Oct. 5, 1954 R. W. MASTERS 2,691,102
HIGH GAIN VHF ANTENNA SYSTEM
Filed Aug. 14, 1950 3 Sheets-Sheet 1

Fig_1

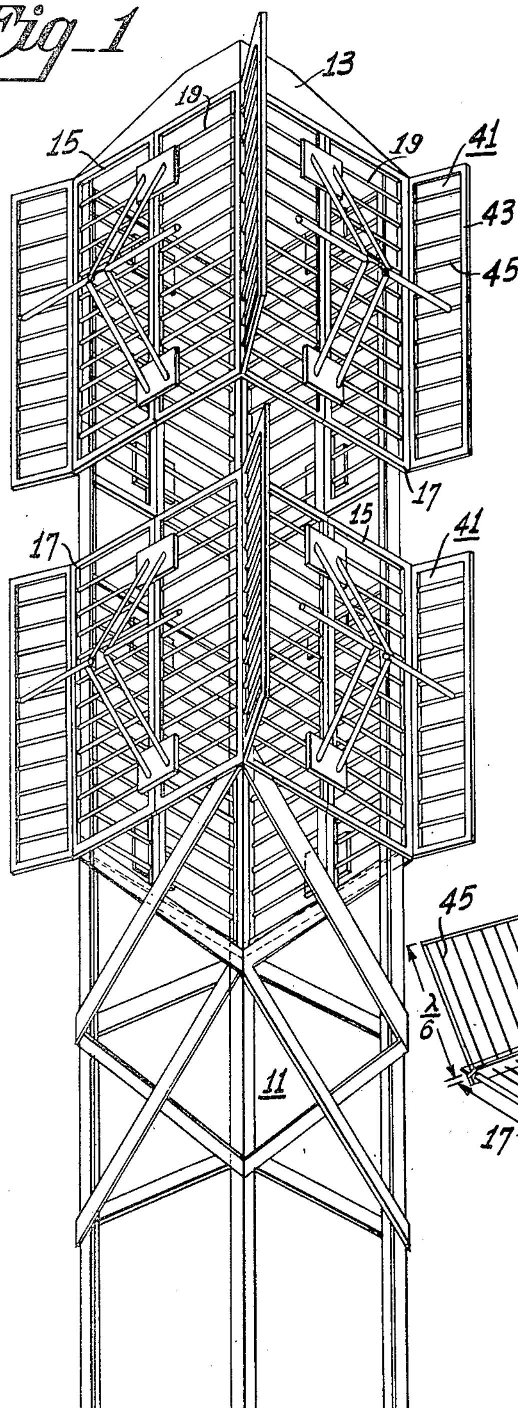


Fig_3

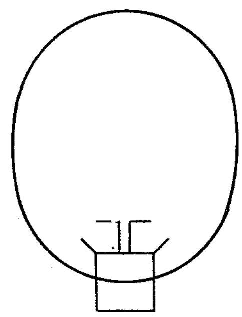
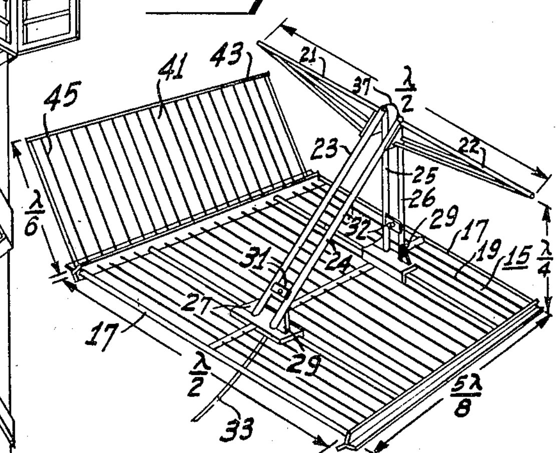


Fig_2



INVENTOR
R. Wayne Masters
BY
Charles H. Brown
ATTORNEY

Oct. 5, 1954 — R. W. MASTERS — 2,691,102

HIGH GAIN VHF ANTENNA SYSTEM

Filed Aug. 14, 1950 — 3 Sheets-Sheet 2

Fig. 6

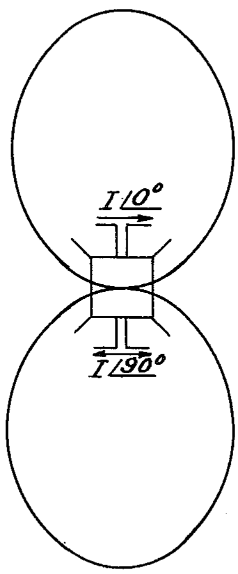


Fig. 5

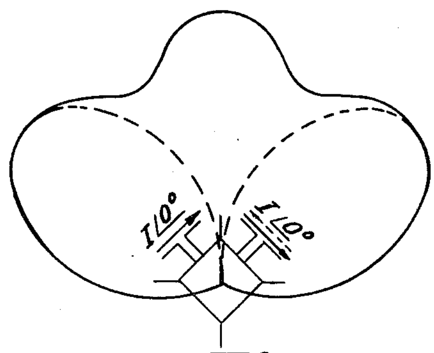


Fig. 8

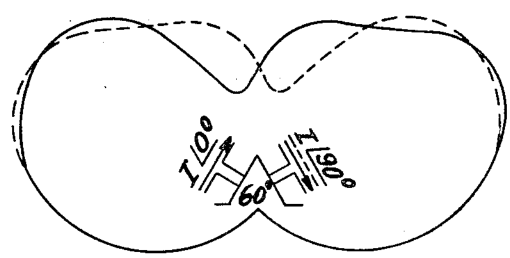


Fig. 4

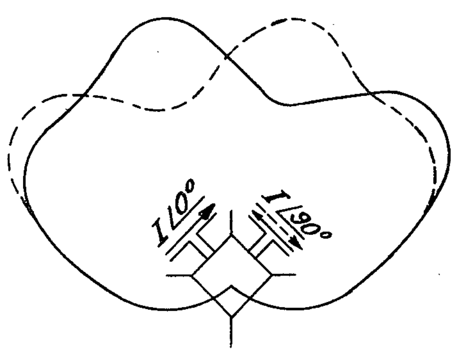
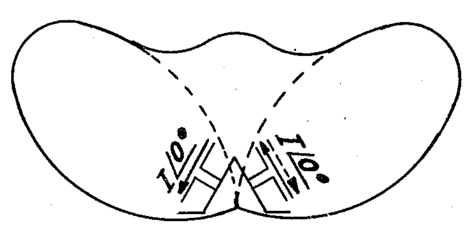


Fig. 7



INVENTOR
R. Wayne Masters
BY
Charles H. Brown
ATTORNEY

Oct. 5, 1954 R. W. MASTERS 2,691,102

HIGH GAIN VHF ANTENNA SYSTEM

Filed Aug. 14, 1950 3 Sheets-Sheet 3

Fig_9

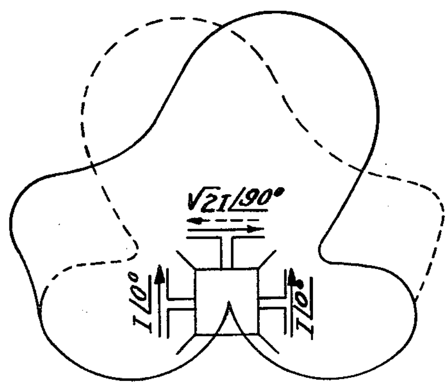
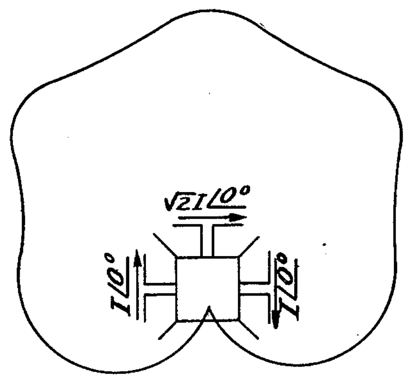


Fig_10



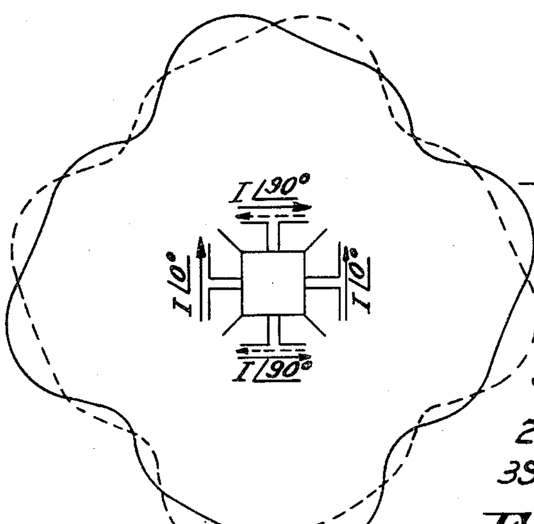


Fig_11

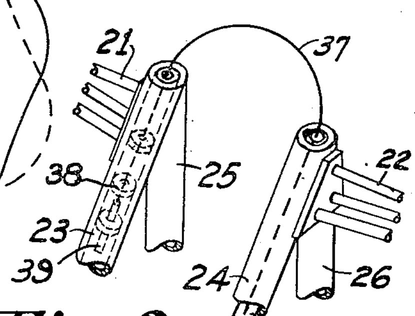


Fig_2a

INVENTOR
R. Wayne Masters
BY
Charles H. Brown
ATTORNEY

Patented Oct. 5, 1954 **2,691,102**

UNITED STATES PATENT OFFICE

2,691,102

HIGH GAIN VHF ANTENNA SYSTEM

Robert Wayne Masters, Columbus, Ohio, assignor to Radio Corporation of America, a corporation of Delaware

Application August 14, 1950, Serial No. 179,181

16 Claims. (Cl. 250—33.53)

The invention relates to VHF broadcasting antennas and particularly pertains to antennas especially suitable for television signal broadcasting incorporating means for obtaining higher gain, increased directivity and decreased element interaction than are obtained with present VHF broadcasting antennas.

Most of the antennas presently employed for television broadcasting are of the turnstiled current sheet radiator type, which type consists of a steel pole supporting large planar perforated radiators. This type of antenna is presently constructed in varying numbers of layers to give desired values of effective radiated power up to the limit specified by government regulations. In many cases, requirements exist which cannot be readily met by this antenna.

The only way to increase the directivity gain of an antenna whose beam width is fixed is to narrow the beam width of the vertical radiation pattern, so that a greater proportion of the energy is radiated in the horizontal plane where it is useful. The simplest and most efficient way to do this for TV applications is to stack layers of radiators and feed them all alike.

The antennas used at present consist of radiator elements mounted on a pole. For lengths up to about 50 or 100 feet the pole mounting is satisfactory, but for lengths greater than that, pole mounting is entirely unsatisfactory; deflection under high wind loading, external mounting of transmission lines and junction boxes, and relative inaccessibility being a few of the more important reasons.

The tower type of construction, consisting of three or four corner legs, with suitable bracing members, so practicable at the lower frequencies is also desirable at VHF for economic and other reasons.

The structure required to support an antenna having the required gain can be made to support other radiating systems at only a slight additional cost. The tower type of construction lends itself to multiple use, such as an AM radiator and to support antennas for FM and other TV stations. The use of a single tower by two or more TV stations is especially promising because all receiving antennas will automatically be oriented in the right direction for all channels so used. The advantages of multiple usage may offset the inherent expensiveness of such structures.

The interior of the tower can be made available for access to the antennas. Thus, one antenna can be serviced or repaired without inconvenience to the schedules of the other stations. The interior of the tower allows more room for the multiplicity of feed lines and connections inherent in the use of a great number of radiators.

At VHF, however, it has been found that the tower structures do not provide the desired results from the viewpoint of radiation desired. It appears that the principal reason is that the interaction between radiator elements as arranged on pole mounting is increased by coupling within the tower to the extent that the tower arrangement as known in the prior art is entirely unsatisfactory.

Most antennas are preferably mounted at rather great heights on buildings or towers. This precludes the use of a radiating system which achieves gain through large horizontal dimensions as this would require a large horizontal area on a building top or a multiplicity of towers for support. It is most desirable, therefore, to provide an antenna system which requires only a single tower or small area on a building top.

In many cases a radiation pattern other than circular can be used to advantage. It has been suggested that some form of shields be placed about the radiator elements to concentrate the radiation in a desired direction. The mechanical support of such screens or shields on a pole poses severe design problems. While no such design problem is encountered with the tower support, the prior art towers have nevertheless been found lacking due no doubt to the inherent intercoupling of the radiators by the tower itself.

There have been suggested modifications of towers made from time to time with the principal object of reducing deleterious effects of the towers themselves on the radiation pattern of antennas supported by or comprising the towers themselves. One such arrangement is described and illustrated in U. S. Patent 2,184,940 issued December 26, 1939 to E. C. Cork and J. L. Pawsey. Such arrangements have not, however, completely solved the problem and have left much to be desired in the way of isolating the tower coupling from the antenna elements.

Therefore, it is an object of the invention to provide a VHF broadcasting antenna system having a higher gain than the prior art antenna systems.

It is another object of the invention to provide a VHF broadcasting antenna system capable of having an increased directive effect over the prior art antenna systems.

It is a further object of the invention to provide a tower supported antenna array having means to prevent coupling between radiator elements by the tower itself.

It is still another object of the invention to provide a radiator-screen structure enabling antenna systems to be assembled in a number of ways to suit the exact conditions under which they are to work.

It is a still further object of the invention to provide an antenna system capable of being used at low and very high frequencies simultaneously.

It is yet another object of the invention to provide a VHF television or FM antenna system incorporating means for turnstile operation.

These and other objects of the invention which will appear as the specification progresses are attained in a tower supported antenna array consisting fundamentally of half-wavelength dipoles mounted approximately one-quarter wavelength in front of conductive surface elements or reflecting screens having dimensions of one-half wavelength wide by five-eighths of a wavelength high mounted on the sides of the supporting tower. The screens are either connected electrically to the tower or to each other at the vertical edges thereof or both and serve to prevent coupling within the tower as well as to redirect energy radiated to the rear of the dipole, to the normal direction of radiation.

There are many ways in which the dipoles can be connected to obtain directional radiation patterns of different configurations in addition to the more frequently used omni-directional pattern. In order to prevent the mutual coupling of the dipoles with each other around the tower when connected in some of these different ways, further conductive surface members or dipole shielding wings are connected to the vertical edges of the screens. These wings are rectangular in shape, being about one-sixth of a wavelength in horizontal width by five-eighths of a wavelength in vertical length. The wings are arranged at an angle of 135° with the screen for a square tower so as to effect a shield around the ends of the dipole. The wings produce excellent back lobe suppression, to less than one per cent in development models of the antenna, and therefore offer an ideal solution to the protection problem ever present in directional antenna installations.

The invention will be described in detail in connection with the accompanying drawing forming a part of the specification and in which:

Fig. 1 is a perspective view showing the general arrangement of an antenna system according to the invention;

Fig. 2 is a detailed view of one of the screen and dipole assemblies shown in Fig. 1;

Fig. 2*a* is a detailed view of an alternate mode of connecting the dipole assemblies to the transmission line; and

Figs. 3–11 are graphical representations of radiation patterns obtained with various antenna systems incorporating the fundamental structure of the invention.

Referring to Fig. 1, there is shown more or less generally an antenna system according to the invention. A tower 11, preferably straight-sided for a portion of its length but which may be entirely conventional in construction, is fitted with a cap member 13, shown here as a simple hood on which a beacon or a supporting pole for another antenna (neither of which is shown) may be mounted. Within the tower are the usual ladder and provisions for mounting the necessary transmission line (neither of which is shown). Tower 11 as thus far described may be used as a low frequency radiator or if desired only as a support for the very high frequency antenna system to be described.

Arranged about the periphery of tower 11 are conductive surface elements 15. These elements may be in the form of thin sheet metal or other conductive material, but from a practical standpoint are constituted by a rigid frame 17 having a number of cross conductors 19 welded thereto. Alternately the screens could be effected by welding conductors 19 directly to tower 11, but in the interests of flexibility of application screens 15 are preferably made separate and self-supporting. As shown in greater detail in Fig. 2, half-wave dipole elements 21, 22 are mounted on screen 15 by means of conductive supporting members 23, 24 and 25, 26. Preferably, plates 27 and brackets 29 are provided to insure rigidity.

Broad band operation over the six megacycle/second channel is obtained by employing three conductors in pyramided configuration to make up dipole elements 21 and 22. Adjustable shorting bars 31 and 32 are utilized to trim the impedance of the radiator to the desired value since the transmission line sections formed by conductors 23, 24 and 25, 26 are in parallel with dipole elements 21, 22. The coaxial transmission line 33 is led through one of the support members, shown here as member 24, and the sheath conductor is connected to dipole element 22 at the end adjacent dipole element 21, to which element the inner conductor 37 of transmission line 33 is connected.

Referring for the moment to Fig. 2*a*, there is shown in brief detail an additional means for trimming the impedance of the radiator. The inner conductor 37 of transmission line 33 is not directly connected to dipole element 21 but is extended into hollow support 23 whereby the inner conductor 37 is capacitively coupled to dipole element 21 to provide series impedance tuning. Conductor 37 is preferably spaced from the walls of conductor 23 by means of insulating discs 38. The desired capacity may be obtained simply by sliding the end of conductor 37 into or out of conductor 23, but preferably a movable sleeve 39 arranged on the innermost end of conductor 37 is adjusted instead. By means of a combination of series and parallel impedance tuning the dipole can be effectively matched to the transmission line over the desired band.

Dipole elements 21, 22 are located between 0.3 and 0.25 wavelength in front of screens 15. Screens 15 are preferably five-eighths of a wavelength high and half a wavelength wide. The width is somewhat critical. Widths substantially less than a half wavelength result in interference between dipoles on adjacent sides whereas a larger side dimension leads to pattern difficulties. Thus the width varies from nine feet for Channel 2 to two and one-half feet for Channels 10, 11, 12 and 13.

In the interest of flexibility, a few standard tower widths may be used and screens 15 spaced outwardly therefrom as required.

The reflecting screen is used to keep radiation out of the tower and thus prevent changes in the impedance over the channel width due to coupling with objects within the tower. Hence, even if but one dipole were used the tower would be screened on all sides. In addition the screens tend to narrow the pattern of each dipole radiator. The reflecting screens can either be furnished as separate screens as shown in Fig. 2 to mount on the tower face, or can be fabricated into the tower itself.

In either case, the dipoles with backing screens are mounted in layers, having a vertical separation of slightly less than one wavelength, approximately 0.9 to a full wavelength in practice, as measured center to center.

Electrical excitation of the dipole elements is usually accomplished in practice by using feedlines, all of equal length, joining the radiators to common junction boxes. Either one or two transmission lines, depending on the system used, connect the junction boxes to the TV transmitter.

In addition to the beneficial effect resulting from the placing of screens 15 completely around the tower, the addition of further conductive surface elements 41 to the vertical edges of screens 15 serves to reduce coupling between the dipole elements around the tower. Wings 41 are constituted by a rigid frame 43 and horizontal conductors 45 spaced at intervals so small with respect to the operating wavelength that the same electrical effect is had as would be obtained with a thin conductive sheet. A spacing of 20 conductors 19 or 45 to the five-eighths wavelength dimension has been found very satisfactory.

Referring particularly to Fig. 2, the assembly comprising a screen 15, dipole elements 21, 22 and wing 41 is particularly useful in the construction of various antenna systems to meet the prevaling circumstances. Four such assemblies will complete one turnstile layer and can be installed in short order. If fewer than four such assemblies are used an extra wing section 41 or two may be quickly attached. Thus an entire set of assemblies for a given antenna design can be fabricated in a manufacturing plant and the antenna readily assembled on the tower by relatively unskilled workmen without fabricating equipment. As previously mentioned, the radiating system according to the invention can be employed to obtain several types of directional radiation patterns, as well as for a circular pattern. In general, radiators may be placed on any of the faces of the tower structure and thus provide several combinations of directional pattern. In discussing possible directional patterns, each screen and radiator can be considered to have the same horizontal pattern as that from one side of a horizontal dipole, with the beam narrowed and shaped by completely screening the tower and using wing members as shown in Fig. 3.

In order to review some of the advantages of the antenna systems according to the invention and to have a complete understanding of the possibilities, several of the feed line connection schemes and the resulting field patterns will be discussed. The turnstile connection is employed and recommended in every instance where it is possible. It consists in connecting the antenna feed system in such a way that there are two feed points of equal impedance which are driven by equal voltages having a 90° phase difference. The superiority of this type of connection has been demonstrated repeatedly, especially where it is necessary to separate and absorb antenna reflections to prevent system reverberations from causing ghost images on a receiver screen.

For instance, radiators may be placed on two adjoining sides of a tower as shown in Fig. 4 and thus cover approximately 180°. Since the input power is concentrated in two instead of four sets of radiators, the power gain in the maximum direction is approximately doubled.

The arrangements illustrated in Figs. 5–11 are more or less self-explanatory, but some of the connection schemes may bear additional comment. It is possible to reverse the direction of the current in any dipole by the simple expedient of physically turning the dipole 180° on its screen mounting. Figures 4, 6, 8, 9 and 11 are radiation patterns obtained when the antenna according to the invention is arranged for turnstiling. The solid line is for visual signal radiation pattern and dashed line is for the aural signal radiation pattern, or they may be vice versa if desired. Figures 3, 5, 10 and 7 illustrate the resultant field patterns where all radiators are excited in 0° or 180° phase relation. Still other variations of pattern not shown are available through proper dipole connections. In all cases the solid line arrows representing current directions are to be associated with the solid line curves and the dash line arrows with the dash line pattern shapes. Figure 10 is drawn for the condition in which the antenna is adjusted to radiate twice as much power in the 0° direction as in the plus and minus 90° directions. Obviously, this is an arbitrary current distribution, and others are as easily obtained. Similarly, screen orientations other than 60° and 90° (which are practical for towers of triangular and square cross-sections) are possible.

Impedance characteristics of tested antenna systems according to the invention are such that the antenna could operate over a 25 per cent band width with an 87 per cent impedance match or better should the necessity arise. No such operation is expected, but there is good insurance in the large band-width that little change if any in tuning would occur, for example, due to icing.

No upper limit on power gain has been found for the antenna according to the invention. The ultimate limit may be reached due to narrowing of the beam in the vertical plane rather than by structural complications. The radiators are spaced a nominal 0.9 wavelength apart vertically so that a close approximation to a uniform current distribution throughout the height of the antenna is achieved. It is well known that the power gain over a dipole of a uniformly excited antenna whose height is greater than two or three wavelengths and whose pattern is circular has a value which approaches a maximum given by:

$$\text{Gain}=1.22\,H \qquad (1)$$

where H is the effective height in wavelengths at the operating frequency. Since each bay of the antenna, whose dipoles are spaced S wavelengths vertically, approximates in array, an equal section of uniformly excited vertical aperture, Equation 1 becomes:

$$\text{Gain}=1.22\times S\times n \qquad (2)$$

where n is the number of bays of dipoles. Since S is normally equal to 0.9 wavelength, the maximum possible gain of the antenna is given by:

$$\text{Gain}=1.1\,n \qquad (3)$$

These values are understood to be average values taken throughout the 360° azimuth angle, and therefore do not include the plus and minus variations due to the small deviations from circularity naturally inherent in the omnidirectional antenna. These deviations will be in the order of plus or minus 15 per cent in voltage. The realizable gain for a practicable antenna may be somewhat less, on the order of 10 per cent, than that indicated by Equation 3 because the pattern of one bay of dipoles is not too closely equal to that of the section of uniform continuous current distribution which it is supposed to replace.

The gains of the directional radiation patterns are all different, and are greater than the average gain of the omnidirectional antenna of the same height by factors ranging from 4.0 in the case of Fig. 3 to 2.85 for Fig. 4 and 2.0 for Fig. 6. These directional gains are calculated relative to a circle by finding the ratio of the maximum power in the horizontal direction to the average power in the horizontal. This result is multiplied by the gain due to vertical height of a circular antenna to find the final directivity gain of the antenna. Gains are then referred to the location of the main junction box by accounting for the small loss in the branch lines of the distribution system in the antenna.

For antennas having a gain of ten or more, a means can be provided for tipping the pattern a slight amount. This is useful, for instance, in the case of an uneven terrain. The pattern can be tipped down a degree or so to effect better coverage close in, or it can be adjusted to increase the coverage at a distant locality. To accomplish this beam tipping, the antenna is divided into upper and lower groups by the feed system. The phasing of one of these groups can be changed to provide a slight change in vertical angle without affecting the gain adversely.

A typical application of the invention was made in the arrangement of a 12-layer antenna for operation on television channel 4 with a circular pattern. This antenna had a theoretical gain of 13.2. Both the E–W and N–S feeds were split into upper and lower groups to permit phasing sections to be used for controlling the angle of the vertical pattern.

The invention claimed is:

1. An antenna system including a supporting tower structure, conductive surface elements arranged about the circumference of said tower structure to enclose the same, and at least one dipole radiator element arranged externally of said tower structure on one of said conductive surface elements and in parallel relationship thereto, further conductive surface members arranged in a plane intersecting the axis of said dipole radiator element and the intersecting edges of adjacent conductive surface elements and bisecting the external angle between said adjacent conductive surface elements, and means to connect a radio frequency transmission line to said dipole element.

2. In an antenna system including a supporting tower structure, a structural element comprising a conductive surface element, a dipole radiator element mounted on and centrally located in front of said conductive surface element, a further conductive surface member arranged along one edge of said conductive surface element and disposed at an angle thereto in a plane intersecting the axis of said dipole radiator, means to mount said structural element on said supporting tower structure, and means to connect a radio frequency transmission line to said dipole element.

3. An antenna system including a supporting tower structure, conductive surface elements arranged about the periphery of said tower structure to enclose the same, said conductive surface elements being substantially one-half wavelength in width and five-eighths of a wavelength in height at the desired operating frequency, at least one dipole radiator element arranged in parallel relationship to one of said conductive surface elements, further conductive surface members arranged at intersecting edges of adjacent conductive surface elements and bisecting the external angle between said adjacent conductive surface elements, said further conductive surface members having a width of substantially one-sixth wavelength at said frequency and located in a plane intersecting the axis of said dipole radiator element, and means to connect a radio frequency transmission line to said dipole element.

4. In an antenna system including a supporting tower structure, a structural element comprising a conductive surface element, said conductive surface element being substantially one-half wavelength in width and five-eighths of a wavelength in height at the desired operating frequency, a dipole radiator element mounted on and centrally located between three-tenths and a quarter wavelength at said frequency in front of said conductive surface element, a further conductive surface member arranged along one edge of said conductive surface element and disposed at an angle thereto, said further conductive surface member having a width of substantially one-sixth wavelength at said frequency and located in a plane intersecting the axis of said dipole radiator, means to mount said structural element on said supporting tower structure, and means to connect a radio frequency transmission line to said dipole element.

5. An antenna system including a supporting tower structure, conductive surface elements having width and height substantially a half wavelength and five-eighths of a wavelength, respectively, at the desired operating frequency, said conductive surface elements being mounted about the circumference of said tower structure to enclose the same in at least two layers, said layers being spaced center-to-center a distance lying between substantially nine-tenths and one wavelength at said frequency, at least one of the conductive surface elements of each layer having a dipole element arranged thereon at a distance lying between three tenths and a quarter wavelength at said frequency in front of said element and in a plane normal to the axis of said tower, further conductive surface elements having width and height substantially one-sixth and five-eighths of a wavelength at said frequency, said further conductive surface elements being substantially parallel to the axis of said tower and projecting outwardly from the corners of said tower structure to bisect the angle between adjacent conductive surface elements, and means to couple radio frequency transmission lines to said dipole elements.

6. An antenna system including a supporting tower structure, a plurality of conductive surface elements having width and height substantially a half wavelength and five-eighths wavelength at the desired operating frequency, respectively, said conductive surface elements being mounted about the circumference of said tower structure to enclose the same in a number of layers, said layers being spaced center-to-center a distance lying between substantially nine-tenths and one wavelength at said frequency, at least one of the con-

ductive surface elements of each layer having a dipole element arranged thereon substantially a quarter wavelength at said frequency in front of said element, and means to couple radio frequency transmission lines to said dipole elements, further conductive surface elements having width and height of substantially one-sixth and five-eighths of a wavelength at said frequency, respectively, said further conductive surface elements being arranged in pairs on either side of the conductive surface elements having dipole elements arranged thereon and in a plane intersecting the axis of said dipole elements.

7. An antenna system including a supporting tower structure arranged to radiate radio frequency energy at a predetermined operating frequency, a radiator system comprising a number of dipole radiator elements arranged on said tower structure in a plane normal to the longitudinal axis thereof to radiate radio frequency energy at a different frequency, and means interposed between said tower structure and said radiator system to prevent intercoupling of radio frequency energy between the tower structure and the radiator system, said means comprising conductive surface elements substantially a half wavelength wide by five-eighth wavelength high at said different frequency, said conductive surface elements being arranged about the periphery of said tower structure to enclose the same, means to prevent energy from said radiator system from passing around said tower immediately adjacent thereto, said last-mentioned means comprising further conductive surface elements projecting from said tower structure at the corners of adjacent conductive surface elements to bisect the angles formed thereby, means to couple a transmission line to said radiator system, and means to bond a conductor of said transmission line to said tower structure on the interior thereof.

8. A unitary antenna radiator and reflector assembly for assembly with additional such reflector assemblies on a conductive tower structure having apertures therein relatively large with respect to the operating wavelength to prevent loss of energy through coupling between the interior of said conductive tower structure and the radiator element of said assembly, including a substantially rectangular conductive surface element, a dipole radiator element mounted substantially a quarter of the operating wavelength in front of said cnductive surface element and substantially parallel to one edge thereof, means to couple a radio frequency transmission line to said dipole radiator element, and a further conductive surface element electrically connected to the first said conductive surface element along an edge thereof normal to said one edge and arranged at an angle to the first said conductive surface element substantially greater than ninety degrees and substantially less than one hundred eighty degrees, and means to mount said assembly on said conductive tower structure.

9. A unitary antenna radiator and reflector assembly for assembly with additional such reflector assemblies on a conductive tower structure having apertures therein relatively large with respect to the operating wavelength to prevent loss of energy through coupling between the interior of said conductive tower structure and the radiator element of said assembly, including a substantially rectangular conductive surface element substantially five-eighths of the operating wavelength in one direction and substantially half of the operating wavelength in the other direction, a dipole radiator element mounted substantially a quarter of the operating wavelength in front of said conductive surface element and substantially parallel to said other direction, means to couple a radio frequency transmission line to said dipole radiator element, and a further substantially rectangular conductive surface element substantially five-eighths of the operating wavelength in one direction and substantially one-sixth of the operating wavelength in the direction normal to said one direction, said further conductive surface element being electrically connected to the first said conductive surface element along an edge in said one direction and arranged at an angle to the first said conductive surface element substantially greater than ninety degrees and substantially less than one hundred eighty degrees, and means to mount said assembly on said conductive tower structure.

10. A unitary antenna radiator and reflector assembly for assembly with additional such reflector assemblies on a conductive tower structure having apertures therein relatively large with respect to the operating wavelength to prevent loss of energy through coupling between the interior of said conductive tower structure and the radiator element of said assembly, including a conductive surface element comprising a plurality of elongated conductors substantially one-half of the operating wavelength long and arranged in parallel relationship in substantially a single plane, a dipole radiator element mounted substantially a quarter of the operating wavelength in front of said conductive surface element and substantially parallel to said elongated conductors, means to couple a radio frequency transmission line to said dipole radiator element, and a further conductive surface element comprising a plurality of elongated conductors substantially one-sixth of the operating wavelength long and electrically connected to the first said elongated conductors at given ends thereof, said further conductive surface element being arranged at an angle to the first said conductive surface element substantially greater than ninety degrees and substantially less than one hundred eighty degrees, and means to mount said assembly on said conductive tower structure.

11. An antenna system including a plurality of conductive surface elements arranged to form a hollow multi-sided structure, a dipole radiator element arranged on each of said conductive surface elements substantially a quarter of the operating wavelength in front thereof and in a plane substantially normal to the axis of said multi-sided structure, means to connect a radio frequency transmission line to each dipole radiator element, and further conductive surface elements connected to the first said conductive surface elements along the lines of intersection and bisecting the exterior angle between the first said conductive surface elements.

12. An antenna system including a plurality of conductive surface elements arranged to form a hollow multi-sided structure, each of said conductive surface elements being substantially five-eighths of the operating wavelength in the direction of the axis of said multi-sided structure and substantially one-half of said operating wavelength in the other direction, a dipole radiator element arranged on each of said conductive surface elements substantially a quarter of said operating wavelength in front thereof and in a plane substantially normal to the axis of said multi-sided structure, means to connect a

radio frequency transmission line to each dipole radiator element, and further conductive surface elements substantially one-sixth of said operating wavelength in one direction and substantially five-eighths of said operating wavelength in the direction of the axis of said multisided structure connected to the first said conductive surface elements along the lines of intersection and bisecting the exterior angle between the first said conductive surface elements.

13. An antenna system including a plurality of conductive surface elements arranged to form a hollow structure having a cross section of plane geometrical configuration, each of said conductive surface elements being substantially five-eighths of the operating wavelength in the direction of the axis of said structure and substantially one-half of said operating wavelength in the other direction, at least one dipole radiator element arranged in a plane substantially normal to the axis of said structure substantially a quarter of said operating wavelength in front of and substantially parallel to one of said conductive surface elements, means to connect a radio frequency transmission line to said dipole radiator element, and further conductive surface elements connected on either side of said dipole radiator element to the first said conductive surface elements along the lines of intersection thereof and bisecting the exterior angle between adjacent ones of the first said conductive surface elements.

14. An antenna system including a plurality of conductive surface elements arranged to form a hollow structure having a cross section of plane geometrical configuration, each of said conductive surface elements being substantially five-eighths of the operating wavelength in the direction of the axis of said structure and substantially one-half of said operating wavelength in the other direction, at least one dipole radiator element arranged in a plane substantially normal to the axis of said structure substantially a quarter of said operating wavelength in front of and substantially parallel to one of said conductive surface elements, means to connect a radio frequency transmission line to said dipole radiator element, and further conductive surface elements connected on either side of said dipole radiator element to the first said conductive surface elements along the lines of intersection thereof and bisecting the exterior angle between adjacent ones of the first said conductive surface elements, said conductive surface elements being constituted by a plurality of elongated conductors defining planes substantially normal to the axis of said structure and spaced apart by distances small with respect to the operating wavelength.

15. In an antenna system including a substantially planar conductive screen, the combination with said conductive screen of a dipole antenna element including elongated conductors arranged in pyramidal configuration with the bases thereof in back-to-back relationship, an elongated conductor of said antenna element being substantially parallel to said conductive screen, four further conductors arranged in two pairs of parallel conductors, one conductor of each pair being connected at one end to the base of one

of said pyramidal antenna elements, the other conductor of each pair being connected at the same end to the base of the other of said pyramidal antenna elements, each of said further conductors being connected at their other ends to said conductive screen, said further conductors supporting said pyramidal antenna elements and spacing said antenna elements from said conductive screen, each of said pairs of conductors having an adjustable shorting bar thereon, at least one of said further conductors being hollow, and means to couple a coaxial transmission line through said hollow further conductor to the adjacent ends of said pyramidal elements, the sheath conductor of said coaxial transmission line being coupled to the pyramidal element connected to the hollow further conductor, and means to couple the inner conductor of said coaxial transmission line to the other of said pyramidal elements.

16. In an antenna system including a substantially planar conductive screen, the combination with said conductive screen of a dipole antenna element including elongated conductors arranged in pyramidal configuration with the bases thereof in back-to-back relationship, an elongated conductor of said antenna element being substantially parallel to said conductive screen, four further conductors arranged in two pairs of parallel conductors, one conductor of each pair being connected at one end to the base of one of said pyramidal antenna elements, the other conductor of each pair being connected at the same end to the base of the other of said pyramidal antenna elements, each of said further conductors being connected at their other ends to said conductive screen, said further conductors supporting said pyramidal antenna elements and spacing said antenna elements from said conductive screen, at least one of said further conductors being hollow, and means to couple a coaxial transmission line through said hollow further conductor to the adjacent ends of said pyramidal elements, the sheath conductor of said coaxial transmission line being coupled to the pyramidal element connected to the hollow further conductor, and means to couple the inner conductor of said coaxial transmission line to the other of said pyramidal elements.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,093,886	Hahnemann	Sept. 21, 1937
2,270,314	Kraus	Jan. 20, 1942
2,272,312	Tunick	Feb. 10, 1942
2,313,513	Brown	Mar. 9, 1943
2,471,515	Brown et al.	May 31, 1949
2,477,647	Pickles et al.	Aug. 2, 1949
2,521,550	Smith	Sept. 5, 1950
2,577,469	Kumpf	Dec. 4, 1951
2,580,462	Ranger	Jan. 1, 1952

OTHER REFERENCES

Publication by RCA Engineering Products Department, Camden, N. J., "High Gain and Directional Antennas" (for Television Broadcasting, Fig. 19 (page 1), by Lester J. Wolf), received in Patent Office, September 15, 1949.