

[54] **STRIPLINE SLOTTED BALUN DIPOLE ANTENNA**
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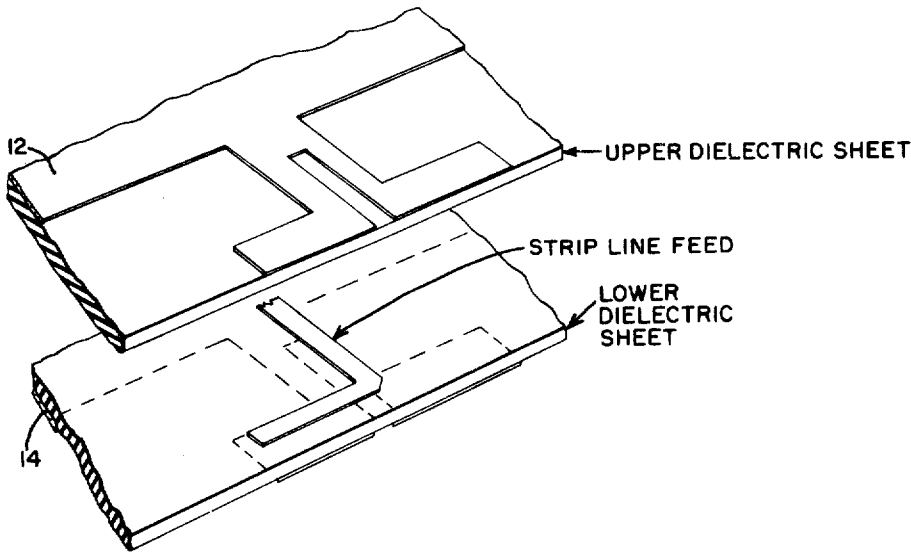
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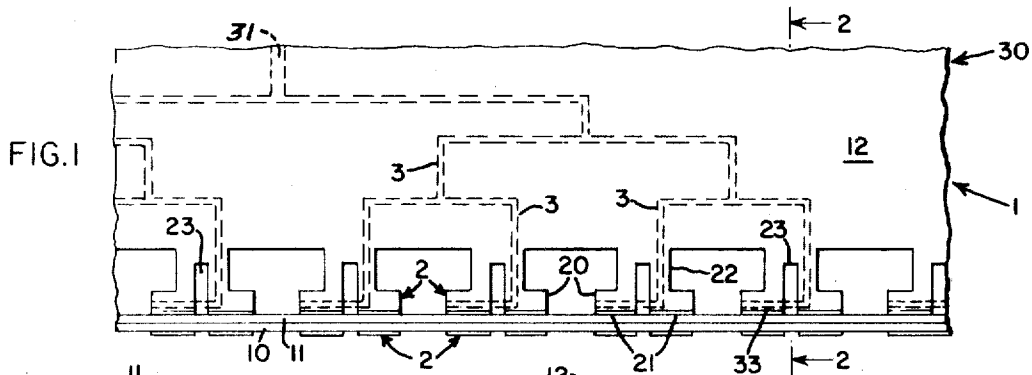
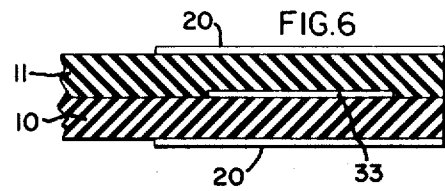
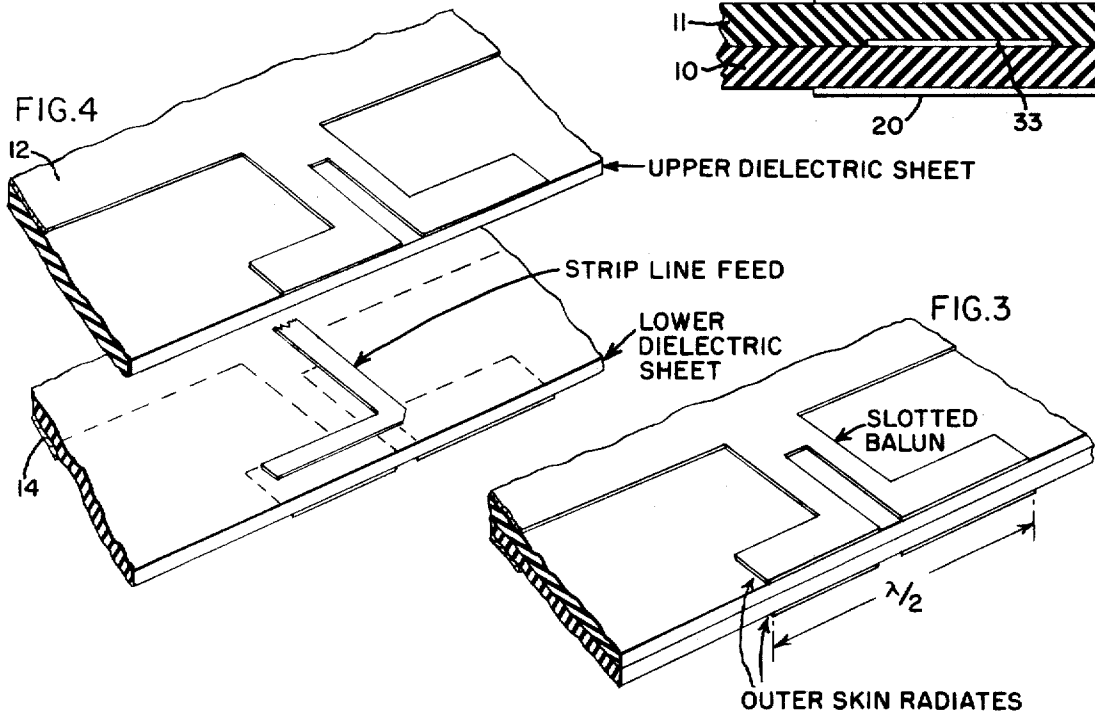
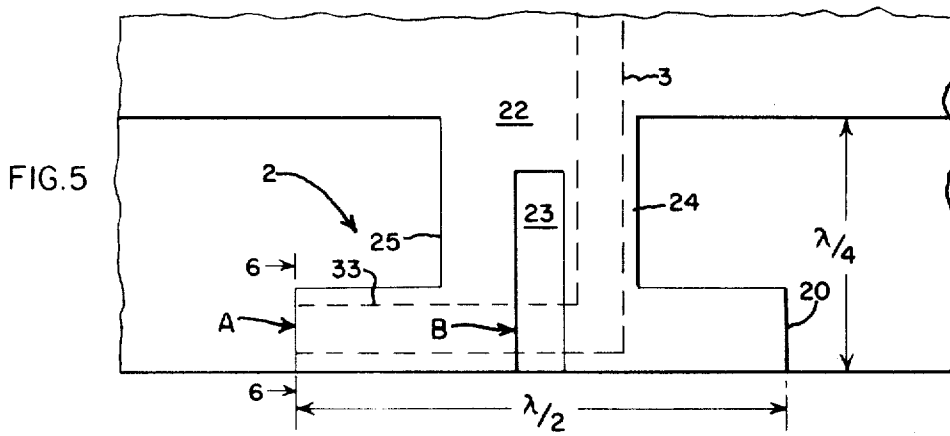
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[57] **ABSTRACT**
A stripline slotted balun dipole antenna, suitable for use as a single antenna or as an array antenna element, is fabricated from two metal-clad dielectric sheets, from which metal has been removed in predetermined patterns, and then the sheets are sandwiched together to form both the slotted balun dipole antenna and its stripline feed. The metal remaining on the exterior of the laminated structure constitutes a slotted balun dipole and the metal remaining between the dielectric sheets constitutes the center conductor of the stripline feed. The structure obviates the need for metallic connections in the antenna area.

9 Claims, 6 Drawing Figures





STRIPLINE SLOTTED BALUN DIPOLE ANTENNA

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention pertains to microwave dipole antennas of a type identified as "slot fed" and the means for connecting such antenna to a transmission line generally referred to as stripline.

2. Description of the Prior Art

Slot fed dipole antennas have been constructed using various techniques as, for example, weldments fabricated from tubing or rod or in the form of castings. In addition, slot fed dipoles have been used in phased array antennas using many different construction techniques and in some instances in combination with stripline feed systems. U.S. Pat. Nos. 3,056,925 Borck et al. and 3,496,566 Walter et al. are examples of previous dipoles. Borck feeds a dipole by means of a parallel conductor cable running through a dielectric support structure. Walter discloses a dipole with associated baluns made of hollow tubing through which is run a coaxial cable to the dipole portion of the antenna where the conductors are individually fastened to portions of the dipole structure. U.S. Pat. Nos. 3,518,579 to Hoffman and 3,573,831 to Forbes show the use of microstrip structures as an antenna feed line. All of these structures to some extent require individual spot connections of conductors which require a degree of specialized labor in their construction and in varying degrees these patents disclose the fact that certain types of structural weaknesses have been almost inherent in the art.

SUMMARY OF THE INVENTION

A principal object of this invention is to provide an integral microwave dipole antenna and stripline feed which will be durable, rugged and simple to construct. The structure is as readily adaptable to use in arrays as to use as a single antenna. The structure can be fabricated without the necessity for the physical interconnection of electrical conductors which in other constructions require a plurality of solder joints, brazes or welds. Structural rigidity, particularly in arrays constructed according to this invention, is provided by the fact that an entire row of axially aligned dipoles is most easily fabricated in the form of a single slab of fairly rigid material. Elimination of the many electrical connections has been made possible by use of a feeding arrangement which establishes a virtual short to the feed center conductor at the base of one dipole arm at the edge of the slot so that no actual physical connection is needed to permit the current to excite the dipole. Similarly, the structure provides for the connection of the unbalanced transmission line to the balanced dipole without the use of solder joints, brazing, welding or bolting.

Briefly, in accordance with this invention, there is a sheet of dielectric material of which one edge defines the position of one or the alignment of a plurality of dipole antennas. The antenna and outer conductor of the transmission line are in the form of a shaped metallic partial skin on each side of the dielectric sheet with each antenna being a T-shape portion of skin adjacent to the edge of the sheet and having the stem of each T extending away from that edge to join to a portion of the metallic skin covering the entire sheet except for

the band proximate to the edge of the dielectric sheet. Each T is slotted to separate the antenna into two quarter wave radiating arms and to cause the legs of the T to constitute a slotted balun connected to the dipole.

The metal skins remaining on the two sides of the sheet in identical configuration are joined electrically at the base of the transmission line portion of the sheet to constitute one side of the transmission line. The other side of the transmission line is in the form of a metallic conductor embedded in the dielectric sheet between the two T shape sections. It is a conductor of finite dimensions running off center and toward the propagating edge of the sheet between the two parallel metallic skin portions of the leg of the T shape portion to the intersection of balun and dipole and thence to terminate one quarter wavelength from the center of the dipole arms. This invention also contemplates the construction of such an integral transmission line and antenna from prefabricated dielectric sheets clad on both sides with a metal skin as for example copper. The metal skin is partially removed from two clad sheets to form the dipole and the sheets laminated together to form the desired structure.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partial planar view of an antenna array constructed according to the invention showing a plurality of the individual slotted balun dipole antennas;

FIG. 2 is a cross section of a portion of the antenna construction taken along line 2-2 of FIG. 1;

FIG. 3 is a perspective view of a single dipole antenna according to the invention;

FIG. 4 is an exploded view of a single dipole antenna according to this invention which in part illustrates a preferred method of construction of the invention;

FIG. 5 is an enlarged planar view of a single dipole antenna taken from the antenna array of FIG. 1; and

FIG. 6 is a partial section of the antenna taken along the line 6-6 of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of this invention as illustrated in FIG. 1 constitutes an antenna array although the invention is also suitable for implementation in single dipole constructions. FIG. 1 illustrates a portion of the radiating edge of an antenna array in which there are a plurality of dipoles along the edge of the structure excited from a single input line 31. The antenna structure 1 is made up of two sheets of dielectric material 10 and 11 which are large sheets of a fairly rigid dielectric material pre-clad with metallic copper or other electrically conducting sheets 12 and 14. This structure is most easily fabricated from two individual sheets 10 and 11, with 10 being pre-clad on both sides and 11 clad on one side with sheets 12 and 14 from which portions of the sheet have been cut away to leave dipoles 2 and striplines 3. By cutting away the electrically conducting sheets on each of the two sheets of dielectric in mirror image fashion to form the dipoles, and with the center conductor 3 being formed on the double clad dielectric sheet, the two sheets can be laminated together so that the total laminated antenna structure 1 includes the interior striplines 3 and the dipole structures which are portions of the electrically conducting sheets 12 and 14 comprising the exterior of the laminated structure.

Each of the dipoles 2 is comprised of a T-shaped portion 20 of the exterior electrical conducting sheets 12 and 14 of the laminated structure. Each T-shaped antenna portion includes a dipole 21 and a slotted balun 22. In addition, each antenna segment has been partially separated by a slot 23 extending from the exterior center of the dipole into the stem portion of the T. This slot defines the balun and serves to isolate the dipole arms and to separate a portion of the stem 22 into two stem portions 24 and 25. In each instance, the dipole and the balun portions when functioning as an antenna include the corresponding portion of the metallic sheet on both exterior surfaces of the laminated structure. Each of the dipoles has an edge contiguous with the edge of the dielectric sheets so that the exterior edge in question can be referred to as the radiating edge of the array. The dipole arms should have a total length of one-half wavelength and the height of the T is on the order of one-quarter wavelength. The end of the copper strip 33 is electrically one-quarter wavelength from slot 23, and is open circuited at point A. It therefore reflects a short circuit between the center conductor and the dipole arms at point B; thus, in effect connecting the strip line center conductor to one side of the dipole. The balun slot 23 presents a high impedance between the dipole arms enabling a balanced potential difference to be applied between the dipole arms.

Details of the construction to which this structure lends itself will be more evident by reference to FIGS. 2, 3 and 4 wherein the exploded view of FIG. 4 indicates the positional registry of the dipoles on the two exterior surfaces of the laminated structure. It is most obvious from these figures that the process of removal of portions of the clad material permit construction without the necessity of soldering, brazing, welding, or bolting of electrically conducting materials. It is this feature that provides minimum fabrication labor cost and eliminates all problems concerning the physical joining of transmission line to radiator which has been common to previous structures.

It is also possible, of course, to apply the present invention to microstrip construction merely by the elimination of the electrically conducting skin from one exterior surface of the laminated antenna structure. It is also obvious that structures according to the invention and generally in the configuration accomplished by the Applicants and as illustrated in the drawings might be produced by other methods of manufacture as for example, molding. The configuration of the device makes the preferred simple fabrication process possible which is to say that the particular concept of the invention makes possible construction of antennas by means of processes which are considerably less expensive, particularly in the terms of labor hours, than was true of the prior art. It is also obvious to those familiar with the microwave art that the stripline center conductor may, after crossing the slotted balun, be bent toward the base of the balun rather than parallel to the dipole without interfering with the general operation, and that moderate changes in the dipole, slot and other dimensions may be incorporated without varying from the basic configuration. Furthermore, the stripline feed 31 may have quarter-wave transformers or other impedance matching devices distributed throughout.

A further embodiment of the antenna invention is also possible through use of air as the dielectric medium. In that configuration, the metallic conductors

would be thicker and nearly self-supporting, requiring dielectric and metallic separators at only appropriate positions throughout the feed line and in the dipole-balun region.

Another embodiment of the structure is possible by stacking a number of the above described rows of dipoles either horizontally or vertically to form a planar array of dipoles.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An integral antenna and transmission line structure comprising two sheets of dielectric material each partially covered with a skin of electrically conducting material arranged in predetermined pattern, said sheets being joined together in a laminated structure, said laminated structure having an antenna portion proximate one edge, the remainder of said structure constituting a transmission line portion, said skin on the sides of said sheets which form the exterior of said structure substantially covering said transmission line portion and on said antenna portion defining a T-shaped antenna dipole with the crossbar of the T adjacent an edge of said structure and the stem of the T extending from the center of the crossbar to said transmission line portion of the structure, each said T portion of skin being slotted from the center of the crossbar into the stem to divide the dipole defined thereby into two separate arms each having a separate pillar of the stem of the T, said skin on the sides of said sheets which have been joined interiorly of said laminated structure constituting the center conductor in the transmission line portion and a stripline antenna feed in the antenna portion.

2. The structure of claim 1 wherein said stripline antenna feed extends within one pillar of the stem of said T to its arm and has a leg extending from that point to the remote end of the opposite arm of the T whereby electrical connection of line and antenna is accomplished by means of a virtual short at the base of said other arm and whereby said structure constitutes a dipole antenna connected to an unbalanced line by means of a balun.

3. A dipole antenna and transmission line structure comprising:

- a. two identically shaped exterior members of electrically conducting material placed in spaced parallel overlapping registering relationship; said members being T-shaped and slotted from the exterior center of their cross bars to a point in their stems to separate each said cross bar into distinct dipoles and to cause both said members in cooperation to define a slotted balun dipole antenna; the base of said stems beyond said slot constituting one conductor of a transmission line;
- b. an L-shaped antenna feed line piece of electrically conducting material spaced intermediate said two members with its stem portion parallel to the stem portions of said members to one side of the slots and with its foot parallel to said cross bars extending from one side of said slots to the remote end of the dipoles on the opposite side of said slots, the base of said stem constituting a second conductor of said transmission line; and
- c. a dielectric material separating said piece from said members whereby said piece and said members constitute an integral slotted balun dipole antenna and transmission line.

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4. The dipole antenna and transmission line structure of claim 3 further comprising at least one additional set of members and piece in a common plane with the first set with their stems parallel to the first and with said foot and said cross bars in tandem with those of said first set and having the bases of said stems electrically connected in parallel to form an array of integral slotted balun dipole antennas.

5. An integral antenna and transmission line structure comprising a thin slab of dielectric material having two sides and a plurality of edges; a sheet of electrically conducting material applied to each side of said slab substantially coextensive with said slab except for a border along one said edge, said sheets within said border only partially covering said slab and defining a T-shaped slotted balun dipole antenna with its radiator along said one edge and its stem extending across said border; and a stratum of electrically conducting material embedded in said slab generally parallel with and electrically insulated from said sheets whereby said stratum and sheets form a transmission line, said stratum inside said border comprising an L-shaped conductor extending into said antenna within one side of said stem and thence to the remote end of the crossbar of the T.

6. The structure of claim 5 wherein there are a plurality of said antennas and conductors within said border.

7. An integral antenna and transmission line structure comprising a slab of dielectric material of substantial length and width when compared with its thickness to cause said slab to have two sides and a plurality of

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edges; a sheet of electrically conducting material adhered to each side of said slab substantially coextensive with said slab except for a border along one said edge, said border constituting the antenna portion and the remainder constituting the transmission line portion of said structure, said sheets within said border only partially covering said slab and defining a T-shaped slotted dipole antenna having a crossbar portion contiguous to said edge and a stem portion connecting between said crossbar and said sheet in said line portion, each said crossbar and stem being slotted centrally from said one edge toward the base of said stem to divide said T-shaped antenna into two identical but reversed L-shaped portions; and an electrical conductor embedded in said slab, said conductor constituting the central conductor of the transmission line and extending into the antenna portion of said structure between the stem portions of the L portions on one side of said slot to near said edge and further extending parallel to said edge across said dipole slot and terminating at the remote end of the antenna whereby said structure constitutes a dipole antenna connected to an unbalanced line by means of a balun.

8. The structure of claim 7 wherein said central conductor within said antenna portion of said structure constitutes a stripline.

9. The structure of claim 8 wherein there are a plurality of T-shaped antennas in said antenna portion and wherein said stripline has a branch for each said antenna.

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