May 14, 1968 R. S. KAHN ET AL 3,383,693

FOLDABLE PLANAR BASE ANTENNA STRUCTURES

Filed Aug. 20, 1965 2 Sheets-Sheet 1

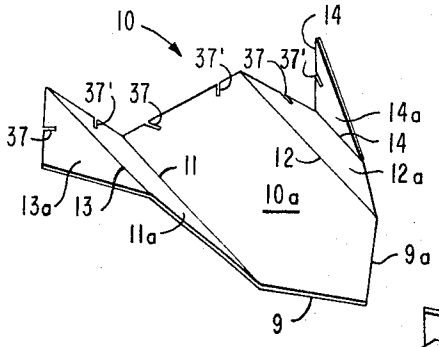


FIG.-1A

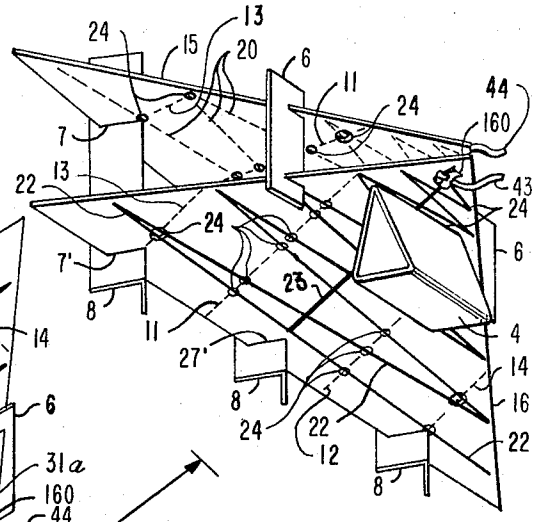


FIG.-2

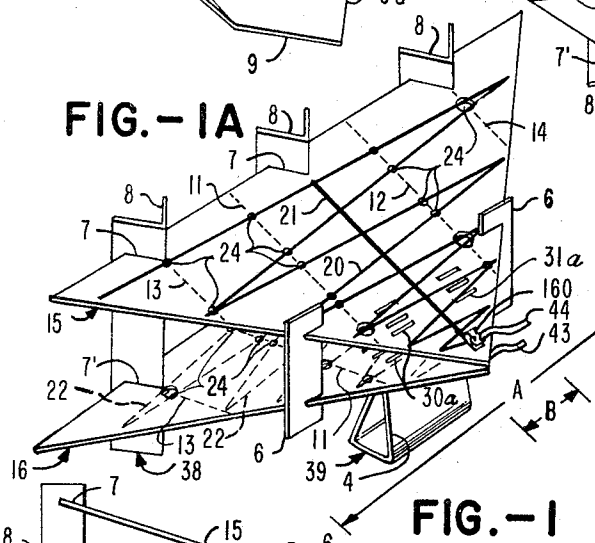


FIG.-1

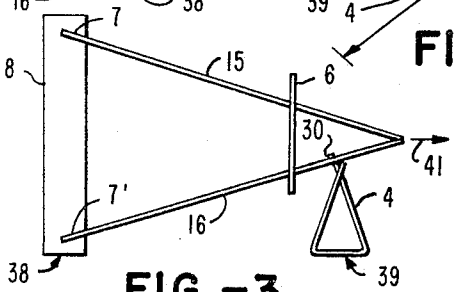


FIG.-3

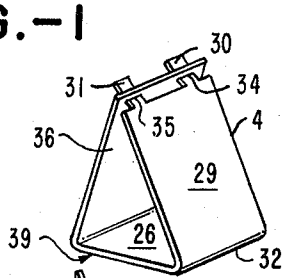


FIG.-4

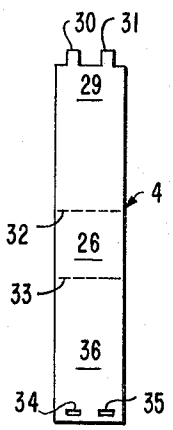


FIG.-5

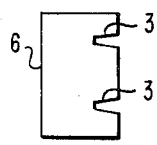


FIG.-6

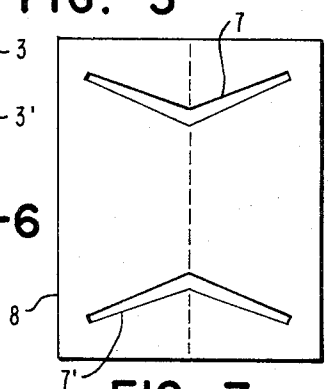


FIG.-7

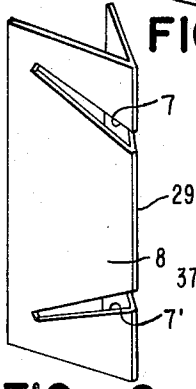


FIG.-8

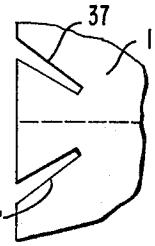


FIG.-9

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FOLDABLE PLANAR BASE ANTENNA STRUCTURES

Filed Aug. 20, 1965 2 Sheets-Sheet 2

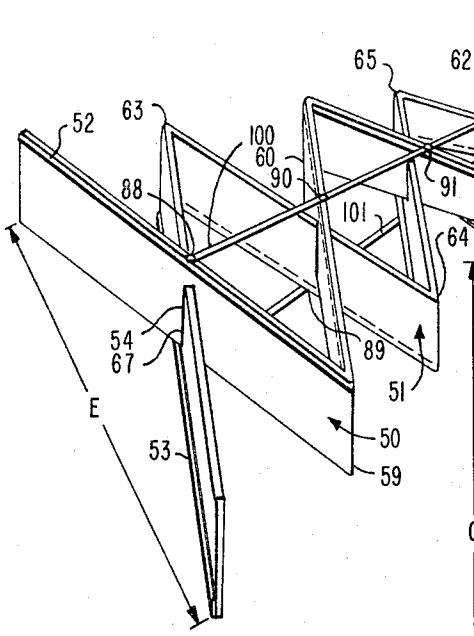


FIG.-10

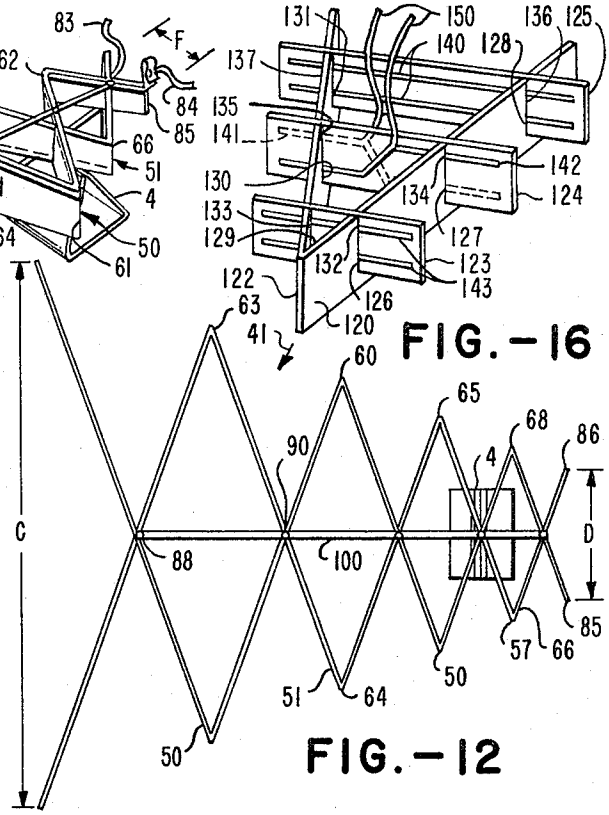


FIG.-12

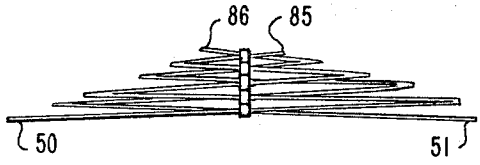


FIG.-15

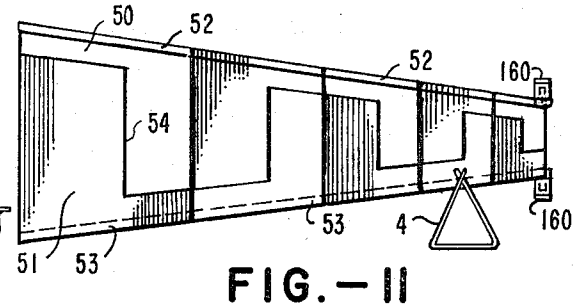


FIG.-11

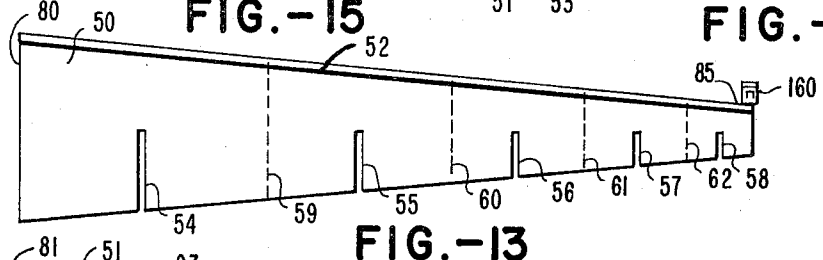


FIG.-13

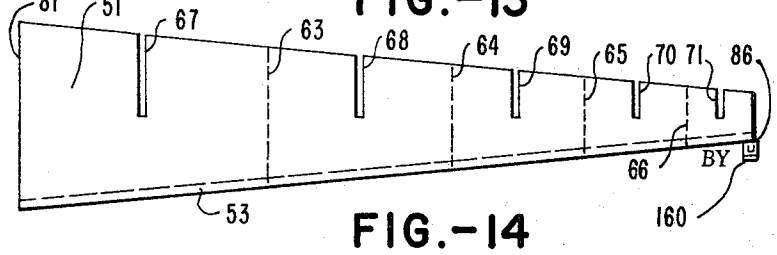


FIG.-14

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FOLDABLE PLANAR BASE ANTENNA STRUCTURES

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7 Claims. (Cl. 343—792.5)

This invention relates generally to antenna structures and more particularly to such antenna structures embodying foldable planar bases for greater ease of transportation, storage, handling, and erection.

It may be desirable in the use of array antenna equipment to place such equipment in locations where access space thereinto is limited, although the space is sufficiently large to receive such antenna arrays.

One such use of antenna arrays may be in an attic which is provided with only a small access door. Getting through such a door with the usual array could prove nearly impossible. If an array is to be assembled in such a location it may be possible to bring the usual components of the array into the area but there may not be room enough to move about comfortably with the antenna elements while assembling them.

This invention contemplates antenna array assemblies wherein the antenna conductors are disposed upon foldable cardboard or other insulative sheet material. These sheet materials may be suitably treated so as to make them weatherproof, fireproof and otherwise acceptable to the building codes of municipalities or in accord with other safety code entities within whose jurisdictions such antennas are to be installed.

The structure for supporting antenna elements according to this invention, being foldable, is thus collapsible for storage, or transportation, into a size small enough to be passed into an attic or other area through the small entry or access aperture usually encountered. When the structure is in the desired area, simply unfolding the component parts and interfitting them together erects the antenna without any need of special, or even ordinary tools; nor will any bolts, screws, nuts, clamps or other hardware items be required for erecting the antenna as in prior art antenna array structures.

Modern entertainment television is broadcast over a wide range of transmitting frequencies between 54 megacycles and nearly a 1000 megacycles in the United States. Gaps exist in the spectrum between these limits which are not used for commercial entertainment broadcasting. It has been the practice therefore to provide separate antenna arrays for very high frequency (VHF), frequency modulation (FM) and ultra high frequency (UHF) reception. When such antennas are used they make an unsightly installation unless located in such out of the way places as attics. With the prior art antenna structures this is impractical because of the large size of the VHF antenna for the range 54–216 megacycles, and, the fact that another antenna is required for the UHF band, and still another for the FM band, simply adds to the difficulty.

One modern form of antenna structure which in a single array is known to be capable of efficient reception of the total band of frequencies above mentioned, is the logarithmically periodic antenna array. This, too, however is structurally large.

This invention provides novel means for implementing a log-periodic antenna structure which, despite its large size, may be folded into a neat compact package for shipment and which, in the extremely small volume of its folded form, can be readily brought into an attic or through other small entry areas.

For emergency communication and particularly for

such communication to be made on a point-to-point basis, the use of antenna array structures in accordance with this invention will provide the communications technicians with easily transported foldable array structures that can be carried to and erected quickly in almost any location.

In the prior art, the heavy metallic, although disassembled, structures would have required great effort in transporting the structure and consume a substantial amount of valuable time while nuts and bolts and clamps and other hardware are put together with the structure in order to erect it. Foldable planar cardboard base array structures as defined herein overcome such difficulties.

Several forms of foldable antenna arrays according to this invention are disclosed herein from which it will be abundantly clear that there are many forms of antenna structures that may be implemented in accordance with the teachings herein by using the techniques described. Efficient, foldable antenna structures employing the invention can be made for all frequency ranges currently used for commercial, entertainment, amateur, educational television, FM broadcasting, military, and other communications.

In one form of the invention a scored cardboard, stiff corrugated paper base, or other insulative sheet material, treated in an approved manner, is used as a supporting surface for antenna elements. The base is formed to encompass the geometric configuration of any array to which it may be applied. It consists of as many of such geometric forms, with conductive elements thereon, similarly arrayed, so that, when the plurality, or single unit, of such forms is assembled together, in an interfitting relationship, an appropriate array structure is achieved. The desired array configuration is accomplished with various angular or rectilinear arrangements of the foldable base supports. These are held together by notched and folded erectors and separators which interfit with corresponding notches in the unfolded planar surfaces of the foldable bases or on the peripheral edges thereof.

An example of one foldable antenna array, according to this invention is a conventional zig-zag assembly of log-periodic antenna conductor elements arrayed upon the edges or along the foldable surface of the cardboard base. Upper and lower elements are oppositely notched so as to interfit to form crossed log-periodic arrays.

The cardboard frame or base folds up on its scoring lines for storage and shipment into a package only a few inches high by the length of the longest element in the criss-crossed array. The length is even less for a pyramidal planar array.

In a variation of the log periodic array on foldable insulative base elements, according to this invention, the planar base surface is triangular in form with the antenna conductors disposed in a zig-zag configuration on the foldable but normally flat surface. Two such triangular forms may then be held together in a mirror image arrangement to form a pyramidal array to provide a highly directional wide range antenna. In accordance with the invention the foldability of the array makes it easy to demount, transport, and erect again. When folded an exemplary and typical high gain antenna which covers the FM and television ranges will occupy a space about 1½ feet wide by less than four feet long and no more than about three inches high.

It is accordingly an object of this invention to provide a truly foldable antenna array.

It is another object of this invention to provide a foldable antenna array wherein the antenna conductor elements are supported on foldable planar bases.

It is a further object of this invention to provide an antenna array structure of inexpensive foldable materials.

It is still another object of this invention to provide a foldable emergency antenna array.

It is a still further object of the invention to provide a foldable communication antenna array.

It is yet another object of the invention to provide a wide band FM and television antenna array on a foldable base.

It is an even further object of this invention to provide a wide band log-periodic antenna array wherein the zig-zag antenna conductors thereof are disposed on a foldable base of insulative material.

These and other objects of the invention will be more fully understood from the specification which follows and the accompanying drawings wherein illustrative embodiments of the invention are shown and described. It should be clearly understood that the embodiments shown and described herein are exemplary of the invention and not to be construed as limiting the invention thereto since those skilled in the arts appertaining hereto, in the light of the teachings herein, will be able to devise other ways of implementing the invention within the ambit of the appended claims.

In the drawings:

FIGURE 1 is an overall perspective view of an embodiment of the invention showing the fully extended assembled structure thereof, and inset FIGURE 1A showing the folding of a base thereof;

FIGURE 2 is a view of the antenna array shown in FIGURE 1 as seen from the bottom thereof;

FIGURE 3 is a side elevational view of the antenna array shown in FIGURES 1 and 2;

FIGURE 4 is an assembled perspective view of a front supporting foot, part of the assembly of the invention;

FIGURE 5 is the configuration of the cardboard blank forming the support member shown in FIGURE 4;

FIGURE 6 is a detail of a separator used in the antenna array of FIGURE 1;

FIGURE 7 is the flat blank of rear supporting and separating elements such as used with an antenna array as shown in FIGURE 1;

FIGURE 8 is a folded, in-use view of the member shown in FIGURE 7;

FIGURE 9 is a fragmentary detail of one of the supporting base structures to show the interfitting notching technique to receive the element shown in FIGURE 8;

FIGURE 10 is a top perspective view of a foldable antenna array; another embodiment of this invention;

FIGURE 11 is a side elevational view of the antenna array shown in FIGURE 10;

FIGURE 12 is a top plan view of the array shown in FIGURE 10;

FIGURE 13 is a side view of the blank, prior to folding, which forms the upper part of the array in FIGURE 10;

FIGURE 14 is a side view similar to FIGURE 13 of the lower part of the array shown in FIGURE 10;

FIGURE 15 is a view of the antenna of FIGURE 12 observed in its collapsed form, from a top plan view; and

FIGURE 16 is a perspective view of another embodiment of the invention applied to communication antennae such as colinear arrays.

The antenna structures described herein have been primarily conceived as being usable wherever a high performance antenna embodying portability, economy, and ease of erection is sought. The military, commercial, and domestic entertainment industry can readily employ the means and techniques disclosed herein.

Referring now, specifically, and generally to the various FIGURES 1–9 wherein an embodiment of the invention applied to log-periodic antenna arrays is shown, two identical base members **10** may be seen with a partially folded outline thereof, more specifically detailed in FIGURE 1A. At **15** and **16** bases, such as **10**, are arrayed in a pyramidal configuration in a mirror image relationship of the antenna conductors **20**, **21**, **22**, and **23** disposed thereon.

More specifically, base members, such as **10**, may be seen in FIGURE 1A to be scored at **11–14** so that wings **11***a* and **13***a* fold together and over the surface **10***a* while wings **12***a* and **14***a* fold together and under surface **10***a*. When so folded the resulting sheet will be confined to the narrow rectangle of surface **10***a* with a peaked end defined by score lines **11** and **12** and peak edges **9** and **9***a*.

Base member **10** may be fabricated of corrugated, common grey cardboard, or other insulative material, moisture-proofed, fire-proofed, or otherwise treated to conform with safety and building code requirements. In some environments moisture-proofing may not be necessary.

When opened out, that is, unfolded, base structures **15**, **16** (FIGURES 1 and 2) form triangular support surfaces for antenna conductors **20–23** adhered, printed, or otherwise attached to the surface thereof in the conventional zig-zag configuration of a broad band log-periodic antenna. The conductor **21** forms the center conductor proceeding down the axis of the antenna base **15** in contact with zig-zag conductor **20** at each crossing of the center. A similar central conductor **23** is disposed along the axis of antenna base **16** in contact with the crossings thereover of conductor **22**.

In order to make a rigid pyramidal assembly of the antenna array, side support elements **6** are provided with slots **3–3′** (FIGURE 6), that fit over base cardboards **15–16** near the front thereof; and three rear support elements **8** (FIGURE 8) which are notched as shown at **7–7′** (FIGURE 7 and FIGURE 8) to fit into rear notches **37–37′** (FIGURE 9) of base support members **15–16** to hold the two base elements **15–16** in the pyramidal configuration thereof.

The array shown in FIGURES 1, 2 and 3 is principally designed to set up in an attic and rest on the attic floor. This does not imply a limitation to such locations. To facilitate the positioning of the array in the attic an apical support foot **4** is provided which may be seen attached to the lower base triangle **16** in the several figures. As may be seen in FIGURE 4; as folded, and in the flat blank shown in FIGURE 5, the support **4** is formed from a flat sheet with folds **32** and **33** dividing the sheet into base **26**, upright **36**, which has slots **34** and **35** in the edge and front, and upright **29**, which has tab extensions **30** and **31**. Base **26**, uprights **29** and **36** form an isosceles triangle. Tabs **30**, **31** fit into slots **34**, **35** when the parts of foot **4** are folded up as shown in FIGURE 4 and the tabs **30**, **31** extending from the rear upright **36** are inserted into slots provided in the base triangle **16** as shown at **30***a* and **31***a*. As may be seen at **38**, **39** when the bottoms of rear supports **8—8**, and foot **4** rest on a flat surface the apex of the array points forward towards the source or sink of signals as is indicated by arrow **41** (FIGURE 3).

Several slots **30***a* and **31***a* are shown to provide means to elevate the apex of the antenna array if necessary. Lead-in wires **44–43** are connected by fahnstock clips **160** or like terminators or connectors to the antenna conductors **21**, **23** and carried down to the receiving equipment for which the antenna is to be used.

The dimension A in FIGURE 1 is the half wavelength at the lowest frequency of operation. The dimension B in FIGURE 1 is the half wavelength at the highest frequency to be received, or transmitted.

The apertures **24** shown in various places on the base surfaces **15**, **16** are provided to relieve any stresses that might occur upon conductors **20**, **22** when folding the bases **15**, **16**. It is to be noted that the holes **24** appear on the score lines **11–14** at the points at which conductors **20**, **22** cross over the score lines, **11–14**.

In FIGURE 10 there may be seen another embodiment of a foldable log-periodic antenna array which is in accordance with this invention. On an edge of upper

and lower mirror image truncated triangular cardboard base elements **50** and **51** and antenna conductor elements **52** and **53** are affixed by adhesive means, or otherwise. At predetermined decreasing distances from a base edge **80** or **81**, as may be seen in FIGURES 13 and 14, parallel fold, scoring lines are provided as at **59–62** and **63–66**, along with slots half way up from the edge opposite the conductors **52–53**, as at **54–58** and **67–71**. When each of the foldable base elements **50–51** is folded on the respective fold score lines **59–62, 63–66** and their slots **54–58**, and **67–71** are interfitted together, an array such as shown in FIGURES 10, 11 and 12 is produced, wherein upper and lower converging zig-zag conductor elements **52** and **53** cross over one another as the upper conductor **52** and the lower conductor **53** pass back and forth over the zig-zag path on the interfitting folded bases **50–51** upon which they are supported. Lead in wires **83, 84** are connected to conductor lead ends **85, 86** of conductors **52, 53** by means of fahnstock clips **160**, or other terminators or connectors of known types.

At each cross over above and below as indicated at, for example, **88–91** upper and lower ground straps **100** and **101** are provided in contact with the respective conductors **52** and **53** at their respective center cross overs to form the dipole center similarly to leads **21, 23** described in connection with the array shown in FIGURE 1.

The dimensions C and E correspond with the dimension A shown in FIGURE 1 and the dimensions D and F correspond with the dimension B of FIGURE 1.

In FIGURE 15 the entire array has been collapsed to clearly show how compact the collapsed package can be made for storage, shipment, or to insert through relatively small apertures in attic entry, trap doors, or the like.

Referring now to FIGURE 16 an example of a communications antenna array of the Yagi type is shown implemented according to this invention. A V-shaped cardboard support **120** is shown with its apex **122**, a fold pointed in the general direction of the source or sink of radio signals, as indicated at **41**, to which the antenna is directed. Slots **132–137** arranged in some predetermined spacing for the particular array are disposed in the V-shaped support **120** so as to define lines perpendicular to the axis center of the V.

Rectilinear cards **123–125** are slotted as indicated at **126–131** so as to interfit with slots **132–137** to form a three element Yagi array of conductors **140–143** disposed on cards **123–125**. Obviously the slots **126–131** in cards **123–125** do not cut through the conductor thereon.

For example, card **123** may be a director element with the leads **143** disposed thereon. Card **124** may be a radiator dipole with leads **141–142** thereon. Conductor **141** is on one side of card **124** and conductor **142** is on the opposite side thereof. Card **125** may be a reflector with leads **140** thereon. Leads **140–143** are shown in pairs as they may be used in a vertically stacked array of known configuration. It is thus clearly obvious that any further combinations of multi-element array configurations can be erected in similar fashion with added elements such as the radiator card **124** and leads **141, 142** and additional director cards appropriately dimensioned similarly to card **123** with leads **143** thereon.

The dimensioning of elements of multi-element beam antenna arrays in colinear or stacked or combined forms are well known in the art and the principles of this invention as hereinabove discussed are applicable to any type of antenna structure involving appropriate conductors or radiators, reflectors and directors which can be disposed on foldable bases as has been described above.

It can be seen from the above that collapsible and foldable moisture-proofed or other forms of insulative based antenna arrays can be provided by scoring and slotting or otherwise perforating the base for folding and adhesively or otherwise firmly attaching thereto flat conductor ribbons of metallic substances like aluminum or copper foil or other material in such manner that the antenna conductors of almost any type of antenna array are formed thereform.

What is claimed is:

1. A collapsible and foldable colinear antenna structure comprising:

a scored and foldable base means having slots therein, said base means being arranged in a V with the slots upwardly disposed and opposite one another along the legs of the V on a line perpendicular with the altitude of the V; and

colinear antenna element cards having disposed on respective ones thereof colinear antenna element conductors forming respectively at least a director, a radiator and a reflector; said colinear antenna element cards being fitted into said slots across said V forming thereby a colinear directive antenna array.

said element cards and said collapsible base means being disassemblable for storage and shipment.

2. A log-periodic antenna array comprising:

a first and a second trigonal foldable supporting base wherein the folds thereof are longitudinally disposed from base to apex thereof;

first and second zig-zag antenna conductors in a log-periodic configuration disposed respectively on said first and said second supporting bases, each antenna conductor crossing over said folds angularly in opposite directions from the other about a center line on the respective base forming the altitude of said trigonal base;

said first and said second bases being assembled together to form a pyramidal structure encompassing a log-periodic antenna array when erected; and

said bases including relief apertures at each crossing over said folds by said antenna conductors so as to avoid any strain upon said antenna conductors when said foldable bases are folded on said folds thereof for storage or shipment.

3. An antenna structure of the log-periodic type comprising:

a first truncated triangular supporting base having folds thereon transversely disposed at predetermined intervals thereon perpendicularly to the altitude of said supporting base and having slots therein parallel to said folds and midway between each adjacent pair of folds, said slots being cut halfway into said base from one edge thereof;

a first conductive element affixed to said first base on the edge thereof opposite said slots;

a second truncated base identical with said first and arranged to be a mirror image of said first base and having said folds, said slots and a second conductive element affixed to the edge of said second base; and

said first and said second bases being interfitted on said respective slots thereof by folding on the respective folds thereof in a zig-zag configuration of the respective truncated triangular bases crossing over one another,

whereby the crossing over zig-zag elements may be collapsed on said folds, and which when not collapsed forms a criss-crossed pyramidal log-periodic antenna array by virtue of the crossing over of the antenna conductors on the bases to which said conductors are affixed.

4. A collapsible and foldable log-periodic antenna structure comprising:

a pair of triangular base structures of relatively rigid insulative material arranged in a generally pyramidal configuration, each of said pair of base structures having score lines thereon to make each base structure foldable along said score lines; and

respective arrays of antenna elements in log-periodic configuration disposed adhesively on mirror image surfaces and in mirror image orientation respectively on said triangular base structures.

5. A collapsible and foldable insulative antenna structure comprising:

a scored and foldable base means having a pair of oppositely tapered scored and foldable base elements having slots in predetermined locations to permit interfitting of said base elements in a criss-cross configuration; and

antenna element means disposed on one surface of said base elements whereby a converging triangular antenna is formed by the zig-zag of said antenna element means disposed on said base elements criss-crossing one another.

6. An antenna structure comprising:

a first relatively rigid scored and foldable supporting cardboard base of generally triangular configuration;

a second relatively rigid scored and foldable supporting cardboard base of generally triangular configuration;

a first array of antenna conductors adhesively disposed upon said first triangular scored and foldable supporting base; and

a second array of antenna conductors being disposed in mirror image relation to that of the elements of said first array and being adhesively disposed on said second triangular scored and foldable supporting base,

said first and said second triangular foldable supporting bases being connected together with interfitting units so as to form a multi-element antenna array wherein said base elements thereof may be folded to a small size for storage and shipment thereof and which when erected may be located in areas to which access entry is of limited size by being brought into said area in the folded condition thereof through said limited size access entry.

7. A collapsible and foldable antenna array comprising:

a foldable, relatively rigid cardboard base structure including upper and lower mirror image, relatively rigid, scored and foldable base units;

antenna elements adhesively disposed, respectively, on each of said base units;

said antenna elements being arrayed in mirror-image relationship on said respective base units in the form of a zig-zag, crossed, log-periodic antenna; and

respective spacers of increasing length interfitted with said base units to hold said mirror image base units apart to form said base units into a converging pyramidal array.

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