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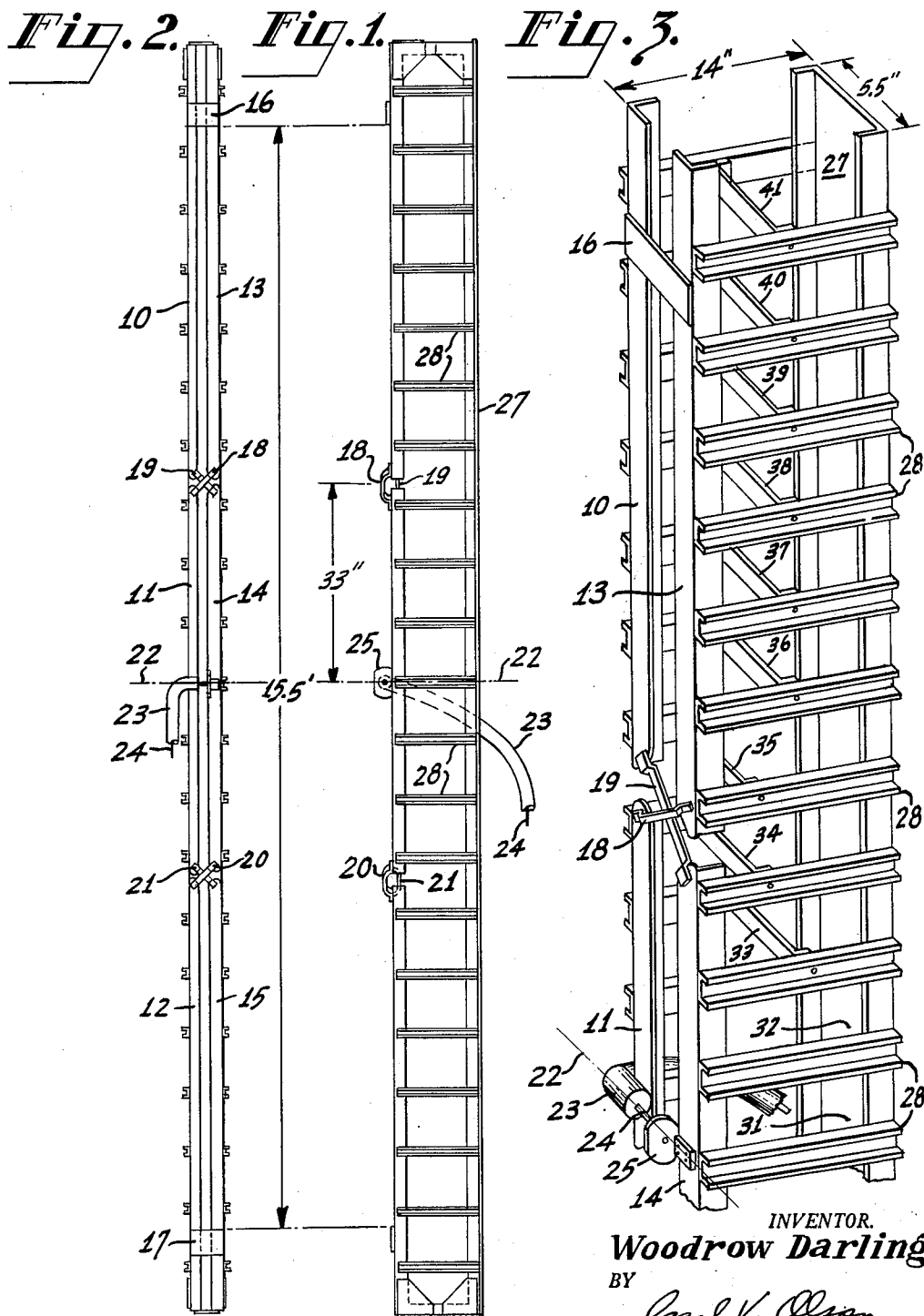
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2,807,019

OMNI-DIRECTIONAL LONG SLOT ANTENNA

Filed March 2, 1956

2 Sheets-Sheet 1



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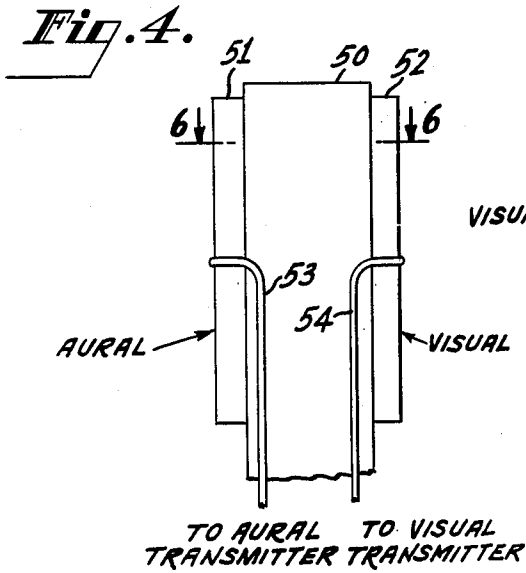
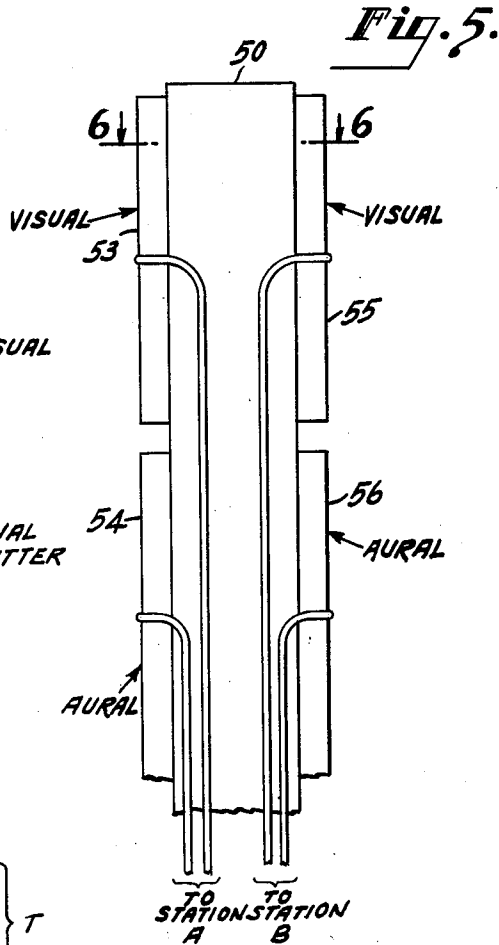
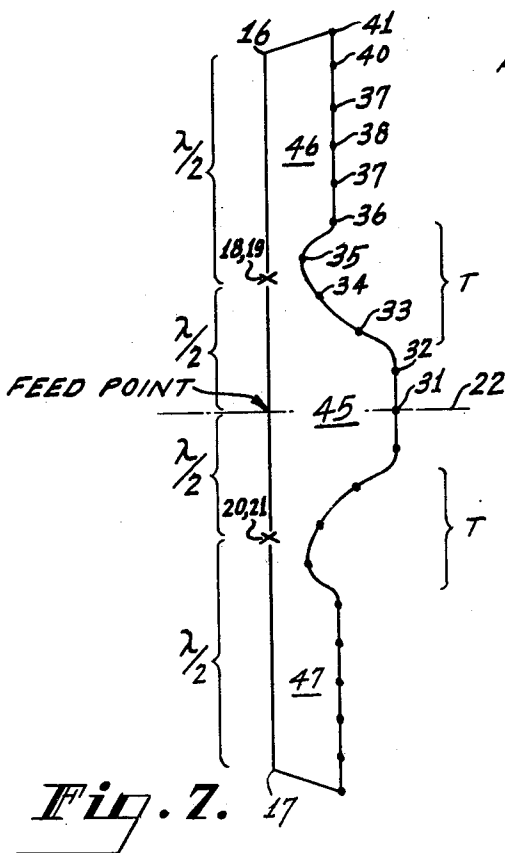
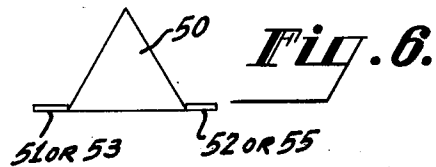
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OMNI-DIRECTIONAL LONG SLOT ANTENNA

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OMNI-DIRECTIONAL LONG SLOT ANTENNA

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10 Claims. (Cl. 343—770)

This invention relates to antennas of the type wherein the radiating elements are slots in a conductive surface, and particularly to vertically arranged broadcast type antennas having an omni-directional characteristic in the horizontal plane and a directive characteristic in vertical planes, to best serve home receivers located at various distances around the antenna. The invention is particularly useful as a television broadcasting antenna in the very high frequency range from 76 to 216 megacycles.

It is an object of this invention to provide an improved omni-directional slot antenna having a longer radiating slot associated with a single feedpoint than has heretofore been practical, with the result that important economies in the feed system are realized.

It is another object to provide an improved simple omni-directional antenna which may be mounted on one side of a supporting tower without appreciably affecting the omni-directional characteristics of the antenna.

It is a further object to provide an improved antenna system for radiating visual and aural television signals from separate antennas on a single tower so arranged as to eliminate the need for a diplexer to combine the outputs of the respective transmitters.

It is a still further object to provide an improved omni-directional antenna having a basic structure which can easily be modified during assembly for use at any desired frequency band within a large range of frequencies.

An antenna according to the invention includes an elongated conductive member having a longitudinal slot therein, the conductive member being interrupted at points equidistant from the longitudinal center of the slot and provided with crossover members bridging the interruptions. By this arrangement, the slot may be made to have an electrical length equal to a plurality of half wavelengths in the slot at the operating frequency. A feeder line is connected across the slot at the longitudinal centerpoint. Additional conductive members are provided to cooperate with said elongated conductive member to define an elongated cavity in communication with the slot throughout its length. The cross-sectional dimensions of the elongated cavity are varied along the length of the cavity in such a way that the plurality of half wave portions of the slot are substantially equally energized from the single feeder line. Stated another way, the impedance of the elongated cavity is symmetrically varied from the center towards the two ends in such a way as to uniformly energize the plurality of half wavelength sections of the slot.

For a better understanding of the invention, reference is had to the following more detailed description taken in conjunction with the appended drawings wherein:

Figure 1 is a side view of an antenna constructed according to the teachings of this invention;

Figure 2 is a front view of the antenna of Figure 1;

Figure 3 is a perspective view showing the top half of the antenna of Figures 1 and 2 in enlarged form to reveal constructional details;

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Figure 4 is an outline diagram illustrating two antennas of the type shown in Figures 1 and 2 mounted on a single triangular tower, one of the antennas being connected to an aural transmitter, and the other antenna being connected to a visual transmitter;

Figure 5 is an outline diagram illustrating four antennas of the type shown in Figures 1 and 2 mounted on a single triangular tower for radiating the visual and aural outputs of two independent television stations;

Figure 6 is an outline sectional or top view of the structures of Figures 4 and 5 illustrating the antennas supported by the triangular tower; and

Figure 7 is a diagram illustrating the electrical boundaries of the cavity in the antenna, which is in communication with the radiating slot, and by means of which the plurality of half wave sections of the slot are substantially uniformly energized from the single feedpoint.

Referring in greater detail to the drawings, the antenna shown in Figures 1 through 3 includes electrically conductive angle members 10, 11 and 12 arranged in end-to-end relationship beside similarly arranged conductive angle members 13, 14, and 15. A metallic shorting plate 16 is connected across the top ends of angle members 10 and 13; and a metallic shorting plate 17 is connected across the bottom ends of angle members 12 and 15. Metallic crossover members 18 and 19 connect the bottom end of angle member 13 to the top end of angle member 11, and the bottom end of angle 10 to the top end of angle 14. Similarly, metallic crossover members 20 and 21 connect the bottom end of angle member 14 to the top end of angle member 12 and the bottom end of angle member 11 to the top end of angle member 15. The members thus far described may be viewed as constituting an elongated conductive front member having a longitudinal slot therein, the conductive member being interrupted or transversely slotted at points equidistant from the longitudinal center of the slot and the interruptions being bridged by crossover members. The slot extends longitudinally from the shorting plate 16 to the shorting plate 17 and has a center line 22 about which the structure is symmetrical.

A feeder transmission line including an outer conductor 23 and an inner conductor 24 is connected across the slot at the center. The connection is made by connecting the outer conductor 23 to the angle member 11 and by connecting the inner conductor 24 to the angle member 14 through a capacitive plate 25. The capacitive plate 25 is dimensioned to balance the effect of the outer conductor 23 on the opposite side of the slot.

The antenna also includes a structural metallic back member 27 and a plurality of channel-shaped metallic side members 28 connecting the structural back member 27 to the angle members defining the slot at the front of the antenna structure. The side members 28 are sufficiently closely spaced with reference to the wavelength at the operating frequency so that they constitute a conductive sheet. Sheet metal may, of course, be substituted for the individual side members 28 provided that interruptions are maintained at the crossover points. Individual side members 28 are preferred to sheet members because they provide more strength for a given weight of material, and they result in a structure having less wind resistance than a solid imperforate structure. A plurality of parallel horizontal conductive bars 33 through 41 are connected between certain of the side members 28 as shown in Figure 3 illustrating the upper half of an antenna. The lower half of the antenna is a mirror image of the upper half. The bars 33 through 41 are sufficiently closely spaced relative to the wavelength at the operating frequency so that they constitute a conductive sheet.

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The vertical angle members 10 through 15, the conductive side members 28, the conductive bars 33 thru 41, and the central portion of the structural back member 27 (at points designated 31 and 32 in Figure 3) define a cavity in communication with the slot formed by the angle members 10 through 15 and the shorting plates 16, 17. The cavity and the slot extend a total distance corresponding with two nominal electrical wavelengths in the cavity. The cavity and the slot have a length corresponding with about 4 wavelengths in free space. The cavity is restricted in one cross-sectional dimension, that is, depth, by means of the conductive bars 33 through 41. It will be noted that the conductive bars 33 through 41 are located at varying distances from the angle members 10 through 15. The arrangement below the center line 22 of the antenna is symmetrical with that shown in Figure 3 above the center line. It is thus apparent that there is provided an elongated cavity which is in communication with the radiating slot along its entire length, and that a cross-sectional dimension of the cavity is varied along its length from the center towards both ends to permit the energization of the entire long slot from the single central feedpoint.

Figure 7 is a diagram illustrative of the antenna structure shown in Figures 1 through 3 when viewed from the same side of the antenna as is viewed in Figure 1. The points 31 and 32 represent the back member 27, and the points 33 through 41 represent the correspondingly numbered conductive bars in Figure 3 of the drawings. The left hand vertical line represents the radiating slot extending from the shorting plate 16 to the shorting plate 17. The positions of the crossover members 18, 19 and 20, 21 are indicated.

Figure 7 illustrates how one cross-sectional dimension of the cavity, namely the depth, varies along the length of the cavity and the associated radiating slot. The center portion 45 of the cavity has the maximum depth. The end portions 46 and 47 are of reduced depth. The sections of the cavity labeled T may be viewed as impedance transforming portions for matching the impedance of the center portion 45 to the end portions 46 and 47. Or, the conductive bar 35 may be considered as providing an impedance discontinuity which establishes the end portion 46 as a resonant cavity, and wherein the conductive bars 33 through 35 constitute an impedance transforming portion for properly coupling the cavity 46 to the central cavity 45. The conductive bars constitute inductive impedance elements and may be replaced by capacitive elements which similarly vary an effective cross-sectional dimension of the cavity. Of course, the arrangement below the center line 22 is a mirror image of that above the center line.

Since the center portion 45 of the cavity has a greater depth than the end portions 46 and 47, the velocity of propagation of radio frequency energy outwardly from the feedpoint is greater in the center portion 45 than it is in the end portions 46 and 47 of the cavity. Or, it may be stated that the phase velocity is greater in the outer cavity than in the inner cavity. Therefore, an electrical half wavelength at the radiating slot opposite the center portion 45 of the cavity has a shorter physical length than an electrical half wavelength along the slot in the end portions 46 and 47 of the cavity. The increased physical length of the half wave slot sections opposite the end portions 46 and 47 of the cavity is advantageous in that it extends the physical length of the radiating slot and thereby improves the directivity of the antenna in vertical planes. In other words, most of the radiated energy is directed normal to the vertically extending slot and little energy is wasted by being directed upwardly into the sky or downwardly into the earth.

The depth of the center portion 45 of the cavity at the center line 22 is selected to provide an impedance which matches the characteristic impedance of the feeder line 24, 25. The impedance of the cavity looking upwardly

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from the center line 22 is in parallel with the impedance of the cavity looking downwardly from the center line 22. Therefore, the total impedance of the cavity presented to the feeder line is equal to half the impedance looking in one direction from the center line 22.

It will be observed from the diagram of Figure 7 that the radiating slot of the antenna has a nominal length of two electrical wavelengths. All the energy radiated from the slot is in phase because of the appropriately positioned crossover members 18, 19, and 20, 21. The characteristics of the antenna are such as to provide a more directive pattern in vertical planes than can be obtained from four independently fed half wavelength radiators of equal phase and current amplitude. Additionally, the antenna of this invention is superior to known arrays of antenna elements for the reason that the antenna is energized from a single feedpoint by a single feeder line. Feeder lines are normally constructed in coaxial line form and are relatively expensive. The usual array of antenna elements must be fed from a feeder line harness constructed to include additional lengths of feeder line to insure the feeding of each antenna element in the same phase as the others. The additional lengths of feeder line are not only expensive but are difficult to mount on the antenna structure because of space requirements and because of disturbing effects they may have on the radiation characteristics of the antenna. The center portion 45 of the cavity may have a length of only one nominal half wavelength if desired, but this reduces the length of the radiating slot and the directivity characteristic in vertical planes.

Reference will now be made to Figures 4 through 6 for a description of the manner of mounting the antenna of Figures 1 through 3 on a triangular tower. A tower of triangular cross-section is advantageous from a structural point of view for the reason that it provides the necessary mechanical strength with a minimum of material. Unlike some antennas, the antenna of this invention is suitable for mounting on a tower of triangular cross-section without impairing its radiation characteristics.

Referring to Figures 4 and 6, the triangular tower 50 is shown in outline. The tower 50, of course, consists of vertical members and many cross bracing structural members. The outline 51 of one antenna like that shown in Figures 1 through 3 is mounted at one corner of the triangular tower, and the outline of another similar antenna 52 is shown at another corner of the tower. The antenna 51 is connected by means of a feeder line 53 to an aural transmitter, and the antenna 52 is connected by means of a feeder line 54 to a visual transmitter. The aural antenna 51 and the visual antenna 52 are similarly constructed but are slightly differently dimensioned to accommodate the slightly different frequencies of the aural and visual signals of a given television channel. Both the aural signal and the visual signal are independently radiated with omni-directional patterns in the horizontal plane and without interference between the two antennas. The cross-coupling between the aural and visual antennas is found in practice to be down about 26 decibels.

The arrangement shown in Figure 4 for radiating aural and visual signals is very advantageous for the reason that the two antennas are connected directly to the respective aural and visual transmitters without the need for an intervening diplexer. Diplexers are necessary for some types of antennas to combine the outputs of the aural and visual transmitters prior to application to antenna elements which radiate both signals. Diplexers must handle high radio frequency powers and are therefore relatively large and expensive.

Figure 5 shows an arrangement for transmitting the visual and aural signals from two television stations A and B. The visual antenna 53 and the aural antenna 54 are associated with television station A, and the visual antenna 55 and aural antenna 56 are associated with television station B. The television stations A and B are of course assigned different frequencies corresponding with

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different television channels. The signal from one television station does not interfere with the signal from the other television station. Since there are relatively few locations ideal for mounting an antenna to serve a community, and for obvious economic reasons, it is very advantageous to mount antennas for a plurality of television stations on a single tower.

An antenna according to the invention which was constructed and is in use for transmitting a channel 13 television signal (210 to 216 megacycles) has the dimensions shown on Figures 1 through 3 of the drawings. The conductive bars 36 through 41 are spaced $5\frac{3}{8}$ inches from the radiating slot. Conductive bar 33 is spaced $6\frac{7}{8}$ inches, bar 34 is spaced 4 inches, and bar 35 is spaced $2\frac{7}{8}$ inches from the radiating slot. The feeder line 23, 24 is a 3 inch diameter coaxial line having a characteristic impedance of 51.5 ohms. The dimensions, of course, are given solely by way of example. The antenna described radiates 50 kilowatts of television radio frequency signal.

It is apparent that according to this invention there is provided a relatively simple, economical and effective antenna wherein a relatively long radiating slot is fed from a single feedpoint. The construction is such that the antenna is easily modified during assembly to accommodate any one of many different frequency bands. The antenna provides an omni-directional pattern in the horizontal plane and is highly directive in vertical planes.

What is claimed is:

1. An antenna comprising, an elongated conductive member having a longitudinal slot therein, interruptions in said conductive member at points substantially equidistant from the longitudinal center of said slot, crossover members bridging said interruptions, whereby said slot has a plurality of electrical half wavelength sections, a feeder line connected across said slot at substantially the longitudinal center thereof, and additional conductive members cooperating with said elongated conductive member to define an elongated cavity in communication with said slot, said cavity having at least one cross-sectional dimension varying along the length of the cavity to substantially uniformly energize the plurality of electrical half wavelength sections of said slot from said feeder line.

2. An antenna comprising, an elongated conductive member having a longitudinal slot therein, interruptions in said conductive member at points substantially equidistant from the longitudinal center of said slot, crossover members bridging said interruptions, whereby said slot is a plurality of electrical half wavelengths long, a feeder line connected across said slot at substantially the longitudinal center thereof, and additional conductive members cooperating with said elongated conductive member to define an elongated cavity in communication with said slot, said cavity having a center portion with cross-sectional dimensions to match the impedance of the cavity to the impedance of the feeder line, said cavity having end portions of reduced cross-sectional dimension, and said cavity having impedance transforming portions of varying cross-sectional dimension between the center portion and the end portion of the cavity.

3. An antenna comprising, an elongated conductive member having a longitudinal slot therein, interruptions in said conductive member at points substantially equidistant from the longitudinal center of said slot, crossover members bridging said interruptions, whereby said slot has a plurality of electrical half wavelength sections, a feeder line connected across said slot at substantially the longitudinal center thereof, and additional conductive members cooperating with said elongated conductive member to define an elongated cavity in communication with said slot along the length thereof, said cavity having a depth from said slot which varies symmetrically from the longitudinal center towards the ends to substantially uniformly energize the plurality of electrical half wavelength sections of said slot from said feeder line.

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4. An antenna comprising, an elongated conductive member having a longitudinal slot therein, interruptions in said conductive member at points substantially equidistant from the longitudinal center of said slot, crossover members bridging said interruptions, a feeder line connected across said slot at substantially the longitudinal center thereof, and additional conductive members cooperating with said elongated conductive member to define an elongated cavity in communication with said slot along the length thereof, said slot and said elongated cavity being dimensioned to provide a nominal electrical length of two wavelengths therein, the entire slot being energized from said single feeder line.

5. An antenna comprising, an elongated conductive member having a longitudinal slot therein, interruptions in said conductive member at points substantially equidistant from the longitudinal center of said slot, crossover members bridging said interruptions, a feeder line connected across said slot at substantially the longitudinal center thereof, and additional conductive members cooperating with said elongated conductive member to define an elongated cavity in communication with said slot along the length thereof, said additional conductive members being interrupted at points adjacent said interruptions in said elongated conductive member, and impedance means in said elongated cavity to energize said slot along its entire length from said single feeder line.

6. An antenna comprising, an elongated conductive structure having a front, two sides and a back, said front being provided with a longitudinally extending slot, said front and sides being interrupted at two points equidistant from the longitudinal center of the slot to divide the structure into a central section having a nominal electrical length of one wavelength and two end sections each having a nominal electrical length of a half wavelength, crossover members bridging the interruptions in said front, a feeder line connected across said slot at the longitudinal center thereof, two impedance discontinuities in said structure to divide the interior thereof into a central cavity and two end cavities, the depth of the central cavity being varied symmetrically from the center feedpoint to said impedance discontinuities to provide an impedance transformation.

7. An antenna comprising, an elongated conductive structure having a front, two sides and a back, said front being provided with a longitudinally extending slot, said front and sides being interrupted at two points equidistant from the longitudinal center of the slot to divide the structure into a central section having a nominal electrical length of one wavelength and two end sections each having a nominal electrical length of a half wavelength, crossover members bridging the interruptions in said front, a feeder line connected across said slot at substantially the longitudinal center thereof, two impedance discontinuities in said structure to divide the interior thereof into a central cavity and two end cavities, the depth of said end cavities from the front to the back being as shallow as practical to propagate the desired radio frequency signal, whereby the physical length of the end sections is as great as practical, the depth of said center cavity at the feedpoint being sufficiently great to provide an impedance match to said feeder line, the depth of said center cavity being varied symmetrically from the center feedpoint to said impedance discontinuities to provide an impedance transformation between the center cavity and the end cavities.

8. An antenna comprising an elongated conductive structure having a front, two sides and a back, said front being provided with a longitudinally extending slot, said front and sides being interrupted along said structure at points spaced an integral number including one of nominal electrical half wavelengths apart, and crossover members bridging the interruptions in said front.

9. An antenna comprising an elongated conductive structure having a front, two sides and a back, said front

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being provided with a longitudinally extending slot, said front and sides being interrupted by a transverse slot intermediate the ends thereof, and two conductive crossover members having ends connected to said front and bridging said transverse slot.

10. A transmitting antenna system comprising a tower having a triangular cross-section, a pair of elongated antennas of rectangular cross-section mounted on two corners of said tower, each of said antennas including an

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elongated conductive structure having a front, two sides and a back, said front being provided with a longitudinally extending slot, said front and sides being interrupted along said structure at points spaced an integral number including one of nominal electrical half wavelengths apart, and crossover members bridging the interruptions in said front.

No references cited.