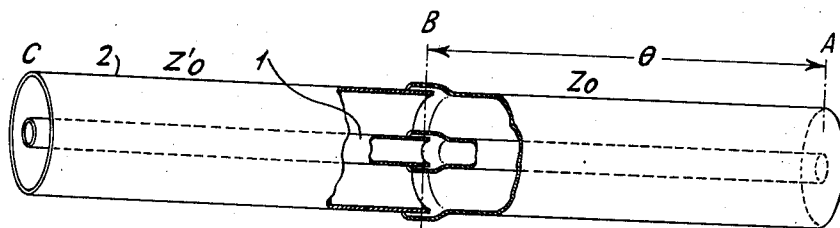


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HIGH FREQUENCY SIGNALING SYSTEM

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INVENTORS
EDWARD CECIL CORK AND
JOSEPH LADE PAWSEY
BY *H.S. Brown*
ATTORNEY

UNITED STATES PATENT OFFICE

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HIGH FREQUENCY SIGNALING SYSTEM

Edward Cecil Cork, Ealing, London, and Joseph Lade Pawsey, Hillingdon, England, assignors to Electric & Musical Industries Limited, Hayes, Middlesex, England, a British company

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This invention relates to high frequency signaling systems and is particularly concerned with feeder systems for short wave transmitting aeri-

5 In short wave transmitting systems it is desirable that the impedance of any piece of apparatus should be matched to the impedance of any other piece of apparatus with which it is connected. In particular cases it may be necessary, for example, to match the impedance of a feeder system with that of an aerial or of another feeder system, or again it may be desired to match and tune a transmitter to a feeder system.

10 According to the present invention, in a method of matching the impedance of a line connected with apparatus having an impedance different from that of said line, the impedance of said line is matched with that of said apparatus by an impedance matching transformer constituted by a portion of said line having a selected impedance. In a particular application of the invention, a short wave signaling system includes a coaxial feeder cable connected to apparatus having an impedance different from that of said feeder, and the impedance of the feeder is matched with that of said apparatus by an impedance matching transformer constituted by a portion of said feeder. The apparatus connected to the feeder may, for example, be a transmitting aerial and the impedance matching portion of the feeder cable may be given electrical lengths such that impedance matching is effected over a range of frequencies.

15 In order that the invention may be more clearly understood and readily carried into effect, an impedance matching transformer constituted by a portion of a coaxial feeder cable, will now be described by way of example with reference to the drawing.

20 Referring to the drawing, the feeder comprises an inner conductor 1 arranged concentrically within an outer conductor 2 and has an impedance Z_0 . An additional length of feeder θ is inserted between the end of the feeder and the aerial to which it is connected. It can be shown mathematically that by selecting the length of line θ and the characteristic impedance it may transform a given impedance Z_1 to a required pure resistance R .

25 The length of line θ and characteristic impedance Z_0 may be determined from the following equations for a lossless line.

$$R = \frac{Z_0^2 r}{(Z_0 \cos \theta - x \sin \theta)^2 + r^2 \sin^2 \theta} \quad (1)$$

$$X = \frac{Z_0 \left(Z_0 x \cos 2\theta + \frac{Z_0^2 - r^2 - x^2}{2} \sin 2\theta \right)}{(Z_0 \cos \theta - x \sin \theta)^2 + r^2 \sin^2 \theta} \quad (2)$$

where R and X are the input series resistance and reactance at B when terminated with the aerial of resistance and reactance r and x at the point A.

It is desired to make $X=0$ and R a given value. Since there are two equations, it is possible, in general, to find values of Z_0 and θ which satisfy them.

If in Equations (1) and (2) the condition is put that the reactance X should be zero, the following equations are obtained.

$$Z_0^2 = Rr \left(1 - \frac{x^2}{r(R-r)} \right) \quad (3)$$

and

$$\tan 2\theta = \frac{-2xZ_0}{Z_0^2 - r^2 - x^2} \quad (4)$$

It will be seen that this permits of a complex impedance $r-jx$ being matched to a chosen pure resistance at one frequency.

It may be desired that the input resistance R should remain pure over a band of frequencies and it will be seen that this condition is satisfied for two frequencies at which the aerial reactances are x and x_2 and the electrical lengths of the transforming line are θ and θ^2 , providing that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2} \left(\frac{Z_0^2 - r^2 - x_2^2}{Z_0^2 - r^2 - x^2} \right) \cdot \frac{x}{x_2} \quad (5)$$

In Equation (5), the approximation is true providing either the magnitude of the aerial impedance remains constant over the side band frequencies, or if the variation is small compared to the characteristic impedance.

The method of working is to choose from Equation (3) Z_0 to give an assigned value of R , for example to match the feeder. We then find from (4) the required value of the length of line.

In order for this to hold over a frequency range, Equation (5) must be satisfied throughout the range. Should it be far out, the reactances may be modified at the aerial by a suitable circuit adjustment, or an alternative choice of R .

In a particular case, an impedance of $24.2 + j6.48$ has been transformed to $69.5 - j0$ by a line of $Z_0=40$ and $\theta=76^\circ$.

If in the example shown in Fig. 1 the feeder is connected to a tuned aerial, the length θ will be equal to $\frac{1}{4}$ of the working wavelength, which is a well known result.

It will be seen that the impedance matching is produced by very simple and practical means, since the line constitutes its own transformer and the use of special tuning circuits, including lumped inductance and capacity, is avoided. When the arrangement is used in a system handling a wide range of frequencies, the input resistance for a constant terminating impedance is passing through a stationary value and the variation is therefore slow.

What is claimed is:

1. A signaling system including a feeder connected to an antenna having an impedance Z_1 composed of resistance r and reactance x different from the impedance of said feeder wherein the impedance of said feeder is matched to that of said antenna by an impedance matching transformer constituted by a portion of said feeder having an impedance Z_0 the resistance component of which is equal to the resistance of said feeder and having an electrical length θ such that

$$\tan 2\theta = \frac{-2xZ_0}{Z_0^2 - r^2 - x^2}$$

whereby the impedance of said antenna and matching transformer is purely resistive at the operating frequency.

2. A signaling system including a coaxial feeder cable connected to an antenna having an impedance Z_1 composed of resistance r and reactance x different from the impedance of said feeder wherein the impedance of said feeder is matched to that of said antenna by an impedance matching transformer constituted by a portion of said feeder having an impedance Z_0 the resistance component of which is equal to the resistance of said feeder and having an electrical length θ such that

$$\tan 2\theta = \frac{-2xZ_0}{Z_0^2 - r^2 - x^2}$$

whereby the impedance of said antenna and matching transformer is purely resistive at the operating frequency.

3. A signaling system including a coaxial feeder cable connected to a transmitting antenna having an impedance Z_1 composed of resistance r and reactance x different from the impedance of said feeder wherein the impedance of said feeder is matched to that of said antenna by an impedance matching transformer constituted by a portion of said feeder having an impedance Z_0 the resistance component of which is equal to the resistance of said feeder and having an electrical length θ such that

$$\tan 2\theta = \frac{-2xZ_0}{Z_0^2 - r^2 - x^2}$$

whereby the impedance of said antenna and matching transformer is purely resistive at the operating frequency.

4. A signaling system for operation over a band of frequencies including a feeder connected to an antenna having an impedance Z_1 composed of a resistance r and a reactance x at one extreme frequency of said band and a resistance r_2 and a reactance x_2 at the other extreme frequency of said band, said impedance differing from that of said feeder wherein the impedance of said feeder is matched with that of said antenna by an impedance matching transformer constituted by a portion of said feeder and having an impedance Z_0 so dimensioned that the resistance

of said transformer is equal to resistance of said feeder and having a length such that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2} \left(\frac{Z_0^2 - r^2 - x^2}{Z_0^2 - r_2^2 - x_2^2} \right)$$

where θ and θ_2 are expressions of electrical length of said portion at said extreme frequencies whereby the impedance of said antenna and matching transformer is purely resistive over said band of frequencies.

5. A signaling system for operation over a band of frequencies including a coaxial feeder cable connected to an antenna having an impedance Z_1 composed of a resistance r and a reactance x at one extreme frequency of said band and a resistance r_2 and a reactance x_2 at the other extreme frequency of said band, said impedance differing from that of said feeder wherein the impedance of said feeder is matched with that of said antenna by an impedance matching transformer constituted by a portion of said feeder and having an impedance Z_0 so dimensioned that the resistance of said transformer is equal to resistance of said feeder and having a length such that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2} \left(\frac{Z_0^2 - r^2 - x^2}{Z_0^2 - r_2^2 - x_2^2} \right)$$

where θ and θ_2 are expressions of electrical length of said portion at said extreme frequencies whereby the impedance of said antenna and matching transformer is purely resistive over said band of frequencies.

6. A signaling system for operation over a band of frequencies including a coaxial feeder cable connected to a transformer having an impedance Z_1 composed of a resistance r and a reactance x at one extreme frequency of said band and a resistance r_2 and a reactance x_2 at the other extreme frequency of said band, said impedance differing from that of said feeder wherein the impedance of said feeder is matched with that of said antenna by an impedance matching transformer constituted by a portion of said feeder and having an impedance Z_0 so dimensioned that the resistance of said transformer is equal to resistance of said feeder and having a length such that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2} \left(\frac{Z_0^2 - r^2 - x^2}{Z_0^2 - r_2^2 - x_2^2} \right)$$

where θ and θ_2 are expressions of electrical length of said portion at said extreme frequencies whereby the impedance of said antenna and matching transformer is purely resistive over said band of frequencies.

7. A signaling system for operation over a band of frequencies including a feeder connected to an antenna having an impedance Z_1 including a reactive component having a value x at one extreme frequency of said band and a value x_2 at the other extreme frequency of said band, the total impedance Z_1 varying by only a small amount over said band, said impedance differing from that of said feeder wherein the impedance of said feeder is matched to that of said antenna by an impedance matching transformer constituted by a portion of said feeder having an impedance Z_0 the resistive component of which is equal to the resistance of said feeder and having a length such that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2}$$

where θ and θ_2 are expressions of electrical length of said transformer at said extreme frequencies

whereby the impedance of said antenna and matching transformer is purely resistive over said band of frequencies.

8. A signaling system for operation over a band of frequencies including a coaxial feeder cable connected to an antenna having an impedance Z_1 including a reactive component having a value x at one extreme frequency of said band and a value x_2 at the other extreme frequency of said band, the total impedance Z_1 remaining substantially constant over said band, said impedance differing from that of said feeder wherein the impedance of said feeder is matched to that of said antenna by an impedance matching transformer constituted by a portion of said feeder having an impedance Z_0 the resistive component of which is equal to the resistance of said feeder and having a length such that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2}$$

where θ and θ_2 are expressions of electrical length of said transformer at said extreme frequencies whereby the impedance of said antenna and matching transformer is purely resistive over said band of frequencies.

9. A signaling system for operation over a band of frequencies including a coaxial feeder cable connected to a transmitting antenna having an impedance Z_1 including a reactive component having a value x at one extreme frequency of said band and a value x_2 at the other extreme frequency of said band, the total impedance Z_1 remaining substantially constant over said band, said impedance differing from that of said feeder wherein the impedance of said feeder is matched to that of said antenna by an impedance matching transformer constituted by a portion of said feeder having an impedance Z_0 the resistive component of which is equal to the resistance of said feeder and having a length such that

$$\frac{\tan 2\theta}{\tan 2\theta_2} = \frac{x}{x_2}$$

where θ and θ_2 are expressions of electrical length of said transformer at said extreme frequencies whereby the impedance of said antenna and matching transformer is purely resistive over said band of frequencies.

EDWARD CECIL CORK.
JOSEPH LADE PAWSEY.