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(54) **An electric insulator and a method of producing such an electric insulator**

(57) An electric insulator (1) comprising a main insulating body (4). The main insulating body (4) comprises a matrix of a polymer material in which there are distributed electrically conducting particles.

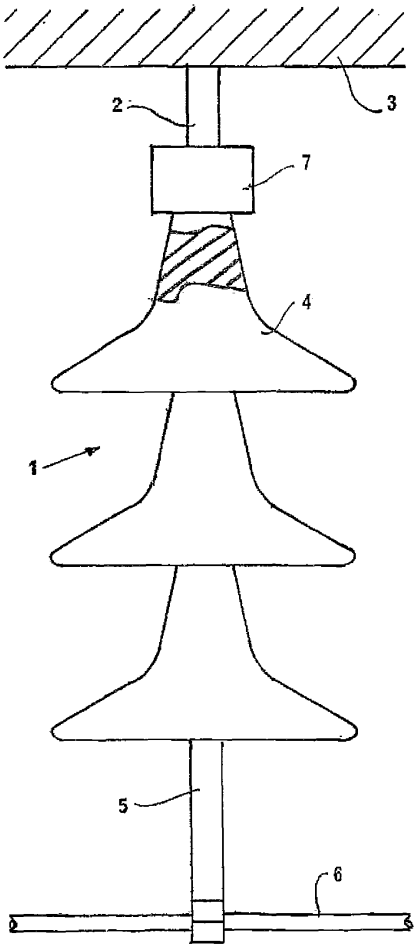

Fig 1

EP 2 099 038 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a method of producing an electric insulator, wherein a main body of the insulator, comprising a polymer material, is moulded.

[0002] The invention also relates to an electric insulator as such, comprising a main insulating body.

[0003] The insulator may be a line insulator, an apparatus insulator, such as a cable termination, or a support insulator, such as station post. Accordingly, a wide range of insulators are within the scope of protection applied for.

[0004] Typically, the insulator is a medium voltage or high voltage insulator, wherein medium voltage is referred to as voltages in the range of 1-36 kV, and high voltage is referred to as voltages above 36 kV. Thus, also ultra high voltages, e.g. 800 kV are included.

[0005] The invention is particularly relevant to insulators arranged in such environments in which the insulating body thereof is subjected to a deposition of any kind of particles on the outer surface thereof, and in which there is such humidity conditions that moisture will also be likely to deposit on said outer surface, and in which the outer surface of the insulator is likely to be subjected to wear or impacts that might partly damage said surface. Typically, but not necessarily, such an environment is an outdoor environment.

BACKGROUND OF THE INVENTION

[0006] Electric high voltage insulators comprising a main insulating body made of a polymer are prior art. When such insulators are to be installed in environments and applications in which the outer surface of the insulator is likely to be subjected to deposition of moisture in combination with deposition of dust or other particulate matter a semi-conducting outer surface might be arranged for the purpose of preventing the up-coming of partial discharges on said outer surface. Thereby, a separate process step will be required in which such a semi-conducting protection layer is applied to the outer surface of a main insulating body of the insulator.

[0007] The semi-conducting protection surface may, as time goes by, become worn or deteriorate to due many reasons, and accordingly its protecting ability will decrease.

THE OBJECT OF THE INVENTION

[0008] It is an object of the present invention to present a method an insulator that remedies the above-mentioned draw-backs of prior art. Accordingly, it is an object of the invention to provide a method of producing an electric insulator whereby the insulator is produced in a cost-efficient manner. It is also an object of the invention to proved an electric insulator the design of which permits a cost-efficient production thereof and the functionality of which is less sensitive to wear on its outer surfaces than is the case of corresponding electric insulators of prior art.

SUMMARY OF THE INVENTION

[0009] The object of the invention is achieved by the initially defined method, **characterised in that,** before or during said moulding, particles of an electrically conducting material are added to the polymer material of said main body and moulded together with said polymer material. By introducing electrically conducting particles into the main insulating body, the latter is provided with a certain conductibility. Provided that the amount and type of particles are selected such that a pre-determined, preferred electric conductivity or resistivity of the material of the main insulating body is the obtained, the material of the main insulating body will in itself be able of playing the role of a semi-conducting outer layer or glaze, whereby the step of providing a separate such layer or glaze on top of the main insulating body may be omitted. Preferably, the moulding is an injection moulding, and the polymer used as a bulk or matrix material in the main insulating part is, preferably, a thermoplastic polymer.

[0010] The main insulating body, as referred to herein, is a part of the insulator over which a main part of an electric field is concentrated during operation of the insulator, i.e. when subjected to an electric field from an adjacent electric conductor or a high voltage carrier. The main insulating body may consist of a plurality of individual bodies, as might be the case in line insulator, wherein at least one, preferably a majority, and most preferably all of said individual bodies are designed in accordance with the teachings of the invention. Alternatively, each individual body of a line insulator may be regarded as an separated insulator, provided with its own main insulating body. The insulator may also be designed as a one-piece insulator in which the main insulating body is formed by only one such body. The main insulating body or bodies form a bulk part of each insulator, responsible for the absorption of most of the electric field between two elements of different electric potential, such as a high voltage line and an element connected to earth. The above teaching is also valid for the following description of an electric insulator according to the invention.

[0011] The object of the invention is also achieved by means of the initially defined electric insulator, which is **characterised in that** said main insulating body comprises a matrix of a polymer material in which there are distributed electrically conducting particles. Such a design will, on one hand, permit the omission of a step in which a separate semi-conducting protective layer is applied onto the main insulating body, and, on the other hand, provide for a certain redundancy of the insulator. Damages on the outer surface of the insulator will not be as crucial as before with regard to the prevention of partial discharges. Since the bulk, i.e. the main insulating body, of the insulator will be to some extent electrically con-

ducting, a small leak current will flow through the latter during operation thereof, given that the insulator is connected to two element of different voltages. The current might lead to a slight increase of the temperature of the insulator, which might prevent condensation and deposition of moisture on the outer surface thereof, thereby further protecting the insulator against partial discharges on the outer surface thereof. However, it is important that the electric resistance of the conductor, and the resistivity of the material thereof, is high enough to prevent excessive current, and thereby excessive temperature increase and thermal losses in the insulator. The main insulating body of the insulator will also control the electric field as it is it conductive to a certain degree, and this fact may be taken advantage of for the purpose of field control.

[0012] Preferably, said electrically conducting particles are evenly distributed throughout said main body. Thereby, the production of the main insulating body is simplified. A conventional injection molding procedure may be used for the production, which is advantageous both from a technical and economical point of view. With an even distribution, areas of field concentration in which the ability of preventing partial discharges on the outer surface might be reduced are avoided to a higher degree.

[0013] According to one embodiment, the electric resistance of the moulded main body is in the range of 1 MegaOhm - 20 GigaOhm. Thereby, it is conceived that the bulk of the insulator, i.e. the electrically insulating part thereof, will be electrically resistant enough in order to fulfil its task as an insulator but will permit a small leak current to flow through it, i.e. through a major part of a cross-section of the insulator. The outer surface thereof will have a certain degree of semi-conducting ability, resulting in an increased resistivity against partial discharges thereon.

[0014] According to a further preferred embodiment, the electric resistance of the moulded main body is above 0.5 GigaOhm. Thereby, the risk of having so called thermal runaway and energy losses in the bulk or main part of the insulator is reduced.

[0015] According to a further preferred embodiment, the electric resistance of the moulded main part is below 10 GigaOhm. Thereby, it is conceived that the semi-conducting character of the material will be good enough to enable use of the bulk material itself as a protection against partial discharges on an outer surface thereof.

[0016] In connection to the discussion regarding resistance of the main insulating body, the resistivity of the material of the main insulating body should be mentioned. Here, a preferred resistivity is at least 10 Ohm.m, preferably at least 20 Ohm.m. Preferably, the resistivity is below 100 MegaOhm.m, preferably below 40 MegaOhm.m. The resistivity of the material in combination with the geometric shape and size of the insulator and its main insulating body will be decisive for the electrical resistance of the insulator. In practice, a layer of water or moisture on the outer surface of the insulator will decrease the resistance thereof.

[0017] According to a preferred embodiment, the conducting particles comprise particles of carbon black. Carbon black has the advantage of both conferring the electric conductivity needed and of protecting the polymer, upon basis of which the main insulting body is formed, from any ultraviolet radiation that the insulator might be subjected to.

[0018] Preferably, at least some of said conducting particles comprise particles based on a semi-conducting material. By adding semi-conducting particles to the polymer, in particular if added as a supplement to carbon black particles, the finding of a suitable resistivity/conductivity of the material of the main insulating body will be facilitated.

[0019] According to one embodiment, said semi-conducting material is present as a metal oxide. Preferably, the metal oxide is any one of chrome oxide, zinc oxide or iron oxide. Other metal oxides are, however, also conceivable. The added oxides may be doped, in order to enable a further facilitation of finding the requested resistivity/conductivity of the material in question. Typically, zinc oxide may be doped with bismuth.

[0020] According to one embodiment, at least some of said particles comprise a carbide, preferably silicon carbide. Silicon carbide may be doped with aluminum in order to facilitate the control of the conductivity of the main insulating body.

[0021] According to one embodiment, at least some of said particles are fibers. It should be understood that spherical particles require to be present in a higher concentration than otherwise shaped particles in order to confer a predetermined conductivity to the material in question. If elongated particles, preferably fibers, are added, the weight percentage, i.e. the content, of added particles may be reduced and the desired functionality of the insulator still be achieved. Typical examples of fibers that might be used according to the invention are carbon fibers or steel fibers.

[0022] According to yet another embodiment, the invention suggests that a major part of said particles be carbon black particles. Carbon black has the advantage of being readily produced and, therefore, being relatively inexpensive. It also confers UV-radiation protection to the polymer with which they are mixed, especially if the polymer is a thermoplastic polymer.

[0023] According to a preferred embodiment said polymer material is a based on a thermoplastic resin, thereby forming a thermoplastic polymer when molded. It should be understood that thermoplastic resins are more easily injection molded into complex shapes than thermosetting resins, and that they are also preferred from and environmental point of view.

[0024] Preferably, said thermoplastic resin and polymer comprises any one of PE, PEX, PP, Nylon, PBT, PET, PC, PS, or ABS. The polymer may be unfilled or filled with any strengthening filler such as glass fiber or any mineral.

[0025] According to the invention, it is preferred that an outer surface of said main insulting body will form an outer, semi-conducting surface of the electric insulator. Thereby, the extra process step during which a separate protective glaze is applied to the surface of the insulator may be omitted.

[0026] The object of the invention is also achieved by means of an electric power distribution arrangement, comprising a high-voltage carrying element, an element connected to earth and an electric insulator connected to the high-voltage carrying element and to the element connected to earth, **characterised in that** said electric insulator is an insulator according to the invention.

[0027] According to the invention, the main insulating body of the electric insulator presents a conductivity such that, at the operation voltage of the voltage carrying element, a leakage electric current flows from said high-voltage carrying element to the element connected to ground through the main insulating body of the insulator. The design of the insulator, including material properties and geometrical shape, should be adapted in order to permit a predetermined leak current through it at operational conditions. Accordingly, the design will be adapted to the nominal operational voltage of the voltage carrying element connected thereto.

[0028] Preferably, the electric current is of a magnitude that increases the temperature of said insulator. Preferably, the temperature increase is of such a degree that, under specific, operational conditions, condensation and deposition of water on the outer surface of the insulator is inhibited or at least reduced, whereby partial discharges on the surface are prevented. A temperature increase in the range of 1-10 °C, preferably 1-5 °C, or even more preferably 1-2 °C, is conceivable.

[0029] Further features and advantages of the invention will be presented in the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Hereinafter, an embodiment of the invention will be described by way of example with reference to the annexed drawing, on which

Fig. 1 shows a line insulator in accordance with the invention, partly cut, and

Fig. 2 shows an alternative insulator in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Fig. 1 shows an embodiment of an insulator 1 according to the invention. The insulator 1 shown in fig. 1 is a line insulator. The insulator 1 is suspended in a steel rod 2 which, in its turn, is connected to a beam 3, which might be connected to earth.

[0032] The insulator 1 comprises a plurality of insulating bodies 4 interconnected by interconnection pins or the like (not shown). An overhead transmission or distribution line 6 for electric power is suspended at an end part or line holder 5 of the insulator 1. Thereby, the line 6 is electrically insulated from the beam 3 by means of the insulator 1.

[0033] Each of the insulating bodies 4 of the insulator 1 is mainly constituted by an electrically insulating material, preferably a polymer. Both thermosetting and thermoplastic polymers are conceived as a suitable polymer of said bodies 4. However, a thermoplastic polymer is preferred.

[0034] Above the insulating bodies 4 there is provided a surface protection element 7. The surface protection element 7 is attached to the rod 2 in which the insulator 1 is suspended. The surface protection element 7 comprises a solid body made of a silicone-based material, preferably silicone rubber. The body of silicone rubber of the protection element 7 contains a predetermined amount of silicone oil that will slowly be drained off from the said body and be deposited onto the neighbouring underlying insulating body 4. The surface protection element 7 is not essential for the invention and may be omitted. However, it will confer further protection against partial discharges on the outer surface of the insulator, and it might be a preferred solution in combination with the suggested design of the insulating bodies in accordance with the teaching of the present invention.

[0035] A part of the insulator 1 shown in fig. 1 is shown in cross section. As can be seen the bulk material of an insulating body 4 of the insulator extends all the way to and forms the outer surface of the insulator 1. Preferably, each of the bodies 4 of the insulator 1 shown in fig. 1 has a corresponding design in this regard. The material of the insulating body 4, i.e. the main insulating body, comprises a matrix of a thermoplastic polymer such as PE, PEX, PP, Nylon, PBT, PET, PC, PS, or ABS. In said matrix there are distributed electrically conducting particles to such a degree that an electric resistance in the range of 0,5-10 GigaOhm. is achieved for the bulk material, i.e. the main insulating body. The exact resistivity of the material is adapted to the design of the insulator (i.e. the thickness and the length of the insulator, and the resistivity of the chosen polymer) and strength of the electric field that it is subjected to. The resistivity is high enough to assure the electrical insulation function of the insulator and to prevent excessive electric losses which could lead to thermal runaway and electrical or mechanical failure of the insulator. However, the resistivity is also low enough for making the outer surface of the insulator 1 capable of transferring leak currents, and thereby prevent the upcoming of partial discharges thereon. If combined with one or more surface protection elements like the element 7 shown in fig. 1, the resistivity of the insulation material may be permitted to be somewhat higher than else.

[0036] The filler that confers the electric conductibility to the insulation material preferably comprises particles

of carbon black. Preferably those particles, being of small size and generally spherical, are supplemented by further particles of more elongated or extensive shape, such as fibers. The supplementary particles may also contain a metal composition such as a metal oxide or carbide, and may be doped in any suitable way in order to confer further semiconducting character to the material. Typically, supplementary fibers may comprise carbon fibers or steel fibers.

[0037] Fig. 2 shows an alternative, perhaps more likely embodiment of the invention, in which the insulator 8 is formed by a rod shaped main insulating body with circumferential fins 9. In a first end the insulating body is connected to a first element 10 to be connected to a medium or high-voltage carrying element (not shown) and in a second end it is connected to a second element 11 that is to be connected to an element (not shown) connected to ground or of other electric potential than the medium or high-voltage carrying element. The main insulating body forms a major part of the cross section of the insulator, here the whole cross section, as indicated by the cut section indicated with reference number 12 in fig. 2.

[0038] It should be understood that the number of alternative embodiments within the claimed scope is immense, and that the person skilled, in the art, once he or she has been confronted with the idea of the present invention will be fully capable of providing such alternatives without undue work. Features such as the type of polymer of the insulation body, the type, size, shape and amount of electrically conducting particles added, etc. may be varied within wide ranges, as long as the resistivity of the material becomes the one preferred for a specific application.

Claims

1. A method of producing an electric insulator (1), wherein a main body (4) of the insulator (1), comprising a polymer material, is moulded, **characterised in that,** before or during said moulding, particles of an electrically conducting material are added to the polymer material of said main body (4) and moulded together with said polymer material.

2. An electric insulator (1) comprising a main insulating body (4), **characterised in that** said main insulating body (4) comprises a matrix of a polymer material in which there are distributed electrically conducting particles.

3. An electric insulator (1) according to claim 2, **characterised in that** said electrically conducting particles are evenly distributed throughout said main body (4).

4. An electric insulator (1) according to claim 2 or 3, **characterised in that** the electric resistance of the moulded main body (4) is in the range of 1 MegaOhm - 20 GigaOhm.

5. An electric insulator (1) according to any one of claims 2-4, **characterised in that** the electric resistance of the moulded main body (4) is above 0.5 GigaOhm.

6. An electric insulator (1) according to any one of claims 2-5, **characterised in that** the electric resistance of the moulded main body (4) is below 10 GigaOhm.

7. An electric insulator (1) according to any one of claims 2-6, **characterised in that** the said conducting particles comprise particles of carbon black.

8. An electric insulator (1) according to any one of claims 2-7, **characterised in that** at least some of said conducting particles comprise particles based on a semiconducting material.

9. An electric insulator (1) according to claim 8, **characterised in that** said semiconducting material is present as a metal oxide.

10. An electric insulator (1) according to claim 9, **characterised in that** said metal oxide is any one of chrome oxide, zinc oxide or iron oxide.

11. An electric insulator (1) according to any one of claims 2-10, **characterised in that** at least some of said particles comprise silicon carbide.

12. An electric insulator (1) according to any one of claims 2-11, **characterised in that** at least some of said particles are fibers.

13. An electric insulator (1) according to any one of claims 2-12, **characterised in that** a major part of said particles are carbon black particles.

14. An electric insulator (1) according to any one of claims 2-13, **characterised in that** said polymer material is a based on a thermoplastic resin.

15. An electric insulator (1) according to claim 14, **characterised in that** said thermoplastic resin comprises any of PE, PEX, PP, Nylon, PBT, PET, PC, PS, or ABS.

16. An electric insulator (1) according to any one of claims 1-15, **characterised in that** an outer surface of said main insulting body (4) forms an outer, semiconducting surface of the electric insulator (1).

17. An electric insulator (1) according to any one of

claims 1-16, **characterised in that** said insulator (1) is an high-voltage insulator.

18. An electric power distribution arrangement, comprising a medium- or high-voltage carrying element (6), an element (2) connected to earth and an electric insulator (1) connected to the medium- or high-voltage carrying element (6) and to the element (2) connected to earth, **characterised in that** said electric insulator is an insulator according to any one of claims 2-18.

19. An electric power distribution arrangement according to claim 18, **characterised in that** the main insulating body (4) of the electric insulator (1) presents a conductivity such that, at the operation voltage of the voltage carrying element (6), an electric leakage current flows from said high-voltage carrying element (6) to the element (2) connected to ground through the main insulating body (4) of the insulator (1).

20. An electric power distribution arrangement according to claim 19, **characterised in that** the electric current is of a magnitude that increases the temperature of said insulator.

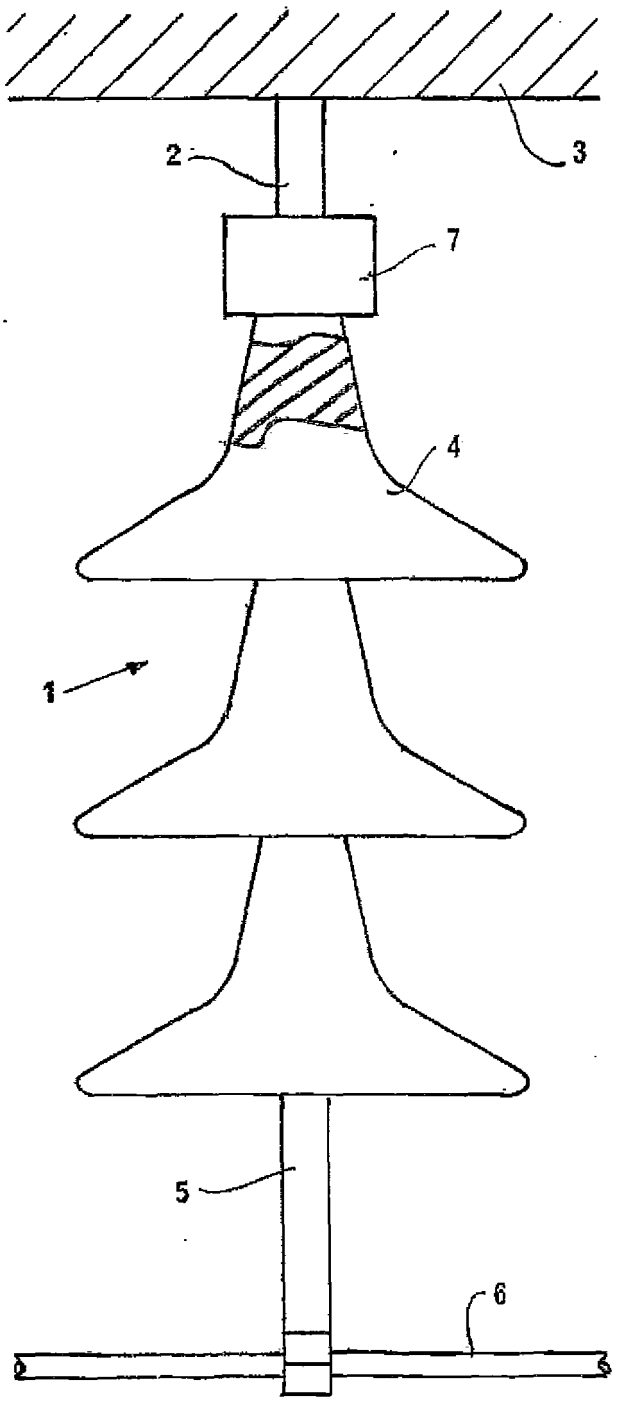

Fig 1

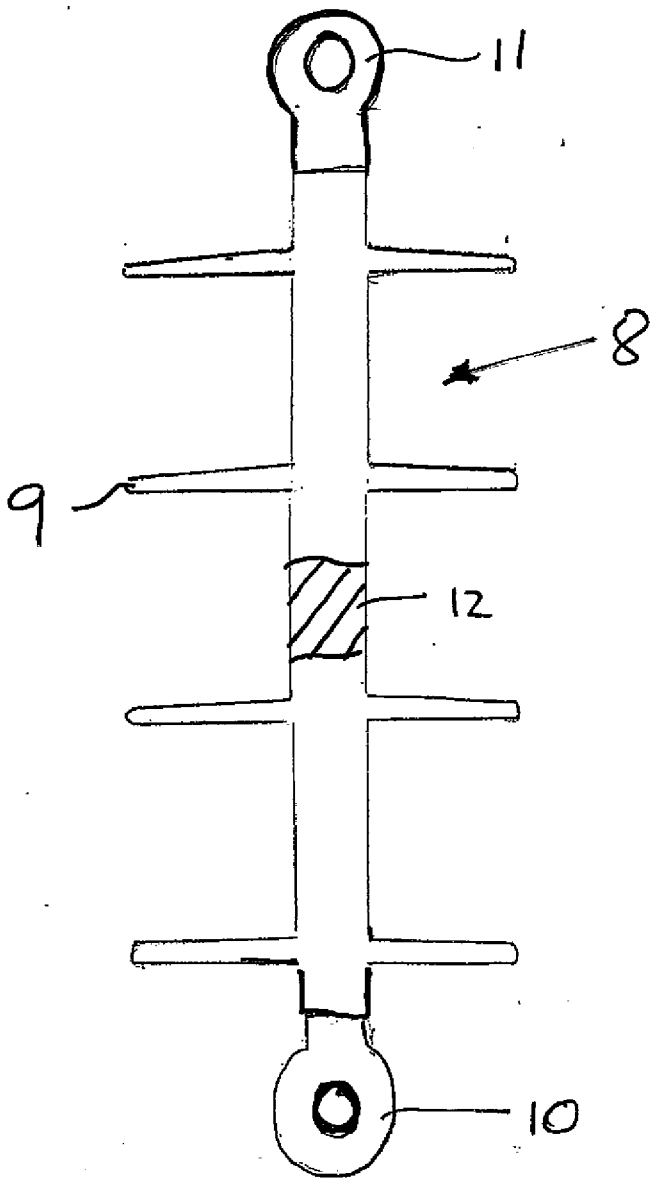

Fig 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 15 2271

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TECHNICAL FIELDS SEARCHED (IPC)

H01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 July 2008	Hillmayr, Heinrich

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 15 2271

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