May 27, 1947. G. W. FYLER 2,421,255

ULTRA-HIGH FREQUENCY OSCILLATOR

Original Filed Nov. 30, 1942

Fig. 1.

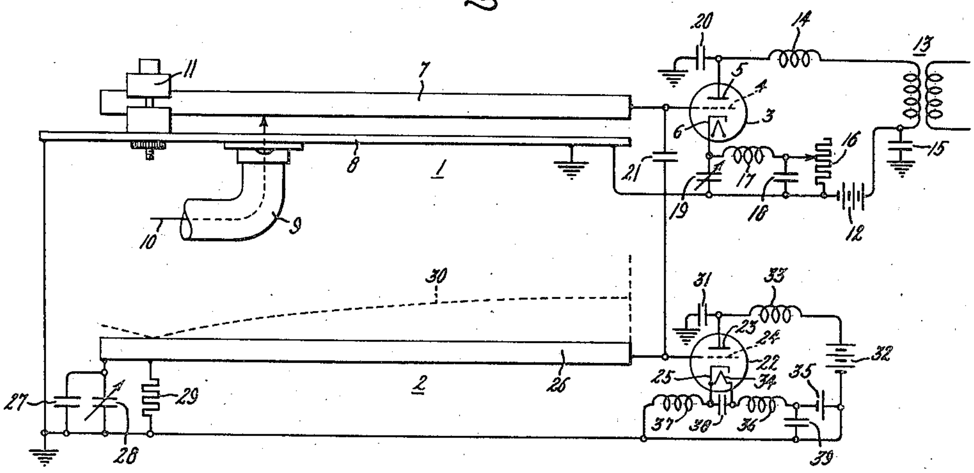
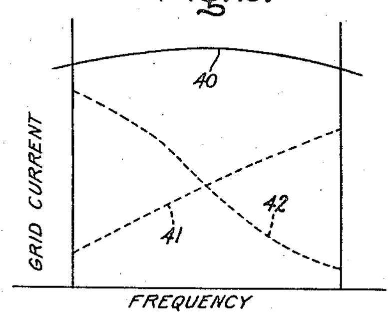


Fig. 2.



Inventor:
George W. Fyler,
by Harry E. Dunham
His Attorney.

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ULTRA HIGH FREQUENCY OSCILLATOR

George W. Fyler, Stratford, Conn., assignor to General Electric Company, a corporation of New York

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2 Claims. (Cl. 250—36)

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My invention relates to ultra high frequency oscillators and particularly to such oscillators which are suitable for use in ultra high frequency receivers of the heterodyne type. This application is a division of my copending application Serial No. 467,286, filed November 30, 1942, Patent Number 2,416,577 dated February 25, 1947.

Ultra high frequencies are normally employed in radio locating and range finding apparatus and losses become important which are negligible in apparatus operated at lower frequencies. Various losses in the input circuit of the apparatus tend to decrease the signal strength, but in most cases these losses may be reduced so that they become negligible. To a greater degree, the strength of the signal may be reduced by the input conductance of the electron discharge device or tube employed in the circuit. The input conductance of an electron discharge tube depends upon several factors among which is the loading effect due to the transit time of electrons through the electron discharge device. In an ultra high frequency superheterodyne receiver the input conductance of the electron discharge device employed in the converter of the receiver and which is due to transit time loading effects decreases with increased plate voltage, and a high plate voltage is therefore desirable provided that adequate oscillator voltage and adequate emission and safe plate dissipation are available. Under optimum conditions of operation the amplitude of the oscillator voltage is critical and therefore it is desirable to maintain the voltage at the local oscillator output uniform throughout the range of frequencies at which it is desired to operate the oscillator. Accordingly it is an object of my invention to provide an improved oscillation generator for ultra high frequency superheterodyne receivers for securing uniform and adequate voltage at ultra high frequencies with a minimum loading effect on the converter circuit.

It is another object of my invention to provide an ultra high frequency oscillator including an improved arrangement for insuring a uniform voltage with respect to ground over a wide band of frequencies.

The features of my invention which I believe to be novel 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

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Fig. 1 is a diagrammatic illustration of an ultra high frequency receiver provided with an oscillator embodying my invention and Fig. 2 represents certain operating characteristics of the receiver shown in Fig. 1.

Briefly, the receiving apparatus illustrated in the drawings comprises a superheterodyne receiver including a three-electrode electron discharge device connected as a converter and a second three-electrode electron discharge device connected as a local oscillator. Radio frequency signals are supplied to the converter through a tuned grid circuit, and the oscillations produced by the local oscillator are also coupled to the control grid of the converter. The oscillator is provided with a tuned grid circuit which is grounded and the electron discharge device of the oscillator has its plate grounded for frequencies within the range of operation of the oscillator. An inductance is provided in the cathode lead of the oscillator electron discharge device and has a critical value selected so that the grid current of the oscillator is substantially constant over the tuning range of the grid circuit.

Referring now to the drawing, the receiving apparatus shown in Fig. 1 comprises a converter 1 and a local oscillator 2. The converter includes an electron discharge device 3 having a control electrode or grid 4, an anode 5, and a cathode 6. A tuned circuit comprising a line or bar conductor 7 parallel to and closely spaced from a portion of the chassis or shield 8 is connected between the grid 4 and ground, the chassis being grounded. Radio frequency signals are supplied to the tuned circuit through a concentric line including a shielding tube 9 and a conducting lead 10. The bar 7 is mounted in an adjustable conducting clamp 11, and the circuit is tuned by adjusting the position of the bar to change the length of the bar from the grid to the grounded chassis. The output circuit of the converter is connected between the anode 5 and ground, a suitable source of direct current, such as a battery 12, being provided. The output circuit includes an intermediate frequency transformer 13 and a radio frequency choke 14. The primary winding of the transformer 13 is connected to ground for alternating currents by a suitable condenser 15 to bypass the battery 12. The load circuit is completed by a grid biasing resistance 16 and a radio frequency choke 17 connected in series between the cathode 6 and ground. A condenser 18 is connected across the resistance 16 between the choke coil 17 and ground; a condenser 19 is connected in the cathode lead between the cathode 6 and ground; and a condenser 20 is connected between the anode 5 and ground. The cathode lead and the lead connecting the anode to ground through the condenser 20 are preferably made as short as possible. The values of the several components of the converter circuit are selected and adjusted to provide optimum conditions of operation in the manner described in my aforesaid copending application.

The oscillator 2 is coupled to the grid 4 through a condenser 21, and the peak voltage of the oscillator is preferably about equal to the bias voltage of the grid 4, which is selected by adjustment of the resistance 16. The oscillator frequency may be either above or below the signal frequency. However, it has been found that it is preferable to operate the oscillator at a frequency below the signal frequency and that the stability of the oscillator is increased thereby and adequate excitation of the converter is assured. The explanation of the advantage to be gained in this manner lies in the fact that the signal input is capacitive at the higher oscillator frequency and only a portion of the oscillator voltage appears on the grid 4 as determined by the capacity divider including the condenser 21 and the capacitive signal input circuit. Furthermore the signal voltage tends to be greater at the oscillator than at the grid 4 because the oscillator circuit is inductive at the signal frequency and a partial series resonance tends to occur. If the oscillator 2 operates at a frequency lower than that of the signal, more oscillator voltage may be made to appear on the grid 4 than exists at the oscillator, and also the coupling of the signal to the oscillator is reduced. The result of operating the oscillator at a lower frequency than the signal frequency is a definite improvement in the signal-to-noise ratio; in some cases the ratio may be doubled.

In order to decrease the input conductance due to the transit time of electrons through the discharge device 3 of the converter, it is desirable to employ a high voltage on the anode 5. However, it is also desirable that the adequate or correct oscillator voltage impressed upon the grid 4 be maintained at a definite value which is substantially uniform over the range of frequencies within which the oscillator is required to operate. In order that the oscillator may be maintained at a substantially fixed level, the plate or anode circuit of the oscillator is grounded at radio frequencies.

Referring again to the drawings, the oscillator 2 shown in Fig. 1 comprises an electron discharge device 22 having an anode 23, a control electrode or grid 24, and a cathode 25. Between the control electrode 24 and ground is connected a series tuned circuit including a transmission line or bar conductor 26 connected to the grid 24 and condensers 27 and 28 in parallel connected between the other end of the bar 26 and ground. The bar 26 is preferably mounted parallel to a grounded chassis or shielding plate of the oscillator and is spaced a short distance therefrom. A control electrode biasing resistance or grid leak 29 is connected between the bar 26 and ground near the end to which the condensers 27 and 28 are connected. The condenser 28 is variable and is employed to tune the resonant circuit. The effective length of the transmission line 26 is increased by the capacity of the condensers 27 and 28, the effective length being tuned to a quarter wave length at the desired frequency so that the total voltage of the tuned circuit appears at the end of the bar 26 adjacent the grid 24 as indicated by the dotted voltage curve 30, the minimum voltage appearing at the bar adjacent its connection with the resistance 29. The condenser 27 limits the tuning range of the condenser 28 so that the condenser 28 will not have rapid tuning at the minimum end of its range. The anode 23 is connected at radio frequencies to ground through a condenser 31. The direct current power supply, such as a battery 32, is connected to the anode 23 through a radio frequency choke coil 33. The device 22 is provided with a filament heater 34 which is supplied with current from a battery or other suitable source 35 through a radio frequency choke coil 36, the current returning through an inductance 37 in the cathode lead of the device 22. A by-pass condenser 38 is provided across the two leads of the heater 34 and a condenser 39 is provided to bypass the battery at radio frequencies. The grid 24 at which the full voltage of the oscillator appears is coupled to the grid 4 of the device 3 through the condenser 21. Since the plate 23 is grounded at radio frequencies, the voltage appearing at the grid 24 may be adjusted and maintained at a predetermined level.

It has been found that the size of the inductance coil 37 in the cathode lead of the device 22 is critical and that by selecting the proper value of this inductance the voltage of the oscillator may be made substantially uniform at all frequencies within the tuning range. In Fig. 2 the grid current of the device 22 has been plotted against frequency for three values of the inductance 37. The two vertical lines in Fig. 2 represent the lower and upper frequency limits of the normal tuning range of the oscillator. The curve 40 represents the grid current when the correct value of the inductance 37 is employed. The dotted curve 41 represents the grid current when the value of the inductance 37 is too small, and the dotted curve 42 represents the grid current when the value of the inductance 37 is too large. The correct value of the inductance 37, as indicated by the curve 40, makes it possible to tune the oscillator 2 over its entire range of frequencies without any substantial change in the adequate and uniform voltage supplied to the converter 1. Values of the inductance 37 either too large or too small may cause the oscillations to stop or may cause the oscillator to superregenerate. In either case, uniformity of operation is obviously lost.

At frequencies at the upper end of the range of the oscillator there is an increased tendency toward radiation which might produce nonuniformity of oscillation. However, this effect can be reduced until it is negligible by close spacing between the grid line 26 and the grounded shield or chassis of the oscillator. By arranging the oscillator so that the grid line 26 is tuned in series with the condenser 28, it is possible to employ a larger condenser which is preferable mechanically and increases the stability of operation.

During the operation of the converter, the oscillator is tuned solely by adjustment of the variable condenser 28. The value of the inductance 37, once selected, is fixed so that the oscillator will operate at all frequencies within its range of frequencies with the grid current following the curve 40 of Fig. 2. It will be evident that my invention provides an ultra high frequency oscillator which is structurally simple and employs a three-electrode electron discharge device within its ultra high frequency range. By way of illustration only and not by way of limitation, there are listed below the values of circuit constants which have been found to be suitable for the circuit of Fig. 1 when employed in a particular superheterodyne frequency converter operating at a radio frequency of 400 megacycles and with the oscillator tuned to either 358 megacycles or 442 megacycles to provide an intermediate frequency of 42 megacycles. The full normal tuning range of the oscillator was over a band 120 megacycles wide and extended from 340 megacycles to 460 megacycles. The devices **3** and **22** were type 955 Acorn triodes. The bars **7** and **26** were one-fourth inch square brass rods approximately four inches long which had been silver plated and were spaced one-eighth inch from the grounded shield or chassis.

Converter

Condenser 15=1000$\mu\mu$ farads
Condenser 18=220$\mu\mu$ farads
Condenser 19=3–30$\mu\mu$ farads
Condenser 20=2$\mu\mu$ farads
Choke 14=0.2μ henrys
Choke 17=.064μ henrys
Resistance 16=300–3000 ohms
Transformer 13=42 mc. I. F. transformer
Coupling condenser 21=0.2$\mu\mu$ farads, oscillator at 358 mc., 2$\mu\mu$ farads, oscillator at 442 mc.

Oscillator

Condenser 27=5$\mu\mu$ farads
Condenser 28=3 to 12$\mu\mu$ farads
Condenser 31=220$\mu\mu$ farads
Condenser 38=100$\mu\mu$ farads
Condenser 39=250$\mu\mu$ farads
Choke 33=resonant at 400 mc.
Choke 36=resonant at 400 mc.
Choke 37=.064μ henrys
Resistance 29=8500 ohms

Although I have illustrated my invention as embodied in a superheterodyne receiver, other applications will readily be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular circuit arrangements shown and described, and I intend in the appended claims to cover all modifications 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. A generator for producing ultra high frequency oscillations including an electron discharge device having an anode and a cathode and a control electrode, means including a bar transmission line and a variable condenser connected in series between said control electrode and ground for tuning the control electrode circuit of said device in series resonance for ultra high frequencies within a predetermined range, means for connecting said anode to ground at frequencies within said range, a source of direct current connected between said anode and said cathode, and an inductance connected between said cathode and ground and having a value such that the current in the control electrode circuit of said device remains substantially constant over said range of frequencies.

2. A generator for producing ultra high frequency oscillations including an electron discharge device having an anode and a cathode and a control electrode, a plate connected to ground, a bar transmission line secured in closely spaced relationship with said plate and having one end connected to said control electrode, a variable condenser connecting the other end of said line to ground, said line and said condenser being tunable in series resonance at ultra high frequencies within a predetermined range, a condenser for connecting said anode to ground within said range of frequencies, a source of direct current having its positive terminal connected to said anode and its negative terminal connected to ground, and an inductance connected between said cathode and ground and having a value such that the current in the control electrode circuit of said device remains substantially constant for all frequencies within said range.

GEORGE W. FYLER.

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