

The present invention relates to an omnidirectional antenna.

This antenna applies particularly to transmission of radio or television signals in the decimetric waveband (band known as UHF), in which it will be seen that it confers particularly beneficial advantages.

The invention is not, however, limited to this application nor to this frequency band, and could equally well suit a very wide diversity of different situations.

For radio and television antennae, a radiating system has to be available (allowing for exceptions), having a diagram which is as omnidirectional as possible ("omnidirectional diagram", will be understood to mean a diagram having no troughs less than 3 dB over 360°).

This system, which must moreover exhibit mechanical characteristics of compactness and of lightness, making it possible to place it at the peak of a mast, while minimizing both the static load (actual weight of the radiating system) and the dynamic load (wind resistance) which are withstood by the latter.

For this purpose, an antenna system known as "panel antenna" is most often used, constructed from radiating elements each formed by a dipole placed in front of a reflector, the dipole being oriented vertically or horizontally according to the desired polarization.

As such a radiating element is an element with gain, and thus directional, it is necessary to group together four of them, arranged at 90° from one another, in order to obtain the omnidirectional diagram required.

In order to increase the allowable power, a plurality of these radiating elements are generally superimposed (most often two, four or eight radiating elements) so as to form radiating panels, the reflector most often being common.

Each panel is fed separately with the same phase and the same power as the others (unless it is desired to vary the shape of the diagram by introducing phase-shifts or power variations) by means of a distributor assembly.

This configuration, although operating satisfactorily on a very large number of present-day transmitting stations, exhibits a certain number of drawbacks.

First of all, it is necessary to provide a stub
5 mast at the peak of the mast proper, making it possible suitably to arrange the superimposed radiating elements forming the four radiating faces of the configuration.

This stub mast must satisfy two conflicting conditions:

10 - in the first place, it must be dimensioned adequately so as to allow the feeds for each panel to be installed and to allow a man to pass in the centre of the configuration in order to be able to carry out maintenance thereof; it has
15 been seen, in fact, that each radiating element was fed by its own coaxial feed cable and, since this coaxial cable necessarily has to be placed behind the reflector panel of the radiating element in order not to disturb the operation of
20 the latter, the bundle of coaxial cables will have to pass within the mast, which must therefore be of adequate size (for faces with eight superimposed radiating elements, there are therefore 32 coaxial cables to be passed through this
25 mast).

For this convenience of installation, and also for good mechanical rigidity, it is therefore desirable for the structure of the mast to be as wide as possible.

30 - in the second place, from the radio frequency point of view, the hollows in the diagram will be accentuated in proportion as the phase centres of the radiating elements are spaced further apart. In order to obtain the most regular diagram
35 possible, it is therefore desirable to bring the radiating elements of each group as close together as possible, and thus to provide the smallest possible mast cross-section (limited, however, by the minimum dimension of the

reflectors).

5 In order to reduce to the minimum the static load and the dynamic load mentioned above, it is also desirable to reduce to the minimum the cross-section of the mast, all the more so since the radiating assembly has to be protected by a radome, whose size, having regard to the dimension of the radiating elements, will exhibit a very large wind-resistance surface area and will therefore stress the mast all the more.

10 Another drawback of this type of antenna results from the complexity of its feed system (each of the radiating elements having to be fed by its own coaxial cable, as set out above), which makes it necessary to provide a large number of secondary coaxial feed cables and connecting boxes; the cost price of such an antenna system will thus grow very quickly with the number of radiating elements.

20 Moreover, losses will increase rapidly, both by reason of the multiplicity of the connection boxes and of the elongation of the secondary coaxial feed cables; typically, for a radiating system with panels of eight superimposed radiating elements dimensioned for the 470-860 MHz band, the height of the mast, and thus of the longest coaxial cables, is of the order of 12 metres, which creates not insignificant losses in such a frequency range.

25 This therefore leads, typically, to mast cross-sections of the order of 0.8×0.8 m and radome diameters of the order of one metre for transmissions in the 470-860 MHz band, a group of four panels with its radome having an actual weight of 350 to 400 kg and presenting a surface to the wind of the order of 1.3 m^2 .

30 These problems are encountered equally in the antenna with multiple radiation in a horizontal plane described in the Patent DE-A-2026984. The antenna disclosed in this patent includes pairs of dipoles mounted along a central support and fed, in groups of two, from conductors coupled to the central support with the aid of

distributors regularly arranged on this support. This antenna does not allow the abovementioned conflicting conditions to be satisfied (wide support for maintenance and mechanical rigidity, but narrow to obtain a regular radiation diagram, nor the drawbacks related to the complexity of the feed to be overcome).

Another type of antenna suitable for the above-mentioned use, although less widely used, is the so-called "superturnstile" antenna.

In this type of antenna, in order to obtain the omnidirectional diagram desired, the principle of the rotating field is used, the radiating element then consisting of two "batwings", which are planar, vertical and perpendicular to each other, crossing over at their centre and phase shifted by 90° with respect to one another.

Thus a large number of radiating elements are superimposed, each radiating element being fed separately by virtue of a common distributor system, and the two dipoles formed by the "batwings" of each radiating element being fed in quadrature in an aperiodic way by a 3 dB coupler.

This type of antenna, although it exhibits an overall diameter which is much smaller than a system with antenna panels, due to the absence of a reflector, and thus makes it possible significantly to reduce the sizing of the mast, nevertheless exhibits a certain number of drawbacks:

- first of all, the necessity of carrying out the aperiodic feed in quadrature between the dipoles entails the use of 3 dB couplers placed in the radiating field, the balancing load of the coupler having to be dimensioned as a function of the power to be transmitted,
- next, the coaxial feed cables for the dipoles are situated in the radiating field of the antenna and therefore disturb the radiation of the latter by creating troughs in the diagram,
- moreover, with equal gain, the total antenna

height is greater than that of an antenna with radiating panels, in addition entailing corresponding problems of compensation of the diagram in terms of elevation in the case of antennae with a large number of radiating elements,

- finally, the cost price thereof is high due to the mechanical complexity, to the presence of the 3 dB couplers and to the multiplicity of coaxial feed cables.

Thus as can be seen the two types of antenna used up to the present for radio or television transmitters in the decimetric wave range do not give entire satisfaction since they do not make it possible simultaneously to achieve the performances both in mechanical terms (compactness to limit the wind resistance, reduced weight, structure simple to manufacture) and in radio frequency terms (omnidirectional nature of the diagram, possibility of accepting significant power) which are desirable.

The present invention proposes to resolve these drawbacks by proposing a new type of antenna which, while exhibiting excellent radio frequency properties, is compact, light and can be produced at a modest cost by virtue both of its simple mechanical structure (absence of stub mast, especially) and of the reduction to a minimum of the coaxial cable connections.

To this end, according to the invention, the antenna has the characteristics according to Claim 1.

According to a certain number of advantageous characteristics:

- the radiating arrays are three in number;
- each radiating array includes four horizontal dipoles;
- the dipoles are of the shortened half-wave type, calculated on the central operating frequency of the antenna with a shortening coefficient of about 0.9, the distance between two consecutive superimposed dipoles is one shortened half-wave, calculated for the central operating frequency of

the antenna with a shortening coefficient of about 0.85, and the distance from the dipoles to the central axis of the system is one non-shortened quarter-wave, calculated for the central operating frequency of the antenna;

- the power distribution system is entirely housed within the central support tube;
- the two-wire line includes a lower half and an upper half, each of these halves being excited at a point situated at mid-height by a coaxial line passing within one of the conductors of the two-wire line, this line being itself linked to the power distribution system situated within the central support tube approximately at the level of the connection of the two halves of each two-wire line;
- each branch of the dipole has a substantially circular curvature, the centre of curvature of which lies approximately on the central axis of the antenna.

The subject of the invention is also a radiating system formed by a plurality of antennae of this type, these antennae being superimposed and fed separately by their own coaxial cables linked to a common distributor.

Preferably, each antenna is then enclosed in a substantially cylindrical, self-supporting and super-imposable leaktight radome.

Other characteristics and advantages of the invention will emerge on reading the detailed description below, given with reference to the attached drawing in which:

- Figure 1 is a perspective view of a radiating assembly constituting the antenna according to the invention,
- Figure 2 shows a plurality of these radiating assemblies, superimposed and coupled in such a way as to increase the radiated power, the assembly being protected by an outer radome,
- Figure 3 is a section along the line III-III of

Figure 2, showing the radiating assembly of the present invention seen from above,

- Figure 4 is an elevation view, partially in section, of the radiating assembly of Figure 1,
- 5 - Figure 5 is a front view, taken along the direction V-V of Figure 4, of one of the three radiating arrays which this radiating assembly includes,
- 10 - Figure 6 is a top view, in section along the line VI-VI of Figure 4, showing the detail of the first section of the coaxial feed cable of the radiating array,
- 15 - Figure 7 is a front view, in section, corresponding to the region marked VII in Figure 5, showing in greater detail one of the two branches constituting the second section of this coaxial feed cable,
- 20 - Figure 8 is an azimuth diagram plotted for an antenna according to the invention, showing the omnidirectional nature of the diagram of the latter,
- 25 - Figure 9 is the elevation diagram corresponding to the same antenna, and
- Figure 10 is a comparison of the azimuth diagrams which two similar antennae would have, one of which includes three arrays radiating at 120° (as in Figures 1 to 7), and the other four arrays radiating at 90° .

30 On all the figures, the same numerical references relate to similar elements.

Figure 1 shows the general structure of a radiating assembly constituting the antenna according to the invention: the latter essentially comprises a central vertical support tube 100, provided at its lower part and at its upper part with fixing plates, respectively 110 and 120, making it possible to assemble, end-to-end, several superimposed support tubes - and thus a plurality of identical radiating assemblies - so as to increase the total radiated power.

5 Around this support tube three identical radiating arrays 200 are arranged at 120° to one another, each including a vertical two-wire line with two parallel conductors 210,210' supporting a plurality of horizontal dipoles 220,220' (four in the example represented) regularly distributed along this two-wire line.

10 The radio frequency feed, which is brought in at 310 by a coaxial cable arriving at the base of the antenna - thus in a region which will not disturb the radiating diagram much -, passes (while remaining coaxial) within the support tube 120, then is distributed (still coaxial) to each of the three radiating arrays, by passing within a horizontal tube 340, mounted at mid-height on the central tube 100, which also provides the
15 mechanical support for these radiating arrays in combination with the support arms 130,140 at the upper part and at the lower part.

20 As can be seen, the feed and the distribution of radio frequency energy are entirely internal to the structure of the antenna, which eliminates any possibility of disturbance of the diagram due to the physical presence of feed lines in the radiating field, as in the case of antennae of the prior art.

25 Characteristically, the antenna does not include a reflector panel.

30 In order to increase the radiated power it is possible (Figure 2) to superimpose a plurality of modules 10 each formed by a radiating assembly 11 similar to that illustrated in Figure 1 and fed by a coaxial cable 12 linked to a distributor at the lower part of the antenna, and by a cylindrical protective radome 13. The assembly is placed at the peak of a mast 14, the upper module being closed by a cover 5 and possibly surmounted by a lightning conductor (not represented) as is well known.

35 The radome 13 (Figures 2 and 3) is a cylinder made of reinforced polyester provided at each of its ends with flanges 16,17 intended for assembling the various superimposed modules, making it possible thus to produce a self-supporting radome, which greatly simplifies the

mechanical production thereof. The assembly of the system is, needless to say, rainwater proof.

Figures 4 to 6 describe in more detail the structure of the radiating assembly according to the invention, especially of the feed for the three arrays of dipoles.

The radio frequency feed, connected at 310, is led in up to mid-height on the central tube 100, within the latter, by a coaxial line 320 (the return conductor being formed by the wall itself of the support tube) including a plurality of sections 321 to 325 of increasing diameters forming a quarter-wave impedance transformer, and which are held centrally within the support tube 100 by struts 326,327.

The feed is then distributed between the three radiating arrays by equi-phase, equi-power distribution, again by a coaxial link.

The coaxial link 330,340 feeding each of the radiating arrays consists (Figure 6) of a conductor 332, kept within a tube 341 by struts 333, one of the ends 331 of which is linked to the central common line 320.

This tube 341 constitutes both the return conductor of the coaxial line and a mechanical support linking the radiating array to the central support tube; to this end, this tube 341 is provided at one of its ends with a link 342 to a part 150 integral with the central tube, and at its other end with a part 343 supporting the two conductors 210,210' of the two-wire line, which extend on either side of this part 343 (Figure 7), and consist of hollow tubes made of a conducting material, fixed by brazing, for example.

The core 332 of the coaxial line is next linked to a distributor element 334 which symmetrically feeds the upper branch and lower branch of one of the conductors (on the drawings, the conductor 210') of the two-wire line, the other conductor (the conductor 210) being linked to the common earth.

To do that, the core of the coaxial cable is extended within the conductor 210 up to a point 339

situated at about mid-height on each of the two, upper and lower, branches (this point 339, which will be the point of excitation of the two-wire line, is marked with a P in Figures 4 and 5).

5 To this end, between this point 339 and the distributor 334, a conductor is provided, produced in two sections 335,336 of increasing diameter so as to act as impedance transformer, these two sections being held within the conductor 210 by struts 337. The end of the
10 feed line then passes through the conductor 210 at 211 in order to excite the conductor 210' at 339 by means of a transverse connecting part 338.

 Thus, as can be seen, the feed is entirely coaxial from the entry connector 310 up to the point of
15 excitation P, this coaxial feed system being, moreover, entirely contained within the supporting structure of the antenna (which thus plays a double mechanical and electrical role).

 The two-wire line carries a plurality of dipoles
20 220,220' which will thus be fed symmetrically, and constitutes the radiating elements proper of the antenna.

 The dipoles 220,220' used are of the shortened half-wave type, calculated on the central operating frequency of the antenna with a shortening coefficient of
25 about 0.9.

 The distance between two consecutive superimposed dipoles is one shortened half-wave, calculated for the central operating frequency of the antenna with a shortening coefficient of about 0.85.

30 The distance from the dipoles to the central axis of the system is one non-shortened quarter-wave, calculated for the central operating frequency of the antenna.

 The impedance brought back to the region of the point of excitation P, that is to say of the connection
35 of the two-wire lines feeding the dipoles, is 50 Ω , the feed taking place via the coaxial lines for which a constant impedance of 50 Ω is maintained by virtue of the system of quarter-wave line transformers set out above.

 It will be noted that the ends of the two-wire

line correspond to current nodes, and can therefore be earthed directly by the struts 130,140, which, moreover, mechanically support the assembly.

5 The assembly can be produced from copper tube or from tube made from copper alloy, and assembled by brazing, which makes the mechanical production thereof particularly simple.

10 From the electrical point of view, the antenna thus constituted is therefore made up of four superimposed crowns (like those visible in Figure 3), each formed by three dipoles placed horizontally at 120° to one another on the three sides of an equilateral triangle, and fed in phase with equal power.

15 Such a configuration, without the aid of a reflector, confers a quasi-omnidirectional diagram, as can be seen in Figure 8, which represents an azimuth diagram plotted for an antenna including an element such as that illustrated in Figures 4 to 7 and which has just been described, calculated for a central operating
20 frequency of 520 MHz; as can be seen, the diagram is omnidirectional to about 0.9 dB.

Figure 9 shows the plot of the diagram in elevation, the shape of which is entirely suitable for a radio or television broadcast antenna.

25 As far as the electrical performance is concerned, it has been noted that the antenna makes it possible, without damage, to radiate a power of the order of 5 to 7 kW, this power being capable, needless to say, of being multiplied by superimposing several identical
30 radiating assemblies.

The impedance, as was set out above, is 50Ω , the gain of 5 dB is the mean standing wave ratio of 1.15.

35 As far as the mechanical performance is concerned, for antennae operating in the 460-860 MHz band, the radiating assemblies are enclosed in radomes of 0.54 m in diameter and of 1.16 m in height presenting a surface to the wind of 0.63 m^2 (compared with a wind-resistance surface of the order of 1.35 m^2 for an antenna operating in the same range, but produced from antenna

panels, as described in the introduction to the present description), and a complete module (radome plus radiating assemblies) with a mass of about 40 kg (against 375 kg in the case of an antenna with panels).

5. The choice consisting in grouping arrays of dipoles which are three in number is not limiting, but it is particularly advantageous.

In fact, if the number of arrays is increased, the adjacent ends of the dipoles of the same crown will
10 be closer and closer together, which will increase their mutual coupling and accentuate the troughs of the diagram.

Figure 10 illustrates this phenomenon: the azimuth diagram D4 plotted for a 4-array system has been
15 represented there, for comparison with the diagram D3 for the three-array system forming the subject of the present description, it will be noted that the maximum troughs are now at least 2 dB instead of 0.9 dB in the other case.

20 The three-array solution is thus the one which gives the most uniform diagram.

Finally, in a variant, the dipoles can be optimized by modifying their shape: instead of having them straight-line and forming the three sides of an equilateral triangle escribed with the circle passing through
25 the centres of the three two-wire lines (configuration of Figure 3), the dipoles can be deformed or curved in such a way as to bring them closer to the contour of this circle, or even to make them follow this contour (shape
30 illustrated in broken lines in Figure 3).

This improvement makes it possible to reduce the radiating phase-shifts between the different points of the dipole, and thus to make the azimuth diagram even more omnidirectional.



CLAIMS

1. Omnidirectional antenna, particularly for transmission of radio or television signals in the decimetric wave band, including:
 - 5 - a vertical central support tube (100),
 - a plurality of identical radiating arrays (200),
 - an equal-phase, equal-power, power distribution system identically and simultaneously feeding the radiating arrays from a single coaxial feed line (320)
- 10 characterized in that
 - the radiating arrays (200) are regularly distributed around the central tube and each formed by a vertical two-wire line (210, 210') supporting, coupling and feeding in a symmetric way a plurality of horizontal
 - 15 dipoles (220, 200') regularly distributed along this two-wire line,
 - the single coaxial line (320) is entirely housed within the central support tube, and
 - the power distribution system comprises coaxial lines
 - 20 (340, 341) connected to the single coaxial line and respectively feeding each of the radiating arrays, the coaxial lines (340, 341) at the same time constituting a mechanical support linking the respective radiating array to the central support tube.
- 25 2. The antenna of Claim 1, in which the radiating arrays (200) are three in number.
3. The antenna of one of Claims 1 or 2, in which each radiating array (200) includes four horizontal dipoles (220, 220').
- 30 4. The antenna of one of Claims 1 to 3, in which the dipoles (220, 220') are of the shortened half-wave type, calculated on the central operating frequency of the antenna with a shortening coefficient of about 0.9.
5. The antenna of one of Claims 1 to 4, in which the
- 35 distance between two consecutive superimposed dipoles (220, 220') is one shortened half-wave, calculated for the central operating frequency of the antenna with a shortening coefficient of about 0.85.
6. The antenna of one of Claims 1 to 5, in which the



distance from the dipoles (220, 220') to the central axis of the system is one non-shortened quarter-wave, calculated for the central operating frequency of the antenna.

5 7. The antenna of one of Claims 1 to 6, in which the power distribution system (320) is entirely housed within the central support tube.

8. The antenna of one of Claims 1 to 7, in which the two-wire line (210, 210') includes a lower half and an
10 upper half, each of these halves being excited at a point (P) situated at mid-height by a coaxial line (335, 336) passing within one (210) of the conductors of the two-wire line, this line being itself linked to the power distribution system situated within the central support
15 tube approximately at the level of the connection of the two halves of each two-wire line.

9. The antenna of one of Claims 1 to 7, in which each branch of the dipole has a substantially circular curvature, the centre of curvature of which lies approxi-
20 mately on the central axis of the antenna.

10. Radiating system formed by a plurality of antennae (11) according to one of Claims 1 to 9, these antennae being superimposed and fed separately by their own coaxial cables (12) linked to a common distributor.

25 11. The radiating system of Claim 10, in which each antenna (11) is enclosed in a substantially cylindrical, self-supporting and superimposable leaktight radome (13).