

March 17, 1936.

W. A. HARRIS
FREQUENCY CONVERTER
Filed Dec. 8, 1933

2,033,986

Fig. 1

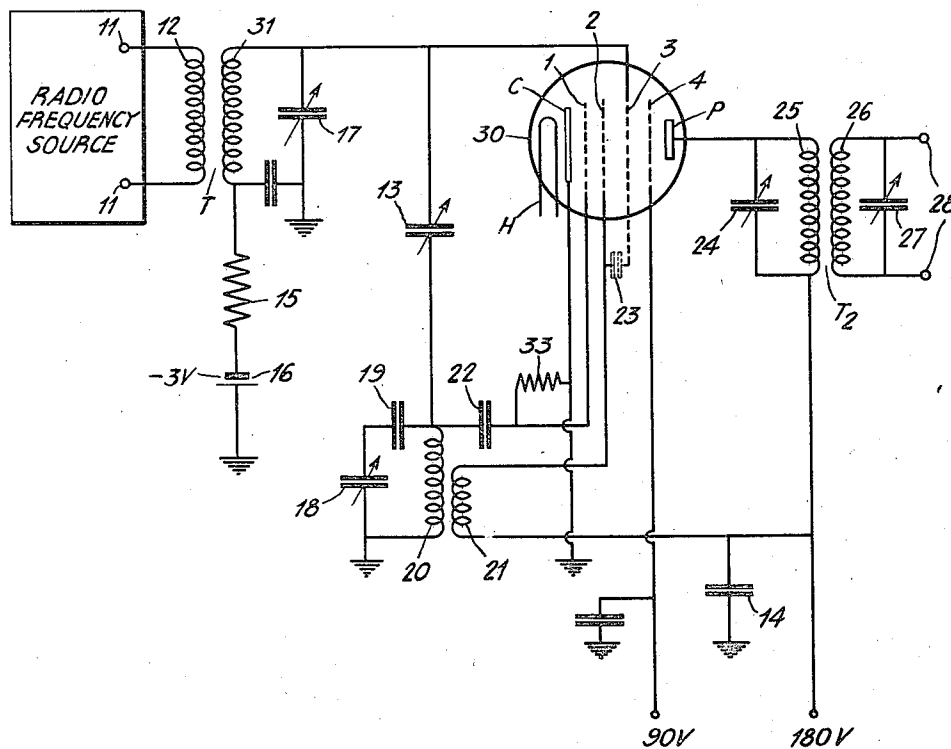
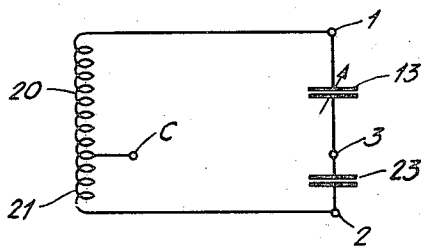


Fig. 2



INVENTOR
WILLIAM A. HARRIS
BY *H. S. Hoover*
ATTORNEY

UNITED STATES PATENT OFFICE

2,033,986

FREQUENCY CONVERTER

William A. Harris, Belleville, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

Application December 8, 1933, Serial No. 701,446

8 Claims. (Cl. 250—20)

5 An object of the present invention is to provide a frequency converter having an oscillator portion comprising a plurality of grids and a signal amplifier portion within the same envelope.

10 A further object of the invention is to provide a frequency converter tube adapted for use in a superheterodyne receiver having a plurality of grids between certain of which undesired capacity exists and means for compensating for or neutralizing the energy fed through said capacity.

15 Other objects of the invention are to improve the operation and construction generally of frequency converter or detector arrangements and more especially those adapted for use in superheterodyne receivers. For a better understanding of the invention reference is made to the following description taken in connection with the accompanying drawing in which I have indicated diagrammatically a circuit arrangement whereby my invention may be carried into effect. In the drawing,

20 Figure 1 is a schematic circuit diagram of a frequency converter made according to my invention; and,

25 Figure 2 is a simplified diagram of the bridge circuit formed according to my invention.

30 In the drawing, any desired modulated radio frequency signal source may be connected to the input terminals 11 of a transformer T comprising primary coil 12 and secondary coil 31, the secondary being tunable to any signal frequency in the broadcast band by means of variable condenser 17. The high potential end of coil 31 is shown connected to a grid 3 of a vacuum tube 30 having a heater H, cathode C, grids 1, 2, 3, 4 and plate or anode P arranged in the electron stream in the order shown. The signal grid 3 may be given the desired negative bias with respect to cathode C by means of a circuit including a battery 16 and resistor 15. The signal amplifier portion of the tube also comprises a screen grid 4, which may be connected to a source of potential of about 90 volts as shown, and the plate P which may be connected to a steady voltage source of about 180 volts through the primary coil 25 of an intermediate frequency transformer T₂, the primary 25 and secondary 26 of which may be tuned to the desired intermediate frequency by adjustable condensers 24 and 27 respectively.

40 The intermediate frequency as obtained from the output terminals 28 may be further amplified and the amplified currents detected by means well known to those skilled in the art.

45 The inner or oscillator portion of the tube com-

prises the anode-grid 2 connected to the 180 volt source through the coil 21. A coil 20 inductively coupled to coil 21 may be tuned to the desired oscillation frequency by variable condenser 18, the oscillation frequency being preferably higher than the signal frequency by an amount equal to the intermediate frequency but it may be lower than the signal frequency if desired. The high potential end of coil 20 is connected to grid 1 through a circuit including stopping condenser 22 and grid 1 is also connected to cathode C through a high resistance 33.

5 With the arrangement described, it was found that the amplification varied considerably as the condenser 17 was adjusted to tune the input circuit over the broadcast frequency band and the gain was reduced to a low value, and in some instances to zero, at the high frequency end of the range.

10 I found that the cause of this effect was the voltage of oscillator frequency induced across the signal input circuit by the capacity between the oscillator grid 2 and signal control grid 3, this capacity being due to the grids being positioned relatively close to each other within the tube and to a less extent to the stray capacity between their leads. The electron stream between cathode and plate P is modulated by the voltage of oscillator frequency on the oscillator control grid 1. The voltage of grid 2 is 180° out of phase with that of grid 1. When the oscillator frequency is higher than the signal frequency, the tuned circuit 31, 17 acts as a capacity reactance to the oscillation frequency. The voltage induced across this circuit by the capacity between grids 2 and 3, which capacity I have represented by the dotted condenser 23, is then in phase with the voltage on grid 2, 180° out of phase with the voltage on grid 1 and tends to demodulate the electron stream. This voltage is proportional to the reactance of the input circuit, which is highest at the high frequency end of the range when condenser tuning is used. I also found that the direct plate current was reduced when this effect occurred and that the reduction in plate current gave an approximate measure of the reduction in the signal amplification.

15 My invention consists of a means and method for preventing the occurrence of the effect described above by introducing a voltage of oscillator frequency in phase with the voltage of grid 1 across the signal input circuit and of such magnitude as to partially or completely cancel the voltage induced thereon by grid 2. A convenient means and method for accomplishing this

is to connect an adjustable condenser 13 between the grids 1 and 3. As shown this is connected to the high potential end of coil 20 and thus also to grid 1 through condenser 22.

- 5 This neutralizing arrangement forms a bridge circuit as shown in Fig. 2 and a balance will be secured and no radio frequency voltage exist between cathode C and grid 3 due to capacity 23 when condenser 13 has a value=

$$10 \quad C_{23} \times \frac{E_2}{E_0} = C_{23} \times \frac{M}{L_0}$$

- where E_0 =the voltage developed across coil 20 at oscillation frequency; E_2 =the voltage developed across coil 21 at oscillator frequency, L_0 is the inductance value of coil 20 and M is the mutual inductance between coils 20 and 21. If the voltage ratio varies over the broadcast band, as it may do on account of stray capacitances, condenser 13 is preferably adjusted to effect a balance at the high frequency end of the range, since the reactance of the grid circuit 31, 17 is highest there. Then the balance will be found to be satisfactory at the lower frequencies also. I have also found that a very simple method of determining the proper value of condenser 13 is to give it such a value that the value of the direct plate current remains unchanged when coil 31 is short circuited. In the circuit arrangement shown, the capacity of condensers 14 and 22 is many times larger than that of stray capacity 23, so that the capacities of these two condensers may be disregarded in the bridge circuit shown.

Having described my invention what I claim and desire to secure by Letters Patent is:

- 35 1. In a frequency converter, the combination of a vacuum tube having an oscillator section and a signal amplifying section there being undesired capacity coupling between said sections, said signal amplifying section comprising a plate circuit and a tunable grid circuit including a coil shunted by a variable condenser and means for neutralizing the effect of said undesired coupling consisting of a condenser having one side connected to said oscillator section and its other side to the high potential end of said coil, said latter condenser having such a value that the average value of the direct current in said plate circuit remains substantially unchanged when said coil is short circuited.

- 50 2. In a frequency converter, the combination of a vacuum tube having a cathode, an oscillator grid, an oscillator grid-anode, a signal control grid and a plate, a circuit tunable to the oscillation frequency connecting said oscillator grid and cathode, a feedback connection between said grid-anode and said tunable circuit, there being inherent capacity between said signal control grid and said grid-anode, a neutralizing condenser having one side connected to the high potential end of said tunable circuit and its other side to said signal control grid and an input circuit tunable to a signal frequency differing from said oscillation frequency connecting said signal-control grid and cathode.

- 65 3. In a device of the class described, the combination of a vacuum tube having a cathode, an oscillator grid, an oscillator grid-anode, a signal control grid, a screen grid and a plate arranged in the order named, a circuit tunable to the signal frequency connecting between said signal control grid and cathode, a circuit tunable to the oscillator frequency connected to said oscillator grid and cathode and including a coil, a circuit connected to said grid-anode and including a

second coil inductively coupled to said first named coil, there being undesired capacity coupling between said signal grid and said oscillator grid-anode, a capacity external to said tube connected to said signal grid and said oscillator grid, means for impressing a positive potential on said screen grid and a circuit tunable to an intermediate frequency connected to said plate.

4. In a frequency converter, the combination of a vacuum tube having a cathode, an oscillator grid, an oscillator grid-anode, a signal control grid and a plate, a circuit tunable to the oscillation frequency connecting said oscillator grid and cathode, a feedback connection between said grid-anode and said tunable circuit, there being undesired capacity between said signal control grid and said grid-anode and means for impressing a voltage on said signal control grid in phase with that of said oscillator grid and of such magnitude as to neutralize the effect of said undesired capacity.

5. In a frequency converter having an oscillator grid, an oscillator grid-anode, a signal control grid and a plate and a feedback connection between said grid-anode and said oscillator grid, the method of neutralizing the capacity coupling between said grid-anode and said signal control grid which consists in capacitively coupling said oscillator grid and said signal control grid and adjusting the value of said latter coupling so that the voltage impressed thereby on said signal control grid is equal to that impressed thereon by said oscillator grid-anode.

6. In a frequency converter having an oscillator grid, an oscillator grid-anode, a signal control grid and a plate and a feedback connection between said grid-anode and said oscillator grid, the method of neutralizing the capacity coupling between said grid-anode and said signal control grid which consists in impressing a voltage on said signal control grid in phase with that of said oscillator grid and of a magnitude substantially equal to that impressed thereon by said oscillator grid-anode.

7. In a frequency converter, the combination of a vacuum tube having a cathode, an oscillator grid, an oscillator grid-anode, a signal control grid and a plate, an input circuit connecting said signal control grid and cathode including a variable condenser for tuning the circuit to a desired signal frequency, a resonant circuit connecting said oscillator grid and cathode and including a variable condenser adjusted to tune said circuit to an oscillation frequency substantially higher than said signal frequency, a circuit connected to said grid-anode having a feedback connection to said last named circuit, an output circuit connected to said plate, there being undesired capacity coupling between said signal control grid and said grid-anode, and means for compensating for the decrease in the amplification of said tube as said first named variable condenser is adjusted to tune to a higher signal frequency, comprising a condenser having one terminal connected to said signal control grid and its other terminal connected to said oscillator grid.

8. In a frequency converter, the combination of a vacuum tube having a cathode, an oscillator grid, an oscillator grid-anode, a signal control grid and a plate, a circuit tunable to a desired signal frequency connected between said signal control grid and cathode, a circuit tunable to the oscillator frequency connected to said oscillator grid and cathode and including a coil, a circuit connected to said grid-anode and including a sec-

ond coil inductively coupled to said first named coil, the capacity coupling between said signal grid and said grid-anode having a value C and a capacity having the value

connected between said signal control grid and said oscillator grid, wherein M is the value of the mutual inductance between said coils and L is the inductance value of said first named coil.

5

$$C \times \frac{M}{L}$$

WILLIAM A. HARRIS.

5