

[54] **RADIO ANTENNA STRUCTURE**
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[58] **Field of Search**.....343/840, 912, 915, 916

[56] **References Cited**
UNITED STATES PATENTS
3,261,016 7/1966 Burr.....343/915

3,438,039 4/1969 Altmann.....343/912
3,153,789 10/1964 Ashton.....343/912

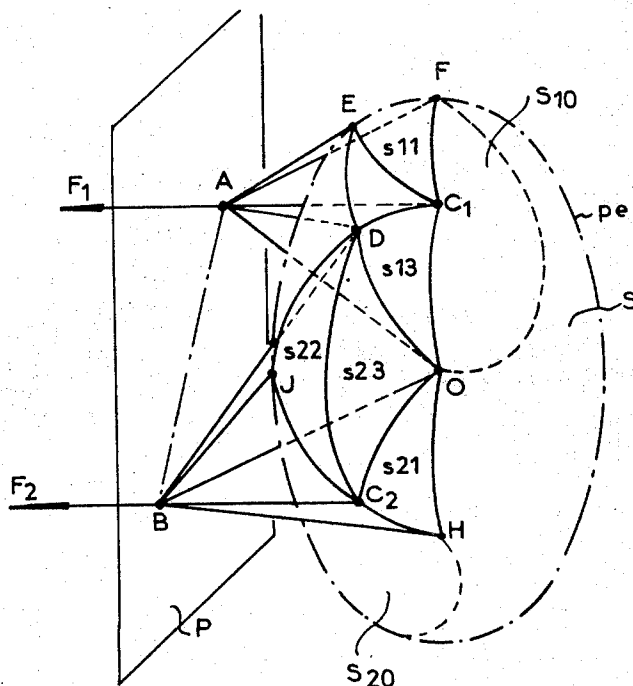
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[57] **ABSTRACT**

Radio antenna structure of large size enabling as easy erection on the site by assembly of separate panels. The structure comprises an assembly of curvilinear triangles whose projection defines a network of lines intersecting at 60°, several assemblies of these triangles constituting the base of pyramids constituted by bars transmitting forces rearwardly of the reflecting surface of the antenna. The apices of these pyramids are united in a plane by rigid bars so that the whole of the structure is completely triangulated and indeformable.

The antenna provided with a radio source lends itself to an installation resisting wind and frost.

6 Claims, 12 Drawing Figures



SHEET 1 OF 4

Fig-1

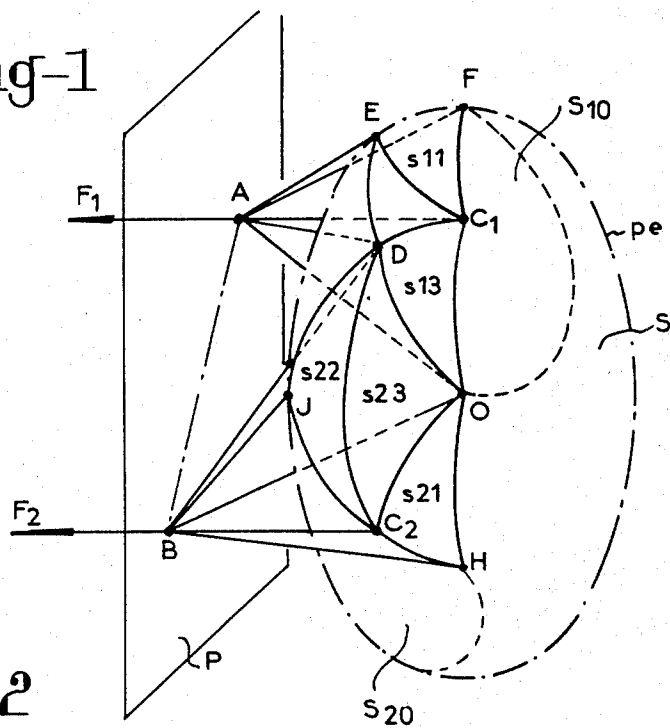


Fig-2

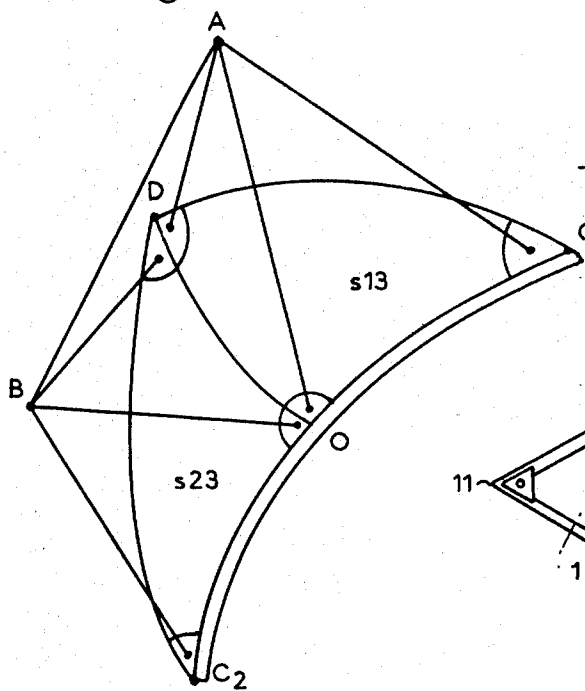


Fig-3

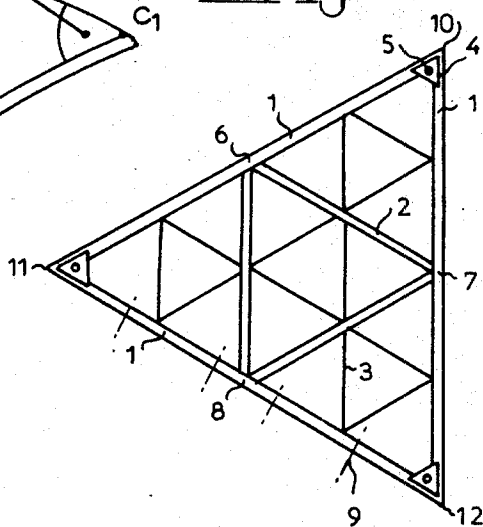


Fig 4

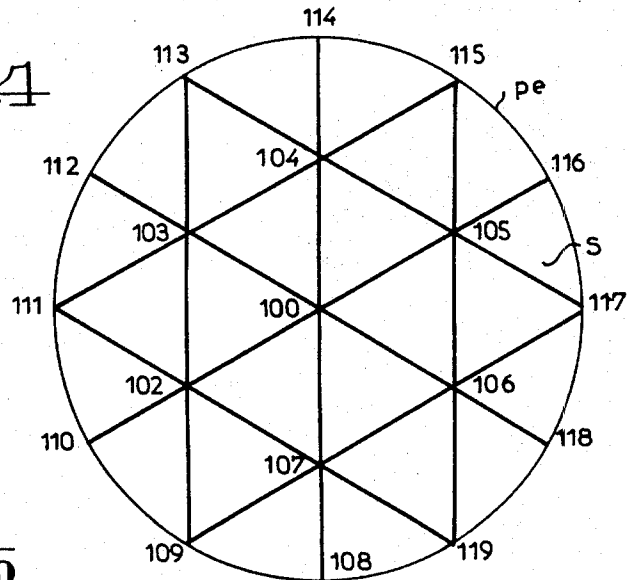


Fig 5

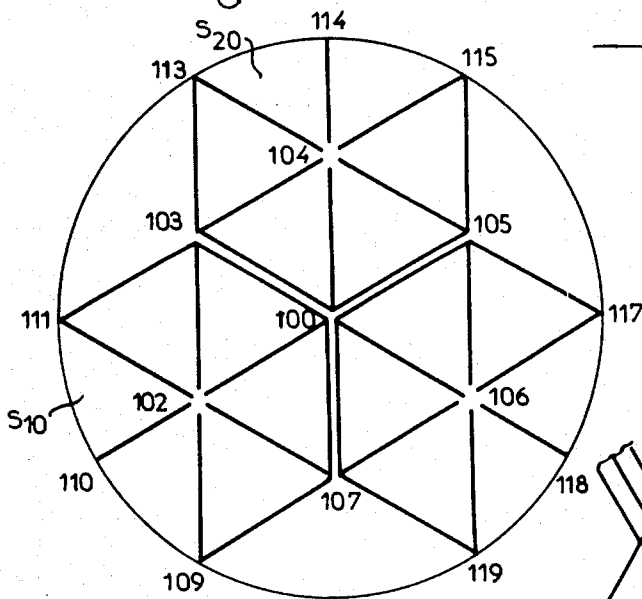


Fig 5^a

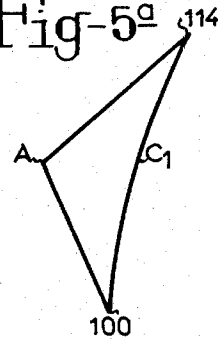


Fig 7

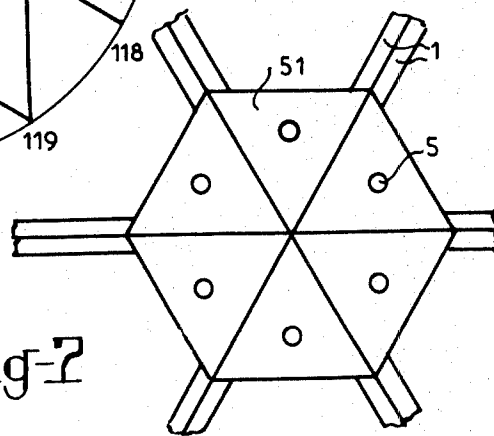


Fig-6

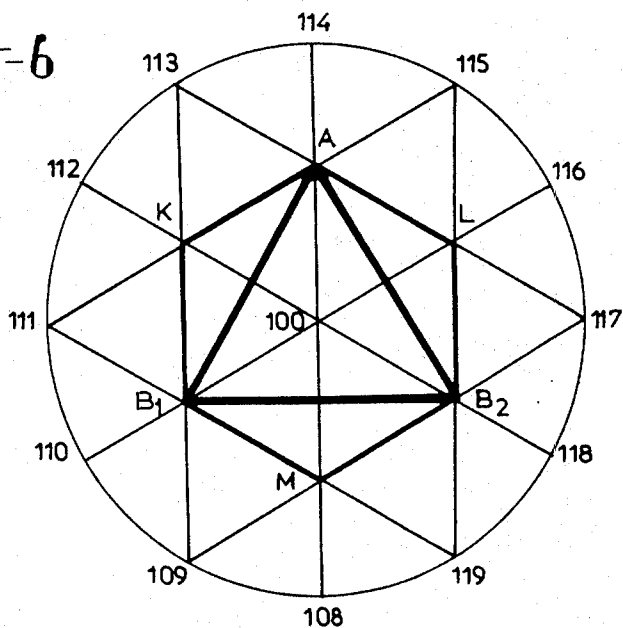


Fig-6^a

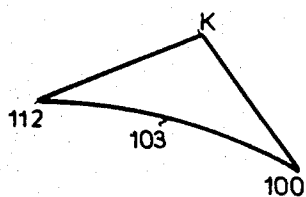
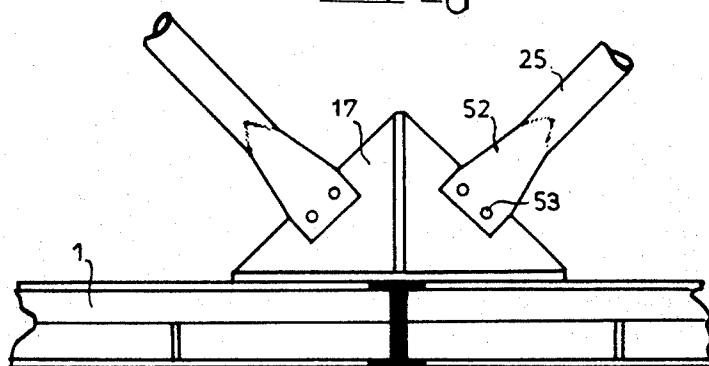
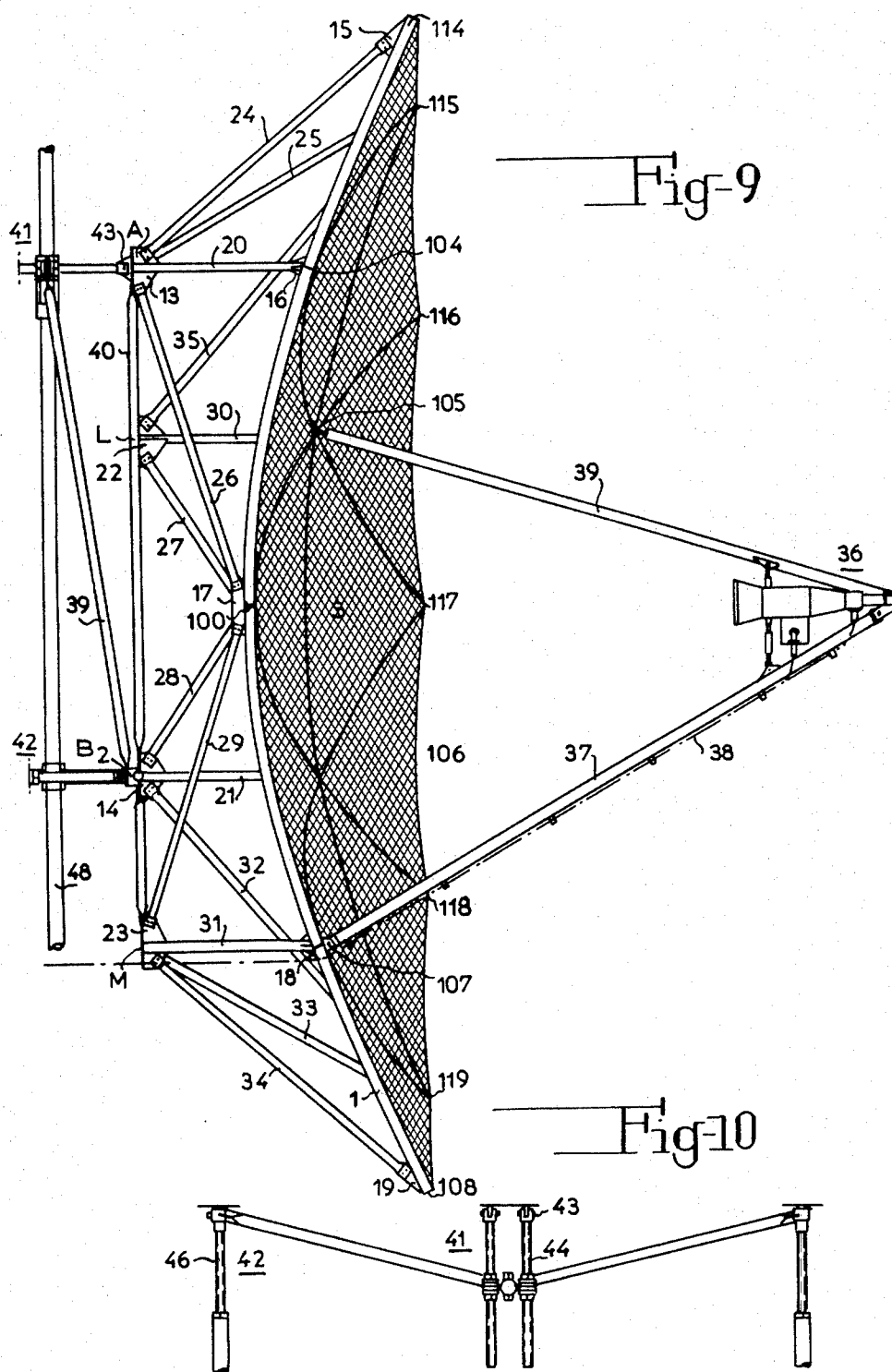


Fig-8





RADIO ANTENNA STRUCTURE

The invention relates to a radio antenna support structure, the latter comprising a very large reflecting surface having a concave curvature of revolution and capable of resisting static and dynamic forces without deforming.

For such antennas comprising a generally parabolic metal lattice whose outside diameter may range from 10 to 60 meters, very large support structures are required and there have already been proposed frameworks comprising trihedral girders connected at the rear by a fixed stand.

The concave surface of the antenna is of necessity constituted, for assembly on the site, by metal elementary surfaces which are connected together on the site.

Such surface elements are known and comprise curvilinear trapeziums to which the grillage of the antenna is attached, the sides of the trapezium being fixed at the rear by a plane frame of section members and welded members of different lengths connecting said sides to the frame. It will be understood that such structures are very heavy and not indeformable and that their assembly is expensive. Antennas have also been constructed which are in the form of radial sections of a paraboloid, these sections being bordered by sheets which are perpendicular to the surface and fixed to outer or median rings. As such an arrangement has no triangulation, it cannot withstand large forces and does not lend itself to the construction of large antennas.

The invention provides a structure which is transportable to the site of erection in the form of indeformable elements which are capable of undergoing, when assembled, dynamic and static stresses due to the wind and to frost, this structure being mounted at the top of high pylons so as to place the axis of the antenna for example 20-30 meters off the ground.

The invention also permits reducing to three points the connection of the structure to the reinforcements of the support pylon and by means of these three points, a very easy adjustment of the angles of elevation and direction of the antenna is possible.

According to the invention, the antenna structure comprises, arranged in accordance with a concave surface of revolution a network of section members supporting the radio surface, said network comprising meshes constituted by adjoining curvilinear triangles, and on at least two non-neighboring corners of said triangles respectively a bar for rearwardly transmitting forces, each of said bars having one end in a common substantially vertical plane and the bars being perpendicular to said plane, each of said bar ends being connected to a plurality of apices of the curvilinear triangles by other bars thus defining pyramids which are such that the apices of the pyramids opposed to the curvilinear triangular surfaces transmit the resultants of the forces applied to said surfaces.

The following further means are also included in an embodiment of the invention:

Two bar ends forming the aforementioned force transmitting apices are interconnected by a rigid bar so as to oppose the twisting forces which may be applied to the curvilinear bases of the pyramids.

The reflecting surface is a paraboloid and it is arranged that the projections onto a rear plane perpendicular to the axis of the paraboloid of the curvilinear

sides of the network of section members are in alignment with three groups of three parallel straight lines spaced equal distances apart the middle line of each group intersecting the center of the projection of the surface and the free middle lines making therebetween angles of 60° so that said projections form 12 equilateral triangles, six of which are grouped into a center hexagon and six are exterior and adjacent to the aforementioned six. The center hexagon is provided on three of its apices spaced 120° apart with the aforementioned force-transferring bars perpendicular to the reference plane, which thus defines three pyramids having six faces which cover at their base virtually the whole of the concave surface.

The projection of the three other apices of the center hexagon form secondary force-transferring points connected by bars to the exterior triangles not covered by the three aforementioned pyramids. As the three main apices and the three secondary apices are, according to the invention, in a common plane, this plane can be employed as directing means for the whole of the antenna with the aid of three connecting means which are adjustable between the apices of the three main pyramids and the masts forming part of the pylon.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawings.

In the drawings:

FIG. 1 is a theoretical perspective diagram of the main force-transmitting elements according to the invention;

FIG. 2 is a simplified diagrammatic perspective view of two neighboring pyramids;

FIG. 3 is a plan view of the framework of a panel element;

FIG. 4 is a diagrammatic view of the antenna support network in vertical projection;

FIG. 5 is a view of the projection shown in FIG. 4 split up into three hexagons;

FIG. 5a is a partial projection in side elevation of the paraboloid shown in FIG. 5.

FIG. 6 is a diagrammatic view of the connections between the apices of the pyramids;

FIG. 6a is a partial projection in side elevation of the paraboloid shown in FIG. 6;

FIG. 7 is a plan view of the center junction of the panel elements;

FIG. 8 is an elevational view of the connection between the stays and support framework of the antenna;

FIG. 9 is a sectional view of the antenna structure, and

FIG. 10 is a plan view of the means adjusting the structure on the pylons.

The main components of the antenna according to the invention are seen first in FIG. 1 which shows diagrammatically a concave antenna surface S which has a circular periphery pe. The surface is divided into triangular elements which appear deformed in perspective. For reasons of clarity, only six of these elementary surfaces are shown, namely s11, s12, s13, s21, s22, s23 which are respectively defined by the curvilinear sides CI FE, CI ED, CI DO, C2 HO, C2 OD, C2 DJ. Considering now a practically vertical reference plane P intersecting the apices of elementary surfaces C1 and C2,

let perpendiculars respectively C1 A, C2 B be dropped onto this plane. By joining the apices O, D, E, F respectively to the point A, and H, O, D, J to the point B, two pyramids having apices A and B are defined whose bases, formed of curvilinear surfaces, adjoin along the line OD.

It will be seen hereinafter that, in fact, the points C1 and C2 are the surface centers S10, S20 marked on the antenna of each of the elementary surfaces s11 or s21 having a surface which is asymmetrical with respect to the points C1 or C2. This signifies that the lines C1 A, and C2 B which are parallel and perpendicular to the plane P can be embodied as lines applying the forces transmitted by the surfaces such as S10 or S20 of which C1 or C2 are the centers. Further, by embodying the line joining the apices A B in the form of a metal bar, the stiffness of the structure is increased, as can be seen in FIG. 2. FIG. 2 shows the elementary surfaces S13 and S23 which have a common curvilinear side DO, the other parts of the pyramids respectively having centers C1 and C2 not having been shown. The sides AO, AD, BO, BD in addition to the connecting bar AB form an indeformable tetrahedral structure which neutralizes the relative forces between OI A and C2 B.

It will now be seen how the framework supporting a surface such as S13 can be constructed. According to FIG. 3 which shows the projection of metal bars which are in fact curvilinear, the contour of each panel forming the triangle 10, 11, 12 is constituted by three parts of a U-section member, for example having the dimensions 120mm $\times$ 40mm $\times$ 3mm. Each of these parts is subjected to a permanent deformation edgewise so as to obtain the required shape corresponding to the profile of the paraboloid of the antenna surface. The three parts 1 are then assembled by electric welding on an assembling jig. Also assembled on the same jig by electric welding are intermediate stiffeners 2 and fixing gussets 4.

As can be seen in FIG. 3, the panel appears in projection as an equilateral triangle, the intermediate stiffeners 2 interconnecting the middle of the sides. In each of the triangles thus formed, secondary stiffeners 3 are also provided. The intermediate stiffeners 2 can be, for example, U-section members having the dimensions 70mm $\times$ 70mm $\times$ 3mm, and the secondary stiffeners round bars of 14mm diameter.

In order to bring the surfaces of the stiffeners in the same plane as that of the contour section members surfaces, the U-section stiffeners are countersunk by means of a press and the round bars are crushed at their ends.

The reflecting surface, which is constituted by a metal grillage of galvanized steel wires, is secured by electric welding on the same assembly jig.

Each corner assembly gusset 4, which is of triangular shape, is welded to the section members 1 and is provided with an aperture 5 through which it is possible to pass a bolt which is secured to a gusset plate, as will be understood hereinafter. The neighboring surfaces such as S13 and S23 are adjacent by two curvilinear section members, such as 1, either for example on the side 11, 12 of FIG. 3 and the connection of the two neighboring panels can be achieved by means of transverse bolts on axes such as 9.

There will now be examined the arrangement of the elementary surfaces, that is, the panels already described, in the whole of the surface of the paraboloid constituting the antenna. As can be seen in FIG. 4, the division into meshes or lattices is shown geometrically by three groups of straight secant lines, each group having three parallel lines spaced equal distances apart, the median line of each group intersecting the center of the projection of the surface and these median lines making therebetween angles of 60°.

Arranged around the center 100 are six hexagon apices: 102, 103, 104, 105, 106, 107 formed by the crossing of the lines of the three groups. The same lines encounter the exterior circle at 12 points spaced equal distances apart: 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, the apices having odd numbers forming adjacent triangles and opposed to the sides of the center hexagon. In FIG. 5 the same drawing is repeated but the surface elements are separated into three adjoining hexagons having centers 102, 104, 106 and whose triangulated outer elements touching the periphery of the antenna surface are slightly truncated. It is on the basis of the drawing of FIG. 5 that the real shape of the surfaces S10 and S20 serving to explain the invention shown in FIG. 1, will be understood.

Corresponding to the theoretical point 104 is the support center C1 with a force diagram as shown in FIG. 5a, the line 114—C1—100 being a portion of the parabolic section of the antenna, the forces being transmitted to the point A by the bars 114—A, C1—A, 110—A and the same is true in respect of the four other points 103, 115, 105, 113.

The three hexagons defined hereinbefore thus permit forming in space a support framework for the antenna constituted by three pyramids having six faces, which enable the forces applied to all the panel apices except three, namely for the latter, the apices 108, 112 and 116 to be transferred. FIGS. 6 and 6a show a related arrangement concerning the latter apices.

In FIG. 6, the point A is the same as that shown in FIG. 1, corresponding to the arrangement in FIG. 5, there are two symmetrical centers B1 and B2 which are the centers of the two pyramids adjoining that of the center A. The line A B1 corresponds with the line AB shown in FIG. 1. There are two other connections A B2 and B1 B2 which form an equilateral triangle A-B1-B2 in the reference plane P (FIG. 1).

The three pyramids are thus connected by an indeformable configuration embodied by metal stays constituting the main parts of the framework of the antenna. Further, corresponding to the points 103, 105, 107 in the reference plane are three points K, L, M or secondary apices which are respectively connected to the points 112, 116, 108 by bars. Thus, the three peripheral support points of the antenna are maintained in space by pyramids interlocking in the first and determining in the reference plane three intermediate apices bringing the periphery of this plane to a regular hexagon.

FIG. 6a shows the arrangement of the forces applied to the section 100—102 forming a portion of a parabola 100—103—100 and to which the bars K-112, K-103, K-100 are joined.

In conclusion, the major part of the paraboloid surface directly transmits in a balanced manner its forces

to the rear support points A, B1, B2 and the intermediate bars leading from K, L, M in the reference plane only undergo unbalancing forces from the local actions of the wind, or from the non-uniform distribution of the dynamic pressure on the surface of the paraboloid.

The principle of FIG. 1 associated with the distribution of the triangular surfaces as explained hereinbefore, permits the construction of an antenna framework as shown in section in a vertical plane in FIG. 9.

Elementary panels as defined in FIG. 3 are assembled into a general surface S of a paraboloid, each assembly having been achieved by means of U-section members such as 1. The points of junction of the triangular surfaces 100 to 119, as shown in the right half of FIG. 4, are also seen. The vertical reference plane is defined by the bar A—B2 shown in side elevation. As already mentioned, the point 104 is the center of one of the pyramids having a hexagonal base and is connected to the point A by the bar 20 perpendicular to the reference plane. The point 106 is the center of one of the lower pyramids and it is connected to the point B2 by the bar 21.

The complex junctions of the bars at the points A and B2 respectively are effected by gusset assemblies 13 and 14. The point of the surface identified by the projection 105 is connected to the secondary apex L by a bar 30 with a junction by means of a gusset 22 and, similarly, the point 107 is connected by a bar 31 to the secondary point M with a junction by means of a gusset 23. By means of gussets 13, 14, 22, 23 there are formed junctions of bars with all the points of the surface, as defined by the layouts shown in FIGS. 4, 5 and 6. For reasons of clarity of the drawing some bars of the framework have not been shown in FIG. 9 since this would have resulted in an excessively complicated drawing. It is easy to see that the gusset 13, which embodies the apex A, can be connected by bars to the points of the antenna surface 100, 103, 113, 114, 115, 105, but only the bars 20, 24, 25, 26 relating respectively to the points 104, 114, 115, 100 have been shown in FIG. 9. Likewise, the apex B2 comprises in the figure bars 21, 28, 32 relating to the points 106, 100, 119.

The apex L (gusset 22) comprises the bars 27, 30, 35 concerning the points 100, 105, 115. The apex (gusset 23) comprises the bars 29, 31, 33, 34 relating the points 100, 107, 119, 108. The radio source, generally indicated by the reference character 36, is disposed in a horn fixed in the acute angle corner defined by two legs 37, 39 bearing at points 107 and 105 plus another leg, not shown in the section and symmetrical to the leg 39. The leg 37 also serves as a support for the coaxial line 38 of the power supply.

FIG. 9 shows only one connecting bar 40 between the apices A and B2, but it will be understood that there are three bars, (as shown in thick line in FIG. 6) which form a triangle A-B-B2. The force-concentrating apices thus defined serve as points of fastening and adjustment on the pylon supporting the antenna framework. Adjustment of the angle of elevation is indicated generally by the reference character 41 and adjustments of the angle of direction are indicated generally by the reference character 42. These adjustments are also shown in plan in FIG. 10. Adjustment of the angle of elevation is effected on screw threaded

rods 44 attached at 43 by pins to tabs on the gusset 13. Nuts and stop-nuts 49, 50 permit locking the assembly to the mast 48. The adjusting device 42 for the angle of direction comprises, on each side of the axis of the mast 48, adjustable screwthreaded rods 46 attached at fixed points on the supporting pylon (not shown).

The antenna framework is built by a careful assembly of the panels, and of the bars of the framework on the junction gussets. The geometric precision obtained by the tridimensional system according to the invention depends on precision in the length of the bars and precision of the assembling means, that is, the gussets. The bars should not have play with respect to the gussets after assembly. The bars such as 24, 25, etc., are tubes terminating in forks without addition of metal or welding.

The bars are assembled with the gussets solely by bolts fitted in as precise a manner as possible in holes in the gussets. The center points of the triangular junction of six panels are provided with a hexagonal gusset 51 with holes 5 which are exactly calculated to make the junction of the webs of the members 1 coincide with the theoretical lines of division into meshes in FIG. 4. In a gusset such as 17 receiving convergent bars 26, 29, the axis lines are so arranged as to meet at the level of the rear faces of the members 1. For this the holes 53 provided for fixing forks 52 have to be carefully calculated.

The various measures just described permit the construction of antennas mounted on high pylons and undergoing considerably forces. By way of example, provision is made for static loads coming from a thickness of frost of 3cm on all the faces of the antenna. The antenna must also be capable of resisting under the same conditions of frost a permanent thrust of the wind at a velocity of 160 kph.

The invention is also applicable to antenna structures having a triangular arrangement of different elementary surfaces, without departing from the scope of the invention.

I claim:

1. In an antenna structure comprising: a concave surface of revolution made of a metal trellis supported on metal frame panels assembled in the form of curvilinear triangles placed edge to edge, six of said panels being mounted about the axis of the said surface and projected in the form of a regular hexagon on a plane at right angles to the said axis, the improvement in which three stress bars parallel to said axis connect three non-consecutive apexes of the hexagon to an equilateral triangle forming a plane of reference at right angles to said axis, at the back of the said concave surface, the apexes of said equilateral reference triangle also being connected to the other apexes of said curvilinear triangles placed edge to edge, the whole forming a non-deformable assembly of pyramids.

2. A structure according to claim 1, in which the projection of the curvilinear triangles on said reference plane has in addition to the six triangles combined in said hexagon, six triangles symmetrical with the former in relation to the outline of said hexagon, and 12 triangles produced by the circle circumscribed in the first twelve triangles and the three diameters of said central hexagon.

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- 3. A structure according to claim 2, in which the twelve equilateral triangles of said structure are reinforced by median subdivisions, dividing each triangle into four equal triangles.
- 4. A structure according to claim 3 in which said triangles resulting from the first subdivision are further split into four by a second sub-division.
- 5. A structure according to claim 2, in which the sides of the curvilinear triangles are bent metal sec-

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tions, a metal trellis being welded to the assembly of sections.

6. A structure according to claim 2, in which the equilateral reference triangle has one apex pointing upwards and connected to a fixed mast by a joint and an adjustable threaded rod, while the two bottom apexes are respectively joined to a fixed support by joints and adjustable rods.

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