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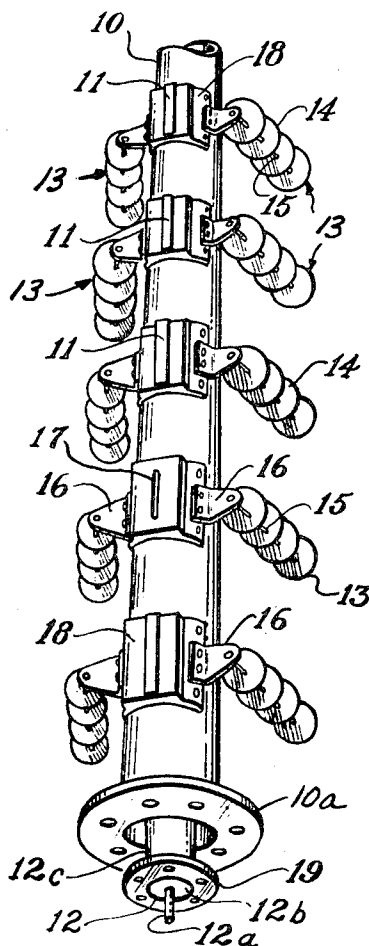
[54] **TRANSMITTING ANTENNA EMPLOYING END-FIRE ELEMENTS**
31 Claims, 20 Drawing Figs.
[52] U.S. Cl. **343/770,**
343/785, 343/833, 343/891, 343/912, 343/914
[51] Int. Cl. **H01q 13/10,**
H01q 1/12, H01q 15/14
[50] Field of Search **343/767,**
785, 833, 890, 891, 770

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ABSTRACT: A transmitting antenna assembly wherein an elementary driven antenna and parasitic end-fire directors may be supported by a tower or the like, and by positioning the end-fire directors in various orientations relative to the driven antenna and tower, various selected radiation patterns may be obtained, ranging from an omnidirectional type to a single lobe directional type. Driven antennas of different polarizations may be employed.



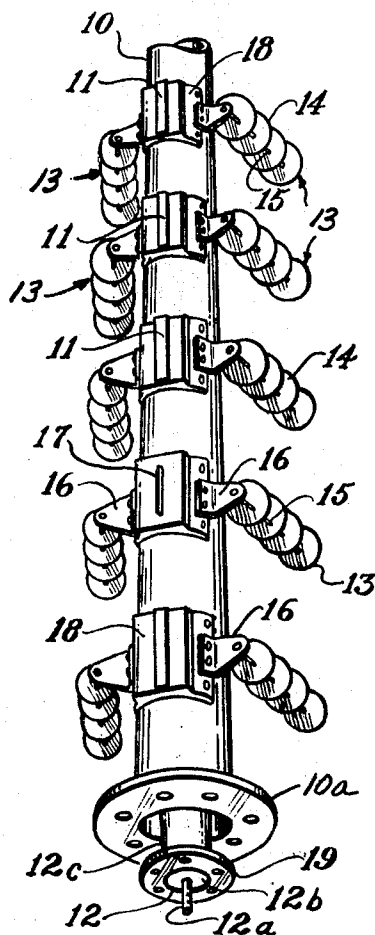


FIG. 1

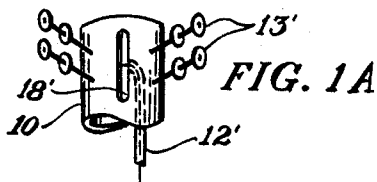


FIG. 1A

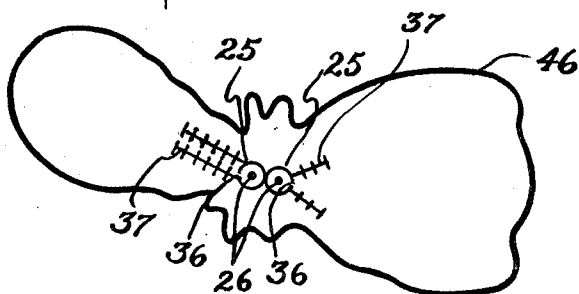


FIG. 3

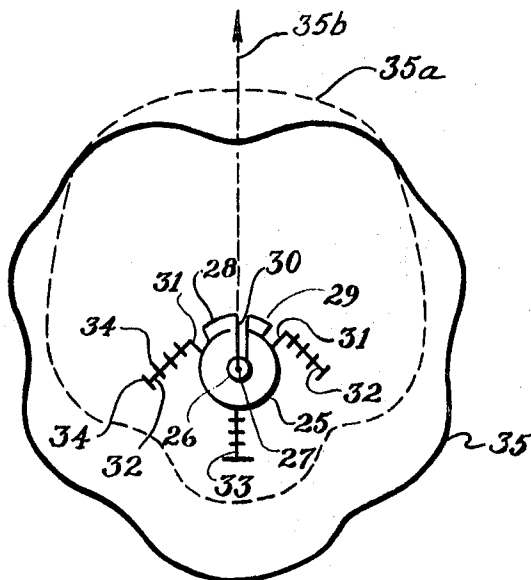


FIG. 2

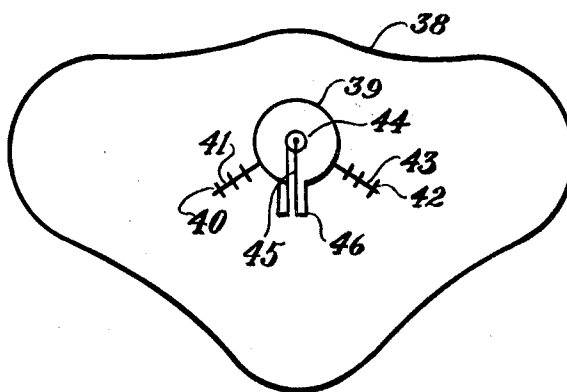


FIG. 4

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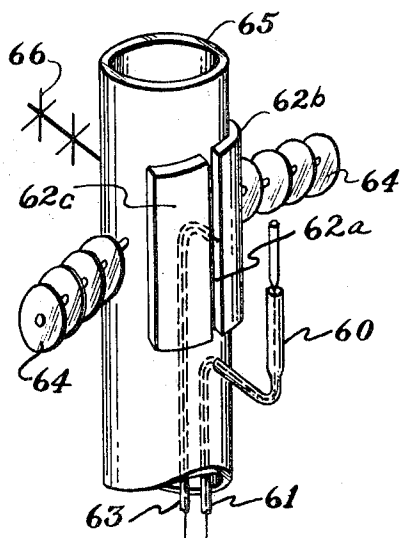


FIG. 5

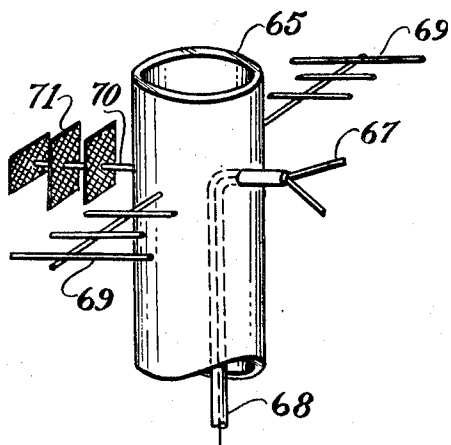


FIG. 6

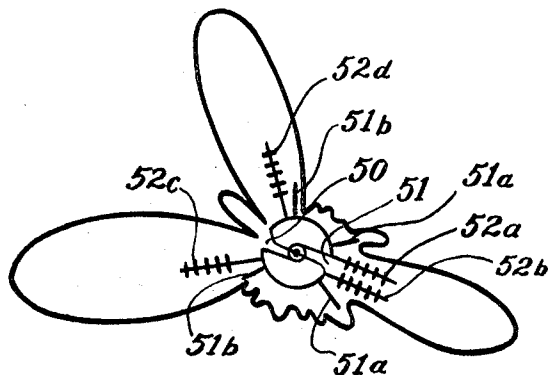


FIG. 9

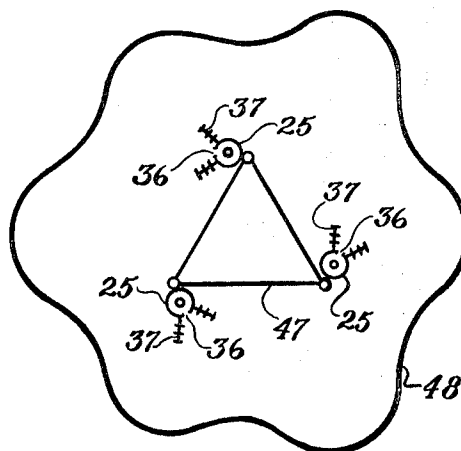


FIG. 7

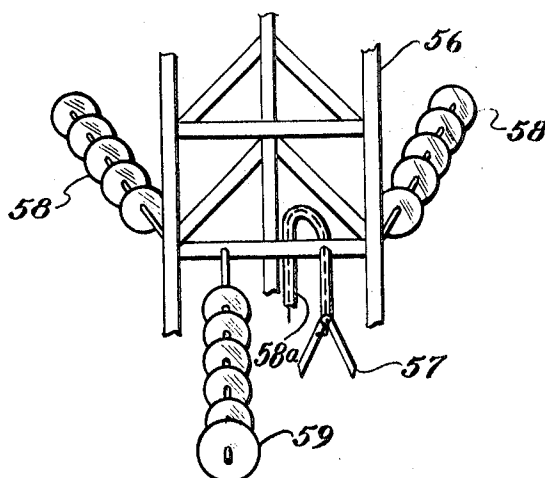


FIG. 8

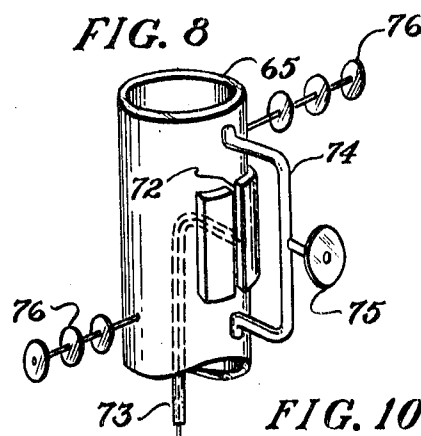


FIG. 10

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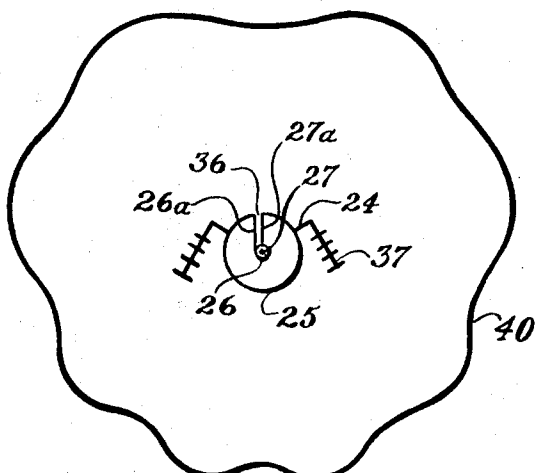


FIG. 11

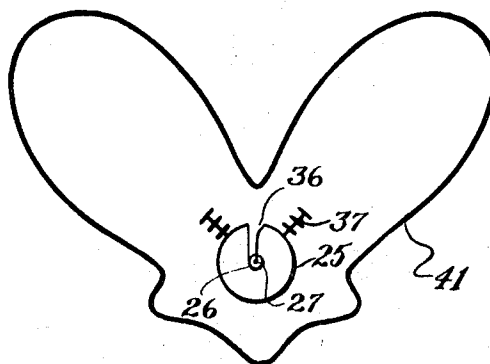


FIG. 12

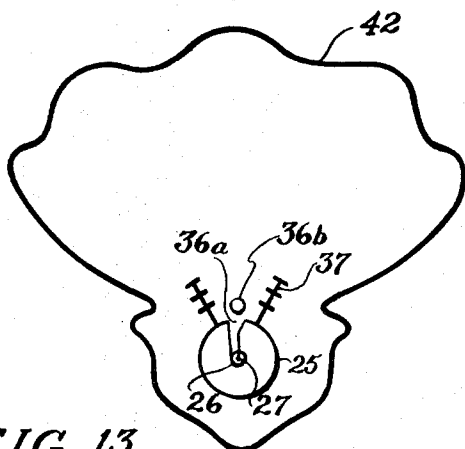


FIG. 13

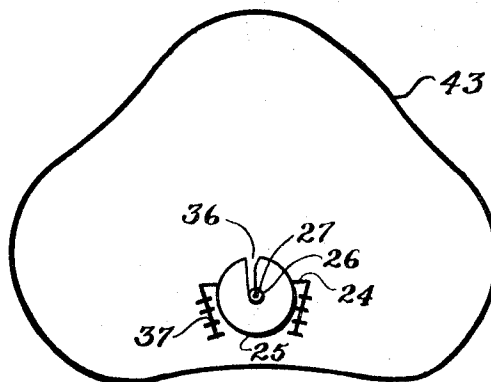


FIG. 14

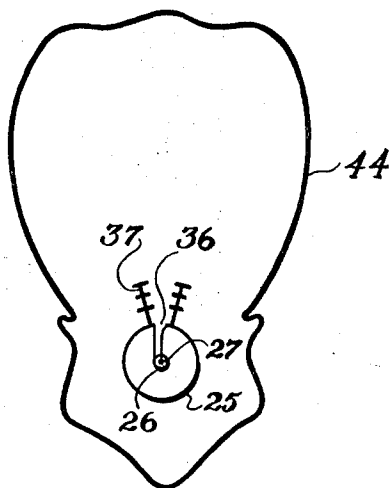


FIG. 15

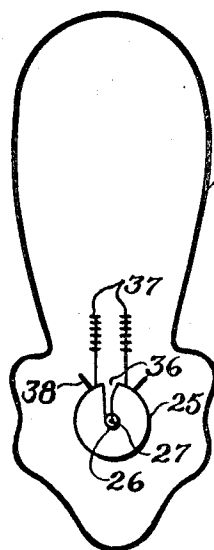


FIG. 16

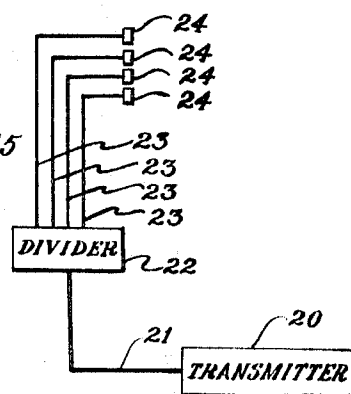


FIG. 17

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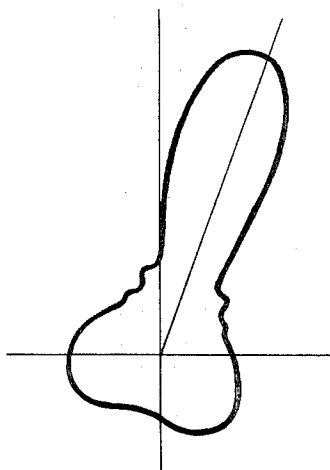


FIG. 18

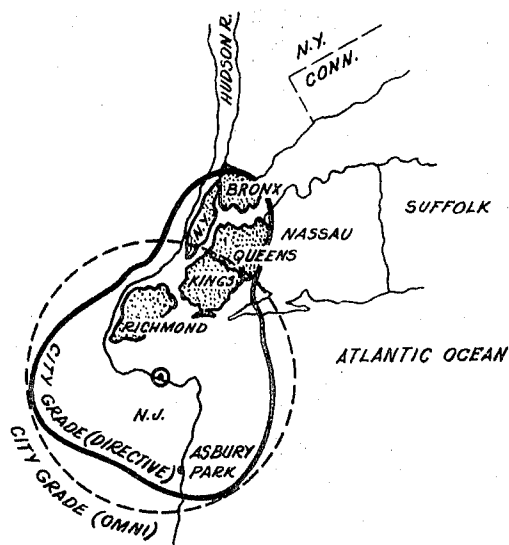


FIG. 19

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TRANSMITTING ANTENNA EMPLOYING END-FIRE ELEMENTS

This invention relates to transmitting antennas employing end-fire parasitic elements.

A problem encountered in UHF-TV broadcasting antenna design is the achievement of high gain with an omnidirectional pattern in the azimuth plane at minimum cost. (Omnidirectional patterns in the azimuth plane, and horizontal polarization, are most commonly employed at this time). Prior approaches have included, for example, the use of inherently nondirective horizontally polarized elementary antennas such as slots, loops or V's mounted or arranged on towers to form vertical linear arrays. These array component antenna elements are interconnected by transmission lines of series, parallel or combined types, such that each is fed a portion of the transmitter power. In order to achieve high overall gain, a vertical array of many such elementary antennas must be long, e.g., in the order of 20 feet to 50 feet or more for the frequencies used in UHF-TV broadcasting (470 mHz. to 890 mHz.). Therefore, the supporting pole or tower must be of substantial diameter in terms of wavelength in order to physically support the antenna and maintain stability in wind; in this case "substantially large" is intended to encompass those towers having a major towers having a major transverse dimension above $\lambda/4$ and in practice, often greater than λ . A simple single vertical linear array of loops or the like, supported by a tower of open-work structural members or of solid cylindrical form, such as a pipe, of this order of magnitude in size, will not provide an omnidirectional pattern, but will typically exhibit a substantially larger deviation than 3 db. from omnidirectional. (A total signal strength variation as a function of azimuth plane direction of up to around 3 db. is accepted in the trade to be omnidirectional). Therefore, it is a practice, particularly in UHF-TV broadcasting, to employ a considerably more elaborate and expensive installation than a single vertical linear array of simple antennas. Often such installations employ, e.g., dipole or zigzag panels on each of three or four sides of a tower, or alternatively, staggered arrays of many slots cut into heavy wall cylinders or long helices wrapped around such cylinders.

There will be disclosed hereinafter a very simple and inexpensive means of achieving an omnidirectional pattern, employing a single vertical linear array of elementary antennas such as slots, loops, or V's, even when these are mounted on a large cylinder (e.g., 10 inch diameter round pipe or 18 inch/side triangular framework tower at UHF-TV frequencies) which would normally cause pattern departure from omnidirectional by more than e.g., 8 db. due to shadowing by the tower. It has been found that by locating one or more suitable end-fire directors, such as the discrete metallic member or plate-on-rod types, on portions of the outside of the pole or tower, and in or near the plane of each elementary antenna, but not mounted in the conventional manner, i.e., not on the axis of the antenna beam, the plate-on-rod directors act as parasitic elements, but in a different way. The pattern can by this means be varied and for example be made omnidirectional, if these parasitic elements are so adjusted as to fill in the tower shadow.

It is well known that a feature of disc-rod antennas such as are disclosed, for example, in U.S. Pat. Nos. 2,955,287 and 3,015,821, is that if conventionally constructed and excited symmetrically about the "launcher" antenna, they form narrow beam patterns with high gain directed in one direction along the director axis. Accordingly, a rather surprising aspect of the present invention is that these highly directional elements can provide an omnidirectional pattern.

Of considerable additional value is the further finding that specially shaped directional azimuth plane radiation patterns (i.e., patterns not omnidirectional, but departing slightly, or even considerably from omnidirectional) can very easily be obtained by the same general means. This may be used, for ex-

ample, to provide optimization of coverage for a particular terrain or site without necessarily violating F.C.C. null depth rules. These results are obtained by varying the number, design, or pointing, or combinations, of the parasitic end-fire directors used in conjunction with each elementary antenna on a pole or tower. In the same manner in which the energy can be directed around the tower to fill nulls behind it to form omnidirectional patterns, the energy can be so directed to provide lobes, or even deep nulls, in certain azimuth directions. Sometimes more than one elementary fed antenna may be used at one level or bay on a pole or tower (each radiator level being called a "bay" in the industry), with the relative phase and amplitude adjusted, along with parasitic element adjustment, to achieve the desired or required patterns.

Since TV broadcasting in the United States at present employs horizontal polarization, the antennas so far primarily considered herein have had this polarization, with the elementary antennas described being inherently nondirective in their E planes, which is made the azimuth plane. It has been found in addition, however, that if elementary antennas inherently nondirective in their H planes are used, and they are arranged to provide polarization parallel to the pole or tower (i.e., vertical polarization), similar pattern control through the use of parasitic directors can be obtained in this polarization. Such elementary antennas include the dipole. Further, horizontally and vertically polarized elementary antennas may be used simultaneously with proper relative interconnection to achieve other composite polarizations including circular, both polarizations using common parasitic end-fire directors for pattern control. It is anticipated that TV broadcasters in the United States may, as has been the case for FM radio, be authorized by the F.C.C. to radiate vertical polarization. While antennas of the prior art generally cannot do this, the antennas described herein can be designed to do it initially, or as a simple future addition.

This combination of end-fire directors and elementary antennas provides a broad bandwidth and low Q which renders the antenna insensitive to environmental changes caused by dirt, ice, snow, etc.

It is a general object of this invention to provide an improved transmitting antenna exhibiting a high azimuth plane gain.

A further object is to provide a low cost, fully omnidirectional antenna eliminating, in a simple manner, nulls caused by the "tower shadow."

Another object is to provide a low cost, high gain antenna which can easily give a shaped azimuth radiation pattern.

Still another object is to provide a simple antenna which exhibits high gain and directivity over a large frequency band.

A further object is to provide a high gain antenna which can transmit any polarization.

Another object is to provide a low cost antenna which exhibits high gain and directivity for any polarization, including simultaneous vertical and horizontal, and circular.

Still a further object is to provide an antenna with a simple means of adjusting relative lobe and null angles to achieve a desired radiation pattern.

These and other objects, features and advantages of the invention will, in part, be pointed out with particularity and will, in part, become obvious from the following more detailed description of the invention taken in conjunction with the accompanying drawings which form an integral part thereof.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing a typical section of an antenna in accordance with an embodiment of the invention;

FIG. 1A is a perspective view showing a single bay of an antenna array in accordance with a second embodiment of the invention;

FIG. 2 is a plan view of a slot-fed array, in accordance with a third embodiment of the invention shown schematically at the center of plots of corresponding radiation patterns, with and without directors, the latter being shown in broken line;

FIG. 3 is a schematic plan view showing the radiation pattern obtained by combining two antennas in accordance with a fourth embodiment of the invention;

FIG. 4 is a horizontal plane pattern for a modified slot-type launcher antenna, in accordance with a fifth embodiment of the invention, shown schematically at the center of the pattern;

FIG. 5 is a perspective view showing a bipolarized antenna, in accordance with a sixth embodiment of the invention, employing a dipole launcher for vertical polarization and a slot for horizontal polarization, wherein a pair of thin crossed arms serve as the plates for one of the end-fire directors;

FIG. 6 is a perspective view showing a V launcher, a mesh plate director and a pair of rod end-fire element directors at the sides, in accordance with a seventh embodiment of the invention;

FIG. 7 is a schematic plan view showing three slot-fed antennas in accordance with an eighth embodiment of the invention, side-mounted on a large tower, and the corresponding pattern therefor;

FIG. 8 is a perspective view of a V-launcher and disc-rod director assembly on an open triangular tower in accordance with a ninth embodiment of the invention;

FIG. 9 is a schematic plan view of a pair of slot-launchers and a plurality of disc-rod elements superimposed on a pattern, using additional plates around the slots to aid in pattern control, and having deep pattern nulls in certain directions in accordance with a tenth embodiment;

FIG. 10 is a perspective view showing a single disc director supported on a cross polarized metal support in front of a slot-launcher plus a second director, in accordance with an eleventh embodiment;

FIGS. 11-16 are schematic plan views of typical horizontal plane patterns which are produced by array configurations in accordance with various embodiments of the invention;

FIG. 17 is a schematic diagram of a typical transmission line feeding an array of radiating elements;

FIG. 18 shows the horizontal azimuth radiation pattern designed for a particular station; and

FIG. 19 shows a comparison of omnidirectional and directional city grade UHF-TV coverage of a particular station, predicted according to F.C.C. rules.

DESCRIPTION OF PREFERRED EMBODIMENTS

The antenna assembly generally comprises a support member, an elementary driven antenna coupled to feed lines or the like from a transmitter, and an end-fire parasitic element so positioned as not to intersect the axis of the beam radiated by the driven antenna. The beam radiated by the driven antenna is generally approximately symmetrical about its axis from the driven antenna and the axis of the beam projects in the direction away from the radiating side of the driven antenna which is usually the direction of maximum radiation and may be called the radiation axis.

The basic concept of the invention can best be described with reference to FIG. 1. A section of a typical antenna assembly in conformance with the instant invention is shown. A tubular member 10 provides support for the antenna. Typically, the tube may be standard pipe of hot-dip galvanized structural steel to retard corrosion and provide strength at low cost. Cut into, or mounted on, the tube is an array of slots 17 (one of which is shown open), backed by cavities 18. Cavities 18 are elementary devices commonly used in radiation antennas to form and impedance-match slots and may be sheet metal structures. A dielectric cover 11 of, for example, glass fiber cloth impregnated with synthetic resin, may be placed over the slot as a radome.

Each slot is fed a portion of the transmitter power through a transmission line network which can be located within the tubular member 10. This network is described more fully hereinafter in connection with FIG. 17.

Connected to the tubular member on either side of each slot are flanges 16 which support end-fire elements 13. The end-

fire elements include support rods 15 attached to the flanges and extending outward from the tubular members on opposite sides of the slot. Mounted on each rod are planar conductive members, illustrated as conductive discs 14, spaced axially along the rods and disposed normal or transverse thereto.

At one end of tubular member 10 is a flange 10a which can connect to another such flange to interconnect two adjacent sections and extend the length of an antenna section, or can connect to a tower. Coaxial cable 12, comprising inner conductor 12a, insulator 12b and outer conductor 12c, would similarly have a flange 19 which would conductively interconnect sections of transmission lines.

The individual disc-rods 13 are typical end-fire directors which act as parasitic elements. There is no connection except a structural one between the elementary slot antennas which receive transmitter power, and the end-fire directors. The flanges 16 could be connected directly into the tubular member and not necessarily onto the ends of the cavity mounting plates. In fact, it is not necessary for the directors to be located directly adjacent to the center of the elementary antennas in each bay. The axis of the directors should preferably lie in a plane which is about normal to the axis of the tubular member and which plane intersects the tubular member within $\lambda/2$, measured along the axis of the tubular member, of the plane of the center of the elementary driven antenna. More than one level of directors may be associated with each elementary antenna. This arrangement is shown in FIG. 1a with a pair of end-fire elements 13' positioned vertically above each other and within $\lambda/2$ of the plane passing through the center of the elementary driven antenna. The elements may be offset from each other in the azimuth plane. In this embodiment, the slot 18' is cut in the wall of the supporting cylinder 10 and fed by transmission line 12'.

As will be described hereinafter, by directing the angle, location, and design of the directors, the horizontal azimuth plane of radiation can be controlled.

FIG. 17 shows how each elementary antenna in accordance with the invention may be fed transmitter power. A transmitter 20 sends out the signal to be radiated through transmission line 21. At a convenient location, often within the antenna support member, a transmission line divider system 22 divides the power into separate sections, each on a separate line 23, which feeds the elementary antennas 24. The divider uses a system of series, parallel or combined types, to provide each antenna with a portion of the transmitter power of proper relative phase and amplitude.

Suitable plate-on-rod plates have a major dimension between $\lambda/4$ and $\lambda/2$ and preferably about $\lambda/3$. The plate major dimension is that dimension in the plane of the electric field or E vector being the horizontal disc diameter in the embodiment of FIG. 1. A suitable interplate spacing range is between $\lambda/8$ and $\lambda/2$. While these spacing dimensions are preferred, it has been found that for the purposes of this invention, even closer spacing is permissible. A single rod, plate or group of rods or plates may be used as discrete metallic members, as will be explained hereinafter, for certain applications.

It has further been found that for this invention it is often desirable to make the major dimension of the discrete metallic members nonuniform, with members farther from the tower larger than members close to the tower on any one support rod. Specifically, the last or farthest such member may be made larger than the other members. Metal support members for the plates, if used, may be connected directly to the tower. The elementary antennas are preferably spaced greater than 0.9λ and less than one wavelength along the tower, and are interconnected by a transmission line system such that each is fed a portion of the transmitter power of proper relative phase and amplitude.

In the antenna, as shown in FIG. 1, it is contemplated that the entire tower be built in sections connected by flanges. In such design the power divider system could, for example, be placed at the top of the tower, below the antenna, with the separate lines feeding all antennas above it. The divider could

also be placed in between sections with the separate lines feeding antennas above and below the divider.

Referring to FIG. 2, a slot is used as the elementary antenna and three directors are used to shape the radiation pattern. Tubular member 25 contains a coaxial transmission line 12 with outer conductor 26 and inner conductor 27. Mounted on the tubular member are the two cavities 28 and 29, which form the slot. The slot is excited from the coaxial cable by means of center conductor extension 30. On the tube are connected flanges 31 which support rods 32 extending outward from the tube. A third rod 33 is connected directly to the tube on the opposite side to the slot and extends radially outward from the tube. On each rod 32, 33, are placed conductive members 34 spaced axially to and along the rods. These members form directors which shape the horizontal pattern of radiation. As can be seen from the figure, the directors are in no way connected to the transmission lines or to the elementary slot antenna, and are actually shielded from the slot. The two directors are in this case approximately 120° from the slot axis, and the third radial antenna is positioned 180° from the slot axis. The resulting pattern 35 is omnidirectional within the accepted definition, whereas without the directors it would be like dashed pattern 35b, departing considerably from omnidirectional and strongest, or with the principal radiation or lobe, in front of the elementary driven antenna; "in front of" being defined as on the symmetry axis 35a in the direction away from the open radiator, in this case the direction 35a. As can be seen from the patterns 35 and 35a of FIG. 2, the presence of the parasitic plate-on-rod end-fire directors results in the general increase or reinforcement of the antenna radiation intensity or power in the axis direction of each director.

In each illustrated antenna assembly in accordance with this invention a driven antenna element is used as a launcher. Although a slot antenna has been hereinbefore described, it is understood that any driven-type could be used, including, but not limited to, a dipole, V, loop, or short helix. Similarly, in describing the end-fire director elements, a disc-rod type has been described. However, any plate or mesh (or even rod members) can be placed transversely on the support rod or, for example within a nonconductive tube, to construct the director. The term "plate" is thus used herein in an electrical or electromagnetic-wave sense and includes mechanical structures that affect the wave in the general manner of a plate, but which may actually have the mechanical or physical form of a mesh or screen, wires or rods, or other conductive elements whose overall effect is to form a generally planar configuration transverse to the axis of the director. Examples of some of these forms will be described in greater detail hereinafter. The plate dimensions should preferably be between $\lambda/4$ and $\lambda/2$ in the plane of each major E vector and the plate spacing axially less than $\lambda/2$. (For a slot launcher, for example, the plane of the major E vector is the horizontal plane. For a dipole, it would be the vertical plane. For both used together, both planes.)

FIG. 11 shows a plan view of the general type of antenna shown in FIG. 1, together with the horizontal radiation pattern produced by this system, plotted in all cases from the center of the tower in the plan view. The tubular conductive support or mast 25 contains the coaxial transmission line 26, 27 and the branch to the slot bay, shown as 26a, 27a. The driven antenna element 36 can be a simple slot, as shown, or a loop, etc. Directors 37 are attached to the tube by means of flanges 24 and extend outward from the tube at about 120° on either side of the element 36. The resulting pattern 40 is omnidirectional within ± 1.5 db. over the entire 360° azimuth. Although the elementary slot antenna element alone is omnidirectional without using the directors, the resulting radiation pattern of the slot on the tower would have a null resulting from the "shadow effect" of the tower. The directors, shaped and angled as in FIG. 11, fill in the null areas around the tower and provide a full omnidirectional radiation pattern, as shown.

By changing the position, angle and design of the directors, it is possible to direct the radiation pattern to cover only certain areas with lobes while having large nulls of various depth, as desired, in other areas or angular sectors.

FIG. 12 shows the two directors 37 in radial position outward, each at about 45° from the elementary antenna element 36. The resulting radiation pattern 41 contains 2 large lobes, each centered near the radial axis of the directors. At the joining point of the two lobes, which occurs directly in front of the antenna element, there is a deep null.

FIG. 13 shows two disc-on-rod directors located radially outward at 30° on either side of an elementary slot antenna element 36a and an elementary dipole antenna element 36b. The resulting pattern 42 is a sector of the entire circumferential area covering a span of 120° . The pattern is essentially the same for both polarizations.

FIG. 14 shows the two directors connected to the tube 25 by means of flanges 24 which extend outward. The directors are held by the flanges and extend backward. The resulting pattern 43 is almost semicircular.

FIG. 15 shows the two directors located radially outward at around 15° on either side of the elementary antenna. The resulting pattern 44 is a single lobe centered about the radiation axis of the elementary antenna with a beamwidth of about 90° .

FIG. 16 shows the two directors 37 generally parallel to each other and to the radiation axis of the elementary antenna 36. A pair of radiators 38 are also provided, each on opposite sides of the elementary antenna, the overall arrangement producing pattern 45 as shown.

In FIGS. 11—16, each of the directional patterns has been designed to have no level more than 15 db. below the peak, as required by present F.C.C. regulations.

Additional directional patterns besides those hereinbefore described can also be formed by combining two or more of the antennas. These combinations may be top or side mounted on towers, buildings, or the like.

FIG. 3 shows two antennas combined to form a single radiation pattern. In this example, the antennas shown in FIG. 15 and FIG. 16 are combined at 160° , using a power splitter at the inputs. The resulting pattern 46 is then to a first order the direct composite obtained by simple pattern addition at the chosen relative amplitudes.

In a similar manner, countless other combinations can be created simply, from the radiation patterns of FIGS. 11—16, or from other radiation patterns easily obtained.

Directional or omnidirectional patterns can be formed by mounting the antennas of FIGS. 11—16 on large towers and buildings. Referring to FIG. 7, three identical antennas of the general type shown in FIG. 13, each covering 120° , are mounted as panels and fed with equal phase and amplitude signals on the corners of a large triangular tower 47. The resulting pattern 48 is omnidirectional.

The antenna of FIG. 4 results in essentially the same radiation pattern as in FIG. 14, but uses a narrow slot extending further from the supporting pole, and a somewhat different disc-rod arrangement.

FIG. 9 is another example of how various antennas and directors can be combined to meet specific pattern requirements. By using pattern tests and experimental adjustment, it is possible to develop various lobes and nulls as may be needed in various locations. The particular pattern shown in FIG. 9 was obtained by using two slot launchers 50 and 51, as the elementary antenna elements in one bay. A plurality of long disc-rod elements 52a, 52b, 52c, and 52d, were used to direct the pattern lobes. In addition, radiator pairs 51a and 51b were used to aid in the pattern control. The resulting pattern, a specific requirement in a TV broadcasting application, meets the requirements of two deep nulls, about 20° apart, with transmission required to a city only 10° off a null. The nulls had to be in the order of 50 db. below the peak level. By using the method of the instant invention, a low cost system could be used to provide the necessary gain, and yet be controlled to direct the radiation pattern as desired.

Another example is a station designed for Asbury Park, New Jersey, from which it was also desired to cover New York City. FIG. 18 shows the azimuth radiation pattern and FIG. 19 shows a map of predicted city grade (80 dbu) coverage (using F.C.C. rules to compute coverage) comparing a directional and an omnidirectional antenna. For both cases, all parameters were assumed to be the same, except azimuth directivity, to allow a meaningful comparison. The directive antenna provides the maximum F.C.C. allowable 5 megawatts ERP (effective radiated power) compared to 10 db. less, or 500 kw. for the omnidirectional, both using a 33-foot antenna length (20 bays at 1.65 feet spacing) and 25 kw. transmitted power, a 500 feet AAT (above average terrain) tower, 5 percent pattern null fill and 1° down tilt of the vertical beam. The coverage difference results entirely from the fact that the directive antenna has a power gain of 8½ in azimuth and 30 in elevation, or 8½×30250 (=24.0 db.), while the omnidirectional antenna has a gain of only 1×25 (=14.0 db.). This virtually "no cost" difference in this case more than doubles the listening market population (12 million compared to 5 million) in the city grade contour alone, without violating the F.C.C. 15 db. deepest null rule. For additional comparison, other presently used directional antennas would have difficulty achieving even a 2 megawatt ERP under this same set of conditions because they cannot attain azimuth gain values as high as 8½, and therefore require more than twice the power (over 50 kw.) or more than twice the antenna length (over 66 feet) to provide 5 megawatts ERP. (NOTE: "null fill" is in elevation plane pattern.)

The antenna used to achieve the above pattern was constructed as shown in FIG. 8. At each bay a V launcher 57 fed by line 58a was used on a stock 18 inch side triangular open tower 56. The normal "tower shadow" nulls opposite the V were filled in by the pair of disc-rods 58 at each bay. The pattern of each bay was then further shaped by an additional parasitic disc-rod 59 to achieve the pattern of FIG. 18. Such construction is inherently inexpensive since the basic load-carrying structure may in every case be a stock size and shape tower or pole, adapted to meet the required patterns by disc-rod adjustment only. The antenna here consisted of four sections each 8¼ feet long to form the 33 feet total antenna height. The VSWR was 1.08 maximum over the 6 mHz. television channel, power handling 2 'kw. per bay, or 32 kw. total for this 20-bay design. Much higher power can be handled simply by using larger transmission line, or dielectric filled line.

The particular antennas thus far described have been horizontally polarized. However, the ability of controlling directivity and providing high gain is the same for other polarizations as well. FIG. 5 shows typical directors used with a bipolarized antenna assembly. Dipole 60 is driven by connection to a transmission line 61. As with all dipoles, the radiation from a vertical dipole will be vertically polarized. Separately, a slot 62a is driven from transmission line 63. The slot will provide horizontal polarization. It is understood that the power to each antenna element is provided with desired phase and amplitude. The antennas are connected to tubular member 65. Extending from the tube are parasitic directors 64 used to shape the radiation pattern. Although a bipolarized signal is being transmitted, the concept of the present invention still applies since the members are symmetrical in the azimuth and elevation planes. In FIG. 5, in addition to disc-rod type directors, a pair of cross-arms are also used as end-fire director elements. These are also effective for both polarizations. It will be noted that the parasitic directors in themselves are not driven directly by the transmission lines, but are merely attached to the tubular member. Here, the slot 62 is formed by cavities 62b and 62c and driven by coaxial line 63 which excites the slot near the center across the cavities.

FIG. 6 shows a different variety of launchers and directors. V launcher 67 is driven by the transmission line 68. The V is shown oriented horizontally, but may be rotated 90° to be vertical. The V is connected to tubular member 65. Extending outward are a pair of "yagi," "rod" or "ladder" end-fire ele-

ments 69. These types of elements per se, are commonly used as directors and perform similarly to wider plate members but are narrow band, and the gain is not as great as from the disc-rod type of the same length. FIG. 6 also shows a rod 70 extending radially outward from the tube and having axially spaced mesh plates 71 rather than discs. The mesh plates also serve as parasitic directors.

FIG. 10 shows one director member being supported with a cross polarized bracket 74 to eliminate interference and yet allow mounting in front of a cavity backed slot 72, which is connected onto a tubular member 65 and is fed by transmission line 73. The polarization resulting from the slot is horizontal and the support bracket 74 does not interfere with this polarization. A single disc director 75 supported on the metal support 74 is used in this case as one director to shape the radiation pattern. Of course, more discs could be used if desired on this director. Parasitic elements 76 typify the use of other directors.

There has been disclosed heretofore the best embodiment of the invention presently contemplated and it is to be understood that various changes and modifications may be made by those skilled in the art without departing from the spirit of the invention.

What I claim as new and desire to secure by letters Patent is:

1. An antenna assembly for transmitting signals of a given wavelength, comprising an elongated electrically conductive supporting structure having a major transverse dimension greater than a quarter wavelength, at least one bay including a driven antenna carried by said supporting structure and defining a radiation axis extending therefrom, means for feeding electrical energy to said driven antenna, and at least one end-fire parasitic director having a longitudinal axis and comprising a plurality of discrete planar conductive plates disposed in spaced parallel relation along said longitudinal axis and being normal thereto, said discrete conductive plates having their respective major dimensions in the plane of the electric field vector of the transmitted signal at least a quarter wavelength, said end-fire parasitic director being so positioned relative to said driven antenna and supporting structure as to alter the shape of the antenna pattern produced by the combined effects of said driven antenna and supporting structure, while not intersecting the radiation axis of said driven antenna, to provide a selected pattern for said antenna assembly.

2. The antenna assembly of claim 1 wherein the respective major dimensions of said conductive plates are between one-fourth and one-half wavelength.

3. The antenna assembly of claim 2 wherein the major dimension of at least one of said conductive plates is one-third wavelength.

4. The antenna assembly of claim 1 wherein the distance between said spaced parallel conductive plates is less than about one-half wavelength.

5. The antenna assembly of claim 4 wherein said distance is between one-eighth and one-half wavelength.

6. The antenna assembly of claim 1 wherein said end-fire parasitic director extends generally away from said supporting structure and includes one of said conductive plates positioned farther from said supporting structure than another of said conductive plates, said one conductive plate having a larger major dimension than said another conductive plate.

7. The antenna assembly of claim 1 wherein said discrete planar conductive plates are in the form of a disc.

8. The antenna assembly of claim 1 wherein said discrete planar conductive plates are in the form of a screen.

9. The antenna assembly of claim 1 wherein said discrete planar conductive plates are in the form of rods.

10. The antenna assembly of claim 1 wherein said discrete planar conductive plates have a supporting rod extending along the longitudinal axis of said parasitic director.

11. The antenna assembly of claim 1 wherein the axis of said parasitic director lies in a plane which is approximately normal to the longitudinal axis of said supporting structure, said plane intersecting said supporting structure within a half

wavelength of the center of the driven antenna, measured along the longitudinal axis of said supporting structure.

12. The antenna assembly of claim 1 wherein said one bay includes another end-fire parasitic director like said one director, each of said directors being positioned on generally opposite sides of said driven antenna.

13. The antenna assembly of claim 12 wherein said bay includes a further pair of directors like said first pair, said further pair of directors being positioned in spaced relation to said first pair along the longitudinal axis of said supporting structure.

14. The antenna assembly of claim 12 wherein a further parasitic director generally extends from said supporting structure at a position approximately 180° from said driven antenna.

15. The antenna assembly of claim 1 further comprising a plurality of bays like said one bay disposed along said elongated supporting structure, the elementary antennas of each successive bay being spaced a distance between nine-tenths wavelength and one wavelength.

16. The antenna assembly of claim 15 wherein each of said bays includes a plurality of said end-fire parasitic directors like said one director.

17. The antenna assembly of claim 1 wherein the longitudinal axis of said supporting structure is vertical and wherein said driven antenna transmits a horizontally polarized wave, the axis of said end-fire director lying in an approximately horizontal plane and said discrete conductive plates having each said major dimension in said approximately horizontal plane.

18. The antenna assembly of claim 17 wherein the plane formed by each of said conductive plates is generally vertically disposed.

19. The antenna assembly of claim 18 wherein said planar conductive plates are circular discs, said major dimension of each being equal to the diameter of the disc.

20. The antenna assembly of claim 17 wherein said bay further includes another driven antenna which transmits a vertically polarized wave.

21. The antenna assembly of claim 17 wherein said supporting structure is generally tubular and has a solid wall, said driven antenna comprising a slot formed on the wall of said tubular structure.

22. The antenna assembly of claim 1 wherein the longitudinal axis of said supporting structure is vertical, said assembly comprising a plurality of bays like said one bay spaced approximately a wavelength apart vertically along said supporting structure, the driven antenna of each bay comprising a slot-type antenna element, and each bay including three end-fire directors like said one director, one of said directors being mounted on said supporting structure in alignment with the radiation axis of said driven antenna, but positioned on the opposite side of said supporting member, and a further pair of said directors each positioned on either side of said first director and between said first director and said driven antenna, said plurality of conductive plates of each director having a major dimension of from one-fourth to one-half wavelength.

23. An antenna assembly for signals of a given wavelength, comprising a supporting structure, a driven antenna carried by said supporting structure and defining a radiation axis extending therefrom, at least one end-fire parasitic director carried by said supporting structure and comprising a plurality of discrete planar conductive plates disposed in spaced parallel relation along an axis normal to said conductive plates, said planar conductive plates having their respective major dimensions one-fourth wavelength and one-half wavelength, the distance between said planar conductive plates being less than about one-half wavelength, the axis of said parasitic director lying in a plane parallel to and within one-half wavelength of a plane passing through the center of said driven antenna and containing the radiation axis thereof, and said end-fire parasitic director being so positioned relative to said driven antenna and supporting structure as to alter the shape of the antenna pattern produced by the combined effects of said driven antenna and supporting structure, while not intersecting the radiation axis of said driven antenna, to provide a selected antenna pattern for said antenna assembly.

24. The antenna assembly of claim 23 wherein said discrete planar conductive plates are in the form of a disc, said assembly comprising a rod extending along the axis of the parasitic director and supporting said discs in said spaced parallel relation.

25. The antenna assembly of claim 23 comprising a pair of said end-fire parasitic directors, each being positioned on generally opposite sides of said driven antenna.

26. The antenna assembly of claim 25 wherein each of said directors extends generally from said supporting structure at angles of about 120° to said driven antenna on each side thereof to provide an omnidirectional antenna pattern.

27. The antenna assembly of claim 25 wherein each of said directors extends generally from said supporting structure at angles of about 45° to said driven antenna on each side thereof to provide an antenna pattern containing two large lobes generally centered on the respective axis of each director and a deep null directly in front of said driven antenna.

28. The antenna assembly of claim 25 wherein each of said directors extends radially outward from said supporting structure at approximately 30° on each side of said driven antenna, and a further driven antenna is disposed on the radiation axis of said driven antenna to provide an antenna pattern covering a span of approximately 120° about said radiation axis.

29. The antenna assembly of claim 25 wherein each of said directors extends generally backwards and inwards from said supporting structure relative to said radiation axis to provide a generally semicircular antenna pattern.

30. The antenna assembly of claim 25 wherein each of said directors extends radially outward from said supporting structure at approximately 15° on each side of said driven antenna to provide an antenna pattern having a single large lobe centered about said radiation axis with a beamwidth of approximately 90°.

31. The antenna assembly of claim 25 comprising a further one of said end-fire directors extending generally parallel to said radiation axis.