April 6, 1965 M. RATEAU 3,177,491

CAVITY ANTENNA WITH FLARED HORN

Filed Dec. 2, 1960 5 Sheets-Sheet 1

Fig. 1.

PRIOR ART

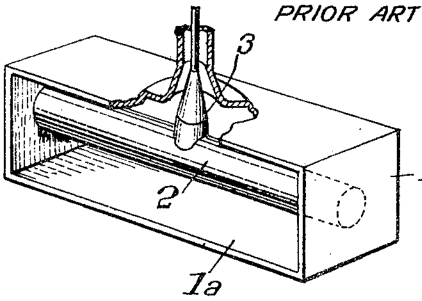

Fig. 9.

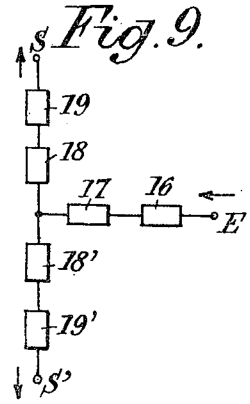

Fig. 3.

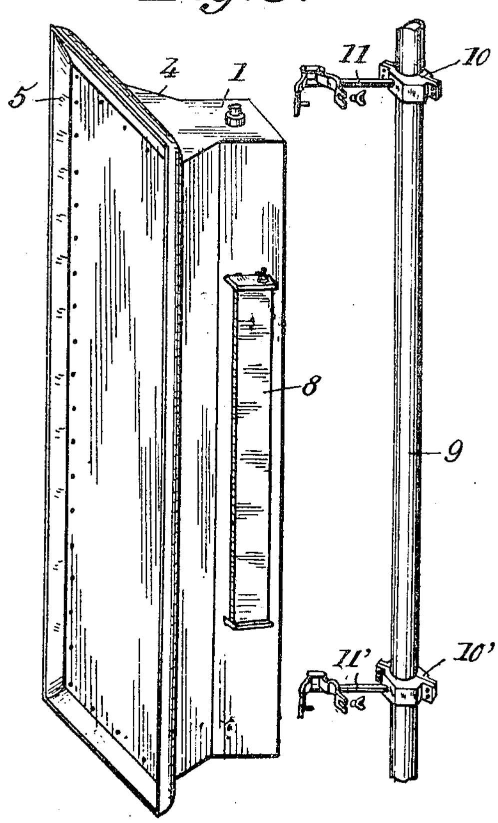

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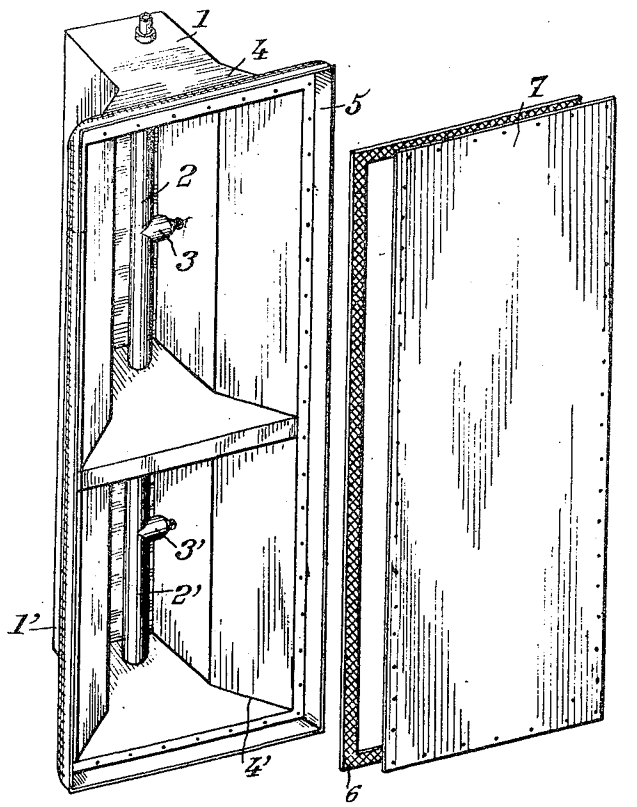
Fig. 2.



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CAVITY ANTENNA WITH FLARED HORN

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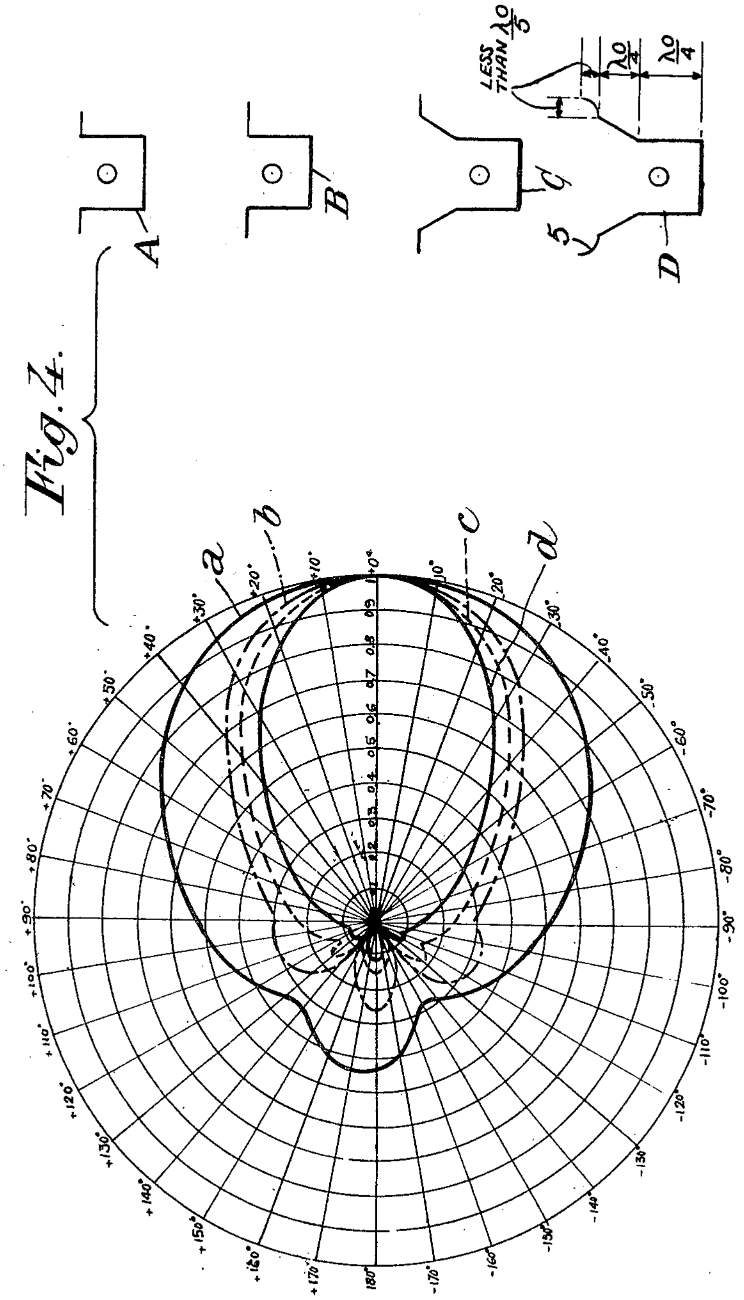

Fig. 4.

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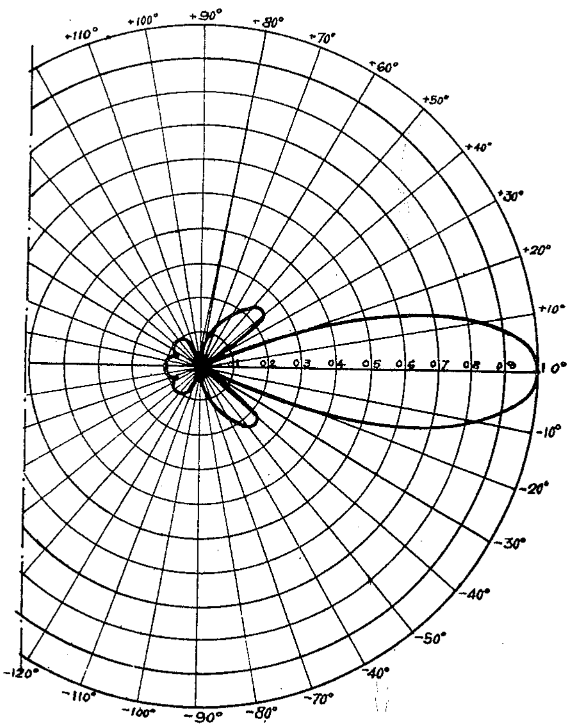
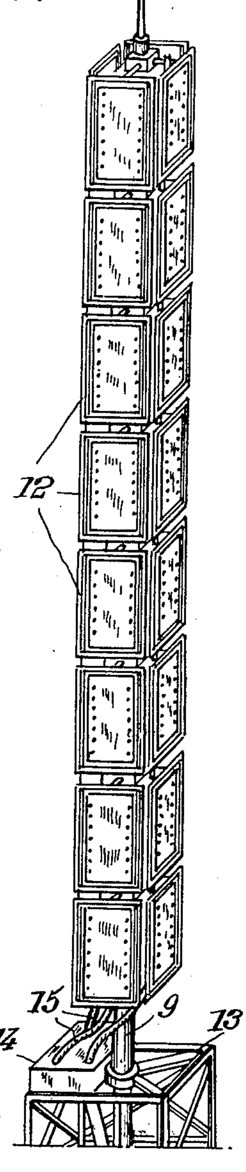
Fig. 6.

Fig. 5





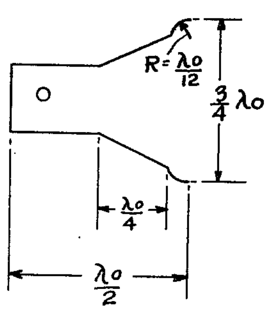


Fig. 10

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CAVITY ANTENNA WITH FLARED HORN

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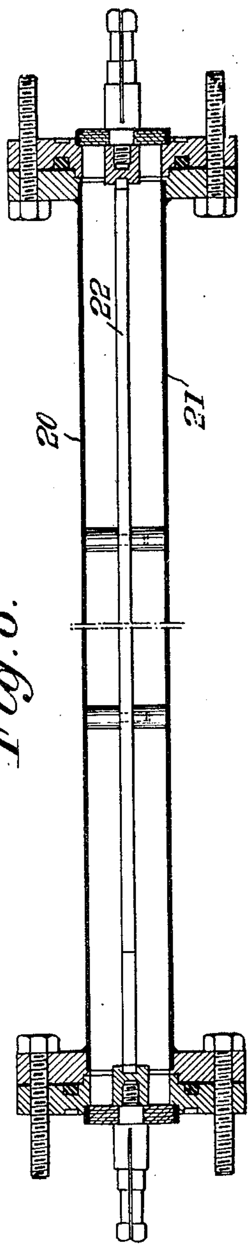

Fig. 8.

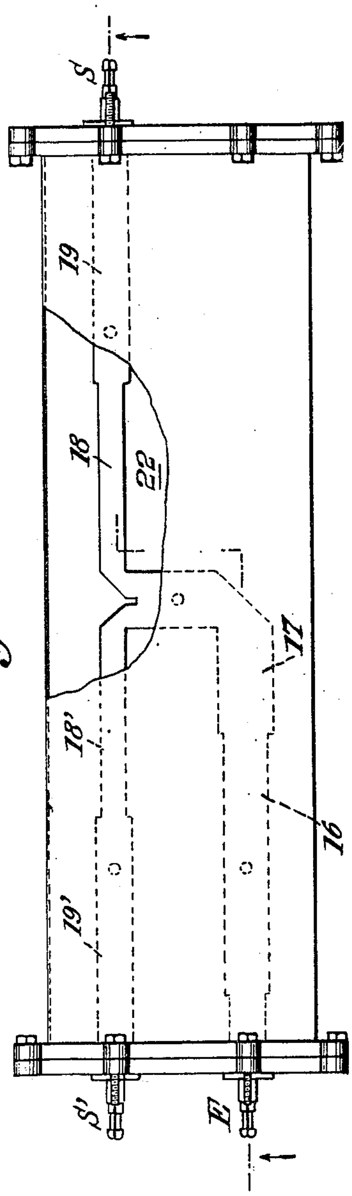

Fig. 7.

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CAVITY ANTENNA WITH FLARED HORN

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Filed Dec. 2, 1960, Ser. No. 73,349
11 Claims. (Cl. 343—786)

This invention relates to an improved wide-band aerial of the slotted "panel" type, such as described, for example, in FIGURE XIV–9, page 353, of "Les antennes" by Thourel, published in France in 1956.

This antenna has been shown in FIG. 1 of the appended drawings to illustrate the structure of the aerial type concerned. It is constituted by a parallelepiped-shaped cavity **1** made of or covered with an electrically conducting material such as iron sheet or the like, opened on its longitudinal face *1a* and provided with an inner exciting conductor **2**, preferably tubular, which is energised, for example, by means of a coaxial cable associated with a cross-bar transition **3**.

The invention has for its purpose to provide an aerial adapted to transmit television waves. The television radiating aerials are usually constituted by dipole arrays, which are often relatively cumbersome and difficult to feed conveniently with the required power, while furthermore requiring hardly rigid accessory parts.

If one tries to resort to slotted antenna arrays for the above mentioned use, it may be observed that the various separate slotted antennae or radiating members interfere with each other, which has objectionable effects on the output and directivity of the aerial constituted by the radiating member assembly.

An object of the invention is to provide a novel and improved slotted antenna of the type described.

Another object of the invention is to suppress substantially any interference between a plurality of radiating members, each one of which has the shape of a unidirectional slotted antenna of the panel type, simultaneously fed with high frequency power.

A further object of the invention is to permit associating a great number of such antennae without altering the electrical characteristics of any of them.

Still another object of the invention is to provide a short-wave wide-band aerial of the type set forth with a flared horn made of an electrically conducting material, extending outwardly from the opening of the parallelepiped-shaped cavity and co-axial therewith, the height of said horn being equal to a small portion of the mean exciting wavelength.

Yet another object of the invention is to feed simultaneously a plurality of slotted antennae by means of flat distributors of the so-called "strip-line" type, having a negligible thickness which permits designing compact antenna arrays.

The invention also has for its purpose to provide, as new articles of manufacture, aerials of the above described construction, parts and special tools used for manufacturing the same as well as stationary or portable arrays comprising such aerials.

The principles of the invention may best be explained by reference to the attached drawings in which:

FIG. 1 is a diagrammatic view of a conventional slotted antenna.

FIG. 2 is an exploded perspective view of an aerial according to the invention including two radiating members.

FIG. 3 is a three quarter face view of the same aerial removed from its support.

FIG. 4 shows the horizontal directional response patterns of several slotted antennae.

FIG. 5 shows the vertical directional response patterns of several slotted antennae.

FIG. 6 shows an array comprising a plurality of slotted aerials.

FIGS. 7 and 8 show a distributor for an aerial of the type shown in FIG. 3; said figures being respectively a plane and a vertical sectional view.

FIG. 9 is a block diagram of the distributor.

FIG. 10 illustrates the cross-section dimensions of the antenna elements of FIG. 6.

Referring first to FIG. 2, two radiating members according to the invention are attached together by one of their side faces.

These members again present parallelepiped-shaped cavities such as **1**, designated by **1** and **1'**, respectively energised by tubes **2**, **2'**, through transitions **3**, **3'**.

According to the invention, instead of directly opening outwardly, each one of said cavities is associated with:

A flared portion **4**, **4'** (flaring out along the electric plane E), which permits better matching the cavity impedance with the sky impedance; it is to be noted that such a radiating member is not to be confused with the conventional radiating horns, wherein the feeding waveguide opens out as a horn and whose height reaches several wave-lengths;

A concave flared edge **5** meeting with the said flared portion; the function of the latter is to make the associated radiating members independent of each other while contributing to the directivity of the whole assembly.

The exact shapes and sizes of these extensions have been determined experimentally. These shapes and sizes will be given hereunder.

It may be seen in FIG. 2 that a frame **6** and a plastic sheet **7** (rholene, polyester glass, or the like) is pressed upon an edge within the "horn" by means of a plurality of bolts so as to seal the opening perfectly, thus thoroughly protecting the "active" portions of the antenna against weathering, and hence permanently preserving the electrical characteristics of this antenna.

It may be also seen in FIG. 2 wherein two radiating members have been secured side by side, that no edge has been provided between the same. Such an edge has a full efficiency only in plane E and is merely used in plane H for mechanical reasons.

Thus the intermediary edges could be omitted if more than two radiating members were successively placed longitudinally behind each other.

FIG. 3 shows another view taken from the side of the same example of two associated radiating members, fed by a repartitor **8**, the construction of which will be described in detail hereunder. The supporting mast **9** of the radiating system which is secured thereon by means of collars and rods **10**, **11**, **10'**, **11'**, at each end, has been shown separately. When the main axis of the aerial extends vertically, the polarization of the radiated wave is horizontal. The vertical height of each parallelepiped is about $0.90\lambda_0$ (λ_0 being the mean operating wavelength at frequency F_0) and the horizontal depth of the parallelepiped is about $\lambda_0/4$; the horizontal depth of the horn is $<\lambda_0$ and preferably

$$\cong\frac{\lambda_0}{4}$$

which substantially reduces the width of the directional response pattern in plane E. The depth of the small horn infers on the slot matching by permitting, when suitably chosen, matching within a very wide band. The width and depth of the concave flange are less than

$$\frac{\lambda_0}{5}$$

these dimensions are shown in FIG. 4(D).

Furthermore, the field E induces in the edges **5**, currents which also take part to the aerial radiation, which results in artificially increasing the slot opening and moreover permits a still more pronounced narrowing of the directivity in this plane. FIG. 4 effectively shows the directional response pattern which may be obtained by varying the shape of the slotted antenna. Each small letter *a*, *b*, *c*, *d*, designates a pattern belonging to that slot which is designated by the corresponding capital letter A, B, C, D. It may be seen that A designates the slot of a conventional aerial with a small straight edge, B showing a slot of the same type with a wider edge, C designating a slot provided with a flared extension merging with a straight edge, while D refers to an antenna according to the invention comprising a flared portion merging with a concave edge. It may be seen that the pattern progressively improves from *a* to *d*; the shape shown at D has for its effect to reduce the amount of the radiation in the plane right-angled to the normal to the panel.

It also results in reducing the side lobes to an admissible value (about —20 db); in other words it makes it possible to secure two radiating members together at right-angles without any substantial interference. Such arrays are shown for example in FIG. 6.

The characteristics of an aerial having two radiating members thus designed, in a specific embodiment are as follows:

Absolute gain: 14 db
Input impedance: 50 ohms
Band width for a standing-wave voltage ratio (S.W.V.R.) of 1.10: F_0—17.5% (e.g. 460–650 mc./s.) band width for a S.W.V.R. of 1.05: $F_0 \pm 15\%$ (e.g. 475–630 mc./s.)
Admissible power: 4 kw.

Angular size of the directional response patterns for 3 db:
- Plane E: 60°
- Plane H: 26°

Overall size of a double radiating member:
- Height: $2\lambda_0$
- Width: $\frac{3}{4}\lambda_0$
- Depth: $\frac{1}{2}\lambda_0$
- Depth of the horn: $\frac{1}{4}\lambda_0$
- Radius of the concave edge: $\frac{1}{12}\lambda_0$

The cross-section dimensions of the above example are illustrated in FIG. 6. As an illustration, there is also shown in FIG. 5 the directional response pattern of the two-member aerial according to FIGS. 2 and 3 in plane H.

A practical difficulty which arises to design an aerial according to FIG. 6 comprising four longitudinal "chains" each of eight double radiating members **12** according to FIGS. 2–3 (these four "chains" being arranged square-like so as to practically constitute an omni-directional aerial) supported by a central rod **9** mounted on a mast **13**, is to correctly feed the said members in phase, since repartitors providing the required phases have to be incorporated somewhere. This difficulty can be overcome by using extremely flat distributors as shown at **8** in FIG. 3 and also shown in FIGS. 7–8 for such a double radiating member.

These distributors are fed in turn from a main distributor **14** of any suitable type and through feeders **15** extending upwardly within the inner space between the radiating members.

To ensure the suitable feeding of each of the two slots of a double radiating member, from a perfectly matched point the distributor has to offer a wide band.

When the said band is comprised between 0.8 F_0 and 1.25 F_0, a symmetrical T-shaped distributor comprising six sections and constituted by quarter-wave transformers may be designed according to the diagram shown in FIG. 9. It may be seen that between each output S, S' and the input E, is interposed a series of four quarter wave transformers, respectively **16**, **17**, **18**, **19** and **16'**, **17'**, **18'**, **19'**. The impedance of these quarter-wave transformers

are preferably and for example respectively as follows, for an input impedance equal to Z:

$$\text{for 16: } Z\sqrt[4]{\frac{\sqrt[2]{2}}{2}}$$

$$\text{for 17: } Z\sqrt[4]{\frac{\sqrt[2]{2}}{4}}$$

$$\text{for 18 or 18': } Z\sqrt[4]{2\sqrt[2]{2}}$$

$$\text{for 19 or 19': } Z\sqrt[4]{2\sqrt[2]{2}}$$

The said distributor is designed according to the "strip-line," technique. It comprises two conducting planes **20**, **21** spaced by a small wave-length portion (0.025 to $0.1\lambda_0$). The central conductor **22** is flat and extends in a direction parallel to the above mentioned planes. Its shape is varied to provide successive transformers.

As a specific example, the overall size of such a distributor, adapted to operate in band IV with an admissible power of 4 kw. would be:

Length: λ_0
Thickness: $0.04\lambda_0$
Width: $0.20\lambda_0$

With similar principles, it is also possible to design extremely flat distributors capable of feeding more than two radiating members at the same time.

From the foregoing, it will be seen that this invention is one well adapted to attain all the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent in the device.

What I claim is:

1. A wide-band short-wave aerial comprising, in combination, a parallelepiped-shaped cavity whose walls are made of an electrically conducting material and having an open face, an exciting conductor mounted parallel to the length of said cavity in its interior, a flared horn extending outwardly from said cavity in axial alignment therewith, said horn having the external shape of a frustum of a right prism constituted by two diverging planes extending from the larger sides of the opening of said open face and by extensions of the small faces of the walls of said parallelepiped-shaped cavity, the height of said horn being equal to the depth of said cavity and to one-fourth of the mean exciting wavelength, and a concave flaring flange made of an electrically conducting material, prolonging at least two edges of said horn outwardly and whose height and width are smaller than one-fifth of said mean wavelength, said flange extending along at least a portion of the outer periphery of said horn.

2. A wide-band short-wave aerial as claimed in claim 1, where said concave flaring flange has substantially the shape of a cylinder portion, the radius of curvature of said concave flange being substantially equal to one twelfth of the mean exciting wavelength.

3. A dual wide-band short-wave antenna, comprising a first parallelepiped-shaped cavity whose walls are made of an electrically conducting material and one face of which is open, an exciting conductor mounted parallel to the length of said first cavity in its interior, a second parallelepiped-shaped cavity whose walls are made of an electrically conducting material, one face of which is open and flush with the open face of said first cavity, and one small face of which is juxtaposed with and secured to one small face of said first cavity, an exciting conductor mounted parallel to the length of said second cavity in its interior, a flared horn extending outwardly from and in axial alignment with the assembly of said two cavities and whose height is equal to a small portion of the mean exciting length, and a concave flaring flange made of an electrically conducting material and whose height and width are smaller than one fifth of the mean wavelength,

said flaring flange extending outwardly along the whole outer periphery of said horn.

4. A wide-band short-wave antenna as claimed in claim 3, wherein said concave flaring flange has substantially the shape of a cylinder portion, the radius of curvature of said concave flange being substantially equal to one-twelfth of the mean exciting wavelength.

5. A dual wide-band short-wave antenna, comprising a first parallelepiped-shaped cavity whose walls are made of an electrically conducting material and one face of which is open, an exciting conductor mounted parallel to the length of said first cavity in its interior, a second parallelepiped-shaped cavity whose walls are made of an electrically conducting material one face of which is open and flush with the open face of said first cavity and one small face of which is juxtaposed with and secured to one small face of said first cavity, an exciting conductor mounted parallel to the length of said second cavity in its interior, a flared horn extending outwardly from and in axial alignment with the assembly of said two cavities and whose height is equal to a small portion of the mean exciting length, said horn having the external shape of a frustum at a right prism constituted by two diverging planes extending from the larger sides of the rectangle formed by the two said open faces and by extensions of the small faces of the outer walls of the assembly of two cavities, and a concave flaring flange made of an electrically conducting material and whose height and width are smaller than one-fifth of the mean wavelength, said flaring flange extending outwardly, along the whole outer periphery of said horn.

6. A wide-band short-wave antenna as claimed in claim 5, wherein said concave flaring flange has substantially the shape of a cylinder portion, the radius of curvature of said flange being substantially equal to one-twelfth of the mean exciting wavelength.

7. An aerial array constituted by a plurality of dual wide-band short-wave antennae, each comprising a first parallelepiped-shaped cavity whose walls are made of an electrically conducting material and one face of which is open, an exciting conductor mounted parallel to the length of said first cavity in its interior, a second parallelepiped-shaped cavity whose walls are made of an electrically conducting material, one face of which is open and flush with the open face of said first cavity, and one small face of which is juxtaposed with and secured to one small face of said first cavity, an exciting conductor mounted parallel to the length of said second cavity in its interior, a flared horn extending outwardly from and in axial alignment with the assembly of said two cavities and whose height is equal to a small portion of the mean exciting length, and a concave flaring flange made of an electrically conducting material and whose height and width are smaller than one-fifth of the mean wavelength, said flaring flange extending outwardly along the whole outer periphery of said horn.

8. An aerial array as claimed in claim 7, wherein said concave flaring flange has substantially the shape of a cylinder portion, the radius of curvature of said flange being substantially equal to one-twelfth of the mean exciting wavelength.

9. An aerial array constituted by a plurality of dual wide-band short-wave antennae, each comprising a first

parallepiped-shaped cavity whose walls are made of any electrically conducting material and one face of which is open, an exciting conductor mounted parallel to the length of said first cavity in its interior, a second parallelepiped-shaped cavity whose walls are made of an electrically conducting material one face of which is open and flush with the open face of said first cavity, and one small face of which is juxtaposed with and secured to one small face of said first cavity, an exciting conductor mounted parallel to the length of said second cavity in its interior, a flared horn extending outwardly from and in axial alignment with the assembly of said two cavities and whose height is equal to a small portion of the mean exciting length, said horn having the external shape of a frustum of a right prism constituted by two diverging planes extending from the larger sides of the rectangle formed by the two said open faces and by extensions of the small faces of the outer walls of the assembly of two cavities, and a concave flaring flange made of an electrically conducting material and whose height and width are smaller than one-fifth of the mean wavelength, said flaring flange extending outwardly, along the whole outer periphery of said horn.

10. An aerial array as claimed in claim 9, wherein said concave flaring flange has substantially the shape of a cylinder portion, the radius of curvature of said flange being substantially equal to one-twelfth of the mean exciting wavelength.

11. A wide-band short-wave aerial comprising at least one aerial element, said aerial comprising, in combination, a parallelepiped-shaped cavity made of an electrically conducting material and having an open face, an exciting conductor mounted within said cavity in a plane parallel to said opening, the walls of said cavity adjacent to said open opening being outwardly lengthened to form an external horn-shaped element comprising a linear diverging part adjacent the opening, and a concave curved edge extending from at least two external edges of said linear part, said concave curved edge having substantially the shape of a cylinder portion the concavity of which is inwardly directed, the concavity radius being substantially equal to one-twelfth of the mean wavelength.

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