due to the symmetrical field distribution which enables said transformer to be used as real resonance inductor for soft-switching circuits.

[0071] Finally, a symmetrical three-chamber disc transformer as described herein is symmetrical also in respect of parasitics: the ohmic resistances of two the "halves" of the one winding (coil) are equal, and the cross-winding capacitance from each of these "halves" to the second coil is equal. This is due both to the same winding diameters - thus the same wire lengths - and to the sorting of the wires within each "half" coil.

[0072] Figure 12 is a schematic representation of a preferred arrangement that may be adopted in connection with any of the coil formers 200, 300, and 400. Specifically, the coil former 400 is shown in figure 12 as being provided with pin stands 406, 404 in the form of clamp-like formations. While only two of these stands are actually used in the embodiment shown, these clamps may be in any number (e.g. four, as shown, with the empty clamps 407 and 408) depending on the number of ends of the winding wound on the relative coil former.

[0073] In the example shown, the winding 490 wound on the coil former 400 has two winding ends 484, 486. These are simply clamped in the pin stands 404, 406 and can be easily reinforced (e.g. by applying a solder mass onto them) to form winding pins of sufficient rigidity to permit direct insertion in the receiving holes provided in

the mounting substrate (PCB) for the transformer.

[0074] The arrangement shown in figure 12 is particularly effective when the winding wound on the relative coil former is comprised of Litz wire or a braid of wires.

[0075] Consequently, without prejudice to the underlying principles of the invention, the details and embodiments may vary with respect to what has been described and shown, by way of example only, without departing from the scope of the invention, as defined by the annexed claims.

Claims

1. A transformer including a plurality of windings (290, 390, 490) wound on an insulating bobbin, **characterized in that:**

- said bobbin includes a plurality of coil formers (200, 300; 200, 300, 400), each said coil former having at least one respective winding (290, 390; 290, 390, 490) wound thereon,
- each said coil former (200, 300; 200, 300, 400) includes two separating end walls (212 ... 215; 312 ... 315; 412 ... 415) providing insulation of said at least one respective winding, and
- at least one of said end walls (214, 215; 314, 315; 414, 415) has a protruding portion (204, 225, 226, 305, 309, 403, 405, 429) extending in correspondence with a neighbouring coil former.

2. The transformer of claim 1, **characterized in that** said protruding portion includes at least one of:

- a wall extension (225, 305, 405) at least partly covering the respective winding provided in said neighbouring coil former, and
- a pin stand (204; 306, 309; 403) for one of said windings.

3. The transformer of claim 2, **characterized in that** said wall extension (305) includes at least one shaped pad-like formation (323, 329) matching the shape of said respective winding provided in said neighbouring coil former.

4. The transformer of claim 2, **characterized in that** said transformer has a mounting bench side and that said at least one wall extension (225, 305, 325, 405) is located at said bench side.

5. The transformer of claim 2 or claim 4, **characterized in that** said at least one wall extension (225, 305, 405) extends substantially orthogonal to the end wall (215, 314, 414) from which said at least one wall extension (225, 305, 405) extends.

6. The transformer of any of claims 2 to 5, **character-**

ized in that said protruding portion includes at least one said wall extension (225, 305, 405) as well as at least one said pin stand (204, 306, 309, 403) forming a one-piece arrangement with said at least one wall extension (225, 305, 405).

7. The transformer of claim 6, **characterized in that** said at least one pin stand (204, 306, 309, 403) protrudes from said at least one wall extension (225, 305, 325, 405).

8. The transformer of claim 2, **characterized in that** at least one of said coil formers (200, 300, 400) includes at least two said pin stands (203, 204; 306, 309; 403, 404) arranged at opposite sides of said respective winding.

9. The transformer of either of claims 2 or 8, **characterized in that** at least one of said coil formers (200, 300, 400) includes at least two said pin stands (203, 204; 306, 309; 403, 404) arranged on the same side of the transformer.

10. The transformer of either of claims 8 or 9, **characterized in that** said at least one coil former (300) is arranged between two adjacent coil formers (200, 400).

11. The transformer of any of the previous claims 2 to 10, **characterized in that** said plurality of coil formers (200, 300; 200, 300, 400) are aligned in a longitudinal direction of said transformer, the transformer having opposite edge sides with respect to said longitudinal direction, and **in that** said pin stands (203, 204; 306, 309, 403, 404) of said plurality of coil formers are at least partially arranged in correspondence with said opposite edge sides of the transformer.

12. The transformer of any of the preceding claims, **characterized in that** the transformer includes a core having a leg (3, 4) defining a longitudinal direction of the transformer and **in that** said plurality of coil formers (200, 300; 200, 300, 400) are arranged side-by-side over said leg (3, 4).

13. The transformer of claim 12, **characterized in that** said plurality of coil formers (200, 300; 200, 300, 400) have a hollow-spindle-like shape with inner tubular wall portions (202, 302, 402) arranged around said leg (3, 4) of said core.

14. The transformer of claim 13, **characterized in that** said tubular wall portions (202, 302, 402) are of an insulating material providing insulation of the respective windings wound on said plurality of coil formers (200, 300; 200, 300, 400) with respect to said common leg of the core (3, 4).

15. The transformer of any of the previous claims, **characterized in that** said bobbin includes an insulating cover cap (100) forming a common insulating structure for said respective windings wound on said plurality of coil formers (200, 300; 200, 300, 400). 5
16. The transformer of claim 15, **characterized in that** said transformer has a mounting bench side, and **in that** said cover cap (100) substantially covers said coil formers (200, 300; 200, 300, 400) with the exception of said mounting bench side. 10
17. The transformer of either of claims 15 or 16, **characterized in that** said cover cap (100) includes wall portions (22 ... 31) extending towards said coil formers (200, 300; 200, 300, 400) and forming labyrinth formations with said end walls (212, 213; 312, 313; 412, 413) of said coil formers. 15
18. The transformer of any of claims 15 to 17, **characterized in that** said coil formers have base portions carrying pin stands (203, 204; 306, 309; 403, 404) for said respective windings wound on said plurality of coil formers (200, 300; 200, 300, 400) and **in that** said cover cap (100) includes partitioning walls (9 to 18) surrounding said pin stands to provide insulation between the pin stands of the respective windings wound on different coil formers of said plurality. 20 25
19. The transformer of any of claims 15 to 18, **characterized in that:** 30
- said coil formers have base portions carrying pin stands (203, 204; 306, 309; 403, 404) for said respective windings wound on said plurality of coil formers (200, 300; 200, 300, 400), 35
 - said coil formers (200, 300; 200, 300, 400) have associated a common transformer core (3, 4), and
 - said cover cap (100) has a central portion (20, 21, 22, 23, 24, 25) surrounding said plurality of coil formers (200, 300; 200, 300, 400) providing insulation between said coils (290, 390, 490) and said core (1, 2) together with the lateral free space, and has a shoulder wall (19) supporting a transformer core (1, 2) and providing insulation between said core (1, 2) and said pin stands (203, 204; 306, 309; 403, 404). 40 45
20. The transformer of claim 19, **characterized in that** said cover cap (100) includes peripheral skirt walls (5, 6, 7, 8) extending from said shoulder wall (19) down to said bench of the arrangement and surrounding said pin stands (203, 204; 306, 309, 403, 404) associated with said coil formers (200, 300; 200, 300, 400), providing insulation between these pin stands and the lateral free space. 50 55
21. The transformer of claim 17, **characterized in that** said wall portions of said cover cap (100) extending towards said coil formers (200, 300; 200, 300, 400) are generally distally tapered and said end walls (212, 213; 312, 313; 412, 413) of said coil formers include chamfered end portions matching said wall portions of the cover cap (100) extending towards said coil formers (200, 300; 200, 300, 400).
22. The transformer of claim 21, **characterized in that** the chamfered end portions of the facing end walls (312, 213; 412, 313) of two adjacent coil formers (200, 300; 300, 400) of said plurality jointly define a groove for receiving a respective wall portions of said cover cap (100) extending towards said coil formers.
23. The transformer of any of the previous claims, **characterized in that** at least one group of at least two coil formers (200, 400) out of said plurality of coil formers (200, 300; 300, 400) includes bench-side protruding portions, like pin stands (204, 403) and/or wall extensions (225, 405) and/or pad-like formations (226, 429) which are directed towards each other, respectively, and surrounds at least one other coil former (300) out of said plurality.
24. The transformer of claim 23, **characterized in that** at least one of the bench-side protruding portions like the pin stands (204, 403) and/or the wall extensions (225, 405) and/or the pad-like formations (226, 429) are touching each other in the situation of the completely assembled transformer.
25. The transformer of claim 24, **characterized in that** a horizontal meander link is approached between that wall extensions (225, 405) and pad-like formations (226, 429) which are touching each other in the case of assembly of the transformer and being in parallel to sections of the outer shape of the surrounded windings.
26. The transformer of claim 24, **characterized in that** at least one of the bench-side protruding portions which are touching each other in the situation of the completely assembled transformer are moulded together.
27. The transformer of claim 26, **characterized in that** all the bench-side protruding portions which are touching each other in the situation of the completely assembled transformer are moulded together as a unique part.
28. The transformer of claims 23 and 26, **characterized in that** said pin stands (204, 403) are augmented by an horizontal tunnel for providing a direct series connection between windings arranged on adjacent coil formers (200, 400).

29. The transformer of claim 26, **characterized in that** at least two coil formers out of that plurality of coil formers are surrounded by other coil formers of that plurality of coil formers while the adjacent separating end walls of these at least two surrounded coil formers have chamfered end portions on their bench sides, providing a groove and having distally tapered wall portion extending upwards from the unique bench isolation, matching that groove between the bench sides of the facing end walls of that at least two coil formers. 5 10
30. The transformer of any of the previous claims, **characterized in that** said plurality of coil formers includes three coil formers (200, 300, 400). 15
31. The transformer of any of the previous claims, **characterized in that** said coil formers includes pin stands (203, 204; 306, 309; 403, 404) for said respective windings wound on said plurality of coil formers (200, 300; 200, 300, 400) and **in that** at least one of said coil formers includes guiding grooves for the end portions of the respective winding wound thereon. 20 25
32. The transformer of any of the previous claims, **characterized in that:**
- at least one (400) of the coil formers of said plurality (200, 300; 200, 300, 400) includes pin stands (404, 406) for said respective winding wound thereon, said pin stands (404, 406) being in the form of clamp-like formations, and 30
 - said respective winding (490) has winding ends (484, 486) clamped in said pin stands (404, 406) in the form of clamp-like formations. 35
33. The transformer of claim 32, **characterized in that** said respective winding (490) is comprised of a wire selected out of Litz wire and a braid of wires. 40

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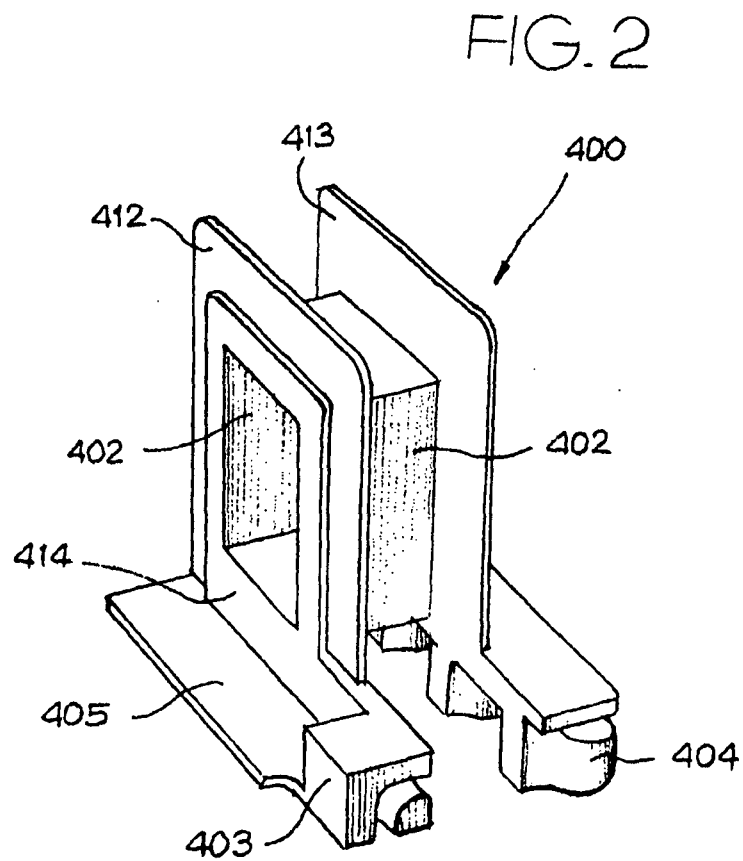
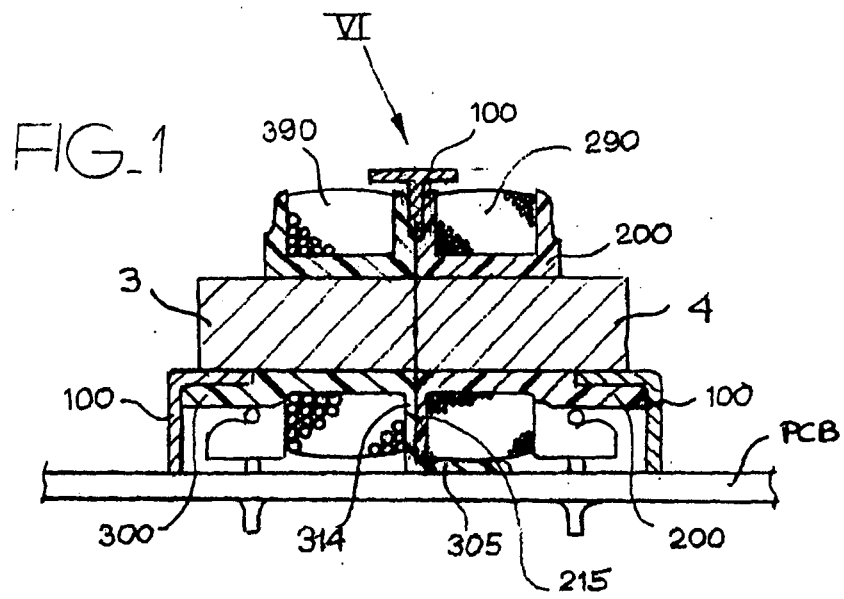


FIG. 3

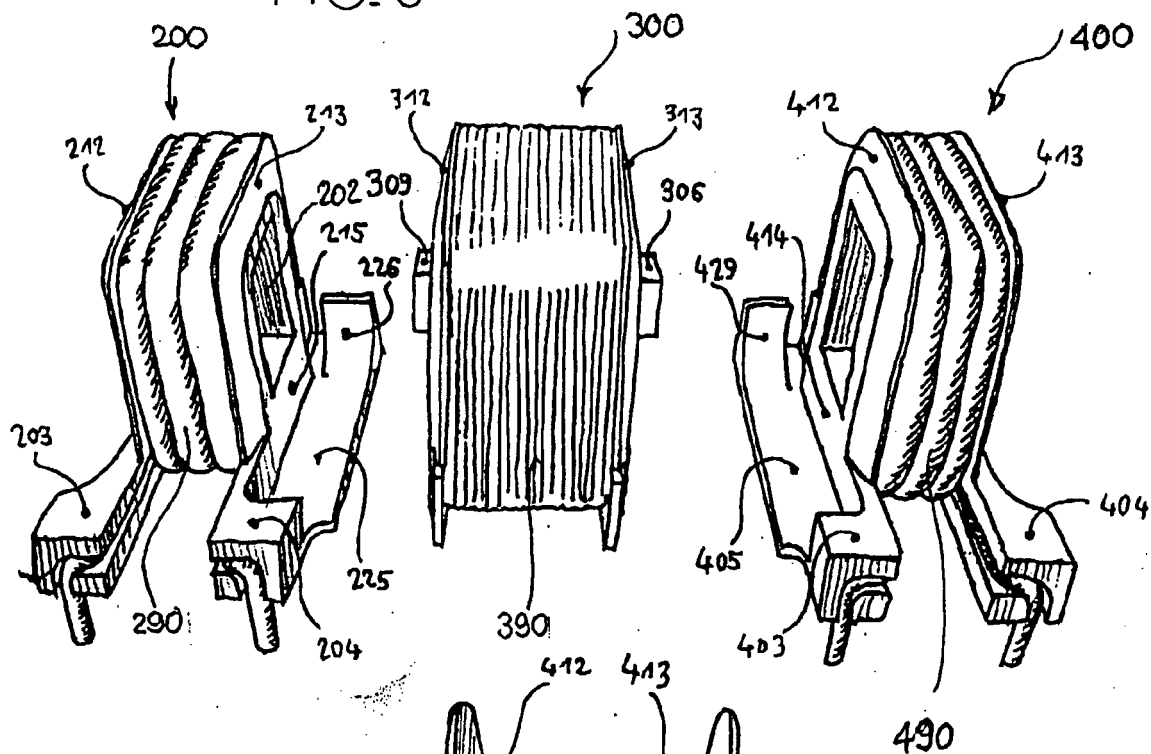


FIG. 4

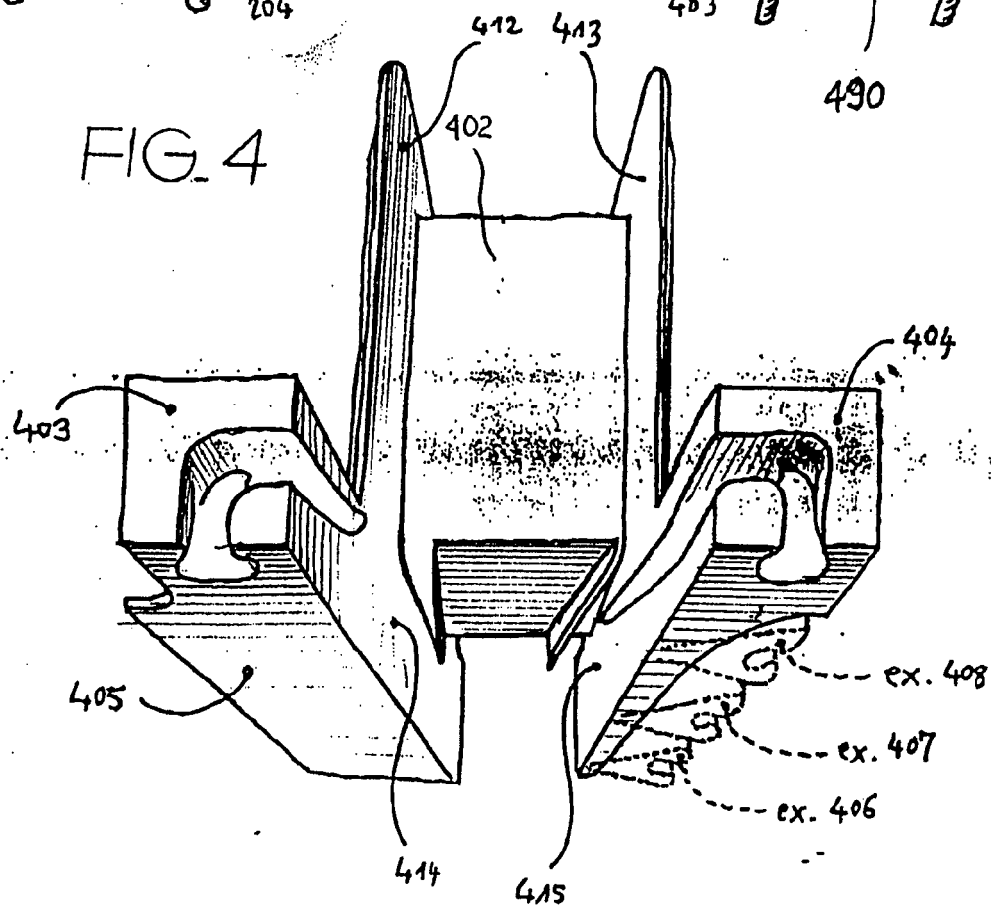


FIG. 5

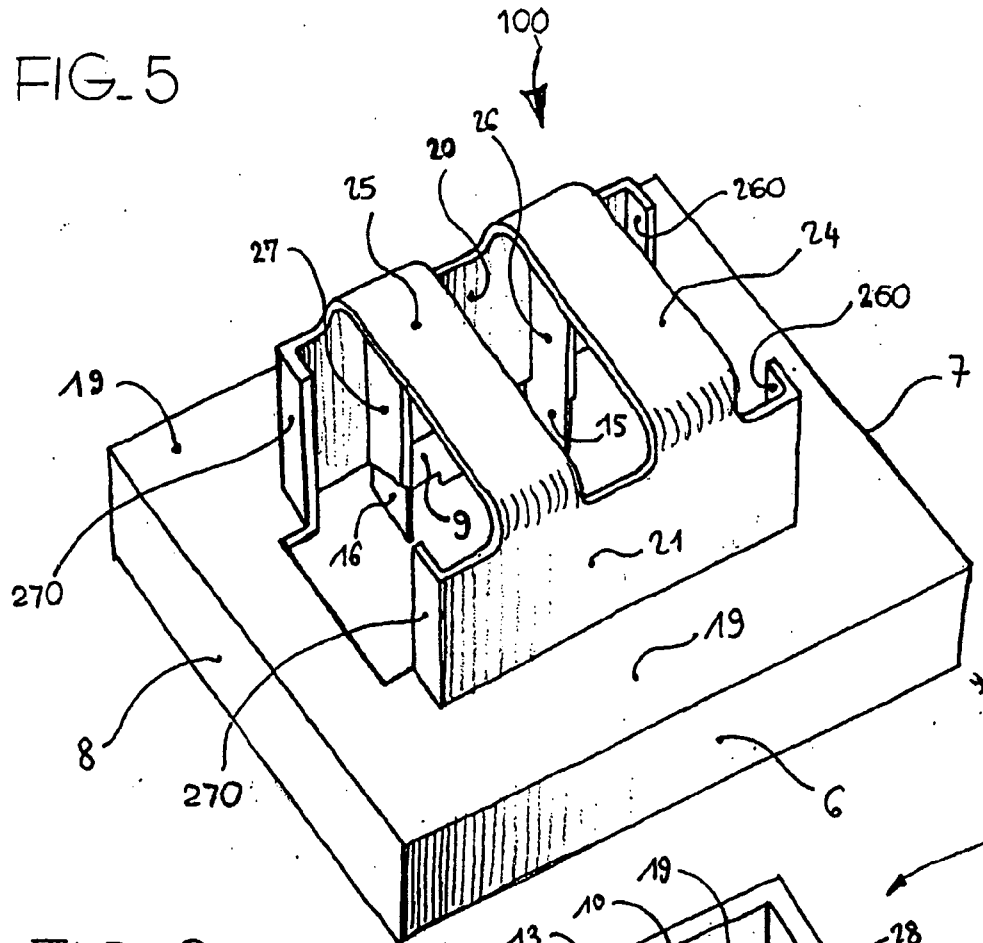


FIG. 6

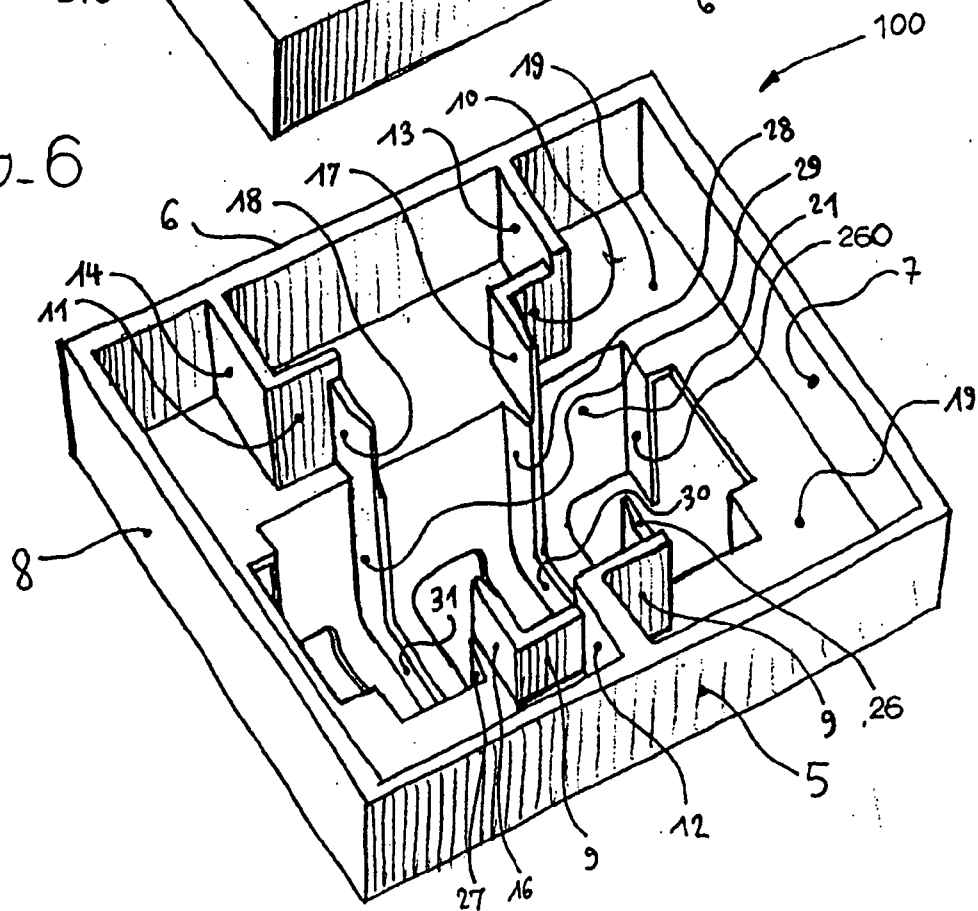


FIG. 7

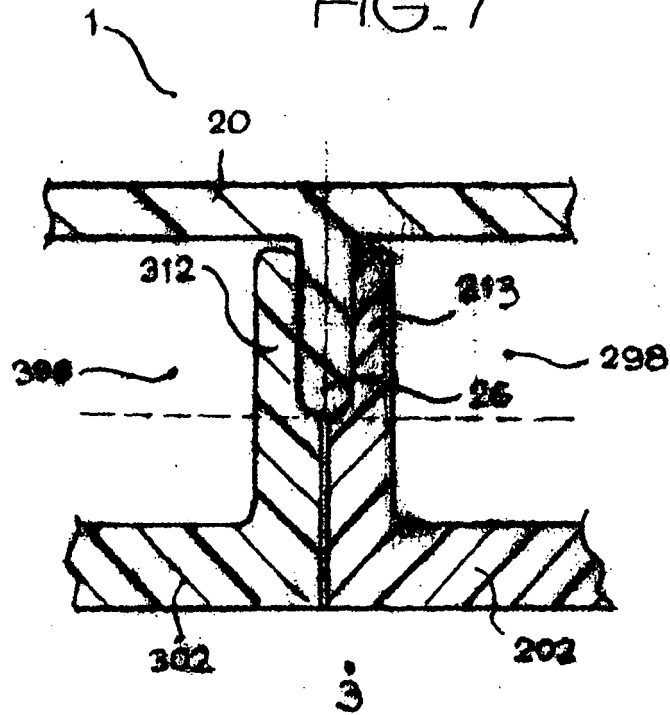
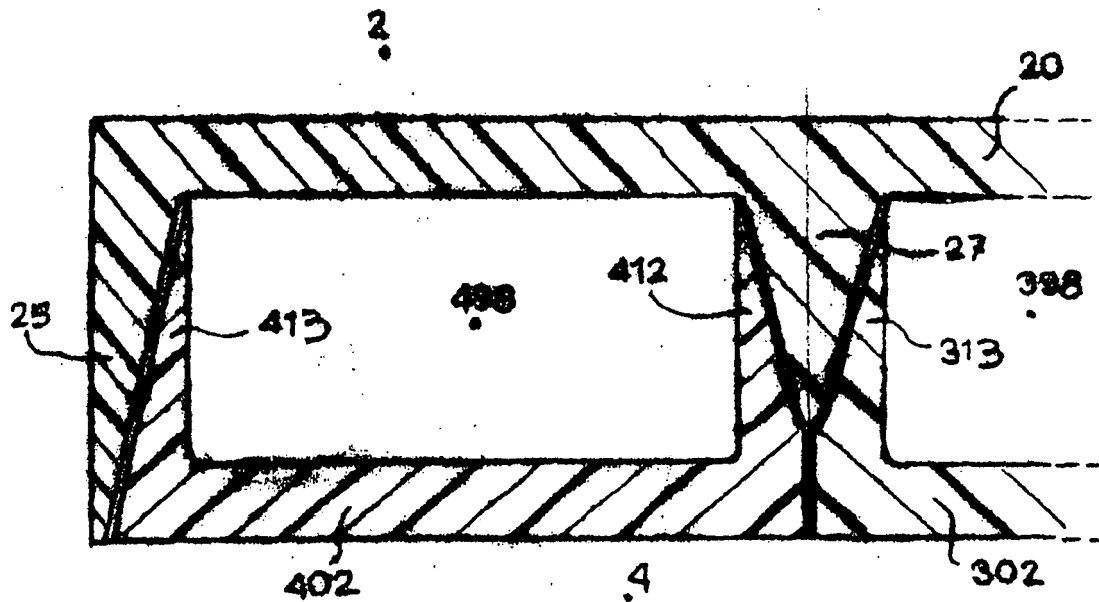


FIG. 8



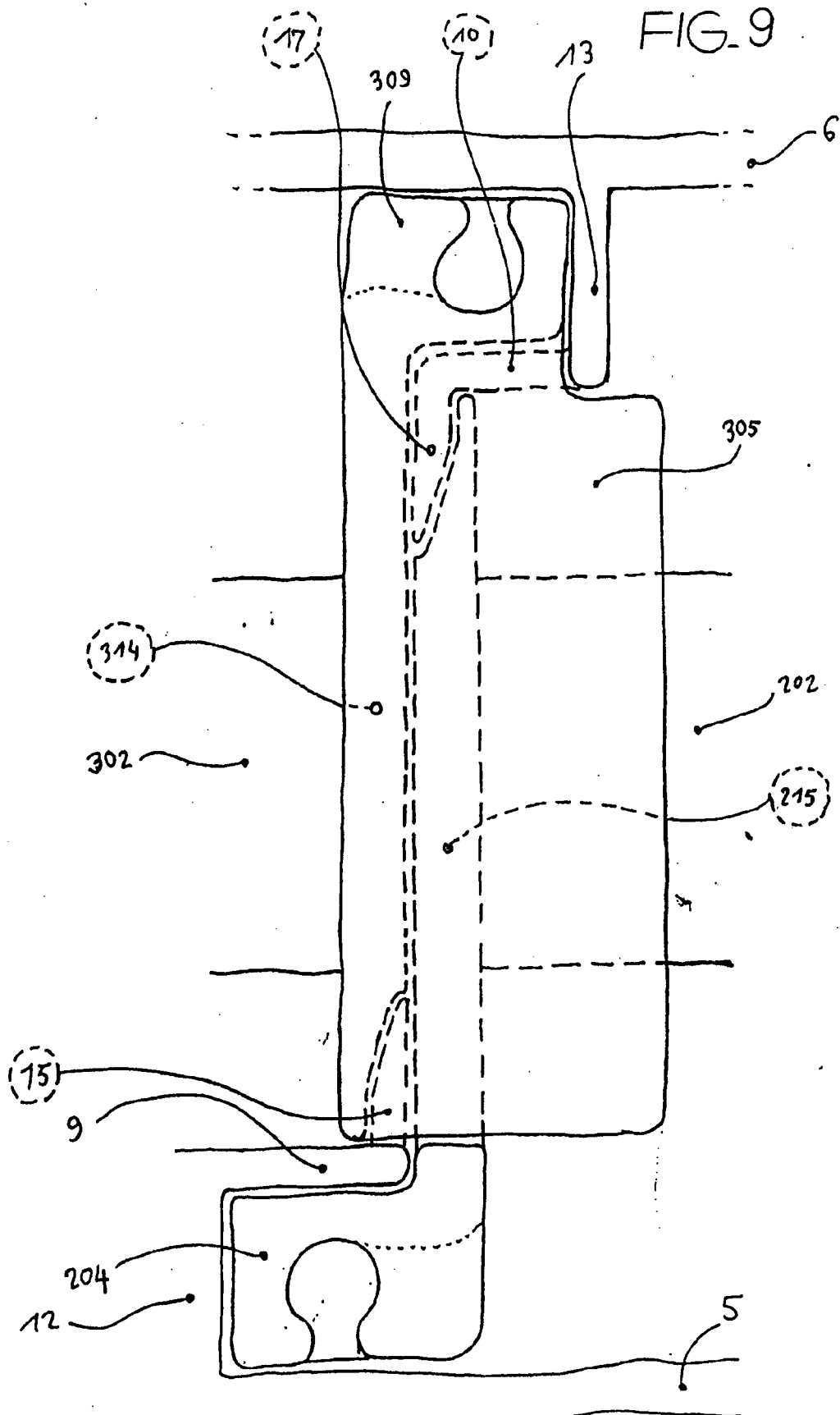


FIG. 10

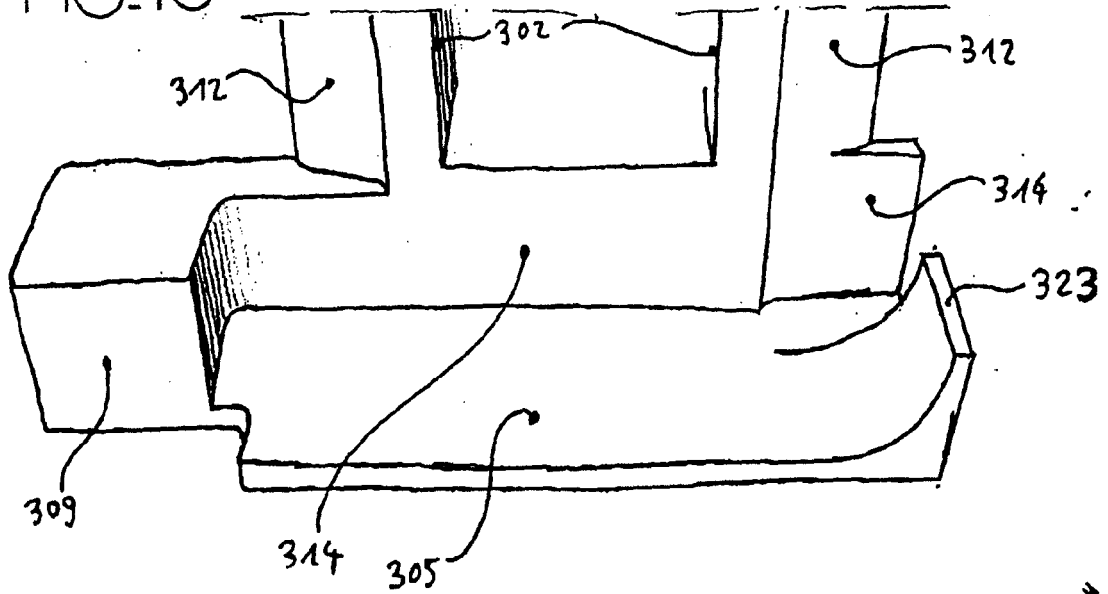


FIG. 11

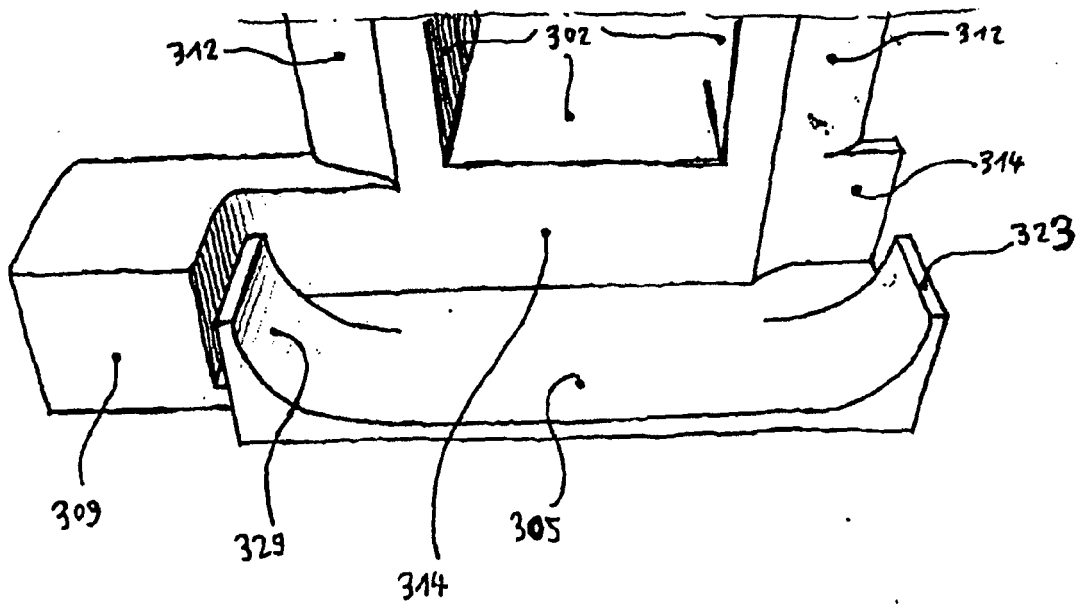
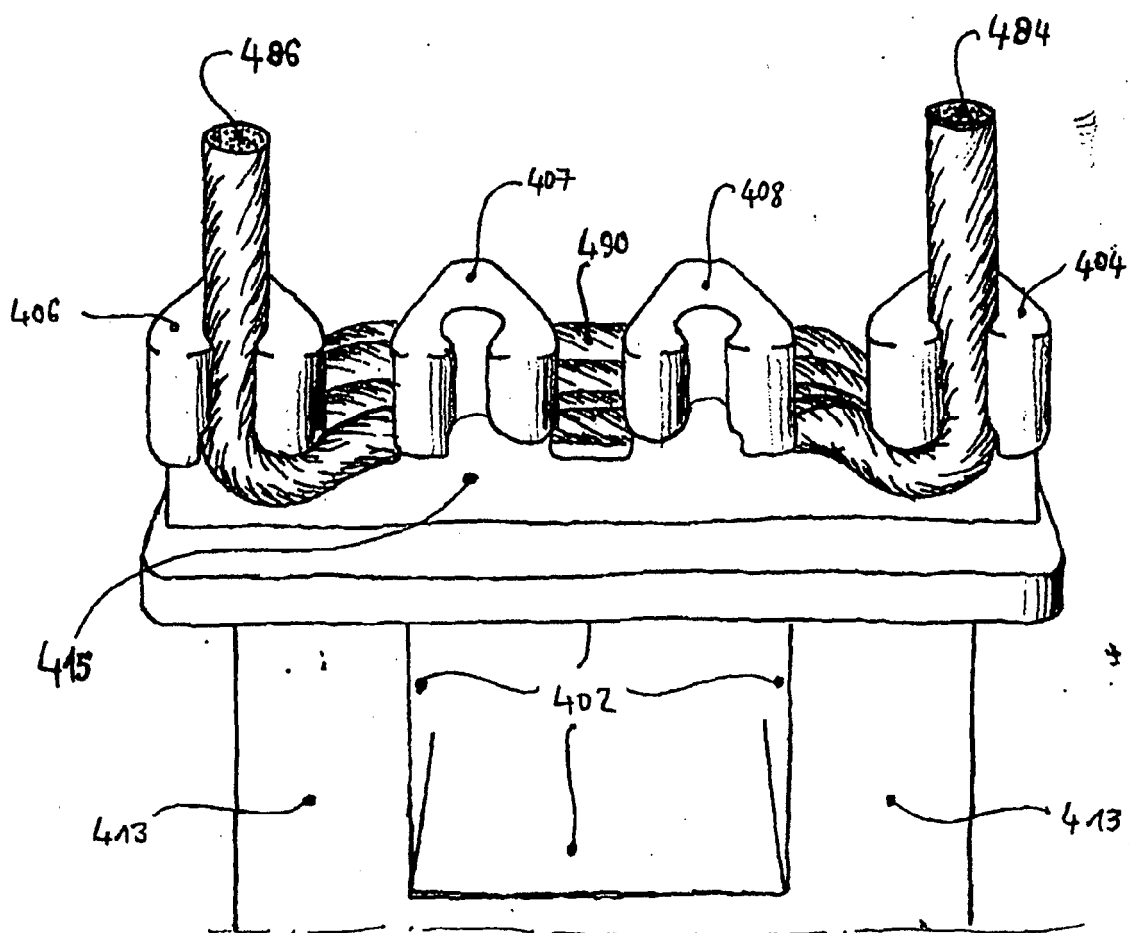


FIG. 12





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 00 3265

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 534 839 A (MACKIN ET AL) 9 July 1996 (1996-07-09)	1-12, 15-18, 21,22, 30-33 13,14,19	INV. H01F5/02 H01F27/32
A	* claims 1,2,5-7 * * column 3, line 53 - line 64 * * figures 1-3 * -----		
A	US 4 250 479 A (BAUSCH, JAMES F ET AL) 10 February 1981 (1981-02-10) * claim 1 * * figures 1,4 * -----	1,2,4-6, 8,10-17, 19,30-32	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 May 2006	Examiner Stichauer, L
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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22-05-2006

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