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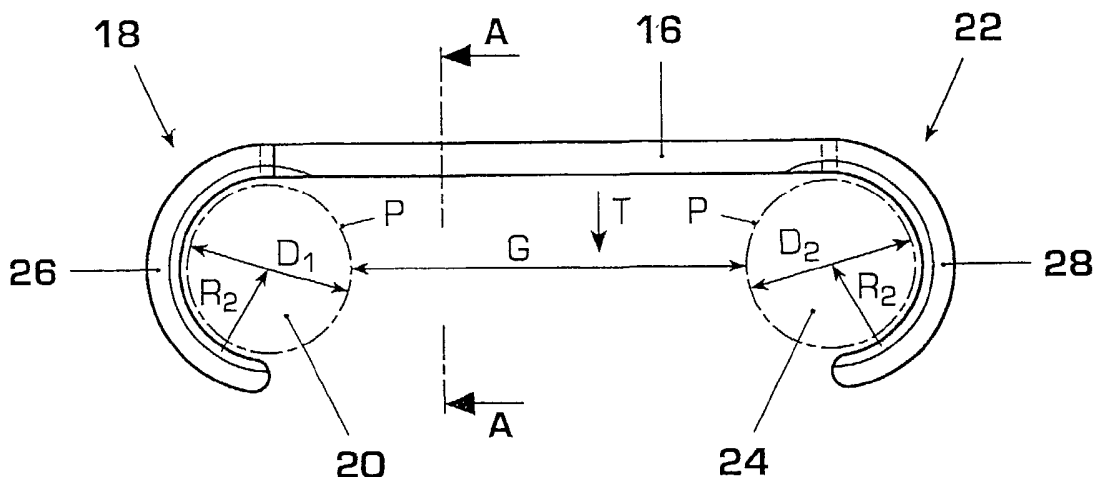
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(54) Title: DEVICE AND METHOD FOR SUPPORTING CABLES OF HIGH VOLTAGE GENERATORS



(57) Abstract: The present invention relates to a device (14) for supporting cable arcs (10) at a stator (2) of a high voltage generator having high voltage cables (4) as stator winding. The device (14) comprises an elongated body (16, 16') which at one end (18) is intended for engagement with a portion of a first cable arc (20) having a diameter (D1), and at one other (22) end is intended for engagement with a portion of an adjacent second cable arc (24) having a diameter (D2), the extension (L) of the elongated body is longer than the extent of the cable diameters (D1, D2) of the first and second cable arcs (20, 24) taken together, such that the first and second cable arcs, respectively, arranged at each end (18, 22) of the elongated body (16, 16') are kept apart and are fixedly supported. The present invention also relates to a method for supporting cable arcs and a use of a device for supporting cable arcs at a stator of a high voltage generator.

- 1 -

DEVICE AND METHOD FOR SUPPORTING CABLES OF HIGH VOLTAGE GENERATORS

Technical field

The present invention relates to a device for supporting
5 cable arcs at a stator of a high voltage generator. The present
invention also relates to a method for supporting cable arcs and
a use of a device for supporting cable arcs at a stator of a
high voltage generator.

10

Background

Powerformer™ is a new concept for high voltage generators
and has resulted in a revolution in the field of power
generation. High voltage generators based on Powerformer™
technology uses high voltage cables as the stator winding
15 instead of the traditional medium voltage stator bars which are
used in stators of conventional generators. Pluralities of
cables are arranged in parallel throughout the stator core in
the longitudinal direction. A rotor is arranged centrally in the
generator and is surrounded by the stator. An air gap is
20 provided around the rotor adjacent the surrounding stator, such
that the rotor is allowed to freely rotate and that the rotor
can be easily assembled or disassembled. At both ends of the
stator, cables are protruding out from the side of the stator
core. Each cable comes out from the side of the stator end at
25 one position on the stator radius. Each cable is then curved
outside, forming a cable arc on the side of the stator and
introduced back again at another position on the stator radius.

The magnetic field created by the rotor of the generator
produces forces, such as attractive and tractive forces, on the
30 core of the stator. The forces causes deformation of the stator
core that follows the rotation of the rotor during operation and
causes resulting cyclical vibrations that propagate through the
entire generator, including the cable arcs and the support
structure of the generator. Due to the large amount of cables,

- 2 -

each cable arc is arranged close to an adjacent cable arc.

Vibrations in a PowerformerTM generator are transmitted to the cable arcs. If the cables are not isolated from each other, the vibrations may result in wear on the cables because of the close contact with neighbouring cables. In addition, the cables also have to be kept apart since electrical disturbances may occur between cables that are in close contact. The cable arcs outer semi-conducting layer, respectively, shall not be allowed to have direct contact.

Moreover, during the operational lifetime of the generator, electrical disturbances, such as a short circuit, may occur and then result in an instant pulse that is 10-15 times larger than the normal load on the generator. Hence, consideration should also be taken to such instant pulses for the support of the cable arcs.

One problem associated with the cable arcs, protruding out from the side of the stator, is that they tend to be bent in the radial direction of the generator. This is undesirable, especially when the cable arcs are bent and falls-in towards the centre of the generator, over the air gap between the stator and the rotor. When a rotor is to be assembled in, or disassembled from, the generator, there is a risk that the cables gets caught in between the rotor and the stator if the cables are not adequately restrained from falling in towards the centre of the generator.

The traditional way to avoid cable arcs from falling in towards the centre of the generator, as well as prevent wearing and electrical disturbances between adjacent cables, is to support the cable arcs individually and attach them to the stator frame. More precisely, this has been carried out by fixing two neighbouring cables tightly together with pre-shrunk bands that are arranged at several positions along the cable arc where the cables intersect with each other, usually at about five positions along the extension of the cable arc. An

- 3 -

interlayer of silicon is also arranged in between the cables in order to avoid a direct contact between the neighbouring cables. Hence, each cable arc is supported by tying these shrinkage bands around the cable arc and one neighbouring cable arc, generally at about five positions. Consequently, this procedure is inefficient and very time-consuming. Moreover, two neighbouring cables are in contact with each other, some electrical disturbances may occur.

10

Description of the invention

The object of the present invention is to restrain cable arcs from falling-in towards the centre of a high voltage generator. Another object of the present invention is to provide a device that is easy and fast to assemble to cables in a high voltage generator, and further cost efficient and uncomplicated to produce.

Accordingly, in accordance with the present invention, there is provided a device for supporting cable arcs at a stator of a high voltage generator having high voltage cables as stator winding, in that the device comprises an elongated body which at one end is intended for engagement with a portion of a first cable arc having a diameter, and at one other end is intended for engagement with a portion of an adjacent second cable arc having a diameter, the extension of the elongated body is longer than the extent of the cable diameters of the first and second cable arcs taken together, such that the first and second cable arcs, respectively, arranged at each end of the elongated body are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator.

Consequently, according to the present invention cable arcs can in a satisfactory efficient and safe way be prevented from being bent in the radial direction towards the centre of the

- 4 -

generator. The cable arcs outer semi-conducting layer, respectively, are not permitted to come into direct contact with each other. Further, the device provides for a secure and rigid suspension of the cable arcs. Moreover, the device according to
5 the present invention also facilitates for a faster and easier way to fix the cable arcs during assembly of the generator. The erection time can be reduced significantly compared to the previous procedure where each cable arc is supported by tying pre-shrinkage bands around the cable arc and one neighbouring
10 cable arc, which generally has been done at about five positions along the cable arc. In fact, with the device according to the present invention it can be sufficient to arrange only one elongated body at a portion of the cable arc, if the elongated body is arranged at carefully selected portions of the cable
15 arc, e.g. between the tops of neighbouring cable arcs. Furthermore, the device provides such a rigid suspension that other closely arranged cable arcs need not to be supported individually at all, but only secured such that direct contact with an adjacent cable is avoided e.g. by arranging an
20 interlayer or the like in between the cables. For each cable arc, which has an elongated body arranged to it, it is possible to suspend up to about four other neighbouring cable arcs that need not to be individually supported by any additional means.

Conveniently, the device is arranged at the portions of the
25 cable arcs where the cable bending radius is large, i.e. at the top of each cable arc.

Adjacent arranged cable arcs supported by the elongated body are arranged apart at sufficient distance from each other, such that there is at least a space in between the cables.

30 The ends, respectively, of the elongated body comprises preferably, attachment means, protruding in an oblique direction relatively the longitudinal extension of the elongated body, for engagement with each cable arc. Such attachment means may protrude substantially transverse relatively the longitudinal

- 5 -

extension of the elongated body. The attachment means can have a semi-circular shape with a radius corresponding to a perimeter of the cable. The attachment means at the ends, respectively, of the elongated body may protrude in the same or in different
5 directions. According to one preferred embodiment, the attachment means at one end of the elongated body protrudes in the same direction as the protrusion of the attachment means at the other end of the elongated body.

In other words, the device can also be described as a cable
10 arc bracket for bracing cables.

It is suitable that each end of the elongated body comprises a projecting flange, propagating in the same plane as the longitudinal extension of the elongated body. A projecting flange at each end, respectively, of the elongated body may
15 protrude from each side of the elongated body. Preferably, a projecting flange at one end of the elongated body may protrudes only from one side of the elongated body, in the diametrically opposite direction compared to the protrusion of the flange at the other end of the elongated body.

20 In order to provide for a solid support of the cable arcs, at least one of the ends of the elongated body can be arranged to a supporting structure of the stator, by fastening means.

According to a second aspect of the present invention, there is also provided an arrangement for supporting cable arcs
25 at a stator of a high voltage generator having high voltage cables as stator winding, the arrangement includes at least two co-operating devices for supporting the cable arcs, a first and a second device, where the first and the second device, respectively, comprises an elongated body, the first elongated
30 body is at one end arranged to a portion of a first cable arc and at one other end is arranged to a portion of an adjacent second cable arc, and where the second elongated body is at one end arranged to a portion of the first cable arc and at one other end is arranged to a portion of an adjacent third cable

- 6 -

arc, the extension of the first and second elongated body, respectively, is longer than the extent of the cable diameters of the first and second, or the second and third, cable arcs taken together, such that the first, second and third cable arc, respectively, arranged at each end of the elongated bodies are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator.

Hence, according to this second aspect, in order to support pluralites of cable arc at the side of the stator, two or more elongated bodies can be arranged in connection in series, forming a chain of elongated bodies for supporting bundles of cables.

The present invention also relates to a method for supporting cable arcs at a stator of a high voltage generator having high voltage cables as stator winding, comprising the steps of: attaching on end of a first elongated body to a portion of a first cable arc; attaching one other end of the first elongated body to a portion of an adjacent second cable arc, the extension of the first elongated body is longer than the extent of the cable diameters of the first and second cable arcs taken together, such that the first and second cable arcs arranged at each end of the elongated body are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator; attaching one end of a second elongated body to a portion of the first cable arc; and attaching one other end of the second elongated body to a portion of an adjacent third cable arc, the extension of the second elongated body is longer than the extent of the cable diameters of the first and third cable arcs taken together, such that the first and third cable arcs arranged at each end of the elongated body are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator.

The present invention also relates to a use of a device for

- 7 -

supporting cable arcs as disclosed above, according to the main claim 1 and the independent claims dependent on claim 1, for a high voltage generator.

5 **Brief description of the drawings**

Embodiments of the present invention are hereinafter described more in detail, with reference to the accompanying drawings, bearing in mind however that the scope of protection of the present invention is indicated by the independent
10 appended claims and not limited to the specific illustrative embodiments, in which drawings:

fig. 1 illustrate in a partial side view pluralities of cable arcs bent on the outside of a stator,

fig. 2 shows in a schematic top view the side of a high
15 voltage generator where the cable arcs have been supported by utilising the present invention,

fig. 3A shows in a side view a device for supporting cable arcs according to the present invention,

fig. 3B shows in a view from above the device in fig. 3A,
20 fig. 3C shows a cross sectional view along line A-A in fig. 3A,

fig. 4A shows a partial side view of an arrangement according to a second aspect of the present invention, where several devices for supporting the cable arcs are co-operating,
25 and

fig. 4B shows in a view from above the arrangement in fig. 4A.

Detailed description of the invention

Fig. 1 illustrates generally pluralities of cable arcs bent
30 at the outside of a stator core 2 of a Powerformer™ high voltage generator. Pluralities of high voltage cables 4 are arranged as the stator winding in parallel throughout the stator core 2 in its longitudinal direction 6 and in parallel to a centrally positioned rotor (not shown in fig. 1) surrounded by the stator

- 8 -

core. At each short end side 8 of the stator, around its perimeter, cables 4 form so called cable end windings, e.g. bundles of cables arranged at the side of the stator. Each cable 4 comes out from the side 8 of the stator short end at one position along the stator radius R. Each cable 4 is curved outside the side of the stator and introduced back again at another position on the stator radius R, thus forming so called cable arcs 10.

Fig. 2 shows a survey view the side of a high voltage hydro power plant generator 12, in which the device of the present invention has been utilised for supporting individual cable arcs. Fig. 2 shows that bundles of cables are arranged side by side at the end side 8 of the stator, around its perimeter. Each cable 4 comes out from the side 8 of the stator short end at one position along the stator radius R. Further is shown the centrally positioned rotor 7 surrounded by the stator core. An air gap 9 is provided between the rotor 7 and the surrounding stator 2. As easily understood, if the cable arcs are allowed to fall-in towards the centre C of the generator 12, so that they are situated over the air gap 9, the cable arcs can be caught in between the rotor 7 and the stator 2, and thus will be damaged, when the rotor is to be lifted out (in the direction perpendicular to the plane of the paper) or assembled in the generator. Figs. 3A-3C shows a device 14 for supporting cable arcs according to the present invention. The device 14 comprises an elongated body 16 having a longitudinal extension L. At one end 18, the elongated body 16 is intended for engagement with a portion of a first cable arc 20 (illustrated by phantom lines), whereas one other end 22 of the elongated body is intended for engagement with a portion of an adjacent second cable arc 24 (illustrated by phantom lines). The extension L of the elongated body is longer than the extent of the cable diameters D1 and D2 of the first and second cable arcs 20, 24 taken together. By arranging the elongated body 16 to the first and second cable

- 9 -

arc 20, 24, respectively, arranged at each end 18, 22 of the elongated body, the cable arcs can be kept apart and fixed at a distance from each other providing a gap G in between the cable arcs. As shown in the embodiment according to figs. 3A-3C, the
5 ends 18, 22, respectively, of the elongated body comprises attachment means 26, 28, protruding in an oblique direction relatively the longitudinal extension L of the elongated body, for engagement with each cable arc 20, 24. These attachment means 26, 28 are protruding substantially transverse T
10 relatively the longitudinal extension L of the elongated body. The attachment means 26, 28 have a semi-circular shape with a radius R2 corresponding to a perimeter P of the cable. In addition, an interlayer (not shown), e.g. an annular member of plastics such as silicon or the similar, can be arranged in
15 between the cable and the attachment member 26, 28. As shown in figs. 3A-C, the attachment means 26 at one end of the elongated body can protrude in the same direction as the protrusion of the attachment means 28 at the other end of the elongated body.

As further shown in the embodiment in figs. 3A-3C, each end
20 18, 22 of a first elongated body 16, comprises a projecting flange 30, 32, propagating in the same plane as the longitudinal extension L of the elongated body. As evident from fig 3B, the purpose with the projecting flanges 30, 32 is to provide for separation from one end 18' of another, second elongated body
25 16' if arranged to the same cable arc 20, in connection adjacent to the first elongated body 16 (see also fig. 4B). Due to the flanges 30, 32, transferral of forces to the cable can be minimised. Instead the occurring forces are directed between adjacently arranged flanges 30, 30', of two elongated bodies 16,
30 16' arranged in contact with each other at the same cable arc 20. As shown in figs. 3A-B, the projecting flange 30 at one end 18 of the elongated body 16 can protrude in the diametrically opposite direction X1 compared to the protruding direction X2 of the flange 32 at the other end 22 of the elongated body. The

- 10 -

flanges may also, as shown in figs. 3A-C, protrude from the attachment means 26, 28, along the transverse direction T. Although not shown in figs. 3A-3B, the projecting flanges 30, 32 may protrude on both sides of the elongated body 16.

5 Suitably, as further described below with respect to the arrangement according to the present invention, at least one of the ends of an elongated body 16, 16' can be arranged to a supporting structure 34 of the stator 2. As shown in figs. 4A-4B this can be carried out by attaching a separate supporting
10 member 36 having fixing means 38 in one end for secure arrangement to an outermost situated cable arc 24, which is closest to the stator support structure 34. The fixing means 38 can be semi-circular shaped, similar to the attachment means 26, 28 of the elongated body 16 as described above, to fit and
15 correspond to the cable diameter D. The other end of the separate supporting member 36 is fixed to the stator support structure 34, e.g. by a rigging screw 40 or the similar. Furthermore, figs. 4A-4B shows an arrangement according to a second aspect of the present invention, where several devices
20 (principally similar to the devices 16, 16' described above), for supporting cable arcs 10, are co-operating along the radius R of the stator of a high voltage generator having high voltage cables 20, 24 as stator winding, giving a solid support for the cable arcs 10. The arrangement includes at least two co-
25 operating devices for supporting the cable arcs 10, a first 42 and a second 44 device, where the first and the second device, respectively, comprises an elongated body 16, 16', the first elongated body 16 is at one end 18 arranged to a portion of a first cable arc 20 and at one other end 22 is arranged to a
30 portion of an adjacent second cable arc 24, and where the second elongated body 16' is at one end 18' arranged to a portion of the first cable arc 20 and at one other end 22' is arranged to a portion of an adjacent third cable arc 46, the extension of the first and second elongated body 16, 16', respectively, is longer

- 11 -

than the extent of the cable diameters D1, D2, or D1, D3, of the first 20 and second 24, or the first 20 and third 46, cable arcs taken together, such that the first, second and third cable arcs, respectively, arranged at each end of the elongated bodies
5 are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator.

- 12 -

List of references

2	stator core
4	high voltage cables
6	longitudinal direction of stator core
5 7	rotor
8	short end side of stator core
9	air gap
10	cable arcs
12	high voltage hydro power plant generator
10 14	device for supporting cables
16,16'	elongated bodies
18,18',22,22'	ends of elongated body
20,24	first and second cable arcs, respectively
26,28	attachment means
15 30,30',32	flanges of elongated body
34	supporting structure
36	supporting member
38	fixing means
40	rigging screw
20 42,44	first and second device, respectively
46	third cable arc
C	centre of generator
D,D1,D2,D3	cable diameters
G	gap
25 L	longitudinal extension of elongated bodies
P	perimeter of cable
R	stator radius
R2	radius of attachment means
T	transverse extension of elongated bodies
30 X1, X2	protruding directions of flanges

- 13 -

Claims

1. Device for supporting cable arcs (10) at a stator (2) of a high voltage generator having high voltage cables (4) as stator winding, **characterised in** that the device comprises
5 an elongated body (16, 16') which at one end (18) is intended for engagement with a portion of a first cable arc (20) having a diameter (D1), and at one other (22) end is intended for engagement with a portion of an adjacent second cable arc (24) having a diameter (D2), the extension (L) of the elongated body
10 is longer than the extent of the cable diameters (D1, D2) of the first and second cable arcs (20, 24) taken together, such that the first and second cable arcs, respectively, arranged at each end (18, 22) of the elongated body (16, 16') are kept apart and are fixedly supported so that the cable arcs are restrained from
15 falling-in towards the centre of the generator.

2. Device according to claim 1, **characterised in** that the ends (18, 22), respectively, of the elongated body (16, 16') comprises attachment means (26, 28), protruding in an
20 oblique direction relatively the longitudinal extension (L) of the elongated body (16, 16'), for engagement with each cable arc (20, 24).

3. Device according to claim 2, **characterised in**
25 that the attachment means (26, 28) are protruding substantially transverse (T) relatively the longitudinal extension (L) of the elongated body (16, 16').

4. Device according to claim 2 or 3, **characterised**
30 **in** that the attachment means (26, 28) have a semi-circular shape with a radius corresponding to a perimeter (P) of the cables (20, 24), respectively.

5. Device according to any of the claims 2 or 3,

- 14 -

characterised in that the attachment means (26) at one end (18) of the elongated body (16, 16') protrudes in the same direction (T) as the protrusion of the attachment means (28) at the other end (22) of the elongated body.

5

6. Device according to any of the preceding claims, characterised in that each end (18, 22) of the elongated body (16, 16') comprises a projecting flange (30, 32), propagating in the same plane as the longitudinal extension (L) of the elongated body.

10

7. Device according to claim 6, characterised in that the projecting flange (30) at one end (18) of the elongated body (16) protrudes in the diametrically opposite direction (X1) compared to the protrusion (X2) of the flange (32) at the other end (22) of the elongated body.

15

8. Device according to any of the preceding claims, characterised in that at least one of the ends (18, 22) of the elongated body (16, 16') is arranged to a supporting structure of the stator (34).

20

9. Arrangement for supporting cable arcs (10) at a stator (2) of a high voltage generator having high voltage cables (4) as stator winding, characterised in that the arrangement includes at least two co-operating devices (42, 44) for supporting the cable arcs (10), a first (42) and a second device (44), where the first and the second device, respectively, comprises an elongated body (16, 16'), the first elongated body (16) is at one end (18) arranged to a portion of a first cable arc (20) and at one other end (22) arranged to a portion of an adjacent second cable arc (24), and where the second elongated body (16') is at one end (18') arranged to a portion of the first cable arc (20) and at one other end (22') is arranged to a

25

30

- 15 -

portion of an adjacent third cable arc (46), the extension (L) of the first and second elongated body, respectively, is longer than the extent of the cable diameters (D1-D3) of the first and second, or the second and third, cable arcs taken together, such that the first, second and third cable arcs (20, 24, 46), respectively, arranged at each end of the elongated bodies are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator.

10 10. Method for supporting cable arcs (10) at a stator (2) of a high voltage generator having high voltage cables (4) as stator winding, comprising the steps of:

 attaching on end (18) of a first elongated body (16) to a portion of a first cable arc (20),

15 attaching one other end (22) of the first elongated body (16) to a portion of an adjacent second cable arc (24), the extension (L) of the first elongated body (16) is longer than the extent of the cable diameters (D1, D2) of the first and second cable arcs (20, 24) taken together, such that the first and second cable arcs (20, 24) arranged at each end of the elongated body (16) are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator,

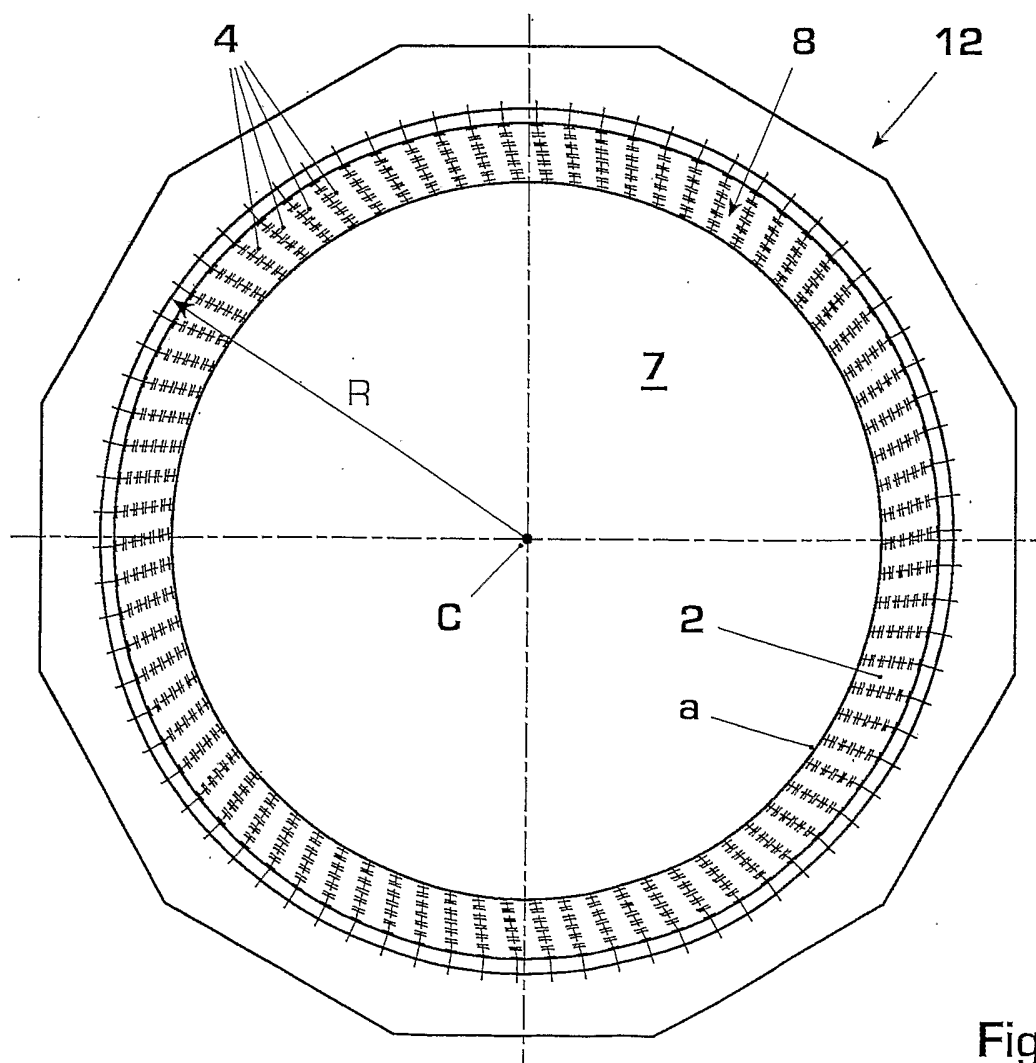
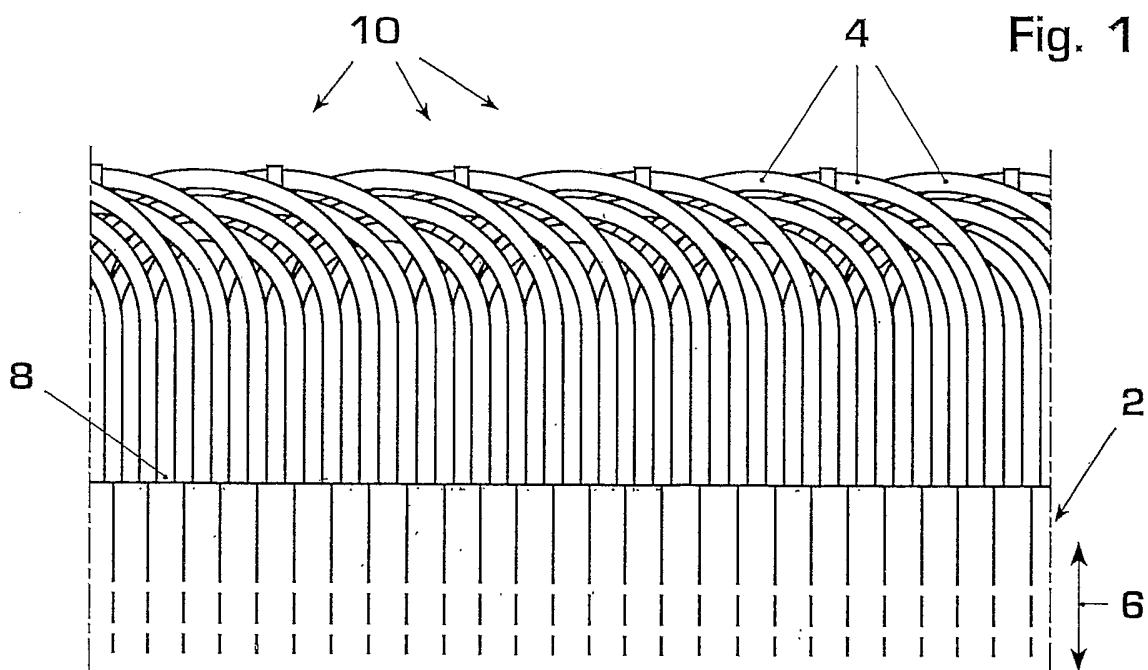
 attaching one end (18') of a second elongated body (16') to a portion of the first cable arc (20), and

25 attaching one other end (22') of the second elongated body to a portion of an adjacent third cable arc (46), the extension (L) of the second elongated body (16') is longer than the extent of the cable diameters (D1, D3) of the first and third cable arcs (20, 46) taken together, such that the first and third cable arcs arranged at each end of the elongated body are kept apart and are fixedly supported so that the cable arcs are restrained from falling-in towards the centre of the generator.

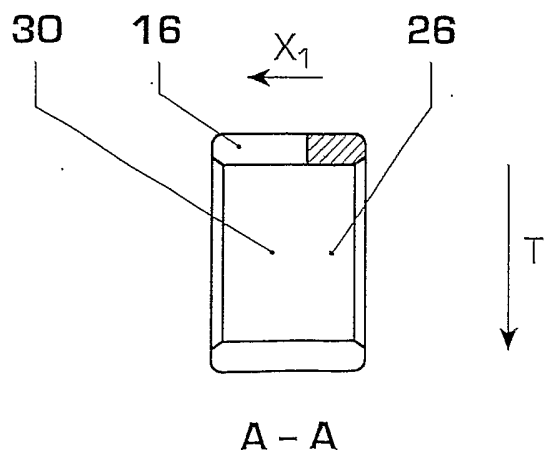
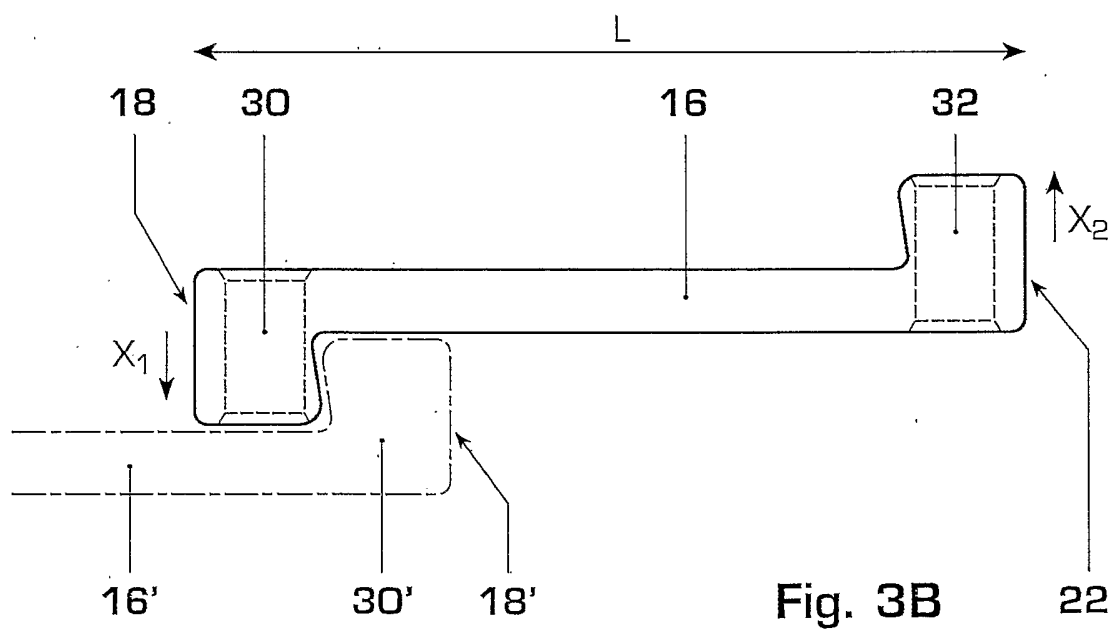
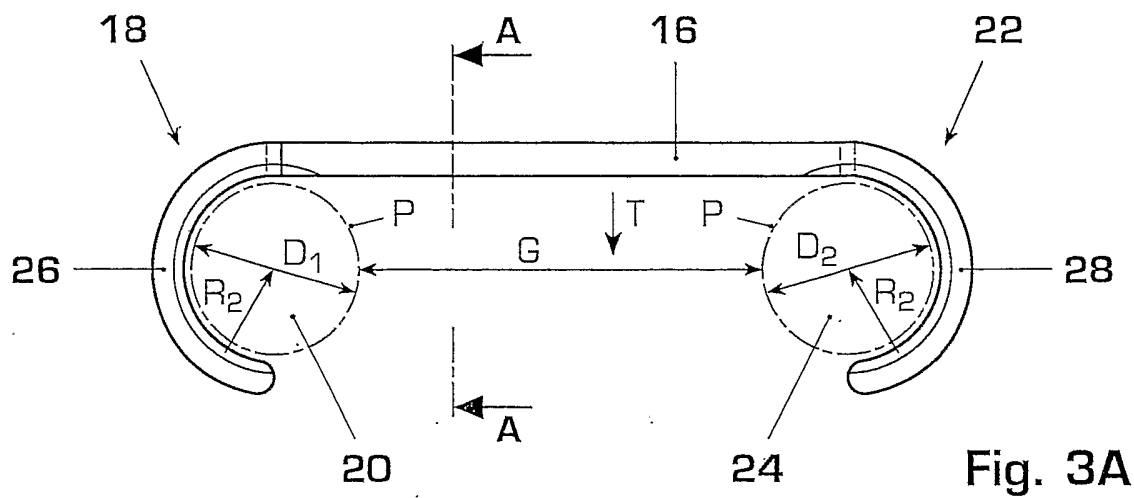
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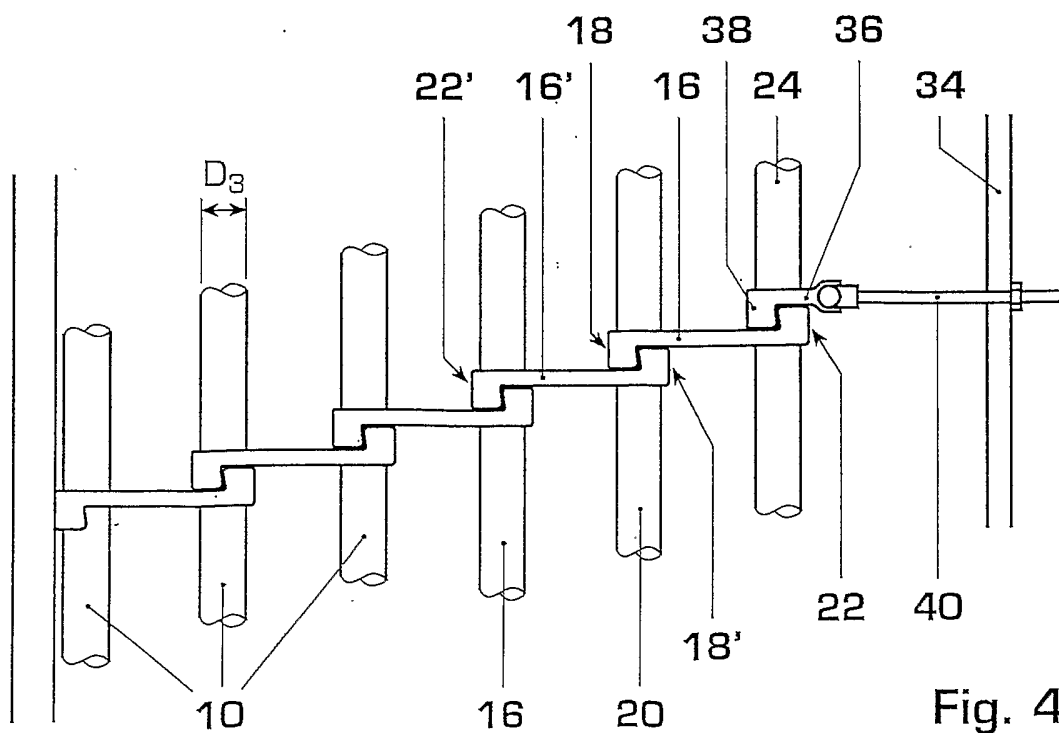
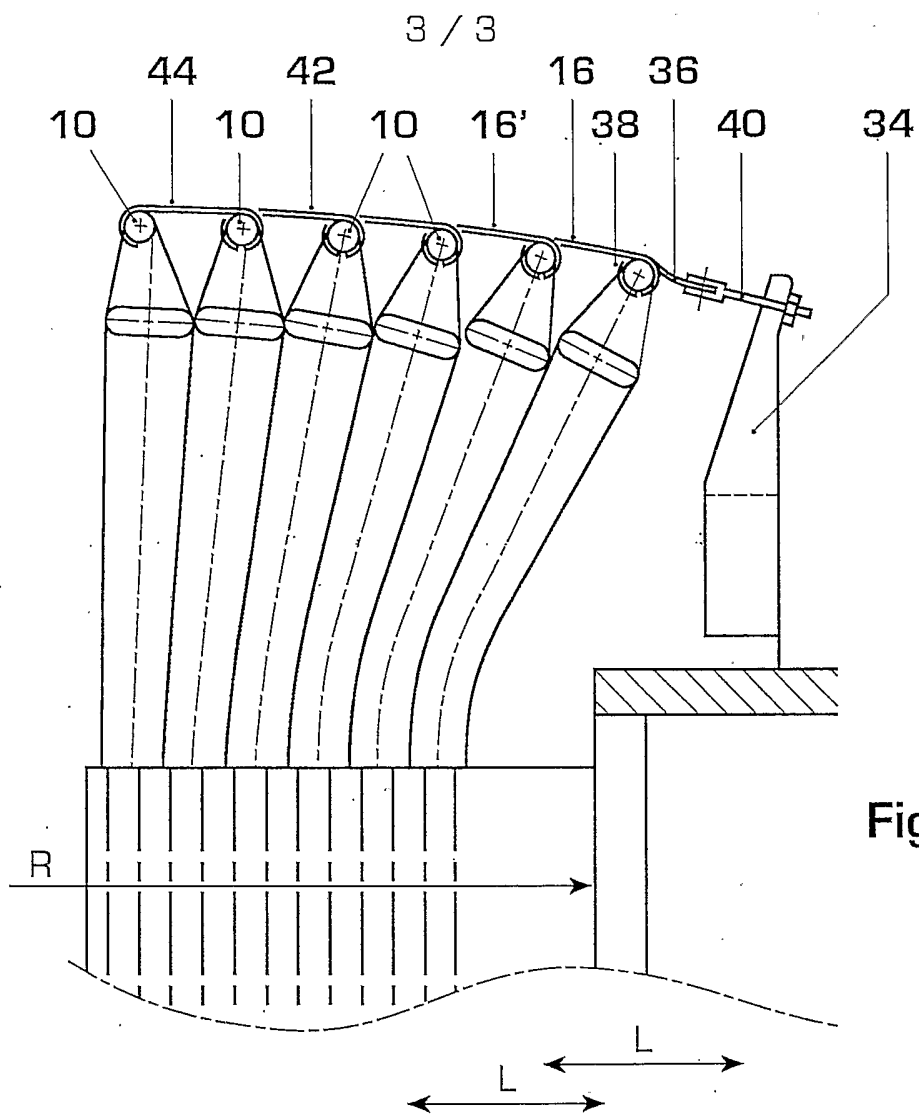
11. Use of the device according to any of claims 1-8, for supporting cable arcs (10) at a stator of a high voltage generator.

1 / 3



2 / 3





INTERNATIONAL SEARCH REPORT

International Application No

PCT/CH 03/00513

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K3/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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