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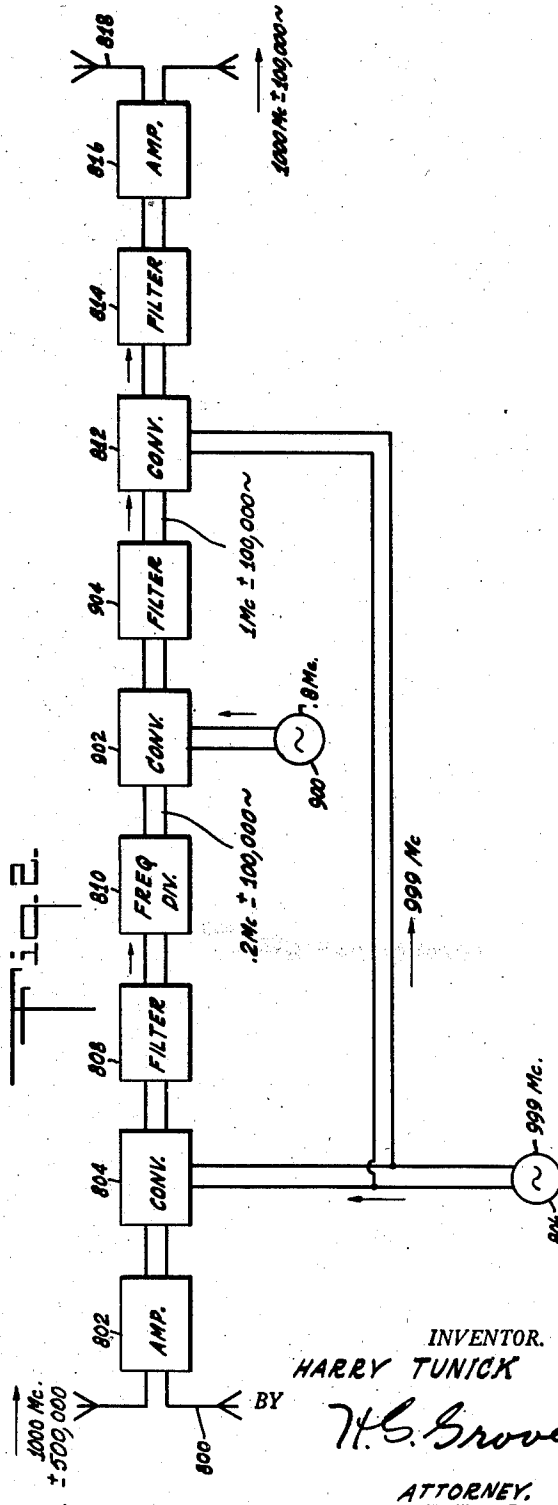
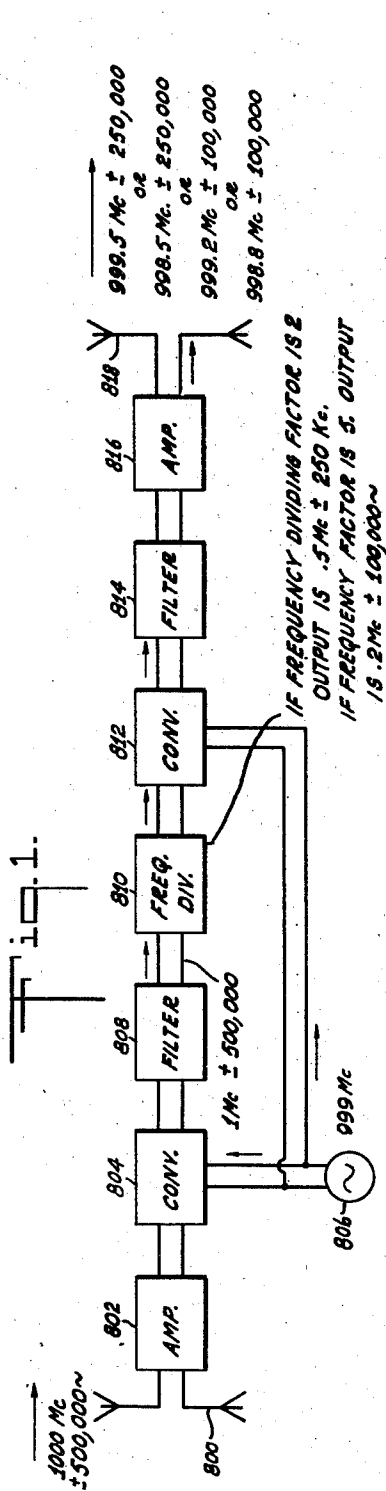
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2,407,213

RADIO RELAYING

Original Filed June 16, 1942

2 Sheets-Sheet 1



INVENTOR.  
HARRY TUNICK

BY

H. B. Grover

ATTORNEY.

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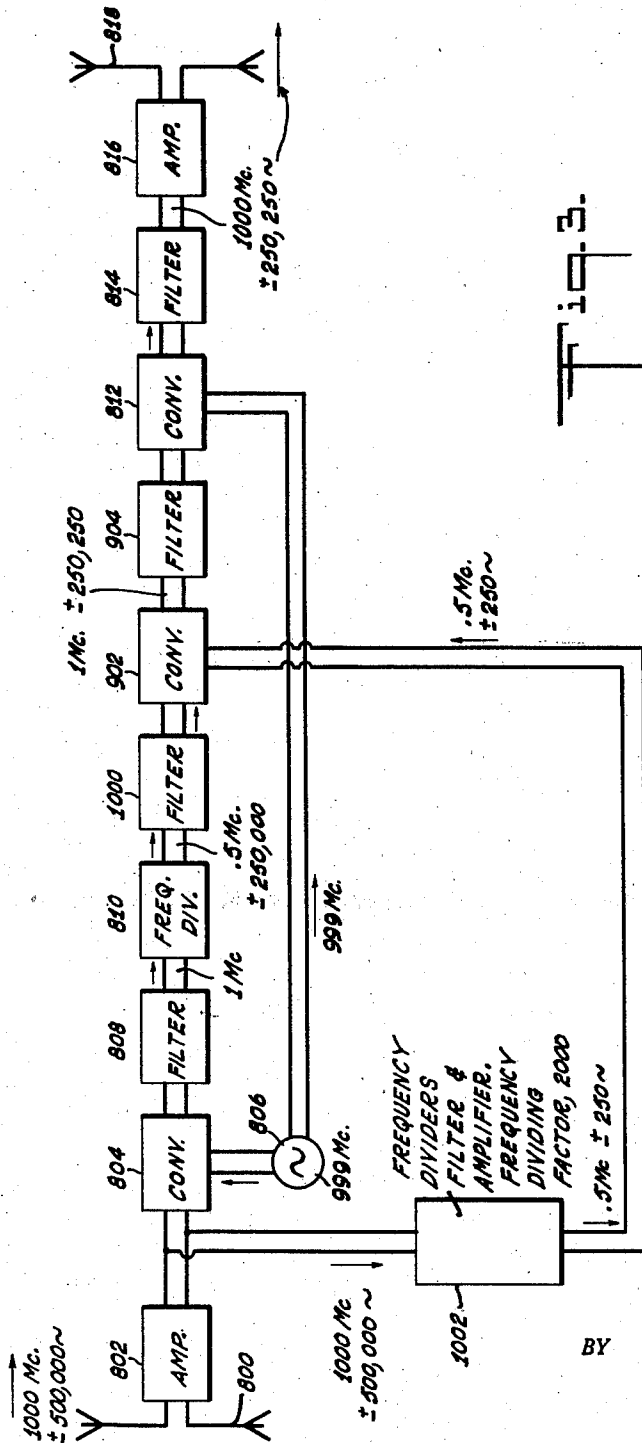
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H.G. Brover

ATTORNEY.

## UNITED STATES PATENT OFFICE

2,407,213

## RADIO RELAYING

Harry Tunick, Rye, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Original application June 16, 1942, Serial No. 447,225. Divided and this application June 13, 1944, Serial No. 540,061

10 Claims. (Cl. 250—15)

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This is a division of my copending application Serial No. 447,225, filed June 16, 1942. Figures 1, 2, and 3 herein are, respectively, original Figures 8, 9, and 10 of my parent application as filed in the United States Patent Office.

The present invention is directed towards radio relaying and is particularly useful for relaying angle, phase and frequency modulated waves. One object of the invention is to provide an improved radio relaying system in which waves received on one carrier of one mean frequency are retransmitted on a new carrier of different mean frequency, the retransmitted waves having reduced angle, phase or frequency deviation as compared to that received.

In a modification of the present invention, waves received with one degree of angle, phase or frequency deviation are retransmitted at the same carrier or mean frequency with, however, reduced deviation.

Other objects of my invention will appear as the more detailed description thereof proceeds, as will also advantages and other features.

Figure 1 illustrates schematically a radio relaying system in which angle modulated waves received at one frequency are retransmitted at a different frequency with reduced deviation;

Figure 2 is a modification of Figure 1 wherein the retransmitted waves are of the same mean or carrier frequency as received but with, however, reduced deviation; and

Figure 3 is a modification of Figure 2.

Referring to Figure 1, let it be assumed that the received waves have a mean frequency of one thousand megacycles and a maximum frequency deviation of plus and minus 500,000 cycles. The waves received upon the antenna 800 are amplified in amplifier 802 and then fed to the converter 804. Converter 804 is also fed from a local generator 806 whose frequency of operation may be 999 megacycles.

The output of converter 804 is fed to a filter 808 which passes into frequency divider 810 the difference frequency or one megacycle plus and minus 500,000 cycles. Assuming the frequency divider to have a frequency dividing factor of two, its output will be .5 megacycle plus and minus 250,000 cycles. If the frequency divider 810 has a dividing factor of, for example, five, then its output will be a frequency modulated wave having a mean frequency of .2 megacycle and a maximum deviation of plus and minus 100,000 cycles.

The output of the frequency divider 810 is combined in a converter 812 with another portion of waves derived from local generator 806 having a

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frequency of 999 megacycles. Filter 814 and amplifier 816 are designed so as to pass and amplify either the sum or difference of the frequencies fed to converter 812.

5 If the frequency dividing factor is two for frequency divider 810 then the re-radiated wave from antenna 818 may be made either 999.5 megacycles plus and minus 250,000 cycles or 998.5 megacycles plus and minus 250,000 cycles. If the frequency divider has a dividing factor of five then the re-radiated wave from antenna 818 will be either 999.2 megacycles plus and minus 100,000 cycles or 998.8 megacycles plus and minus 100,000 cycles.

15 Figure 2 shows an arrangement for retransmitting at the same mean frequency as that received with, however, a reduction in frequency deviation of the received frequency or phase modulated waves.

20 Figure 2 is similar to Figure 1 with the exception that the generator 900, converter 902, and filter 904 have been added. It is assumed that the frequency divider 810 has a dividing factor of five, hence its output for the values assumed will be .2 megacycle plus and minus 100,000 cycles. To this divided output a low frequency of 800,000 cycles is added from generator 900 by the action of converter 902. The sum frequency is preferably selected by filter 904 and its output, as indicated, is one megacycle plus and minus 100,000 cycles. To the output of filter 904 there is added in converter 812 another portion of waves from the high frequency generator 806 and preferably filter 814 is arranged to pass the sum frequency or 1000 megacycles plus and minus 100,000 cycles which is amplified by amplifier 816 and re-radiated over antenna 818.

40 Figure 3 is the same as Figure 2 with the exception that a filter 1000 has been added after the frequency divider 810 and the low frequency oscillator 900 of Figure 2 has been replaced by frequency dividers, filters, and amplifiers 1002 fed with waves from the output of amplifier 802. As in Figures 1, 2, and 3, it will be observed that changes in frequency of the local high frequency source 806 prove substantially self-cancelling. The drifts in frequency of the local oscillator 900 of Figure 2 are substantially eliminated in Figure 3 by using as the source of relatively low frequency local oscillations, the output of divider 1002 which has a dividing factor of 2000. Hence, the output of divider 1002 will be a wave of .5 megacycle having a maximum frequency deviation of plus and minus 250 cycles, which deviation obviously may be neglected.

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Assuming in Figure 3 the divider 810 to have a dividing factor of two, the output of filter 1000 will be .5 megacycle plus and minus 250,000 cycles. To this is added in converter 932 .5 megacycle plus and minus 250 cycles from the output of divider 1002. Filter 904 thereupon passes one megacycle plus and minus 250,250 cycles which when combined with the 999 megacycle wave from oscillator 806 in converter 812 produces in the output of filter 814 a wave having a mean frequency of 1000 megacycles having a maximum deviation of plus and minus 250,250 cycles which is amplified by amplifier 816 and re-radiated over antenna 818.

I claim:

1. The method of reducing the phase or frequency deviation of phase or frequency modulated waves which includes generating oscillations of relatively constant frequency, utilizing a portion of the generated oscillations to heterodyne the phase or frequency modulated waves down to a relatively low intermediate frequency, frequency dividing the waves of intermediate frequency, and utilizing another portion of the locally generated waves to heterodyne the frequency divided waves to a higher mean frequency.

2. The method of reducing the phase or frequency deviation of a phase or frequency modulated wave which includes generating relatively constant frequency local oscillations, heterodyning a portion of said locally generated oscillations with said phase or frequency modulated waves to produce waves of intermediate frequency, frequency dividing the waves of intermediate frequency, heterodyning the frequency divided energy with another portion of wave energy locally generated, filtering the product of the last-mentioned heterodyning process, and utilizing the filtered output.

3. A radio relaying system for phase or frequency modulated waves which includes an antenna for receiving phase or frequency modulated waves, an amplifier amplifying the received waves, a converter to which said amplified waves are fed, a source of locally generated relatively constant frequency waves, apparatus for feeding a portion of said locally generated waves to said converter whereby in the output of said converter energy of intermediate frequency appears, a filter for filtering the energy of intermediate frequency, a frequency divider for frequency dividing the filtered energy of intermediate frequency, a converter to which the output of said frequency divider is fed, circuits for feeding another portion of waves, locally generated, to said second converter, a filter for filtering the heterodyned output of said second converter, an amplifier coupled to said last-mentioned filter, and a radiating antenna coupled to said last mentioned amplifier.

4. The method of relaying waves which includes receiving the waves, heterodyning the waves to an intermediate frequency, frequency dividing the waves of intermediate frequency, adding a wave of substantially constant frequency to the waves resulting from frequency division, filtering the waves resulting from the addition, and utilizing the filtered waves.

5. The method of relay waves which includes receiving the waves, heterodyning the waves to an intermediate frequency, frequency dividing the waves of intermediate frequency, adding a wave of relatively constant frequency to said frequency divided waves, filtering the waves re-

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sulting from said addition, and heterodyning the filtered waves to a relatively higher frequency suitable for re-radiation.

6. The method of receiving phase or frequency modulated waves and retransmitting them at substantially the same mean frequency but with a changed phase or frequency deviation which includes receiving phase or frequency modulated waves, heterodyning the waves to an intermediate frequency, changing the mean frequency of said waves of intermediate frequency by a process other than a heterodyning process, algebraically adding to the intermediate frequency waves of changed frequency a wave of substantially constant frequency, filtering the waves resulting from the algebraic addition, and heterodyning the filtered waves to the same mean frequency as that received.

7. Apparatus for relaying received phase or frequency modulated waves which includes an antenna for receiving such waves, a local source of heterodyning oscillations, apparatus for heterodyning energy derived from the received waves with waves from said local source so as to produce waves of intermediate frequency, a frequency divider for frequency dividing the waves of intermediate frequency, a detector coupled to the output of said frequency divider, a generator of relatively low frequency waves also coupled to said detector, a filter for filtering out from the output of said detector waves having the same mean frequency as said intermediate frequency, apparatus for utilizing another portion of the output of said local source of heterodyning oscillations for heterodyning the output of said last-mentioned filter to the same mean frequency as that received, and a radiating antenna for radiating waves derived from the output of said last-mentioned heterodyning apparatus.

8. Apparatus for relaying phase or frequency modulated waves comprising a receiving antenna for receiving such waves, an amplifier for amplifying waves picked up by said antenna, a converter coupled to the output of said amplifier, a local heterodyning oscillator, apparatus for feeding waves from said local oscillator to said converter, a filter for filtering the output of said converter, a frequency divider for frequency dividing the output of said filter, a second converter to which the output of said frequency divider is fed, a generator of relatively constant frequency waves, a circuit for feeding the output of said generator to said second converter, the frequency of said generator being chosen so that in the output of said converter waves having the same mean frequency as are applied to the input of said frequency divider appear, a filter for filtering the output of said second converter, a third converter to which are fed the output of said last-mentioned filter and waves from said first-mentioned local heterodyning oscillator, a filter for filtering the output of said third converter, an amplifier for amplifying the output of said last-mentioned filter, and a radiating antenna fed by said last-mentioned amplifier.

9. The method of relaying received waves which includes receiving the waves, amplifying the waves, frequency dividing a portion of the amplified waves, locally generating waves, heterodyning down in frequency another portion of said amplified waves with a portion of said locally generated waves, frequency dividing the heterodyned waves, combining the frequency divided heterodyned waves with waves derived from the frequency divided portion of the ampli-

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fied received waves, filtering the combined waves, heterodyning the filtered waves up in frequency with another portion of the locally generated waves, filtering and amplifying the waves resulting from the last-mentioned heterodyning process, and radiating the filtered and amplified waves.

10. A radio relay system comprising a receiving antenna, an amplifier for amplifying waves received by said receiving antenna, a converter to which a portion of the output of said amplifier is fed, a frequency divider to which another portion of the output of said amplifier is fed, a local source of oscillations, circuits for feeding a portion of the output of said local source to said con-

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verter, a filter for filtering the output of said converter, a frequency divider for frequency dividing the output of said filter, a second converter to which the outputs of both of said frequency dividers are fed and combined, a filter for filtering the output of said second converter, a third converter to which the output of said last-mentioned filter and another portion of the output of said local source of oscillations are fed, a filter for filtering the output of said third converter, and a radiating antenna for radiating waves derived from the output of said last-mentioned filter.

HARRY TUNICK.