ANTENNA SYSTEM COMBINATIONS AND ARRAYS

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Fig.1

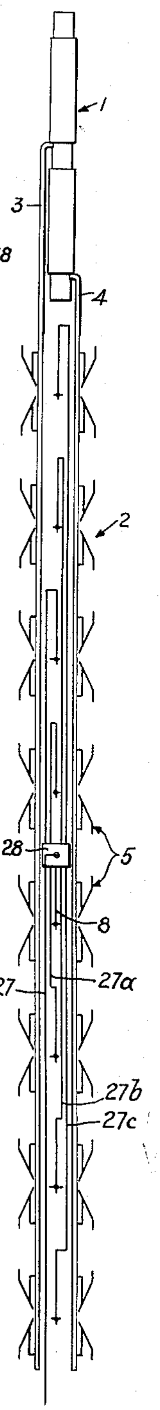


Fig.2

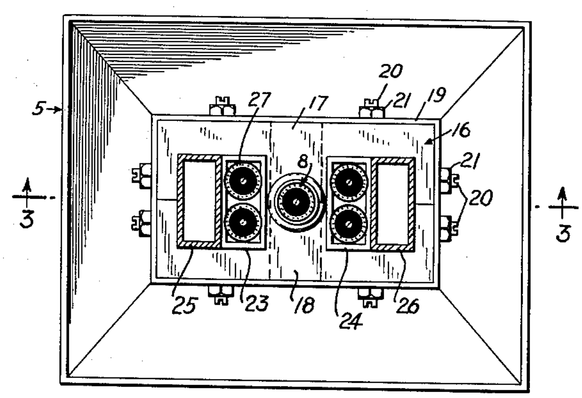


Fig.4

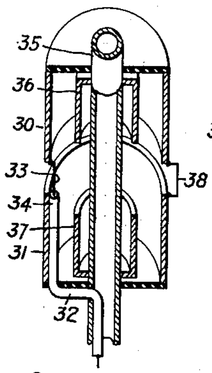
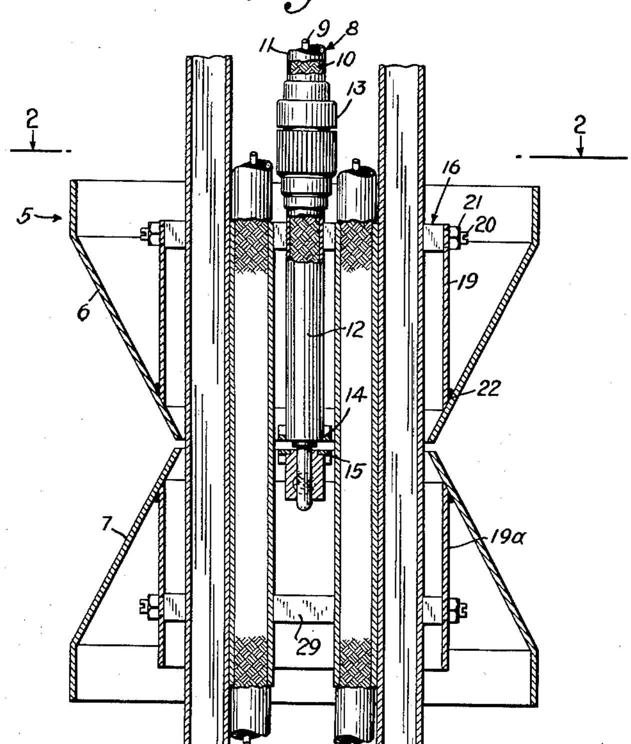


Fig.3



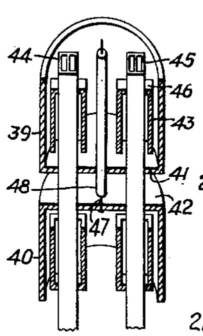


Fig.5

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ANTENNA SYSTEM COMBINATIONS AND ARRAYS

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12 Claims. (Cl. 343—774)

This invention relates to antenna systems and more particularly to antenna system combinations and arrays.

In aircraft navigation it is sometimes desirable to combine certain antenna systems. One example is the supporting of a beacon antenna above an antenna array. Such an array may comprise a stack of di-poles, disc-cones, or bi-conical radiators, and one of the main problems involved is to so arrange the transmission leads to the various antenna units lengthwise of the stack without disturbing the impedance and radiation characteristics of the antenna units. Such transmission leads may include wave guides to be disposed lengthwise of the stack from the beacon antenna above to the beacon transmitter and receiver below the stack. To minimize interference, the transmission leads and wave guides have been arranged by spiraling them around the stacked array. The effect of this arrangement of transmission leads on the array was to increase somewhat the minor lobes of the radiation pattern in a random fashion. While this did not affect the over-all performance of the array, it reduced the antenna gain between about 0.5 and 1 db.

One of the objects of this invention is to provide an antenna unit for use in stacked antenna arrays, which is capable of accommodating transmission lead lines, such as coaxial cables and wave guides, lengthwise therethrough without their presence affecting the impedance or radiation characteristics of the antenna unit.

Another object of the invention is to provide a high gain omnidirectional antenna array.

Still another object of the invention is to provide an antenna system combination having a combined structure for supporting two or more antenna systems in stacked relation with substantially no mutual interference.

One of the features of the invention is the novel antenna construction whereby feed lines such as coaxial cables and wave guides are disposed lengthwise through the antenna structure without affecting its impedance or radiation characteristics. Briefly, the antenna radiators may simulate a di-pole of revolution or they may comprise oppositely disposed horns or bi-conical radiating elements, or other radiator shapes as may be desired so long as they provide enough interior space for extension of antenna leads therethrough together with necessary isolating means. One preferred form comprises a pair of horns disposed back-to-back having radiation characteristics similar to a di-pole, disc-cone or bi-conical antenna. The important feature of the invention is the location of a supporting structure through which transmission leads may be located and the provision of means for isolating the radiating elements of each antenna unit with respect to such lead lines and supporting structure. This isolating means is preferably a form of radio frequency choke disposed about the lead lines and supporting structure at each radiator element. By this antenna construction not only is the presence of external wave guides or other transmission lines to adjacent antenna systems avoided, but also the presence of external feed lines to adjacent antenna units of a stacked array are avoided.

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The above mentioned and other features and objects of this invention will be best understood by reference to the following description taken in conjunction with the following drawings, wherein:

Fig. 1 is a diagrammatical illustration of a plurality of antenna systems shown in stacked relation in accordance with the principles of this invention;

Fig. 2 is a cross-sectional view taken substantially along line 2—2 of Fig. 3, and Fig. 3 is a longitudinal cross-sectional view taken substantially along line 3—3 of Fig. 2, showing one of the antenna structures which may comprise one of the antenna units of the array shown in Fig. 1; and

Figs. 4 and 5 show in longitudinal sectional views two additional antenna units that may also be used in arrays in accordance with the principles of this invention.

Referring to Fig. 1 of the drawing, two antenna systems **1** and **2** are shown in vertically stacked relation. The antenna system **1** is a beacon antenna of the type which requires two X band wave guides **3** and **4** leading down through the antenna **2** to the usual transmitter and receiver of the beacon. The antenna system **2** comprises a vertical stacked array of antenna units **5** used in conjunction with distance measuring equipment. These antenna units which form the array provide vertical polarization and an omnidirectional horizontal radiation pattern with a power gain of approximately 8 over a half-wave di-pole, and a beam direction which may be tilted up or down with respect to the horizontal. By reference to Figs. 2 and 3 in conjunction with Fig. 1, a preferred embodiment of an antenna unit for the array is shown, including an illustration of the supporting structure and means for passing the coaxial transmission lines and wave guides therethrough without their presence affecting the impedance or radiation characteristics of the radiating elements of the unit.

The unit **5** comprises upper and lower radiating elements **6** and **7** shown in the form of truncated rectangular horns disposed back-to-back. In place of horns, the elements may comprise cylinders or frusto-conical elements. The radiating elements **6** and **7** are fed by a solid dielectric coaxial cable **8** comprising a center conductor **9**, and a unit conductor **10** of conductive braid coated by an insulation jacket **11**. The insulating jacket **11** is stripped from the outer conductor which in turn is disposed in a conductive tubing **12** at the coupling **13**. The outer conductor is thus coupled through the tubing **12** and a bracket **14** to diametrically opposed points at the small end of the horn **6**. The inner conductor **9** is likewise coupled to a bracket **15** which is connected at diametrically opposed points to the small end of the horn **7**. This feeding arrangement insures an omnidirectional horizontal pattern since the time phase of the electric charges along the periphery of each radiator is substantially constant. In other words, the radiators are so fed that the waves are all launched in all azimuth directions in the same phase.

The conductive tubing **12** is passed through a conductive plate **16** made up of two parts **17** and **18**. This plate is adjustably supported in a rectangular conductive housing **19** by means of threading stems **20** and clamping nuts **21**. The plate **16** thus forms an end wall closing the upper end of this housing **19**. The lower end of the housing **19** is secured electrically as well as mechanically to the lower portion of the radiator **6** as indicated at **22**. Also passing through the plate **16** are four rectangular pipes **23**, **24** and **25**, **26**. The pipes **23** and **24** provide ducts to accommodate from one to four coaxial lead lines. In the unit shown in Figs. 2 and 3, four coaxial lines **27**, **27***a*, **27***b* and **27***c* are shown, two in the pipe **23** and two in the pipe **24**. The coaxial line **27** comprises the input lead for a transformer coupling unit 28 from which lead lines, preferably of corresponding electrical lengths, are extended to the eight units of the array 2. The rectangular pipes 25 and 26 comprise parts of the wave guides 3 and 4 for the antenna system 1 and also constitute the supporting structure for the antenna units. To isolate the radiator 6 with respect to the pipes 23 to 26 which contain the coaxial leads and form transmission wave guides 3 and 4 for the antenna system 1, the housing 19 and the plate 16 and the conductive walls of the pipes comprise a radio frequency choke substantially one-quarter wave length long. By means of this choke substantially no RF energy is coupled to the coaxial lines and the wave guides passing through the antenna radiator.

The lower radiator 7 of the antenna unit is likewise provided with a radio frequency choke comprising housing 19*a*, adjustable plate 29, and the walls of the pipes 23—26.

While the horn-shaped radiators of the unit 5 is fed centrally, the radiator elements may be fed at the peripheries thereof substantially as shown in Fig. 4. In this embodiment the radiating elements are in the form of cylinders 30 and 31 with a coaxial feed line 32 connected across the peripheral gap between the two radiators as indicated by the center conductor connection 33, the outer conductor being electrically connected to the cylinder 31 as indicated at 34. The tubular member 35 on which the cylinders are insulatively supported and through which the lead lines and/or wave guides pass is extended coaxially through the cylinders 30 and 31 and provided with radio frequency chokes 36 and 37. The cylinders 30 and 31 are connected together at a point opposite the feed connections 33, 34 by a phase equalizing short 38. Where the feeding is done along the periphery of the radiators as in Fig. 4, the diameter d of the radiator should be limited in size in accordance with the ratio of the following formula:

$$\alpha=\frac{\lambda}{\pi}$$

In Fig. 5 another means of feeding the radiators is shown. The cylindrical radiators 39 and 40 are each provided with an end disk 41, 42 of conductive material through which tubular elements 44 and 45 pass for the purpose of enclosing transmission leads and/or wave guides. Each of these tubular elements is provided with a radio frequency choke as indicated by the coaxial sleeve 43 which is closed as indicated at 46 with respect to the surface of the tubular member, thus forming a quarter wave shorted trap. In this embodiment a coaxial feed line for the unit is disposed coaxially thereof with the inner conductor 47 connected to the plate 42 and the outer conductor 48 connected to the plate 41. If desired, these connections may be reversed. The feeding at the center of the plates 41 and 42 along the axis of symmetry insures an omnidirectional horizontal pattern in such a manner as to keep the time phase of the electric charges along the periphery of the radiator substantially constant. The waves are thus launched in all azimuth directions in the same phase.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of our invention, as set forth in the objects thereof and in the accompanying claims.

We claim:

1. In an antenna combination having two antenna systems, one supported above the other; an antenna unit for the lower antenna system adapted to permit extension of antenna leads therethrough, comprising a pair of radiators disposed in adjacent spaced relation, means coupling energy to the adjacent portions of said radiators, conductive means providing ducts through said unit internally of said radiators through which said antenna leads extend, and means for isolating said radiators with respect to said duct-providing means.

2. In an antenna combination according to claim 1 wherein said duct-providing means includes a wave guide extending to the upper antenna system.

3. In an antenna combination according to claim 1 wherein the radiator isolating means includes a radio frequency choke disposed in conjunction with said duct-providing means and each of the radiators of said unit.

4. In an antenna combination according to claim 3 wherein said radio frequency choke includes a housing surrounding the duct-providing means and an end plate for said housing having openings therethrough for extension of said antenna leads.

5. In an antenna combination according to claim 1 wherein said lower antenna system includes a plurality of such antenna units disposed one above the other in stacked relation, each unit having an individual lead cable and lead cables for at least certain of said units being extended through the duct-forming means contained in certain of the other of said units.

6. An antenna unit for use in antenna arrays comprising a pair of radiator elements disposed in axial spaced alignment, means providing a duct therethrough whereby leads for other antenna units may be disposed, an antenna lead for each pair of radiator elements, means coupling an antenna lead to the adjacent portions of the radiator elements of each pair, and means forming a radio frequency choke with respect to each of said radiating elements and said duct-providing means whereby each radiating element is isolated electrically with respect to the duct-providing means and the antenna leads extending therethrough.

7. An antenna unit according to claim 6 wherein the means for coupling an antenna lead to each pair of radiator elements includes a conductive member disposed radially from a central axial feed point to the periphery of each radiator.

8. An antenna unit according to claim 6 wherein the means for energizing said radiators includes a means for feeding the radiators at the periphery thereof and means providing a phase equalizing short between said radiators diametrically opposite said feeding point.

9. An antenna unit according to claim 6 wherein said radiating elements comprise horn-shaped radiators disposed back-to-back, said means for coupling an antenna lead to a pair of said elements is coupled to the small ends of the horns and said radio frequency choke includes a quarter wave housing contained in each radiating element with openings through the end thereof to accommodate the leads extending through said duct-forming means.

10. An antenna unit according to claim 6 wherein said radiating elements each includes a radiating surface of revolution and are provided with conductive discs closing the adjacent ends thereof, and said means for coupling an antenna lead to each pair of radiator elements includes a connection axially with respect to said discs, said discs having openings therethrough to accommodate said leads.

11. An antenna unit according to claim 6 wherein said radiating elements each includes a radiating surface of revolution and said means for coupling an antenna lead to each pair of radiator elements includes a peripherial coupling connection and a phase equalizing short disposed diametrically opposite said coupling.

12. An antenna unit for use in antenna arrays comprising a pair of radiator elements disposed in axial alignment, means providing a duct therethrough whereby leads for other antenna units may be disposed, and means forming a radio frequency choke with respect to each of said radiating elements and said duct-providing means whereby each radiating element is isolated with respect to the duct-providing means and the antenna leads extending therethrough, said duct-providing means including a pair of pipes, and said radio frequency choke including a pair of

conductive members surrounding said pipes, one member each being disposed within the confines of one of said radiators, one end of each member being electrically and mechanically connected to the associated radiator and a conductive means at this other end portion of each member closing the space between said member and said pipes and supporting the antenna assembly on said pipes.

References Cited in the file of this patent

UNITED STATES PATENTS

2,199,375	Lindenblad	Apr. 30, 1940
2,218,741	Buschbeck	Oct. 22, 1940
2,323,641	Bailey	July 6, 1943
2,385,783	Alford et al.	Oct. 2, 1945
2,452,202	Lindenblad	Oct. 26, 1948
2,462,865	Himmel	Mar. 1, 1949
2,471,021	Bradley	May 24, 1949
2,519,209	Wheeler	Aug. 15, 1950
2,533,236	Felsenhend	Dec. 12, 1950
2,540,839	Southworth	Feb. 6, 1951