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(56) Documents Cited:
**EP 2501005 A2**
**CN 201528175 U**
**CN 101425666 A**
**US 5175442 A**
**US 20100064598 A1**

(58) Field of Search:
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Other: **EPODOC, WPI**

(54) Title of the Invention: **Cross-arm for high voltage tower**
Abstract Title: **Overhead cable support**

(57) An electrically insulating conductor support 1 for a tower 2 arranged to carry overhead conductors 3, the support comprising an insulating structural member in the form of an endless loop, the structural member having means 4 for attaching it to the tower in a substantially vertical orientation, and further having a plurality of support means (8, figure 3), each for supporting one or more overhead conductors 3, spaced around the loop. A tower for a high voltage power system in which at least one such support is attached to it in a substantially vertical orientation to carry overhead conductors spaced from the tower. Preferably the endless loop is oval or circular, although it may be square or rectangular. The support may comprise a central insulating core attached by a series of sheds and formed from a glass-fibre reinforced insulating resin.

Fig 1

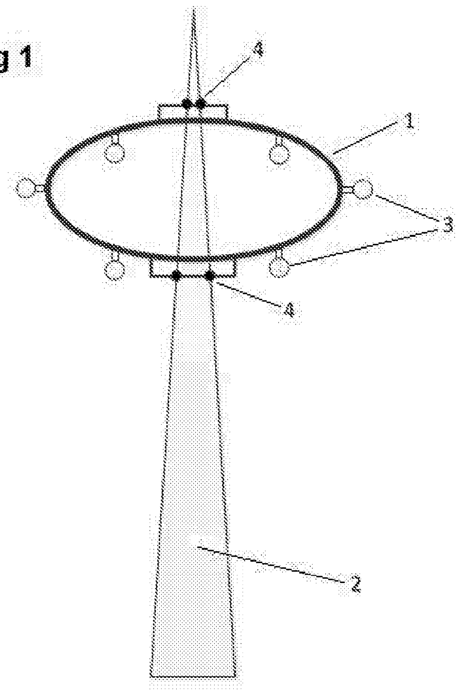


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Fig 1

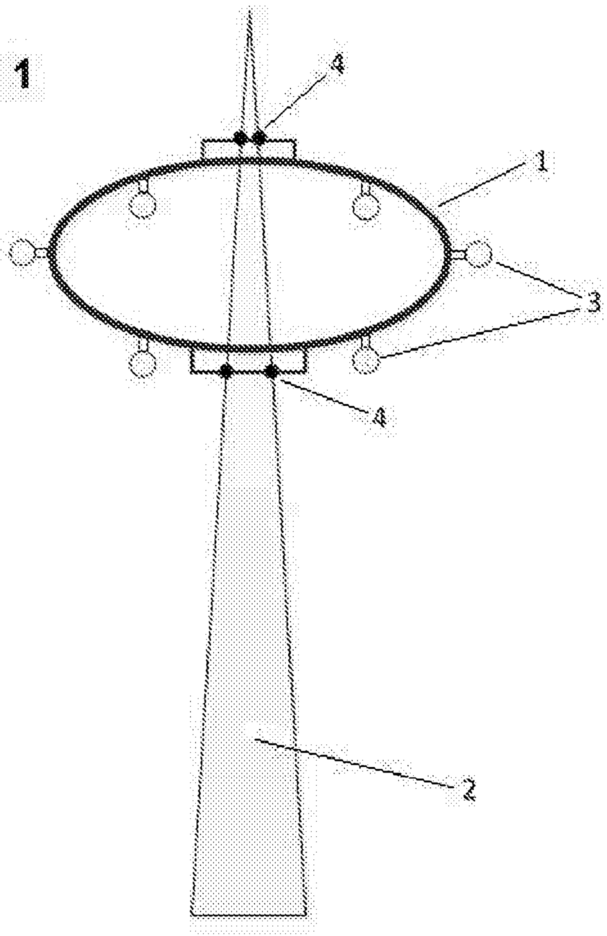

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Fig 2

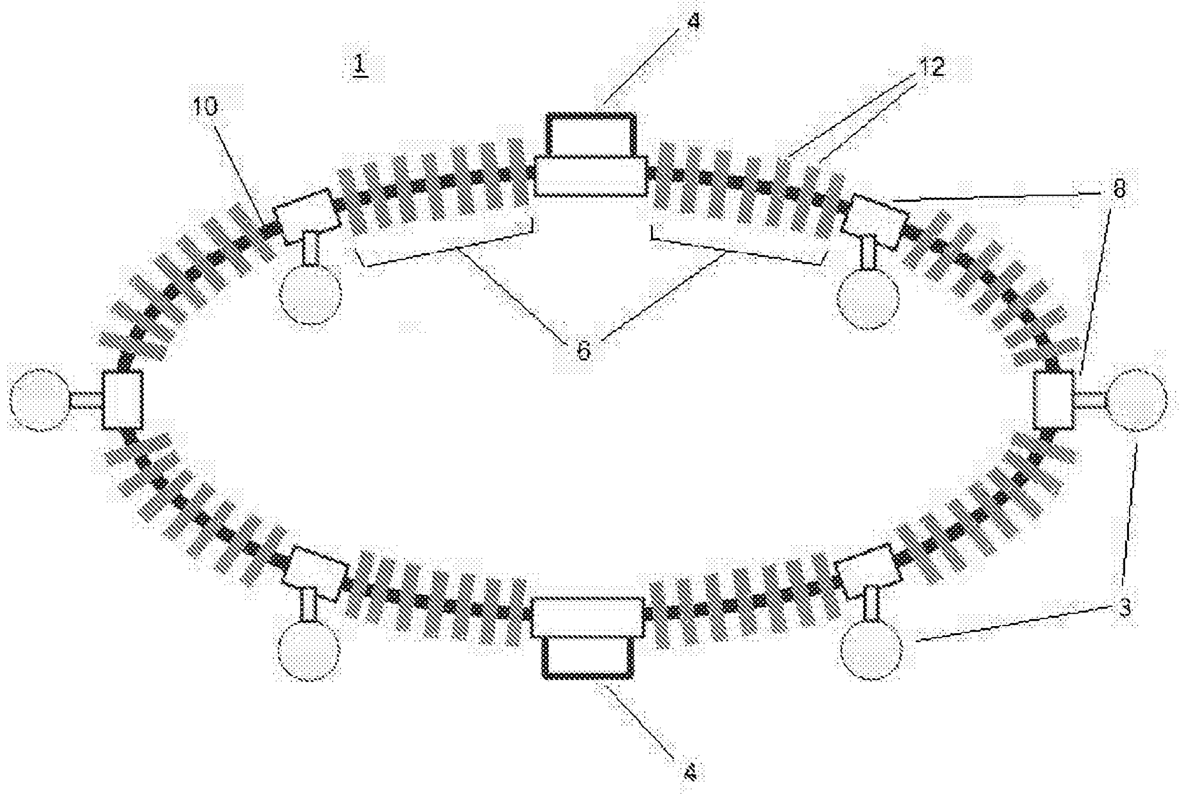

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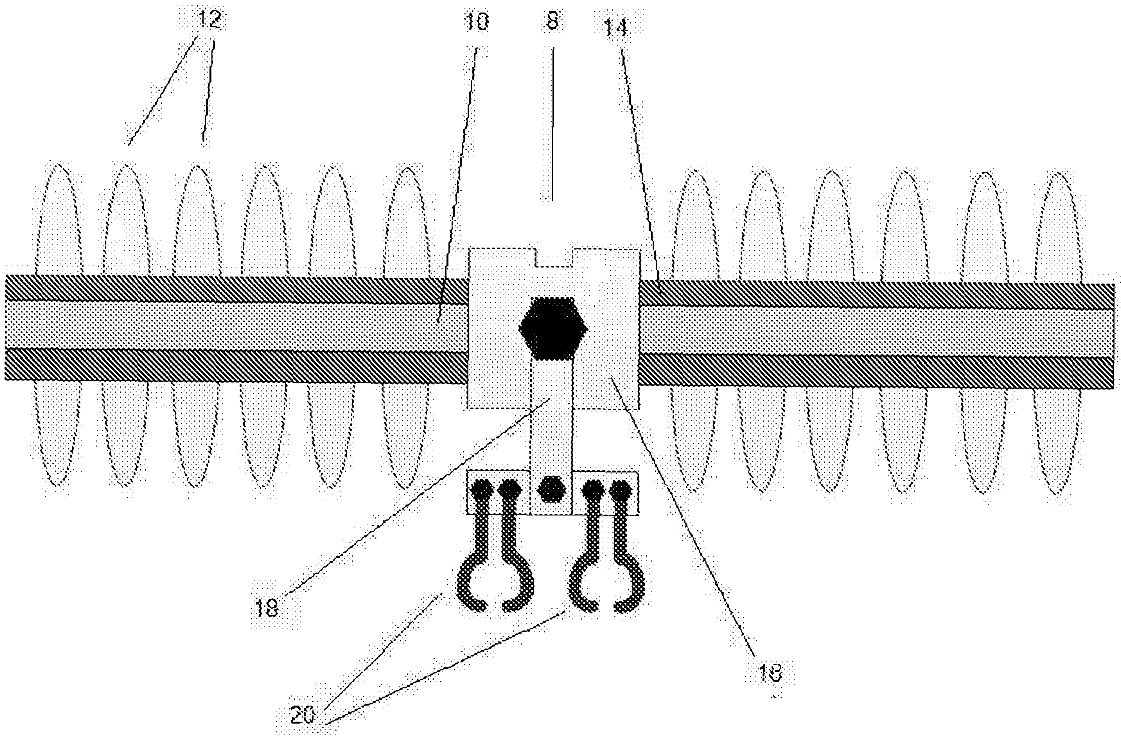
Fig 3



# CROSS-ARM FOR HIGH VOLTAGE TOWER

The present invention relates to insulating members suitable for use in high voltage electrical power networks, and to power network towers incorporating such members. In common usage, support towers for high voltage power systems are also referred to as pylons.

Electricity high voltage transmission networks in the UK are based on designs which are many decades old. The IEC standards define high voltage (HV) as greater than 1 kV. Typically, high voltage transmission lines operate at voltages in excess of 100 kV, perhaps several hundred kV. Typical voltages used in power networks are 275 kV and 400 kV but voltages up to 1200 kV or more may be used. In recent times, as the demand for electricity has increased and more power is generated from dispersed energy sources, transmission networks are approaching full capacity.

Although it is possible to build new networks, this is costly, time consuming and is often regarded as undesirable due to the visual impact. An alternative is to upgrade the capacity of existing networks either by increasing the voltage or by increasing the current of the existing transmission lines. Increasing the current on an existing circuit leads to increased conductor heating which can cause the conductor cable to sag below the minimum allowed height above ground level. Increasing the voltage on an existing circuit will cause a greater risk of flashover (a short circuit to earth or between phases) and may result in the system being in breach of statutory regulations. Either solution also results in increased electromagnetic fields at ground level. The requirements for minimum ground clearances, a reliable system (i.e. one that does not flashover) and limits on the electromagnetic field strength at ground level mean that the possibility of increasing voltages or currents for existing tower designs is limited. These issues also limit the ability to make existing tower designs more compact.

A conventional tower has a steel body carrying cross-arms, usually fabricated from L-section high tensile steel members. The conductors are held suspended from the ends of the cross-arms by insulators. For a 275kV system, the insulators are typically about 2.5m in length. The insulators hold the suspended conductors under tension and keep them spaced from the tower body and from the cross-arm itself. The height of the lowest cross-arm above ground level must take into account sag of the transmission lines due to the combined effects of ambient temperature, temperature rise from solar radiation and temperature rise from resistive heating.

The electromagnetic field levels at ground level generated from the transmission conductors must also be considered. It is also important that the conductors are held high enough above ground that the minimum statutory clearance is not breached. Additionally, the length of the cross-arm must be sufficient to ensure that conductor swing (due to wind-driven swinging of the insulator) does not lead to the conductors coming into close proximity with the tower body, which might result in flashover to the tower. In addition to being capable of bearing the weight of the transmission conductors, the cross-arm must also be strong enough to bear the additional loads that may arise, for instance, as a result of conductor icing, wind loads, conductor breakage (which could lead to high lateral forces on a cross-arm) or a combination thereof.

There is clearly a need to be able to increase the voltage rating or current rating for power transmission networks without the need to replace existing tower bodies and without increasing the risk of flashover. It would also be desirable to reduce electromagnetic field strength at ground level near towers, and to be able to utilise tower bodies that are more compact than existing designs.

In the past it has been proposed to make cross-arms of insulating material. GB 1034224 discloses insulators used as structural members of cross-arms or frames for supporting overhead line conductors from poles or towers. JP 06-335144A discloses the use of cross-arms as insulators for transmission lines, with a number of arm members combined into a truss arrangement. GB 919534 describes cross-arms for supporting overhead electric lines comprising one or more members of resin bonded glass fibre, and having a cast body of thermosetting or cold-setting synthetic resin in which the member or members are embedded.

More recently, WO 2011/021006 discloses making the cross-arms of a conventional tower or pylon from insulating members. The conductors are suspended directly from the end of the cross-arm, allowing a voltage increase without an increased risk of flashover. This permits the conductors to be held higher from the ground, and with a fixed mounting point they cannot swing towards the tower in windy conditions. Suspending the conductors directly from the end of the cross-arm also allows an increase in the overhead line current carrying capability. However this invention is still based on the conventional design of a tower bearing a plurality of cross-arms, and in this case each cross-arm comprises up to four insulating members.

There remains a need for simpler designs of high-voltage tower that can provide the benefits of fixed insulating supports outlined above. Thus in a first aspect the present invention provides an electrically insulating overhead conductor support for a tower arranged to carry overhead conductors, said support comprising an insulating structural member in the form of an endless loop, said structural member having means for securing it to the tower in a substantially vertical orientation, and further having a plurality of support means, each for supporting one or more overhead conductors, spaced around said loop.

A second aspect of the invention provides a tower for a high voltage power system having secured to it in a substantially vertical orientation at least one electrically insulating conductor support adapted to carry overhead conductors spaced from said tower, which support comprises an insulating structural member in the form of an endless loop having a plurality of support means, each for supporting one or more overhead conductors, spaced around said loop.

Comments below apply to both of aspects of the invention.

For convenience, the electrically insulating support comprising an insulating structural member in the form of a loop is referred to hereinbelow simply as a "support".

The support is in the form of a loop. Whilst the exact shape of the loop may be anything which is practical from an engineering and safety perspective, it preferably has at least one axes of symmetry, and may have two. It is also preferred that the longest diameter of the loop is adapted to be arranged horizontally when attached to the tower. The loop is preferably oval or circular, although it may be square or rectangular. In the case of an oval loop, the oval may optionally have only one axis of symmetry, with the long sides of the oval having different radii of curvature. The ratio of the longest diameter to the shortest diameter is preferably at least 1.5, and more preferably between 1.5 and 3.

The support may additionally comprise one or more cross-pieces extending from one side of the loop to the other. These can provide greater structural integrity. Preferably the cross-pieces comprise an insulating material.

The support is preferably attached to the tower along a vertically oriented axis of symmetry such that it extends symmetrically on either side of the tower.

More than one support may be attached to the tower. In one embodiment, two supports which are preferably identical are attached to the tower, one on either side, in a superposed configuration.

The attachment means for securing the support to the tower may comprise a single attachment point on the support. However it is preferred that there are at least two attachment means on the support for securing the support to the tower at two or more points. In the case where there are two attachment means on the support, they are preferably located such that they are aligned vertically one above the other when the support is attached to the tower.

The attachment means and the plurality of support means for supporting overhead conductors are located on the support such that when the support is in position on the tower, the conductors are sufficiently far from the tower to satisfy statutory requirements regarding flashover.

Known insulators used for suspending conductors from tower cross-arms are typically provided with sheds spaced along their length in order to increase the creepage path (i.e. the shortest distance between the ends of the insulator measured over the surface). The support of the present invention preferably comprises a central insulating core to which is attached a series of spaced sheds.

The insulating core of the support is preferably a continuous solid loop which is solid and free of substantial voids (voids may lead to water condensation within the core leading to risk of electrical discharge). The core may be of cylindrical cross-section. Alternatively it may have a T or Y cross-section, with three rib-like protrusions forming the arms. The ends of the arms may be rounded or lobed or alternatively provided with flanges. Such cross sections can increase the resistance to buckling and compressive loading, and are discussed in detail in

WO 2011/021006. In particular, the core may have a cross sectional profile, normal to the long axis, having a centroid in which the second moment of area of the cross sectional profile about every axis normal to the long axis and dissecting the centroid has a value of $A2/2\pi$ or more, where A is the area of the cross sectional profile.

The core is preferably substantially uniform in cross-sectional profile and in cross-sectional area along its entire length.

The core may be formed from a glass-fibre reinforced insulating resin such as E (Electrical Grade) or ECR (Electrical Grade Corrosion Resistant) glass fibres with thermosetting resins such as polyester, vinyl ester or epoxy or thermoplastic resins such as polypropylene, polyethylene terephthalate, polybutylene terephthalate, etc. Other fibres may be used for reinforcement and other suitable insulating polymers may be used with or without reinforcement fibres. Other materials having suitable mechanical and dielectric properties may be used to form the core.

The optional cross-pieces of the support referred to above may be of the same construction as the main loop of the support, comprising a central insulating core optionally carrying sheds. Alternatively they may be of any conventional construction which provides the necessary structural integrity, including non-insulating materials such as metal.

Sheds are commonplace in the field of electrical insulators and for a typical insulator the shed is a disc or plate, usually of glass or silicone polymer, having a central aperture allowing it to be threaded onto the central core. The shed may be provided with concentric ribs to increase the creepage length. Sheds may also be directly moulded onto the core. It is preferred that the creepage path of the support of the present invention is from 2 to 5 times the actual length.

Sheds useful for the present invention may be shaped such that a creepage path length contributed by each shed is substantially the same around its entire perimeter. In other words, rather than having a conventional circular shape, the shed shape may be tailored to substantially follow or be similar to the shape of the cross-sectional profile of the insulating core. This arrangement prevents wastage of shed materials (as the shortest creepage path will be the path followed for discharge) and assists in reducing the weight of the support.

Sheds may be attached to the core in a known manner, for example by coating the core with a layer of insulating silicone polymer and attaching sheds to this layer, for instance by use of a silicone glue. An alternative is to provide the core with a silicone sheath and sheds in a single silicone moulding process.

In addition to the series of sheds, the core also has attached to it in at least one location, preferably two locations, attachment means for securing the support to the tower. Whilst the core is preferably a continuous loop, it may be broken at the location of the attachment means. For example, in the case where there are two attachment means located on diametrically opposed sides of the core, the core may comprise two elongate sections which are joined at each attachment means to form a single loop.

The attachment means for securing the support to the tower may be any conventional attachment means. Typically it is of metal construction and hence non-insulating.

In addition to the attachment means, spaced around the support are support means to which overhead conductors can be attached. These may be similar to conductor support means used on conventional towers carrying suspended or tensioned insulators. In one embodiment the support means comprises a metal joint attached to the core of the support, having suspended from it a bracket for an overhead conductor. The metal joint and/or bracket may be rotatably attached to the core. The conductor bracket carries at least one conductor holder.

The support means are located on the core so that in use the overhead conductors which they carry are positioned sufficiently far away from the tower to satisfy regulatory requirements.

In use, the support is secured to the tower by the attachment means so that its plane is in a substantially vertical orientation. Overhead conductors are then attached to the support means. As previously mentioned, in one embodiment a pair of identical supports may be attached at the same height on either side of a tower, so that each conductor can be supported by the tower at two points, one on each support.

A preferred embodiment of the invention is described with reference to the accompanying drawings, in which:

Fig 1 is a diagrammatic end view of a tower carrying an insulating structural member loop according to the invention;
Fig 2 is a plan view of an insulating structural member loop according to the invention;
Fig 3 is a more detailed view of the means for attaching an overhead conductor to the loop.

Referring to Figure 1, this shows a tower 2 for carrying overhead conductors to which is attached an electrically insulating support 1 according to the invention. The support is in the form of a loop, in this case shown in the shape of an oval, and is positioned symmetrically on the tower 2 in a vertical orientation by attachment means 4. Overhead conductors 3 which run perpendicular to the plane of the loop are supported around the loop. three on each side of the tower. In one embodiment a second identical support may be located in the corresponding position on the opposite side of the tower. so that each conductor is supported from the tower at equivalent positions on each loop.

Figure 2 shows a more detailed view of the support 1 of the invention. The support 1 is divided into a series of insulating sections 6 separated by support points 8 to which the conductors 3 are attached. Also forming part of the loop are the two attachment points 4 which secure the support to the tower. Whilst a total of eight insulating sections and six cable support points have been shown in the this Figure, it will be appreciated that the number may be varied. The insulating sections 6 comprise a central core 10 to which are attached a series of sheds 12 in the manner described previously.

Figure 3 shows a more detailed view of a conductor support 8. The support comprises a metal joint 16 from which is suspended a bracket 18 carrying a pair of conductor holders 20. The attachment of the joint 16 to the core 10 and/or the bracket 18 to the joint may be rotatable. The conductor holders 20 may also optionally be rotatably attached to the bracket 18. Figure 3 also shows that the insulating core 10 is surrounded by a silicone sheath 14 to which are attached the sheds 12.

CLAIMS

1. Electrically insulating power cable support for a tower arranged to carry overhead conductors, said support comprising an insulating structural member in the form of an endless loop, said structural member having means for securing it to the tower in a substantially vertical orientation, and further having a plurality of support means, each for supporting one or more overhead conductors, spaced around said loop.

2. Tower for a high voltage power system having secured to it in a substantially vertical orientation at least one electrically insulating cable support adapted to carry overhead conductors spaced from said tower, which support comprises an insulating structural member in the form of an endless loop having a plurality of support means, each for supporting one or more overhead conductors, spaced around said loop.

3. Support or tower according to claim 1 or 2, wherein the support has at least one axis of symmetry, and the ratio of the longest diameter to the shortest diameter is at least 1.5, preferably between 1.5 and 3.

4. Tower according to claim 3, wherein the support is attached to the tower along a vertically oriented axis of symmetry such that it extends symmetrically on either side of the tower.

5. Tower according to any of claims 2 to 4, wherein two supports are attached to the tower, one on either side, in a superposed configuration.

6. Support or tower according to any preceding claim, wherein the support additionally comprises one or more cross-pieces extending from one side of the loop to the other.

7. Support or tower according to any preceding claim, wherein there are at least two attachment means on the support for securing the support to the tower at two or more points.

8. Support or tower according to claim 8, wherein the two attachment means on the support are located such that they are aligned one above the other when the support is attached to the tower.

9. Support or tower according to any preceding claim, wherein the support comprises a central insulating core to which is preferably attached a series of spaced sheds.

10. Support or tower according to claim 9, wherein the core of the support has either a cylindrical cross-section or a T orY cross-section with three rib-like protrusions forming the arms.

11. Support or tower according to claim 9 or 10, wherein the core of the support has a cross sectional profile, normal to the long axis, having a centroid in which the second moment of area of the cross sectional profile about every axis normal to the long axis and dissecting the centroid has a value of $A2/2\pi$ or more, where A is the area of the cross sectional profile.

12. Support or tower according to any of claims 9 to 11, wherein core is formed from a glass-fibre reinforced insulating resin.

Intellectual Property Office

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|---|---|---|---|
| **Application No:** | GB1710120.5 | **Examiner:** | Mr Tobias Tribe |
| **Claims searched:** | 1-12 | **Date of search:** | 30 November 2017 |

## Patents Act 1977: Search Report under Section 17

**Documents considered to be relevant:**

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance |
|---|---|---|
| X | 1-12 | EP 2501005 A2 (SAG GMBH) See figures and especially paragraphs [0022]-[0024] of the description |
| X | 1-12 | US 2010/0064598 A1 (LEE et al) See especially figure 3, insulated loop 141-148, securing means 151-154, support means 131-136 |
| X | 1-12 | CN 201528175 U (CPECC NORTHEAST ELECTRIC POWER DESIGN) See figure and WPI abstract accession No. 2010-K64974, loop 4-5, securing means 2, support means 3 & 6. |
| X | 1-12 | US 5175442 A (ASHLEY) See figure 1c, loop 21, supporting means 23 |
| X | 1-12 | CN 101425666 A (UNIV TSINGHUA) See especially figures 3 and 4, and WPI abstract accession No. 2009-J12387 |

Categories:

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|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
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| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |

**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC$^{X}$ :

Worldwide search of patent documents classified in the following areas of the IPC

E04H; H02G

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

Intellectual Property Office

**International Classification:**

| Subclass | Subgroup | Valid From |
|---|---|---|
| H02G | 0007/05 | 01/01/2006 |
| E04H | 0012/24 | 01/01/2006 |
| H02G | 0007/20 | 01/01/2006 |