March 8, 1938. G. M. CHARRIER 2,110,698

SIGNAL FREQUENCY INVERTER

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Fig. I.

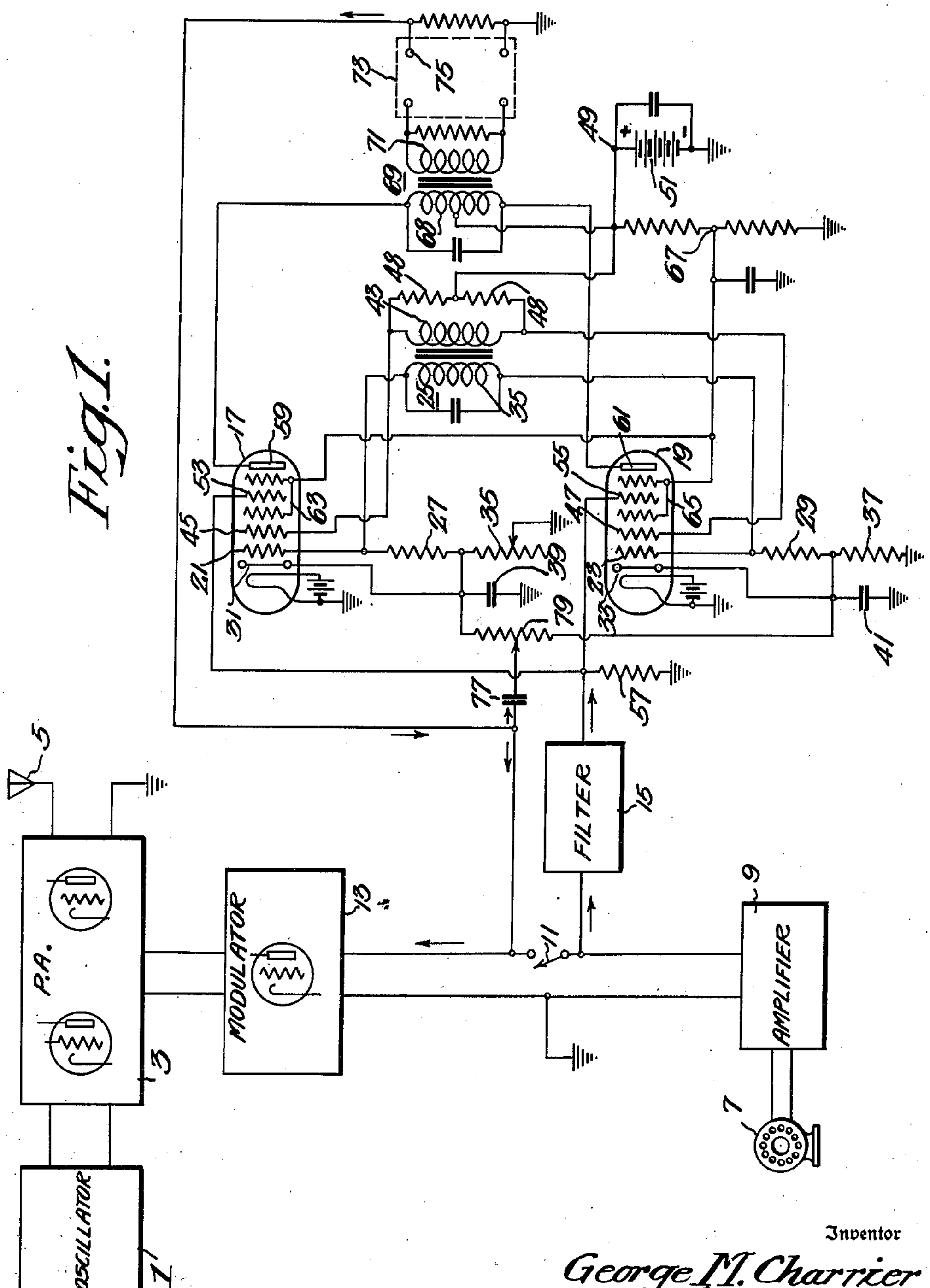

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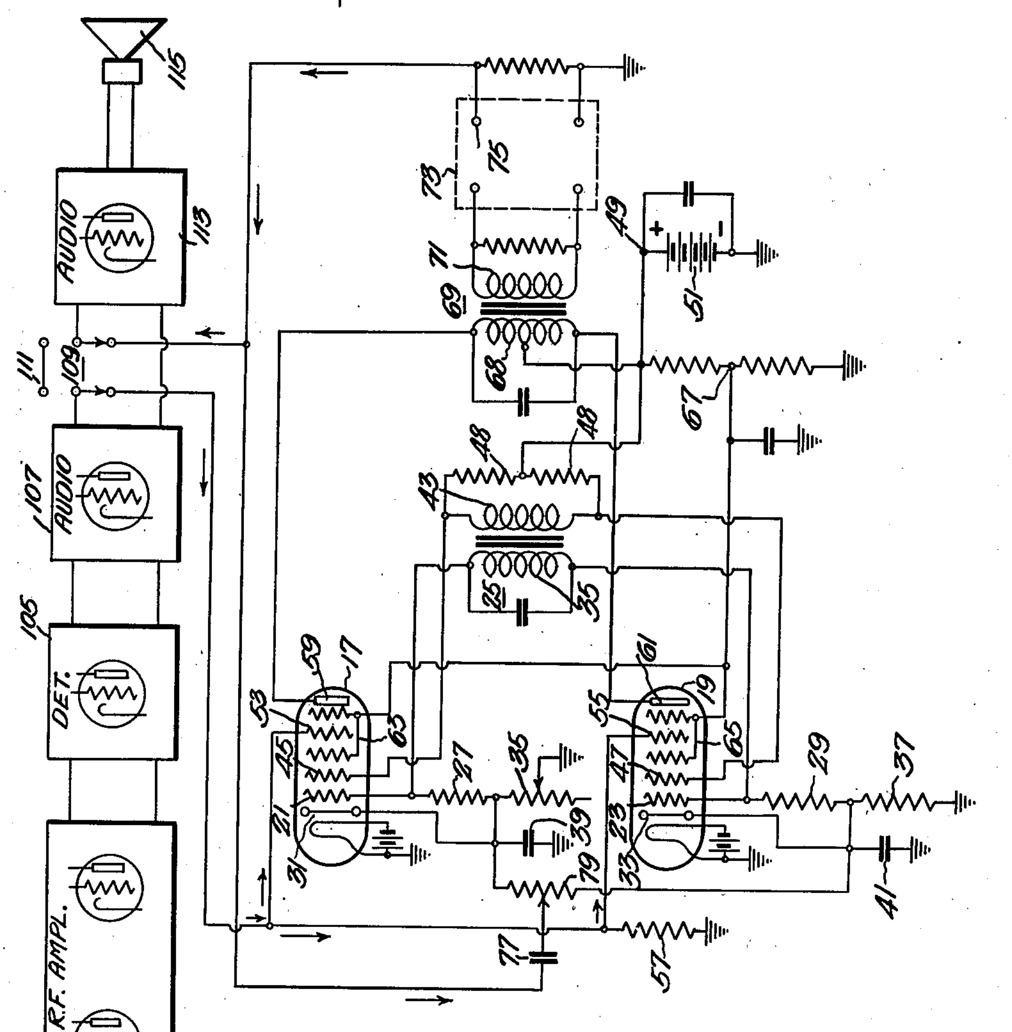
Fig. 2.



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SIGNAL FREQUENCY INVERTER

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6 Claims. (Cl. 179—1.5)

My invention relates to communication systems and more particularly to means for inverting the signal frequency at the transmitter and means for reinverting said inverted signals at the receiver.

I am aware that radio systems for secret communication have been based on frequency inversion. The term frequency inversion has been used to describe the conversion of low signal frequencies into high frequencies and high signal frequencies into low signal frequencies. Speech frequencies which are thus inverted convey substantially no intelligence until such inverted signals are reinverted.

One of the objects of my invention is to provide means for inverting currents of signal frequencies at a transmitter and means for reinverting such inverted signals at a receiver.

Another object is to provide a simple, compact means for the inversion of signal frequencies which may be readily attached to existing transmitters and receivers.

A further object is to provide means for feeding back currents of undesired frequencies from the output to the input of a signal frequency inverter to oppose the transfer of such undesired currents.

A still further object is to connect a pair of multi-purpose thermionic tubes so that sections of each of said tubes act as push pull oscillators and other sections act as balanced modulators.

One embodiment of my invention has been illustrated in Fig. 1 which is a schematic circuit diagram of a signal frequency inverter applied to a transmitter, and

Fig. 2 is a schematic circuit diagram of a signal frequency inverter applied to a receiver.

Referring to Fig. 1, an oscillator 1, which generates currents of carrier frequency, is coupled to a power amplifier 3 which is in turn coupled to an antenna 5. A microphone 7 is connected to an audio amplifier 9. If the switch 11 were closed, the audio amplifier would be connected to a modulator 13, whose output is impressed on the power amplifier 3 to thereby modulate the carrier currents. The foregoing system is that of a conventional radio transmitter.

If the switch 11 is opened as shown, the output currents from the audio amplifier 9 are impressed across the input of the signal frequency inverter. The inverter input circuit includes an input filter 15 which passes currents of the useful range of speech or signal frequencies to prevent audio flutter and interference with the useful signal frequency range of the receiver. By way of example, the filter 15 may pass currents of from 300 to 3000 cycles per second for the transmission of speech.

The signal frequency inverter corprises a pair of multi-purpose thermionic tubes 17, 19. Two of the grids 21, 23 of these tubes are connected to a tuned circuit 25, and through resistors 27, 29 to the cathodes 31, 33. In many cases a single resistor from the midpoint of the inductor 35 to ground may be used in place of the pair of resistors 27, 29. The cathodes 31, 33 are connected to ground by self-bias resistors 35, 37. One of these resistors 35 is made adjustable to balance inequalities in the tube characteristics. The self-bias resistor 35, 37 are repectively bypassed by capacitors 39, 41 having, by way of example, a capacity of 5 microfarads. The tuned grid circuit 25 is coupled to an anode circuit inductor 43, the terminals of which are joined to the grid anode electrodes 45, 47. The anode circuit is connected, through resistors 48 or a midtap, to the positive terminal 49 of a B battery source 51.

The balanced modulator portion of the signal frequency inverter comprises control grids 53, 55 which are connected in parallel and to ground through a resistor 57. The output of the input filter 15 is connected directly to these control grids. The control grids 53, 55 are shielded from the oscillator electrodes 21, 23, 45, 47 and the output anodes 59, 61 by screen grids 63, 65 which are biased positively with respect to the cathodes 31, 33 by a connection to the potentiometer 67 which is connected across the B battery 51. The output anodes 59, 61 are connected to the primary 68 of the push pull or balanced output transformer 69. The midpoint of the primary 67 is connected to the positive terminal 49 of the B battery.

The secondary 71 of the output transformer is connected to an output filter 73 which is designed to pass the desired currents of inverted signal frequency and attenuate the undesired currents which are created by such inversion. At speech frequencies it is both difficult and expensive to provide a filter having sufficiently sharp cut-off to eliminate currents of the oscillatory frequency and the sum frequency. I have found that the high potential terminal 75 of the output of the filter 73 may be connected through a capacitor 77 to the slider of a high resistance potentiometer 79 connected between the cathodes 31, 33. Although the impedance of the self-bias resistors and bypass capacitors is low, it is just sufficient to permit the required feedback. By a suitable adjustment this connection may be used to impress currents which oppose the currents of undesired frequency which are not sufficiently attenuated in the filter 73. The output from the filter 73 is impressed on the modulator 13.

The operation of the inverter is essentially as follows: The push pull oscillator connection generates oscillatory currents whose frequency primarily depends upon the constants of the tuned circuit 25. I prefer to use a large value of capacity to insure stable oscillations, preferably higher than the signal frequencies, and for speech, of the order of 4000 cycles per second. The speech or audio frequency currents are impressed on the control grids 53, 55. Since the output of tubes 17, 19 is arranged as a push pull or balanced circuit connection and the input as a parallel connection, the audio frequency input currents will balance out in the balanced output transformer 69. The oscillator section being arranged as a push pull input and output will transfer currents of the oscillator frequency to the output transformer 69. However, the audio frequency currents and the oscillator currents will interact on each other and form component currents of a frequency equal to the sum and difference frequencies. By way of example, a few frequencies are represented in the accompanying table:

Audio frequency	Oscillator frequency	Sum frequency	Difference frequency
300	4000	4300	3700
500	4000	4500	3500
1000	4000	5000	3000
2000	4000	6000	2000
3000	4000	7000	1000
3500	4000	7500	500
3700	4000	7700	300

If currents of the sum frequency and the oscillator frequency are attenuated by the output filter 73, and currents of the difference frequency are passed by the output filter 73, it is apparent that the high input frequencies become the low output frequencies and vice versa. For example, 300 cycles per second becomes 3700 cycles per second and 3700 cycles input produces a 300 cycle output. In brief, the frequencies are inverted. It will be observed that the oscillator frequency is higher than the upper limit of the signal frequency.

The carrier currents, modulated by currents of inverted signal frequency, may be received by a conventional radio receiver and demodulated but the demodulated signal currents produce audio signals which are unintelligible because of the frequency inversion. These demodulated currents may be inverted to reproduce the original signals. The inverter at the receiver is essentially the same as the signal inverter at the transmitter. In Fig. 2, an antenna 101 is suitably coupled to a radio frequency amplifier 103 which may be tuned to carrier frequency. The output circuit of the amplifier 103 is coupled to a detector 105 which is in turn connected to an audio frequency amplifier 107. If the double throw double pole switch 109 is placed in the upper position 111, the audio frequency amplifier will be connected to a second audio amplifier 113 and a loudspeaker 115 or the like.

If, however, the switch 109 is placed in the lower position, the output of the audio amplifier 107 is connected to the input or control grids of the inverter. This inverter is a duplicate of the inverter previously described. In view of this similarity, the inverter at the receiver will not be described but the same reference numerals will be used to indicate parts which are similar to the inverter at the transmitter.

It may be observed that the input filter 15 is omitted from the inverter employed at the receiver. The receiver is only responsive to the range of frequencies transmitted and therefore requires no further limitation. The output filter is, of course, necessary to attenuate currents of the sum frequency and oscillator frequency. As in the case of the filter at the transmitter, the attenuation is greatly improved at frequencies of the order of the local oscillator frequency by the feedback connection through capacitor 77 and potentiometer 79 previously described. The frequency of the local oscillator of both transmitter and receiver inverters is preferably the same. This avoids any shift of the whole signal frequency band which would result from different inverter oscillator frequencies.

Thus I have described a communication system in which the normal modulating signal currents are fed through a signal frequency inverter. By a suitable balanced system the original signal frequencies are eliminated from the output of the inverter. Undesired currents, which have a frequency equal to the sum of the inverter oscillator and the signal frequencies, are attenuated by an output filter. Residue currents of undesired frequency such as the frequency of the inverter oscillator, are fed back from the output of the filter to the local oscillator input to thereby oppose the currents of undesired frequency. A similar inverter at the receiver restores the received demodulated currents to the original signal frequency. While the foregoing system has been described in connection with a speed modulated transmitter, it should be understood that the frequency inversion may be applied to facsimile, television and the like.

I claim as my invention:

1. A signal frequency inverter comprising a source of signal frequency currents, means for generating local oscillatory currents of a frequency greater than said signal frequency, means for combining said local currents and said signal currents to establish currents having a frequency equal to the sum and difference frequencies of said local and signal frequencies, and means for attenuating currents of said sum frequency and said local oscillator frequency.

2. A signal frequency inverter comprising a source of signal frequency currents, a pair of thermionic tubes including electrodes connected in push pull arrangement for the generation of local oscillatory currents of a frequency greater than said signal frequency, means for impressing said signal frequency currents on parallel connected control electrodes in said tubes, a balanced output circuit, means connecting said output circuit to the outputs of said tubes, whereby said signal frequency currents are balanced in said output transformer and said signal currents and oscillator currents interact to form components whose frequencies equal the sum and difference frequencies of said signal and oscillatory currents, and means for attenuating currents of said sum frequency and for passing currents of said difference frequency to a utilization circuit.

3. In a device of the character of claim 2, means for impressing attenuated output currents on the input of said inverter to further attenuate currents of undesired frequencies.

4. A signal frequency inverter comprising a source of current of signal frequencies, a source of

local oscillator currents of a frequency different from said signal frequencies, means for impressing said signal frequency currents on a balanced output circuit, means for combining said signal currents and said local currents to create component currents in said output circuit equal to said oscillatory frequency and the sum and difference of said local oscillatory frequency and said signal frequencies, means for attenuating currents of said oscillator frequency and said sum frequency, and a feedback circuit for feeding back currents to oppose currents of said local oscillatory frequency.

5. A signal frequency inverter comprising a source of signal frequency currents, a pair of multi-purpose thermionic tubes each having cathode, grid, grid-anode, control grid and anode electrodes, a push pull oscillator circuit connected to said cathode, grid and grid-anode electrodes, means for connecting said control grids in parallel, means for impressing said signal currents on said control grids whereby currents equal to said signal frequency, and oscillator frequency, and the sum and difference of said frequencies are created, a balanced output circuit connected to said anode electrodes, means for attenuating currents of said oscillator frequency and said sum frequency and transferring currents of said difference frequency from said balanced circuit to a utilization circuit, and means for adjusting the characteristics of said tubes whereby their characteristics may be substantially equalized.

6. In a device of the character of claim 5 feedback means for connecting said attenuation means to said oscillator to oppose said currents of undesired frequency.

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