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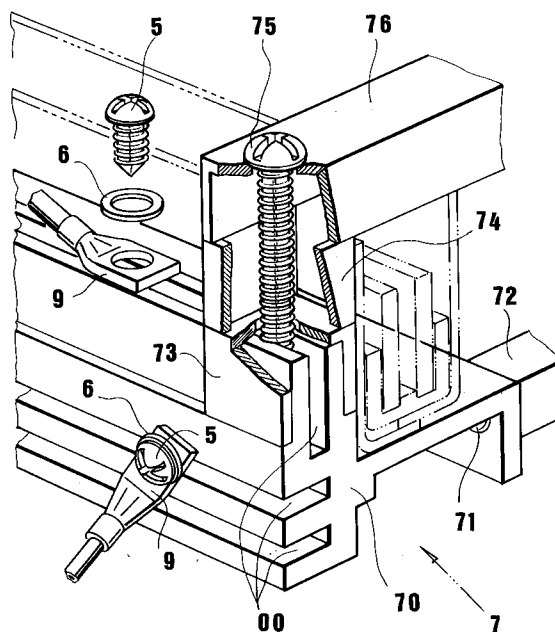
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(54) **Process and means to provide bus bar distribution systems, wherein each bus bar unit comprises more uniform cross-section components, set to receive, anywhere, therealong, a number of terminals and the like, limited only by the principle of impenetrability of bodies.**

(57) Conductor (1, 1', 2) and non-conductor (3,3) components, have uniform cross-section. The nominal cross-section, including two single interspaced bars (1, 1') provides a channel (101) with two parallel opposed walls (10, 10'), set at such a distance ($2r - 2h$) to receive screws (5), particularly self-tapping screws, cutting their own thread (5', 5') into the same walls (10, 10'), whereby terminals (9) can be connected and an elastic strain (T_e) is provided, to prevent unscrewing. Each bar unit comprises five components (1, 1', 2, 3, 3), three of which (1, 1', 2) are conductor and two (3, 3) non-conductor., wherein the centrifugal components (2, 3), act as encompassing members. The ensemble (3, 01, 3,3, 02, 3,3, 03, 3,3, 04, 3) is bound by a frame (7) including longitudinal rods (70, 70') with grooves (00), for fastening grounded conductors terminals (9).

FIG. 5

The present invention relates to a process and means to provide bus bar distributing systems, wherein each bus bar comprises more uniform cross-section components, set to receive, anywhere, therealong, a number of terminals and the like, limited only by the principle of impenetrability of bodies.

At the present state of the art, the bus bars of distributing and/or collecting electrical energy, providing for the connection of terminals and the like, are individual and are rectangular in cross-section. Generally, the longer side of their rectangular cross-section is from three to six times as longer as the shorter side thereof. Such rectangular cross-section bars are drilled and tapped with mating threads, through their main surfaces, to receive the machine screws for terminal and connection fastening. When the number and assignment of such terminals and/or connections is known, the tapped holes are provided correctly, in number and position. Instead, when use and density of connections or terminals are unknown, the holes are provided according to an estimated modular rule, and more frequently, in accordance with a statistical probability. Of course, in the latter case, holes are provided in excess, with the drawback that boring and tapping involve additional costs, while the cross-section, of the bored bar lengths result reduced. Such reduction, of course, is inversely proportional to bar thickness. Moreover, the thinner the bar is, the least safe is the screw and terminal holding, due to the scarce number of threads which can be provided, and this drawback is unavoidable. Since bar conductivity of a bar does not depend only by its cross-section but even by its heat dissipation power, rectangular cross-sections are preferred. However another drawback of rectangular cross-sectioned bars, mainly of those having a high base/height side ratio, is to be cumbersome, not only for having a wider width, but even due to the air gap to be provided between bars for reasons of fault resistance. Moreover, contact between a terminal and a bar occurs substantially in three spots, among which the pressure provided by the screw is shared, and the screw, substantially never is a self-tapping screw but a conventional screw or bolt, as such not adapted to prevent unscrewing. Thus, it is necessary to provide an additional nut, both in case of screws or bolts; in no case, the friction between the screw or bolt thread and its tapped holes and/or nut are safe, as in the case of self-tapping machine screws, making their own thread in the bar into which are driven.

The invention as claimed is intended to remedy these drawbacks. The inventor, with ingenious perception, has conceived a process to provide bus bar distribution systems, comprising the provision of a system unit, made of conductor and non-

conductor components, having uniform cross-section, wherein the bus bars of conductor material of nominal cross-section, being taken in pairs, provide at least a channel, having the opposed, parallel facing walls which are set at such a distance to receive, into their chest, a screw, particularly self-tapping screw, having features mutually adapted to cut its thread in such opposed walls of the channel, providing, at the same time, a permanent elastic strain (T_e) on the structure, operating, at least locally, on the screw, substantially in accordance with the following formula:

$$T_e = M_e \cdot D; \text{ being: } D = n \cdot S \cdot R + F_b \cdot \tan \alpha$$

wherein:

- F_b = Screw (maximum) holding power;
- T_e = Elastic strain;
- M_e = Elastic module (of the outer holding material);
- D = Deformation;
- S = Deformed cross-section;
- n = Number of threads concerned;
- R = Conductor material strength;
- α = Thread inclination.

In practice each bar unit comprises more uniform cross section components, set to receive, anywhere, therealong, a number of terminals and the like, limited only by the principle of impenetrability of bodies. The more uniform cross-section components, comprising each bar unit, provide at least two parallel walls, whose distance therebetween is such to engage together any self tapping screw, which cuts its own thread in said walls, when driven into said interwall groove, self-jamming therewith.

In accordance with a preferred embodiment of the present invention the uniform cross-section components, substantially comprising each bar unit, are five, three of which are electric conductors and two are non-conductors. Two of the three conductor components, the bus bars, provide the parallel walls which can be engaged by the screws, fastening the terminals and the like; the third conductor component and the non-conductor components, act as encompassing members. Noteworthy, the conductor component is in centripetal position, in touch with the single bars or parallel walls, which can be engaged by the screws, fastening the terminals and the like and the non-conductor components, having "L" like cross-section, are in centrifugal position which is complementary to that of the encompassing conductor component; the former component is a channel, which is provided, at the centre of its bottom, with a separating rib, providing, at its sides, a pair grooves, to receive the single conductor bars. The paired parallel single bars, set with the longer side in vertical disposition, minimizes the overall dimensions thereof,

while their surface area results increased. Insulation is provided by components of higher height, which are arranged in stepped fashion and extend over the single bars. They are placed at least at one side, or on both side in case of adjacent bar units, to provide here too, mainly in vertical direction, the necessary dielectric distance, with a minimum of overall dimensions.

Of course, the cross-section of the conductor encompassing component is additional to the cross-section of the single bars, to provide, *coeteris paribus*, a compacted ensemble.

Regarding the holding power or mutual coupling between the fastening screws of terminals and the like and the single bars or parallel walls engageable thereby, the following equation must be fulfilled:

$$F_b = L \cdot S \cdot R_m$$

wherein:

- F_b = Screw (maximum) holding power;
- L = Height concerned;
- S = Cross-section concerned, i.e., area of two segments;
- R_m = Material (specific) strength.

In accordance with a preferred embodiment of the present invention, of the same principle of the invention may take advantage even the structural enveloping arrangement.

In practice, in accordance with a preferred embodiment of the present invention, for provision of each bus bar unit, of the cross-section between 200 and 800 mm², two single bars of copper between mm 5 x mm 20 and mm 5 x mm 80 contained by an aluminium channel rod length of the dimensions of mm 17,5 x mm 20 x mm 2,5, are provided. Thus the single bars, standing with the short side of the rectangular cross-section against the inner bottom of the channel, are fit aside the rib, in order to provide their adjacent main surfaces parallel, at a distance of mm 5. This distance is correct to receive any so said "Parker" screw or equivalent, having an outer diameter of mm 6,3, and a length between 20 mm and 40 mm, i.e. shorter than the corresponding dimension of single bars. Such screws, are duly provided with lock washers and applied to terminals and the like, whereby they cut their own thread into the single bars of copper, along an height L concerned between mm 18 and mm 38. The so fastened terminal, provides a contact in at least four spots, with a conductivity increase of about 80%. An attempt was made to force the screw, in order to strip the copper thread, cut into the copper single bars. This took place when the force applied was at least three or four times as much as the usual fastening force. Thereupon, the same screw was driven in

again, at a distance between 5 and 7 mm from the stripped thread and the same result was obtained, with an equivalent fastening. It will be appreciated that assembling uniform cross-section components, substantially available on the market, bus bar units, to which terminals and the like, at will, may be connected, anywhere, at any time, without any preparation, by self-tapping screws, also them available on the market. Moreover, the normal fastening of the screw, results in creation of suitable threaded segments, accompanied by seizing up of the screw coupling as well as a structure straining, which relieves the effect of vibrations, to prevent unscrewing.

In accordance with another preferred embodiment of the present invention, to confer structural strength to the system of bar units, a binding frame is provided substantially comprising two "Y" like uniform cross-sectioned rod components, fit longitudinally, which are a materialization too, of the principle of the present invention, being adapted to receive self-tapping screws in any cross-section thereof. This arrangement is very important also from the electric point of view, since as material, one with a good conductivity, such as aluminium, is chosen, to be adapted to connect, by self-tapping screws, driven into the more grooves, of which they are provided, the grounded terminals. With the same means and taking advantage of the same principle, the rods with uniform cross-section, providing the binding structure, can be connected, crosswise, at the bottom by screws, i.e., self-tapping screws, engaging the ends of a distancing rod, it too comprised by uniform cross-section rods. In the upper side the structural components rods are connected through staples, thickness, self-tapping screws and bridges, all of them, except the screws, comprised by uniform cross-section rods.

For fastening together the conductor components, to provide each bus bar unit, they are joined by pins.

One way of carrying out the invention is described in detail below with reference to drawings which illustrate only one specific embodiment thereof, in which:

Figure 1 is a perspective, schematic view, of a set of four bar units, wherein, at one end thereof, breakings have been made for showing, at different levels, the details otherwise hidden.

Figure 2 is a perspective, detailed, view, in an enlarged scale, of a terminal fastened to a pair of single bars, in accordance with the present invention.

Figure 3 is a scheme of principle, with two positions, indicating the strain characteristics of the device in accordance with the present invention, in two cases: the former in screwing attitude (left side half) and the latter showing the

finally fastened screw (right side half).

Figure 4 is an exploded, perspective, view of a half frame (right side) embodying the principle of the present invention and comprising a particularly advantageous and generic container, for a bar unit system of the subject kind.

Figure 5 is an assembled, perspective view of a (left side) half frame similar and complementary to that shown in Figure 4.

Referring now to the drawings, in particular to Figure 3, in accordance with the present invention, a system unit is made of conductor(1, 1', 2) and non-conductor (3,3) material components all of uniform cross-section. The conductor material, providing the nominal cross section, provides at least a channel (101) having the opposed parallel walls (10, 10'), which are set at such a distance ($2r - 2h$) to receive in their chest, a screw, particularly self-tapping screw (5), having mutually such features to engrave and cut the thread (5', 5') into such opposed walls (10, 10') of the channel (101), providing at the same time a permanent elastic strain (Te) on the structure, operating at least locally, on the screw (5), substantially in accordance with the following formula:

$$T_e = M_e \cdot D; \text{ being } D = n \cdot S \cdot R + F_b \cdot \tan \alpha$$

wherein:

- Fb = Screw (maximum) holding power;
- Te = Elastic strain;
- Me = Elastic module (of the outer holding material);
- D = Deformation;
- S = Deformed cross-section;
- n = Number of threads concerned;
- R = Conductor material strength;
- α = Thread inclination.

In practice, e.g., to provide bus bar distributing systems, as shown in the drawings, four units 01, 02, 03, 04 are provided. Each bus bar unit comprises more component rods 1, 1', 2, 3, 3, all of them having uniform cross-section, set to receive, anywhere, therealong, a number of adjacent terminals 9 and the like, limited only by the principle of impenetrability of bodies. The more uniform cross-section rod components 1, 1', 2, 3, 3, comprising each bar unit 01, 02, 03, 04, satisfy at least the condition of providing two parallel walls 10, 10', at a distance d, corresponding to the width 2', such as to engage self-tapping screws 5, which, when driven in the interwall groove 101, engrave the two opposed walls 10, 10', self-seizing therewith.

The uniform cross-section components, substantially comprising each bar unit 01, 02, 03, 04, in accordance with the shown embodiment, are five 1, 1', 2, 3, 3. Three of them: 1, 1', 2, are conductors and two, 3 non conductors. The two conductor

components 1, 1' provide the parallel walls 10, 10', which can be engaged by the screws 5, fastening the terminals and the like and the third conductor component 2, and insulator components 3, provide encompassing functions: the conductor member 2 is in centripetal position, in touch, even through the rib 2', with the single bars 1,1' or parallel walls 10, 10' which can be engaged by the screws 5, fastening the terminals 9 and the like; the insulator components 3 are in centrifugal position which is complementary to that of enveloping conductor component 2; the former 2 having "U" or "C" or channel like cross-section, the latter 3 having "L" like cross-section. The arrangement of the single bars 1, 1', parallel, paired with the longer side 10, 10' in vertical disposition, minimizes the overall dimensions thereof, while the conducting area is increased. The insulation space between bar units 01, 02, 03, 04, is provided by components 3 of higher height; they are coupled in stepped conditions and project from the upper side of single bars 1, 1'; they are fit paired to adjacent bar units 01, 02, 03, 04, to provide here too, mainly in vertical direction, the necessary dielectric distance with minimum overall dimensions. Of course the cross-section of the enveloping conductor component 2 is additional to the cross-section of the single bars 1, 1' to provide, *coeteris paribus* a compacted unit.

Regarding the holding power or mutual coupling between the fastening screws 5 of terminals 9 and the like and the single bars 1,1' or parallel walls 10,10' engageable thereby, the following equation must be fulfilled:

$$F_b = L \cdot S \cdot R_m$$

wherein:

- Fb = Screw (maximum) holding power;
- L = Height concerned;
- Rm = Material (specific) strength;
- S = Cross-section concerned i.e., area of two segments;

The cross-section concerned i.e., the area of two segments, is mathematically given by:

$$S = 2 \cdot 0,5 [rl - c (r-h)] \text{ wherein:}$$

- r = radius of the circle segment;
- l = arc length of circle segment;
- c = chord subtending the circle segment arc;
- h = arc height of the circle segment;

In practice, in accordance with the preferred embodiment of the present invention, shown in the drawings, the following example may be given:

EXAMPLE I

For provision of each bus bar unit 01, 02, 03,

04, of the cross-section of 200 mm², were used two copper rectangular single bars 1, 1', of mm 5 x mm 20, contained by an aluminium channel rod 2, of the dimensions of mm 17,5 x mm 20 x mm 2,5, whose inner bottom 2'', 2''' is provided with a central rib 2', which is mm 5 width and mm 3 height. Thus the single bars 1, 1', standing with the short side of the rectangular cross-section against the inner bottom of the channel rod 2, are fit, respectively into the grooves 2'', 2''', aside the rib 2', in order to provide their adjacent main surfaces 10, 10', parallel at a distance corresponding to that of rib 2' i.e., of mm 5. This distance is correct to receive any of so said "Parker" screws 5 or equivalent, having an outer diameter of mm 6,3, and a length of 20 mm, i.e. shorter than the corresponding dimension of single bars 1, 1'. Such screws 5, are duly provided with lock washers 6 and applied to terminals 9 and the like, in order that the same screws 5 cut their own thread into the single bars 1, 1' of copper, along an height L concerned of mm 18. The so fastened terminal 9, provides a contact in at least four spots 09, with a conductivity increase of about 80%. An attempt was made to force a screw 5, in order to strip its matching copper thread 5' it cut thereinto. This took place when the force applied was at least three times as much as the usual fastening force. Thereupon the same screw 5 was driven into again at a distance of mm 5 from the stripped thread 5' and the same results were obtained with an equivalent fastening.

EXAMPLE II

For provision of each bus bar unit 01, 02, 03, 04, having a cross-section of 500 mm² were used two copper rectangular single bars 1, 1', of mm 5 x 50, contained by an aluminium channel rod 2, of the dimensions of mm 17,5 x mm 20 x mm 2,5, whose inner bottom is provided with a central rib 2', which is mm 5 width and mm 3 height. Thus the single bars 1, 1', standing with the short side of the rectangular cross-section respectively on the bottom 2'', 2''' of the grooves siding the rib 2' of channel rod 2, in order to provide their adjacent main surfaces 10, 10' parallel at a distance corresponding to that of rib 2' i.e., of mm 5. This distance is correct to receive any of so said "Parker" screws 5 or equivalent, having an outer diameter of mm 6,3, and a length of mm 40, i.e. shorter than the corresponding dimension of single bars 1, 1'. Such screws 5, are duly provided with lock washers 6 and applied to terminals 9 and the like, in order that the same screws 5 cut their own thread into the single bars 1, 1' of copper along an height L concerned of mm 35. The so fastened terminal 9, provides a contact in at least four spots 09, with a conductivity increase of about 80%. An

attempt was made to force the screw 5, in order to strip its matching copper thread 5' it cut thereinto. This took place when the force applied was at least four times as much as the usual fastening force. Thereupon the same screw 5 was driven into again at a distance of mm 7 from the stripped thread 5' and the same results were obtained with an equivalent fastening.

It will be appreciated that the ensemble 3, 01, 3,3, 02, 3,3, 03, 3,3, 04, 3 is bound with an annular frame 7 comprised by a pair of uniform cross-section rod lengths 70, 70', having, in general, a "Y" like cross-section, connected crosswise, at the bottom by screws, i.e., self-tapping screws 71, 71', engaging the ends of a distancing rod 72, it too comprised by uniform cross-section rods. Instead, in the upper side, the structural components rod lengths 70, 70' are connected through staples 73, thickness 74, self-tapping screws 75 and bridges 76, all of them, except the screws 75, being comprised by uniform cross-section rods. Even for the rod components 70, 70', 72, i.e. for all connections 9, all over the whole system, they may be made anywhere, limited only by the principle of impenetrability of bodies. In fact between the fastening screws 5 and the grooves 00 there is the same arrangement than between the fastening screws 5 and channel 101 provided with walls 10, 10' for terminal fastening. As in that case grooves 00 are adapted for grounded conductors terminals 9 (figures 4 and 5) which can be fastened with screws 5. On the contrary the same grooves 00 may be used for structural binding as in the case of screws 71, 71', 75.

For fastening together the conductor components 1, 1', 2, of each bus bar unit, they are joined by pins 8. As regards as the "L" like cross-section rods 3, of dielectric material they are extended in vertical direction well over the top of the single bars 1, 1' and possibly coupled as to provide a step.

Claims

1. Bus bar distribution system, characterized in that is completely comprised by rods (1, 1', 2, 70, 70', 72, 73, 74, 76) of uniform cross-section particularly extruded, connectible mechanically and/or electrically together, to terminals (9) and the like and to structural means (70, 70', 72, 73, 74, 76), by self-tapping screws (5, 71, 71'), wherein substantially all the metal components of uniform cross-section, capable of receiving such self-tapping screws (5), are adapted to receive them, anywhere (101, 00), therealong, even for fastening terminals (9) and the like, in quantity and dimensions, limited only by the principle of impenetrability of bodies.

2. System, as claimed in claim 1, characterized in that, as individual bar unit, comprises a system ensemble, made of conductor (1, 1', 2) and non-conductor (3), uniform cross-section rod components, wherein conductor material bars (1, 1') of nominal cross-section, provides at least a channel (101) having the opposed parallel walls (10, 10'), which are set at such a distance (2r-2h) to receive in their chest, a screw (5), particularly a self-tapping screw, having features adapted to cut their thread (5', 5') into such opposed walls (10, 10') of the channel (101), providing, at the same time, a permanent elastic strain (T_e), on the structure operating at least locally, on the screw (5), substantially in accordance with the following formula:

$$T_e = M_e \cdot D; \text{ being: } D = n \cdot S \cdot R + F_b \cdot \tan \alpha$$

wherein:

F_b = Screw (maximum) holding power;
 T_e = Elastic strain;
 M_e = Elastic module (of the outer holding material);
 D = Deformation;
 S = Deformed cross-section;
 n = Number of threads concerned;
 R = Conductor material strength;
 α = Thread inclination.

3. System as claimed in claim 1, characterized in that the more components (1, 1', 2, 3) having uniform cross-section, comprising each bar unit (01, 02, 03, 04), fulfil at least the condition of providing two parallel walls (10, 10'), at a distance (d), such as to engage self-tapping screws (5) which, when driven in the interwall groove (101), cut (in 5') their own thread sections into the opposed walls (10, 10') self-seizing therewith.
4. System, as claimed in claim 1, characterized in that the components (1, 1', 2, 3, 3) having uniform cross-section, substantially comprising each bar unit, are five (1, 1', 2, 3, 3), three of which (1, 1', 2), conductors and two (3, 3) non-conductors, wherein two (1, 1') of the three (1, 1', 2), conductor provide the parallel walls (10, 10') engageable by the screws (5), to fasten the terminals (9) and the third conductor component (2) and the insulator components (3), act as encompassing members: the conductor member (2) is in centripetal position, in touch with the single bars (1, 1') and components (3), having "L" like cross-section, are in centrifugal symmetrical position, complementary

among them and to conductor encompassing member (2); the latter being a channel, which in centripetal position, in the inner bottom side, is provided with a distancing rib (2') for setting the single bars (1, 1') providing, for each of same, a mortise (2'', 2''').

5. System, as claimed in claim 3, characterized in that the setting of the single parallel paired bars (1, 1') with their longer side (10, 10') in vertical disposition, minimizes the overall dimensions thereof, while the surface area is increased, wherein insulation is provided by rod components (3) of higher height, which are arranged in longitudinal stepped fashion and extend over the single bars (1, 1'), they are placed at least at one side (3), or on both (3) sides in case of adjacent bar units (3, 01, 3,3, 02, 3,3, 03, 3,3, 04, 3), to provide here too, mainly in vertical direction, the necessary dielectric distance, with a minimum of overall dimensions.
6. System, as claimed in preceding claims, characterized in that regarding the holding power or mutual coupling between the fastening screws (5) of terminals (9) and the like and the single bars (1, 1') or parallel walls (10, 10') engageable thereby, the following equation must be fulfilled:

$$F_b = L \cdot S \cdot R_m$$

wherein:

F_b = Screw (maximum) holding power;
 L = Height concerned;
 R_m = Material (specific) strength;
 S = Cross-section concerned i.e., area of two segments; wherein la Cross-section concerned i.e., area of two segments is mathematically given by:
 $S = 2 \cdot 0,5 [r l - c (r-h)]$ wherein:
 r = radius of the circle segment;
 l = arc length of circle segment;
 c = chord subtending the circle segment arc;
 h = arc height of the circle segment.

7. System as claimed in claim 1, characterized in that the ensemble of bar units (3, 01, 3,3, 02, 3,3, 03, 3,3, 04, 3) is bound with an annular frame (7) comprised by a pair of uniform cross-section rod lengths (70,70') having in general a "Y" like cross-section, and in particular, including an "L" shaped section, an "E" shaped section and an "h" shaped section, with three grooves (00) to receive screws

(5), such a pair of rod lengths (70,70') being in turn bound with rod means having uniform cross-section too and with self-tapping screws (71, 75).

- 5
8. System, as claimed in claim 7, characterized in that the rod lengths (70, 70') comprising the annular frame (7) with the grooves (00) are made with good conductor material, such as aluminium, in order that by screws (5), particularly self-tapping screws, terminals (9) of grounded conductors, may be electrically connected, rod lengths (70, 70') being connected crosswise at the bottom by screws, i.e., self-tapping screws (71, 71'), engaging the ends of a distancing rod (72) it too comprised by uniform cross-section rods, instead, in the upper side, the structural components rod lengths (70, 70') are connected through staples (73), thickness (74), self-tapping screws (75) and bridges (76), all of them, except the screws (75), being comprised by uniform cross-section rods.
- 10
- 15
- 20
- 25
9. Bus bar distribution system means, as claimed in preceding claims, characterized in that for fastening together conductor components (1, 1', 2) they are joined by pins (8).
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10. Bus bar distribution system means, as claimed in claim 9, characterized in that the "L" like cross-section rods (3), of dielectric material are extended in vertical direction well over the top of the single bars (1, 1') and possibly providing a step.
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FIG.1

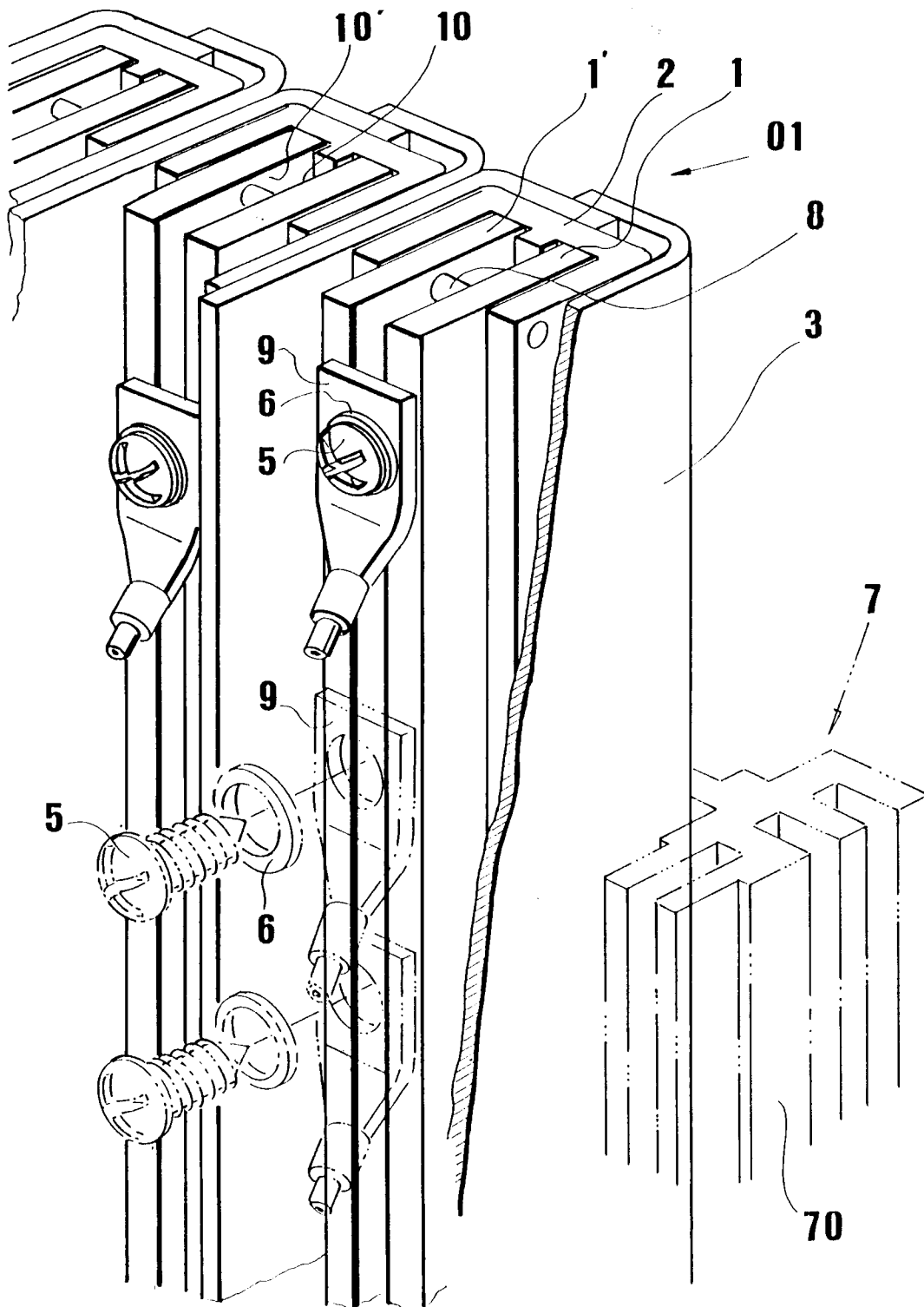


FIG. 2

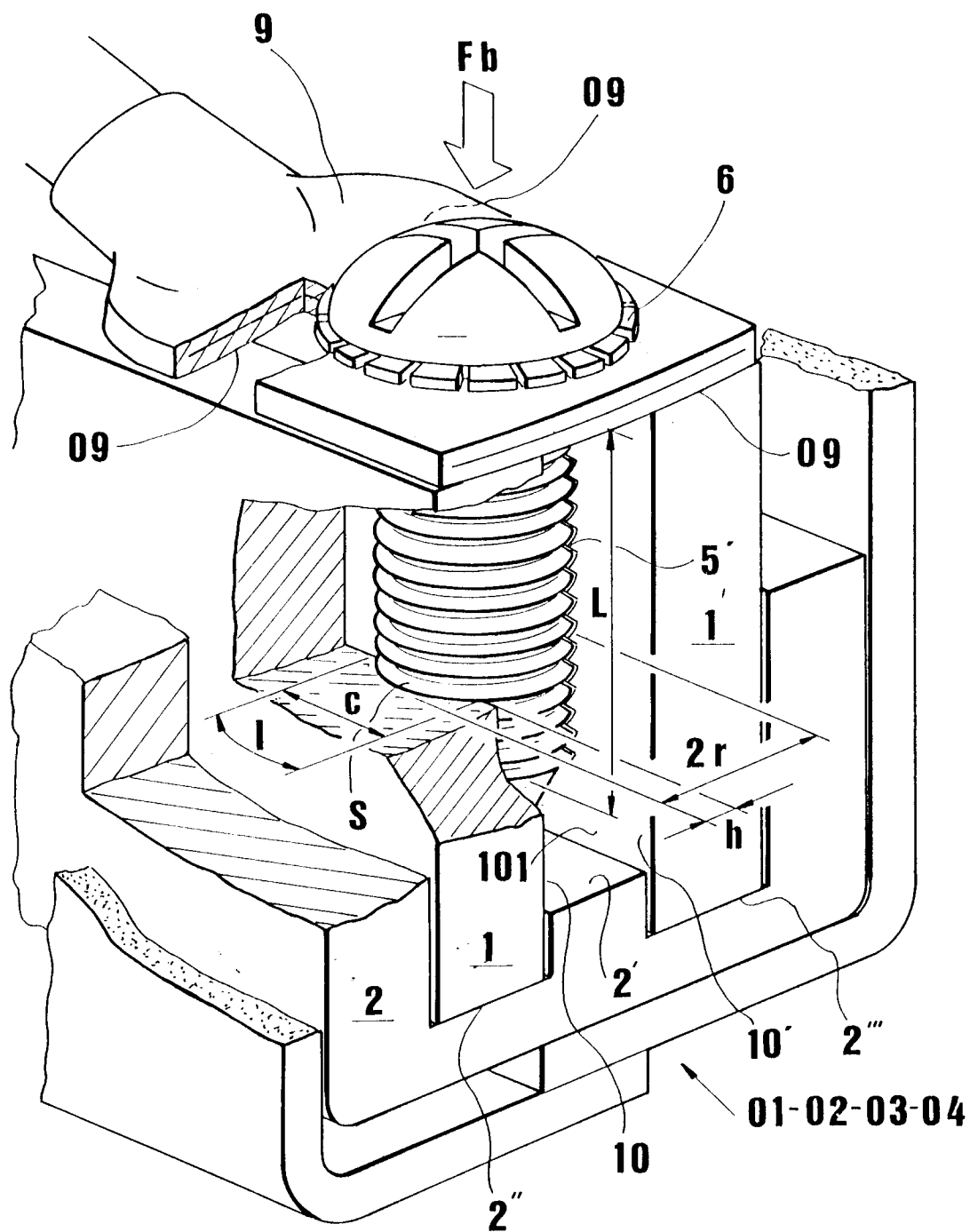


FIG. 3

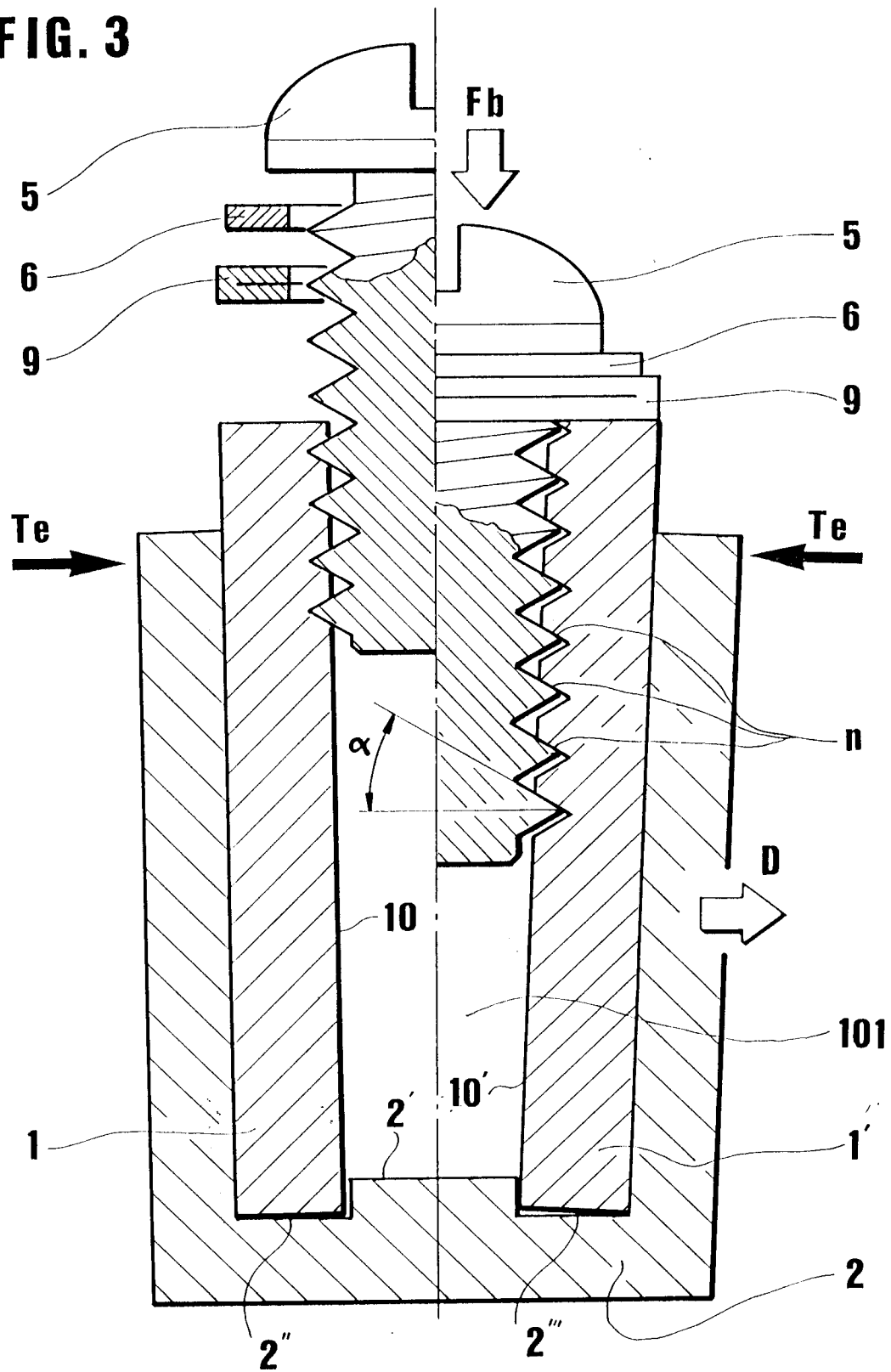


FIG. 4

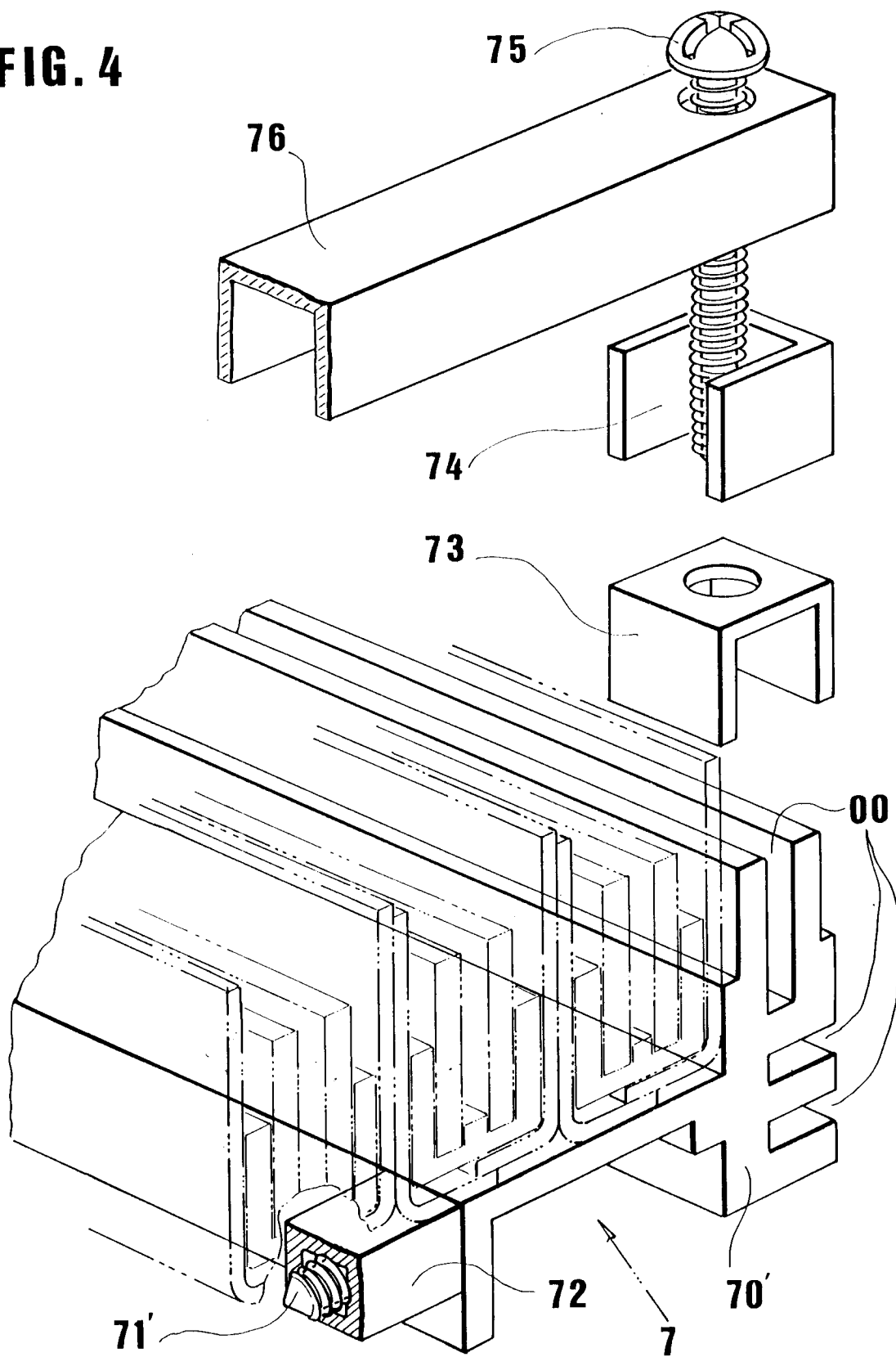


FIG. 5

