Nov. 8, 1927.

1,647,985

W. DEUTSCHMANN

ARTIFICIAL LINE

Filed Nov. 27, 1925

Fig. 3.

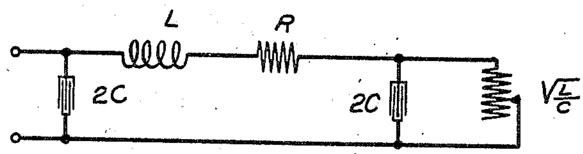


Fig. 1.

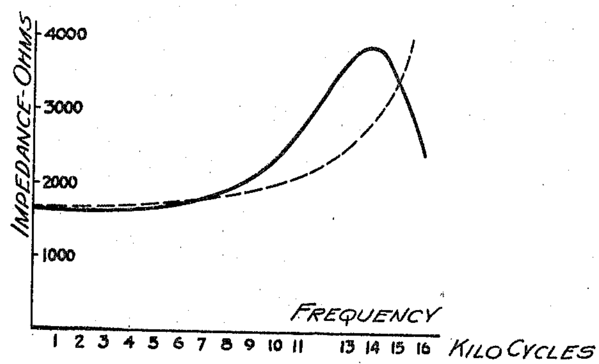
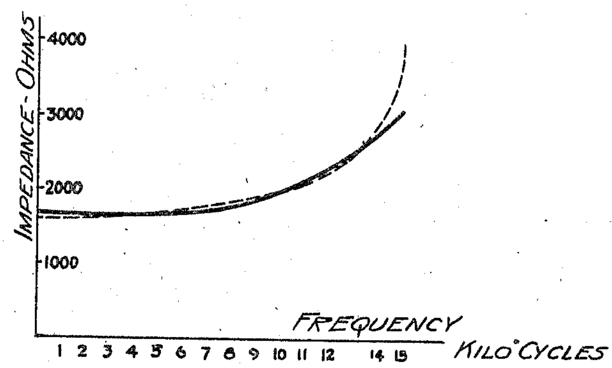


Fig. 2.



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Patented Nov. 8, 1927. **1,647,985**

UNITED STATES PATENT OFFICE.

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ARTIFICIAL LINE.

Application filed November 27, 1925, Serial No. 71,739, and in Germany May 22, 1924.

This invention relates to artificial lines for balancing loaded telephone lines.

When artificial lines are employed in connection with two-element, two-way repeaters for balancing the physical lines, the frequency range in which amplification may take place is definitely restricted in order to simplify the simulation of the line impedance by the artificial line. It then remains necessary only to accurately simulate the impedances of the lines to be connected within this frequency range.

The invention aims to create a good simulation of loaded lines in a simple way, up to frequencies of about 0.8 to 0.9 of the cut-off frequency of the loaded line.

According to the invention, the balancing impedance consists of a network constructed so as to conform to a line section, its cut-off frequency is higher than that of the line to be simulated with equal or approximately equal iterative impedance and closed by means of an ohmic resistance. The invention can be more readily understood by reference to the following detailed description in connection with the drawing in which: Fig. 1 shows the frequency-impedance characteristics of a loaded line and a balancing net-work having the same cut-off frequency, Fig. 2 shows the frequency-impedance characteristics of a loaded line and a network designed according to this invention, and Fig. 3 one form of this invention.

In Fig. 1 of the drawing, the frequency impedance characteristic of a network having the same constants as a section of the line closed by means of an ohmic resistance

$$R=\sqrt{\frac{L}{C}},$$

is shown by the full line curve. The assumption is hereby made that the cut-off frequency of the loaded line is

$$\omega_0=\frac{1}{\pi\sqrt{LC}}=16850$$

and its iterative impedance

$$\sqrt{\frac{L}{C}}=1605.$$

The curve is plotted according to the formula derived from Kirchhoff's Law:

$$Z=\sqrt{\frac{L}{C}}\cdot\frac{1+j\left[2\left(\frac{\omega}{\omega_0}\right)^3-4\left(\frac{\omega}{\omega_0}\right)^5\right]}{1-4\left(\frac{\omega}{\omega_0}\right)^4+4\left(\frac{\omega}{\omega_0}\right)^6}$$

wherein ω_0 represents the cut-off frequency and ω the frequency existing at the time. The impedance which is to be simulated is that of a long loaded line and as is well know in the art may be approximately represented by the equation:

$$Z=\sqrt{\frac{L}{C}}\cdot\frac{1}{\sqrt{1-\left(\frac{\omega}{\omega_0}\right)^2}}$$

It is plotted in Fig. 1 as shown by the dashed curve. It is obvious that the paths of the curves differ especially at the higher frequencies.

The invention is based on the consideration that by decreasing the product LC in the simulating section, the frequency at which the impedance of the balancing network is a maximum increases, and a more exact simulation of the line impedance in the important frequency range may be obtained.

The ratio $\frac{L}{C}$ must naturally be kept approximately constant, that is to say, it must be kept equal to that of the original line. Fig. 2 shows the improved balance obtained by use of a mesh according to Fig. 3, in which the product LC is equal to 0.7 of this product in the case of the line to be simulated, or expressed in another way, whose cut-off frequency is 1.2 times as great as the cut-off frequency of the line. Corresponding to Fig. 1, the dotted line represents the impedance characteristic of the line to be simulated, and the continuous line represents the impedance characteristic of the simulating network. Fig. 2 shows that up to frequency of $\omega=14000$, the simulation and line impedance coincide with a deviation of somewhat less than 5%. The deviation of the imaginary components likewise do not exceed this percentage provided the resistance of the cable is taken into consideration. It would be practical to carry out various small corrections empirically. For example, it has been proved helpful to connect small variable supplementary condensers to the line and the simulating network and to make the final resistance deviate from

$$\sqrt{\frac{L}{C}}$$

according to necessity.

Fig. 3 illustrates the connection of the simulating network.

What is claimed is:

1. An artificial line for simulating the impedance of a long loaded line comprising a section having shunt capacity and series inductance so proportioned that said section has an iterative impedance substantially equal to that of the loaded line and a cut-off frequency substantially higher than that of the line, and a terminating resistance substantially equal to the iterative impedance of the section.

2. An artificial line according to claim 1 in which said inductance and capacity are so proportioned that the cut-off frequency of said section is substantially 1.2 times the cut-off frequency of the line.

3. An artificial net work for simulating the impedance of a long loaded line having an iterative impedance Z and a cut-off frequency f comprising a π type section having a series inductance L and shunt condensers each of capacity 2C of such value that the $\sqrt{\frac{L}{C}}$ is substantially equal to Z and that $\frac{1}{\pi\sqrt{LC}}$ is substantially equal to $1.2f$, and a resistance having a value substantially equal to Z connected in shunt to one of said condensers.

In witness whereof, I hereunto subscribe my name this 26th day of October, A. D., 1925.

WALTER DEUTSCHMANN.