July 7, 1942. W. VAN B. ROBERTS 2,289,041

FREQUENCY MODULATION

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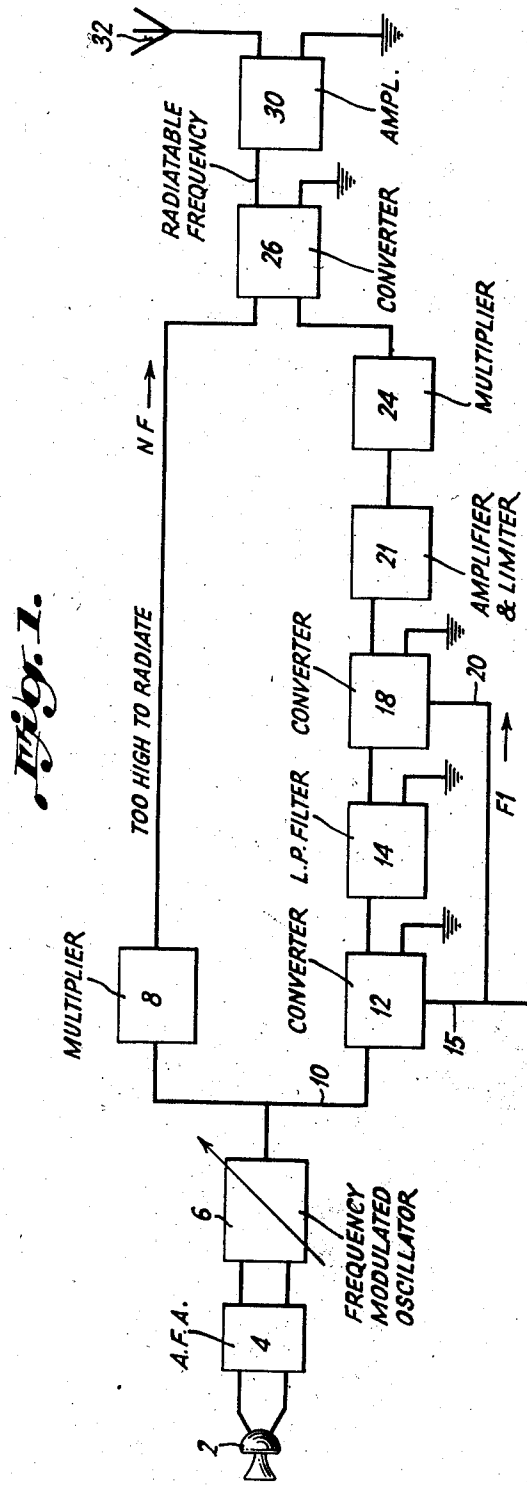


Fig. 1.

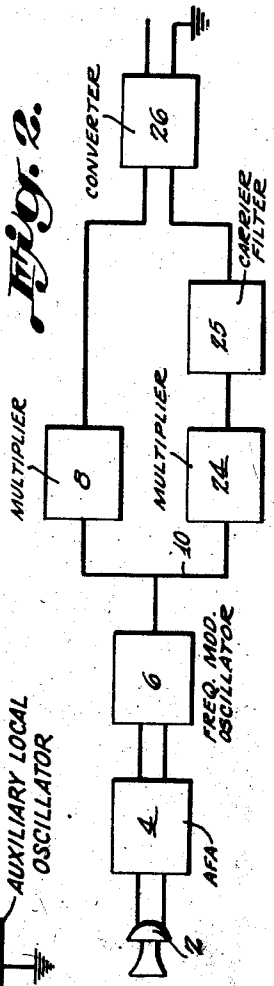


Fig. 2.

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FREQUENCY MODULATION

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6 Claims. (Cl. 179—171.5)

My present invention relates to the art of frequency modulation. One object of my invention is to provide an improved frequency modulation transmitter in which the mean transmitted or carrier frequency is maintained highly constant.

Briefly, in carrying out my invention waves from a frequency modulated oscillator are multiplied in frequency to a value greater than that desired for transmission. Another portion of the waves from the frequency modulated oscillator is beat down with waves from a local auxiliary oscillator. The beat waves are substantially stripped of side bands and the resulting isolated beat frequency carrier is then heterodyned up in frequency with another portion of waves from the auxiliary local generator. This higher frequency beat is then multiplied in frequency and after multiplication combined with the modulated waves which were previously multiplied to a value too high for transmission. The combined waves are then utilized for radiation. This system offers many advantages which will be apparent as the further description thereof proceeds. The latter will be given with the aid of the accompanying drawing in which Figure 1 is a schematic diagram of my improved transmitter and Figure 2 is a modification of the arrangement of Figure 1.

Referring to Figure 1 of the drawing, voice or music impressed upon the microphone 2 is amplified by the voice or modulation frequency amplifier 4. These amplified signal waves are used to vibrate a crystal electrode of a crystal controlled oscillation generator 6, thereby varying the frequency thereof. If desired, of course, the amplified waves from amplifier 4 may be used to vary a reactance tube in shunt to the crystal of the oscillation generator 6 or a reactance tube in shunt to the tuned plate circuit of the crystal controlled oscillation generator 6. The frequency modulated waves from the frequency modulated crystal controlled oscillator 6 having a mean frequency F are fed to a frequency multiplier 8 and multiplied to a high frequency. Multiplier 8 also serves to increase the amount of frequency modulation to a desired degree. Another portion of the crystal controlled oscillator tube output is fed through lead 10 to a detector or converter 12. The latter is supplied through lead 15 with oscillations from a crystal controlled or other controlled oscillation generator 16, the frequency of which is approximately equal to the mean frequency F of the crystal controlled oscillation generator 6.

The beat frequency appearing in the output of converter 12 is fed to a low pass filter 14. The width of the filter 14 is such as to pass substantially only the mean frequency appearing in the output of converter 12 and to strip all side band frequencies from the beat waves appearing in the output of converter 12.

The output of low pass filter 14 is fed to a second converter 18 which is also fed through lead 20 with oscillations from the local generator 16. By means of tuned circuits in the converter 18, as well as tuned circuits in the amplifier and limiter 21, the frequency F is selected, amplified and limited and then fed through lead 22 to a frequency multiplier 24.

The frequency multiplying factor of multiplier 24 is less than that of multiplier 8 so that when the wave outputs of multipliers 8 and 24 are beat together in converter 26, the output therefrom appearing in line 28 is of a suitable radiation frequency.

The output of converter 26 appearing in line 28 is amplified by amplifier 30 and then fed to a suitable radiating antenna 22.

If desired, of course, the output of the converter 26 may be frequency multiplied, as well as amplified, before it is radiated over the antenna 32.

It will be understood that an amplifier and/or limiter may be interposed between converters 12 and 18 instead of at 21, or in addition to the amplifier and limiter at 21.

It is to be clearly understood that apparatus 6 may represent a phase modulated transmitter rather than a frequency modulated transmitter. The rest of the system, however, may remain the same. The term "timing modulation" is used in the appended claims to include either frequency or phase modulation.

If the transmitter is of the frequency modulation type, the A. F. amplifier 4 may have a gain versus frequency characteristic that rises with frequency, as it has been found that in any method of audio frequency transmission the noise is reduced by pre-emphasizing the higher frequencies before transmission and correspondingly de-emphasizing them at the receiver. On the other hand, if element 6 is a phase modulated oscillator and the signals radiated from antenna 32 are intended to be received by an F. M. receiver including means for de-emphasizing higher audio frequencies, then amplifier 4 is preferably arranged to provide pre-emphasis of substantially only the lower audio frequencies rather than to provide gain which is inversely

proportional to frequency over the whole audible range, as has been customary in the past.

The auxiliary oscillator 16 and the oscillator of apparatus 6 may both be of the crystal controlled type and may both be temperature controlled. It is to be noted that the control for the oscillator 16 need not be particularly exact since any changes in frequency thereof become self-cancelling by virtue of the beating down, beating up process by converters 12 and 18.

In Figure 2 I have shown an alternative arrangement. In this modification lead 10 is connected directly to multiplier 24 wherein the wave energy is multiplied to a final frequency less than that produced by multiplier 8. The output of multiplier 24 is then supplied to a carrier filter 25 adapted to pass only the carrier frequency. The output of multiplier 24 and its filter 25 in this case, together with the output of multiplier 8, may, as before, be fed directly to converter 26, the output of which may be subsequently utilized as desired.

It is realized that it is impractical to obtain a strictly unmodulated carrier by simple filtration as suggested above, but useful results may be obtained so long as the filtration is sufficient to bring out the carrier component strongly in comparison with the side bands.

Having thus described my invention, what I claim is:

1. The method of signaling which includes producing a wave modulated as to its timing, in one path multiplying the modulated wave's frequency to a value higher than that to be transmitted, in another path beating the modulated wave to some lower frequency, filtering the waves so beat down, heterodyning the filtered wave to a higher frequency, combining the heterodyned and multiplied waves and utilizing the combined waves.

2. The method as claimed in the preceding claim, characterized by the fact that the heterodyned waves are frequency multiplied prior to combination with the frequency modulated wave which has been multiplied in frequency.

3. A transmitter comprising an oscillation generator, means for modulating the timing of the waves generated by said generator, a frequency multiplier for frequency multiplying a portion of the modulated waves, an auxiliary oscillator, a converter, means for feeding waves from said auxiliary oscillator and for feeding another portion of said frequency modulated waves to said converter to produce a lower beat frequency, a filter for filtering the beat frequency output of said converter, and means for combining and utilizing waves derived from said filter and waves derived from said multiplier.

4. Apparatus as claimed in the preceding claim, characterized by the provision of means for heterodyning the output of said filter with another portion of waves from said auxiliary oscillator to a higher frequency prior to utilization.

5. Apparatus as claimed in claim 3, characterized by the provision of means for heterodyning the output of said filter with another portion of waves from said auxiliary oscillator to a higher frequency prior to utilization, and further characterized by the fact that a frequency multiplier is provided for frequency multiplying the heterodyned waves prior to utilization.

6. In a system for increasing the modulation of a carrier wave the timing of which is modulated in accordance with signals, a source of carrier wave energy so modulated, a mixing stage, a first path coupling said source to said mixing stage, a wave frequency multiplier in said path for multiplying the modulated wave's frequency to a value higher than that to be transmitted, a second path coupling said source to said mixer, a filter in said second path for supplying to said mixer stage carrier wave energy only of a frequency different from the frequency of the multiplied modulated carrier supplied by said first path, and wave transmitting means coupled to said mixer.

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