Fig. 1

Fig. 2

A-B

Fig. 2A

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This invention is a continuation-in-part of my co-pending application Serial No. 223,852, filed September 14, 1962, now abandoned.

This invention relates to an improved dipole antenna structure and particularly to micro-wave antenna arrays which are light, rugged and compact.

Large antenna systems, especially those for approximate or full circular radiation are generally constructed from a plurality of equal elements of relatively small size which are called antenna fields. This method of construction has the advantage that the antenna field can be manufactured on a large scale and thereby at relatively favorable prices. An antenna field of usual construction consists of a certain number of dipoles, usually in tubular form, which are fed in accordance with a method which is called the "band-antenna method." In this case pairs of adjacent dipoles are connected in parallel through feeder lines, the center point of which, for the assembly of two such double groups, is connected to a further feeder line. By repeating this method, eventually all dipoles of the field, usually four or eight dipoles, will be fed through feeder lines of equal length. Since the individual line groups are arranged at a predetermined distance from each other in order to exclude mutual coupling, the broad-band method requires that the lines be disposed in a corresponding plurality of different planes.

For the economic manufacture of antenna fields, it has been proposed to arrange band shaped dipoles on a supporting base or plate of insulating material. In broad-band feeding, therefore, this always had the disadvantage that only the feeder lines serving for the immediate connection of the dipoles could be disposed on the insulating plate. Each of the other line groups, would require an additional insulating plate unless the other feeder lines were arranged in the usual manner; this, however, led to mixing the different manufacturing methods which was found to be unsound construction-wise.

FIG. 1 shows a known antenna arrangement where the band shaped radiators and feeder line systems 2 and 3 are arranged on both sides of an insulating plate 1. This arrangement could not be applied to antenna fields even though the resulting operating frequency range could have been sufficient in most cases, and this in spite of the omission of broad-band feeding. This known system was not found suitable for antenna fields because in order to obtain special radiation properties (at least approximate radiation freedom in directions perpendicular to the direction of the main beam) and also in order to obtain proper impedance matching, it is always desirable to arrange adjacent radiators at a distance of about half of a wave length. In addition, it is necessary to feed the dipoles of such an antenna field at least approximately at equal phase; otherwise the direction of the main beam would be displaced. This latter condition, however, could not be fulfilled in the normal arrangement of FIG. 1 because insulating materials such as required for the making of plate 1 had a dielectric constant far in excess of the required value 1, and mostly of the order of magnitude of 2 to 6. Thus, it was not possible, even approximately, to obtain the desired phase rotation of 180 degrees, as required for the desired equal phase relationship, due to the alternating arrangement of the dipoles; the values obtained were at least at 270 degrees or even very much higher; with the result that the radiation maximum would have been displaced in a manner wholly inadmissible for antenna feeders.

There are the known antenna fields where at least two dipoles form a radiator group and are connected by means of band shaped feeder lines and where the individual radiators of each dipole are arranged in an alternating sequence on different sides of an insulating supporting base.

In accordance with the invention, these defects are eliminated by providing an insulating body, preferably of plastic foam, having a dielectric constant approximately corresponding to that of free space. The propagation speed along feeder lines arranged on such an insulating body corresponds practically to that of free space. At the same time, dipoles fed from such lines and spaced 1/2 wave length apart, produce a phase rotation of 180 degrees, thereby insuring the desired equal phase relationship of all the dipoles.

The arrangement in accordance with the invention has the further advantage that, while the radiators forming a dipole are unavoidably displaced by the wall thickness of the insulating body, this displacement will practically not affect the radiation diagram, provided the insulating body has a dielectric constant comparable to that of air.

In a further embodiment of the invention, the individual radiators can be formed in a particularly favorable manner, especially suitable for broad-band matching, such as in the form of short plates or sheets having rectangular, semi-circular, or club shaped cross sections. Up to now such shapes could hardly be applied to the usual tubular radiators because of manufacturing cost and weight involved.

In accordance with the invention, the plane dipoles and their wiring connections can be inserted in recesses or grooves of the insulating body, corresponding to the contours of the connecting parts.

The metal parts can be applied to the insulating body by gluing or embedding. In case the metal parts are to be inserted in prepared recesses of the insulating body, portions of the recesses which are not filled with the metal parts can be filled up with insulating material. For this purpose, preferably, the same material can be used as for the insulating body itself. Furthermore, a positive grip can be achieved between the insulating body and the metallic radiator and feeder line parts by arranging boreholes in the metal parts. These holes permit the insulating material to penetrate the hole during its formation from one side forming a mushroom shaped anchoring on the other side of the hole.

In accordance with another embodiment of the invention, the dipoles and/or feeder bands can be connected with the insulating body by means of locking flaps provided on dipoles and/or feeder bands and passing through the insulating body. It has been found that, in a plane dipole or feeder band the contour lines control the electric properties, provided they are made sufficiently broad; openings or the like arranged within the plane do not noticeably affect the electric properties. For this reason, it is without substantial effect upon the electric properties of the antenna field, if, in accordance with the invention, U-shaped slots are provided on suitable points of the plane dipole, and if the fixation of the dipole radiators on the insulating body is effected by means of locking flaps.

As a further embodiment of the invention, instead of cutting or stamping the required metal parts, as assumed
above, from corresponding metal foils or metal plates, the desired forms are printed on insulating sheets by means of electrically conducting paint, or etched on insulating material provided with an appropriate metal coating. In the application of this process, usually sheets are attached to the insulating body with the metallized surfaces facing each other, which results in the above mentioned favorable electric properties.

It is also possible, however, to arrange the metallized surfaces on non-conducting sheets facing to the outside. The result is a sheeted dielectric with propagation velocity properties sufficient for most practical requirements, provided the wall thickness of the insulating body can be made large compared to that of the non-conducting sheets additionally applied thereto. These additional non-conducting sheets can be attached in accordance with all of the above mentioned processes. In addition, metallized foils of the self-sticking type can be used.

While insulating materials with a dielectric constant comparable to that of air are of extraordinarily light weight, they can be applied with large wall thickness and therefore provide a relatively high mechanical strength. Their surface hardness, however, may not yet be suitable for all practical requirements. In accordance with the invention, therefore, the insulating body is provided with a synthetic cover sheet which softens its surface. Such a synthetic cover is applied, preferably, after the metal parts have been attached to the surface of the insulating body. Since such layers can be applied with relatively small wall thickness, the electric properties of the systems are not noticeably affected.

In case an antenna field is applied as a unidirectional radiator and a reflector is used, the insulating body can also be arranged in accordance with the invention, in tub shape, with the reflector as a stable unit. The metal parts forming the radiator system can be grounded with the aid of metallic supports engaging the individual radiators at voltage minima. In most cases it is sufficient to provide these metallic supports for immediate connection with those radiators only which are attached to the side of the insulating body facing the grounding plane and, normally, the reflector.

A far reaching compensation of radiation asymmetries such as caused for example by a symmetrization arrangement of insufficient bandwidth, can be achieved in accordance with the invention by arranging the dipoles symmetrically, with respect at least to one central axis of the insulating body. For example all the radiators can be fed in common through the center of the plane determined by the insulating body and, in this case, it is advantageous to dispose the dipoles in mirror symmetry with respect to a line parallel to the dipoles and passing through the feeder point. As a result, the radiators arranged immediately at the feeder point as far as connected to one branch of the feeder will, extend to the same side. Similar considerations apply to the farther removed radiators. This arrangement produces a far reaching compensation of any existing asymmetries in all planes.

As a further embodiment of the invention, the insulating body can be provided with stiffening ribs, one extending preferably perpendicular to the plane of the radiators and carrying a symmetry translator formed for example as a printed circuit. This translator can serve to connect the plane of the radiators and that of the reflector.

In the case above mentioned galvanic grounding of the radiator elements should not be sufficient, the antenna field can be protected against lightning by means of a metal strap arranged preferably in front of the radiator plane. In such an arrangement the metal strap remains without noticeable effect upon the radiation properties of the field, provided the principal direction of its extension is perpendicular to the direction of polarization.

These and other objects of the invention will be more fully apparent from the drawings annexed herein in which:

FIG. 1, as already stated above, represents a known antenna arrangement.

FIGS. 2A, 2B and 2C represent an antenna support embodying certain principles of the invention in the forms of a tub shaped insulating body, in three cross sections, respectively, perpendicular to each other.

FIG. 3 shows a top view on an antenna field in accordance with the invention provided with locking flaps.

FIG. 4 shows, in perspective, part of such a locking flap.

FIGS. 2A, 2B, and 2C show a tub shaped insulating body 4 consisting of suitable insulating material, for example polystyrol foam. Insulating body 4 is provided, on two opposite front faces, with beveled surfaces 5, 6. Surfaces 5 and 6 serve to insert the insulating body grippingly in a reflector of corresponding shape. This results in a stable unitary structure. Other bevels 7 and 8 serve to receive an additional ice protection tub 9, schematically indicated in FIG. 2B, such as required, for example, in cases where the system is exposed to particularly severe weather conditions, and especially icing. Ice protection tub 9 is preferably so shaped as to provide a clearance to be maintained with the outer space. In this way, the effect of eventual ice formation is reduced. Insulating body 4 has recesses 11, 12 formed exactly in accordance with radiator and feeder line parts to be inserted. The dipoles shown each consist of two radiators which are of triangular shape and, therefore, of large bandwidth; one radiator being attached to each side of the insulating body. For example, radiator 13 is attached to the outer surface and radiator 14 to the inner surface of insulating body 4. Radiators arranged in one and the same plane, for example situated on the outer or on the inner surface of insulating body 4, are connected through band shaped conductors so that two conductors are arranged on the two sides of the insulating body facing each other to form a symmetrical twin line. The radiators attached to the inner surface of insulating body 4 are connected in pairs to conductors 15 and 16 and together with the corresponding opposite radiators form a twin system. Each twin system is connected to the common feeder point 17 through lines 18 and 19, respectively. Lines 15 and 16 on the one side, and lines 18 and 19 on the other side, are dimensioned in accordance with the required impedance. Since the twin systems have a lower impedance as compared to the dipoles, wider conductors are here applied. In order to facilitate connection between feeder point 17 and the connection (not shown) to the symmetry translator, insulating body 4 is provided with openings or holes 20 and 21. In order to compensate for eventual asymmetries of the radiation conditions, radiators 22 and 23 adjoining common feeder point 17 are directed to one side and the radiators following at the outside are directed to the other side. By the orientation of an equal number of radiators on each surface of the insulating body 4 towards one and the other side, asymmetries are compensated in the plane parallel to the main electrical axis of the dipoles, for example 26, and perpendicular to the plane determined by the radiators. Since twin systems 24 and 25 are arranged in mirror symmetry with respect to the field center, the radiation diagrams are compensated in a plane orthogonal to the above mentioned plane as well as to the plane determined by the radiators. There exists, therefore, a compensation of the radiation conditions in both principal planes (for example, horizontal and vertical diagrams).

In the antenna arrangement shown in FIG. 3 radiators 33, 34 connected by band lines 32, are connected by a positive lock or grip with insulating body 31 and this, in accordance with the invention, by means of locking flaps 35. For a well defined fixation, preferably, each radiator is provided with three locking flaps. The position of the
locking flaps on the radiators depends on the form of the radiators. In the example shown in FIG. 3, triangular radiators 33, 34 are each provided with three locking flaps 35 arranged in the corners of the radiators. Locking flaps are preferably made from the plane-shaped metallic radiator, for example by stamping.

As apparent from FIG. 4, radiators 33, 34 have U-shaped incisions 36, and flaps 37, formed thereby, and bent out of the plane of the radiator. Locking flaps 37, for example, are bent up perpendicularly to the plane of the radiator and can be pushed without further machining through insulating body 31, provided the metal foil making up the radiator is sufficiently stiff. However, penetration of the insulating body can be facilitated by tapering the locking flaps, for example in such a way that the bases of U-shaped incisions 36 are more pointed. On thermoplastic insulating bodies, the penetration of the locking flaps can be facilitated by heating the metal foil.

In cases in which the insulating body is specially shaped, for example as part of a tub or the like, corresponding recesses can be provided in the manufacture of the body to permit penetration of the locking flaps. Such recesses can also be provided afterwards by means of a suitable tool, which may be heated if necessary.

The locking flaps are finally fixed on the side of the insulating body away from the plane shaped dipole by either turning the projecting ends of the locking flaps as indicated for example in FIG. 3 at 38 or bending over the projecting ends of the locking flaps as shown for example in FIG. 3 at 39. In order to strengthen the connection and secure it against loosening, locking flaps 37 can be incised at their ends as indicated for example in FIG. 4 at 40. In this case, the two halves 41, 43 of the locking flap are bent over in opposite directions on the back of the insulating body as indicated in FIG. 4 at 33.

In a similar manner, band lines 32 can also be attached to the insulating body by means of locking flaps 35. In order to prevent the bent-over ends of the locking flaps from projecting from the back of the insulating body and to avoid eventual contacts with other radiator parts, the insulating body can be provided with recesses 44 at points surrounding the ends of the locking flaps. In order to prevent the locking flaps from touching the band lines arranged underneath, the two band lines can be displaced with respect to each other.

The invention is not limited to the shape, type, or construction of insulating body, radiator, and feeder lines shown and described, nor to their relative arrangement, attachment, and connection, but may be applied in any appropriate manner or form whatever without departing from the scope of this disclosure.

We claim:

1. An antenna structure comprising a homogeneous rigid foamed plastic planar member having a dielectric constant comparable to that of free space, a first longitudinally extending conductive strip feed means secured to one side of said planar member, a first plurality of plane shaped triangular dipole elements secured to one side of said planar member and having one vertex coupled to said first feed means at a distance along its length of the average operating wave length, a second longitudinally conductive strip feed means secured to the opposite side of said planar member and coextensively parallel to said first feed means, a second plurality of plane shaped triangular dipole elements secured to the other side of said planar member and having one vertex coupled to said second feed means at a distance along its length of the average operating wave length, and locking flaps bent out of the plane of said dipoles and said feed means so that the flaps penetrate through the planar member and are bent over on the opposite side of said member.

2. An antenna system comprising a homogeneous rigid foamed plastic planar member having a dielectric constant approximating that of free space, the planar member having two opposite parallel faces each of which has secured thereto one of identical twin halves of an antenna array, each of the twin halves of the antenna array including a conductive line member extending longitudinally on the adjacent face of the planar member and including also a plurality of radiating elements extending transversely from each side thereof on that face, the two radiating elements closest to the midpoint of the conductive line member in each twin half of the array extending to one side of the line member and the two next closest radiating elements to the midpoint of that line member extending to the opposite side thereof, the plurality of radiating elements on the opposite faces of the planar member together forming a like plurality of dipoles, each dipole consisting of one of the radiating elements in each twin half of the array, and the conductive line members on the opposite faces of the planar member together forming a transmission line thereto.

3. The antenna system according to claim 2 wherein each of the twin halves of the antenna array is embedded in the rigid foamed plastic planar member and said member is recessed to accommodate each of said twin halves of the antenna array.

4. The antenna system according to claim 2 wherein each of the twin halves of the array contain the same even number of radiating elements.

5. The antenna system according to claim 2 wherein the plurality of radiating elements in each twin half of the antenna array is interconnected by the line member of the corresponding half of the array.

6. The antenna system according to claim 2 wherein the respective conductive line members are parallel to one another and are separated only by the thickness of the planar member.

7. The antenna system according to claim 6 wherein the midpoints of the line members are juxtaposed on the opposite faces of the planar member.

8. The antenna system according to claim 2 wherein the radiating elements are triangular radiating elements interconnected to the conductive line member at a vertex of each and having a side edge parallel to the longitudinal extent of the line member.

9. The antenna system according to claim 2 wherein the rigid foamed plastic is polystyrol.

References Cited by the Examiner

UNITED STATES PATENTS

2,431,124 11/1947 Kees et al. 343—789 X
2,552,816 5/1951 Root 343—795
2,664,507 12/1953 Mural 343—795
2,673,931 3/1954 Stevens 343—795
2,736,894 2/1956 Kock 343—753
3,005,986 10/1961 Reed 343—708 X
3,110,030 11/1963 Cole 343—792.5
3,177,491 4/1965 Rateau 343—798 X

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