Nov. 26, 1935. J. K. JOHNSON 2,022,085

RADIORECEIVER

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Fig. 1

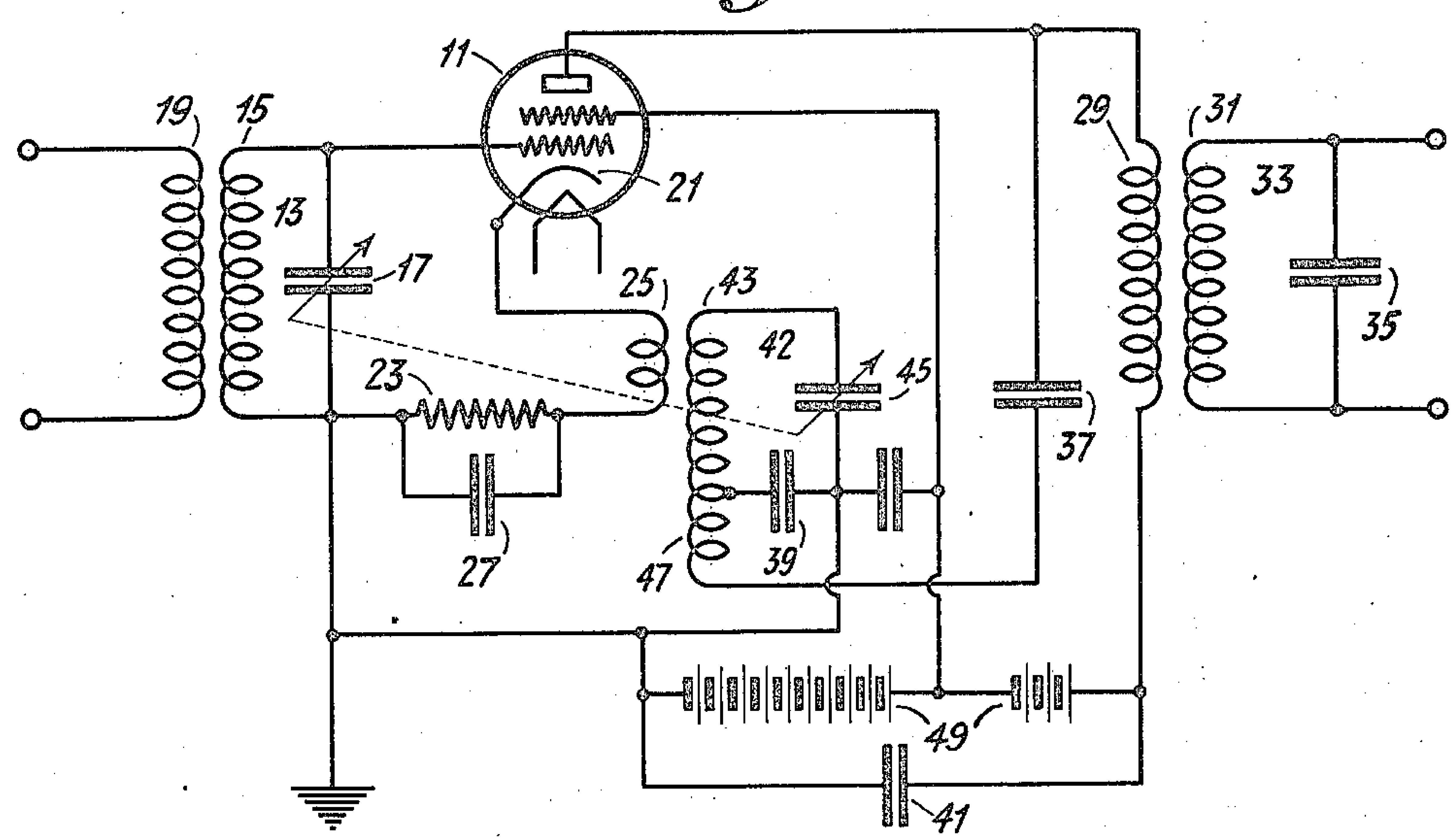

Fig. 2

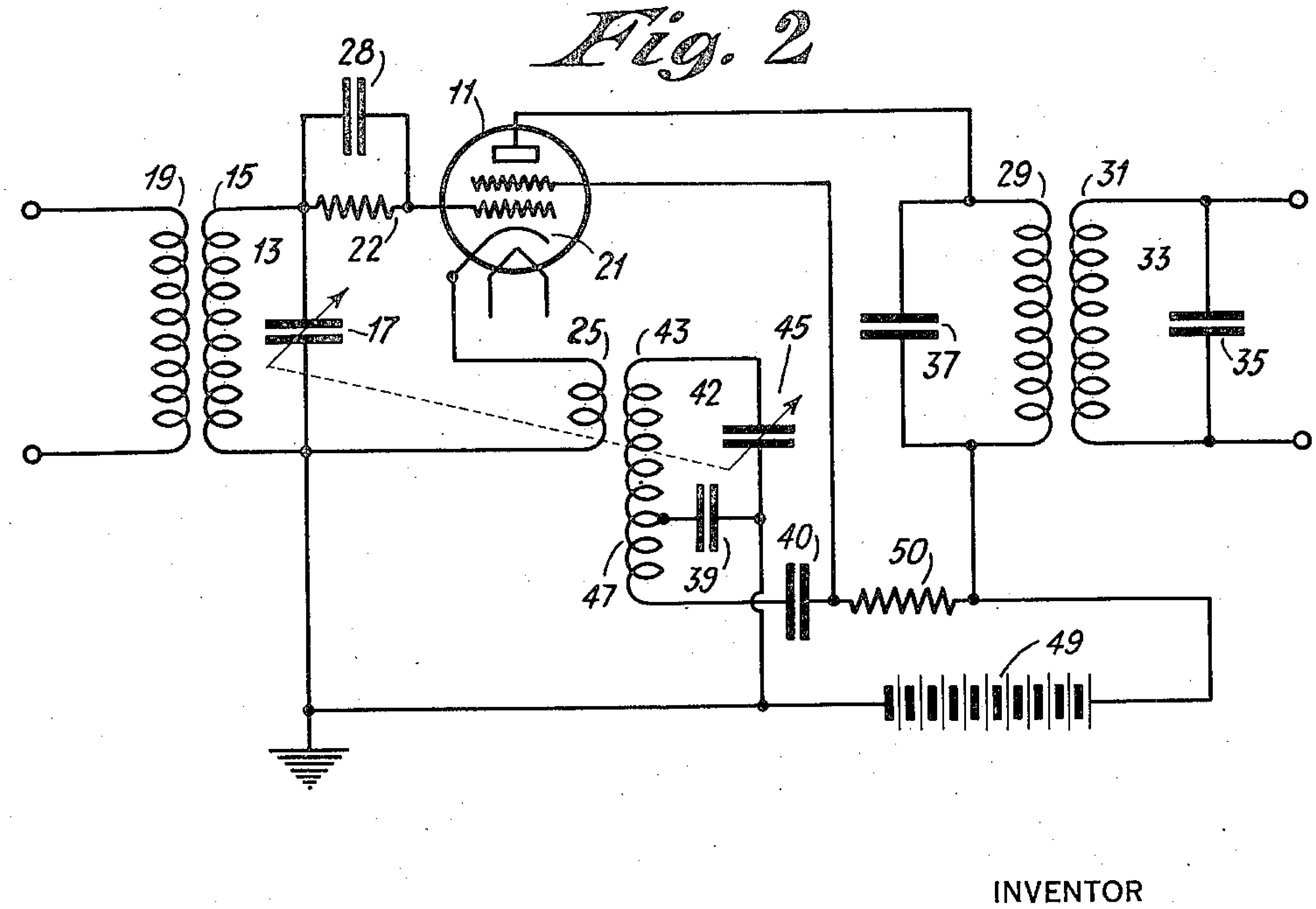

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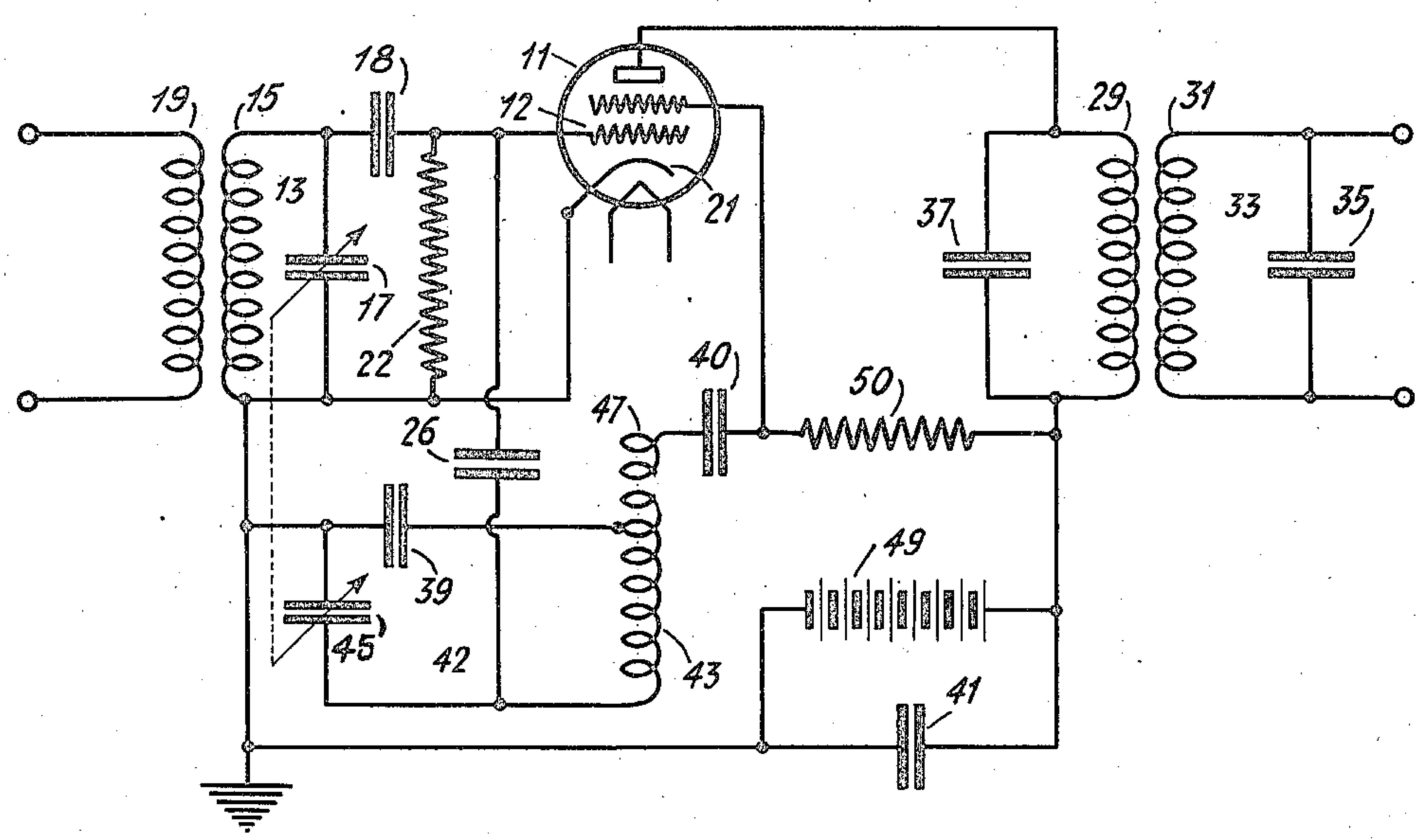
Fig. 3



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RADIORECEIVER

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2 Claims. (Cl. 250—20)

The present invention relates to an oscillator modulator, or, more particularly, to oscillator modulators for use in connection with superheterodyne radio receivers.

In a superheterodyne receiver the signal or carrier frequency is converted into a fixed intermediate frequency which may be amplified readily by specially designed amplifiers with practically uniform results regardless of the frequency of the received signal. It is the usual practice to beat or modulate the incoming frequency signal currents with a locally produced current of a frequency differing from the frequency of the received signals by a fixed amount. This frequency difference is the frequency of the intermediate-frequency currents to which the intermediate-frequency amplifiers are adapted to respond.

It has been proposed to use a single thermionic tube for the purposes of producing the locally generated oscillations and modulating the incoming signal currents. However, as the frequency to which the receiver and oscillator circuits are tuned varies through a broad band, it is difficult to produce an oscillator modulator which will have a sufficient output at all points within its tuning range and not have an output at some other points in the range which will result in overloading the grid circuit and causing the grid to draw current, the effect of which is to reduce the selectivity of the radio-frequency input circuit, and cause cross modulation between the desired and strong interfering signals.

It is the principal object of the present invention to produce an oscillator-modulator arrangement which will permit a substantially uniform translation gain to be obtained throughout the entire tuning range.

It is a supplementary object of this invention to produce an oscillator-modulator circuit in which the grid circuit of the modulator shall be free from overloading at any point in the tuning range to prevent loss of selectivity and other overloading effects.

It is another object of the present invention to produce an oscillator-modulator arrangement which shall maintain a substantially uniform translation gain and substantially uniform selectivity throughout the tuning range by providing a uniform feed-back arrangement so that the oscillation voltage will remain substantially constant throughout the entire frequency range or may be controlled to be limited to a predetermined amount.

These and further objects of the present invention will become apparent from the following specification when considered in connection with the accompanying drawings.

In accomplishing the objects of the present invention, the oscillator modulator is provided with a uniform output oscillation circuit so that the voltage impressed upon the grid circuit by the oscillation circuit will be substantially uniform throughout the tuning range of the oscillator. In other words, the uniform output type oscillator permits the oscillator output voltage to be limited to such a value that it does not overload the tube and it is possible therefore to utilize it as an efficient detector.

A uniform feed-back between an output electrode of the oscillator modulator tube is obtained by combining electromagnetic and electrostatic couplings in the proper phase so that an increase in the electromagnetic coupling as the frequency of oscillations is increased, is offset by a decrease in the electrostatic coupling, and vice versa. The capacitive coupling is obtained by a fixed condenser constituting a portion of the oscillation circuit. This fixed condenser has the dual function of assisting the alignment of the oscillator circuit with the input radio-frequency circuit to permit uni-control of these two circuits by the same control element, as will be explained more fully hereinafter.

The coupling between the oscillator circuit and the grid circuit of the oscillator tube is so adjusted that the maximum voltage on the grid of the tube, caused by the combination of the oscillator voltage and the received signal voltage, will be insufficient to cause the grid to draw current. Preferably, the feed-back coil of the grid circuit is located in the common plate and grid circuits, which will be referred to hereinafter as a cathode circuit, which circuit may also include a self-biasing resistor for maintaining the proper bias on the grid relative to the cathode.

The feed-back to the oscillation circuit may be obtained from either the plate or a screen-grid electrode.

Alternatively, the oscillator circuit may be coupled to the grid of the oscillator-modulator device, which may be isolated from the tuned input circuit by a stopping condenser. In this event, a grid-leak is provided to the cathode lead. This arrangement minimizes the effect of the grid voltage upon the tuned circuit, and the coupling may be so adjusted that, when considered in connection with the substantially uniform output of the oscillator circuit, the grid voltage will normally never reach such a value as to overload the circuit.

Attention is now invited to the drawings, in which:

Fig. 1 is a diagram illustrating a preferred embodiment of the present invention;

Fig. 2 is a modification of Fig. 1 in which a screen-grid-cathode feed-back is utilized, and

Fig. 3 is a second alternative arrangement employing a screen-grid feed-back system.

Referring now more particularly to Fig. 1, a thermionic oscillator tube 11 is connected, as shown, to the tuned input circuit 13, including inductance 15 and variable condenser 17. The inductance 15 may be inductively coupled to the inductance 19, which may be the output inductance of a radio-frequency amplifying stage or the antenna inductance of the receiver. The tuned grid circuit 13 is connected to the cathode 21 of the tube 11 through the resistor 23 and the cathode inductance 25. A capacity 27 is shunted around the resistor 23 for by-passing the high-frequency currents.

The output circuit of the tube 11 comprises an output inductance 29, which is inductively related to the inductance 31, included in the circuit 33, which latter circuit is tuned by means of condenser 35 to be resonant to the intermediate frequency produced by the combining of the locally produced oscillations and the incoming signals by the modulator tube 11. This circuit may be connected to an intermediate-frequency amplifier tube, which is not shown. The output circuit is tuned by means of adjustable condensers 37 and 39, which are connected in series across the inductance 29 and condenser 41. This circuit also is made resonant to the intermediate frequency.

The oscillator circuit 42 includes the inductance 43, the condenser 39, and the variable condenser 45. The inductance 43 is inductively related to the cathode inductance 25 for supplying the oscillation voltage to the input circuit of tube 11. The oscillation circuit is coupled to the output circuit by means of the dual coupling provided between the inductance 47, included in said circuit, and the inductance 43, and the capacity 39, which is common to both the output and oscillation circuits.

For supplying the high potential voltages, there is provided the usual battery 49 connected to the plate of tube 11 through the inductance 29. The battery 49 is by-passed, as shown, by condenser 41. The screen-grid of the tube 11 is connected to an intermediate point in the battery 49 for supplying the proper screen potential to the tube. The specific details of this portion of the circuit, however, constitute no part of the present invention.

The signal input circuit 13 and the oscillation circuit 42 are tuned simultaneously by a unicontrol arrangement of condensers 17 and 45. These tuned circuits are designed to have resonant frequencies differing by an amount substantially equal to the intermediate frequency. The oscillator frequency is preferably the higher. The two tuning condensers 17 and 45 generally have the same capacity variation. The oscillator frequency is made higher by making the coil 43 of lower inductance than coil 15. With this change alone the frequency difference would vary in proportion to the resonant frequency of the signal input circuit. Therefore, the difference at higher signal frequencies is decreased by making the effective minimum capacity of condenser 45 and its associated circuits slightly greater than that of condenser 17 and its associated circuits. Likewise, the difference at lower signal frequencies is increased by inserting the fixed condenser 39 in series with the condenser 45. By proper choice of the oscillator elements 45, 39 and 43 relative to the signal circuit 13, the frequency difference may be made exactly equal to the intermediate frequency at three points in the tuning range. This is called the alignment of signal and oscillation circuits to secure the intermediate-frequency difference.

Padding condensers may be provided in parallel with any or all of the condensers 17, 45 and 39, as required.

The operation of this circuit is as follows: The input circuit 13 is tuned to the incoming signal frequency and impresses upon the grid of the tube 11 a potential, varying relative to the potential of the cathode 21. The self-biasing resistor 23 maintains the proper bias upon the grid relative to the cathode to cause the tube 11 to act as a modulator or detector. The voltages impressed upon the grid cause a fluctuation in the plate current flowing through the output inductance 29 and a corresponding variation in the voltage and current through the circuit including the condensers 37, 39 and 41 and the inductance 47.

The inductance 47 is inductively related to inductance 43, and an oscillation current is set up in the oscillation circuit 42. The frequency of this oscillation current is adjusted by the condenser 45. The feedback voltage introduced into the oscillation circuit 42 from the output of tube 11, due to the electromagnetic coupling between inductances 43 and 47, decreases with a decrease in the frequency to which the circuit 42 is tuned, but the feed-back voltage introduced into circuit 42 by the condenser 39 increases with a decrease in frequency. These two couplings between the output of tube 11 and oscillation circuit 42 are in aiding phase and are so proportioned, by adjusting the turns in the winding of coil 47 and the coupling between coils 43 and 47, that such a resultant feedback obtains throughout the tuning range of the oscillation circuit that the output voltage across coil 25 is substantially uniform. It is to be noted that the sizes of inductance 43 and condenser 39 are predetermined by the requirement that the circuit 42 oscillate at a frequency differing by a constant amount from the frequency to which circuit 13 is adjusted to respond as the condensers, which preferably have similar characteristics, are simultaneously varied. The oscillation voltage produced in this circuit is impressed upon the cathode circuit by coil 25 and results in a potential variation between the grid and cathode at the oscillation frequency. This produces variations of the plate current which are fed back to the oscillation circuit as described above.

The cathode resistor 23 in the fore-mentioned figure being in a circuit common to the plate and grid circuits, effects a regulating action upon the tube 11. In other words, when the plate current tends to become undesirably large, the bias produced by the flow of the plate current through the resistor 23 serves to make the grid more negative relative to the cathode 21, which cuts down the plate current.

The turns in inductance 25 and its coupling to coil 43 are so adjusted that the sum of the voltages impressed upon the grid relative to the cathode, due to oscillator action and due to a normal incoming signal, shall not cause the grid to swing far enough in the positive direction to draw grid current. If the grid draws current, the tube 11 would then act as a resistance short-circuiting and thus dulling the tuning of the circuit 13.

The coupling between 43 and 25 is preferably so regulated that the maximum translation gain for normal applied signal intensities may be obtained in the tube 11 and its associated circuits throughout the entire range of frequencies to which the circuit may be tuned.

Attention is now invited to Fig. 2, in which like parts are designated by the same reference numerals. This circuit is similar to that of Fig. 1 except for the fact that the screen-grid is coupled to the oscillatory circuit through the condenser 40, the mutual capacity 39, and the mutual inductance of coils 47 and 43. Also, the grid circuit includes a grid-leak 22 shunted by a grid-leak condenser 28 for the purpose of permitting grid detection. The output inductance 29 is tuned by the adjustable condenser 37 so that the output circuit responds to the intermediate frequency.

The operation of this circuit is similar to that of Fig. 1. However, the control of the grid current to prevent overloading is solely dependent upon the uniform coupling between the screen-grid circuit and the oscillation circuit 42 and the coupling between the inductances 25 and 43. It is to be noted that, in this embodiment, the plate circuit is used for output purposes only, as the screen-grid supplies the feed-back.

Attention is now invited to Fig. 3, which resembles Fig. 2 in that the feed-back to the oscillation circuit is from the screen-grid. In this figure, in which like parts are designated by similar reference characters, the tube 11 has its grid 12 isolated from the tuned circuit 13 by means of the condenser 18. The screen-grid is coupled to the oscillation circuit 42 through the condenser 40, mutual inductance between coil 47 and coil 43, and condenser 39 to ground. The screen-grid potential is supplied through the isolating resistor 50, which is connected to the high potential end of the battery 49. The oscillation voltages are impressed upon the grid circuit of the tube 11 through the condenser 26, which is connected directly to the grid 12. The proper grid bias is maintained by means of the grid-leak resistor 22 connected to the cathode 21.

The operation of this circuit is similar to that of both Figs. 1 and 2. However, there is no regulating action by the cathode resistor 23 as shown in Fig. 1, and the proper operation of the circuit is produced by means of the uniform gain feed-back to the oscillation circuit, which is similar to that of Figs. 1 and 2, and by the proper choice of the condenser 26 and grid-leak 22. By the proper selection of these two elements, the grid 12 is prevented from going positive to the point where it would draw sufficient grid current to seriously affect selectivity, and the limiting of the oscillator voltage which can be impressed upon the grid 12 permits a uniformly high transfer gain to be obtained in the tube 11 relative to the received signal frequency. The condensers 17 and 45 of circuits 13 and 42, respectively, are connected for uni-control operation, as shown.

Whereas a screen-grid tube has been shown in each of the figures illustrating the present invention, it is to be understood that an ordinary three-electrode tube or any other suitable tube may be substituted for that shown.

Although many suitable characteristics for the various elements constituting the various circuits may be found, there are given below, for example, a number of characteristics of the various elements of the circuit shown in Fig. 1, designed to give an intermediate frequency of 175 kilocycles which characteristics have been found very satisfactory in operation. These characteristics are not to be construed as a limitation of the scope of the invention, and are given merely for the purpose of illustration.

Inductance 25 equals 17.5 μh.

Inductance 43 equals 195 μh.

Inductance 47 equals 106 μh.

Coefficient of coupling between 25 and 47 equals 48%.

Coefficient of coupling between 43 and 47 equals 71%.

Capacity of condenser 27 equals 1500 $\mu\mu$f.

Resistor 23 equals 10,000 ohms.

Condenser 39 equals 732 $\mu\mu$f.

Maximum capacity of condensers 17 and 45 about 350 $\mu\mu$f.

With these constants, a type UY-224 tube was used, and a substantially constant translation gain was obtained covering the entire broadcast band.

It is to be understood that whereas the oscillator modulator embodying this invention is primarily for the purpose of superheterodyne radio receivers in which the grid circuit is coupled to the input of a radio receiver or the output of a radio-frequency amplifier tube and the plate circuit of the oscillator modulator is coupled to an intermediate-frequency tuned circuit, the oscillator modulator described may be utilized in any other suitable connection, and its use, therefore, in a superheterodyne is not to be construed as a limitation of the invention.

Furthermore, whereas the above-noted improvements have been found especially useful in radio-frequency circuits, it is to be understood that the principles involved are equally applicable for use in connection with vacuum-tube circuits operating at any desired frequency. Also, the principles involved may be useful in connection with heterodyne, self-heterodyne or autodyne methods of receiving radio-frequency signals in which the oscillator modulator produces an audio beat. Similarly, the elements constituting the present invention may be utilized in connection with a homodyne or zero beat receiver. Oscillators of this type may be readily synchronized when tuned approximately to a master oscillator or to a harmonic of a master oscillator.

What is claimed is:

1. In an oscillator-modulator circuit, a tube, an oscillation circuit coupled to an output electrode of said tube, a tuned grid circuit for said device, tuned to input frequency currents, a connection between said oscillation circuit and said grid circuit to permit the modulation of the input frequency currents by the oscillatory frequency currents, and a stopping condenser and grid-leak connected between said grid circuit and the grid of said tube to prevent the effect of the oscillations produced by said oscillation circuit raising the grid voltage to the point where the grid will draw current sufficient to seriously impair the selectivity of the tuned input circuit.

2. In a superheterodyne, an oscillator-modulator circuit, including a thermionic tube having input and output electrodes, a tuned input circuit

coupled to one of said input electrodes, an oscillation circuit coupled to one of said output electrodes, a condenser for tuning each of said circuits, connected for simultaneous operation, a series condenser in said oscillation circuit for permitting a substantially constant difference frequency between the frequencies to which said input and oscillation circuits are tuned, a duel coupling between said thermionic device and said oscillation circuit including said last-mentioned condenser, and an inductive coupling device, said couplings being so arranged that the voltage produced by said oscillation circuit will be substantially constant throughout its range of frequencies, and a grid-leak and a condenser connected between said tuned input circuit and the input electrode of said thermionic device to prevent the increase of voltage caused by the combining of the current produced by said oscillation circuit and the input current from causing the grid to draw current sufficient to impair seriously the selectivity of the tuned input circuit.

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