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BROADBAND ANTENNA

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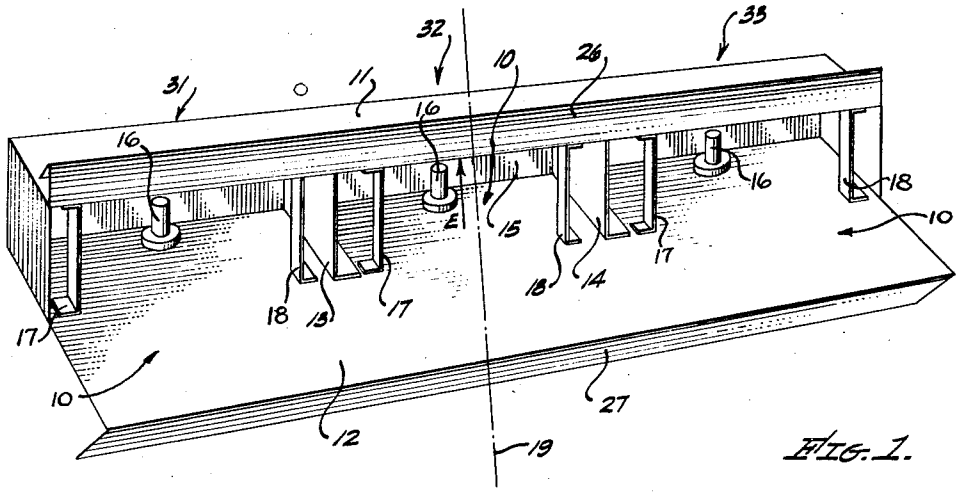


FIG. 1.

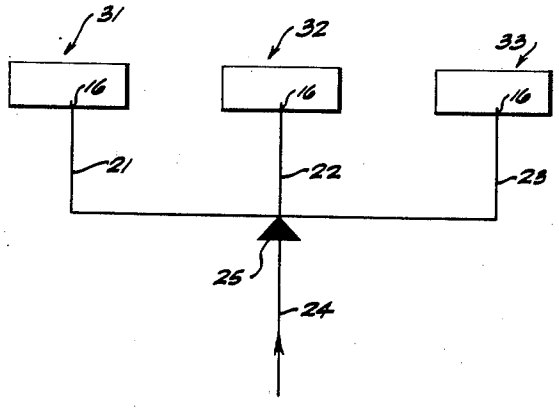


FIG. 2.

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BROADBAND ANTENNA

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6 Claims. (Cl. 343—770)

This invention relates to antennas, and, more particularly, to a linear array of radiating elements for operation over a relatively wide band of frequencies.

As is well known, an antenna comprising a linear array of individual radiating elements is often used to form a beam of radiant energy which is most narrow in a plane parallel to the axis of the array. The length of the array, that is, the aperture of the antenna, determines the minimum beam width obtainable whereas the spacing of the elements and their manner of excitation determines the magnitude and distribution of secondary beams or side lobes. In an antenna of this type it is required that adjacent elements be spaced from each other a distance less than one wavelength in order to form a single primary beam, with the result that mutual coupling between individual radiating elements may be relatively high. Consequently, the impedance of an element in the array is caused to differ substantially from the impedance of the same element when operated by itself. In general, this effect presents little difficulty when a large number of elements is used and the frequency of operation is substantially fixed. If the antenna is to be operated at substantially different frequencies, however, the mutual coupling and therefore the impedance of the radiating elements will change appreciably from one frequency to the next. Thus, it is desirable to minimize mutual coupling in this case so that the antenna impedance will remain more nearly constant over the band of operating frequencies thereby permitting a more perfect match to be obtained between the antenna and its associated transmission line.

Patent No. 2,615,132, entitled "Directive Broad Band Slot Antenna System," issued October 21, 1952, on the application of Victor H. Rumsey (June 5, 1946, Serial No. 674,437) discloses an antenna comprising a linear array of radiating elements operating in accordance with the slot principle. As pointed out in the patent, this type of antenna is particularly suited for wide band operation because of the small amount of mutual coupling present. To further reduce mutual coupling and also to provide individual elements having superior impedance characteristics in themselves, the present invention discloses an antenna comprising a linear array of improved slot-type radiators. Consequently, the antenna according to the present invention may be more closely matched to its associated transmission line over a broad band of operating frequencies.

It is an object of this invention, therefore, to provide a linear array of improved slot-type radiating elements.

It is another object to provide an antenna having a substantially constant input impedance over a wide band of frequencies.

It is still another object to provide slot-type radiating elements which are particularly adapted for operation over a wide band of frequencies.

It is a further object to provide a slot-type radiator configuration that is less critical as to dimensional variations thereby facilitating its manufacture.

The novel features which are believed to be characteristic of this invention, both as to its organization and method of operation, together with further objects and advantages, thereof, will be better understood from the following description considered in connection with the accompanying drawing in which:

Fig. 1 is a perspective view of an antenna in accordance with the invention;

Fig. 2 is a schematic diagram of a transmission line system suitable for feeding the antenna illustrated in Fig. 1.

With reference to Fig. 1, there is shown by way of illustration an antenna consisting of a three-element array of radiators **31, 32, 33** in accordance with the present invention. As seen in Fig. 1, each of the radiators **31, 32, 33** comprises a rectangular box or duct **10** having broad top and bottom walls **11, 12**, narrow side walls **13, 14**, and a back wall **15** closing one end of the duct **10**. The spacing between side walls **13, 14** is approximately .8 wavelength in free space while the spacing between top and bottom is approximately .3 wavelength in free space. Top wall **11** is extended a short distance beyond side walls **13, 14** and twice folded backwardly as shown in Fig. 1. Similarly, bottom wall **12** is extended beyond walls **13, 14** a substantial distance and also bent back at an acute angle. By means of these bends, chokes **26** and **27** are formed along the top and bottom of each duct **10** to minimize radiation in a backward direction.

The open end of duct **10** provides a rectangular aperture which may be excited with electromagnetic energy wherein the electric vector E extends between the top and bottom walls **11, 12** parallel to the side walls **13, 14**. To excite the aperture in this manner, a probe **16** is inserted into each of the ducts **10** through bottom wall **12** and disposed parallel to side walls **13, 14**. Probe **16** is located at a point remote from the aperture and equidistant from side walls **13, 14**. Connected between the top and bottom walls **11, 12** of each duct **10** and disposed parallel to side walls **13** and **14** is a pair of conductive straps **17** and **18** which provide inductive reactance. Straps **17** and **18**, which are in the form of ribbon-like structures each having a width which is substantially greater than its thickness, are positioned at the aperture of each duct **10** approximately one-fourth wavelength either side of a line **19** vertically bisecting the aperture, and have a width which is less than one-tenth wavelength in free space.

By placing each of the ducts **10** side by side, there is formed an exemplary three-element array according to this invention. As shown in Fig. 1, the top, bottom and back walls **11, 12** and **15**, respectively, of each duct **10** may comprise single sheets of conductive material. Similarly, the adjacent sides of the ducts **10** may be formed with a common conductive wall so that side walls **13, 14** associated with radiator **32** also serve as side walls **14, 13** associated with radiators **31, 33**, respectively.

Fig. 2 illustrates schematically a system of transmission lines suitable for feeding the antenna described in Fig. 1. As seen in Fig. 2, individual radiators **31, 32, 33** are fed by branch transmission lines **21, 22, 23**, respectively, which terminate in the probes **16**. Branch transmission lines **21, 22, 23** are, in turn, connected to a main transmission line **24** which is supplied with electromagnetic energy. If identical transmission lines are used throughout, it will be necessary to provide a matching section **25** at the junction of lines **21, 22, 23, 24** for matching the impedance of the main transmission line **24** to the impedance of the parallel combination of branch transmission lines **21, 22, 23**. As is apparent, this method of feeding the antenna is illustrative only, since the feeding arrangement utilized will to some extent depend on the radiation pattern which is desired. That is to say, the

radiation pattern of the antenna as a whole depends upon the relative amplitudes and phases of the energy contributed by the radiators which, in turn, may be controlled most conveniently by the design of the feed system in accordance with well known principles.

The operation of any one of the radiators **31, 32, 33** is as follows. Straps **17** and **18** divide the aperture of the duct **10** into three regions, each of which may be regarded as a slot. Owing to the one-half wavelength separation of straps **17** and **18**, the central region, that is, the region bounded by top wall **11**, bottom wall **12** and straps **17, 18** is substantially resonant. Thus, probe **16** produces electromagnetic waves within the duct **10** which radiate from the central region. The two outer regions, on the other hand, are highly inductive and do not radiate an appreciable amount of electromagnetic energy since the distances between strap **17** and side wall **13**, and strap **18** and side wall **14** are substantially less than one-half wavelength in free space. By minimizing radiation from the sides of the aperture, the amount of mutual coupling between adjacent radiators is correspondingly reduced, thereby improving the impedance characteristics of the antenna as a whole. In addition, straps **17, 18** also serve as inductances which improve the antenna impedance characteristics still further by compensating the individual radiators **31, 32, 33**. That is to say, straps **17, 18** do not act as pure inductances, but rather provide an amount of inductive reactance appropriate to compensate for the reactive components of the individual radiator impedances at all frequencies within a relatively broad band. Thus the straps perform two functions each of which contributes to the desired result, namely, the provision of an antenna having a substantially constant impedance over a relatively broad band of frequencies.

These facts are best evidenced by the voltage standing wave ratio measured at the branch transmission lines. In particular, an antenna comprising a three-element array of radiators in accordance with this invention, as illustrated in Fig. 1, and operated at frequencies in the range between 950 and 1150 megacycles produced a standing wave ratio on each branch transmission line **21, 22, 23** which did not exceed 1.15. It should also be noted in this regard that the impedance characteristics and also the radiation pattern of the antenna of this invention remain substantially the same even though the dimensions of the antenna structure are changed considerably. Thus the antenna may be readily duplicated without the need for close manufacturing tolerances and their attendant high cost.

Therefore what is claimed is:

1. In a box-type radiating element having a rectangular aperture formed in part by upper and lower elongated walls supported in spaced opposition and in parallel planes and having a probe supported by one of said walls for exciting the aperture with electromagnetic waves, a pair of substantially rectangular conductive straps each having a width which is substantially greater than its thickness, said straps being connected across the upper and lower walls of the aperture with their widths parallel to the vertical axis of the aperture and perpendicular to the direction of elongation of the aperture, each of said straps being spaced from the center of the aperture a distance of approximately one-quarter wavelength in free space to maintain the impedance of the radiating element substantially constant over a wide band of operating frequencies.

2. A radiator of electromagnetic waves comprising an apertured structure shaped substantially in the form of a rectangular duct having two broad walls, two narrow walls, and a back wall closing one end of the duct, a probe within said apertured structure for producing electromagnetic waves wherein the electric vector extends between said broad walls parallel to said narrow walls, said probe being located adjacent said back wall and equidistant from said narrow walls, means for coupling said probe to a source of electromagnetic energy, and a pair of substantially rectangular conductive straps each having a width which is substantially greater than its thickness, said straps being connected across the mouth of said apertured structure, with their widths being parallel to the narrow walls of said structure, said straps being equally spaced from the respective narrow walls and separated across the mouth of the aperture by a distance of approximately one-half wavelength in free space, thereby minimizing electric fields in the vicinity of said narrow walls and providing inductive reactance to compensate for variations in the impedance of said apertured structure with variations in the wavelength of said electromagnetic waves.

3. In an antenna of the type which comprises a series of rectangular ducts, each closed at one end and open at the other end to form a series of rectangular apertures, and each including a probe for exciting the apertures with electromagnetic waves wherein the electric vector extends between the broad walls parallel to the narrow walls of the ducts; a pair of substantially rectangular conductive straps, the width of each of said straps being substantially greater than its thickness, said straps being connected across each aperture with their widths parallel to the narrow walls of each duct, said straps being equally spaced from the respective narrow walls, and each of said straps within each duct from the other strap in that duct separated by a distance of approximately one-half wavelength in free space, thereby minimizing electric fields in the vicinity of the narrow walls and providing inductive reactance to compensate for variations in the impedance of the antenna with variations in the wavelength of the electromagnetic waves.

4. An antenna comprising a series of rectangular ducts aligned so that the narrow walls of adjacent ones of said ducts are parallel and contiguous, said ducts being closed at one end and opened at the other end to form a series of rectangular apertures, a probe within each duct for producing electromagnetic waves wherein the electric vector extends between the broad walls parallel to the narrow walls of said ducts, said probe being positioned at a point remote from the open end and equidistant from the narrow walls of each of said ducts, means for coupling the probes to a source of electromagnetic energy, and a pair of substantially rectangular conductive straps, the width of each of said straps being substantially greater than its thickness, said straps being connected across the aperture with their widths parallel to the narrow walls of each duct section, said straps being equidistant from said probe and spaced from each other a distance of approximately one-half wavelength in free space, thereby minimizing electric fields in the vicinity of the narrow walls and providing inductive reactance to compensate for variations in the impedance of the antenna with variations in the wavelength of said electromagnetic waves.

5. A radiator of electromagnetic waves comprising an apertured structure shaped substantially in the form of a rectangular duct having two broad walls, two narrow walls spaced from each other a distance in the range between three-fourths and one wavelength in free space, and a back wall closing one end of the duct, a probe within said apertured structure for producing electromagnetic waves wherein the electric vector extends between said broad walls parallel to said narrow walls, said probe being located adjacent said back wall and equidistant from said narrow walls, means for coupling said probe to a source of electromagnetic energy, and a pair of substantially rectangular conductive straps, the width of each of said straps being substantially greater than its thickness, said straps being connected between said broad walls across the mouth of said apertured structure with their widths parallel to the narrow walls thereof, said straps being equally spaced from the respective narrow walls and separated by a distance of approximately one-half wavelength in free space, thereby minimizing electric fields in the vicinity of said narrow walls and providing inductive reactance to compensate for variations in the

impedance of said apertured structure with variations in the wavelength of said electromagnetic waves.

6. In an antenna of the type which comprises a series of rectangular ducts, having transverse dimensions in the order of .3 and .8 wavelength in free space, each closed at one end and open at the other end to form a series of rectangular apertures, and each including a probe for exciting the apertures with electromagnetic waves wherein the electric vector extends between the broad walls parallel to the narrow walls of the ducts; a pair of substantially rectangular conductive straps, the width of each of said straps being substantially greater than its thickness, said straps being connected across each aperture with their widths parallel to the narrow walls of each duct,

said straps being equally spaced from the respective narrow walls and separated by a distance of approximately one-half wavelength in free space, thereby minimizing electric fields in the vicinity of the narrow walls and providing inductive reactance to compensate for variations in the impedance of the antenna with variations in the wavelength of said electromagnetic waves.

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