May 14, 1935. P. O. FARNHAM 2,001,694

OSCILLATOR CIRCUIT

Filed Sept. 23, 1931 2 Sheets-Sheet 1

Fig. 1.

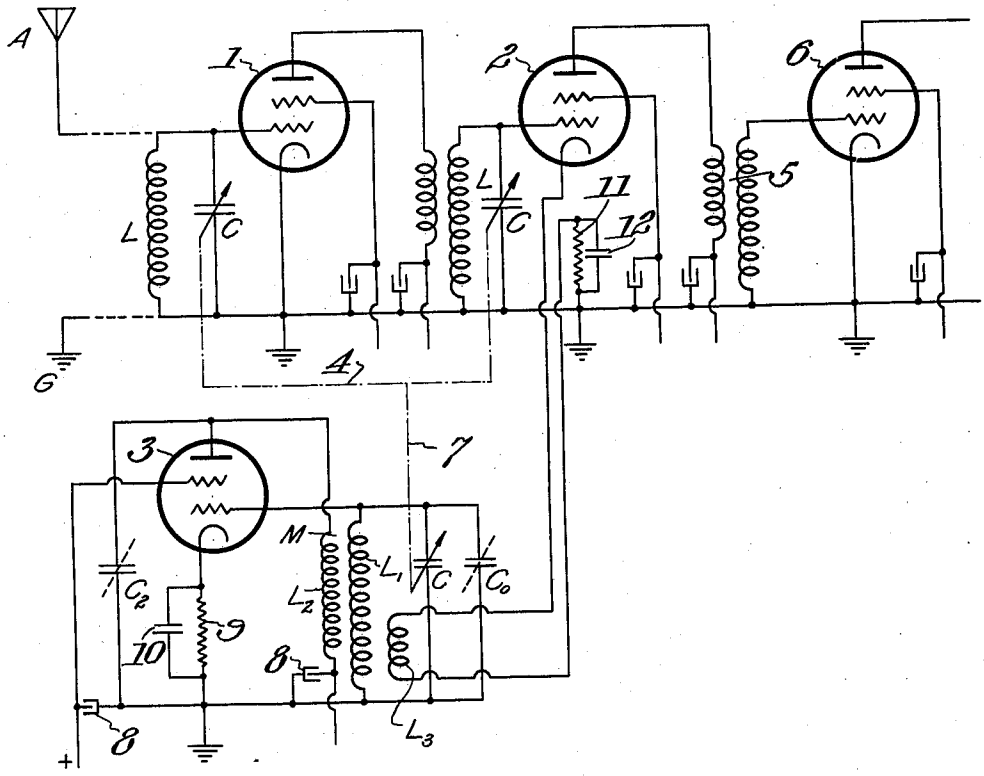
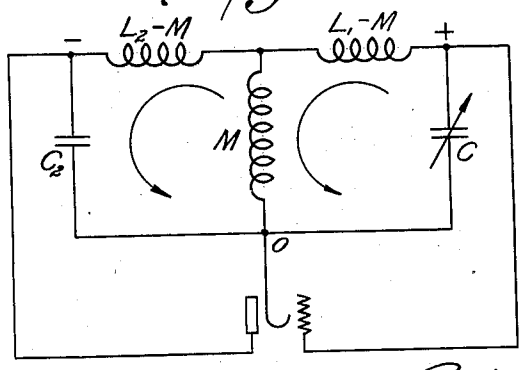


Fig. 2.



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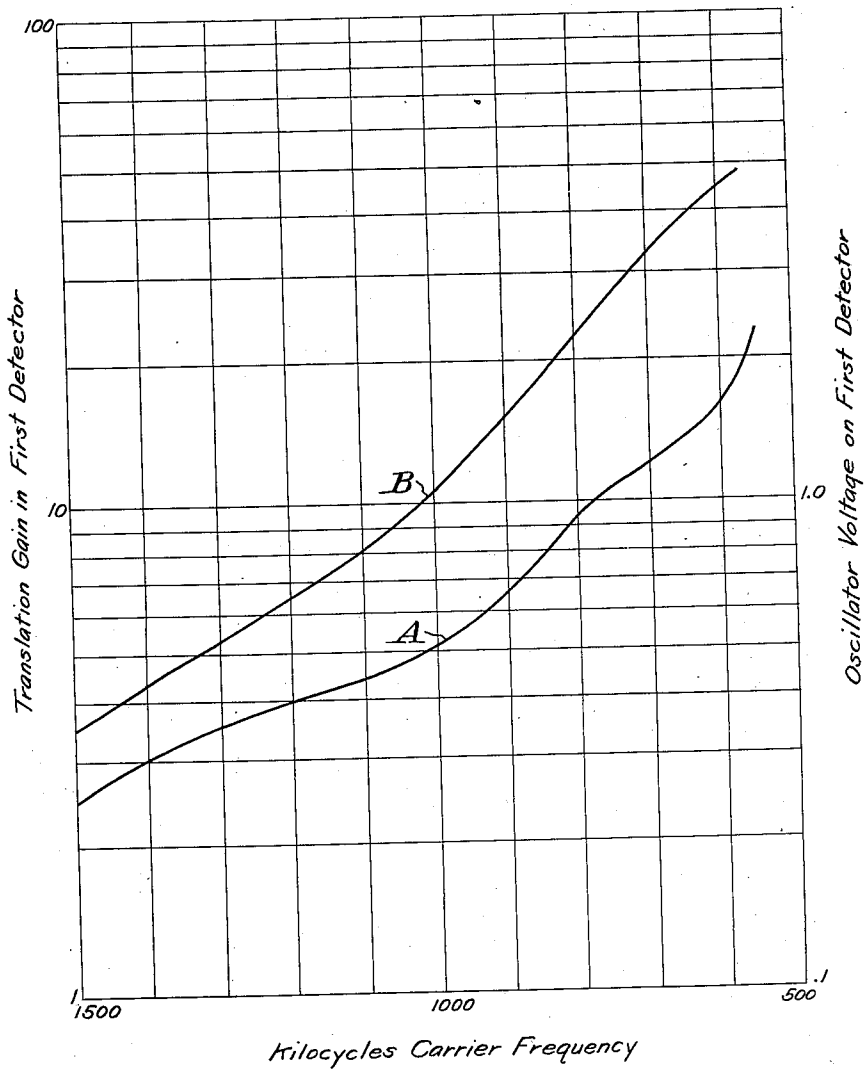
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Fig. 3.



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UNITED STATES PATENT OFFICE

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OSCILLATOR CIRCUIT

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Application September 23, 1931, Serial No. 564,676

9 Claims. (Cl. 250—20)

This invention relates to oscillator circuits and more particularly to tuned oscillator circuits adapted to form part of a superheterodyne receiver having a single control for adjusting both the carrier and oscillator frequency.

It is possible to design tuned carrier frequency and local oscillator circuits which exhibit a substantially constant frequency difference when tuned over a band of frequencies by similar sections of a gang condenser. The usual method for securing "tracking" of the circuits is to employ a relatively complex oscillator circuit having an inductance somewhat less than that of the carrier circuit, and having a large capacity in series with and a small capacity shunted across a tuning condenser which is substantially identical with the carrier frequency tuning condenser. In actual practice, the large series capacity usually takes the form of a large fixed condenser shunted by a small adjustable condenser, since the series capacity will be of the order of 1000 micromicrofarads in the case of receivers for signals in the 550 to 1500 kilocycle band, and must be adjustable to effect alinement of the oscillator and carrier frequency circuits.

An object of the invention is to provide an oscillator circuit adapted for use in a single control superheterodyne receiver and which is of simpler and less expensive construction than the known oscillator circuits. Another object is to provide a tuned oscillator which will deliver higher output voltages as the oscillator is tuned to lower frequencies. More specifically, an object is to provide an oscillator circuit having coupled grid and plate coils which are wound and connected in the same sense, the phase reversal between grid and plate voltages necessary for oscillation being obtained by making the reactance of the leakage inductance of the plate coil larger than the capacity reactance between plate and cathode for all frequencies in the tuning range of the oscillator. A further specific object is to provide a superheterodyne receiver in which the oscillator voltage impressed on the first detector increases automatically with decreasing frequency, thereby offsetting the frequency variation of signal energy transmitted to the first detector.

These and other objects of the invenion will be apparent from the following specification when taken with the accompanying drawings, in which:

Fig. 1 is a fragmentary circuit diagram of a superheterodyne receiver embodying the invention,

Fig. 2 is an equivalent diagram of the oscillator circuit, and

Fig. 3 is a curve sheet showing the variation, with frequency, of the oscillator voltage and the translation gain of the first detector.

In the drawings, the reference numeral 1 identifies a vacuum tube for amplifying signal energy at carrier frequency, the amplified energy being passed to the detector tube 2 and there combined with local oscillations generated by oscillator tube 3 to produce a beat or intermediate frequency. With the exception of the oscillator circuits, this portion of the superheterodyne receiver may be of any appropriate design. In the typical arrangement shown in the drawings, the input circuit of the carrier amplifier comprises an inductance L and tuning condenser C, the input circuit being connected or coupled in any appropriate manner to the antenna or collecting structure AG.

The plate circuit of amplifier 1 is coupled to the detector input circuit L, C, which may be, and preferably is, substantially identical with the amplifier input circuit, the adjustable capacities being usually provided by sections of a gang condenser, as is indicated by the broken line 4 which connects the tuning condensers of the amplifier and detector stages. The beat frequency set up in the detector is passed, as by coupling transformer 5 to the intermediate frequency amplifier tube 6.

The oscillator circuit includes a tuning condenser C shunted across the grid inductance L_1 which is coupled to the plate inductance L_2. As indicated by broken line 7, the adjustable element of condenser C is mechanically connected to the tuning condensers C of the amplifier and detector stages and the several tuning condensers are preferably similar sections of a gang condenser.

The oscillator tuning condenser is shunted by a small condenser C_0 which, as in the described prior arrangements, is initially adjusted to secure the desired frequency difference between the oscillator and carrier frequencies when the tuning condensers C are adjusted to tune the circuits to their respective higher frequencies. The plate coil L_2 is coupled to the grid coil L_1 with a coefficient of coupling of the order of somewhat less than 0.5. The coil L_2 may be, and preferably is, a choke coil mounted within and centrally of the coil L_1 so that any small variation of its position with respect to coil L_1 will not have any appreciable effect upon the mutual inductance M. A small condenser C_2 is connected between the oscillator plate and cathode, and the screen grid and plate supply leads are connected to

ground by condensers 8 of the order of 0.1 microfarad.

The cathode circuit includes a bias resistor 9 of about 7,500 ohms, shunted by a condenser 10 of about 0.001 microfarad. The tube 3 is preferably a screen grid tube, since substantial capacity coupling between the plate and control grid will, if not neutralized, cause the circuit to stop oscillating at the higher frequencies.

It is particularly to be noted that the grid and plate coils L_1, L_2 are wound and connected in the same sense, which arrangement is contrary to the usual oscillator practice. A phase reversal of grid and plate voltages, with respect to the cathode voltage, which is necessary for oscillation, is obtained by the action of the leakage inductance of the plate coil L_2 and the plate-cathode capacity C_2. This will be apparent from the circuit diagram, Fig. 2, which shows a net work equivalent to that of the oscillator circuit. The direction of the oscillatory current flow is indicated by the arrows and, for current flow as indicated, the polarities at points in the circuits are indicated by the plus and minus signs, the cathode potential being taken as zero.

In one particular circuit for use in a receiver covering the band of from 550 to 1500 kilocycles, L_1 had a value of 139 microhenries and L_2 was 453 microhenries, the coupling producing a mutual inductance M of about 105 microhenries. The tuning condensers C were sections of a 500 micromicrofarad gang condenser, and the condenser C_2 was adjustable from 120 to 220 micromicrofarads and consisted of a small trimming condenser of the type used in adjusting intermediate frequency transformers.

The oscillatory voltage may be introduced into the first detector stage by coupling to the detector circuit in any appropriate manner. As shown, a coil L_3 is coupled to the oscillator grid coil and included in the detector cathode circuit between the cathode and the bias resistor 11 which is shunted by condenser 12.

In general, the oscillator grid inductance L_1 is somewhat smaller than the inductances L of the tuned carrier circuits, an appropriate ratio of L_1 to L being about 0.83. As stated above, the trimming condenser C_0 of the oscillator is adjusted to obtain the desired tracking of the oscillator and carrier circuits at the high frequency end of the band, and the plate cathode capacity C_2 is adjusted for tracking at the low frequency end. It is to be noted that capacity C_2 is comparatively small and is provided by a single condenser, which is in contrast to the prior superheterodyne oscillator circuits employing a high series capacity which, to obtain the desired preliminary adjustment, usually consists of a fixed and variable condenser.

The oscillator has the special property of generating a voltage which is a function of the frequency, varying approximately inversely with the frequency. In Fig. 3, the curve A represents the variation, with carrier frequency, of the oscillatory voltage introduced into the cathode circuit of the first detector. Assuming that the carrier voltage input to the first detector remains constant over the frequency band, curve B shows the variation, with carrier frequency, of the translation gain in the first detector stage.

It will be noted that the translation gain is approximately proportional to the oscillator voltage, and increases with decreasing frequency. The significance of this is that the antenna input system may be designed for maximum efficiency as regards energy transfer and noise suppression. Such input systems exhibit a marked frequency variation of transmission and it has been customary to employ less efficient and/or more expensive circuit arrangements to secure a gain at the lower frequencies which was not substantially less than the gain at the high frequency end of the band. The present invention avoids this necessity for special input systems by automatically increasing the transmission gain in the first detector as the transmission gain of the antenna system decreases with decreasing frequency.

I claim:

1. A vacuum tube system comprising an oscillator tube having grid and plate electrodes cooperating with a cathode, a pair of inductively coupled coils wound in the same direction, the two adjacent terminals at one end of said pair of coils being connected respectively to the grid and plate, the other two adjacent coil ends each having a connection to the cathode, an adjustable condenser shunted across the grid coil, and means comprising a condenser connected between plate and cathode for effecting a reversal of the phase of the alternating voltages developed at the grid and plate terminals of the coupled coils.

2. A vacuum tube system comprising an oscillator having at least one grid and a plate in addition to a cathode, inductively coupled grid and plate coils wound in the same direction and similarly coupled to grid and plate, an adjustable condenser shunted across the grid coil, and capacity between plate and cathode resonating with the leakage inductance of the plate coil to effect a reversal of the phase of the grid and plate voltages.

3. A vacuum tube system comprising an oscillator having at least one grid and a plate in addition to a cathode, inductively coupled coils each having one terminal connected to the cathode by circuit elements which maintain the same at the potential of the cathode for the oscillation frequency, the two other terminals of said coils being connected respectively to said grid and plate, the sense of the inductive coupling between said coils being such as to give the said other terminals the same open-circuit polarity, and capacity connected across each of the respective coils and of such magnitude as to tune each coil individually to substantially different frequencies, whereby the phase of the voltage between the grid and cathode is made opposite to that between the plate and cathode.

4. In an oscillator system, the invention as claimed in claim 3, wherein one of said capacities is adjustable to vary the frequency of oscillation.

5. In an oscillator system, the invention as claimed in claim 3, wherein the capacity connected across one coil is of fixed value, and the other capacity is adjustable to vary the frequency of oscillation over a frequency range higher than the natural frequency to which said fixed value capacity tunes its associated coil.

6. In a radio transmission system, the combination with a tuned circuit including an inductance and an adjustable condenser, of a vacuum tube having a plate electrode and at least one grid electrode cooperating with a cathode, a tuned impedance network associated with said tube; said network comprising a pair of magnetically coupled inductances connected between the cathode and the respective electrodes, a tuning condenser connected across one of said coupled

inductances, said tuning condenser being substantially identical with said adjustable condenser and mechanically connected therewith for simultaneous adjustment of the said condensers, and fixed condensers shunted across each of said coupled inductances to establishes a frequency interval between the resonant frequencies of said tuned circuit and tuned network as said condensers are simultaneously adjusted.

7. In a superheterodyne receiver, the combination with a radio frequency circuit including an inductance shunted by one section of a gang tuning condenser, of an oscillator system adapted to resonate at a frequency spaced by a fixed interval from the resonant frequency of said radio frequency circuit as said tuning condenser is adjusted, said oscillator system comprising a vacuum tube having a plate electrode and at least one grid electrode cooperating with a cathode, magnetically coupled inductances connected between the cathode and the respective electrodes, a second section of said gang tuning condenser connected across one of said inductances, and a relatively fixed capacity connected across the other inductance.

8. In a superheterodyne receiver, the combination with a radio frequency circuit including an inductance shunted by one section of a gang tuning condenser, of an oscillator system adapted to resonate at a frequency spaced by a fixed interval from the resonant frequency of said radio frequency circuit as said tuning condenser is adjusted, said oscillator system comprising a vacuum tube having a plate electrode and at least one grid electrode cooperating with a cathode, magnetically coupled inductances connected between the cathode and the respective electrodes, a pair of inductively coupled coils wound in the same direction, the two adjacent terminals at one end of said coils being maintained at the oscillating potential of the cathode, the other terminals of said coils being connected to the respective plate and grid electrodes, circuit elements shunting a second section of said gang tuning condenser across the grid coil, and means comprising a fixed capacity connected between the plate electrode and cathode for effecting a reversal of the phase of the alternating voltages developed at the plate and grid terminals of the coupled coils.

9. In a superheterodyne receiver, the combination with a radio frequency circuit including an inductance shunted by one section of a gang tuning condenser, of an oscillator system adapted to resonate at a frequency spaced by a fixed interval from the resonant frequency of said radio frequency circuit as said tuning condenser is adjusted, said oscillator system comprising a vacuum tube having a plate electrode and at least one grid electrode cooperating with a cathode, a pair of coils each having one end maintained at the alternating potential of the cathode, the opposite ends of said coils being connected to the plate and grid electrodes respectively, coupling between said coils of such sense as to give the plate and grid terminals of said coils the same open-circuit polarity, circuit elements shunting a second section of said gang tuning condenser across the grid coil, means reversing the phase of the oscillating voltages developed at the plate and grid terminals of said coils, and means comprising a fixed capacity connected between the plate electrode and cathode for maintaining the oscillator frequency spaced from the resonant frequency of said radio frequency circuit by a fixed interval as said gang tuning condenser is adjusted.

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