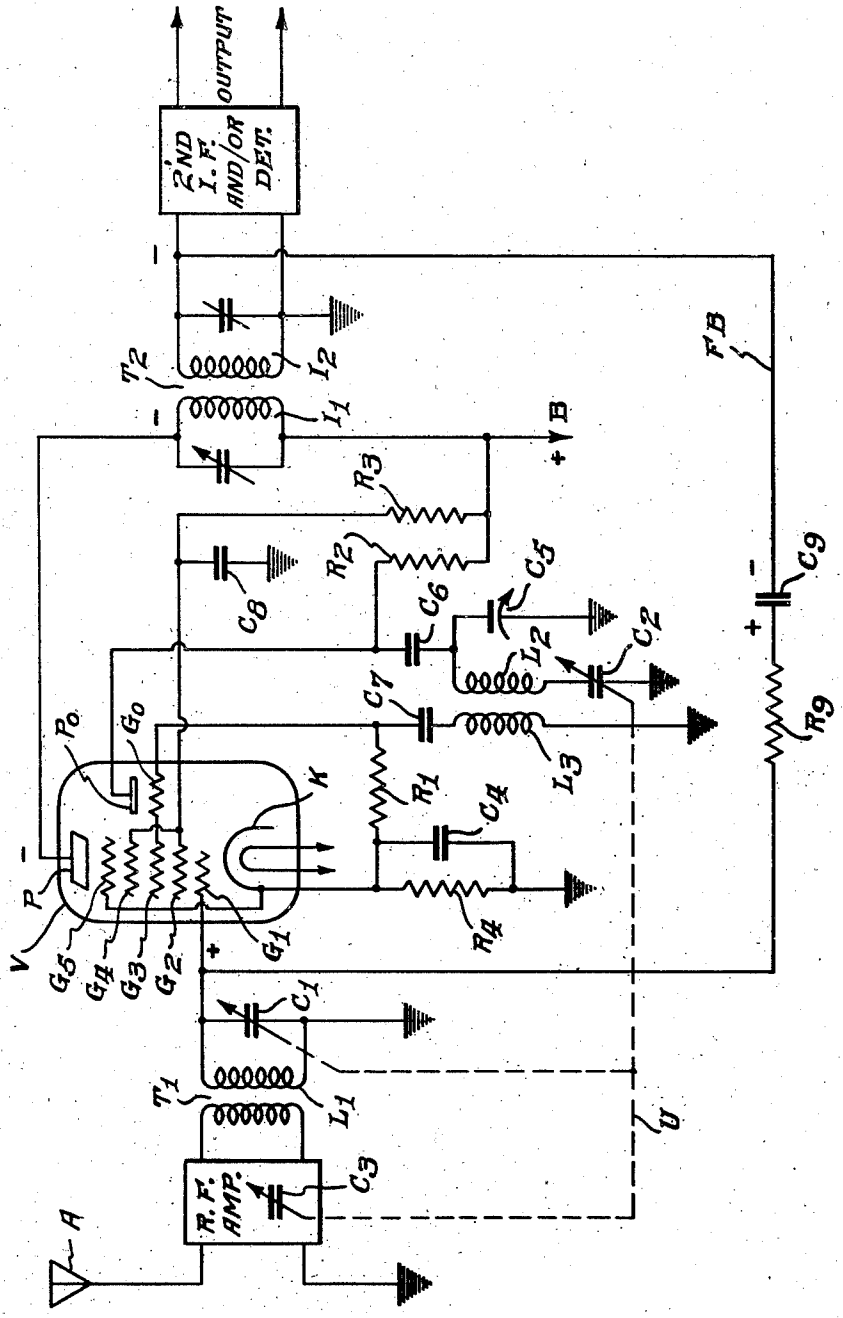
Aug. 21, 1945. K. SEILER, 3D 2,383,345

REFLEX CONVERTER CIRCUIT

Filed Sept. 15, 1942



Inventor

Karl Seiler, 3rd

By H. S. Brower

Attorney

Patented Aug. 21, 1945

2,383,345

UNITED STATES PATENT OFFICE

2,383,345

REFLEX CONVERTER CIRCUIT

Karl Seiler, 3rd, Jenkintown, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Application September 15, 1942, Serial No. 458,432

10 Claims. (Cl. 250—20)

This invention is concerned with an improvement in radio receivers of the superheterodyne type and more particularly with a reflex converter circuit which combines the functions of a first detector, oscillator, and first intermediate frequency stage.

In the present state of the art it is known to use in superheterodyne circuits a multi-electrode type of tube designed to perform simultaneously the functions of a first detector and an oscillator. These combined functions are frequently referred to as frequency conversion. According to my present invention the same or equivalent multi-electrode tube is made to perform in addition the function of intermediate frequency amplification. As a result necessity for the use of a separate tube to perform the function of intermediate frequency amplification is dispensed with.

More specifically, it is an object of the invention to provide in a superheterodyne receiver, a circuit for performing the combined functions of first detector-oscillator and intermediate frequency amplifier, utilizing an electron discharge tube having within a common envelope electrodes constituting a triode and other electrodes constituting a heptode, the received signal oscillations being impressed on a tuned input circuit connected to the signal grid electrode of the heptode, the triode electrodes having circuit elements connected thereto to constitute a generator of local oscillations which are injected into the electron stream of the heptode, the output of the heptode including an intermediate frequency circuit, between which circuit and the signal grid electrode of the heptode a feed back circuit is connected for the purpose of reflexing and amplifying said intermediate frequency energy.

Other objects of the invention are to provide a converter circuit which would be attractive in small low-price receiving sets where the cost must be kept down to a minimum; to provide a receiver of reduced size and weight; and in battery-operated sets to provide economical operation by reducing battery consumption. In single frequency receivers where the greatest gain from the smallest number of tubes and a consequent reduction in power consumption and size of the equipment are of paramount importance, the present invention would be most practical.

The novel features characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and mode of operation together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawing in which the single figure illustrates a preferred converter circuit embodying the present invention of combined first detector, oscillator and intermediate frequency stages.

In the circuit of the accompanying drawing the tube designated V is a multi-electrode vacuum tube and may be of the type known as "6J8—G," or one equivalent thereto. This tube, also known as a "triode-heptode converter," contains a triode section and a heptode section within the same evacuated envelope, an indirectly heated cathode K being common to both. The heptode section comprises the cathode K, an output or plate electrode P and a plurality of grids G_1 to G_5 interposed in the space between K and P in the order named. The triode section comprises the cathode K, grid G_0 and plate P_0. In the normal use of this tube as a converter, the cathode K, first grid G_0 and plate P_0 constituting the triode section have external circuit elements connected thereto to perform the function of a local oscillator for generating the local oscillations, the grid G_0 serving as the output electrode of the oscillator. The signal oscillations are impressed on the grid G_1 of the heptode section and the locally produced oscillations are injected into the electron stream between cathode K and plate P by way of the grid G_3 which has a direct connection to the oscillator grid G_0 within the tube. Due to the mixing action within the tube, oscillations of intermediate frequency appear in the output circuit connected to the plate P. The second and fourth grids G_2, G_4 are connected together inside the tube envelope, have a positive potential impressed thereon, and serve to accelerate the electron stream and to shield electrostatically the signal control grid G_1 from voltage fluctuations on the injector grid G_3 and on the plate P. Grid G_5 is the usual suppressor grid having an internal connection to the cathode K.

The use of the above or equivalent tube and the circuit connections therefore in accordance with the present invention will now be pointed out more particularly. The grid G_1 serves as the signal control grid and has connected between it and the cathode K the input circuit L_1—C_1 which is tuned to the received incoming signal oscillations. If desired, an RF amplifier stage may precede the detector-oscillator-I. F. amplifier tube V, the same being interposed between the antenna A and said resonant circuit L_1—C_1 through the radio frequency transformer T_1.

The grid G_3 being directly connected to the

triode grid G_0 derives therefrom the oscillations generated by the triode section, the electrodes of which have connected thereto external circuit elements to constitute the local oscillator of the system. The tuned circuit of the oscillator which is tuned to a frequency above or below the signal frequency by the amount of the intermediate frequency (I. F.) consists of the variable tuning condenser C_2, inductance L_2 and the series tracking condenser C_5 and is connected to the triode plate P_0 by way of the blocking condenser C_6. Coupled to the coil L_2 of the tuned plate circuit is the grid coil L_3 to provide feed back from the output to the input of the oscillator.

R_1 and C_7 are respectively the usual grid-leak and grid-condenser employed in oscillators of this type. Voltage for plate P is applied from a suitable power supply source indicated by +B+. Voltage for the plate P_0 is applied from said source through a voltage dropping resistor R_2 and that for screen grids G_2—G_4 is applied through a dropping resistor R_3. C_8 is a screen grid bypass condenser.

In order to provide suitable operating bias for the signal control grid G_1 and oscillator grid G_0, the cathode K has connected between it and ground the conventional self-biasing resistance-capacity network, R_4—C_4. In the event that it is desired to provide the receiver with automatic volume control, the AVC control bias may be obtained in the usual manner from the second detector and fed either to the signal grid G_1 or to the injector grid G_3, or both.

The variable tuning condensers C_1 and C_2, and the variable condenser C_3 of the R. F. amplifier, if one is used, are mechanically interconnected as shown by the dotted line U for the purpose of providing uni-control.

As is well known, by reason of the interaction between the received signals impressed on grid G_1 and the locally generated oscillations injected on grid G_3 there will be developed in the fixed tuned circuit I_1 connected to the plate P oscillations of the intermediate frequency (I. F.). Coupled to the circuit I_1 is a second fixed tuned circuit I_2 also resonant to the intermediate frequency oscillations, the coils of said circuits constituting the transformer T_2. The oscillations occurring in the circuit I_2 may then be further amplified in a second intermediate frequency stage or else fed directly to a second detector, the resulting audio currents being fed to an audio frequency amplifier and reproduced by a loudspeaker in the usual manner, the latter elements not being shown.

In order that the frequency converter above described may assume the additional function of an amplifier of the resulting intermediate frequency, the latter frequency (sum or difference) developed in the plate circuit of the combined converter oscillator tube V is fed for maximum gain back onto the signal control grid G_1 by way of the feedback loop FB which includes the filter network in the form of I. F. transformer T_2 and series-connected condenser C_9 and resistor R_9 so that only the difference (or sum) frequency is fed back, the original and the unwanted sum (or difference) of the original frequencies being suppressed by the I. F. transformer tuned circuit acting as a band pass filter for only the difference (or sum) frequency in the heptode plate circuit. This arrangement is most advantageous in applications where the intermediate frequency is considerably removed from the tuning range frequencies and oscillator frequency because lock-in of the intermediate and signal frequencies in the I. F. transformer would occur were the difference (or sum) too close.

The I. F. signal in the plate circuit of the heptode is in phase with the I. F. signal in the grid circuit of the heptode because there is a 180° phase reversal through the tube itself and an additional 180° phase reversal through the condenser C_9 in the feedback loop since when one plate of this condenser is positive the other is simultaneously negative and therefore adequate amplification of the signal can under these conditions take place.

The gain that can be realized from the arrangement is limited because if a considerable amount of intermediate frequency is fed back, the circuit will oscillate, hence the reason for the series resistor R_9 in the feed back loop. With a converter tube of the type having a high conversion conductance maximum gain will be obtained.

While I have shown and described only one preferred embodiment of the invention, it will be understood that modifications and changes may be made without departing from the spirit and scope of the invention, as will be understood by those skilled in the art.

What I claim is:

1. In a superheterodyne receiver, a circuit for performing the combined functions of first detector-oscillator and intermediate frequency amplifier, comprising an electron discharge tube having within a common envelope a cathode, a plurality of grid electrodes and a pair of anode electrodes, a tuned input circuit having impressed thereon the received signal oscillations connected between cathode and one of the grid electrodes, external circuit elements connected between a second grid electrode, said cathode and one of the anode electrodes to serve as a generator of local oscillations, an intermediate frequency circuit connected to the second anode electrode and having an output terminal, and a circuit for feeding back some of the intermediate frequency energy for amplification by said tube, said circuit being connected between the output terminal of the intermediate frequency circuit and the grid electrode to which the tuned input circuit is connected.

2. In a superheterodyne receiver, a circuit for performing the combined functions of first detector-oscillator and intermediate frequency amplifier, comprising an electron discharge tube having within a common envelope a cathode, a plurality of grid electrodes and a pair of anode electrodes, a tuned input circuit having impressed thereon the received signal oscillations connected between cathode and one of the grid electrodes, external circuit elements connected between a second grid electrode, said cathode and one of the anode electrodes to serve as a generator of local oscillations, an intermediate frequency circuit connected to the second anode electrode and having an output terminal, and a circuit for feeding back some of the intermediate frequency energy for amplification by said tube, said circuit including a series resistor-capacitor network connected between the output terminal of the intermediate frequency circuit and the grid electrode to which the tuned input circuit is connected.

3. A combined first detector-oscillator and intermediate frequency amplifier circuit, comprising an electron discharge tube having within a common envelope a cathode, a plurality of grid

electrodes and an output anode electrode, a tuned input circuit having impressed thereon the received signal oscillations connected between cathode and one of the grid electrodes, external circuit elements connected between other electrodes of the tube to serve as a local oscillator, a first circuit tuned to the intermediate frequency oscillations resulting from the interaction between the received and local oscillations connected to the output anode electrode, a second circuit tuned to the intermediate frequency oscillations coupled to the first intermediate frequency circuit, and means for feeding back to the signal grid in phase with the received signal oscillations the intermediate frequency oscillations derived from said second circuit for further amplification by said discharge tube.

4. A circuit as defined in claim 3 wherein the feedback means comprises a circuit including series connected resistance and capacity connected between the second intermediate frequency circuit and the signal input grid.

5. In a superheterodyne receiver, a circuit for performing the combined functions of first detector-oscillator and intermediate frequency amplifier, comprising an electron discharge tube having within a common envelope electrodes constituting a triode and other electrodes constituting a heptode, the triode and heptode having a common cathode, a tuned input circuit having impressed thereon the received signal oscillations connected to the signal grid electrode of the heptode, circuit elements connected to the triode electrodes constituting a generator of local oscillations, means for injecting said local oscillations into the electron stream of the heptode, an intermediate frequency circuit connected to the output of the heptode, and a feedback circuit connected between said intermediate frequency circuit and the signal grid electrode of the heptode whereby said intermediate frequency energy is amplified by the heptode portion of the tube.

6. A circuit as defined in claim 5 wherein the feedback circuit includes a resistor and a condenser connected in series.

7. In a superheterodyne receiver, a circuit for performing the combined functions of first detector-oscillator and intermediate frequency amplifier, comprising an electron discharge tube having within a common envelope electrodes constituting a triode and other electrodes constituting a heptode, the triode and heptode having a common cathode, a tuned input circuit having impressed thereon the received signal oscillations connected to the signal grid electrode of the heptode, circuit elements connected to the triode electrodes constituting a generator of local oscillations, means for injecting said local oscillations into the electron stream of the heptode, a band-pass filter network which transmits only the intermediate frequency resulting from the frequency conversion connected to the output of the heptode, and a feedback circuit connected between said filter network and the signal grid electrode of the heptode whereby said intermediate frequency energy is amplified by the heptode portion of the tube.

8. A combined frequency converter-intermediate frequency amplifier stage utilizing a tube having a plurality of electrodes, comprising a tuned input circuit on which the received signal oscillations are impressed connected to the signal control grid electrode of the tube, said electrode constituting the input to said stage, external circuit elements connected to certain of the tube electrodes to serve as a generator of local oscillations, a circuit tuned to the intermediate frequency resulting from the interaction between the received signal oscillations and the locally produced oscillations connected to an electrode of the tube, which electrode constitutes the output of said stage, and a circuit connected from the output to the input of said stage for feeding back some of the intermediate frequency energy to be amplified by said stage.

9. A combined frequency converter-intermediate frequency amplifier stage as defined in claim 8 wherein the feed back circuit includes a resistor and a condenser connected in series.

10. In a superheterodyne receiver, a circuit for performing the combined functions of first detector-oscillator and intermediate frequency amplifier, comprising an electron discharge tube having within a common envelope, cathode, grid and anode electrodes which constitute a triode, and a cathode, an anode and a plurality of interposed grids which constitute a heptode, said grids including a signal grid and a mixer grid, said cathode being common to said triode and heptode, a tuned input circuit having impressed thereon received signal oscillations connected to the signal grid electrode of the heptode, circuit elements connected to the triode electrodes constituting a generator of local oscillations, a connection between the grid of the triode oscillator and the mixer grid of the heptode for injecting the local oscillations into the electron stream of the heptode, an intermediate frequency circuit connected to the anode of the heptode, and a feedback circuit connected between said intermediate frequency circuit and the signal grid electrode of the heptode whereby said intermediate frequency energy is amplified by the heptode portion of the tube.

KARL SEILER, 3RD.