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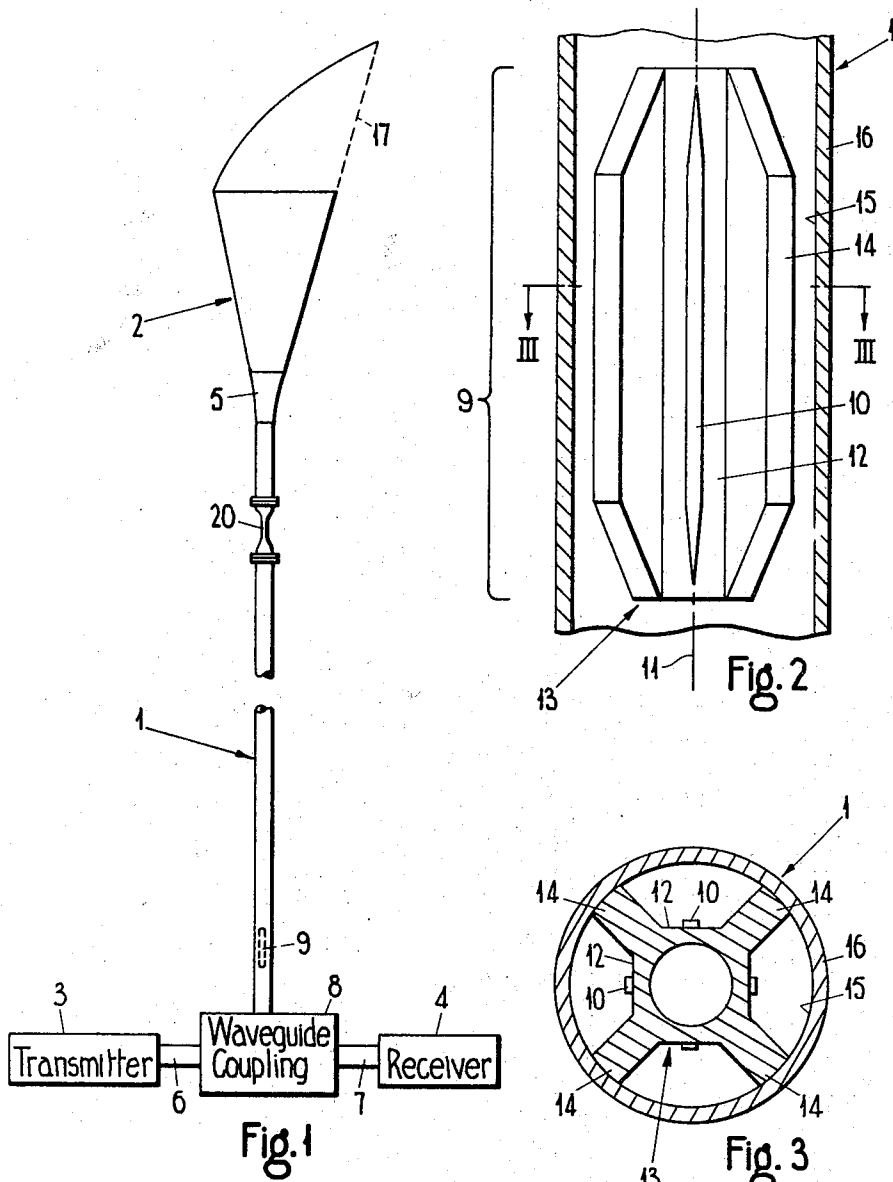
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MODE SUPPRESSING FILTERS IN AERIAL FEEDERS

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Sheet 1 of 2



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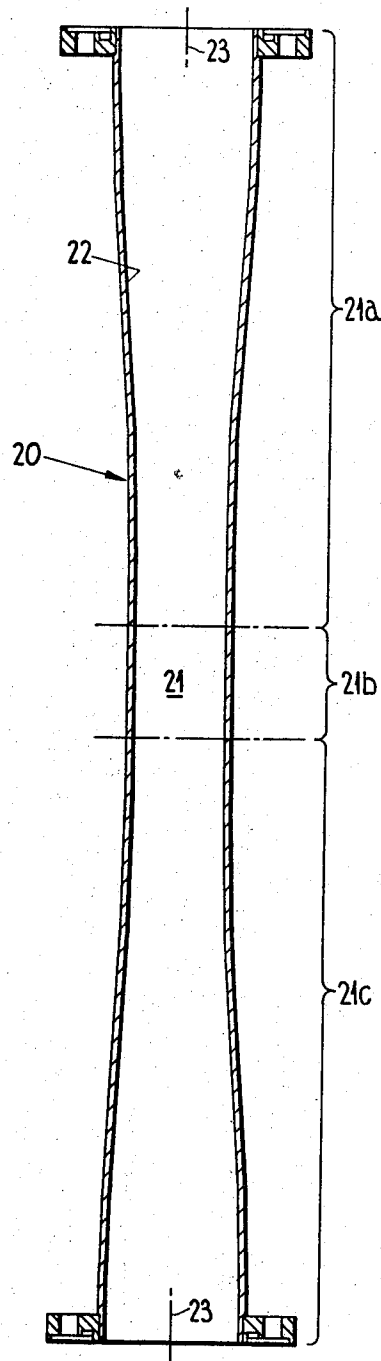


Fig. 4

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MODE SUPPRESSING FILTERS IN AERIAL FEEDERS

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8 Claims

ABSTRACT OF THE DISCLOSURE

In an aerial feeder provided by a waveguide of circular cross-section that is required to pass waves in the dominant H_{11} mode, there are two filters which are located one adjacent each end of the waveguide and which are arranged to pass waves in the dominant mode but to suppress unwanted modes, particularly E_{11} . One of these filters is a portion of waveguides of reduced cross-section to reflect waves of unwanted modes while the other has resistive elements to absorb such waves.

This invention relates to aerial feeders.

It has previously been proposed to utilise a waveguide of circular cross-section as an aerial feeder, the waveguide being arranged to be excited in its dominant (H_{11}) mode. The diameter of the waveguide is conveniently chosen to be somewhat greater than that necessary to propagate in the required mode wave in a particular range of frequencies to be used so as to reduce the attenuation of such waves by the feeder.

In such a waveguide feeder it has now been found that the group delay/frequency characteristic contains ripples which are undesirable when the feeder is of appreciable length, say over 100 feet, particularly if the aerial is a paraboloidal horn (of the general type shown in U.S. patent specification No. 2,416,675) to which the waveguide feeder is connected by way of a suitable waveguide transition. One object of the present invention is to reduce this effect.

According to the present invention, an aerial feeder which is formed at least mainly by waveguide of uniform cross-section has a filter which is arranged during use to pass waves propagated along the rest of the feeder in the dominant (H_{11}) mode but which attenuates waves of the same frequency in at least the E_{11} mode, said filter being formed by a length of waveguide which contains at least one pair of elongated resistive elements which extend longitudinally of said length of waveguide and which lie on diametrically opposite sides of the longitudinal axis of the waveguide. This filter is provided close to one end of the aerial feeder and close to the other end of this feeder a portion thereof is of reduced cross-section, this portion being arranged during use to pass waves propagated along the rest of the feeder in the H_{11} mode but serving substantially to suppress waves of the same frequency in at least the E_{11} mode.

The invention is based on the realisation that the ripples on the group delay/frequency characteristic have, in some circumstances, been in part due to waves in undesired modes (particularly the E_{11} mode) being set up in the feeder as a result of the required waves in the dominant mode. The arrangement set out in the last paragraph is believed to improve the situation.

Radio station apparatus which forms one terminal

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of a point-to-point microwave radio link and which includes an aerial feeder in accordance with the present invention will now be described by way of example with reference to the accompanying drawings in which

5 FIGURE 1 shows the complete apparatus diagrammatically,

FIGURE 2 shows a sectional elevation of a mode suppression filter in the aerial feeder,

FIGURE 3 shows a cross-section at the line III—III in FIGURE 2, and

10 FIGURE 4 shows a sectional elevation of another mode suppression filter in the aerial feeder.

Referring now to FIGURE 1, the apparatus comprises an aerial feeder 1 which carries waves between an aerial 2 on one hand and a radio transmitter 3 and a radio receiver 4 on the other hand. The aerial 2 is a paraboloidal horn aerial (of the general type shown in United States patent specification No. 2,416,675) and is mounted a considerable distance above ground, say on a tower (not shown). The transmitter 3 and the receiver 4 are at ground level so that the feeder 1, which is formed mainly by waveguide of uniform circular cross-section, has a length exceeding 100 feet. The feeder 1 is connected to the aerial 2 by means of a suitable waveguide transition 5 in known manner.

The transmitter 3 and receiver 4 are connected to the waveguide feeder 1 by way of waveguides 6 and 7 of rectangular cross-section and a waveguide coupling 8. The feeder 1 in fact passes waves in the dominant mode (H_{11}) that have two different planes of polarisation inclined at 90° to one another. Waves having these two planes of polarisation are concerned with transmitting and receiving respectively, the waves actually transmitted and received by the aerial 2 through its "window" 17 (shown as a broken line in FIGURE 1) therefore being cross-polarised. The coupling 8 is adapted, in known manner, to provide the necessary coupling between the waveguide 6 and 7 and the feeder 1, the arrangement giving no direct coupling between the waveguides 6 and 7 due to the different planes of polarisation of waves on the feeder 1 to which they are coupled.

Close to the lower end of the aerial feeder 1 there is provided a mode suppression filter 9.

Referring now to FIGURES 2 and 3, the mode suppression filter 9 comprises four elongated resistive elements 10 which are disposed parallel to one another and to the longitudinal axis 11 of the waveguide 16 that constitutes the aerial feeder 1. The four resistive elements 10, which are provided by resistive cards in known manner, are symmetrically disposed around the axis 11. For this purpose the four elements 10 are secured to four planar surfaces 12 respectively of a hollow body 13 of foamed polystyrene, this body having four radial fins 14 (FIGURE 3) and the free edges of these four fins bearing against the inner surface 15 of the waveguide 16 to support the body. The ends of the four resistive elements 10 and of the fins 14 are tapered to reduce impedance discontinuity within the waveguide 16.

The body 13 preferably lies within the waveguide 16 so that opposite pairs of the resistive elements 10 lie in the two previously-mentioned planes of polarisation of waves propagated along the waveguide 16. It will be appreciated that the resistive elements 10 have a negligible effect on the propagation of these waves.

As far as waves in the E_{11} mode which are propagated in the aerial feeder 1 (due to mode conversion either within the feeder or external to it) are concerned, the

resistive elements 10 are disposed in regions of relatively high electric field intensity, the lines of force extending parallel to the axis 11, and accordingly a substantial part of the energy of these waves is dissipated in the resistive elements as heat. The mode filter 9 also serves to attenuate waves in the H_{01} mode.

The aerial feeder 1 is also provided with a mode suppression filter 20 (FIGURE 1) close to the upper end thereof. Referring now to FIGURE 4, the mode suppression filter 20 is formed by a length of waveguide which consists of three portions that are referenced 21A, 21B and 21C respectively, the whole of the waveguide 21 being of copper. The centre portion 21B of this waveguide is of uniform circular cross-section that is somewhat less than the cross-section of the main portion of the waveguide feeder 1. The portions 21A and 21C provide waveguide transitions between the main portion of the waveguide feeder 1 and the portion 21B of reduced cross-section. The inner surface 22 of each of the waveguide portions 21A and 21C is a surface of revolution (about the longitudinal axis 23) of a curve, this surface merging into the main portion of the waveguide feeder 1 on one side and into the waveguide portion 21B on the other side. For this purpose said curve may be of the form $y = AX^5 + BX^3 + CX$, where A, B and C are constants with points of inflexion at the ends of the transition where it meets the main portion of the waveguide feeder 1 and the waveguide portion 21B.

The cross-section of the waveguide portion 21B is such that it is not able to support waves in at least the E_{11} , H_{01} and H_{31} modes having the frequency of waves in the H_{11} mode that are being propagated through the aerial feeder 1 during use. Accordingly any waves of these unwanted modes are reflected by the filter 20.

In one example of the aerial feeder 1 for use in the range of frequencies 5,800 to 6,800 megacycles per second, the internal diameter of the waveguide 16 is 2.812 inches. The overall length of the body 13 of the filter 9 is 6 inches and the distance between each pair of opposing surfaces 12 to which the resistive elements 10 are secured is 1.35 inches. As far as the filter 20 is concerned, the waveguide portion 21B has an internal diameter of 2.046 inches and a length of 4.5 inches. Each of the waveguide portions 21A and 21C has a length of 11.086 inches, the surface 22 thereof being based on a surface of revolution of the curve stated in the last paragraph but one where $A=6$, $B=-5$ and $C=15/8$.

In the absence of the mode suppressing filters 9 and 20, waves of unwanted modes which have different speeds of propagation to the wanted H_{11} mode waves would be set up in the aerial feeder 1 and these waves, possibly after multiple reflections along the feeder 1, would result in unwanted components appearing in the waveguide 7. (As previously mentioned this effect may be seen by the ripples in the overall group delay characteristic of the aerial feeder.)

As far as waves in at least the E_{11} , H_{01} and H_{31} modes that may be produced by waves that are received by the aerial 2 are concerned, these are reflected by the filter 20 back to the aerial 2 and being of very low power are of no subsequent significance. Waves of at least the E_{11} mode that may be produced, say by the coupling 8, as a result of wanted waves supplied by the transmitter 3 over the waveguide 6, are in the main absorbed by the filter 9. Any portion of such waves that are propagated along the aerial feeder 1 are believed to be reflected back by the filter 20 and are then absorbed by the filter 9.

We claim:

1. An aerial feeder comprising a feeder waveguide of uniform circular cross-section, a first mode suppressing filter connected in said waveguide and a second mode suppressing filter connected in said waveguide at a point spaced from the first mode suppressing filter, the first mode suppressing filter comprising a portion of waveguide of smaller cross-section than said feeder waveguide so

that it is arranged to pass waves propagated along the feeder in the H_{11} mode but to reflect waves of the same frequency in at least the E_{11} mode and the second mode suppressing filter comprising a second portion of waveguide, at least one elongated resistive element, and means to mount said element to lie longitudinally within said second portion of waveguide spaced from both the longitudinal axis and the waveguide wall of that portion so as to enable this filter to pass waves in the H_{11} mode but to absorb waves in at least the E_{11} mode.

2. An aerial feeder according to claim 1 wherein the first mode suppressing filter has two waveguide transitions, one on either side of said waveguide portion of that filter, which each merge gradually into the feeder waveguide on one side and into said waveguide portion on the other side.

3. An aerial feeder according to claim 1 wherein the second mode suppressing filter has a pair of elongated resistive elements mounted to lie on diametrically opposite sides of the longitudinal axis of the waveguide portion of that filter.

4. An aerial feeder according to claim 3 wherein the second mode suppressing filter has a second pair of elongated resistive elements which are arranged in the same manner as the previously mentioned pair of elements but are displaced relative thereto round said longitudinal axis by 90° .

5. An aerial feeder according to claim 4 wherein the two pairs of resistive elements are mounted on a common body of dielectric material that is supported within the waveguide portion of the second mode suppressing filter.

6. In a radio station which comprises a paraboloidal horn aerial, a feeder comprising a waveguide of uniform circular cross-section, a waveguide transition connected between said aerial and one end of said waveguide, radio apparatus, and means to couple said radio apparatus to the other end of said waveguide, said feeder also includes first and second mode suppressing filters that are connected in said waveguide each adjacent one end of the feeder, the first mode suppressing filter comprising a first portion of waveguide of smaller cross-section than said feeder waveguide so that it is arranged to pass waves propagated along the feeder in the H_{11} mode but to reflect waves of the same frequency in at least the E_{11} mode and the second mode suppressing filter comprising a second portion of waveguide, at least one elongated resistive element, and means to mount said element to lie longitudinally within the second portion of waveguide spaced from both the longitudinal axis and the waveguide wall of that portion so as to enable this filter to pass waves in the H_{11} mode but to absorb waves in at least the E_{11} mode.

7. Radio station apparatus comprising a feeder waveguide of uniform circular cross-section, an aerial, waveguide connecting means to connect said aerial to one end of the waveguide to enable waves in the H_{11} mode to pass either way between the waveguide and the aerial, a radio transmitter, first connecting means to connect the transmitter to the other end of the waveguide to enable waves in the H_{11} mode to be fed into the waveguide, a radio receiver, second connecting means to connect the receiver to said other end of the waveguide to enable received waves passed along the waveguide in the H_{11} mode to be fed to the receiver, a first mode suppressing filter which is connected in said feeder waveguide between the waveguide connecting means on one side and the first and second connecting means on the other side and adjacent to the end thereof that is connected to said waveguide connecting means and which comprises a portion of waveguide of smaller cross-section than said feeder waveguide so as to pass waves propagated along the feeder waveguide in the H_{11} mode but to reflect waves of the same frequency in at least the E_{11} mode, and a second mode suppressing filter which is connected in said feeder waveguide between the first mode suppressing filter on one

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side and the first and second connecting means on the other side and adjacent to the end thereof that is remote from the aerial and which comprises a portion of waveguide of circular cross-section, a plurality of elongated resistance elements and means to mount said resistive elements to lie longitudinally of said waveguide portion of this filter in a region between the longitudinal axis and the waveguide wall of that portion so as to pass waves in the H_{11} mode but to absorb waves in at least the E_{11} mode.

8. Radio station apparatus according to claim 7 wherein said aerial is a paraboloidal horn aerial.

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