Jan. 19, 1943. J. A. WORCHESTER, JR 2,309,031

CONVERTER CIRCUIT

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Fig. 1.

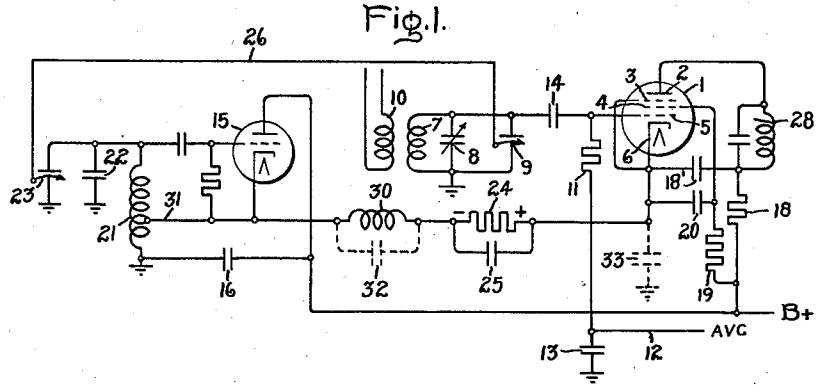
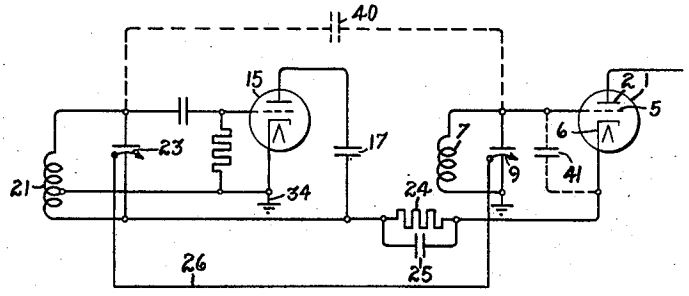


Fig. 2.



Inventor:
Joseph A. Worcester Jr.,
by Harry E. Dunham
His Attorney.

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CONVERTER CIRCUITS

Joseph A. Worcester, Jr., Fairfield, Conn., assignor to General Electric Corporation, a corporation of New York

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5 Claims. (Cl. 250—20)

My invention relates to converter circuits such as are used, for example, in superheterodyne radio receivers and particularly to converter circuits in which the local oscillations are generated in a discharge device separate from that on which the conversion is effected.

It has for one of its objects to provide means to reduce certain objectionable effects which occur in such circuits, particularly when variably tuned over a range of short wave lengths.

In tuning superheterodyne receivers of this type over a range of short wave lengths difficulty is sometimes encountered by reason of the proximity of the frequency of the local oscillator to that of the received signal. This difficulty may arise by reason of a condition of series resonance at the oscillator frequency occurring in the input circuit of the converter where the interelectrode capacity of the converter may tend to resonate with the effective inductance of the input circuit external to the discharge device. If this occurs, undesirably high voltage at the oscillator frequency is likely to be produced between the converter input electrodes causing objectionable action of the circuit in respects which I shall later explain.

One of the objects of my present invention is to provide means to avoid such objectionable effects.

Another object of my invention is to prevent the production between the input electrodes of the converter of undesirable high voltages of the oscillator frequency notwithstanding the existence of the tendency to series resonance above mentioned.

Another object of my invention is to provide means to neutralize a part of the oscillator voltage appearing between the converter input electrodes.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 represents an embodiment of my invention and Fig. 2 represents a modification thereof.

Referring to Fig. 1 of the drawing, I have shown at 1 therein an electron discharge device connected to serve as a frequency converter, or first detector, in a superheterodyne radio receiver. This discharge device comprises an anode 2, a suppressor grid 3, a screen grid 4, a control electrode 5 and a cathode 6. The control electrode 5 is connected to ground through a tuned circuit comprising a secondary winding 7 of an input transformer which is shunted by a trimmer condenser 8 and a variable tuning condenser 9. The primary winding 10 of the input transformer may be connected, in any suitable well-known way, to an antenna, or to the output of an earlier stage of radio frequency amplification. This control electrode 5 is also connected through the usual grid resistance 11 to a conductor 12, which may comprise the conductor of the radio receiver over which unidirectional bias voltage varying with the intensity of the received signal is supplied to the control electrodes of the receiver for automatic volume control purposes. This conductor is grounded for radio and audio frequency potentials by means of condensers such as that indicated at 13. The blocking condenser 14 prevents the short circuiting of the unidirectional potential of conductor 12 through secondary winding 7.

The local oscillator is shown at 15 and may comprise an anode, a cathode and a control electrode. The anodes of the two discharge devices may, of course, be supplied from a common source of operating potential indicated by the conductor bearing the legend B+ and the negative terminal of which may be grounded. This source of operating potential may be bypassed by condenser 16 and through filter resistance 18 by condenser 18'. Potential from this same source may be supplied to the screen grid of the converter through the usual filter comprising a resistance 19 and a condenser 20.

Connected between the control electrode of the electron discharge oscillator 15 and ground is an oscillatory circuit comprising inductance 21, trimmer condenser 22 and tuning condenser 23, all in parallel. The cathode of the oscillator 15 and also the cathode 6 of the converter are connected to an intermediate point on the inductance 21. In this way feedback is provided between the anode and grid circuits of the oscillator, causing it to generate oscillations at the frequency to which its oscillatory circuit 21, 22, 23 is resonant, and a portion of these oscillations is injected between the cathode 6 and control electrode 5 of the converter. The connection of the cathode 6 of the converter to the inductance 21 of the oscillator includes a biasing resistance 24, which is shunted by a condenser 25. The cathode current of the converter (discharge device 1) flowing in this circuit produces

a unidirectional potential upon the resistance 24, which serves to bias the cathode of the discharge device 1 positively with respect to ground. The value of resistance 24 may be such that the cathode is biased positively with respect to the potential of the control electrode 5 of the converter.

The tuning condensers 9 and 23 are arranged for variation by means of the variation of a single control member in the usual way in such receivers. This connection for unicontrolled action is indicated by the line 26. These condensers may be arranged to tune both the oscillator and the input to the converter over a range of frequencies spaced apart by a fixed amount so that an intermediate frequency of constant value, as, for example, 455 kilocycles, may be produced in the circuit 28 which is connected between the anode and cathode of the converter. Of course in certain applications this intermediate frequency may not be constant. For example, in certain receivers where two or more converters are employed in cascade, the intermediate frequency produced by the first converter may vary in response to variation of the tuning condensers 2 and 23.

Normally in the operation of such circuits the bias voltage biasing the control electrode 5 of the converter negative with respect to the cathode thereof is greater than the intensity of oscillations injected into the converter circuit by the local oscillator; that is, the negative unidirectional potential existing between the electrodes 5 and 6 of the converter exceeds the voltage of the local oscillator frequency existing between the cathode and ground of the local oscillator as shown in Fig. 1. Thus, no grid current flows in the grid of the converter and the two circuits operate independently and satisfactorily.

It may occur, however, particularly in the higher portion of the frequency ranges over which the circuits are tunable, that a series resonant condition at the oscillator frequency tends to exist in the input of the converter. This occurs in the higher frequency portion of the band because in this portion of the band the frequencies of the two bands, namely that over which the input circuit is tunable and that over which the oscillator is tunable, differ by a smaller percentage than is the case in the lower frequency portion of the band. This is especially true in the short wave bands. If the local oscillator frequency be lower than the signal frequency, the impedance of the external circuit comprising elements 7, 8 and 9, as represented on the drawing, is inductive at the oscillator frequency and it may tend to resonate in series with the capacity existing between the control electrode 5 and the cathode 6 of the converter. If this occurs, a very large voltage of the oscillator frequency may exist between the control electrode 5 and the cathode 6, this voltage being sufficient to overcome the bias voltage between these electrodes and thus cause the flow of grid current in the control grid circuit of the converter thereby causing certain undesirable effects. For example, in the adjustment of the circuits 21, 22, 23 and 7, 8, 9 for alignment thereof during manufacture, the voltage between the control electrode 5 and cathode 6 may be so great as to cause interlocking of the two circuits, thus greatly complicating the alignment procedure. The extreme voltage between the cathode and the grid may vary widely in intensity in response to the alignment adjustments and vary the output of the receiver to such a degree as to mask the indications of resonance to the signal frequency which are necessary to such alignment. Loading of the oscillator results from the flow of grid current in the converter, tending to render the oscillator unstable and increasing the noise level of the receiver. Motor boating of the local oscillator is likely to occur; that is, the oscillations from the local oscillator tend to cause grid current in the converter, which, in turn, loads the oscillator and shifts its frequency thereby reducing the intensity of oscillations produced by the oscillator, which, in turn, reduces the grid current in the converter and hence the loading of the oscillator, this cycle repeating itself and setting up the motor boating phenomenon.

It has been found that these undesirable effects may be completely eliminated by the use of an inductance 30 in the circuit between the cathodes of the two converters thereby to reduce the amount of oscillator voltage which is supplied to the converter in the high frequency part of the band. This inductance may be so proportioned that it has little effect in the low frequency part of the band; that is, the intensity of oscillations supplied from the local oscillator to the converter is determined, in the low frequency part of the band, principally by the position of the tap 31 upon the inductance 21. At the higher frequencies the impedance of the inductance 30 may increase, thus reducing the intensity of oscillations supplied to the converter to such an extent that at the frequencies where the above mentioned series resonance tends to occur the oscillations supplied to the converter are of such low intensity that the voltage of the oscillator frequency appearing between the input electrodes of the converter is less than the bias voltage on the converter. This prevents the flow of grid current in the converter and avoids the above mentioned undesired effects. If desired, the inductance 30 may be one designed to have inherent capacity 32 such that it tends to resonate near the frequency at which the series resonance in the converter input occurs. Thus as the voltage on the converter grid tends to rise, that on the inductance 30 also tends to rise by reason of its own inherent resonance thereby maintaining voltage of desired magnitude between the input electrodes of the discharge devices notwithstanding the presence of the series resonant condition.

If the band of frequencies over which the circuit 7, 8, 9, for example, is tunable extend, for example, from 5.6 megacycles to 18.2 megacycles, the inductance 30 may have a value of 23 microhenries. Lower inductance may be employed but it should not be so low that it tends to produce series resonance with the capacitance between the cathode 6 of the converter and ground, this capacitance being indicated by the dotted lines at 33. I have found that the value of the inductance previously mentioned avoids this latter condition as well as preventing the undesired effects resulting from the series resonance previously mentioned.

In Fig. 2 I have shown a circuit similar to that in Fig. 1 and in which like reference numerals are applied to corresponding parts. It differs, however, from the circuit shown in Fig. 1 in that the cathode of the oscillator is grounded directly as indicated at 34 and is connected to the intermediate point on the coil 21. The lower terminal of this coil as shown on the drawing

is connected, not to ground as in Fig. 1, but through condenser 17 to the anode of the oscillator and through the resistance 24 and by-pass condenser 25 to the cathode of the converter. The two tuning condensers 23 and 9 are shown as unicontrolled as indicated by the lines 26. These condensers are, of course, of the usual, so-called, "gang" construction having separate condenser units for the oscillator circuit and tuned input circuit respectively, these units being mounted in a single mechanical assembly for unicontrolled adjustment. Ordinarily the rotors of such condensers are grounded and the stators thereof have a certain amount of capacitance between them as indicated by the dotted lines 40.

With the circuit as shown in Fig. 2 this capacitance 40 is connected between the control electrode 5 of discharge device 1 and the side of the oscillatory circuit 21, 23 opposite to that which the cathode of device 1 is connected. The voltage supplied between the control electrode 5 and ground through capacitance 40 is therefore in opposed phase relation to the voltage supplied to the control electrode 5 through the interelectrode capacity 41. In practice the voltage supplied between the control electrode 5 and ground through capacitance 40 is less than that supplied through capacitance 41 but it is sufficient to neutralize the voltage supplied through capacitance 41 to such an extent that the undesired effects above pointed out are avoided. Of course, if increased, or complete, neutralization be desired it may be effected by connecting a capacitor of proper size in shunt with the capacitance 40.

Viewed somewhat differently the capacitance 40 and capacitance 41 form a potentiometer directly across the oscillatory circuit 21, 23. Since an intermediate point on this circuit is grounded at 34 the control electrode 5 is maintained at a definite voltage with respect to ground by this potentiometer the value of this voltage being determined by the ratio of the capacitances 40 and 41.

In describing my invention I have particularly mentioned the use of a local oscillator operating at a frequency lower than the frequency of the received signals. The effects which my invention seeks to avoid occur even though the oscillator be at a frequency higher than the frequency of the received signal. This is because the circuit 7, 8, 9 of Fig. 1 or 7, 9 of Fig. 2, disregarding the interelectrode capacitance, resonates at a higher frequency than does this input circuit including the interelectrode capacity of the discharge device and it resonates in series with the interelectrode capacity near the oscillator frequency thereby causing the objectionably large oscillator voltage at the input electrodes of the converter.

While my invention is particularly advantageous in the short wave bands such as that extending from 5.6 to 18 megacycles in which the circuits are tunable over a range of 1 to 3 ratio, it operates to produce higher gain also in the broadcast band extending from 550 to 1700 kilocycles. It permits the use of a discharge device 1 as a converter having high transconductance and avoids the use in this stage of a low transconductance discharge device having high cathode current, such as the commonly used pentagrid converter, and hence excessive shot noise. It thus lends to the construction of a receiver having improved signal to noise ratio.

While I have shown particular embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto since various modifications may be made both in the circuit arrangement and in the instrumentalities employed and that I contemplate, by the appended claims, to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination, in a superheterodyne receiver, of an electron discharge converter having a cathode and an input electrode, a circuit tuned to the frequency of signal oscillations and a source of local oscillations connected between said cathode and input electrode in series, said signal oscillations and said source of local oscillations being different in frequency by such an amount that the interelectrode capacity between said cathode and control electrode tends to produce series resonance with the impedance of said tuned circuit at the oscillation frequency thereby producing objectionably large voltage of the local oscillator frequency between said input electrode and cathode of said converter, and means operative to reduce the voltage having the frequency of said local source which appears between said cathode and control electrode to a desired value notwithstanding the presence of said series resonant condition.

2. The combination, in a superheterodyne receiver, of an electron discharge converter having a cathode and an input electrode, a circuit tunable over a range of signal frequencies and a source of local oscillations connected between said input electrode and cathode in series, said source being variable in unison with the tuning of said circuit over a range of frequencies different from said range of signal frequencies by a fixed amount, said amount being sufficiently small that at one part of said ranges the interelectrode capacity between said cathode and control electrode tends to produce series resonance with the impedance of said tunable circuit thereby objectionably increasing the voltage between said input electrode and cathode, and means to maintain the voltage of said local oscillations appearing between said cathode and input electrode at a desired value notwithstanding said series resonant condition.

3. The combination, in a superheterodyne receiver, of an electron discharge local oscillator, an electron discharge converter, said local oscillator and converter each having a cathode and a control electrode, an oscillatory circuit connected between the control electrode of said oscillator and ground, both of said cathodes being connected to an intermediate point on said oscillatory circuit, a signal input circuit connected between the input electrode of said converter and ground, said input circuit and said oscillatory circuit being tunable in unison over corresponding ranges of frequency, and the capacity between said cathode and input electrode of said converter tending undesirably to resonate with the impedance of said input circuit in at least a part of said range, and an inductance connected between said cathodes to reduce the voltage of the frequency produced by said oscillator appearing between the control electrode and cathode of said converter in said part of said range.

4. The combination, in a superheterodyne receiver, of an electron discharge converter having a cathode, an anode, and a control electrode, a tunable input circuit and a source of local oscilla-

tions connected between said cathode and control electrode through a source of unidirectional potential biasing said control electrode negative with respect to said cathode, the intensity of the oscillations of said source being less than the potential of said unidirectional potential, the frequency of said source and the tuning of said input circuit being variable over corresponding ranges, and the input capacity between said control electrode and cathode tending objectionably to resonate with the impedance of said input circuit in a portion of said ranges thereby undesirably increasing the oscillations of the local oscillator frequency between said control electrode and cathode and overcoming said bias, and means to maintain the voltage between the control electrode and cathode produced by said local oscillator at a value less than the value of said bias notwithstanding said tendency to resonate.

5. The combination, in a superheterodyne receiver, of an electron discharge converter, an electron discharge oscillator, said oscillator and converter each having a cathode and a control electrode, a tuned circuit including a condenser connected between the control electrode of said converter and ground, an oscillatory circuit for said oscillator connected between the cathode of said converter and the control electrode of said oscillator an intermediate point thereof being connected to ground, each of said circuits including a respective variable condenser to tune said circuits over corresponding ranges of frequencies, said condensers having capacity therebetween, said capacity forming with the capacity between the control electrode and cathode of said converter a potentiometer across said oscillatory circuit determining the voltage of the frequency of the oscillator existing between said control electrode and cathode of said converter.

JOSEPH A. WORCESTER, JR.

CERTIFICATE OF CORRECTION.

Patent No. 2,309,031. January 19, 1943.

JOSEPH A. WORCESTER, JR.

It is hereby certified that the name of the assignee in the above numbered patent was erroneously described and specified as "General Electric Corporation" whereas said name should have been described and specified as --General Electric Company, a corporation of New York--; as shown by the record of assignments in this office; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of March, A. D. 1943.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.