April 28, 1936. O. E. KEALL 2,038,570

FREQUENCY CHANGING SYSTEM

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Fig. 1

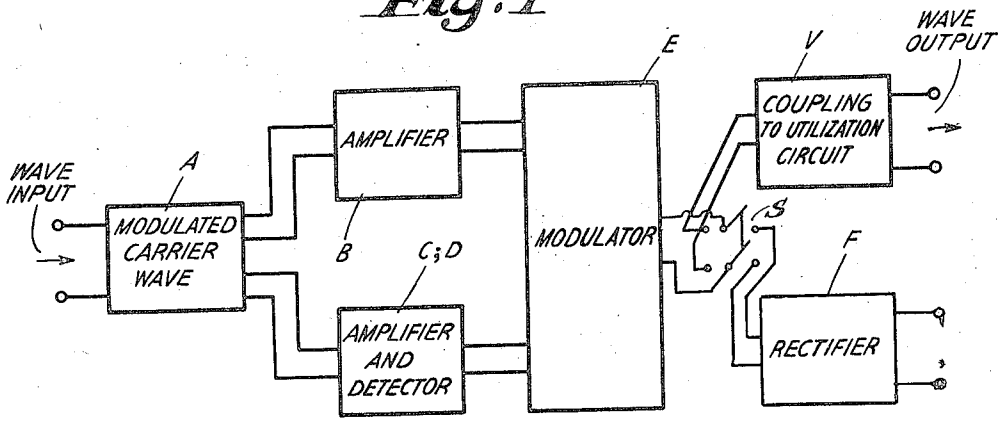
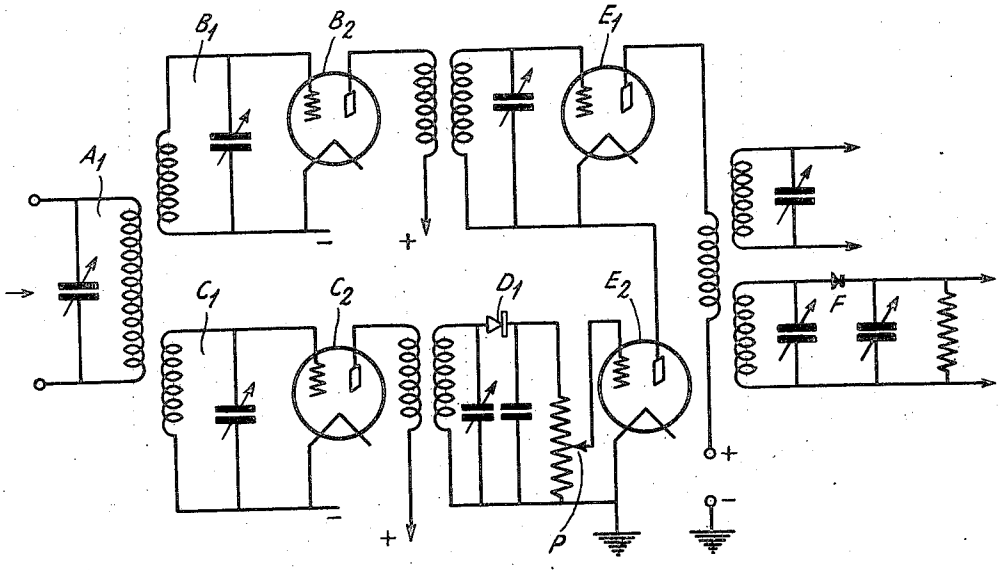


Fig. 2



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FREQUENCY CHANGING SYSTEM

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5 Claims. (Cl. 250—36)

This invention relates to frequency changing circuit arrangements and to modulated carrier wave circuit arrangements.

The invention has for its object to provide a simple circuit arrangement whereby a frequency constituted by a modulation of a carrier frequency may be multiplied to produce either a frequency equal to the said modulation frequency multiplied by two or some power of two or to produce a carrier frequency modulated by a frequency which is equal to the original modulation frequency multiplied by two or some power of two.

According to this invention a modulated carrier frequency is applied to the input terminals of two channels which are arranged in parallel one channel including a detector and the other not including a detector. The outputs from the two channels are fed as inputs to a modulator so that one output modulates the other and the phase of the voltage applied from the detector channel to the modulator is so arranged that voltage from the other channel is modulated by the voltage from the said detector channel at 180° out of phase with the existing modulation upon the carrier from the non-detector channel. The resultant output from the modulator constitutes the useful output of the system and may be utilized direct or may be detected or may be used as the input to another arrangement like that just described.

The invention is illustrated in and further explained in connection with the accompanying drawing, in which Figure 1 is a simplified block diagram of one embodiment and Figure 2 a corresponding simplified circuit diagram.

Referring to Fig. 1, a carrier wave of frequency f_0 modulated by a frequency f is applied via a suitable circuit at A to the input ends of two channels which are in parallel one of the channels consisting merely of an amplifier B and the other comprising an amplifier and a detector C; D. For example, referring to Fig. 2, the modulated carrier may be applied to a tuned carrier frequency circuit A_1 which is magnetically coupled to two other turned carrier frequency circuits B_1, C_1, B_1 of which constitutes the input circuit for one channel and the other C_1 of which constitutes the input circuit for the other. The amplifier B of Fig. 1 is represented as a tube B_2 in Fig. 2, the tube C_2 and crystal rectifier D_1 of Fig. 2 corresponding to the amplifier and rectifier C:D of Fig. 1. The detector in the detecting channel is preferably one having as nearly as possible rectilinear rectification characteristics and is, as stated, shown in Fig. 2 as a crystal though any other suitable form of rectifier may be used. The outputs from the two channels are fed to a modulator E (Fig. 1) which is preferably one possessing as nearly as possible rectilinear modulating characteristics. In Fig. 2, the modulator is shown as of the series type and comprises a tube E_1 which receives its grid input from the amplifier B_2 and has its anode to cathode space in series with the anode to cathode space of a tube E_2 which receives its grid input (via an amplitude adjusting potentiometer P) from the rectifier D_1. By suitably adjusting the relative amplitudes of the two inputs to the modulator arrangement, energy of modulation frequency f may be caused to be eliminated from the output energy from the said modulator, the said output energy being modulated by a frequency $2f$. If desired, the said output modulated by the frequency $2f$ may be detected to produce the frequency $2f$ alone by connecting the rectifier F of Figs. 1 and 2 to the output of E by putting switch S in the proper position or it may be utilized direct by connecting V to the output of E, or said output may be utilized as the input to an additional frequency multiplying system similar to that shown in Figures 1 and 2 between A and E. The output from this additional system will consist of carrier energy modulated by a frequency $4f$. The phase of the energy fed from the amplifier-detector channel C, D to the modulator is so arranged (for example as illustrated in Fig. 2) that it would produce modulation on a carrier 180° out of phase with respect to the modulation that already exists on the input carrier fed to the said amplifier detector channel B.

Suppose the original modulated input carrier may be expressed by $E \cos A(1+\cos B)$ for 100% modulation where $A=2\pi f_0 t$ and $B=2\pi f t$, then remodulating this input 180° out of phase with f will give rise to

$$[E \cos A(1+\cos B)](1-\cos B)=E \cos A$$

$$(1-\cos^2 B)=\frac{E}{2} \cos A(1-\cos 2B)$$

It will thus be seen that the frequency of the original modulation f has been doubled. If desired, the initial input carrier may be changed by heterodyning and again, if desired, the amplifiers in the channels may be equipped with automatic volume control arrangements as known per se.

The invention is capable of fairly broad application and numerous cases will arise where it may be used with advantage. For example, in broadcasting installations where a plurality of

transmitting stations are required to operate upon a common frequency, a tuning fork or similarly controlled master frequency might be generated at a central station and used to modulate a carrier frequency and the resultant modulated carrier frequency transmitted to the various stations and there subjected to frequency changers in accordance with this invention, the original master modulation frequency being doubled as many times as may be required with or without changing the carrier frequency.

In some cases it may be advantageous from the practical point of view to effect frequency doubling of a modulation frequency in circuits tuned to a carrier frequency which is remote from that upon which the modulation frequency was originally carried.

What is claimed is:

1. A method of multiplying a frequency constituted by a modulation of a carrier frequency to produce either a frequency equal to said modulation frequency multiplied by two or to produce a carrier frequency modulated by a frequency equal to the first mentioned modulation frequency multiplied by two which includes the steps of, separating the original modulated carrier into two portions, rectifying the energy of one of said portions, and modulating the unrectified portion by the energy produced by rectifying the other portion in such manner that the phase of the modulation in the rectified portion is substantially 180° different from the phase of the modulation in the unrectified portion.

2. In combination, a source of modulated carrier energy, a pair of channels each having an input circuit and an output circuit, means for applying said energy to the input circuits of said channels, a detector, in one of said channels, and a modulator arrangement, for modulating output energy from one channel with output energy from the other channel, connected with said output circuits, and means for shifting the phase of the modulation applied from the channel including the detector to said modulator substantially 180° relative to the phase of the modulation applied from the other channel to said modulator.

3. Apparatus as claimed in claim 2 wherein one channel includes a thermionic amplifier and the other a thermionic amplifier in cascade with and preceding said rectifier.

4. Apparatus as claimed in claim 2 wherein the modulator arrangement is a series modulator arrangement comprising two tubes with their discharge paths in series, one of said tubes receiving its grid input from one channel and the other from the other channel.

5. Apparatus as claimed in claim 2, including means for adjusting the relative input amplitudes to the modulator arrangement from the two channels.

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