Aug. 16, 1938. W. S. PERCIVAL ET AL 2,127,088

FEEDER AND THE LIKE FOR ELECTRIC CURRENTS OF HIGH FREQUENCY

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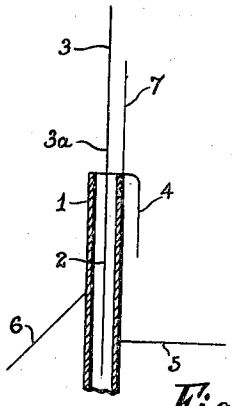


Fig. 1.

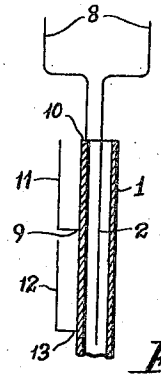


Fig. 2.

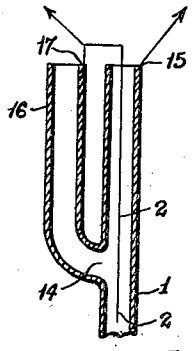


Fig. 3.

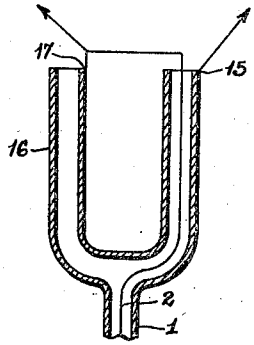


Fig. 4.

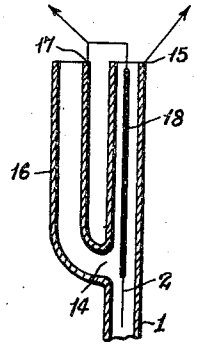


Fig. 5.

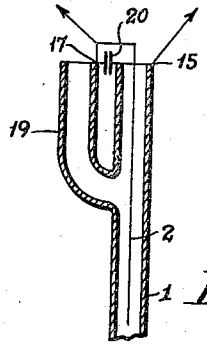


Fig. 6.

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## FEEDER AND THE LIKE FOR ELECTRIC CURRENTS OF HIGH FREQUENCY

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24 Claims. (Cl. 250—33)

The present invention relates to feeders and the like for electric currents of high frequency.

The invention is concerned with feeders and the like of the non-symmetrical kind, such for example as the kind in which one or more conductors are surrounded by an outer conductor in the form of a sheath. The sheath may for example act as one conductor of a two wire feeder or as an electrostatic shield for the inner conductor or conductors.

The present invention is concerned with apparatus in which it is desired to maintain a required distribution of current in a system connected to a non-symmetrical feeder and particularly with the case where the desired distribution is a symmetrical one, as for example in certain aerial systems.

When the sheath of a concentric feeder is used as one conductor of the feeder to transmit current at wavelengths of a few metres it is found that, while the feed current normally flows on the inside of the sheath, currents also tend to flow on the outside.

It is clear that when a feeder is connected to a system with a given current distribution, such distribution may be upset by a current flowing along the outside of the sheath of the feeder. Furthermore, it is difficult to make allowance for this current since the impedance of the outside of the sheath will depend on neighbouring objects, on the length of the feeder, and on any earthing points that may be provided. In the case of a directional aerial system such an undesired current may not only radiate on its own, but, also by upsetting the distribution of currents in the aerial, destroy the required directional characteristics of the aerial.

It is an object of the present invention to provide means for producing attenuation of undesired waves travelling along the outer sheath. For example, where the feeder is used to connect an aerial with a radio receiver, it is an object of this invention to provide means for attenuating undesired waves which may be picked up by the outer sheath in order that such undesired waves shall not reach the ends of the sheath and from thence be radiated on to the aerial at one end or the receiver at the other end.

It is another object of the present invention to reduce the current flowing along the outside of the sheath of a feeder at the operating frequency of the system.

According to the present invention there is provided a feeder for electric currents of high frequency, said feeder comprising one or more conductors surrounded by a conducting sheath and means associated with the sheath whereby the impedance offered to the travel of undesired waves along the sheath is increased, characterized in that said means comprise one or more auxiliary conductors attached at one end to the sheath and having a length substantially equal to one quarter of the wavelength of said undesired waves or to a finite odd multiple of one quarter of this wavelength.

The auxiliary conductor or conductors may comprise one or more pieces of wire or the like and may be attached at one end to the sheath at a suitable point or points therealong, the other end or ends projecting from the cable at right angles or at some smaller angle. Alternatively, the wire or wires may be bent to run parallel with the sheath.

The effect of a piece of wire connected to the sheath as described may be regarded in a number of different ways. Firstly, it may be looked upon as a radiator for the undesired interfering frequency having a low impedance at the point of attachment to the feeder. Secondly, (especially in the case of a quarter wavelength wire attached to one end of the sheath and bent back along it) it may be regarded as transmitting the wave propagating up the sheath back along the wire in contrary voltage phase to the tip of the wire. Thirdly, it may be regarded as a circuit bridged across a part of the sheath, one connection between this circuit and the sheath being constituted by the connection between the wire and the sheath and the other connection being constituted by the capacity between the wire and the sheath.

In another case the auxiliary conductor may be arranged to give to the outer surface of the outer conductor a high impedance at the operating frequency of the apparatus. In another example, the auxiliary conductor has external dimensions substantially equal to those of the outer conductor and serves to render the feeder symmetrical at the end to which the auxiliary conductor extends. With the latter example it can be arranged that any currents flowing along the outer surface of the outer conductor tend to be neutralized by currents in opposite phase flowing along the outside of the auxiliary conductor.

The present invention further provides high frequency electrical apparatus comprising a non-symmetrical feeder having an inner conductor surrounded by an outer conductor and a symmetrical system arranged to feed or to be fed by said feeder wherein means are provided in the

neighbourhood of the end of the feeder coupled to said system for rendering said feeder symmetrical.

The invention will be described by way of example with reference to the accompanying diagrammatic drawing showing various arrangements according to the present invention wherein

Fig. 1 represents a portion of that end to which an aerial is attached of a concentric feeder connecting an aerial to a receiver or transmitter,

Fig. 2 shows a similar portion of a feeder with a symmetrical aerial connected thereto,

Figs. 3 and 4 show further arrangements of the end of a feeder to which a symmetrical aerial may be connected,

Figs. 5 and 6 show modifications of Fig. 3.

Referring to Fig. 1 of the drawing, the feeder comprises a cylindrical metal sheath 1, acting as one conductor, surrounding and co-axial with the second conductor 2. An aerial, a part of which is shown at 3, is connected to the conductor 2. One or more pieces of wire such as 4, 5, 6, each preferably slightly less than one quarter of the wavelength of the undesired waves which it is required to suppress from the sheath are connected at one end to the sheath 1. Any or all of these pieces of wire may be bent to lie parallel to the outer surface of the sheath 1 as shown at 4, or may be arranged to project therefrom at right angles as at 5 or at some intermediate angle as shown at 6.

At least one of the pieces of wire is preferably connected to the end of the sheath nearer the aerial, extends a short distance at right angles away from the sheath and is bent back to run substantially parallel to the sheath as shown by wire 4.

The aerial 3 may be in the form of a straight conductor one half wavelength long connected to the central conductor 2 of the feeder and forming a continuation thereof. An exposed quarter wavelength transformer may be provided in the form of a wire 7 one quarter wavelength long connected to the end of the sheath 1 and extending parallel to the aerial 3. In this case the first quarter wavelength of exposed central conductor 3a co-operates with wire 7 to form the transformer and the aerial 3 may then comprise a further half wavelength of conductor connected to the upper end of the transformer. By this means impedance matching between the aerial 3 and the feeder may be realized.

The presence of the quarter wavelength of wire 4 attached to the end of the sheath 1 and bent back along the sheath serves to reduce the transfer of energy at the undesired frequency from the end of the sheath 1 to the aerial 3. Pieces of wire also having lengths about equal to a quarter of the wavelength of an undesired frequency and connected at one end to the sheath act somewhat as rejector circuits and tend to produce selective attenuation of the unwanted oscillations when these are propagated along the sheath.

One or more wires such as 4, 5, 6 which are attached to the sheath 1 may alternatively have lengths equal to or slightly less than any odd multiple of one quarter of the wavelength of the undesired waves.

In general, the undesired waves will be waves of the same wavelength as the waves being transmitted or received. In some cases however, it may be desirable to suppress the travel along the sheath of other waves. In these cases the procedure is as described above, the length of the auxiliary conductor or conductors being substantially one quarter of the wavelength of the undesired waves, or an odd multiple thereof.

The aerial above described has a transformer in the form of a pair of exposed quarter wavelength conductors. The invention may, however, be applied to aerials having transformers enclosed within shielding. A transformer of this type may comprise a section of feeder of length one quarter of the operating wavelength having a characteristic impedance of suitable value. This length of feeder is usually adjacent the aerial and may or may not have a sheath which is similar to the sheath of the main part of the feeder. Such shielding or sheath may in any case be considered as a continuation of the main shielding of the feeder constituted by the sheath.

The aerial described is a half-wave radiator but any other suitable array, other than an aerial having the same length as the attached wires 4, 5 and 6, may be used in place of this and attached to the upper end of the feeder.

In Fig. 2 the aerial comprises two suitably spaced vertical conductors 8, one connected to the inner conductor 2 and the other to the outer conductor or sheath of the feeder. In this arrangement there is connected to the outer surface of the sheath 1, at a point 9 distant one quarter of the operating wavelength, or preferably slightly less than this, from the end 10 of the feeder adjacent the aerial, an auxiliary conductor 11 which may be in the form of a wire and which projects outward substantially normally to the outer surface of the sheath and is bent over to lie parallel with the surface of the sheath and to run parallel with the length of the feeder close to the feeder but spaced therefrom. This conductor is arranged to extend substantially to the end 10 of the feeder adjacent the aerial.

If desired a second auxiliary conductor 12 may be connected to a point 13 distant about one half of the operating wavelength, or rather less, from the aerial end 10 of the feeder, this conductor being also bent over to run parallel to and in the same direction as the first mentioned auxiliary conductor. The second auxiliary conductor extends to a point close to the first auxiliary conductor. More than two quarter wave elements may also be provided if desired.

In the arrangement shown in Fig. 3, there is connected to a suitable point 14 on the outer surface of the sheath 1, for example a point distant a quarter of the working wavelength from the end 15 thereof connected to the aerial, an auxiliary conductor 16 having substantially the same external dimensions as the sheath 1. This auxiliary conductor may be solid or it may be hollow as shown and it is arranged to extend substantially parallel to the sheath to a point level with the aerial end 15 thereof. The auxiliary conductor may be spaced by one or two inches from the sheath.

In a modification of Fig. 3 shown in Fig. 4, the feeder is deformed in such a manner that with the auxiliary conductor 16 it forms a U-shaped structure. In both Fig. 3 and Fig. 4 one aerial element is connected to the end 15 of the sheath and another aerial element is connected to the end 17 of the auxiliary conductor 16 and to the central conductor 2 of the feeder. The aerial elements may be arranged to project vertically and symmetrically upward from the U-shaped structure of Fig. 4 or from the structure of Fig. 3. In this way the aerial end of the feeder is made substantially electrically symmetrical.

The normal feed current to the aerial element

connected to the sheath flows along the inner surface of the sheath and any current which, instead of flowing into this aerial element, flows back along the outer surface of the sheath, tends to be neutralized by current from the central conductor which flows along the outer surface of the auxiliary conductor. By making the length of the auxiliary conductor approximately equal to a quarter of the operating wavelength, the impedance between the two upper ends of the U shaped structure around the outer surfaces of the sheath and auxiliary conductor is made high compared with the characteristic impedance of the feeder and thus has no appreciable effect upon the tuning arrangements. The auxiliary conductors 16 may have lengths approximately equal to or slightly less than any odd multiple of a quarter wavelength of the operating frequency.

Fig. 5 shows the way in which an enclosed quarter wave transformer may be arranged in the construction of Fig. 3. The quarter wavelength of central conductor 18 adjacent the aerial end of the feeder is of a suitable radius greater (as shown) or less than the radius of the main part of the central conductor 2. The end quarter wavelength of the feeder therefore has a characteristic impedance different from that of the main part of the feeder, and this characteristic impedance may be arranged to give impedance matching between the feeder and an aerial attached thereto.

In some cases it may be inconvenient to employ auxiliary conductors of length substantially equal to one quarter of the wavelength of undesired waves or to an odd multiple of this wavelength. The construction shown in Fig. 6 in its application to Fig. 3 may then be employed. In Fig. 6 the auxiliary conductor 19 has a length less than one quarter of a wavelength of the undesired waves and a condenser 20 of suitable value is connected between the upper ends 17 and 15 of the auxiliary conductor 19, and the sheath 2, respectively. This condenser has the effect of compensating for the lack of length of the auxiliary conductor and tunes the circuit comprising the auxiliary conductor 19, the end part of the sheath and the condenser 20 so that a high impedance to the undesired waves is produced at the end of the feeder. The use of an auxiliary conductor of length less than a quarter wavelength together with a condenser is preferable where the auxiliary conductor has external dimensions similar to those of the feeder, as shown in Fig. 6. This arrangement may however also be applied to cases where the auxiliary conductor is in the form of a wire less than a quarter wavelength long extending to a point near to the end of the feeder.

The use of an impedance, such as condenser 20, is not confined to cases where the length of the auxiliary conductor is less than one quarter wavelength. It may also be applied where the length lies between multiples of a quarter wavelength. In some cases the impedance will require to be inductive and in other cases capacitative.

We claim:

1. A feeder system for electric currents of high frequency comprising a conductor, a conducting sheath surrounding said conductor, means associated with said sheath for increasing the impedance offered by said sheath to the travel of undesired waves therealong and including an auxiliary conductor having a length differing from a finite odd integral multiple of one quarter of the wavelength of said undesired waves, one end of said auxiliary conductor connected to said sheath, the other end of said auxiliary conductor located adjacent but spaced from an end of said sheath, an impedance connected between the second named end of said auxiliary conductor and said end of said sheath, said impedance being adapted to compensate for the difference in length of said auxiliary conductor from a finite odd integral multiple including unity of a quarter of said wavelength.

2. A feeder system for electric currents of high frequency comprising a conductor, a conducting sheath surrounding said conductor, means associated with said sheath for increasing the impedance offered by said sheath to the travel of undesired waves therealong, said means including an auxiliary conductor having a length differing from a finite odd integral multiple of one quarter of the wavelength of said undesired waves, one of the ends of said auxiliary conductor connected to said sheath, the other end of said auxiliary conductor located adjacent but spaced from an end of said sheath and an impedance connected between the second named end of said auxiliary conductor and said end of said sheath, said impedance being adapted to compensate for the difference in length of said auxiliary conductor from a finite odd integral multiple including unity of a quarter of said wavelength, the cross section of said auxiliary conductor being substantially the same as that of said sheath.

3. A feeder system for electric currents of high frequency, comprising a conductor, a conducting sheath surrounding said conductor, coupling means for coupling an end of said feeder to an aerial system, means associated with said sheath for increasing the impedance offered by said sheath to the travel of undesired waves therealong, said means including an auxiliary conductor having a length differing from a finite odd integral multiple of one quarter of the wavelength of said undesired waves, one of the ends of said auxiliary conductor connected to said sheath, the other end of said auxiliary conductor located adjacent but spaced from said end of said sheath and an impedance connected between the second named end of said auxiliary conductor and said end of said sheath, said impedance being adapted to compensate for the difference in length of said auxiliary conductor from a finite odd integral multiple including unity of a quarter of said wavelength.

4. A feeder system for electric current of high frequency, comprising a first conductor, a conducting sheath surrounding said first conductor, an aerial system, coupling means for coupling said aerial system to one end of both said conductor and said sheath, and an auxiliary conductor attached at one end to said sheath, having its other end located adjacent but spaced from said end of said sheath and having a length substantially equal to an odd integral multiple including unity of one-quarter of the wavelength at which the system is arranged to operate, thereby increasing the impedance of said sheath to currents flowing on its outer surface without affecting the impedance between said first conductor and said sheath.

5. In a feeder system according to claim 4, said other end of said auxiliary conductor electrically connected to said end of said first conductor.

6. In a feeder system according to claim 4, said auxiliary conductor lying for the greater part of its length substantially parallel to said sheath.

7. In a feeder system according to claim 4, said

coupling means including an impedance matching device.

8. A feeder system for electric currents of high frequency comprising a conductor, a conducting sheath surrounding said conductor, an aerial system, coupling means for coupling said aerial system to one end of both said conductor and said sheath, a portion of said conductor and said sheath near said end thereof having a characteristic impedance different from that of another part of said feeder, thus constituting an impedance matching device, and an auxiliary conductor attached at one end to said sheath having its other end located adjacent but spaced from said end of said sheath and having a length substantially equal to an odd integral multiple including unity of a quarter of the wavelength at which the system is arranged to operate, thereby increasing the impedance of said sheath and said conductor in parallel without affecting the impedance between said conductor and said sheath.

9. A feeder system for electric currents of high frequency, comprising a first conductor, a conducting sheath surrounding said conductor, an aerial system, coupling means for coupling said aerial system to one end of both said conductor and said sheath, and an auxiliary conductor having a cross-section substantially the same as that of said sheath, said auxiliary conductor attached at one end to said sheath having its other end located adjacent but spaced from said end of said sheath and having a length substantially equal to an odd integral multiple including unity of a quarter of the wavelength at which the system is arranged to operate, thereby increasing the impedance of said sheath to currents flowing on its outer surface without affecting the impedance between said first conductor and said sheath.

10. A feeder system according to claim 9, comprising a substantially U-shaped structure constituted by said auxiliary conductor and a portion of said sheath adjacent said coupling means.

11. A feeder system for electric current of high frequency comprising a first conductor, a conducting sheath surrounding said conductor, an aerial system, coupling means for coupling said aerial system to one end of both said conductor and said sheath, and an auxiliary conductor attached at one end to said sheath, having its other end located adjacent but spaced from said end of said sheath and having an electrical length substantially equal to an odd integral multiple including unity of a quarter of the wavelength at which the system is arranged to operate, thereby increasing the impedance offered to the travel of waves of the operating frequency along said sheath.

12. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor, and means associated with said sheath for increasing the impedance offered by said sheath to the travel of undesired waves therealong, said means including an auxiliary conductor an odd multiple including unity of a quarter wavelength electrically connected at one end to said sheath and open at the other end.

13. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor, and means associated with said sheath for increasing the impedance offered by said sheath to the travel of undesired waves therealong, said means including an auxiliary conductor an odd multiple including unity of a quarter wavelength electrically connected at one end to the outer surface of said sheath and open at the other end.

14. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor and means associated with said sheath for increasing the impedance offered by said sheath to the travel of undesired waves therealong, said means including an auxiliary conductor electrically connected at one end to the outer surface of said sheath and open at the other end, said auxiliary conductor being not substantially greater than one-quarter of the length of the operating wave.

15. A feeder system for electric current of high frequency, comprising a conductor, a conducting sheath surrounding said conductor, an aerial system, coupling means for coupling said aerial system to one end of both said conductor and said sheath, and an auxiliary conductor attached at one end to said sheath intermediate its ends, having its other end located adjacent but spaced from said end of said sheath and having an electrical length substantially equal to an odd integral multiple including unity of the wavelength at which the system is arranged to operate, thereby increasing the impedance of said sheath to the flow of currents on its outer surface without affecting the impedance between said conductor and said sheath.

16. A feeder system for electric current of high frequency, comprising a conductor, a conducting sheath surrounding said conductor, an aerial system, coupling means for coupling said aerial system to one end of both said conductor and said sheath, and an auxiliary conductor attached at one end to the outer surface of said sheath intermediate its ends, having its other end located adjacent but spaced from said end of said sheath and having an electrical length substantially equal to an odd integral multiple including unity of a quarter of the wavelength at which the system is arranged to operate, thereby increasing the impedance of said sheath to currents on its outer surface without affecting the impedance between said conductor and said sheath.

17. A feeder system for high frequency electrical currents, comprising a conductor and a conducting sheath surrounding said conductor, an auxiliary conductor associated with said sheath for preventing currents of the operating frequency from flowing over the outer surface of said sheath, said auxiliary conductor being arranged for the greatest portion of its length parallel to said sheath and having a length substantially an odd integral multiple including unity of a quarter of the wavelength at which the system is arranged to operate, one end of said auxiliary conductor being open and positioned adjacent the end of said sheath, the other end being directly connected to the outer surface of said sheath.

18. A feeder system for high frequency electrical currents, comprising a conductor and a conducting sheath surrounding said conductor, an auxiliary linear wire conductor associated with said sheath for preventing currents of the operating frequency from flowing over the outer surface of said sheath, said auxiliary conductor being arranged for the greatest portion of its length parallel to said sheath and having a length substantially an odd integral multiple including unity of a quarter of the wavelength at which the system is arranged to operate, one end of said auxiliary conductor being open and

positioned adjacent the end of said sheath, the other end being directly connected to the outer surface of said sheath.

19. In combination, a feeder for high frequency electrical currents, said feeder comprising a conductor, a conducting sheath surrounding said conductor, translating apparatus coupled to said conductor, said sheath being open at its end near said translating apparatus, and means for increasing the impedance offered by said sheath to any undesired wave comprising an auxiliary conductor attached at one end to said sheath and having its other end located adjacent but spaced away from said open end of said sheath, said auxiliary conductor being arranged parallel to said sheath for the greatest portion of its length and having a length substantially equal to an odd integral multiple including unity of a quarter of the wavelength of said undesired wave.

20. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor, an auxiliary conductor electrically connected at one end to the end of said sheath, said auxiliary conductor having such length and being so arranged that it combines with a portion of the outer surface of the sheath, measured from the end thereof, of a length substantially the same as the length of said auxiliary conductor, to form a circuit of high impedance to the travel of undesired waves along the outer surface of said sheath.

21. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor, an auxiliary conductor directly connected at one end to said sheath, said auxiliary conductor having such length and being so arranged that it combines with a portion of the outer surface of the sheath, measured from the end thereof, of a length substantially the same as the length of said auxiliary conductor, to form a circuit of high impedance to the travel of undesired waves along the outer surface of said sheath.

22. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor, an auxiliary conductor directly connected at one end to the end of said sheath, said auxiliary conductor having such length and being so arranged that it combines with a portion of the outer surface of the sheath, measured from the end thereof, of a length substantially the same as the length of said auxiliary conductor, to form a circuit of high impedance to the travel of undesired waves along the outer surface of said sheath.

23. A feeder for electric currents of high frequency, said feeder comprising a conductor, a conducting sheath surrounding said conductor, an auxiliary conductor capacitively connected at one end to the end of said sheath, said auxiliary conductor having such length and being so arranged that it combines with a portion of the outer surface of the sheath, measured from the end thereof, of a length substantially the same as the length of said auxiliary conductor, to form a circuit of high impedance to the travel of undesired waves along the outer surface of said sheath.

24. A feeder system for high frequency electrical currents comprising a conductor, a conducting sheath surrounding said conductor, an auxiliary conductor having a length an odd integral multiple including unity of a quarter wavelength arranged parallel to and adjacent said sheath, one end of said auxiliary conductor being directly connected to said sheath, the other end of said auxiliary conductor being directly connected to said inner conductor.

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