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SHORT WAVE TRANSMISSION
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1,939,053

FIG. 1

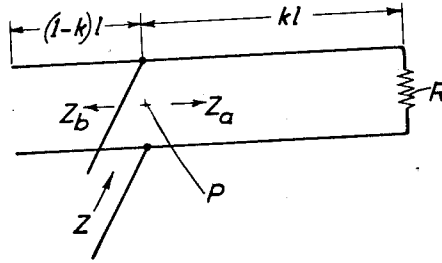
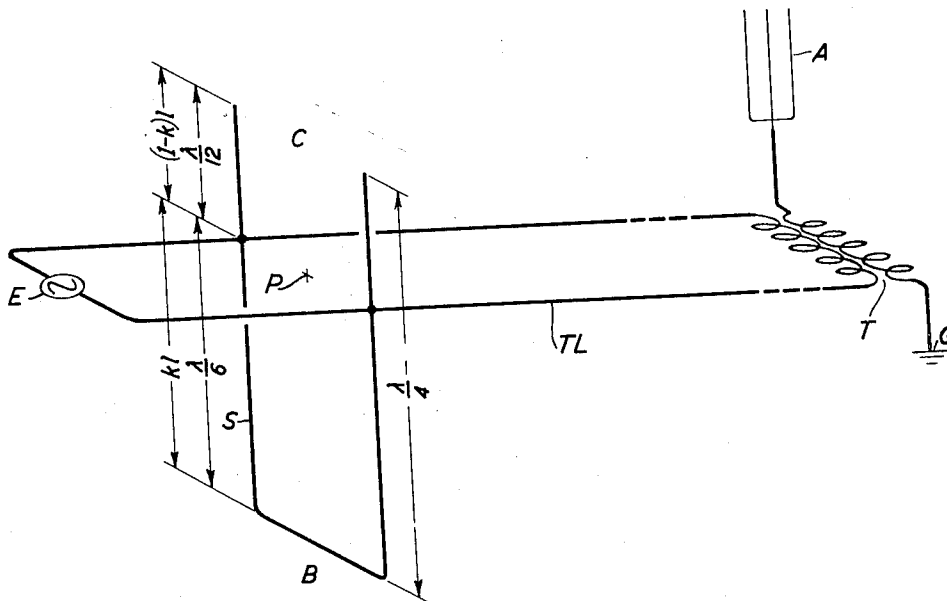


FIG. 2



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SHORT WAVE TRANSMISSION

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6 Claims. (Cl. 178-44)

This invention relates to short wave transmission and more particularly to means for eliminating from high frequency lines undesired waves that may accompany the wave to be transmitted.

The principal object of the invention is to suppress the harmonic frequencies while freely transmitting a fundamental wave over a transmission line.

This object is attained by bridging across the transmission line a section of uniform line the length of which is proportioned in accordance with the wave length of the transmitted wave and which is connected to the main line at an intermediate point determined by the length of the wave to be suppressed. In the preferred form of the invention the connected line is short-circuited at one end and open at the other and has a length equal to one-quarter of the length of the fundamental wave to be transmitted. For suppression of the third harmonic the connection to the main line is made at a point one-quarter of the third harmonic wave length from the open end, or one twelfth of the length of the bridging line. If suppression of other harmonics is desired, the point of connection may be changed in accordance with the frequency of the harmonic.

The invention will be more readily understood by reference to the following detailed description in connection with the accompanying drawing in which:

Fig. 1 is a diagrammatic circuit to which reference is made in explaining the invention, and Fig. 2 shows an application of the invention to a transmission line.

The diagram of Fig. 1 represents a section of uniform transmission line of length l and characteristic impedance Z_0 , having negligible resistance and leakage, formed of two parallel wires, open at one end and terminated at the other end in a resistance R . It can be demonstrated by electric circuit theory that if the terminating resistance R is zero the impedance Z_a looking toward the short-circuited end and measured from a point P of distance kl from the short-circuited end is given by the equation

$$Z_a = jZ_0 \tan k\theta \quad (1)$$

and the impedance Z_b looking toward the open end is

$$Z_b = -jZ_0 \frac{1}{\tan (1-k)\theta} \quad (2)$$

where θ = "angle of the line" = $l\omega\sqrt{LC}$. Here L and C are the inductance and the capacitance,

respectively, per unit length of the line, and $\omega = 2\pi$ times the frequency.

The impedance Z of the two portions of the section in parallel, as seen from P is

$$Z = \frac{Z_a Z_b}{Z_a + Z_b} = \frac{jZ_0 \tan k\theta}{1 - \tan k\theta \tan (1-k)\theta} \quad (3)$$

It will be recognized that θ , the angle of the line, depends upon the length λ of the wave being transmitted and is given more specifically by

$\theta = \frac{2\pi l}{\lambda}$. It will be noted that if $\theta = \frac{\pi}{2}$ at some frequency, say f_0 , that is, if l is $\frac{\lambda}{4}$, then equation (3) becomes

$$Z = \frac{jZ_0 \tan k \frac{\pi}{2}}{1 - \tan k \frac{\pi}{2} \tan (1-k) \frac{\pi}{2}} \quad (4)$$

Or, substituting $\cot k \frac{\pi}{2}$ for $\tan (1-k) \frac{\pi}{2}$ in the denominator, Equation (4) becomes

$$Z = \frac{jZ_0 \tan k \frac{\pi}{2}}{1 - \tan k \frac{\pi}{2} \cot k \frac{\pi}{2}} \quad (5)$$

The denominator of Equation (5) is equal to zero and therefore Z is equal to infinity. It follows then that at the frequency f_0 for which the section of line is a one-quarter wave length the impedance offered to a source is infinite, no matter where the source may be connected so long as it is not in the short circuit; that is, as long as k is not equal to zero.

On the other hand, Z is equal to zero if $\tan (1-k)\theta = \infty$ that is, if

$$(1-k)\theta = \frac{n\pi}{2},$$

where n is any odd integer. Taking the condition where n is unity and inserting for θ its value

$$\frac{2\pi l}{\lambda'}$$

where λ' is the wave length of the wave to be suppressed it appears that

$$(1-k)l = \frac{\lambda'}{4}$$

It follows then that if the section of line used as a suppressor is connected to the transmission

line the distance from the open end of the section equal to

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

then an effective short circuit is provided for the wave which has a length equal to λ' . Thus, if it is desired to suppress the third harmonic, then

$$\lambda' = \frac{\lambda}{3} \text{ and } (1-k)l = \frac{\lambda}{12}$$

The suppressor section will then have a length l equal to

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

and the point P at which connection to the transmission line is made will be a distance

$$(1-k)l = \frac{\lambda}{12}$$

from the open end of the section of line.

Fig. 2 shows an embodiment of the invention in a transmission line TL which leads from a generator E to an antenna A. The line is coupled to the antenna through transformer T. The antenna is connected to one terminal of a winding of the transformer and the other terminal of this winding is grounded at G. Generator E is a single frequency source of alternating voltage of fundamental frequency f_0 , but there are also present frequencies which are harmonics of the fundamental, as for example, the third harmonic, which has a frequency of $3f_0$. The section of line S which serves as the suppressor is bridged across the transmission line at a point P preferably near the generator. The suppressor S is a uniform section of transmission line comprising two parallel wires, short-circuited at the end B and open at the end C. The length of the suppressor section is equal to

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

where λ is the wave length corresponding to the fundamental frequency f_0 of the generator, which is to be conducted along the transmission line TL to the antenna A. Assuming that it is desired to suppress the third harmonic then the distance $(1-k)l$ from the open end C of S to the point of connection P is made equal to

$$\frac{\lambda}{12}$$

The distance from P to the short-circuited end B will, of course, be equal to

$$\frac{\lambda}{6}$$

Since the suppressor S offers a high impedance to the fundamental frequency f_0 , this frequency will be freely transmitted along the line TL to the antenna, but as S is effectively a short circuit across the line for the third harmonic $3f_0$, this frequency will be suppressed and prevented from reaching the antenna.

The suppressor may, of course, be designed to suppress any other harmonic by making the length $(1-k)l$ equal to

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

where h is the order of the harmonic concerned.

The suppressor section S may be either an open wire transmission line or a concentric conductor line, since the principles here presented apply equally well to either form.

What is claimed is:

1. In a wave transmission system, a wave source, a transmission line connected thereto and a uniform section of transmission line bridged across said first-mentioned transmission line, the length of said section of line being equal to one-quarter of the length of the wave generated by said wave source, said section of line being short-circuited at one end and open at the other end and said section of line being bridged across said first-mentioned transmission line at a distance from the open end of said section of line equal to one-quarter of the wave length corresponding to a frequency which is a harmonic of the frequency generated by said wave source.

2. In combination, a single frequency wave source in which harmonics are present, a transmission line connected thereto and a uniform section of transmission line bridged across said first-mentioned transmission line, the length of said section of line being equal to one-quarter of the length of the fundamental wave of said wave source, said section of line being short-circuited at one end and open at the other and bridged across said first-mentioned transmission line at a distance from the open end of said section of line equal to one-quarter of the wave length of the third harmonic of the fundamental frequency of said wave source.

3. In a wave transmission system, a wave source, a transmission line leading therefrom and a harmonic suppressor, said harmonic suppressor comprising two sections of uniform transmission line connected in parallel and bridged across said first-mentioned transmission line, one of said sections being open-circuited at the far end and the other of said sections being short-circuited at the far end and of twice the length of said one section, and the sum of the lengths of said two sections being equal to one-fourth of the length of the fundamental wave of said wave source.

4. In a wave transmission system, a wave source, a transmission line leading therefrom, and a third harmonic suppressor, said suppressor comprising two sections of transmission line connected in parallel and bridged across said first-mentioned transmission line, one of said sections being short-circuited at the far end and the other of said sections being open-circuited at the far end and of a length equal to one-twelfth of the length of the wave corresponding to the fundamental frequency of said wave source, and the sum of the lengths of said two sections of line being equal to one-fourth of the length of the fundamental wave of said wave source.

5. In combination, a single frequency wave source in which harmonics are present, a transmission line connected thereto and a third harmonic suppressor, said suppressor comprising a uniform section of transmission line bridged across said first-mentioned transmission line, the length of said section of line being equal to one-quarter of the length of the fundamental wave of said wave source, said section of line being short-circuited at one end and open at the other and the bridging point being at a distance from the open end of said section equal to one-third of the length of said section of line.

6. In a wave transmission system, a single frequency wave source in which harmonics are present, a transmission line connected thereto and a third harmonic suppressor, said suppressor comprising a uniform section of transmission line bridged across said first-mentioned transmission line, the length of said section of line being equal to one-quarter of the length of the fundamental wave of said wave source, said section of line being short-circuited at one end and open at the other and the bridging point being at a distance from the open end of said section equal to one-third of the length of said section of line.

quency wave source in which harmonic frequencies are present, a transmission line connected thereto and a section of concentric conductor transmission line bridged across said first-mentioned transmission line, the length of said section of line being equal to one-quarter of the length of the fundamental wave of said wave source, said section of line being short-circuited

at one end and open at the other and bridged across said first-mentioned transmission line at a distance from the open end of said section of line equal to one-quarter of the wave length corresponding to a frequency which is a harmonic of the fundamental frequency of said wave source. 80

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