July 5, 1938. E. H. ARMSTRONG 2,122,401

FREQUENCY CHANGING SYSTEM

Filed Sept. 14, 1935

Fig. 1.

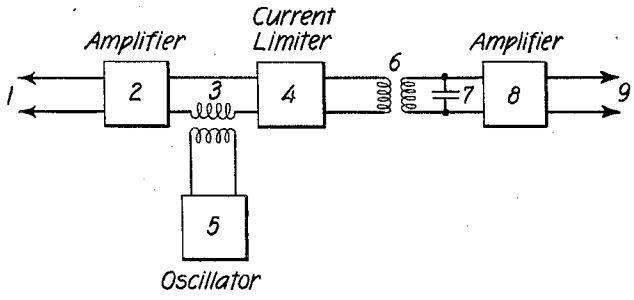
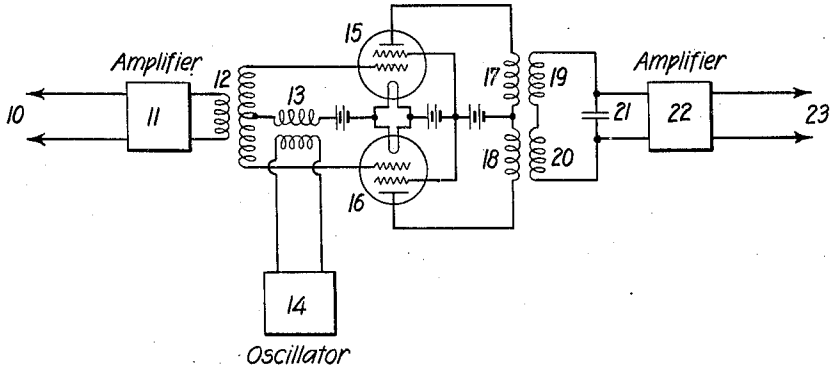



Fig. 2.

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## FREQUENCY CHANGING SYSTEM

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3 Claims. (Cl. 250—36)

This invention relates to a method of frequency changing somewhat akin to heterodyning but following different laws of frequency relations.

It is of great value where slight changes in frequency are required to which the heterodyne method is not well adapted.

The general method of applying the principle of the invention is illustrated by the diagram of Fig. 1. A more desirable arrangement for practical operation is illustrated in the arrangement of Fig. 2.

Referring now to Fig. 1, 1 represents the input to the system for supplying the current whose frequency is to be changed. 2 represents an amplifier for this current and 4 a current limiter. 5 represents an oscillator coupled to the input of the current limiter by the transformer 3. The output of the current limiter is coupled to a tuned circuit 6—7 which is coupled to a device 8 which may be either an amplifier or a detector as desired. The output circuit is represented by 9. The operation of the system is as follows. The strength of the currents applied to the current limiter 4 by the oscillator 5 is adjusted to be sufficiently strong to saturate the current limiter. The frequency of the oscillator is set according to the formula $F^2=2F^1-F$, where F is the incoming frequency, $F^1$ is the local frequency and $F^2$ is the desired frequency. The circuit 6—7 is tuned to the desired frequency $F^2$ to select it from the various other frequencies which are created in the current limiter. After selection by the system 6—7 the signal may be either amplified or detected at 8 as desired. The operation is strictly linear so long as the amplitude of the incoming frequency is small compared to the amplitude of the local oscillator.

The principle of operation is as follows. Since the current limiter is saturated and since the incoming current is small with respect to the local oscillator current, the combination of the two currents in the current limiter can produce no change in amplitude of the output current of the current limiter. It does, however, produce by what we may call cross modulation a shift in phase of the output current of the current limiter which occurs at a rate depending on the difference in frequency between the incoming and the local currents. In effect, the combination of the two currents of constant frequency produces in the output circuit of the current limiter a phase-modulated current whose rate of phase modulation is the difference of the two frequencies; hence there appears in the output circuit of the current limiter a series of frequencies, three of which are of the first magnitude. One is the input frequency, the other is the local frequency and a third is an image frequency which lies on the opposite side of the local frequency by an amount equal to the difference between the incoming and local frequencies. This image frequency may be made anything that is desired by properly selecting the local frequency.

In Fig. 2 a balanced current limiter system is employed that eliminates the local oscillation from the output of the current limiters, which has various practical advantages when the frequency change desired is very slight. In this arrangement 10 represents the input or signalling current, 11 an amplifier for that current, 12 a transformer for applying the signal to the input of the current limiters in push-pull, 13 a transformer for applying the oscillator current to the input of the limiters in push-push. 15—16 represent the two current limiters and 17—18 the primaries of the transformers which couple differentially with the secondaries 19—20. 21 is a condenser for tuning the secondary circuit to the frequency which it is desired to receive and 22 is an amplifying or detecting system as is desired. The operation of the system is the same as previously described for Fig. 1 except that on account of the balanced current limiting system 15, 16 the only currents of importance which appear in the output of the current limiter are the original incoming frequency and the image frequency. The frequency of the local oscillator is eliminated.

I claim:

1. The method of changing the frequency of an alternating current, which consists in providing a second alternating current of greater amplitude than the first and having a frequency which is the mean value between the frequency of the first-mentioned current and the desired frequency, simultaneously combining said currents and limiting the amplitudes thereof, and selecting the desired frequency from the current resulting from such simultaneous combining and limiting.

2. In combination, a plurality of sources of current differing in frequency, one of said sources being greater in amplitude than the other, a current limiter, means for impressing currents from said sources on the input side of said current limiter, and means connected to the output side of said current limiter for selecting therefrom current of a frequency equal to the algebraic sum of the frequency of the current of greater amplitude and the difference between its frequency

and the frequency of the current of lesser amplitude.

3. In combination, a plurality of sources of current differing in frequency, one of said sources being greater in amplitude than the other, a balanced current limiter, means for supplying current from the lesser source cumulatively to said limiter and for supplying current from said greater source differentially thereto and means connected to the output side of said limiter for selecting therefrom current of a frequency equal to the algebraic sum of the frequency of the greater current and the difference between its frequency and the frequency of the lesser current.

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