Nov. 11, 1947. M. J. O. STRUTT ET AL 2,430,835

MIXING CIRCUITS COMPRISING DISCHARGE TUBES

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Fig. 1.

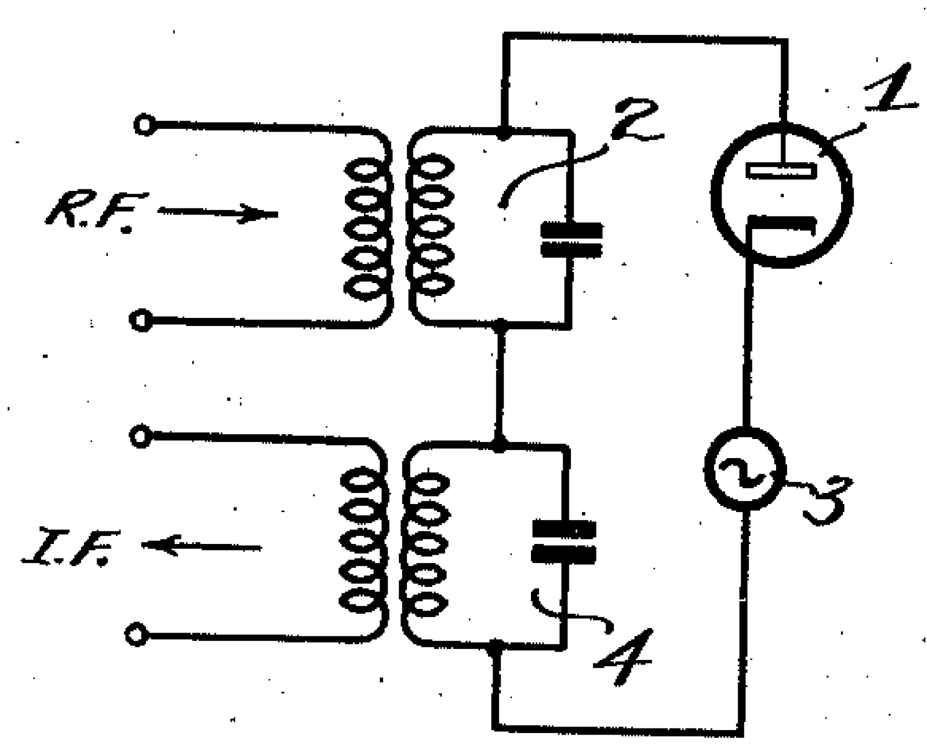


Fig. 2.

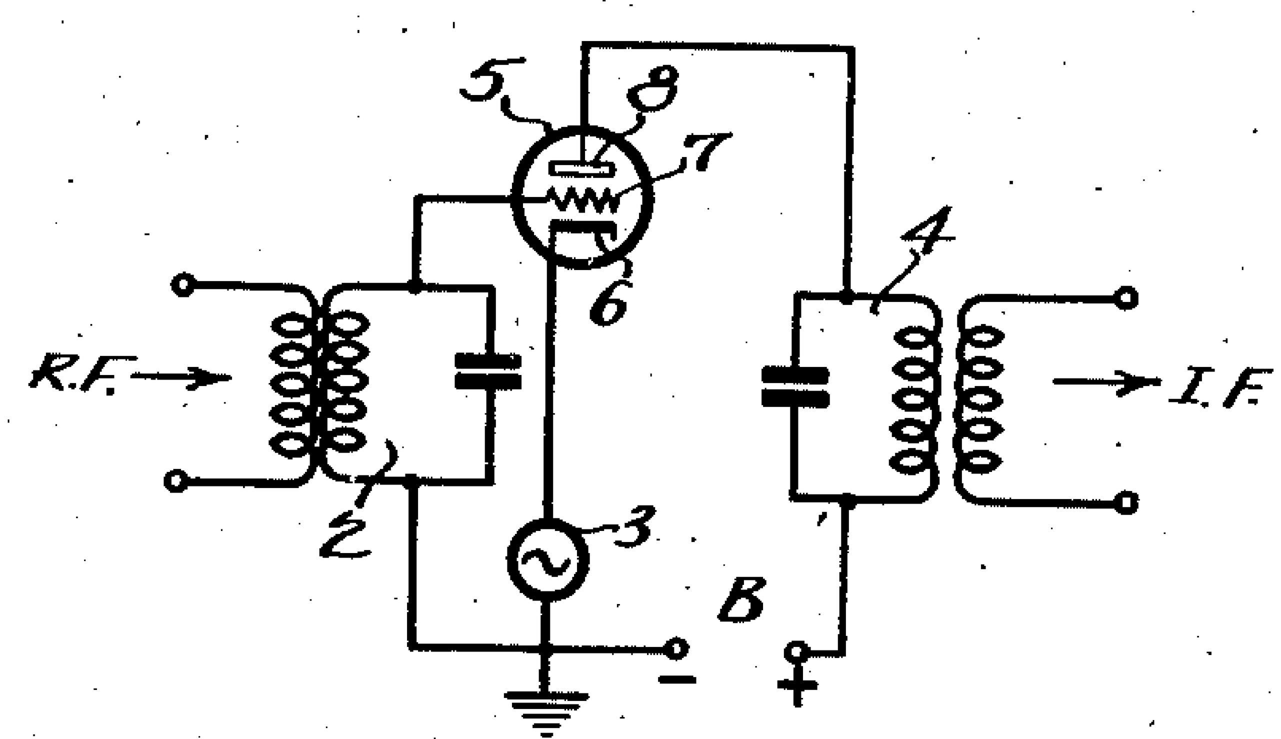


Fig. 3.

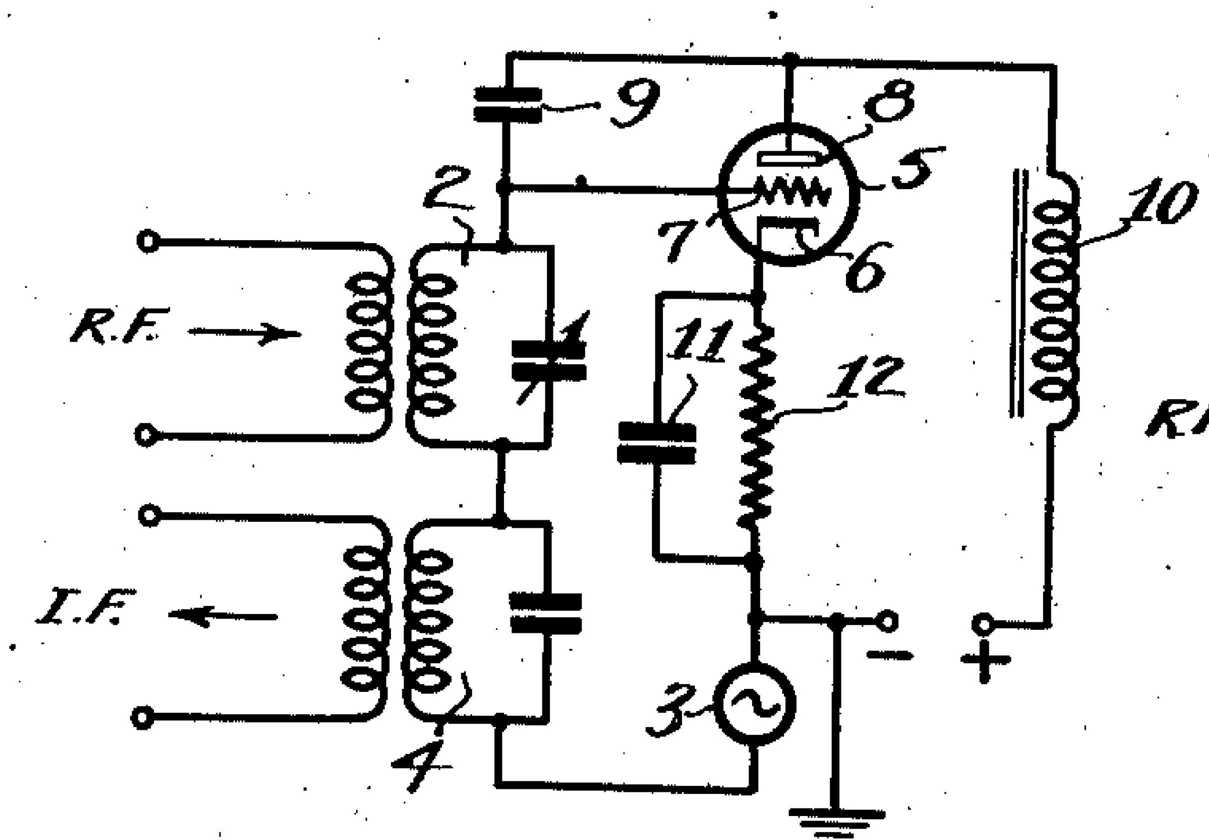


Fig. 4

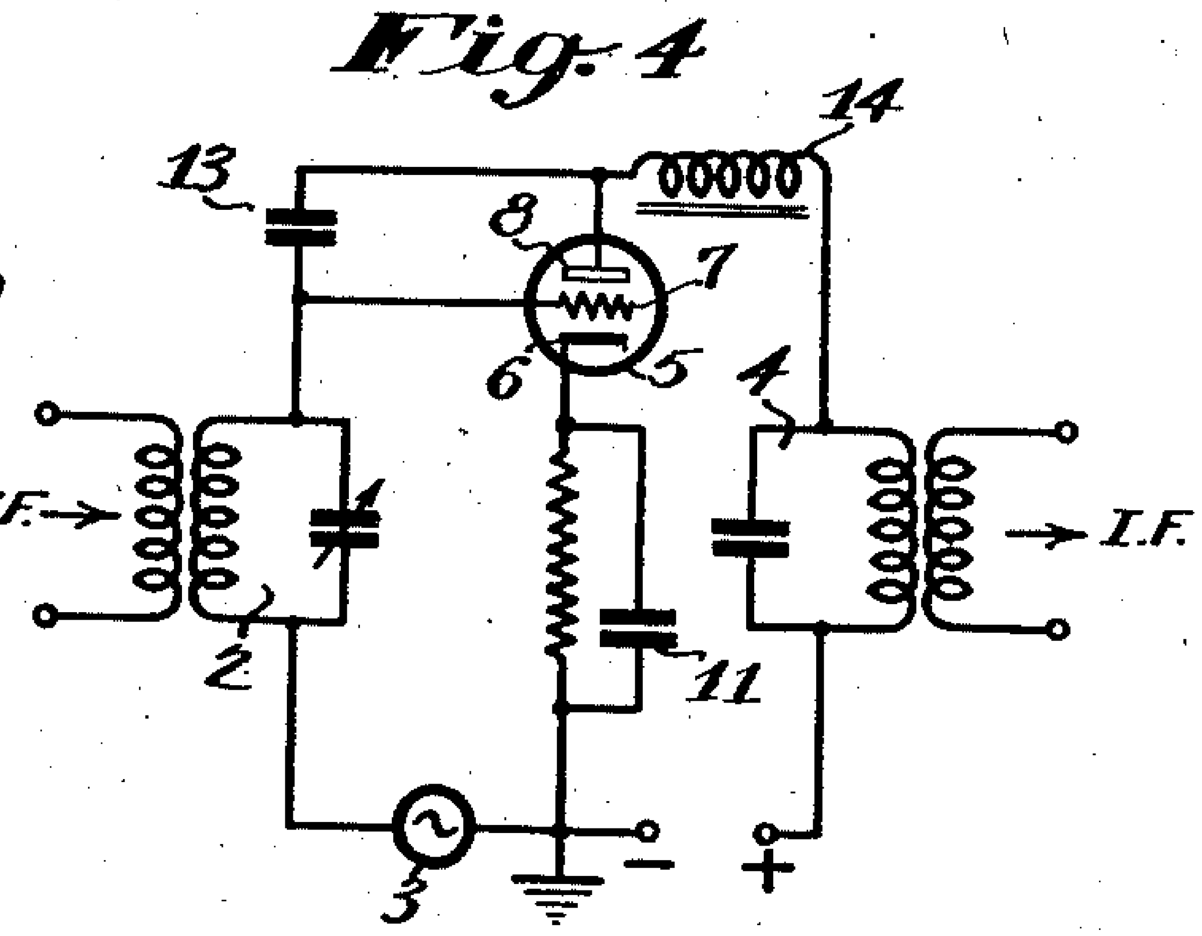
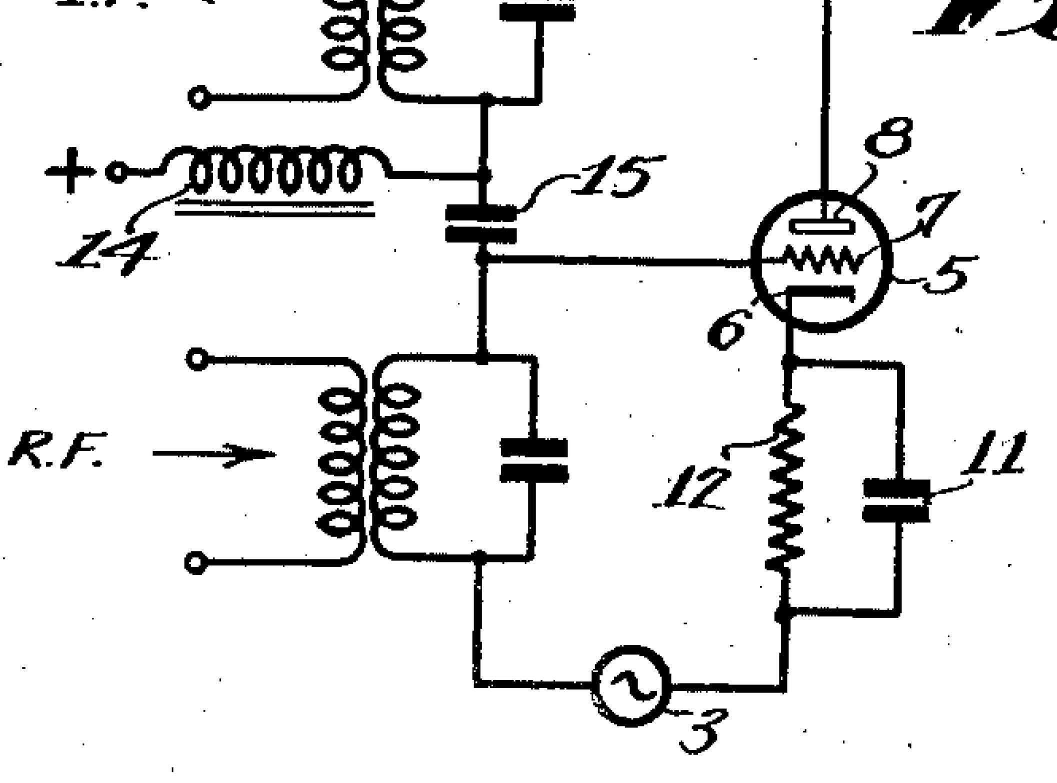


Fig. 5.



INVENTORS.
GERRIT HENDRIK PETRUS ALMA
MAXIMILAAN J. O. STRUTT &
ALBERT VAN DER ZIEL
BY H. G. Grover
ATTORNEY.

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MIXING CIRCUITS COMPRISING DISCHARGE TUBES

Maximiliaan Julius Otto Strutt, Aldert van der Ziel, and Gerrit Hendrik Petrus Alma, Eindhoven, Netherlands, assignors to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

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10 Claims. (Cl. 250—20)

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This invention relates to a frequency connecter or mixing circuit comprising a discharge tube which in addition to a cathode and an anode contains at least one grid to which the oscillations to be mixed are fed.

The invention has for its object to obtain a mixing circuit in which a minimum I. F. hiss voltage is set up.

According to the invention, this object is achieved by connecting the anode, at least so far as the frequencies of the oscillations to be mixed are concerned, through a low impedance to the said grid.

The grid preferably has such a negative potential that a direct grid current does not occur at any time.

In one embodiment of the invention I. F. oscillations are obtained from an I. F. circuit included in the circuit of the said grid and in this case it is necessary for the impedance connected between the anode and the grid to have a low value even so far as the I. F. oscillations are concerned.

In a further embodiment of the invention the I. F. oscillations are obtained from an I. F. circuit included in the anode circuit and in this case it is necessary for the impedance connected between the anode and the grid to have a high value so far as the I. F. oscillations are concerned, a high impedance being included preferably in the anode circuit for the oscillations to be mixed.

Alternatively, in this latter case the impedance connected between the anode and the grid may be constituted by the I. F. circuit from which the I. F. oscillations are obtained.

In order that the invention may be clearly understood and readily carried into effect it will now be described more fully with reference to the accompanying drawing.

In the use of a triode as a mixing tube a hiss signal ratio is known to occur which is about four times the hiss signal ratio exhibited by the tube when used as an amplifier. This is due to the fact that the optimum conversion-mutual conductance that can be achieved is about a quarter of the mutual conductance at the working point of the tube.

If the tuning circuits are correctly proportioned a diode-mixing tube yields relatively considerably less hiss. This may be explained as follows with reference to Figs. 1 and 2.

Fig. 1 shows a customary diode-mixing circuit. Intermediate the anode and the cathode of the diode 1 is included a series combination of a H. F. circuit 2 tuned to the signals to be received, a source of local oscillations 3 and an I. F. circuit 4.

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Fig. 2 shows a mixing circuit comprising a triode 5. A H. F. circuit 2 is interconnected between the control grid 7 and earth; the connection of the cathode 6 to earth includes a source of local oscillations 3, the anode 8 being connected to earth with the interposition of an I. F. circuit 4 and a battery B.

In the circuit arrangement shown in Fig. 1 the I. F. circuit, the H. F. circuit and the voltage locally generated are all connected in series. Thus, jointly with the oscillator voltage received from the source 3, the I. F. hiss voltage occurring yields a H. F. hiss voltage which may be referred to as the secondary H. F. hiss voltage. This secondary H. F. hiss voltage jointly with the oscillator voltage yields a secondary I. F. hiss voltage which counteracts the primary I. F. hiss voltage.

In the circuit arrangement shown in Fig. 2 this decrease of the resulting I. F. hiss voltage cannot occur due to the fact that the secondary H. F. hiss current which occurs in the anode circuit does not pass through the H. F. circuit 2 and consequently does not give rise to a secondary H. F. hiss voltage and consequently neither to a secondary I. F. hiss voltage.

For this reason, diode mixture would be preferable but researches undertaken by applicants revealed that in the case of diode mixture there is a second source of hiss which can be avoided with a triode. This second source of hiss is constituted by the electrons reflected by the anode which in a diode are incorporated in the space charge and thus contribute to the hiss voltage. With a triode on the contrary the electrons reflected by the anode are held by the grid if the latter has a sufficiently high negative potential so that they cannot reach the space charge intermediate the grid and the cathode and consequently contribute to the hiss voltage.

The invention is based on recognition of the fact that the advantages of diode and triode mixture can be combined and the disadvantages of the two systems can be obviated in that a triode mixing tube is connected as a diode at least so far as the locally generated and H. F. oscillations are concerned, so that a secondary H. F. hiss voltage, and hence also a secondary I. F. hiss voltage, is set up which counteracts the primary I. F. hiss voltage.

For this purpose, care must be taken that the secondary H. F. hiss current is passed through the H. F. circuit. This may be effected in principle in two ways which are set out more fully in

Figs. 3 and 4 each of which shows an embodiment of the invention.

Fig. 3 shows a triode 5 in which the I. F. oscillations are obtained from an I. F. circuit 4 included in the grid circuit in series with the H. F. circuit 2 and the source 3 of local oscillations. Intermediate the anode 8 and the grid 7 is connected an impedance in the form of a condenser 9 which has a low value both so far as the oscillations to be mixed and so far as the I. F. oscillations are concerned. The anode circuit includes a choke 10 which has a high impedance both so far as the oscillations to be mixed and so far as the I. F. oscillations are concerned. Consequently, the H. F. and I. F. oscillations only occur in the circuit formed by the condenser 9, the circuits 2 and 4, the source 3 and the cathode-anode space of the tube so that the entire H. F. and I. F. circuit is equivalent to that shown in Fig. 1. This results therefore in the above-described hiss reduction also occurring here. The hiss voltage due to the electrons reflected by the anode is, however, not present here if the grid 5 is kept at such a negative potential that a direct grid current does not occur. This may be ensured in well-known manner by means of a resistance 12 shunted by a condenser 11. In the circuit arrangement shown in Fig. 3 the mixing tube acts therefore as a diode for the H. F. and I. F. oscillations but as a triode insofar as the negative grid and positive plate D. C. characteristics are concerned.

In the circuit arrangement shown in Fig. 4 I. F. oscillations are obtained from the anode circuit of the tube 5, the anode and the grid having interconnected between them an impedance in the form of a condenser 13 which has a low value so far as the oscillations to be mixed but a high value so far as the I. F. oscillations are concerned. In addition, the anode circuit includes a choke 14 which has a high impedance so far as the oscillations to be mixed are concerned. Consequently, the secondary H. F. hiss current will pass through the circuit 2 in contradistinction to the circuit arrangement shown in Fig. 2 so that in the circuit 2 a secondary H. F. hiss voltage is developed due to which a secondary I. F. hiss voltage is set up which counteracts the primary I. F. hiss voltage in the manner outlined hereinbefore.

Similarly to the circuit arangement shown in Fig. 3 the grid is kept at a negative potential by means of a resistance 12 shunted by a condenser 11.

Fig. 5 shows a further embodiment of the invention which is substantially similar to that disclosed in Fig. 4 except that choke 14 and I. F. circuit 4 are interchanged in position between anode 8 of the tube and the + terminal of the anode voltage source. In this arrangement the impedance between the anode and the grid corresponding to condenser 13 in Fig. 4 is constituted by the I. F. circuit 4, the condenser 15 having only the function of a blocking condenser.

For the reception of very short waves the circuit arrangement according to the invention has the additional advantage that the damping exercised by the tube on the input circuit 2 is largely neutralised due to the finite transit time of the electrons since this damping may be conceived as constituted by one part due to the grid-cathode space and one part due to the grid-anode space. Since in the circuit arrangement according to the invention the grid-anode space is shunted, for the oscillations to be mixed, by a low impedance the last-mentioned part of the damping is removed.

What we claim is:

1. A frequency converter system comprising an electron discharge tube having at least a cathode, an anode and an interposed grid, means for impressing upon the grid received signal oscillations and locally produced oscillations differing in frequency from said signal oscillations to be combined, means for biasing the grid sufficiently negative to prevent the flow of grid current, an impedance connected between the anode and the grid which is low at least for the frequencies of the locally produced oscillations, and means for deriving the combined oscillations.

2. A frequency converter system as defined in claim 1 wherein the means for deriving the combined oscillations is constituted by a circuit tuned to the frequency of said oscillations and included in the grid to cathode circuit, and wherein the impedance connected between the anode and grid is constituted by a condenser which has a low impedance also for the frequency of the combined oscillations.

3. A frequency converter system as defined in claim 1 wherein the means for deriving the combined oscillations is constituted by a circuit tuned to the frequency of said oscillations and included in the plate to cathode circuit, and wherein the impedance connected between the anode and grid is constituted by a condenser which has a high impedance for the frequency of the combined oscillations.

4. A frequency converter system as defined in claim 1 wherein the impedance connected between the anode and grid serves at the same time as the means for deriving the combined oscillations.

5. A frequency converter system comprising an electron discharge tube having at least a cathode, an anode and an interposed grid, a resistor connected between cathode and ground of a value to bias the grid sufficiently negative to prevent the flow of grid current, a source of received signal oscillations and a source of locally produced oscillations differing in frequency from said signal oscillations serially connected between grid and ground, an impedance connected between the anode and the grid which is low at least for the frequencies of the locally produced oscillations, and means for deriving the oscillations resulting from the interaction between said two oscillations.

6. A frequency converter system comprising an electron discharge tube having at least a cathode, an anode and an interposed grid, a resistor connected between cathode and ground of a value to bias the grid sufficiently negative to prevent the flow of grid current, a source of received signal oscillations, a source of locally produced oscillations and a circuit tuned to said combined oscillations serially connected between grid and ground, an impedance connected between the anode and the grid, and an impedance included in the anode circuit.

7. A frequency converter system as defined in claim 6 wherein the impedance connected between anode and grid is constituted by a condenser which has a low impedance for the frequencies of the combined and the locally produced oscillations, and wherein the anode circuit impedance is constituted by a choke coil which has a high impedance for the frequencies of the combined and the locally produced oscillations.

8. A frequency converter system comprising an

electron discharge tube having at least a cathode, an anode and an interposed grid, a resistor connected between cathode and ground of a value to bias the grid sufficiently negative to prevent the flow of grid current, a source of received signal oscillations and a source of locally produced oscillations serially connected between grid and ground, a choke coil and a circuit tuned to a frequency resulting from the ineraction between the signal and local oscillations connected between the anode and ground, and an impedance connected between the anode and the grid.

9. A frequency converter system as defined in claim 8 wherein the impedance connected between anode and grid is constituted by a condenser which has a low impedance for the oscillator frequency and a high impedance for the combined frequency, and wherein the choke coil has a high impedance for the oscillator frequency.

10. A frequency converter system comprising an electron discharge tube having at least a cathode, an anode and an interposed grid, a resistor connected between cathode and ground of a value to bias the grid sufficiently negative to prevent the flow of grid current, a source of received signal oscillations and a source of locally produced oscillations serially connected between grid and ground, a source of potential for the anode, a choke coil and a tuned circuit serially connected between said potential source and the anode, said tuned circuit being resonant to the frequency resulting from the interaction between the signal and local oscillations, and a blocking condenser connected between the grid and the common terminal between the choke coil and the tuned circuit.

MAXIMILIAAN JULIUS OTTO STRUTT.
ALDERT VAN DER ZIEL.
GERRIT HENDRIK PETRUS ALMA.

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