Dec. 6, 1932. V. C. MACNABB 1,890,426

RADIO RECEIVING SYSTEM

Filed July 25, 1930 2 Sheets-Sheet 1

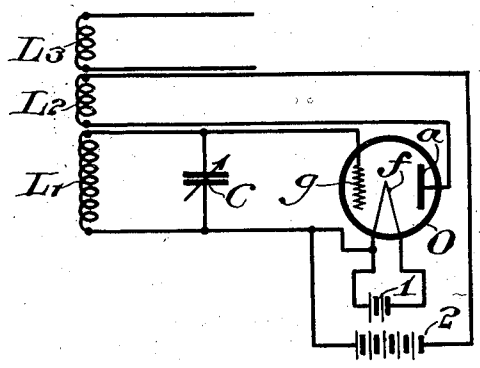


Fig. 1.

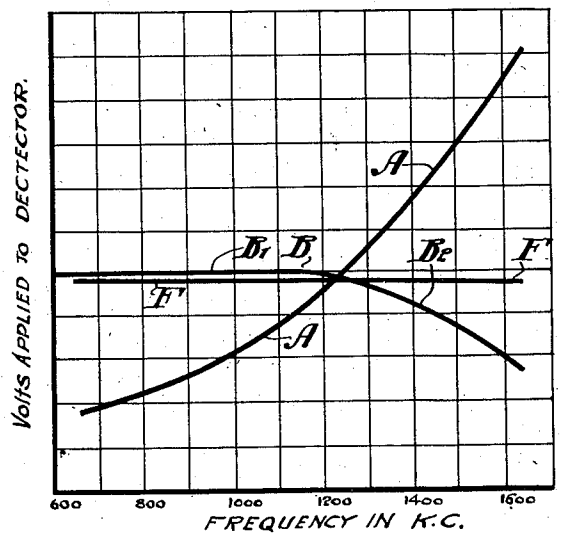


Fig. 2.

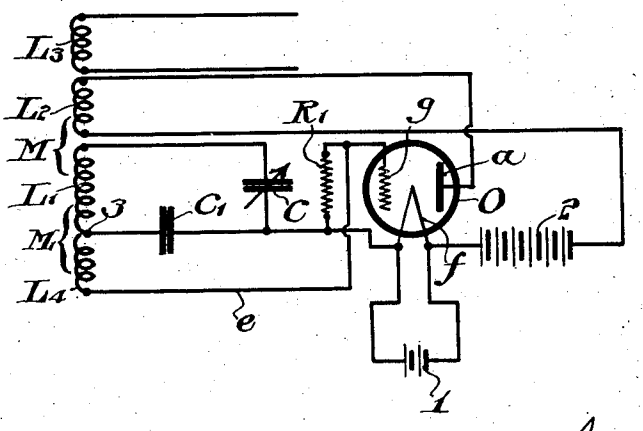


Fig. 3.

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RADIO RECEIVING SYSTEM

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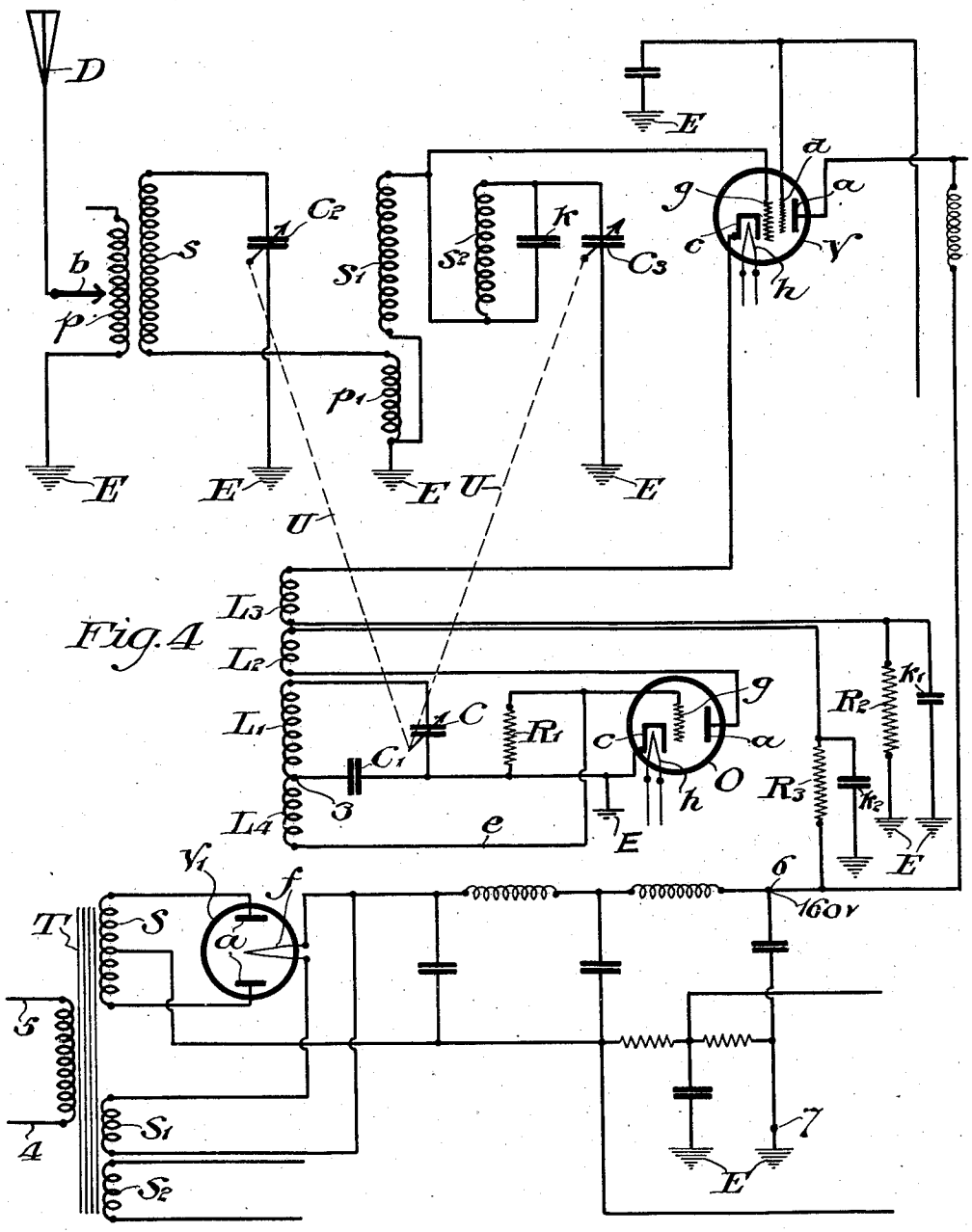


Fig. 4

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Patented Dec. 6, 1932 1,890,426

UNITED STATES PATENT OFFICE

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RADIO RECEIVING SYSTEM

Application filed July 25, 1930. Serial No. 470,557.

My invention relates to radio receiving systems in which beats are produced by interaction of locally produced oscillations with the oscillations representing the received signals; and more particularly, my invention relates to superheterodyne sets for reception of broadcast speech and music.

In accordance with my invention, in a vacuum tube oscillator, the input circuit, regeneratively magnetically coupled to the output circuit, comprises a loop circuit in which there are serially related an inductance, a variable frequency-determining condenser and another condenser, preferably of fixed capacity, across whose terminals are connected, through an inductance coupled to the aforesaid inductance, the input electrodes of the oscillator tube.

Further in accordance with my invention, in an oscillator system of the character aforesaid, a resistance is shunted across the serially connected fixed capacity and second inductance.

Further in accordance with my invention, in a heterodyne or superheterodyne receiving system a vacuum tube oscillator of the character referred to is utilized for producing oscillations superimposed upon the signal-representing oscillations; and more particularly, the locally generated oscillations are impressed upon or in advance of the input circuit of the detector of the receiving system, preferably through an inductive coupling whose effect of increasing the impressed voltage with increase of frequency of the oscillations is offset because in my oscillator system the amplitude of the locally produced oscillations decreases at uniform rate with increase of their frequency.

My invention resides in a system of the character hereinafter described and claimed.

For an understanding of my invention and for an illustration of some of the various embodiments thereof, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a diagrammatic illustration of the commonly used oscillator system;

Fig. 2 comprises curves or graphs illustrating the characteristics of a system generally illustrated by Fig. 1 and of my improved system;

Fig. 3 is a diagram of an oscillator system embodying my invention;

Fig. 4 is a diagram of a portion of a superheterodyne radio receiving system embodying my invention.

Referring to Fig. 1, O is a thermionic vacuum tube having control grid g, anode or plate a, and cathode or filament f maintained at suitable temperature by current from the source 1. In the grid or input circuit is an inductance L1, shunted by the variable condenser C, forming a tunable or resonant loop whose terminals are connected to the grid and cathode. In the plate circuit is the usual source 2 of plate circuit current and an inductance L2 coupled to L1. This system comprises magnetically coupled input and output systems, causing regeneration to the point of production of oscillations whose frequency is to substantial extent, but not substantially entirely, dependent upon the capacity of the variable condenser C. The frequency of the generated oscillations is to substantial extent dependent upon variations in plate circuit voltage, voltage of and current from the source 1, characteristics of the tube O, and other factors. Coupled to the inductance L1 is an inductance or coil L3 across whose terminals appears a voltage which may be impressed upon the input circuit of a heterodyne or superheterodyne system, and which increases rapidly as the condenser C is adjusted to smaller and smaller capacities to produce oscillations of higher and higher frequencies.

The curve A, Fig. 2, in a general way represents the voltage-frequency characteristic of such an oscillator. The voltage impressed upon the detector in such case rises rapidly with increasing frequency, and this is undesirable, particularly in superheterodyne reception.

In accordance with my invention, the vacuum tube oscillator is of the character illustrated in Fig. 3, in which the inductances or coils, L1, L2 and L3 are related to each other generally as described in Fig. 1. There is

the significant variation, however, in that in lieu of connecting the input electrodes *f* and *g* to the terminals of the resonant loop L1 C as in Fig. 1, there is included in the resonant loop an additional condenser C1, preferably of fixed capacity, across whose terminals the input electrodes are connected through a coil or inductance L4 coupled to the coil L1. The coils L1 and L4 may be considered as a single winding or coil, wound throughout in the same direction and tapped at the point 3. So arranged the coupling of coil L4 with coil L1 is in the proper sense for the preferred purposes of my invention. It will be understood that any equivalent arrangement of a coil coupled to L1 and in series with the condenser C1 across the input electrodes of the tube O, is contemplated.

If the coil L4 were omitted or not utilized, as by connecting the lead *e* directly to the point 3 or lower terminal of the coil L1, the condenser C1 of the resonant loop would alone be connected across the input terminals of the tube O. That arrangement is disclosed in Miller application, Serial No. 470,016, filed July 23, 1930. My system, Fig. 3, preferably embodies the relations, proportions and characteristics of the system, disclosed in said Miller application. My invention is an improvement over the system disclosed in that application, by inclusion in series with the condenser C1 of a coil, such as L4, suitably coupled to another coil of the system, and across whose terminals exists a difference of potential which coacts with the difference of potential across the terminals of the condenser C1, preferably in such way that the oscillatory current or amplitude of the oscillations produced so decreases with increase in their frequency that the voltage across the terminals of a secondary such as L3, coupled to L1, remains of substantially constant magnitude throughout the entire range of frequencies of the generated oscillations.

When the coil L4 is omitted, and the lead *e* connects directly to the point 3, the voltage across the secondary L3 remains of suitably constant magnitude throughout a considerable portion of the entire frequency range of the generated oscillations, as indicated by the portion B1 of the characteristic curve B, Fig. 2. With that arrangement, however, in the higher frequency portion of the range, the voltage across the terminals of the secondary L3 actually decreases with further increase of frequency, as indicated by the portion B2 of the curve B.

By utilizing the coil L4 or equivalent, the relation of voltage across the terminals of the secondary L3 to the frequency of the oscillations generated is practically linear throughout the entire frequency range as indicated by the characteristic curve F, Fig. 2.

My system will produce oscillations when

$$\frac{M\,Gm}{R\,C1} \pm \frac{Gm\,w^2\,M\,M1}{R}$$

is equal to or greater than unity; where M is the mutual inductance of the coupling between coils L1 and L2, Gm is the mutual conductance of the tube O, C1 is the capacity of the condenser C1, M1 is the mutual inductance of the coupling between the coils L1 and L4, w is 2π times the frequency, and R is the high or radio frequency resistance effectively in series in the resonant loop L1, C, C1. The resistance R is of maximum magnitude at the highest frequency of the generated oscillations and decreases with decreasing frequency.

The voltage impressed upon the grid and cathode of the tube O may be either the sum of or the difference between the voltage across the terminals of the condenser C1 and the voltage across the terminals of the coil L4, depending upon the sense of coupling of the coil L4 to the coil L1. With one sense of coupling the amplitude of the oscillations produced increases with increase of frequency, and with the opposite sense of coupling decreases with increase of frequency.

As indicated by the characteristic B of Fig. 2, in the case where the coil L4 is omitted, throughout the straight portion B1, the amplitude of the oscillations decreases with increase of frequency, and throughout the portion B2, for the higher frequencies of the range, the amplitude of the oscillations decreases at higher rate with increasing frequency.

For the range of frequencies corresponding with the portion B1, the extra winding or coil L4, with the preferred sense of coupling above described, is neither so effective nor so necessary as for that portion of the frequency range covered by the portion B2 of the characteristic of the circuit without the coil L4. Throughout the higher frequency portion of the range, the voltage across the terminals of the coil L4 becomes more and more effective, operating cumulatively with the voltage across the terminals of the condenser C1, and so affecting the decrease in amplitude of the oscillations, for that portion of the frequency range, that the voltage across the terminals of the secondary L3, also coupled to the coil L1, does not at such great rate decrease with increase of frequency, and the characteristic F for the entire frequency range becomes practically linear, with but small or insubstantial change of voltage across the secondary L3 with change of frequency.

When the sense of coupling of the coil L4 to the coil L1 is opposite to the preferred sense above referred to, the voltage across the terminals of the coil L3 would decrease rapidly with increase of frequency, particularly throughout the higher frequency portion of

the entire range, and more rapidly than indicated by the portion B2 of the characteristic for the system without the coil L4.

In addition, there may be advantageously utilized a resistance R1 bridged across the series combination C1 L4, in lieu of across the terminals of the condenser C1 only when the coil L4 is absent.

My novel oscillation producing system of the character described is of general application. It is especially suitable, however, for a system of the superheterodyne type for broadcast reception of speech and music. In such case the frequency of the oscillations produced may range from 680 to 1630 kilocycles for producing a beat or intermediate frequency of 130 kilocycles by interaction with the signal oscillations of broadcast frequency ranging from 550 to 1500 kilocycles.

Fig. 4 represents a portion of a superheterodyne receiving system embodying a local oscillator in accordance with my invention and of the character illustrated by Fig. 3.

In Fig. 4, D represents an antenna or other suitable absorption structure. In this case between the antenna D and earth E or ground, or equivalent counter capacity, or the metal chassis of a receiving set, is included the primary p to different taps on which connects the antenna switch b to suit the receiving system to antennas of different characteristics or lengths. Coupled to the primary p is the secondary s, in circuit with which is the primary $p1$. In shunt to s and $p1$ is the tuning condenser C2 for tuning the circuit to the frequency of the signal-representing oscillations. Coupled to the primary $p1$ is the secondary $s1$, in series with which is an inductance $s2$, both shunted or bridged by the condenser C3 variable to tune this cascaded circuit to the frequency of the signal representing oscillations. In shunt to the inductance $s2$ is a condenser K.

V is the first detector, of a superheterodyne system, having a control grid g, cathode c, maintained at suitable temperature by the electric heater h, and the plate or anode a, and shield or screen grid d. The control grid is connected to a point between the inductances $s1$ and $s2$, while the cathode is connected through the coil or secondary L3 and grid biasing resistance R2, shunted by condenser K1, to ground E, or other terminal of the loop tuned by the condenser C3.

To the output circuit of the detector V is coupled the input circuit of an intermediate frequency amplifier tube, with which may be cascaded one or more similar intermediate frequency amplifier tubes, the plate circuit of the last of which is coupled to the input of the second detector tube, whose output circuit is operatively related to a signal translating instrument, commonly a loud speaker, either directly or generally through one or more stages of audio frequency amplification. The intermediate frequency amplifiers, second detector, etc., are not illustrated, since that arrangement is well known.

The local oscillator O in this instance is provided with a cathode c, heated by the electric heater h. It will be understood, however, that the oscillator tube may have as its cathode a filament f as in Fig. 3. The parts of the oscillator are generally the same with the action and characteristics of a system such as illustrated by Fig. 3. The plate circuit is coupled by coil L2 to the coil L1 of the input circuit under conditions producing oscillations. The coil L3 in the detector input circuit is coupled with the inductance L1, to impress upon the detector V a voltage of radio frequency differing to fixed extent from the signal frequencies to which the condensers C2 and C3 tune their respective circuits. As indicated by the broken line U, the rotors or adjustable elements of the three condensers C, C2 and C3 are mechanically coupled in unison, so that as the cascaded circuits are tuned to the signal frequency, the condenser C is varied as to its capacity in such amount as to cause the frequency of the oscillations produced by generator O always to differ to fixed extent from the signal frequency, thereby yielding a constant beat or intermediate frequency.

In the example illustrated, for the power for heating the cathodes and supplying current to the plate circuits of the various tubes of the set, there is provided a transformer T whose primary is connected across the commercial alternating current lighting or power lines 4 and 5. The secondary S has its terminals connected to the anodes a of the rectifier tube V1 whose filament or cathode f receives its current from the secondary S1. The rectified current is passed through a filter system comprising a suitable arrangement of inductances and capacities, yielding at the terminals 6 and 7 a rectified filtered current delivered to the plate circuits of the tubes O, V, and of the other tubes of the system. Between the positive terminal 6 and the earth E, or terminal 7, may exist a difference of potential of 160 V., which may be the maximum utilized on the plate circuit of any of the tubes in the system. In the plate circuit of the oscillator O, in series with the coil L2, is a resistance R3, shunted by condenser K2, of suitable magnitude, say 10,000 ohms, which keeps the plate current of the tube O from rising to high magnitude, or regulates the plate current. The resistance R3 is of such magnitude that the effective voltage impressed upon the plate circuit of the tube O is of the order of, say 100 volts, the tube O being of the type now commonly known as UY 227 or C 327.

The secondary S2 of the transformer T supplies current for the heaters h, of the several tubes, for maintaining their cathodes at suitable temperature. In lieu of cathodes c,

filaments such as *f*, Fig. 3, may be utilized, in which case they receive their current from the secondary S2, or a secondary similar or in addition thereto.

By way of illustrative example of proportions suitable for my purposes, the coils L1, L2, L3 and L4 may have inductances of 190, 60, 3.8 and 9 microhenries, respectively. The mutual inductance M, between the coils L1 and L2, may be 55 microhenries; the mutual inductance between coils L1 and L3, 14.3 microhenries; and the mutual inductance M1, between the coils L1 and L4, 15 microhenries. The capacity of the condenser C may be varied from 50 to 400 micro-microfarads; the capacity of condenser C1 may be 1200 micro-microfarads; and resistance R1 of the order of 50,000 ohms. The plate voltage of the tube O may be from about 100 to about 110 volts. The capacities of the tuning condensers C2 and C3 may be variable from 50 to 400 micro-microfarads for tuning to signal frequencies ranging from 550 to 1500 kilocycles. The three variable condensers are adjustable in unison to effect a constant beat or intermediate frequency, which is possible because the frequency of the oscillations produced by the oscillator O is governed substantially solely by the capacity of the condenser C. The condensers C, C2 and C3 may comprise a gang condenser with, for example, the rotors upon a common shaft.

It is of great practical importance, in a superheterodyne system, as herein described, that the local oscillator system have the characteristics hereinbefore described, and in particular that the frequency of the locally generated oscillations shall be dependent substantially entirely upon or strictly related to the capacity of the variable condenser C. It is particularly desirable that the oscillator have this characteristic when utilized in a superheterodyne system provided with highly selective systems, one in advance of the first detector and tunable to the desired signal frequencies, and the other following the first detector and highly selective to the beat frequency. For this purpose it is of importance and highly desirable, particularly in a uni-control system, such as described, that the frequency of the oscillator always differs to substantially strictly the same extent throughout the range of desired signal frequencies, to yield a substantially strictly constant beat frequency to coact with and have full advantage of the highly selective intermediate frequency amplifier system.

What I claim is:

1. A generator of oscillations comprising a vacuum tube, a resonance loop comprising an inductance in series with serially connected capacities, one of said capacities being variable and having a maximum less than another of said capacities, means for coupling the output system of said tube to said inductance, and connections to the input electrodes of said tube from the terminals of said other capacity through an inductance coupled to said first named inductance.

2. A generator of oscillations comprising a vacuum tube, a resonance loop comprising an inductance in series with serially connected capacities, one of said capacities being variable and having a maximum less than another of said capacities, means for coupling the output system of said tube to said inductance, and connections to the input electrodes of said tube from the terminals of said other capacity through an inductance coupled to said first named inductance, the voltages across said other capacity and said last named inductance operating cumulatively to cause the amplitude of the generated oscillations to decrease substantially proportionately to increase of their frequency.

3. In a heterodyne receiver, a detector, means for impressing signal-representing oscillations on said detector, a local generator of oscillations comprising a vacuum tube, a loop in its input system comprising an inductance in series with serially related capacities, one of which is variable and whose maximum capacity is relatively smaller than another of said capacities, means for coupling the output system of said tube to said inductance, connections from the input electrodes of said tubes to the terminals of said other capacity through an inductance coupled to said first named inductance, and an inductance coupled to said first named inductance for impressing the locally generated oscillations upon said detector.

4. In a heterodyne receiver, a detector, a selector system in advance of said detector tunable to desired signal frequencies by at least one variable capacity, a local oscillator comprising a vacuum tube, a loop in the input system of said tube comprising an inductance in series with serially related capacities, one of which is variable and whose maximum capacity is relatively smaller than another of said capacities, all in series with each other, a connection from the terminals of said other capacity to the input electrodes of said tube through an inductance coupled to said first named inductance, means for coupling the output system of said tube to said inductance, an inductance coupled to said first named inductance for impressing a voltage upon said detector, and means for adjusting said variable capacities in unison to cause the frequencies of the locally generated oscillations to differ to fixed extent from said signal frequencies.

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