Dec. 15, 1942. K. OKABE 2,305,456

ELECTRICAL CIRCUIT UTILIZING PARALLEL WIRES OR CABLES

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Fig. 1,

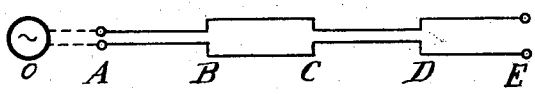
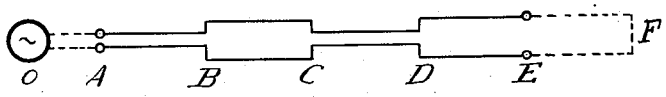


Fig. 2



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ELECTRICAL CIRCUIT UTILIZING PARALLEL WIRES OR CABLES

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6 Claims. (Cl. 178—44)

The present invention relates to frequency stabilizers for ultra-high-frequency circuits.

The principal object of my invention is to provide circuits which in combination with a source of ultra-high-frequency signals will insure oscillation at the desired ultra-high frequency only. More particularly an object of the invention is to provide an electrical line suitable for use as a resonant circuit in an ultra-high-frequency oscillator having good frequency stability. Other objects will appear from the following.

It has been known to employ electrical lines, such as uniformly spaced parallel wires of considerable length, for stabilizing the frequency of ultra-high-frequency circuits. Attainment of the desired stability, however, often necessitated the use of a line at least twenty times the wavelength of the oscillations involved. It has also been known to match the impedance of a high-frequency source to the impedance of a load by the use of several sections of electrical line (such as spaced two-wire line or coaxial line) in series, usually by using sections of line having a surge impedance equal to the geometric mean of the impedance of the source looking back from the section and the impedance of the load looking ahead of the section. This last-mentioned scheme may result in a fairly efficient untuned transmission line.

I have now discovered that it is possible to use an electrical line, made up by connecting in series sections of lines having different surge impedances, as frequency stabilizers in ultra-high-frequency circuits. Such a composite line will afford the same stability, although much shorter than a line using uniformly spaced and similar parallel wires throughout. The line is preferably used as a resonant circuit in which energy is stored during parts of the radio-frequency cycle. One end of the composite line is connected in an ultra-high-frequency oscillation circuit. As little power as possible is removed from the composite line as losses or otherwise. The composite line of the invention cannot therefore serve as an impedance-matching transmission line. As a result of the low removal of power from the line it constitutes a circuit of low power factor. As is well known, such a line will act as a frequency stabilizer if it has sufficient volt-ampere capacity when cut to resonant length. The invention provides means for fulfilling the last-mentioned requirement without using extremely long and cumbersome lines.

The composite line of the present invention comprises a plurality of sections, in series, of electrical line. The first section has a length substantially that of an odd number of quarter-wavelengths of the radio frequency oscillation desired. The second section (and each of the additional sections, if any) of the line also has a length substantially that of some odd number of quarter-wavelengths. Preferably each section is substantially one quarter-wavelength long to conserve space, since the unusual stability obtained is due to differences in electrical characteristics between adjacent sections of the line, rather than merely to the overall length of the line.

The conductors in the second section are of such size and so spaced as to constitute a length of a line having a characteristic impedance or surge impedance different from that of a line constructed as is the first section of the composite line. With a spaced two-wire line the variation in surge impedance may be obtained by changing the spacing of the line for the second quarter-wave or by using conductors of different diameter, or both. If a cable is used having an inner and outer conductor, the impedance change may be obtained by changing the internal spacing, or by making the ratio of diameters of the core and of the external tube different.

A third section having a surge impedance differing from that of the second section may then be added to the line, and a fourth section having a surge impedance differing from that of the third section may be placed after the third section. I prefer to use an even number of sections, and at least four are ordinarily necessary to attain the desired stability. Furthermore, it is my preferred practice to make the first section and each alternate section thereafter of similar construction and of substantially the same characteristic impedance, while making the second section and each alternate section thereafter likewise similar to each other, so that the sections are placed in equivalent pairs connected in series.

The construction of the composite line and its use according to the invention are indicated schematically in the accompanying drawing in which

Fig. 1 represents a preferred form of the composite line connected in an oscillation circuit, and

Fig. 2 represents a modification of the embodiment illustrated in Fig. 1.

Referring to Fig. 1 the composite line shown contains four sections, in series, of spaced two-wire line, the sections being indicated respectively as AB, BC, CD, and DE. Suitably connected to the terminals A of the composite line is an oscillation circuit O, and the terminals of E are left open. Each section is one quarter-wavelength

long and the wires in sections BC and DE are spaced farther apart than the wires in sections AB and CD, so that the second and fourth sections are sections of lines having characteristic impedances different from the characteristic impedance of the lines used in the first and third sections.

The line should be terminated either in a mechanically open circuit, or the last section should be made electrically open-circuited in some other way. The last section may be electrically open-circuited by extending the line one quarter-wavelength and connecting together the ends of the extension, as shown at F in Fig. 2.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A frequency stabilizer for ultra-high-frequency circuits, comprising a resonant circuit made up of an even number of sections, in series, of electrical line, each section being substantially an odd number of quarter-wavelengths long, the conductors in the first section and any alternate sections thereafter being of such size and so spaced as to constitute lengths of lines having substantially the same characteristic impedances, the size and spacing of the conductors in the second and any alternate sections thereafter being such as to constitute these last-mentioned sections lengths of lines having characteristic impedances substantially equal to each other but differing substantially from the characteristic impedance of the line used for the first section, the first section being connected in an oscillation circuit, and the last section being electrically open-circuited.

2. A frequency stabilizer as claimed in claim 1, in which the resonant circuit is made up of four sections of line, each section being substantially one quarter-wavelength long.

3. In a circuit for ultra-high-frequency oscillations, the improvement which comprises a resonant frequency-stabilizing composite line comprising a plurality of sections, in series, of electrical line of different characteristic impedances, each section being substantially an odd number of quarter-wavelengths long, one end of the composite line being connected in the circuit for ultra-high-frequency oscillations, and the other end portion of the line being electrically open-circuited.

4. In a circuit for ultra-high-frequency oscillations, the improvement which comprises a resonant frequency-stabilizing composite line comprising a plurality of pairs, in series, of sections of electrical line, the first section of each pair being in series with a second section having a characteristic impedance different from that of the first section of the pair, each section being substantially an odd number of quarter-wavelengths long, one end of the composite line being connected in the circuit for ultra-high-frequency oscillations, and the other end portion of the line being electrically open-circuited.

5. In a circuit for ultra-high-frequency oscillations, the improvement which comprises a resonant frequency-stabilizing composite line comprising two or more even number of sets of parallel conductors connected in series, each set having a different surge impedance and being substantially an odd number of quarter-wavelengths long, one end of the composite line being connected in the circuit for ultra-high-frequency oscillations, and the other end portion of the line being electrically open-circuited.

6. In a circuit for ultra-high-frequency oscillations, the improvement which comprises a resonant frequency-stabilizing composite line comprising two pairs, in series, of sections of electrical line, the first section of each pair being in series with a second section having a surge impedance different from that of the first section of the pair, each section being substantially an odd number of quarter-wavelengths long, the first section being connected in the circuit for ultra-high-frequency oscillations, and the other end portion of the line being electrically open-circuited.

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