May 19, 1959 F. J. H. CHARMAN ET AL 2,887,682

AERIALS

Filed June 13, 1955

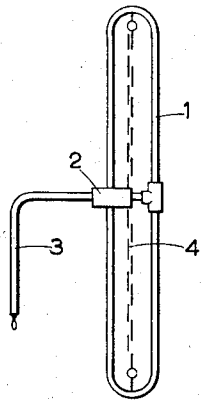


FIG. 1.

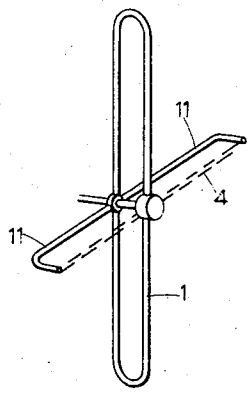


FIG. 2.

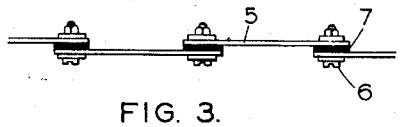


FIG. 3.

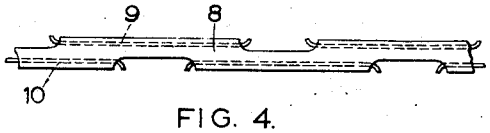


FIG. 4.

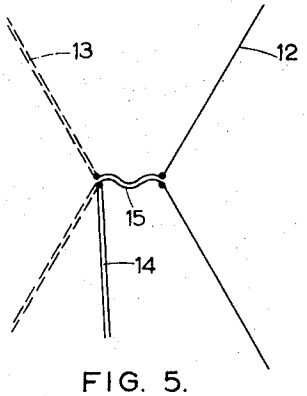


FIG. 5.

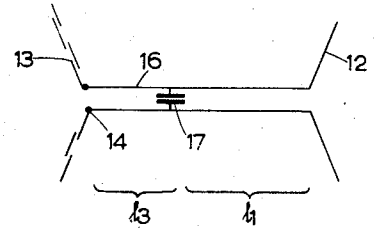


FIG. 6.

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AERIALS

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2 Claims. (Cl. 343—751)

This invention relates to aerials and relates especially to aerial arrangements which are capable of receiving television signals in widely separated frequency bands.

Television programmes are at present radiated in Britain on a carrier wave whose frequencies lie in band I (40–70 mc./s.) but it is now proposed to radiate further programmes on carrier waves having frequencies in band III (174–216 mc./s.) and possibly in bands IV (470–585 mc./s.) and V (610–960 mc./s.). The problem therefore arises of devising a compound aerial which is simple and inexpensive, and can operate in band I and over the whole of, say, band III with preferably a single common feeder.

An object of the present invention is to reduce the aforesaid problem.

According to the present invention there is provided an aerial arrangement comprising two aerials adapted to work in different frequency bands and mounted in such close proximity that cross coupling between the aerials could occur, and wherein one of said aerials is loaded to cause the phase velocity of currents in said aerial to differ from that in the other aerial to such an extent that the cross coupling which would otherwise occur is substantially reduced.

The construction of loaded aerials is described in United States patent application Serial No. 775,783, Patent No. 2,715,184, granted August 9, 1955 and preferably in accordance with the present invention the loaded aerial is a capacity loaded dipole aerial adapted to receive signals in the higher frequency band, and it is suspended on, or in a metal structure which forms the dipole for reception in the lower frequency band.

In accordance with a further feature of the present invention the aerial for reception in the lower frequency band is folded so as to increase its impedance to the same order as that of the loaded aerial and the two aerials can be connected to a single common feeder without impedance transforming means.

While the invention is especially applicable to aerials for receiving television and other high frequency signals, aerials according to the invention may also be used in some cases for transmitting purposes.

In order that the invention may be clearly understood and readily carried into effect, the invention will be described with reference to the accompanying drawings, in which:

Figure 1 illustrates an aerial structure in accordance with the present invention wherein the signals in the two frequency bands have a common polarisation,

Figure 2 illustrates a modification of Figure 1 for use where one of the signals has vertical polarisation and the other horizontal polarisation,

Figures 3 and 4 illustrate suitable constructions for the loaded dipole,

Figure 5 illustrates an application of the invention to a flexible aerial, and

Figure 6 is a detail view of part of Figure 5.

Referring to Figure 1, the aerial arrangement comprises a metal structure which forms a folded dipole 1 adapted to receive television signals radiated on a carrier frequency included in band I. The limbs of the folded dipole are connected within a junction box 2 to the two conductors of a balanced feeder 3 having a characteristic impedance of 150 ohms. The folded dipole may form either an open or closed loop and the folding is arranged to raise its impedance in such a way that it may be connected directly to the balanced feeder. A loaded dipole 4 is suspended within the loop formed by the dipole 1, so as to lie in the plane of the loop and the limbs of the loaded dipole are likewise connected directly to the conductors of the balanced feeder 3. The loading of the dipole 4 is in the form of capacitance distributed at intervals along the wire and it has the effect of increasing the phase velocity of current in the dipole 4 so that waves set up in the loaded dipole 4 have a substantially different velocity from waves set up in the dipole 1. Waves in the two structures 1 and 4 have, therefore, little common ground for interaction and the loaded dipole is very little affected by the close presence of the metal structure which forms the dipole 1. The coupling between the aerials is therefore very small although their proximity is such that the coupling between them would otherwise be substantial. As aforesaid the loaded dipole 4 may be constructed as described in United States patent application Serial No. 775,783 and in one practical form the dipole 4 may be built up of short strips of metal 5 (Figure 3) connected together in succession by bolts 6 and insulated from one another by insulating washers 7. Since the strips 5 overlap the requisite capacity for loading the dipole is provided. An alternative construction for the loaded dipole is illustrated in Figure 4 and according to this construction a conventional balanced feeder 8 is employed comprising two conductors 9 and 10 around which is moulded an insulating covering. Alternate sections of the two conductors are removed leaving overlapping sections which act as capacitors. Alternatively, the sections of conductor which are removed in Figure 4 may be retained in place, since it is found that provided they are severed from the sections which actually form the capacitors, they produce no harmful effect on the performance of the aerial. In one form of the loaded dipole 4, the sections have a length of $\lambda/12$ (that is 30°) and the complete dipole has a length of $3\lambda/2$. The loading is arranged to make X/Z_0 about 0.25, where X denotes the reactance between successive sections and Z_0 the aerial characteristic impedance. The conductors for the loaded dipole may also be formed in the manner described in British patent specification No. 523,060.

The spacing between the front and rear portions of the folded dipole 1 has some effect on the radiation pattern for the loaded dipole 4 and it is found in practice that a 12 inch spacing is satisfactory assuming a band I/band III aerial arrangement. Moreover, the aerials need not be connected directly to the feeder and in some cases transformer coupling may be employed. The feeder 3 may also in some cases be a coaxial feeder and in this case balance-to-unbalance transformation is desirable between the aerials and the feeder.

At the point where the two aerials are connected to the feeder, it is necessary to ensure that energy is not diverted from one aerial into the other. In the case of the higher frequency loaded aerial, this will act as a high pass filter which presents a high impedance at the band I frequencies, and therefore does not accept appreciable energy from the band I aerial.

The band I lower frequency folded dipole should also present a high impedance in band III at the common junction, but because this aerial may have various lengths according to which band I channel it is to receive, it

may not always of itself fulfil this condition. Moreover some leakage of higher frequency energy may occur from the loaded dipole to the unloaded dipole due to stray couplings at the aerial terminals, tending to a reduction of the angle of the main lobe of the radiation pattern for the loaded dipole, and to an increased production of minor lobes. In most cases it is therefore desirable to include in series with the folded dipole some network, such as a suitable length of feeder, or a filter which offers a barrier to band III currents without affecting the operation in band I. When a suitable filter is inserted in this way, substantial reduction in the minor lobes can be achieved and the condition that the minor lobes are a minimum is a sensitive test of the effectiveness of the filter.

Figure 2 illustrates a modification of Figure 1 which is generally similar except for the fact that the loaded dipole **4** is suspended on arms **11** connected to the folded dipole **1** and projecting at right angles to the axis of the folded dipole **1**. This modification allows for the reception of signals by the different aerials having mutually perpendicular polarisations.

Figure 5 shows the application of the invention to a flexible aerial which can be pinned to a wall or hung from the rafters of a roof. The aerial shown in Figure 5 comprises a dipole **12** for receiving signals having frequencies in band I and the loaded dipole **13** for receiving signals having frequencies in band III. The loaded dipole **13** is connected directly to a feeder **14** for feeding the signals to a television receiver whereas a network represented at **15** is interposed between the dipole **12** and the feeder **14**. The limbs of the dipole **12** and of the loaded dipole **13** are angled to form a shallow **V** formation. The angles of the **V**'s are not critical, although the angle in the loaded dipole **13** is preferably selected experimentally to give an optimum compromise between a satisfactory aerial gain and a satisfactory front-to-back ratio. The angle of the dipole **13** may be 120° for example. Moreover, it may be desirable to reduce the factor X/Z_0 for the dipole **13** compared with that required for the cases shown in Figures 1 and 2.

The network **15** is preferably constructed to step up the impedance of the dipole **12** which is not folded in this example, so as to match it more closely to the impedance of **14** which in general will be higher than that of **12**. Preferably, it is also constructed to act as a stopper for frequencies in band III, a stopper for frequencies in band I not being required since the aerial **13** appears as a high pass filter for frequencies in band I, the cut-off of the filter being above band I. A suitable form of network is shown in Figure 6, consisting of a section of a balanced twin feeder **16** the conductors of which are connected at an intermediate point by capacitor **17**. The lengths of the parts of the feeder **16** on either side of the capacitor **17** are denoted by l_1 and l_3 respectively and the length l_1 is chosen in relation to the capacitance of **17** to produce a transformer for transforming the impedance of the aerial **12** to that of the feeder **14**. The impedance of the aerial **12** may, for example, be 70 ohms and that of the feeder **14**, 150 ohms. Moreover, the length l_3 is arranged to be approximately $\lambda/4$ in band III forming with the capacitance of **17** an anti-resonant impedance at the junction between loaded dipole **13** and the feeder **14**. In a practical case l_1 is about 15 inches and l_3 about 12 inches whilst the capacitance of **17** is about 50 micro-microfarads. For frequencies in band III, say in the region of 200 mc./s. the impedance of **17** is only 16 ohms so that the dipole **12** has negligible effect on the performance of the dipole **13** in band III. The isolation between the two aerials can, however, be improved by connecting a second capacitor between the points of connection of the dipole **13** and the feeder **14**, the second capacitor forming with the feeder **16** and capacitor **17** a π-type low pass transformer for frequencies in band I.

In a further form of the invention, each element of the dipole for reception in band I is constructed in the form of a cage of cylindrical or triangular outline in cross-section and constructed of longitudinal spars, the corresponding elements of the loaded dipole being suspended within the respective cages. The arrangement makes use of the fact that a loaded dipole can radiate through openings in a metal structure, because of the difference between the phase velocities of currents in loaded and unloaded conductors. Transforming means for matching the aerials to the feeder can be provided as required.

What we claim is:

1. An aerial arrangement operable in two different frequency bands comprising a folded dipole operable in the lower of said frequency bands and a loaded dipole operable in the higher of said frequency bands, said loaded dipole is suspended within and attached to said folded dipole near the outer extremities thereof and being capacitively loaded to resonate at said higher frequency though having substantially the same longitudinal extent as said lower frequency dipole.

2. An aerial arrangement according to claim 1, said loaded dipole comprises parallel conductors, each conductor being interrupted at intervals, and the interruptions in one conductor being displaced with respect to the interruptions of the other conductor along the dipole, so that successive sections of the two conductors are substantially overlapping.

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