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SYMMETRICAL FREQUENCY DOUBLER

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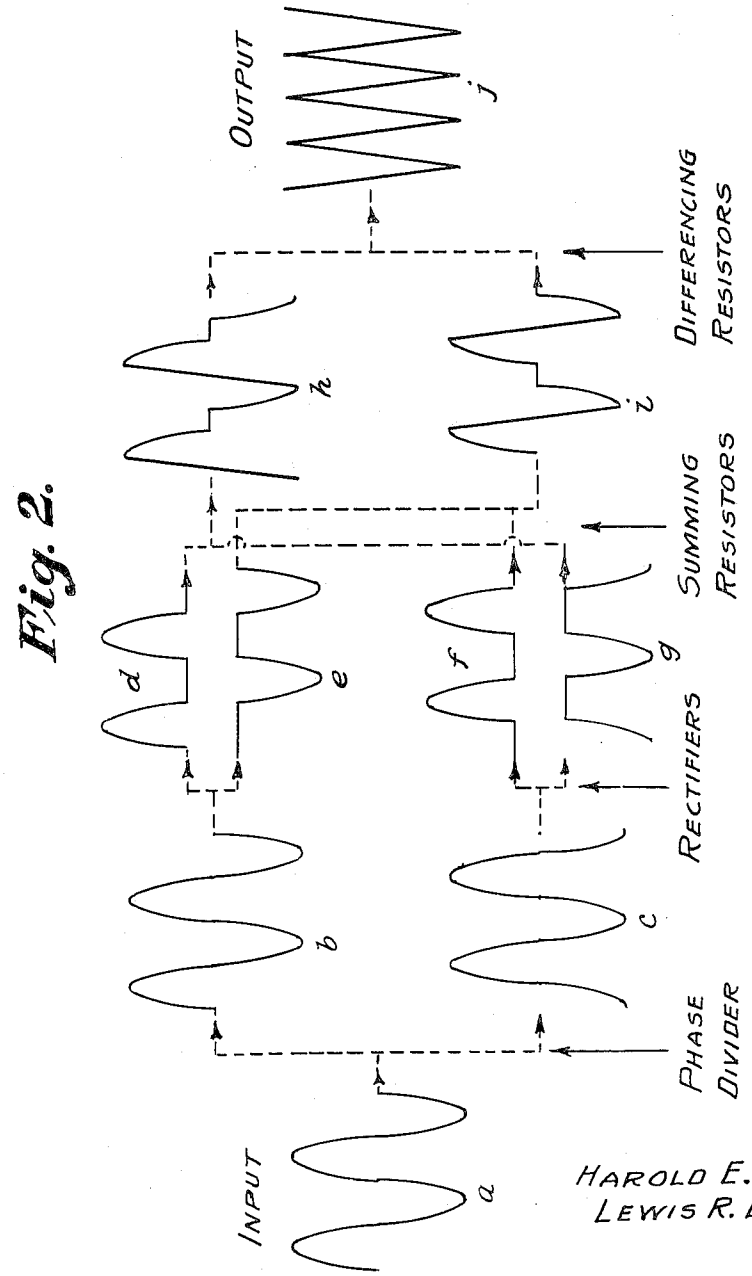


Fig. 2.

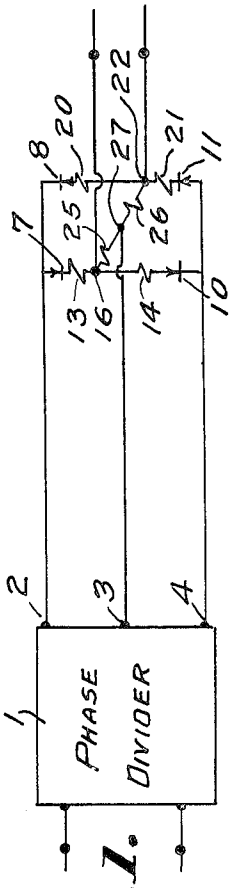


Fig. 1.

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SYMMETRICAL FREQUENCY DOUBLER

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The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to us of any royalty thereon in accordance with the provisions of the Act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

This invention relates to electrical systems, and more particularly to means for and methods of doubling frequency of alternating-current signals.

An object of this invention is to provide an improved and inexpensive means for and method of doubling the frequency of an alternating-current signal and obtaining a symmetrical output which may be used as such or may easily be coverted to a sinusoidal wave form.

Other objects will be apparent from the following description and accompanying drawings wherein:

Figure 1 is a circuit diagram of a preferred embodiment of the invention.

Figure 2 is a graphical representation of the wave forms of signals obtained at various points in the process of doubling the frequency of an input signal.

In a preferred embodiment of the invention illustrated in Figure 1, means are provided for converting a single alternating current signal shown at *a* in Figure 2, into two phase components substantially 90 degrees apart as shown at *b* and *c* in Figure 2. This means may conveniently take the form of a phase divider 1 with three output terminals 2, 3, and 4. The leading phase component, shown at *b* in Figure 2, may conveniently appear between the terminal 2 and the neutral 3, and the lagging phase component, shown at *c* in Figure 2, may appear between the terminal 4 and the neutral 3.

Means are provided for dividing each of the two phase components *b* and *c* into positive and negative parts *d*, *e*, *f* and *g* as shown in Figure 2. Conveniently, a pair of rectifiers 7 and 8, one with its anode and the other with its cathode connected to the terminal 2, may be used to divide the leading phase component *b*. Similarly, another pair of rectifiers 10 and 11, one with its anode and the other with its cathode connected to the terminal 4, may be used to divide the lagging phase component *c*. The terms "anode" and "cathode" are used merely to indicate the direction of flow of current through the rectifiers, and are not a limitation upon the type of rectifiers that may be used. All types of rectifiers may be used in various embodiments of the invention.

Means are also provided for adding the positive half *d* of the leading phase component to the negative half *g* of the lagging phase component. If the cathode of the rectifier 7 is connected to the terminal 2, and the anode of the rectifier 10 is connected to the terminal 4, this may be done by connecting the anode of the rectifier 7 through two resistors 13 and 14 to the cathode of the rectifier 10. The two resistors 13 and 14 are connected to each other at a terminal 16.

Similarly, means are provided for adding the negative half *e* of the leading phase component to the positive half *f* of the lagging phase component. If the anode of the rectifier 8 is connected to the terminal 2 and the cathode

of the rectifier 11 is connected of the terminal 4, this may be done by connecting the cathode of the rectifier 8 through two resistors 20 and 21 to the anode of the rectifier 11. The two resistors 20 and 21 are connected together at a terminal 22.

Those skilled in the art will appreciate that the resistors mentioned above may, in actual practice, take the form of the resistance which is inherent in the other elements of the device, for example, the rectifiers. The resistors need not be separate elements.

The "sum signals" obtained by the two additions of positive to negative halves of the two phase components, are the distorted alternating current signals illustrated at *h* and *i* in Figure 2.

Means are also provided for combining the two "sum signals," as by inverting one of the signals and adding them. Preferably this is done with a pair of so-called "differencing" resistors 25 and 26 which are connected between the terminals 16 and 22, and which are connected to each other and to the neutral terminal 3 at a tap 27. The combined signal which may be taken from the output terminals 16 and 22 is illustrated at *j* in Figure 2.

The wave form of the output *j* is pointed, is composed of approximately straight lines, and is free from any appreciable quantity of the second harmonic. It may be used directly in many devices, but is easily converted to a sinusoidal form when that is desired. The output is fed through a conventional filter. Since there is no second harmonic, the filter need not have a cut-off frequency near the fundamental. It is apparent, therefore, that this invention puts out a signal which is twice the frequency of the input, which is symmetrical, and which is more easily converted to sinusoidal wave form than the output of other frequency doublers known to the art.

It will be understood that the embodiment shown and described is purely illustrative and that modifications may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In a system for obtaining a signal of twice the frequency of two alternating current phase components substantially 90 degrees apart, means for dividing the positive from the negative half of each of said phase components, means for adding the positive half of the first and the negative half of the second of said phase components to obtain a distorted alternating current signal, means for adding the negative half of the first and the positive half of the second of said phase components to obtain another distorted alternating current signal, and means for adding the two distorted alternating current signals in opposite senses whereby a symmetrical alternating current signal is obtained.

2. In an electrical frequency doubler, phase splitting means for obtaining from an alternating input wave two alternating waves substantially 90 degrees apart in phase, said phase splitting means having first, second and neutral terminals, a first rectifier with anode connected to said first terminal, a second rectifier with cathode connected to said first terminal, a third rectifier with anode connected to said second terminal, and a fourth rectifier with cathode connected to said second terminal, the cathode of said first rectifier and the angle of said fourth rectifier being connected to a first output terminal, the anode of said second rectifier and the cathode of said third rectifier being connected to a second output terminal each of said output terminals being respectively connected through a resistor to said neutral terminal the connections from said first and second terminals of said phase splitting means to said first and second output terminals respectively through said four rectifiers each including resistance.

3. A system for deriving, from two fundamental frequency alternating current phases substantially 90° apart,

an alternating current of twice the fundamental frequency, said system comprising (*a*) means for dividing each phase into separate spaced positive half-cycle and spaced negative half-cycle currents of the fundamental frequency, (*b*) means for separately combining the spaced positive half-cycle current divided from each phase with the negative half-cycle current divided from the other phase to produce distorted alternating currents of the fundamental frequency, and (*c*) means for inverting one of the two distorted alternating currents of fundamental frequency and adding it to the other to produce a symmetrical alternating current of twice the fundamental frequency.

4. A system according to claim 3, said inverting and adding means (*c*) comprising differencing resistance means interconnecting said separately combining means (*b*).

5. In a system for doubling the frequency of an alternating signal, in combination, means for dividing said signal into first and second phase components substantially 90 degrees apart in phase, means for rectifying each of said phase components into positive and negative halves, means for adding the positive half of said first phase component to the negative half of said second phase component to obtain a first sum signal, means for adding the negative half of said first phase component to the positive half of said second phase component to obtain a second sum signal, and means for adding said first sum signal to said second sum signal in opposite senses, whereby a wave form substantially free of second harmonic is obtained.

6. Apparatus for doubling the frequency of an alternating current signal, comprising, in combination, means for dividing said signal into first and second phase components substantially 90° apart in phase and not necessarily of the same amplitude, means for rectifying one of said phase components into positive and negative halves each of substantially equal amplitude, means for rectifying the other of said phase components into positive and negative halves each of substantially the same amplitude but not necessarily of the same amplitude as the halves of the first of said phase components, means for adding the positive half of the first phase component to the negative half of the second phase component to obtain a first sum signal, means for adding the negative half of the first phase component to the positive half of the second phase component, to obtain a second sum signal, and means for inverting one of said sum signals and adding it to the other of said sum signals, whereby a symmetrical wave form of uniform amplitude and substantially free of second harmonic is obtained.

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