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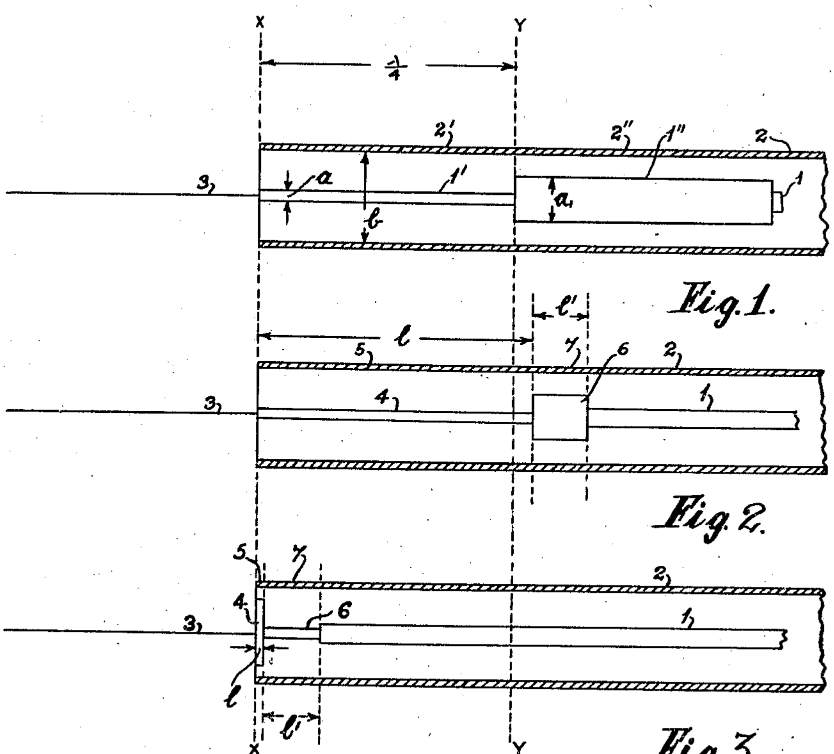

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HIGH FREQUENCY TRANSMISSION SYSTEM

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The present invention relates to high frequency transmission systems such for example as may be used as connections between aerials and transmission lines.

In radio frequency transmitters, an oscillation generator or other source of high frequency oscillations is commonly connected to a radiating aerial through a transmission line. In order to avoid reflection at the point of connection of the transmission line to the aerial it is necessary that the characteristic impedance of the aerial should be matched to that of the transmission line. Since in general it is inconvenient to make the characteristic impedances of the antenna and transmission line equal, it is usual to introduce some form of transformer or equivalent matching device. In certain known systems the matching device has been in the form of a quarter wavelength of additional transmission line of characteristic impedance different from that of the main line, this additional transmission line being inserted between the aerial and the main transmission line. By suitably selecting the value of the characteristic impedance of the additional transmission line any desired effective transformer ratio can be obtained. In certain types of construction however the physical constants required to give the necessary characteristic impedance work out to very inconvenient values.

It is an object of the present invention to provide a simple transforming means for the connection of an antenna to a transmission line which does not involve an inconvenient value of impedance for the transforming unit.

According to the present invention there are provided means for coupling two elements of different characteristic impedances and for providing impedance matching, said means including two transformer elements comprising lengths of transmission line of different characteristic impedances having together a physical length equal to or less than one half wavelength of the oscillations to be transmitted from one element to the other.

The present invention also provides means for coupling an aerial, adapted to operate on relatively short wavelengths, for example below 100 meters, with a transmitter or receiver by way of a transmission line, wherein, in order to obtain impedance matching between the aerial and the transmission line there are provided two transformers, one providing an excessive step-up and the other, in effect, reducing the step-up ratio of the first.

The invention will be described by way of example with reference to the accompanying diagrammatic drawing wherein

Figs. 1, 2 and 3 represent impedance matching transformers according to the present invention.

In the drawing the distance between XX and YY represents one quarter of the wavelength at which the transformers are intended to operate.

In order to match an aerial of impedance Z_A to a transmission line of characteristic impedance Z_C a transformer with a ratio of

$$\sqrt{\frac{Z_A}{Z_C}}$$

is required. It is known that the addition of an extra section of transmission line, of length equal to a quarter of a wavelength, and characteristic impedance Z_O given by this equation—

$$Z_O=\sqrt{Z_A Z_C} \quad \text{--------------}(1)$$

will give the desired transformer effect.

A transmission line of known type comprises a cylindrical conductor situated coaxially within a hollow cylindrical conductor. The transformer is then most conveniently formed by a section of the hollow conductor adjacent the aerial which is a quarter wavelength long and has within it a quarter wavelength of central conductor of diameter different from that of the central conductor of the transmission line.

In many practical cases it will be found that the diameter of the internal conductor which is necessary for a desired transformation ratio is so small that it is impracticable.

According to the present invention, however, two quarter wave sections of characteristic impedances Z_O and Z_O' respectively may be connected in series between the aerial and the transmission line and the desired transformer effect will be obtained when

$$\frac{Z_O}{Z_O'}=\sqrt{\frac{Z_A}{Z_C}} \quad \text{--------------}(2)$$

Any convenient pair of values of Z_O and Z_O' can be chosen provided that they satisfy this equation. In practice it is usually convenient to use a wire of the smallest suitable diameter as central conductor in the section adjacent the aerial. This steps down the impedance of the aerial to a value less than that of the transmission line. The diameter of the central conductor required in the other section of the transformer to give the necessary step up ratio may then be calculated.

As an example, which will be described with reference to Fig. 1, the impedance at the base of a half wave dipole **3** may be of the order of 2,000 ohms and is required to be matched to a feeder **1**, **2** of characteristic impedance equal to 80 ohms.

If the known transformer described above is considered, it will be seen from Equation (1) that Zo (that is the characteristic impedance of the transformer) =400 ohms. For this arrangement in which one conductor is arranged concentrically within the other,

$$Z_O = 138 \log_{10} \frac{b}{a} \qquad (3)$$

where a and b are the diameters of the inner and outer conductors respectively. Applying to this equation the value Z_O=400 and assuming that b=0.625 inch, which is a practical value, it will be found that a has a value less than one thousandth of an inch which is impracticable. The smallest practical size for a is about one hundredth of an inch and this together with the previously chosen value of b gives a value of about 250 ohms for Zo. With this value of Zo it is possible to transform down from 2000 ohms to 31.2 ohms as will be seen from Equation (1). It will be seen from Equation (2) that with Z_A=2000, Z_C=80 and Z_O=250, Z_O' must have the value 50. A second quarter wave transformer of characteristic impedance equal to 50 ohms will therefore serve to transform from 31.2 ohms to the required value of 80 ohms. This can easily be arranged as shown in Fig. 1 by inserting two quarter wave transformers **1'**, **2'** and **1''**, **2''** between aerial **3** and feeder **1**, **2**. The outer conductors **2**, **2'**, **2''** all have the same diameter (indicated by b) and for the required 50 ohm impedance the inner conductor **1''** must have a diameter (indicated by a_1) of a little more than 0.25 inch, the diameter of inner conductor **1'** being 0.01 inch.

In the above described example the output impedance of each transformer element **1'**, **2'** or **1''**, **2''** is, in itself, resistive. With such an arrangement it is impossible to reduce the total length of the transformer below one quarter wavelength per section.

It is however possible, and may in many cases be desirable, to employ two sections of length other than a quarter wavelength, in series, the physical constants being such that the output impedance of the transformer as a whole is resistive. In this way the total length may be appreciably less than one quarter wavelength per section.

Referring to Fig. 2, in order to match an aerial **3** of impedance Z_A to a transmission line **1**, **2** of impedance Z_C there may be connected in series between the aerial and transmission line two additional lengths of line **4**, **5** and **6**, **7** of impedance Zo and Zo' and lengths indicated by l and l' respectively. Then if λ is the wavelength for which the system is designed and

$$\alpha = \frac{2\pi l}{\lambda}, \alpha' = \frac{2\pi l'}{\lambda}$$

the output impedance will be resistive if

$$Z_C = Z_A \left\{ \frac{1 - \frac{Z_0^1}{Z_0} \tan\alpha \tan\alpha'}{1 - \frac{Z_0}{Z_0^1} \tan\alpha \tan\alpha'} \right\} = \frac{Z_0^2}{Z_A} \left\{ \frac{1 + \frac{Z_0^1}{Z_0} \frac{\tan\alpha'}{\tan\alpha}}{1 + \frac{Z_0}{Z_0^1} \frac{\tan\alpha'}{\tan\alpha}} \right\} \qquad (4)$$

An investigation of this equation shows that it is soluble for values of α and α' which make $l + l'$ less than

$$\frac{\lambda}{2}$$

and allow Zo and Zo' to have possible practical values.

In a particular example suppose Z_A=2000 ohms, Z_C = 80 ohms, Z_O = 250 ohms and Z_O'=20 ohms. From the above equation it follows that l = 0273 λ and l' =0.05 λ. The total length is thus 0.323 λ.

It can be shown that if neither Zo nor Zo' exceeds $\sqrt{Z_A Z_C}$ then the total length can never be less than

$$\frac{\lambda}{4}$$

If however either Zo or Zo' exceeds $\sqrt{Z_A Z_C}$ then the total can be reduced below

$$\frac{\lambda}{4}$$

For example if Z_A = 360 ohms, Z_C = 80 ohms, Z_O = 40 ohms, Z_O' = 240 ohms then l = 0.0036 λ and l' = 0.113 λ, the total length being 0.1166 λ. It is therefore possible in such a case to effect a considerable reduction in the length of a transformer section.

Fig. 3 is a modification of Fig. 2 in which the lengths, indicated by l and l' of the sections **4**. **5** and **6**, **7** have been modified to indicate the form which this arrangement may take.

In the examples described above it has been assumed that the diameter of the hollow cylindrical conductor is uniform, and that the diameter of the central conductor in the different sections has different values so that these sections have suitable characteristic impedances. The different characteristic impedances may also be obtained by enclosing a conductor of uniform diameter within a sheath in the form of a hollow cylindrical conductor, sections of the sheath being constructed to have different diameters. In some cases it may be more convenient to employ arrangements in which neither the central conductor nor the sheath has a diameter in the transformer sections equal to that of the main part of the feeder.

Although the invention has been described in its application to the matching of an aerial to a transmission line comprising coaxial conductors through an extra section of line of similar form it is to be understood that it is in no way limited to this. For example the invention is also applicable to other types of transmission line such as two wires spaced apart. Also the additional length of transmission line constituting the transformer device need not be of the same type as the main transmission line. Similarly the invention may be applied to an aerial tapped at a point of maximum current where two connections are required. This may be realized by the connection of both the outer tube and the central wire to the aerial or by the connection to the aerial of two members of some other type of transmission line.

The invention is not limited to the coupling of aerials and transmission lines but can be applied to the coupling of any elements of different characteristic impedances.

We claim:

1. A high frequency transmission system working at a relatively short wavelength, comprising a load, a feeder line of length greater than said wavelength and having a characteristic imped-

ance different from the impedance of said load, and a transformer comprising first and second sections of transmission line being of different characteristic impedances and each having distributed inductance and capacity, said sections arranged serially in the order named between said load and said feeder, and the impedance looking into said first section towards said feeder being substantially equal to the impedance of said load, whereas the impedance looking into said second section towards said load is substantially equal to the characteristic impedance of said feeder.

2. A high frequency transmission system for working at a relatively short wavelength, comprising a load, a feeder line of length greater than said wavelength and having a characteristic impedance different from the impedance of said load, and first and second transformer elements arranged serially in the order named between said load and said feeder, said elements each comprising a section of transmission line of length substantially equal to one quarter of said wavelength and having distributed inductance and capacity, the characteristic impedance of said elements being different from one another, the impedance to which said first element transforms the impedance of said load being less than the characteristic impedance of said feeder, and the overall transformation ratio of said elements being such that substantial impedance matching exists between said load and said feeder.

3. A high frequency transmission system for working at a relatively short wavelength, comprising a load, a feeder line of length greater than said wavelength and having a characteristic impedance different from the impedance of said load, and a transformer comprising first and second sections of transmission line being of different characteristic impedances and each having distributed inductance and capacity, said sections arranged serially in the order named between said load and said feeder and having together a total length less than half said wavelength, the impedance looking into said first section towards said feeder being substantially equal to the impedance of said load, and the impedance looking into said second section towards said load being substantially equal to the characteristic impedance of said feeder.

4. A high frequency transmission system for working at a relatively short wavelength, comprising a load, a feeder line of length greater than said wavelength and having a characteristic impedance different from the impedance of said load, and a transformer comprising first and second sections of transmission line being of different characteristic impedances and each having distributed inductance and capacity, said sections arranged serially in the order named between said load and said feeder and the characteristic impedance of one of said sections being greater than the square root of the product of the impedances of said load and said feeder, the sections having together a total length less than one quarter of said wavelength, the impedance looking into said first section towards said feeder being substantially equal to the impedance of said load, and the impedance looking into said second section towards said load being substantially equal to the characteristic impedance of said feeder.

5. In a transmission system according to claim 1, said sections comprising lengths of concentric feeder.

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