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COMPOSITE ANTENNA OF THE RETARDED SURFACE WAVE TYPE

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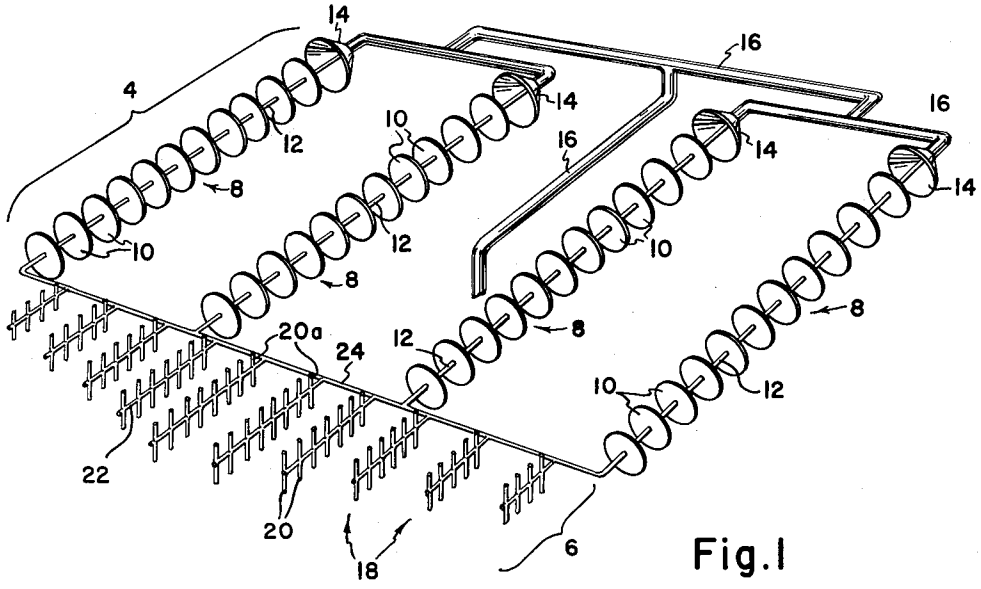


Fig. 1

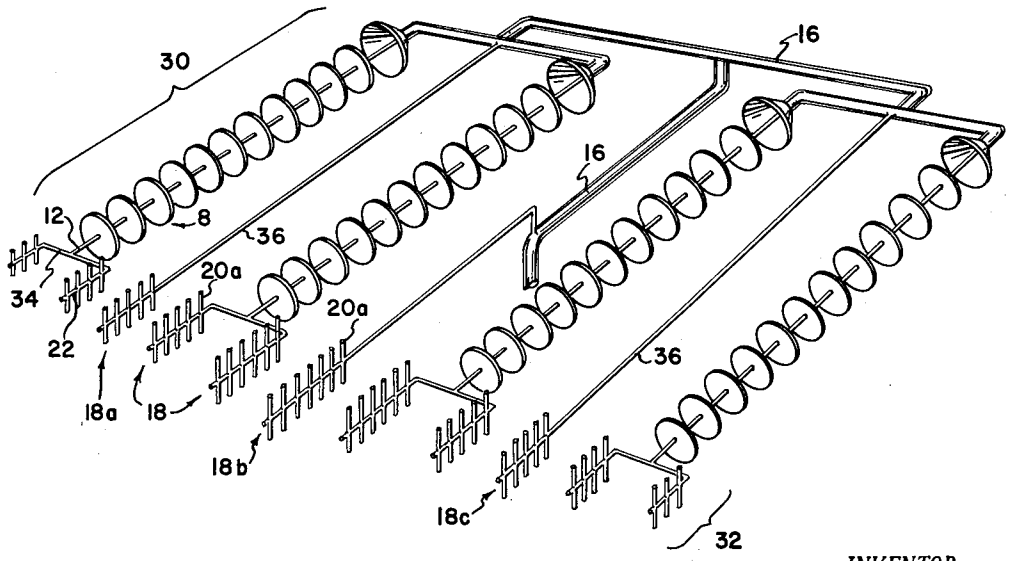


Fig. 2

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COMPOSITE ANTENNA OF THE RETARDED SURFACE WAVE TYPE

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The present invention relates to composite antennas having two or more antenna portions adapted for simultaneous transmission and/or reception of radio signals on different frequencies, particularly within the ultra high frequency range or higher.

It is frequently desirable to have two directional antennas mounted together on a common support. A typical application for such a composite antenna is a radar installation provided with IFF (identification) equipment. As is well known, it is conventional to mount the radar and IFF antennas together for rotation in unison. In most installations, the IFF antenna is mounted above or below the radar antenna. Together they present a rather large and ungainly structure occupying considerable space in the vertical dimension, which is a serious disadvantage in many services, for example, on naval vessels and military aircraft. Moreover, this composite antenna structure is relatively heavy and requires a relatively large and heavy supporting means and powerful rotating mechanism.

I have discovered that a pair of antennas, each comprising a broadside array of endfire elements of the retarded surface wave type may be mounted one immediately in front of the other in the same plane without substantial adverse effect on the operation of either. The individual elements of the two antenna portions, which may be either of the "cigar" or "ladder" type, are each supported on an axial rod, and the supporting rods or tubes of the respective elements of the two antenna portions may be interconnected and mounted on a single supporting and rotating means.

This composite antenna is extremely compact in relation to its performance (gain, beam width and side lobe level). It also is extremely lightweight, and therefore easy to support and rotate. Moreover, it does not involve close dimensional tolerances, and is very inexpensive to manufacture.

In the drawings:

FIGURE 1 is a somewhat diagrammatic isometric view of a composite antenna embodying features of the present invention.

FIGURE 2 is a similar view showing an alternative embodiment of the invention.

The antenna shown in FIGURE 1 comprises two antenna portions, a radar antenna portion **4** and an IFF antenna portion **6**. Each of these two antenna portions **4** and **6** comprises a broadside array of endfire elements of the retarded surface wave type.

In the particular embodiment shown, the radar antenna portion **4** consists of four similar elements **8**, which are of the so-called "cigar" type—that is, each element comprises a series of circular discs **10** coaxially mounted at spaced positions along the length of a central tube **12**. The elements **8** are respectively fed by means of conical horn launchers **14** which are mounted at the rearward end of and coaxial with each element. The elements **8** and launchers **14** are supported by means of a framework of piping **16**, of which the particular structural arrangement shown is merely diagrammatically illustrative. The launchers **14** are fed by means of coaxial transmission line which extends through the piping **16**.

The horn launchers **14** direct the radio frequency energy

along the axes of the respective elements **8**, and the discs **10** serve to retard or confine the wave substantially within the limits of the respective elements, with the energy being radiated from the forward ends of the elements. A more complete discussion of the technical aspects of "cigar" elements and more particularly of the considerations involved in combining such elements in broadside arrays, is set forth in my U.S. Patent No. 2,955,287, issued October 4, 1960.

The IFF antenna portion **6** consists of ten elements **18**, each of which is of the so-called "ladder" type—i.e., it consists of a series of transverse rods **20** mounted in line at spaced positions along the length of a central rod **22**. The rearward end of each of the rods **22** is connected to and supported by a transverse tube **24**, which in turn is connected to and supported by the forward ends of the central tubes **12** of the elements **8** of the radar antenna portion **4**. The rearmost rod **20***a* in each of the elements **18** is fed in conventional manner by means of a coaxial cable which is trained through the transverse tube **24** and through the tubes **12** of the radar antenna portion **4**.

In the alternative embodiment shown in FIGURE 2, the radar antenna portion **30** is electrically similar to the radar antenna portion **4** of the embodiment shown in FIGURE 1, and the IFF antenna portion **32** is likewise similar to the IFF antenna portion **6** of the embodiment shown in FIGURE 1. However, the mechanical arrangement for supporting the IFF antenna portion **32** is different.

In the embodiment of FIGURE 2, at the forward end of the central tube **12** of each of the elements **8** of the radar antenna portion **30** is mounted a short transverse tube **34**, which supports at its outer ends the rearward ends of the central rods **22** of a pair of the elements **18** of the IFF antenna portion **32**. Three of the elements **18***a*, **18***b* and **18***c* of the IFF antenna portion **32** (which are located in the intervals between the four pairs of elements **18** which are supported on the forward ends of the rods **12** of the elements **8** of the radar antenna portion **30**) are mounted at the forward ends of tubes **36** or **36***a*, which extend rearwardly between and generally parallel to the elements **8** of the radar antenna portion **30**, and are supported from the framework of piping **16** which supports the radar antenna portion. The particular structural arrangement shown is, of course, only diagrammatically illustrative. The rearmost rods **20***a* of the respective elements **18** of the IFF antenna portion **32** are fed by coaxial cable trained through the tubes **34** and **12**, or **36**.

Actual tests have shown that the presence of the rods **36** and **36***a* between the elements of the radar antenna portion **30** has no serious adverse effect on the electrical characteristics of the latter portion, but on the contrary in certain types of antennas actually reduces the level of the side lobes in the field pattern thereof.

Although in both composite antennas illustrated in the drawings, the radar antenna portion is shown as having elements of the "cigar" type and the IFF antenna portion is shown as having elements of the "ladder" type, both antenna portions may have elements of either the "cigar" or the "ladder" type, or the radar portion may have "ladder" elements while the IFF portion has "cigar" elements.

In both antennas illustrated, the IFF antenna portion operates at a higher frequency than the radar antenna portion **4** so that the elements of the IFF portion are of smaller physical dimensions than those of the radar portion. It is thus more convenient to mount the IFF antenna portion ahead of the radar antenna portion in order to minimize problems of mechanical support and electrical interference. However, this relationship is not mandatory, and it is also feasible to mount the higher fre-

quency antenna portion to the rear of the lower frequency portion.

In the particular embodiments shown, the lengths of the elements 18 of the IFF antenna portion 6 are tapered from a maximum at the center of the antenna to minima at each side. As is discussed with greater particularity in the aforementioned copending application, this reduces the side lobe level of the IFF antenna. It also gives the forward end of the antenna a rounded conformation so that it may fit snugly within circular radomes, thus minimizing the size of the radome. Or, where the antenna is not mounted within a radome, it minimizes the volume swept by the antenna as it is rotated.

Although the sizes of the transverse components of each element and their spacing along the supporting rod or tube are illustrated as being uniform along the entire length of each element, as will be readily understood by those familiar with retarded surface wave type antennas, the transverse dimensions of the components may be tapered and/or their spacing may be "modulated" or graduated along the length of the supporting rod or tube.

Actual tests have shown that in composite antennas of the type illustrated, although one of the two antenna portions is mounted directly ahead of and closely adjacent to the other, and in the same plane, there is no serious adverse interaction between the two antenna portions. Thus it is possible to provide a dual antenna having two antenna portions operating on different frequencies, in much less space than has been required for a dual antenna system of any type previously known heretofore.

It will therefore be appreciated that the aforementioned and other desirable objects have been achieved. However, it should be emphasized that the particular embodiments of the invention which are described herein and shown in the accompanying drawings, are intended as merely illustrative of the scope of the invention rather than as restrictive of the scope thereof or of the coverage of this patent, which is limited only by the appended claims.

I claim:

1. A dual radio antenna comprising a pair of antenna portions each consisting of a broadside array of endfire elements of the retarded surface wave type, said antenna portions being of the same order of overall width, but one of them having a larger number of elements of smaller physical dimensions at a closer transverse spacing than the other, for operation at a higher radio frequency, the lengths of the elements of the lower frequency antenna portion being substantially uniform, the two said antenna portions being mounted in substantially the same plane, with such higher frequency antenna portion being mounted adjacent to and in front of such lower frequency antenna portion, with both the forward ends of the elements of said lower frequency antenna portion and the rearward ends of the elements of said higher frequency antenna portion being respectively in approximate transverse alignment.

2. A dual radio antenna comprising a pair of antenna portions each consisting of a broadside array of endfire elements of the retarded surface wave type, said antenna portions being of the same order of overall width, but one of them having a larger number of elements of smaller physical dimensions at a closer transverse spacing than the other, for operation at a higher radio frequency, and with the lengths of the respective elements of such higher frequency antenna portion being tapered from a maximum in the central portion of such antenna portion to minima at each side of such antenna portion, while the lengths of the elements of the lower frequency antenna portion are substantially uniform, the two said antenna portions being mounted in substantially the same plane,

with such higher frequency antenna portion being mounted adjacent to and in front of such lower frequency antenna portion, with both the forward ends of the elements of said lower frequency antenna portion and the rearward ends of the elements of said higher frequency antenna portion being respectively in approximate transverse alignment.

3. A dual radio antenna comprising a pair of antenna portions each consisting of a broadside array of endfire elements of the retarded surface wave type, and each having a series of transversely projecting electrically conductive components mounted in alignment at spaced positions along the length of a central rod, one of said antenna portions having elements of smaller physical dimensions at a closer transverse spacing than the other, for operation at a higher radio frequency, and a transverse rod interconnecting the forward ends of the rods of the elements of the lower frequency antenna portion and supporting the rearward ends of the rods of the elements of the higher frequency antenna portion, the two antenna portions extending in opposite directions from said transverse rod but in approximately the same plane.

4. A dual radio antenna comprising a pair of antenna portions each consisting of a broadside array of endfire elements of the retarded surface wave type, and each having a series of transversely projecting electrically conductive components mounted in alignment at spaced positions along the length of a central rod, one of said antenna portions having elements of smaller physical dimensions at a closer transverse spacing than the other, for operation at a higher radio frequency, a transverse rod interconnecting the forward ends of the rods of the elements of the lower frequency antenna portion and supporting the rearward ends of the rods of the elements of the higher frequency antenna portion, the two antenna portions extending in opposite directions from said transverse rod but in approximately the same plane, and a single support connected to the rearward ends of the rods of the elements of the low frequency antenna portion for supporting the entire antenna.

5. A dual radio antenna comprising a pair of antenna portions each consisting of a broadside array of endfire elements of the retarded surface wave type and each having a series of transversely projecting electrically conductive components mounted in alignment at spaced positions along the length of a central rod, one of said antenna portions having elements of smaller physical dimensions at a closer transverse spacing than the other, for operation at a higher radio frequency, the two said antenna portions being mounted in substantially the same plane, with such higher frequency antenna portion being mounted adjacent to and in front of the lower frequency antenna portion, additional rod portions connected to and extending rearwardly from the rods of certain of the elements of the high frequency antenna portion and between and generally parallel to the elements of the lower frequency antenna portion, the rearward ends of the rods of the remaining elements of the high frequency antenna portion being connected to and supported by the forward ends of the rods of the lower frequency antenna portion, and common support means connected to the rearward ends of the rods of the elements of the lower frequency antenna portion and to said additional rods for support of both said antenna portions.

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