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(54) Antenna with low visual impact

(57) The present invention relates to a directional multi-channel antenna of the type comprising a substantially flat reflecting screen (1) and a plurality of dipoles or radiators (2) held up at a certain distance on the reflecting side of the screen (1) and a shell or radome (3) made of a material essentially transparent to the radiation RF transmitted and received by the antenna, containing said reflecting screen, said dipoles or radiators and at least one feeding connector of the antenna.

According to the invention said radome (3) is made of an optically transparent material and said screen is, at least for a major part (1a, 1b) set up by a conductor net arc-welded at the crossings.

According to an alternative embodiment said conductor net is set up by a first plurality of wires arranged on a first plane and a second plurality of wires arranged on a second plane put at a distance of a predetermined entity from said first plane.

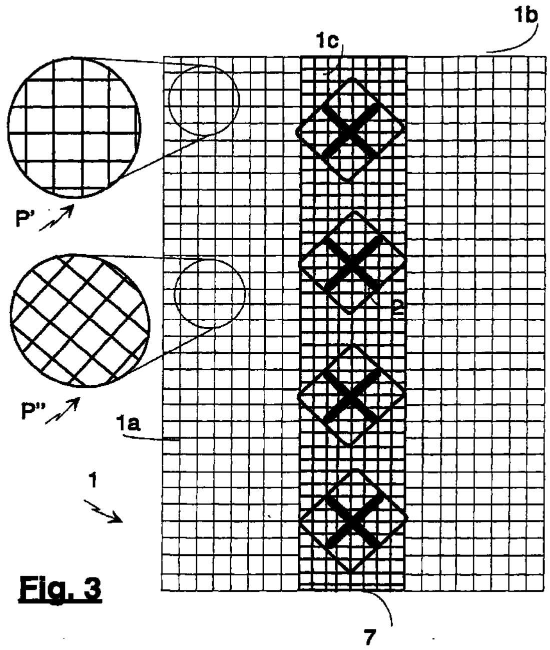

Fig. 3

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Description

Field of the Invention

[0001] The present invention relates to radiomobile telephone systems and in particular the antennas used to realise a cell coverage of the served territory.

[0002] The cellular telephone systems require a complex antenna network with variable shapes and sizes especially in function of the operation frequency spread over the territory.

[0003] Such antennas have to be positioned on territory, supported by poles or pylons, on existing constructions such as church towers, towers, buildings in a variable number generally from 3 to 12 for each emplacement, in function of the subdivision of the area in cells covered by the respective antennas. Areas densely populate by subscribers as residential centres require a high density of cells and therefore of installations of antennas.

Background art

[0004] The commonly used antennas present a perpendicularly extending panel configuration in which a substantially flat screen of conducting material supports a series of dipoles aligned along the perpendicular median axis of the panel suitable to radiate and to receive electromagnetic signals. The flat screen is essential as it carries out the function of reflecting the electromagnetic radiation radiated by the dipoles realising the wanted directivity of the antenna.

[0005] The screen, the dipoles and the necessary connection cables of the dipoles to the connecting clamps to the local station are normally contained inside an shell or radome transparent to RF radiation to protect from atmospheric agents, dust, guano etc. which - when accumulating - could degrade and compromise the functioning of the antenna. The shell or radome is typically made of fibreglass or another opaque plastic material.

[0006] The whole has essentially the shape of an opaque body with a visibly perceptible volume.

[0007] The environmental impact of the installation of such antennas especially in urban areas of recognised and undiscussed historical and architectural value quite often cannot be neglected as these antennas have to be installed in positions strategically efficient for an adequate covering of the respective cell.

[0008] The installation of antennas - apart from other preoccupations which may be overcome by demonstrable checks of sufficiently low electromagnetic field density below the limits foreseen by the law - often raise objections for the unaestheticism that represent on fronts and/or skylines which slow down and ,in some cases, prevent the installation of radiant systems in the points that enable the most efficient covering of the territory.

[0009] The fibreglass radome, if on one hand it satisfies the need of lightness, mechanical resistance and of not being degradable by atmospheric agents and ultraviolet radiation, contributes to confer a bulky appearance to the antenna and to increasing the visibility.

[0010] By the exposure to sunshine the fibreglass shell causes an increase of the internal temperature which may produce a temporary degrading of the performances.

[0011] Moreover the fibreglass covering has a minimum (but absolutely not negligible) capacity to absorb RF enemy which naturally represents a loss and therefore a reduction of the gain of the antenna.

[0012] Object of the invention Its the aim of the present invention to eliminate or reduce considerably the above-mentioned drawbacks deriving from an antenna with a definitely reduced visual impact compared to the known antennas, but assuring comparable or even upgraded performances especially in terms of a better stability of the behaviour within an ample spectre of environmental conditions.

Summary of the invention

[0013] It has been found that a decisive visual aspect of substantial transparency of an installed antenna watched from a certain distance can be implemented by a combination of an optical transparent radome and a reflecting screen presenting a major part, in terms of total area, set up by a conductive metallic net with a high empty/solid relationship.

[0014] The object, when observed at distance and in the contest of other architectural forms among which it is installed becomes little visible and difficult to be noticed by a casual observer. This "invisibility" turns out to be surprisingly raised by favourable illumination conditions.

[0015] If in back lighting condition a certain visibility of the dipoles, the support structures etc. remains, it turns out that this has only a low visual impact in virtue of fact that the observed object results to be substantially transparent for a large part of its outline and it is not perceived as an object with an evident volume.

[0016] Under optimum grazing or crash light conditions within an ample field of angles with the plan of the flat screen the translucency of the transparent radome reduces the visibility even of the above-mentioned opaque structures.

If the use of a conductor net instead of a full screen obviously defining the mesh dimensions of the net in function of the wavelength spectre of the radiation RF managed by the antenna in order to assure a behaviour similar to that of a full screen, is an option known by the sector especially in the sector of satellite antennas and adapted for the aim to reduce the resistance to the wind of the antenna, and therefore to reduce the stress on the supporting structures, in the sector of the directional multi-channel antenna for transmitting and receiving, it has been found out that the use of a reflecting full screen completely realised by a conducting net with the most largest meshes possible to reduce the visual impact and to favour a substantially transparent aspect for the entire antenna, is only possible at a high price in terms of reduced performances.

[0017] Even sizing the dimensions of the meshes of the conducting net in such a way to equalise the reflecting behaviour to that of an analogous full conducting surface such behaviour turns out heavily invalidated by the presence of objects, that is of conducting surfaces behind or in the immediately next to the back of the reticulate screen.

[0018] In the case of the antennas taken into consideration the presence of a generally metallic supporting pole or the presence of metal fixing stirrups of the antenna at the front of a building define the presence, not residual in terms of intensity of a so-called evanescent wave which creates considerable perturbations for the correct functioning of the antenna.

[0019] The phenomenon of the evanescent wave occurring, when relatively adjacent conductors are present at the back of the reticular reflecting screen, is due to a majority exercises by the metallic surface immediately staying behind the reticular screen with respect to the screen itself while attracting part of the radiation RF affecting through the meshes of the reticular screen, a radiation which is therefore reflected by the metallic surface at the back of the reticular screen in spurious directions which do not coincide with the wanted reflection direction.

[0020] It has been found out that a sharp reduction of the visual impact of the complete antenna structure obtainable from said association of an optically transparent radome and of the use of a reticular screen made of sufficiently ample meshes and with the highest possible relation of empty/full to emphasise the "transparency" of the whole can be obtained without running into said bad phenomenon of the evanescent wave realising a minor central part of the screen with the configuration of a full coplanar conductor surface and in electric continuity with the major part of the screen set up by a conductor net, or realising said minor central part of the screen by a conductor net with relatively denser meshes and with a reduced relation empty/full compared to the conductor net, the major part of the reflecting screen is made of.

[0021] In practice the presence of a minor full portion (or made of net with a differentiated structure with respect to the net setting up the major part of the reflecting screen) turns out to be suitable, particularly if its geometric dimensions coinciding; or superior, to the dimensions of the geometric projection of said objects and support structures placed behind the reflecting screen portion.

[0022] In addition, has been found that said central minor full portion (or net with a differentiated structure with respect to the net setting up the major part of the reflecting screen) must be implemented by means of a metallic material with high conductivity properties. In case said additional net is used, the section of the used wire must be incremented with respect to wire used to realize the major part of the screen.

[0023] This central part of the reflecting screen with a differentiated structure compared to the surrounding major part of the screen is submitted to a concentration of induced currents which may reach relatively high current density levels. The presence of at conductor section sufficiently large in this area improves the performances of the antenna (obviously both during the reception phase and during the transmission phase).

[0024] According to a preferred embodiment of the antenna of the present invention, such minor central part of the reflecting screen is set up by a plain face of a tubular metallic body extending for the whole lengthwise dimension of the screen. The tubular body can be conveniently set up by two channels suitable to be coupled to each other, made of galvanised steel or more preferably of brass or of another metallic material suitable for high electric conductivity. The tubular shape of said central element houses the connecting cables of the dipoles according to a defined configuration to one or more connectors which can be installed at one end of the antenna, usually through a final closing cover or bottom of the radome, the latter also made of optically transparent material.

[0025] The metallic wires setting up the conductor net constitutes the major part of the reflecting screen are preferably arc welded at the crossings in order to prevent from the constitution of spurious dipoles for insufficient electric continuity in the reticular structure.

[0026] Besides this it has been found out that favouring during the arc-welding phase the constitution of globules of metallic material at the welding points at the crossing of two metallic wires, the behaviour of the antenna improves. This can be explained by the fact that the globule with an increased conductor section set up at the crossings between the among them arc welded wires present a passing section for the induced currents on the enlarged screen just in coincidence of the junction points and therefore of higher current density.

[0027] Such improving effect can be further emphasised submitting the entire composed screen to a immersion tin-plating procedure using a eutectic alloy of tin and silver, with high electric conductivity or alternatively to a hot galvanisation or to a galvanic silver-plating.

<u>Brief description of the drawings</u>

[0028] This one and other characteristics will turn out to be better pointed out by the following description of a preferred embodiment which will be illustrated hereafter just as an example without being limited to that in the enclosed drawings, in which:

Fig. 1 is a front view of a reflecting screen of an antenna according to the present invention;
Fig. 2 is a view from above of a reflecting screen illustrated in Fig. 1;
Fig. 3 is a front view of a reflecting screen of an antenna according to an alternative embodiment;
Fig. 4 is a view from above of the reflecting screen illustrated in Fig. 3;
Fig. 5 is a front view of a complete antenna structure with double polarisation comprising a reflecting screen as shown in the Figures 1 and 2;
Fig. 6 is a front view frontal of a different type of antenna with single polarisation;
Fig. 7 is a section of a transparent radome at the antenna;
Fig.s 8 and 9 are photos of an antenna according to the invention made under two different light conditions.

Detailed description of some preferred embodiments of the invention

[0029] Referring to the Fig.s 1, 2, the reflecting screen 1 is substantially a flat panel slowly, usually shaped in a rectangular way, which length is commensured to the number of dipoles or radiators 2, mounted on small spacer columns aligned along the central lengthwise axis of the rectangular panel as better illustrated in the Fig.s 5 and 6 (Fig. 1 shows 4 dipoles or radiators 2). Theoretically the number of dipoles which can be arranged on a same antenna, and therefore the length of the reflecting panel 1 can be also very great, depending both on the number of channels managed by the antenna "illuminating" a certain cell the territory is divided in, and on the power requirements RF, that can be satisfied duplicating the number of dipoles to be fed in phase of the same signal.

[0030] According to an essential aspect of the antenna of the invention, the reflecting panel 1 has, at least a major part in terms of area, set up by a conductor net 1a and 1b and a minor central part 1c made of a full metallic material (Fig. 1 and 2) or even this one set up by a conductor net but with a structure differing from the structure of nets 1a and 1b, and more one precisely with denser meshes and with a reduced relationship empty/full with respect to the same features of the two lateral nets 1a and 1b constituting the major part of the panel (Fig.s 3 and 4).

[0031] Either if the central portion 1c of the reflecting screen 1 is a full conductor surface or a metallic net with a different structure, it is essential to assure a perfect electric continuity with the two lateral nets 1a and 1b setting up the major part of the area of the reflecting panel. Preferably such electric continuity between the conductor net 1a and 1b and the central portion 1c is obtained by means of a welding operation, that is by means of the deposit of a welding alloy in the contact points between the surfaces illustrated before.

[0032] The particular P' Fig. 1 shows a peculiar aspect of the present invention, that is the fact that the metallic wires that form the conductor net are parallel to the mechanic axis or of symmetry of the antenna itself and they are arc-welded at the crossings. In such phase of arc-welding the forming of metallic material globules in the welding points at the crossing of two wires has been favoured in order to improve the behaviour of the antenna.

[0033] From studies conducted by the applicant it has also been observed that a further reduction of losses is obtained, if the metallic wires setting up the conductor net are placed at 45° with respect to the principals of the antenna itself as shown in the particular P" always of Fig. 1. Also in that case the forming of metallic material globules has been favoured in the welding points at the crossing between two wires in order to improve the behaviour of the antenna.

[0034] The aforesaid arrangement at 45° of the metallic wires has proved to be particularly useful, when the antenna uses a polarisation comprised between +45° and -45°, because in this way the wires turn out to be parallel to the polarisation plane of the radiated signal.

[0035] When instead a vertical and horizontal polarisation is used, the arrangement of the wires shown in the particular P' of Fig. 1 is preferred.

[0036] Always from the studies conducted by the applicant it has been found out that a better polarisation separation of the radiated wave is obtained when the vertical wires are not put into contact with the horizontal wires. Such advantage is obtained, when the vertical wires are put on a plane at a distance of one entity that it is function of λ, where λ is the wavelength of the signal.

[0037] Without departing from the scope of the present invention it is obviously possible to arrange the wires of the net on two levels in a way that a such wires result inclined by 45° compared to the principle axes of the antenna, especially when a polarisation +45° -45° is used with respect to the plane on which the horizontal wires are arranged. Such arrangement disposal has been illustrated as an attempt in the particular P' of Fig. 3. In the particular P" of Fig. 3 a condition is instead represented which is dual to that shown in the particular P" of Fig. 1 in which the wires (this time not in contact) are arranged at 45° with respect to the mechanic axes boards or of symmetry of the antenna.

[0038] The dimensions of the mesh of the two lateral nets 1a and 1b and the relative relationship empty/full are defined in function of the minimum wavelength managed by the antenna in order to guarantee a behaviour similar to that of a full reflecting screen.

[0039] In case of a typical application in a radiomobile telephone system in the band 900MHz and/or 1800MHz the dimensions of the meshes of the two nets

1a and 1b can be of 5 ÷ 10 mm and, in case a net of arc welded drawn iron wire is used at the crossings with a diameter comprised between 0,5 ÷ 1,5 mm there will be a relationship empty/full between 1/10 and 1/20.

[0040] Employing a material with a higher conductivity than iron it is possible to further reduce the diameter of the wire in proportion to the increased conductivity.

[0041] The central part 1c, along which the dipoles 2 are arranged mounted on small common spacer columns 4 typically aligned along the central axis of the panel, can be, according to the embodiment of the Fig.s 1 and 2 the plane side of a channel 5 with a rectangular section made of a metallic material with high electric conductivity. Galvanised iron, steel, light alloy, brass are materials the metallic channel can usually be made of, which can be conveniently dosed on the side behind the screen by a cover or by an analogue channel with a rectangular section 6, easily to be coupled in a permanent way to channel 5 in order to set up a central tubular element inside of which the connection cables of the dipoles (not shown in the illustration) can be arranged in a comfortable and tidy way.

[0042] Channel 5 or at least the fiat coplanar side and in electric continuity with the nets 1a and 1b has preferably a thickness comparable to the electric continuity characteristics of the material constituting the channel and generally comprised between 0.5 and 1.5 or more millimetres.

[0043] Substantially the central part 1c of the reflecting panel is provided with a stressed electric conductivity on the conductor level of the screen in order to minimise the resistance met by the currents induced on the reflecting screen by the generated fields by the dipoles.

[0044] Fig.s 3 and 4 show another embodiment of the reflecting panel, according to which the central part 1c (minority in terms of area of the panel) is set up by a conductor net 7 with denser meshes and with a reduced relationship empty/full compared to the conductor net of the portions 1a and 1b of the panel.

[0045] Also the equivalent conductor section referred to induced sections on the plane of the reflecting screen is sensibly increased in the central part 1c, realising such net with metallic wire with a major diameter with respect to the diameter used for the realisation of the nets 1a and 1b.

[0046] Always referred to the case of a typical application for radiomobile telephone systems in the bans 900MHz and/or 1800MHz, the dimensions of the mesh of the net constituting the central part 1c of the reflecting panel can be of 1 ÷ 5 millimetres, and in case an iron wire net arc-welded at the crossings with a diameter of 0,5 ÷ 1,5 millimetres is used, the relationship empty/full turns out to be of about 1/10 ÷ 1/20.

[0047] As shown in Fig. 4, on the backside of the central portion 1c of the reflecting panel 1ca channel 8 made of optically opaque material can be associated in order to provide a space to pass through and to arrange in a tidy way the connecting cables of the dipoles.

[0048] Both the nets with a high relation empty/full 1a and 1b and possibly the net with dense meshes 7 constituting the central part minority in terms of area of the reflecting panel, are nets made of metallic wire arc-welded at the crossings in order to assure a homogenous conductivity on the plane of the reflecting protection and the absence of spurious dipoles which could be generated in case of a missed electric continuity at some crossings.

[0049] Analogously to what previously illustrated with reference to Fig. 1, the wires can be arranged at 45° with respect to the principal axes of the antenna. Always analogue to what previously illustrated with reference to Fig. 1 the vertical wires can be put on a plane at a distance of one predefined entity with respect to the plane on which the horizontal wires are arranged.

[0050] Fig.s 5 and 6 are complete views of two directional multi-channel with high transparency according to the present invention.

[0051] Fig. 5 shows a so-called double polarisation antenna, that is, through which the electromagnetic radiation with a polarisation of +45° and with a polarisation of -45° is radiated. Fig. 6 represents an antenna with a single polarisation.

[0052] The radome 3 is entirely set up by an optically transparent material. Preferably the material employed is a polymethyl methacrylate of methyl, even if others transparent plastic materials such as polycarbonate can be employed.

[0053] From the studies conducted by the applicant it has been found out, that the polymethyl methacrylate of methyl represents a very high resistance to the effects of the exposition to ultraviolet rays, and it has low dielectric losses which make it in an exceptional way transparent to the electromagnetic radiation minimising the absorption.

[0054] The radome 3 includes completely the components of the antenna inside a sealed space.

[0055] The tubular body of the radome 3 can be extruded in a unique piece or set up by the junction of two channels suitably shaped.

[0056] The two ends are dosed respectively by a lid 9 and by a bottom 10 made of the same transparent material constituting the tubular body of the radome.

[0057] In the case of the antenna with double polarisation of the Fig. 5, at the bottom 10 two connectors 11 and 12 are installed for the connection of coaxial feeding cables, while in the example of Fig. 6 there is a single collector 11.

[0058] Fig. 7 shows a preferred embodiment of the transparent radome 3 of the antenna with low visual impact according to the invention.

[0059] In the illustrated example the radome 3 is constituted by two channel shaped half-shells 3a and 3b, constituting the face and the backside of the tubular radome, respectively. The two half-shells are permanently put together by a gluing along the overlapping borders of the edges of the two channels 3a and 3b.

[0060] According to a highly preferred realisation the section of the channels is such to realise a polygonal section of the radome constituted by substantially rectilinear sides connected to each other.

[0061] This particular shape, in alternative to a common curved direction of the known radomes eliminates constancy of a generator line reflecting the sun or artificial light impressing on the radome towards an observer.

[0062] On the contrary, a polygonal section will hardly present such an optical reflection line.

[0063] Fig.s 5 and 6 show the presence of a pole of support 13 which can commonly be a pole of galvanised steel or of stainless steel, titanium or even more preferably a pole of fibreglass or another non conducting composition with high mechanic resistance.

[0064] As can be observed, the central part 1c of the flat screen of the antenna represents such a width to hide completely the shape of the supporting pole 13 staying behind.

[0065] In the two examples shown in the Fig.s 5 and 6, the area set up by the nets 1a and 1b of reflecting panel of the antenna turns out to set up about 80% of the total area of the panel.

[0066] It is this remarkable proportion of the area of the reflecting panel of the antenna (about 80%) that in association with the perfectly transparent radome 3 gives to the whole a high and in favourable light conditions a relative "invisibility".

[0067] The transparency of the radome reduces considerably the effect of overheating of the internal space, assuring a major service constancy of the antenna also in conditions of strong sun radiation.

[0068] The transparency effect of the whole can be clearly perceived watching the two photos of an antenna of the type illustrated in Fig. 5 and reproduced in the Fig.s 8 and 9 in relation to two different illumination conditions.

[0069] As can be seen, if observed against the light (worst case) a clear visibility of the opaque elements of the whole remains, in favourable light conditions (Fig. 10) the translucency of the optically transparent radome hides forthe view also the remaining opaque parts of the antenna.

[0070] In any case even under worse conditions the observed object is perceived as an object with a small of insignificant volume and it turns out to be much less evident in a rich architectonic context of particulars such as a spire, a front side of a building, a bell-tower, or something similar.

[0071] In practice antennas realised according to the present invention of the type described in Fig.s 5 and 6 have been tested for a long time and their complete behaviour has been found equal and under certain aspects superior to that of antennas in terms of dimensions and structures perfectly comparable, patented according to the already known technique using a full metallic screen and a radome optically opaque in fibreglass.

Claims

1. Directional multi-channel antenna comprising a substantially flat reflecting screen (1) and a plurality of dipoles or radiators (2) supported at a certain distance on the reflecting side of the screen (1) and a shell or radome (3) made of a material essentially transparent to the radiation RF transmitted and received by the antenna, containing said reflecting screen, said dipoles and connecting cables of the dipoles and at least one feeding connector of the antenna, characterised in that

   said radome is made of an optically transparent material and said screen is at least for a major part set up by a conductor net (1a, 1b).

2. Antenna according to claim 1, characterised in that a minor central part (1c) of said screen is made of a full metallic material having a coplanar face and in electric continuity with said net (1a, 1b).

3. Antenna according to claim 1, characterised in that said minor central part (1c) of said reflecting screen consists also in a conductor net with denser meshes and with a reduced relationship empty/full with respect to the conductor net setting up said major part of said reflecting screen (1a, 1b);

   the dimensions of the single mesh and the relationship empty/full of said minor central portion (1c) of said reflecting screen (1) being reduced compared to said major part (1a, 1b), in a sufficient way to cancel any remaining phenomenon of evanescent wave induced by the used fixing and/or support means of the antenna.

4. Antenna according to claim 1 or 3, characterised in that said conductor nets are made of metallic wire arc-welded at the crossings forming metallic nodules with an increased section with respect to the section of the wire.

5. Antenna according to claim 4, characterised in that the wires are arranged in parallel to the mechanic or symmetry axes of the antenna.

6. Antenna according to claim 4, characterised in that the wires are arranged at 45° with respect to the mechanic or symmetry axes of the antenna.

7. Antenna according to the claims from 1 to 3, characterised in that said conductor nets are set up by a first plurality of wires arranged on a first plane and

by a second plurality of wires arranged on a second plane isolated from the first one and which is placed at a distance of a predetermined entity from said first plane.

8. Antenna according to claim 1, characterised in that said radome (3) made of optically transparent material is made of a thermoplastic resin belonging to the group set up by polymethyl methacrylates and polycarbonates.

9. Antenna according to claim 8, characterised in that said optically transparent radome (3) is made of polymethyl methacrylate of methyl.

10. Antenna according to claim 1, characterised in that said radome (3) made of optically transparent material has a polygonal section set up by a substantially rectilinear sides coupled to each other.

11. Antenna according to claim 2, characterised in that said central portion (1c) of the screen is set up by a plain side of a metallic tubular metallic body extending for the entire height of the screen, inside of which pass the connecting cables of the dipoles (2) through holes of said plain side (1c) of the tubular body (4), on which said dipoles (2) are held.

12. Antenna according to claim 11, characterised in that said tubular metallic body (4) is made of brass or of another metallic material with high electric conductivity.

13. Antenna according to claim 1, characterised in that said minor part (1c) of the screen is constituted by a metallic conductor net having denser meshes and with a relationship full/empty inferior compared to the metallic net setting up said major part (1a and 1b) of the screen.

14. Antenna according to anyone of the previous claims, characterised in that said reflecting screen (1) at least for a major reticular part (1a, 1b), has at least the reflecting side coated by a layer of a conductor material belonging to the group composed of zinc, an eutectic alloy of tin and silver, or silver.

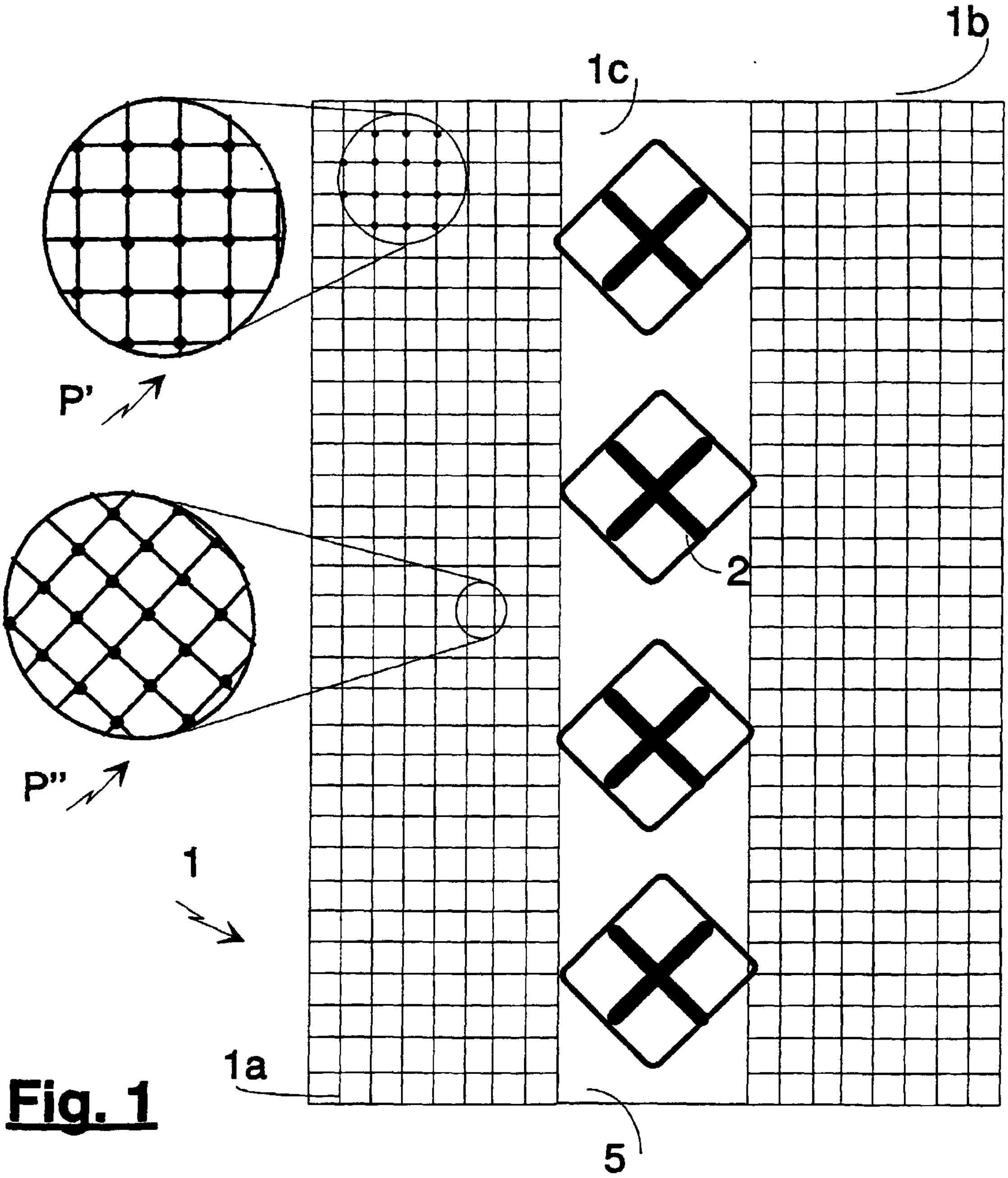

Fig. 1

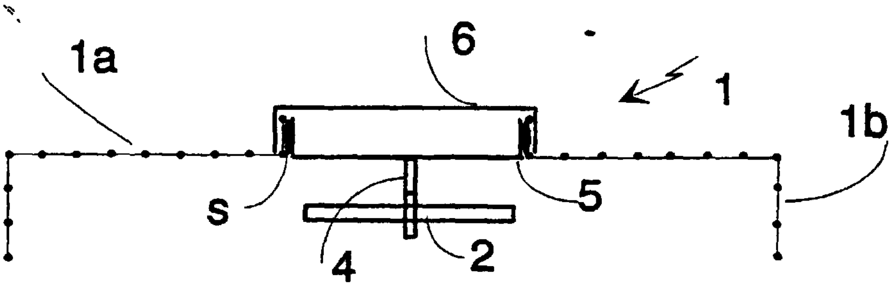

Fig. 2

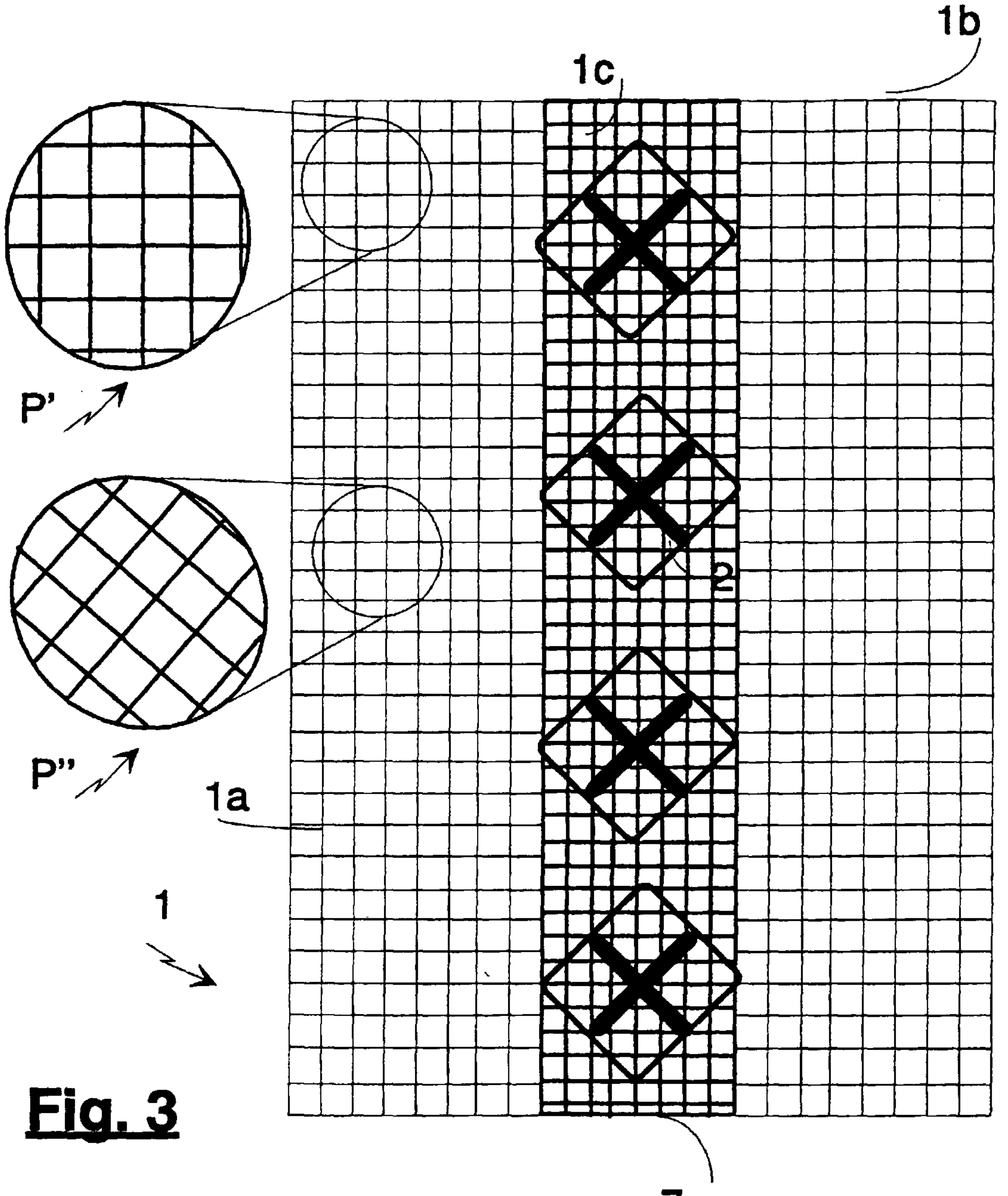

Fig. 3

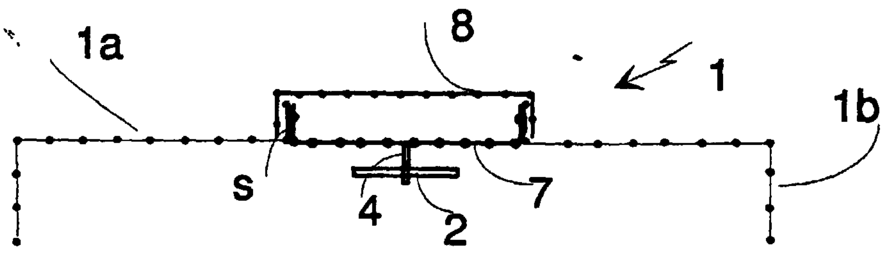

Fig. 4

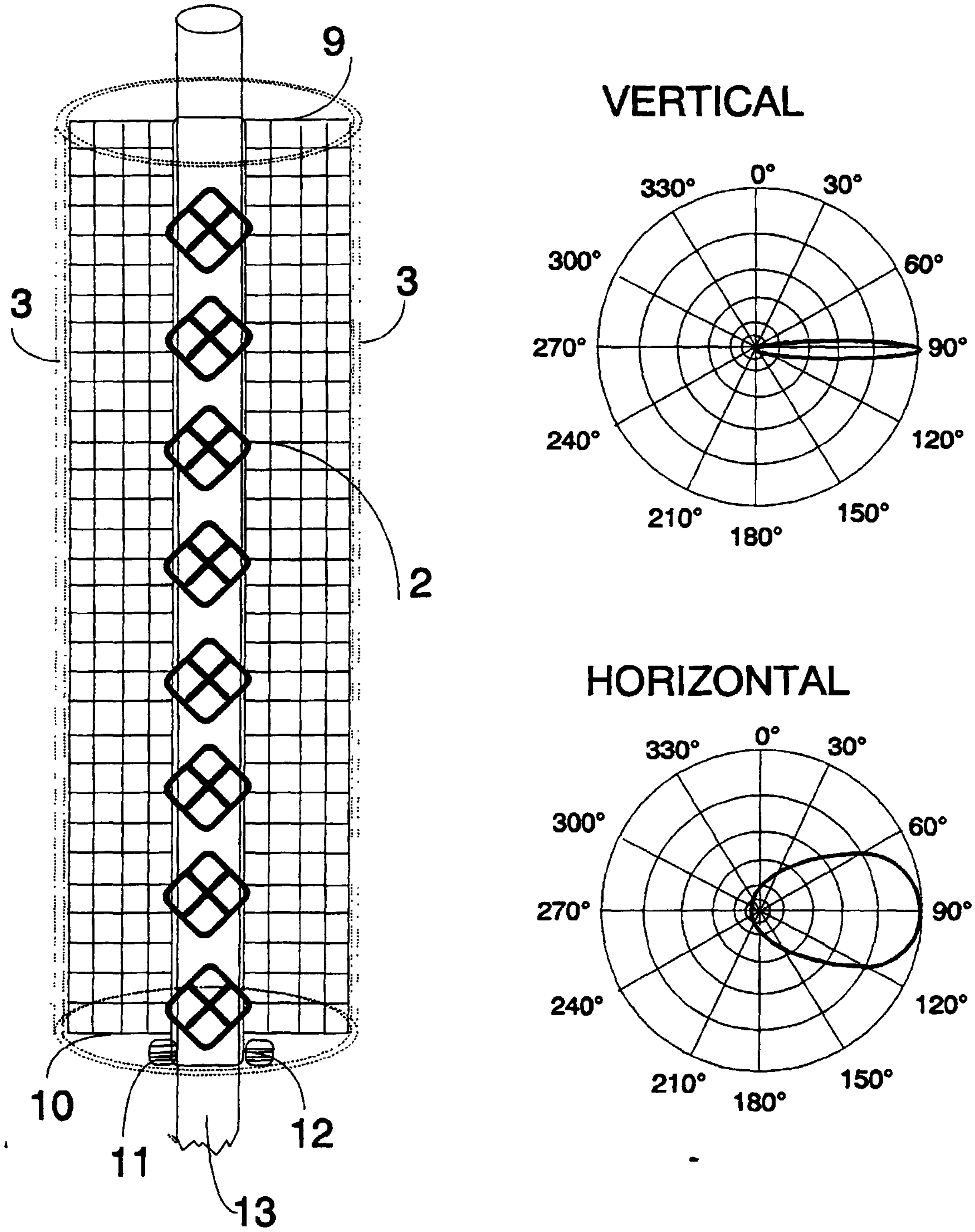
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Fig. 5

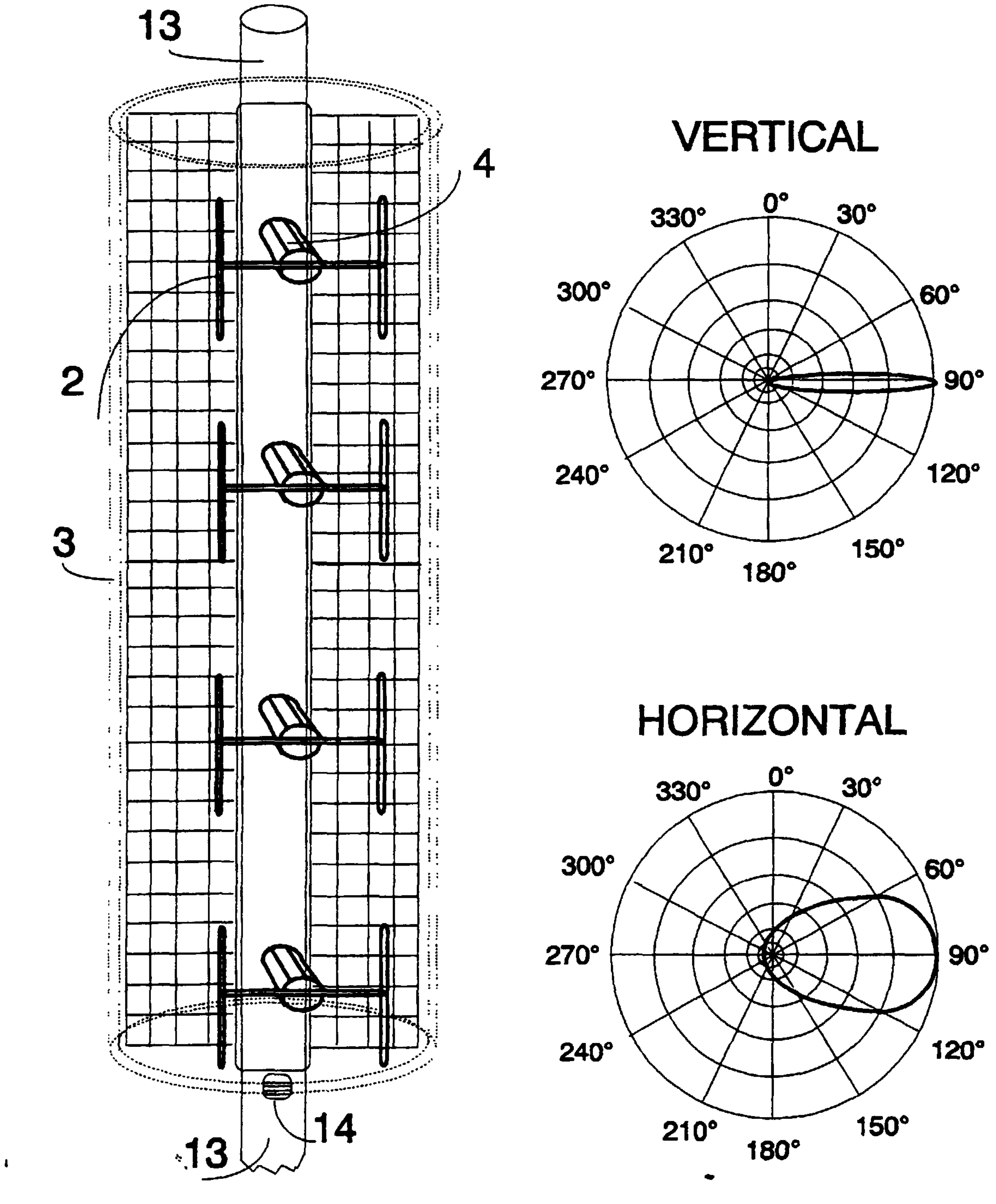
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Fig. 6

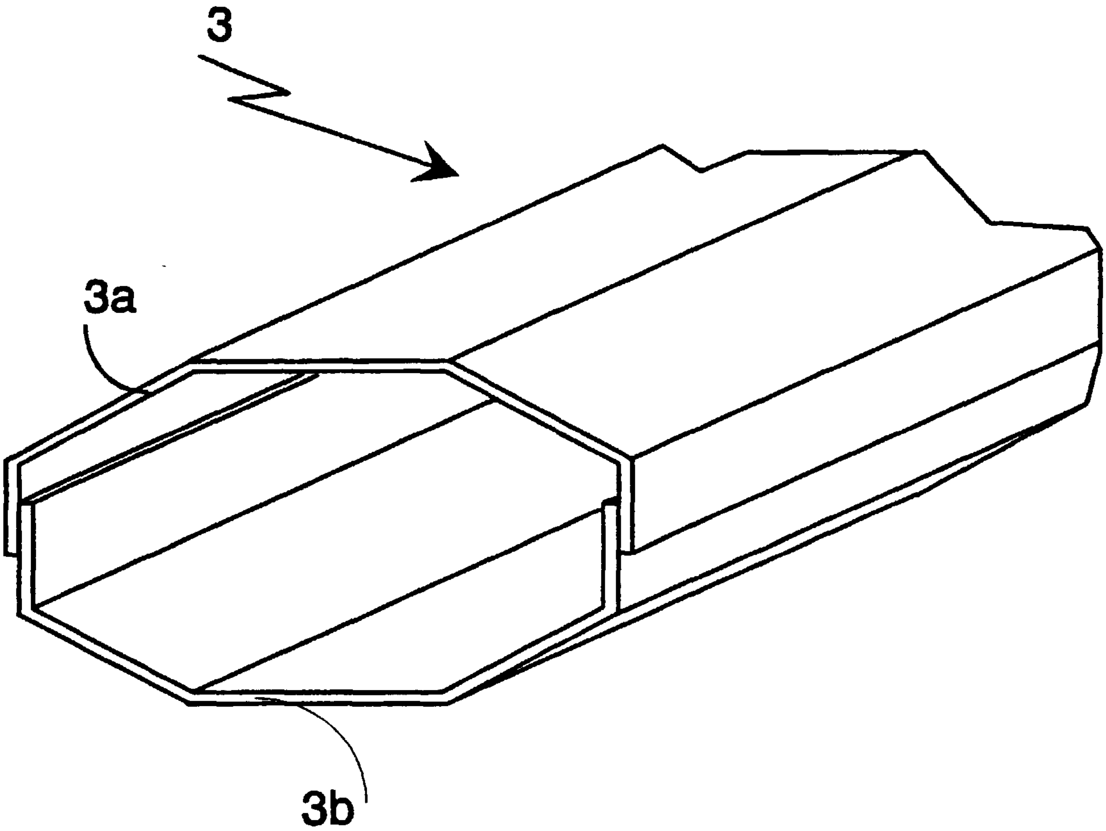

Fig. 7

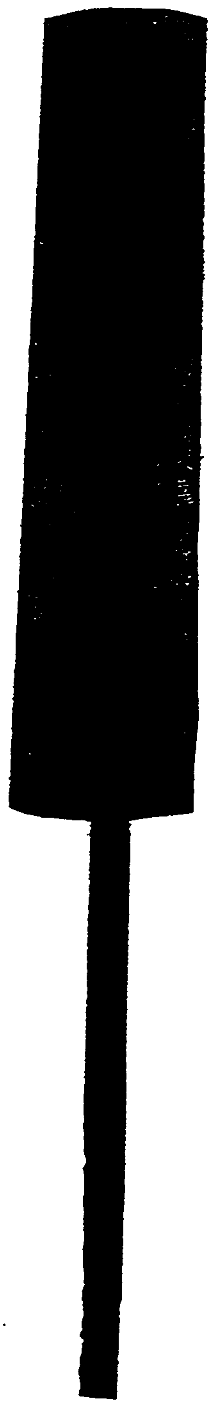

Fig. 8

fig. 9