April 10, 1945. H. E. THOMAS 2,373,275

VOLTAGE CONVERTER SYSTEM

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Fig. 1.

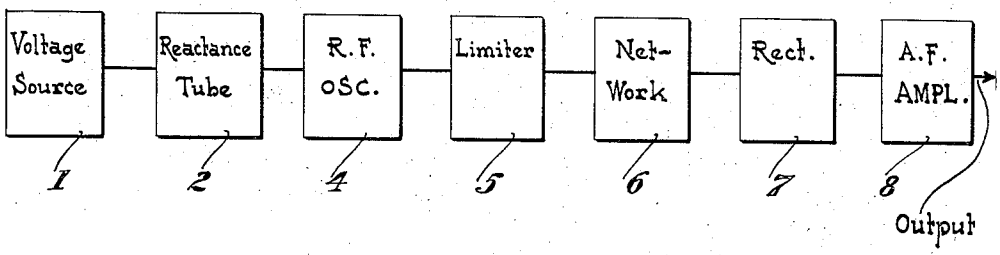


Fig. 2.

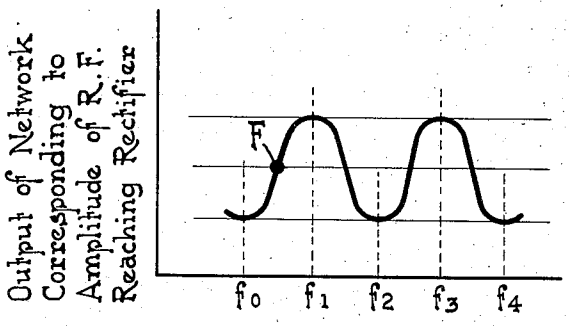
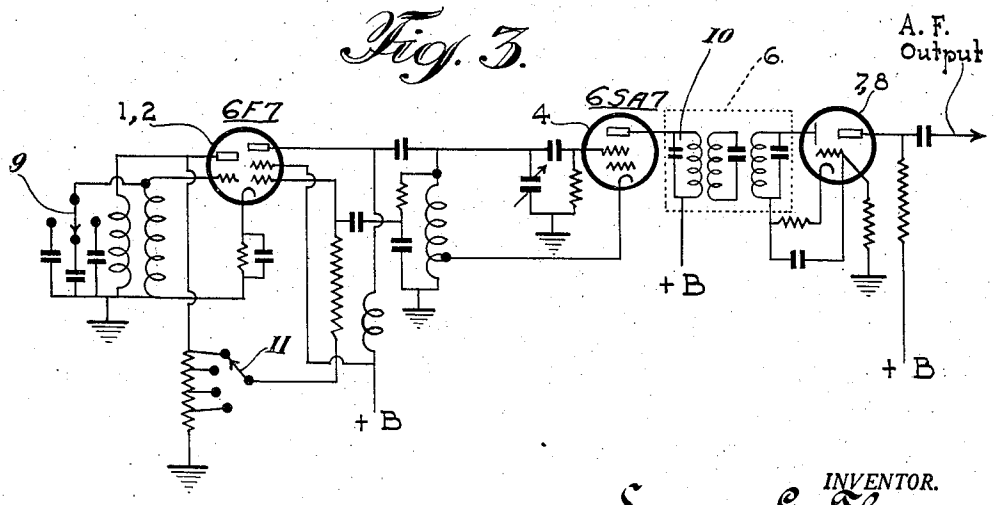


Fig. 3.



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VOLTAGE CONVERTER SYSTEM

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9 Claims. (Cl. 250—36)

The present invention relates to a voltage converter system, and has for its primary object to enable obtaining a voltage having a predetermined relation to a given voltage.

In its broadest aspect, the invention provides means for converting any given varying voltage to another varying voltage which is any desired function of the given voltage. A particular function of interest, given by way of example only and not as a limitation, is a sinusoidal voltage which may have the same frequency or be harmonically related to the given (i. e., applied) voltage. Thus the invention finds use as a frequency multiplier in the case where a cycle of the given or input voltage causes an integral number of output cycles. The invention is also useful for converting one wave shape to another; thus it is possible to convert a sinusoidal input wave to a triangular wave or a square wave or to sharp pulses, depending upon the frequency response characteristic of the network employed in the system of the invention.

A more detailed description of the invention follows in conjunction with a drawing, wherein Figs. 1 and 3 illustrate two different embodiments of the present invention, given by way of example only, and Fig. 2 graphically illustrates one form of network characteristic which may be employed in the practice of the invention.

Referring to Fig. 1 in more detail, there is shown a voltage converter system in accordance with the invention comprising a given varying voltage, represented by source 1 whose voltage is to be converted to another varying voltage of a desired wave shape and which has a desired relation to the given voltage. The voltage from source 1 is impressed on a reactance vacuum tube 2 which, in turn, modulates the frequency of a radio frequency oscillator 4. The output of the oscillator 4 is impressed upon a level setting device or an adjustable amplitude limiter 5, the output of which is applied to a suitable selective wave shaping network 6 which might have, if desired, the characteristic of Fig. 2. The output from the network 6 is rectified in 7 which may comprise a suitable diode, and the rectified energy amplified in audio frequency amplifier 8 from which is derived energy of the desired wave shape and which is a desired function of the given voltage 1.

As an illustration of one embodiment of the invention constituting a frequency multiplier, voltage source 1 may comprise an audio frequency oscillator of triangular wave shape having equal sloping sides. The triangular wave shape is used to provide a constant rate of change of frequency of the frequency modulated oscillator. The reactance tube 2 may be any well known form of variable reactance modulator tube for controlling the frequency of the oscillator 4. The reactance tube 2 may change either the apparent inductance or the apparent capacity of the oscillator tank circuit to produce a frequency modulated wave whose deviation depends upon the magnitude of the audio voltage impressed upon the reactance modulator. To assure a constant output from the radio frequency oscillator 4 there is provided the limiter 5 which is preferably automatically adjustable with the selected amount of deviation. A selector switch in the voltage source, shown in Fig. 3, serves to regulate the amount of frequency deviation. The wave shaping network 6, in order to provide a characteristic like that shown in Fig. 2, may comprise three coupled circuits tuned to the same mid-frequency and suitably damped, or with dissymmetrical damping differently tuned, by slight detuning, to the frequencies corresponding to the humps of the characteristic. The rectifier 7 serves to recover only the audio frequency components from the output of the network, the radio frequency components being discarded. When a sinusoidal network characteristic is employed, the recovered audio frequency components will be harmonic frequencies of sine wave contour, thus producing distortionless frequency multiplication.

Fig. 2 shows a sinusoidal network characteristic which may be used in a frequency multiplier of the invention and is given to aid in an understanding of the principles involved. If the end point frequency of the oscillator 4 corresponds to point f_0 located at the bottom or valley of the curve, and if the total deviation or swing of the radio frequency oscillator is between f_0 and f_2, there will be generated in the output of the network 7 two cycles of audio frequency for each cycle of radio frequency. If the swing of the oscillator 4 is increased so that the deviation is between f_0 and f_3, there will be generated in the output of the network 7 three cycles of audio frequency for each cycle of radio frequency. Greater swings of the oscillator 4 will give correspondingly greater frequency multiplication. If, however, the center frequency f_0 of the radio frequency oscillator 4 is shifted to a linear portion on the network characteristic, for example to point F, we can obtain a voltage of the same frequency generated by source 1 or an odd multiple thereof depending on the deviation of the oscillator 4. In order to prevent blank spaces in the output of the network 6, the frequency of the radio frequency oscillator should never go off the ends of the characteristic curve of Fig. 2, unless it is desired to obtain such a result.

It should be understood that the network 6 can have many different known forms and as many different output characteristics, depending upon the kind of output wave shape desired. Thus, it is possible to convert a given varying voltage, of

let us say a sinusoidal input wave, to a triangular wave or a square wave or to sharp pulses.

Fig. 3 illustrates in detail a frequency multiplier embodiment of the invention. The multi-electrode 6F7 tube has within its envelope two electrode structures, the left hand one of which forms an audio frequency oscillator of sine wave form and the right hand one of which forms a variable reactance modulator. The tube is labeled 1, 2 in order to indicate that it and its associated elements are equivalent to the units of Fig. 1 bearing these same reference numerals. Switch 9 enables the production of any three base audio frequencies in the audio oscillator structure. Switch 11 in the output of the audio oscillator enables the selection of a desired magnitude of voltage for impression on the reactance modulator electrode structure, and hence determines the amount of deviation. The 6SA7 tube forms part of the radio frequency oscillator whose output tuned circuit 10 constitutes one of the three tuned circuits of the wave shaping network 6. Tube 7, 8 is a multi-electrode structure enclosing within its envelope both the diode electrodes and the audio amplifier electrodes corresponding to units 7 and 8 of Fig. 1. It should be noted that the limiter circuit of Fig. 1 is not used in this particular circuit. The use of a given voltage of sine wave form for source 1 will produce a non-uniform output from the network.

The invention is not limited to the precise arrangement shown, since the principles thereof can be used to change the phase of the recovered wave with respect to the applied voltage and even to form frequency modulation of the recovered wave. The phase of the output voltage changes periodically, with appropriately spaced network responses, to produce a frequency modulated result, due to the system of wave shaping networks, in accordance with the invention.

What is claimed is:

1. A circuit for producing a harmonic of a fundamental wave, comprising a radio frequency oscillator, means for modulating the frequency of said oscillator by said fundamental wave, a wave shaping network coupled to the output of said oscillator and having a frequency-amplitude characteristic which varies in amplitude between a maximum and a minimum and back again to maximum in the range of variation of the oscillator frequency, and a rectifier coupled to the output of said network to produce the desired harmonic.

2. A frequency multiplier system comprising a source of audio frequency voltage of triangular wave shape, a reactance modulator tube coupled to said source, a radio frequency oscillator coupled to said modulator tube and having its frequency modulated by said tube, an amplitude limiter in the output of said oscillator, a wave shaping network having a sinusoidal wave characteristic of frequency against amplitude for substantially more than one-half cycle coupled to said limiter, a rectifier coupled to the output of said network, and an audio frequency amplifier coupled to said rectifier.

3. A multiplier in accordance with claim 2, including means for controlling the extent of the deviation of the frequency modulated waves.

4. A circuit for producing a harmonic of a fundamental wave, comprising a radio frequency oscillator, means for modulating the frequency of said oscillator by said fundamental wave, a wave shaping network coupled to the output of said oscillator and possessing a frequency-amplitude characteristic having a double hump in the range of variation of the oscillator frequency, and a rectifier coupled to the output of said network to produce the desired harmonic.

5. A system for producing a voltage which is a desired function of a given voltage, comprising a source of audio frequency voltage constituting said given voltage, a modulator coupled to the output of said source of audio frequency voltage, a radio frequency oscillator coupled to said modulator and having its frequency modulated thereby, a wave shaping network possessing a frequency-amplitude characteristic having a double hump in the range of variation of the oscillator frequency coupled to the output of said radio frequency oscillator, and means coupled to the output of said network for recovering only the audio frequency components.

6. A circuit for producing a harmonic of a fundamental wave, comprising a radio frequency oscillator, means for modulating the frequency of said oscillator by said fundamental wave, a wave shaping network coupled to the output of said oscillator and having a frequency amplitude characteristic which varies in amplitude between a maximum and a minimum twice per cycle in the range of variation of the oscillator frequency, and a rectifier coupled to the output of said network to produce the desired harmonic.

7. A system for producing a voltage which is a function of and a different wave form than a given varying voltage, comprising a radio frequency oscillator, means for modulating the frequency of said oscillator by said given varying voltage, a wave shaping network coupled to the output of said oscillator, said network having a varying frequency-amplitude characteristic which varies periodically for substantially more than one-half cycle of its period.

8. A system for converting a sine wave form of varying voltage to a pulse wave form, comprising a radio frequency oscillator, means for modulating the frequency of said oscillator by said sine wave varying voltage, there being means for maintaining the amplitude of the modulated radio frequency oscillations substantially constant, a frequency selective circuit having a varying frequency-amplitude characteristic which varies periodically for substantially more than one-half cycle of its period, connections for impressing the variable frequency and constant amplitude oscillations upon said frequency selective circuit, and a rectifier coupled to the output of said frequency selective circuit, whereby there is obtained pulses of desired polarity in the output of said rectifier.

9. A system for producing a desired voltage, comprising a source of variable frequency oscillations of constant amplitude, a wave shaping network coupled to the output of said source, said network having a frequency against amplitude characteristic of repetitive form which varies periodically for substantially more than one-half cycle of its repetitive period within the range of variations of said source, and means for deriving from said network said desired voltage.

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