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Puck

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[54] **HIGH VOLTAGE INSULATOR ASSEMBLY FITTED WITH PIVOTAL MOUNTING MEANS FOR SAID INSULATOR**

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Feb. 6, 1973 Switzerland 1646/73

[52] **U.S. Cl.** ..... **174/43;** 174/140 S; 174/161 R; 174/179; 174/189

[51] **Int. Cl.** **H01b 17/16**

[58] **Field of Search**..... 174/40 R, 43, 45 R, 140 S, 174/148, 149 R, 158 R, 161 R, 169, 176, 177, 178, 179, 189, 196, 209; 52/40, 697

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[57] **ABSTRACT**

The high voltage insulator assembly comprises an insulator connected to a mounting which is adapted to pivot on a mast or pylon. The insulator comprises an elongate glass fibre reinforced core which is encased over part of its length by a skirted insulator covering having attached thereto a lug for supporting a high voltage line and over the remainder of its length by a sleeve which is connected to the mounting, the sleeve being joined to the insulator covering to protect the core from the weather. The mounting provides a pivotal connection to a mast so that the assembly can pivot about the mast when the high voltage line is subject to loads imposed by abnormal wind conditions. The connection between the mounting and the insulator is such that the angle between the pivot axis of the mounting and the longitudinal axis of the core is greater than 30° and that the axes are coplanar.

16 Claims, 5 Drawing Figures

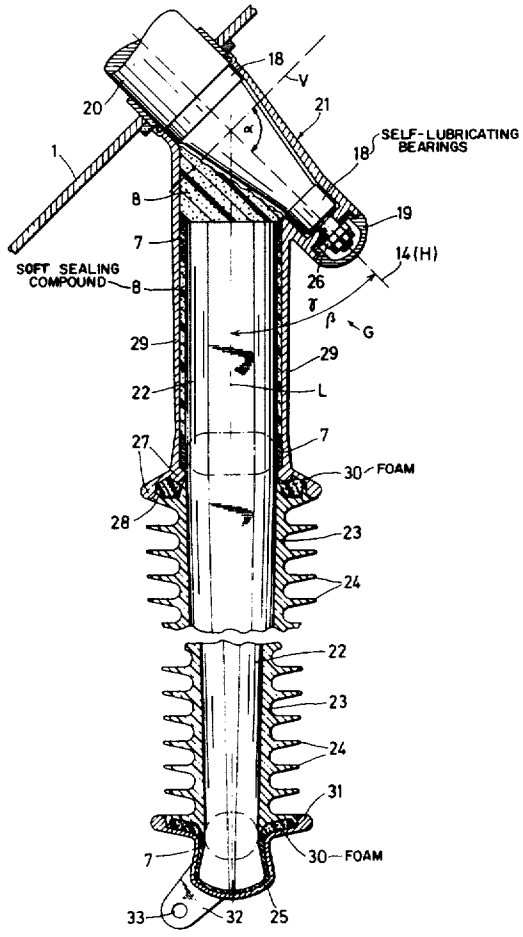


FIG.1

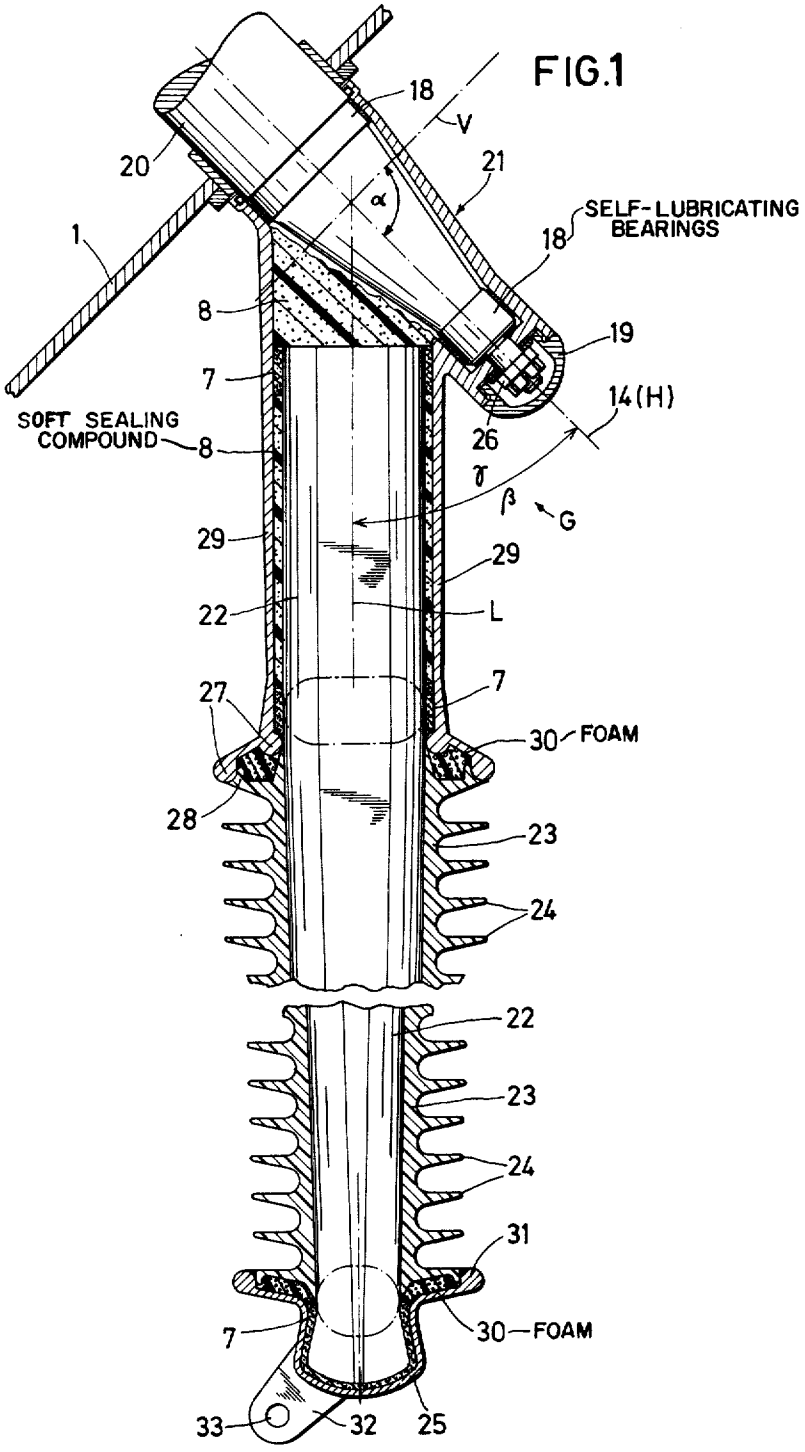

18
V
20
21
α
SELF-LUBRICATING BEARINGS
18
1
8
19
7
14(H)
SOFT SEALING COMPOUND
8
26
γ
β
G
29
29
22
L
27
7
30
FOAM
28
23
24
22
23
24
31
7
30—FOAM
33
32
25

FIG. 2

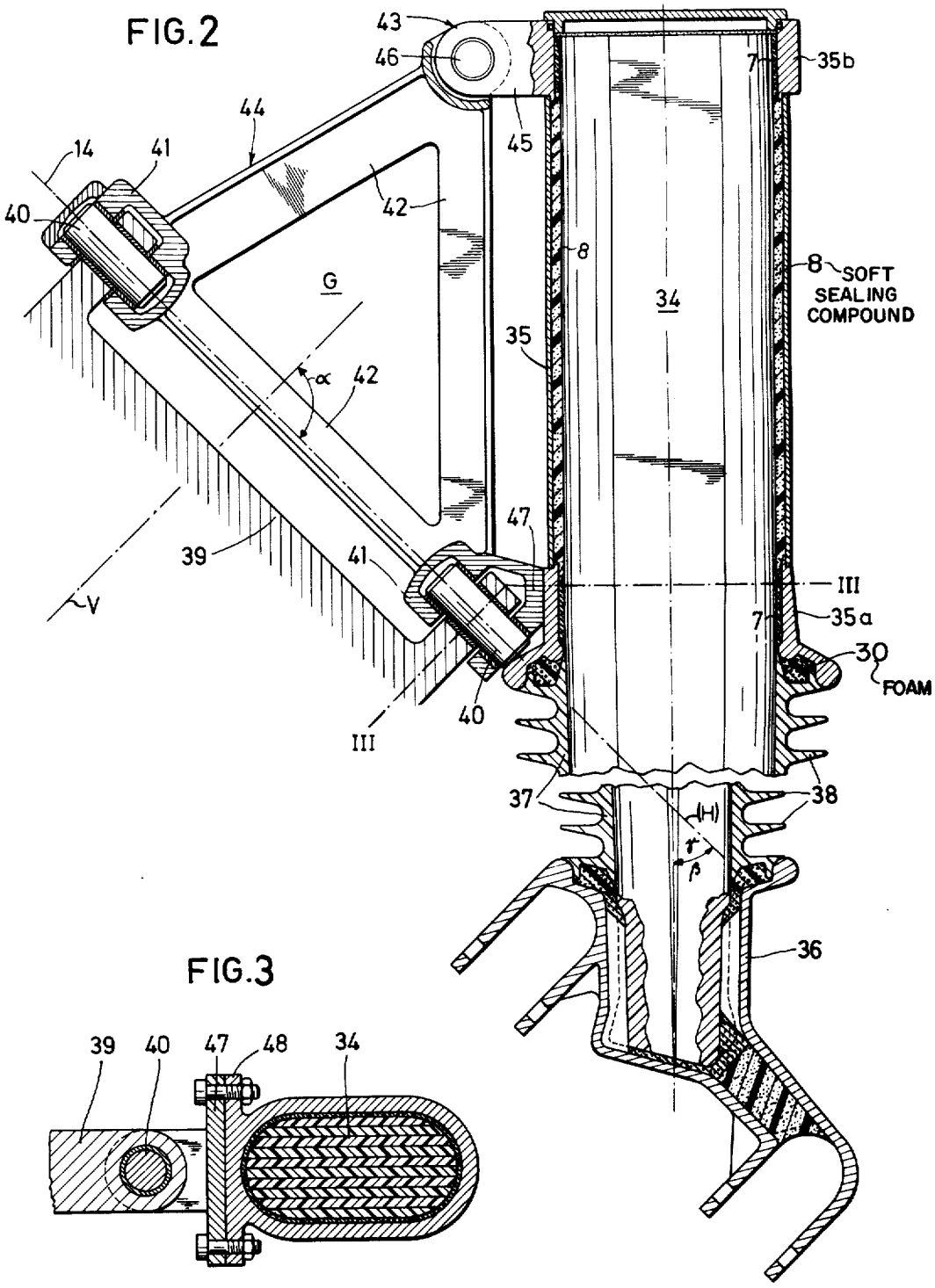

43
46
44
14
41
40
45
42
G
α
42
39
41
V
III
40
47
8
34
35
7
35b
8
SOFT SEALING COMPOUND
III
7
35a
30
FOAM
37
38
(H)
36

FIG. 3

39
40
47
48
34

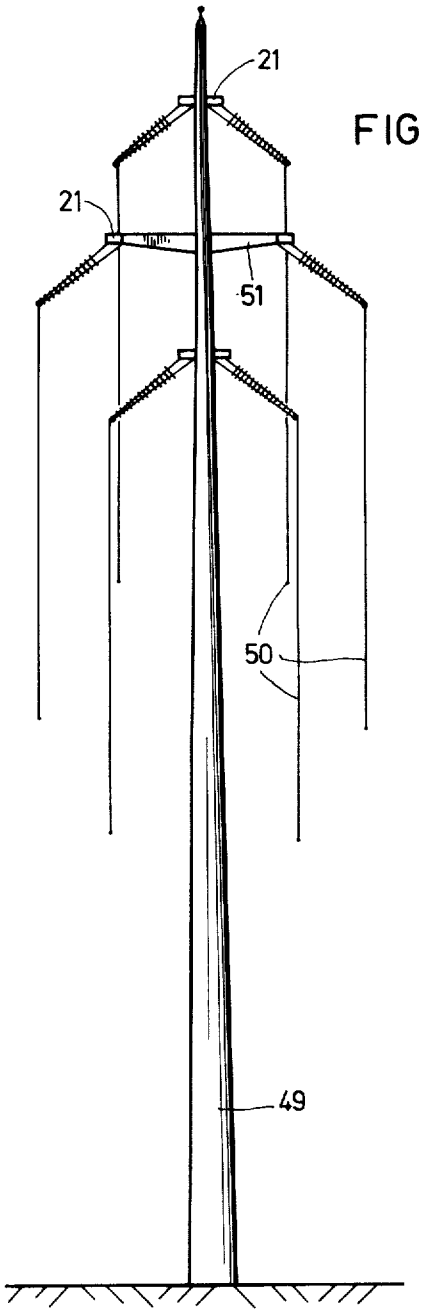


FIG.4

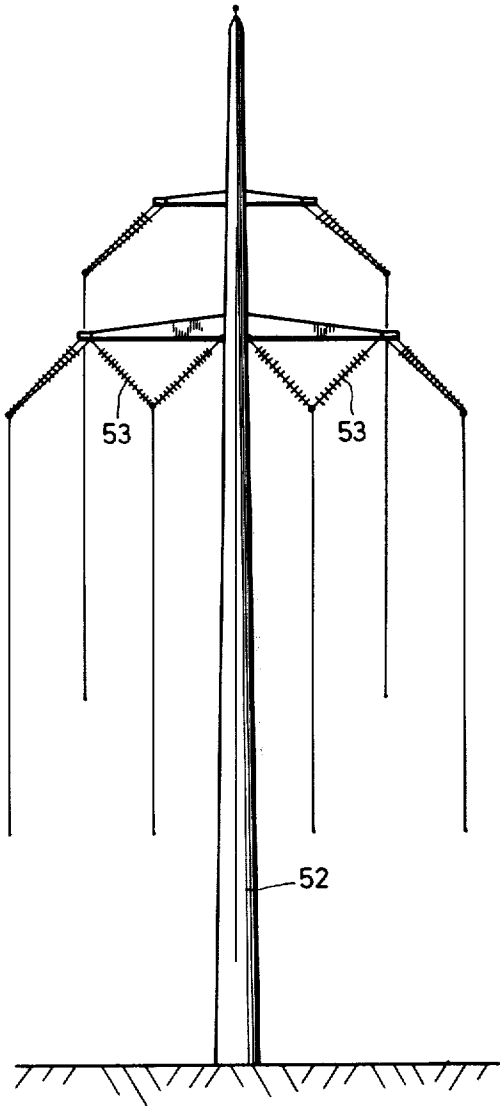


FIG.5

HIGH VOLTAGE INSULATOR ASSEMBLY FITTED WITH PIVOTAL MOUNTING MEANS FOR SAID INSULATOR

FIELD OF THE INVENTION

This invention relates to high voltage insulator assemblies for use in high voltage overhead lines.

PRIOR ART

Conductors of high voltage lines are often suspended by means of suspension insulators on crossarms secured to masts or pylons. The loading on such suspension insulators is almost entirely tensile. The conductor suspension points are not stationary, and if the wind blows across a conductor, the suspension points shift from their initial position to an extent depending upon the length of the suspension insulator with the result that the conductors move towards or away from the mast depending upon the direction of the wind. To ensure a minimum gap between the conductors and the masts, the crossarms must be lengthened by an amount by which the conductors are expected to shift; also the route width must be widened by twice the amount of such shift to ensure a safe minimum distance between the conductors and any other buildings or trees or other high voltage lines.

Oscillations of suspension insulators transversely of conductor length are a nuisance, but the ability of the insulators to oscillate in the direction of conductor length has advantages as regards stressing the actual conductors and the masts.

Devices known as swing or V-insulators have been used to obviate the disadvantage of transverse insulator oscillations. An insulator of this kind comprises two inclined suspension insulators interconnected at their bottom ends, to which the conductor is secured. The top ends of the two suspension insulators are pivotally mounted in spaced-apart relationship to one another on the mast crossarm so that the two suspension insulators together form a V. Swing insulators of this kind preclude shifting of the suspension point transversely of the conductor direction but permit the suspension point to shift in the conductor direction. A difficulty with insulators of this kind is that in the case of very strong side winds the force which is the resultant of weight and wind pressure may be at a considerable inclination, e.g. of up to about 45°, to the vertical. If the two insulators forming the V are less inclined to the vertical than the resultant force, one of the two insulators experiences axial compression which, even if slight, can cause long insulators to buckle.

Another suggestion to reduce route width and to economise on metal crossarms is to use pivoted insulated crossarms in which the line interconnecting the two insulator ends pivoted in spaced-apart relationship to the mast is shifted from the horizontal into the vertical or near vertical position. The metal crossarm can therefore be completely omitted or become at most a very short "stub" crossarm. An insulated crossarm of this kind has a tension insulator and a compression insulator. The size and design of tension insulators is governed by the permissible tensile strength of the material of which they are made, and the design of compression insulators is governed by the consideration that they must not buckle when subject to the maximum axial compression. Buckling strength is determined by the modulus of elasticity of the material. Compression insulators therefore have much larger cross-sections than tension insulators. As a rule, tension insulators can withstand only minor compressive forces as compared with their permissible tensile loadings. One end of the usually horizontal compression insulator and one end of the tension insulator, the latter being inclined to the horizontal, are interconnected and the conductor or a group of conductors is secured to the connection point between the two insulators. The other ends of the insulators are usually so secured to the mast as to be pivotable around an axis which is at an inclination to the vertical of from 10° to 25°; this feature enables the suspension point to move in the direction of conductor length, yet the suspension point cannot move to any great extent towards the mast. If the compression insulator and the tension insulator are of the same length as one another, as is desirable for electrical reasons, what happens when the compression insulator is disposed horizontally is that the pivot axis is inclined to the vertical by an angle which is half the angle between the compression insulator and the tension insulator. The angle between the pivot axis and the vertical is a main factor in determining the behaviour of the insulated crossarm in response to forces which act on the connection point between the two insulators and which the conductor applies to the suspension point. A great disadvantage of insulated crossarms of this kind is their instability in high wind pressures, when the two insulators may possibly collapse towards the mast once the ratio of the horizontal wind pressure acting on the mast to the vertical loading represented by conductor weight exceeds a critical value. To prevent the crossarms from bending too far when such instability occurs at high wind pressures, every third or fourth or fifth mast has to be constructed with non-shifting conductor suspension points. For the sake of uniformity throughout the line, these six suspension points are usually embodied in the form of an insulated tripod crossarm which comprises either one horizontal compression insulator and two tension insulators or one tension insulator and two substantially horizontal compression insulators, the set of three insulators providing a tripod support. Unfortunately, more insulators then become necessary and the bending and twisting loading of the masts having the fixed insulating crossarms is increased so that the cost of constructing a high voltage line is increased.

Overhead lines are also known wherein individual rod insulators which stand off from the mast substantially horizontally are so mounted on the mast by means of an articulation or pivot device as to be pivotable around an axis which is inclined to the vertical. The kinetics of this pivoted insulator mounting are exactly the same as for the known swing insulator but the advantages are obtained at much lower cost. For instance, either very small crossarms or none at all are needed to support or retain the conductors on the mast and only one insulator per conductor or per conductor group is needed. This form of insulator assembly comprising an insulator and a pivotable mounting has previously been used only on relatively low voltages, probably because the strength characteristics of the ceramic insulators used are unsatisfactory. In this assembly there is particularly heavy bending and compressive stressing of the insulators. This is a minor consideration for short low-voltage insulators, but the insulators needed for relatively high voltages are very long — up to 7.5 m — and buckle very easily under such bending and compressive

stressing. Consequently, the resulting constructional difficulties were such that there seemed no chance of being able to use this inherently advantageous insulator assembly for relatively high voltages.

Surprisingly, however, ways and means have been devised of using this form of pivoted insulator assembly for very high voltages.

SUMMARY OF INVENTION

In accordance with this invention, therefore, I provide a high voltage insulator assembly comprising, an insulator having an elongate core made of glass fibre reinforced plastics material and a skirted insulated covering encasing one end portion of the core, a pivotable mounting adapted for connecting the insulator to a mast with the pivot axis of the mounting substantially horizontal, means coupling said mounting to that portion of said core above said covering so that the pivot axis and the longitudinal axis of said core are coplanar and the angle between the axes is greater than 30°, and means connecting said coupling means to said covering.

Constructing the insulator in the form of a core and casing and using unidirectionally glass fibre reinforced plastic lead to an insulator having a very high bending strength. The special choice of angles of inclination between the insulator axis and the vertical when the assembly is mounted on a mast very greatly reduces the compressive forces acting lengthwise of the insulator which are mainly responsible for buckling, and special clamping of the insulator core to the pivotable mounting ensures that forces acting on the insulator are applied satisfactorily to the mounting. The cooperation of all these features leads to a very good line construction which can be used on very high voltages.

Embodiments of the invention will now be described in greater detail with reference to the drawings wherein:

BRIEF DESCRIPTION OF DRAWINGS

FIGS. **1** and **2** each show in section an embodiment of an insulator assembly in accordance with the present invention for use in overhead lines;

FIG. **3** is a section on the line III—III of FIG. **2**; and

FIGS. **4** and **5** each show a mast or pylon supporting insulator assemblies in accordance with this invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Referring to the embodiments shown in FIGS. **1** and **2**, part of the mast **1** (FIG. **1**) and crossarm **39** (FIG. **2**) in practice extend vertically and horizontally respectively as indicated by chain-dotted lines V which denote the vertical.

The insulator assembly shown in FIG. **1** comprises a core **22** which is formed as a flexible support or carrier and which is made of unidirectionally glass fibre reinforced plastic, preferably epoxy resin containing approximately 50–70 vol. percent of glass fibre. The core end portion nearest the mast is embedded in, and rigidly secured to, a metal sleeve **29** which is connected to a pivotable mounting G. Consequently, the sleeve **29** takes up any bending force applied to the core.

Sleeve **29** is connected at one end to a socket **21** forming part of the pivotable mounting and adapted to receive a pivot pin **20** rigidly secured to mast **1**. Pin **20** can extend transversely through mast **1** which may be a conical steel or alloy tubular mast, and another insulator (not shown) can be mounted at the opposite end of the pin **20**. The pivot pin end which extends into the socket **21** is part-conical and has two cylindrical parts **18** received in long-life plain bearings made of a self-lubricating white metal alloy and which are disposed in spaced-apart relationship in the socket **21**. The end of pin **20** has a screwthread which receives a castellated nut **26** to prevent the socket **21** from coming apart from the pin **20**. For weather protection the screwthread and the nut **26** are covered by a cap **19**. The core end which extends into sleeve **29** is retained by two rings **7** made of high-strength sealing compound or a loaded bonding agent, the remaining space being filled up with a soft sealing compound **8**. Consequently forces are transmitted between the core and the pivotable mounting substantially via the engagement of the two rings **7** with the inner surface of sleeve **29**. For the forces to be applied to the pivotable mounting satisfactorily, the spacing between the two rings **7** should be approximately from one-sixth to one-quarter of the length of the unclamped portion of the insulator. If the clamped portion of core has a $\pm$ 45° winding of synthetic resin impregnated glass fibres, the spacing between the rings can be reduced considerably. The insulator core end portion is completely enclosed in the sleeve to protect the core against weathering.

The core portion which extends from the sleeve **29** is encased, except for the terminal zone near the conductor, by a casing **23** comprising skirts **24** to give a long enough surface leakage path. Preferably, casing **23** is produced by potting the core **22** in a casting resin flexible enough to withstand the expansion of the core without cracking.

The junction between the metal sleeve **29** and the resilient casing **23** of casting resin has been designed with particular care. That end of sleeve **29** which is near such junction has an inner and an outer bead **27**. The first skirt **28** of the casing **23** has a shape complementary to that of the outer bead **27** and is stuck thereto. Because of its shape, the casing **23** can, without excessive stressing, undergo radial deformations and bending in all temperature and loading conditions without parting from the rigid metal sleeve. Also, the large collar-like termination of the sleeve **29** is advantageous for the electrical stressing of the casing **23**, since leakage currents from the sleeve **29** to the casing **23** are right from the start distributed over a large area of plastic, and corona discharges from the outer bead **27** of sleeve **29** to atmosphere are kept away from the casing **23**. The space bounded by the inner and outer bead **27** and the first skirt **28** is filled with a fine-pored foam material **30**.

An end cap **25** is fitted on the other end of the core **22** whose diameter increases at its extremity so that, in cooperation with the conical shape of the interior of cap **25** and with the high-strength sealing compound **7**, a positive connection is provided. Cap **25** has a bead **31** which engages around the final skirt of casing **23**; the space bounded by such bead and skirt is filled with a fine-pored foam material **30**. Two links or tags **32** each pierced with a bore **33** are disposed on the end face of cap **25** and serve to secure clamping means (not shown) for the conductor (not shown).

The insulator pivot axis **14** as shown in this embodiment makes an angle α of 90° with the vertical V — i.e., the axis **14** is horizontal. The angle β between the axis **14** and the insulator longitudinal axis L coincides in this

case with the angle γ between the insulator longitudinal axis L and the horizontal H and is approximately 45°. The insulator therefore slopes downwardly at an angle $\alpha + \beta = 135°$ in relation to the vertical V.

A consideration in choosing the angle γ between the insulator longitudinal axis and the horizontal is that the more the insulator slopes downwards, the less is the bending stress it experiences due to conductor weight and to icing. As a rule, it is found that an angle γ of 45° is the limit where the safe distance between the conductor and the mast starts to become too small. The smaller the angle γ, the more mast height can be saved but the less can the insulator pivot out in one direction in response to tension on the conductor since the pivoting radius decreases.

The main consideration in choosing γ is that, apart from the bending stress, no axial compression, or only a relatively slight amount, must act on the flexible carrier core **22,** and any such compressive loads must never last for long, since bending coupled with an extra axial compression may cause buckling. In practice γ is from 30° to 60°, leading to values of from 120° to 150° for $\alpha + \beta$.

The pivoted insulator assembly enables, by the use of appropriate shaping of the component parts, a saving to be made in materials and costs and improves the electrical characteristics. Since the insulator is pivoted to the mast, all the forces acting on the insulator are in a plane passing through the pivot axis **14** and the insulator longitudinal axis. In response to a pull on the conductor in one direction, the insulator follows the force by pivoting until the resultant acting on the insulator is again in the plane formed by the insulator longitudinal axis and the pivot axis **14.** The reason for this is that the position where the load acts — i.e., the place where the conductor is secured to the insulator — is disposed in the plane formed by the pivot axis **14** and the longitudinal axis of the insulator. While the resultant force is outside this plane, it applies a torque to the insulator in relation to the pivot axis thereof and therefore pivots the insulator. Consequently, the pivoting movement not only greatly reduces the unidirectional conductor tension but also automatically ensures that the insulator adjusts itself so that the bending forces are always operative in the same plane of the insulator.

This has great advantages as regards insulator size and design since flexible carriers and supports which are stressed only in a single plane have very low material costs, their cross-section being larger in one direction than in a direction transverse thereto. The core **22,** which acts as a flexible carrier, is substantially frustoconical, with its thick end near the mast **1** and its thin end near the conductor. The core has rounded, semicircular edges and parallel flat sides, the width of the sides decreasing from the thick to the thin end of the core whilst the radius of each rounded edge remains the same. Consequently, core thickness is constant over core length whereas its width decreases linearly so that at the end near the conductor the cross-sectional shape of the core is near circular.

The angle α between the pivot axis **14** and the vertical V is of main importance for determining the kinetics, although insulator stability to wind pressure increases with increasing α. On the other hand, for a given slope of the longitudinal axis of the insulator, the pivoting radius decreases with increasing α. Good values for α in practice are from 45° to 90°.

The insulator described with reference to FIG. **1** is of use in the construction of a high voltage line operating at from 110 to 220 kV.

FIGS. **2** and **3** show another embodiment of an insulator assembly, of use for supporting a 380 or 750 kV line on a high voltage pylon. The thick end of a conical core **34** is anchored in two metal rings **35***a*, 35*b* spaced apart by a metal sleeve **35,** the end face of ring **35***b* being closed by a cover. Similarly to the embodiment according to FIG. **1,** compression rings **7** each made of a material highly resistant to compression are disposed one near each of the two rings **35***a*, 35*b* on the insulator core **34**; the forces in the core act via the rings **7** on the bearing parts connected to the rings **35***a*, 35*b*. As in the previous embodiment, the space between the two rings **7** is filled with a relatively resilient sealing compound **8.** The core part **34** between the ring **35***a* and the end cap **36** is surrounded by a casing or envelope **37** having skirts **38.** Two pivot pins **40** are secured to a small crossarm **39** (only some of which is shown) of the mast (not shown); the pins **40** define the pivot axis **14** which, with the insulator assembled, extends horizontally. Bearing sockets **41** receive the pins **40.** The sockets **41** are rigidly connected via connecting members **42** to a fork-shaped coupling device **43** so that the component parts **41, 43, 42** together form a pivotable mounting **44** which is releasably connected to the rings **35***a*, 35*b*. Ring **35***b* is welded to a link or tag **45** which extends into the fork of the device **43** and is connected thereto by way of a pin **46.** A stirrup-shaped member **47** is secured to the bearing socket **41** adjacent the ring **35***a*. The forked ends of member **47** are screwed to other links or tags **48** which are secured to the ring **35***a*, so that the two rings **35***a*, 35*b* and the spacing sleeve **35** are rigidly but releasably connected to the member **44,** so that the insulator can pivot only around its pivot axis **14.**

In assembly, crossarm **39** is first secured to the mast, the member **44** with the pivot pins is then positioned, and the lug **45** is introduced into the fork of the device **43** and secured by the pin **46,** after which the member **47** is screwed to the ring **35***a*.

The releasable connection between the mounting **44** and the sleeve **35** helps not only to facilitate assembly but also to simplify manufacture and transportation of the insulator since the two parts of the insulator assembly can be carried separately.

In the case of large insulators the core **34** is preferably of laminated construction in which glass fibre reinforced plates or panels are stuck together with the interfaces of the plates or panels extending parallel to the plane of the drawing in FIG. **2.** If the core is produced in this way, one or more panels of reinforced plastic bonded high-stretch organic fibres may be interposed between the glass-fibre-reinforced plastic panels, to ensure that if the insulator is overstressed, the core may rupture to some extent but not be destroyed.

In the case of the insulators hereinbefore described, loadings imposed by the conductors, ice and wind pressure are transmitted to the mast mainly by the bending of the insulator towards the mast and not, as is the case with the insulators conventionally used on high voltage masts, solely as axial forces. With insulators of the length necessary for voltages of 110, 220, 380 and 750 kV and with long spans between-masts, the bending moments applied to the insulator are so high that the same cannot be made of conventional insulants such as

porcelain and glass. However, insulators for use up to voltages of at least 750 kV can be made if high-strength unidirectionally glass-fibre-reinforced plastic is used for the insulator core. More particularly however, the insulator hereinbefore described obviates the need for an insulated crossarm. If an insulator having a horizontal pivot axis is pivotally mounted on a mast, the suspension of the conductors is completely stable in winds to an extent previously achieved only by means of a swing insulator suspended on a very large metal crossarm. Electricity supply undertakings consider high stability to wind pressures to be very important, since in exceptional storms wind pressures may impose greater loads than that imposed by the weight of the conductors. When the insulator hereinbefore described and having a horizontal pivot axis is used, then, so far as stability considerations are concerned, any desired number of pylons or masts can be used consecutively in a straight run of line without alternating with masts having fixed conductor suspension points.

The inclined arrangement of the insulators helps self-cleaning by rain and wind. To assist this self-cleaning action, the angle γ of the insulator to the horizontal should be no larger than necessary. The insulated surface area of the insulators hereinbefore described is smaller than that of a tension and compression insulator; consequently, leakage currents are less than for an insulated crossarm.

If excessive bending occurs, the lever arm of the bending force is considerably shortened due to core sag, more particularly if, with $\gamma > 30°$, the loading is vertical as is the case with conductor weight and icing. Any rupture of the insulator is limited basically to the compression zone, and furthermore the rupture is not a complete break in the core but more a tearing of the glass-fibres with delamination consuming a lot of the energy. There is therefore substantially no risk of an insulator of the kind hereinbefore described being broken off completely, more particularly if the core contains high stretch organic fibres, as hereinbefore suggested.

FIG. **4** shows a high voltage mast or pylon **49** having insulator assemblies of the kind described with reference to FIG. **2**. The sockets **21** of the insulator assemblies are disposed on the ends of pivot pins which extend through the masts. The lines depending from the outer ends of the insulators denote the sag of conductors **50**. The central insulators are disposed on a short crossarm **51** so that the vertical separation between the central conductors and the conductors above and below can be reduced with a corresponding reduction in the overall height of the mast. The path needed for a high voltage line of this kind is very narrow, so that there is a considerable cost saving in the erection of such a high voltage line.

FIG. **5** shows a pylon **52** having known swing insulators **53** in addition to the insulator assemblies hereinbefore described. This combination of different kinds of insulators helps to reduce pylon height, but only at the expense of a wider path, although this disadvantage is not so critical in open country.

What is claimed is:

1. A high voltage insulator assembly comprising an insulator having an elongated core made of glass fibre reinforced plastic material, a pivotable mounting adapted for connecting the insulator to a mast with the pivot axis at the mounting inclined at an angle of from 45° to 90° to the vertical, a skirted insulator covering encasing a first end portion of the core, means coupling said mounting to the non-encased second end portion of said core so that the pivot axis and the longitudinal axis of said core are coplanar and the longitudinal axis is inclined downwardly at an angle of from 30° to 60° to the horizontal, the coupling means including two spaced apart clamping elements which grip said second end portion of said core at two spaced apart zones, and means connecting said coupling means to said insulator covering.

2. An assembly according to claim **1**, wherein the core is made of epoxy resin containing between 50 to 70 percent by volume of glass fibre.

3. An assembly according to claim **1**, wherein said core comprises a plurality of glass fibre reinforced plastic plates secured together with the surfaces of the plates parallel to the plane containing the longitudinal axis of the insulator and the axis of the pivotable mounting.

4. An assembly according to claim **3**, wherein at least one panel of reinforced, plastic-bonded high stretch organic fibres is positioned between and parallel to two adjacent glass fibre-reinforced plastic plates.

5. An assembly according to claim **3**, including a winding of synthetic-resin-impregnated glass fibres about that portion of said core above said covering.

6. An assembly according to claim **1**, wherein at least that portion of the core encased by said covering is tapered, the core being of substantially constant thickness over its length and having semi-circular edges and flat parallel sides.

7. An assembly according to claim **1**, wherein the spacing between said two clamping elements is substantially from one-sixth to one-quarter of the length of the unclamped portion of the insulator.

8. An assembly according to claim **1**, wherein said coupling means includes a sleeve having an inside wall of a diameter greater than the diameter of that portion of the core above said covering, two compression resistant rings each encircling said core portion and spaced apart thereon and engaging the inside wall of said sleeve to form a cavity between the core portion and said inside wall between the rings, and a soft sealing compound within said cavity.

9. An assembly according to claim **8**, wherein said pivotable mounting comprises a frusto conical housing secured to said sleeve at one end thereof, two bearings of different diameters within said housing spaced apart and coaxial with the axis of said mounting, a pivot pin rotatable within said bearings and adapted for securing to a mast, and means retaining said pin in said housing.

10. An assembly according to claim **8**, wherein said coupling means further includes two support rings spaced apart on said sleeve, one of said rings including means releasably securing the sleeve to said pivotable mounting.

11. An assembly according to claim **10**, wherein said pivotable mounting comprises a frame having stirrups positioned to receive pivot pins in coaxial alignment for pivoting said frame to a mast, a forked member having arms with apertures in the ends thereof cooperating with said releasable securing means and a pin passing through said aperture and said securing means.

12. An assembly according to claim **8**, wherein said sleeve includes a flange and said covering at that end

adjacent said sleeve includes a skirt mating with said flange to secure said covering to said sleeve.

13. An assembly according to claim 12, wherein said skirt includes a groove and said flange includes a bead received within and secured to said groove, said skirt including a second groove facing said flange and fine pored foam material within said second groove.

14. An assembly according to claim 13, wherein the end of said core remote from said sleeve is flared and said assembly further includes an end cap over the flared end of said core and means on said cap for holding a high voltage line.

15. An assembly according to claim 14, wherein said covering includes a skirt adjacent the flared end of said core, said skirt having a recess and said end cap a bead received in said recess securing the cap to the covering.

16. A high voltage system comprising a plurality of masts, each mast having at least one insulator assembly according to claim 1 pivotally mounted thereon with the pivot axis at the mounting inclined at an angle of 45° to 90° to the vertical, and means for securing a high voltage line to the insulator of the assembly on each mast.

* * * * *