

Nov. 2, 1937.

N. M. RUST

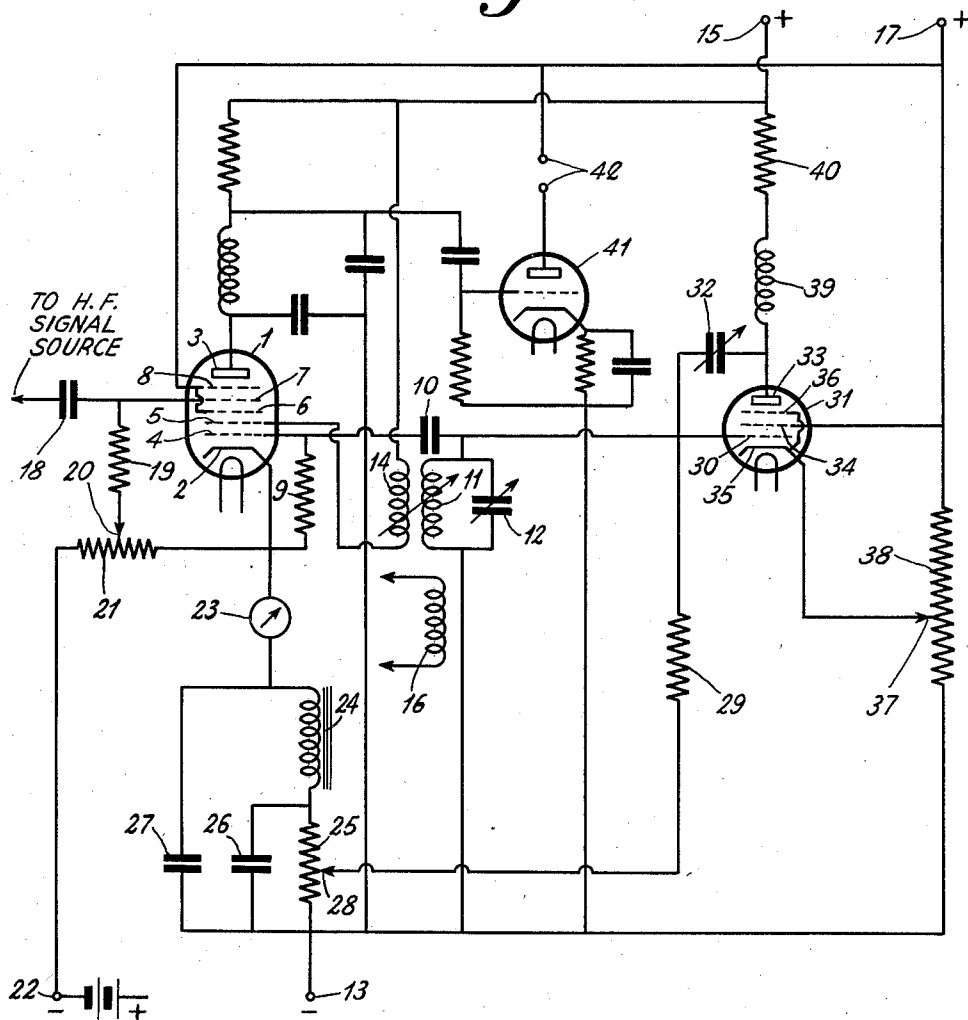
2,097,937

HIGH FREQUENCY OSCILLATING CIRCUIT

Filed Oct. 8, 1935

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Fig. 1



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Fig. 2

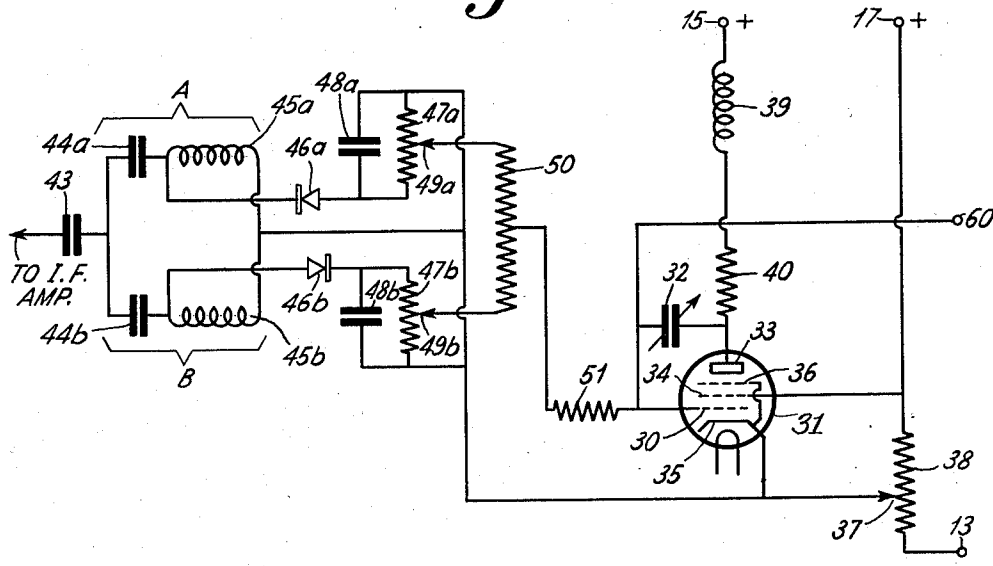
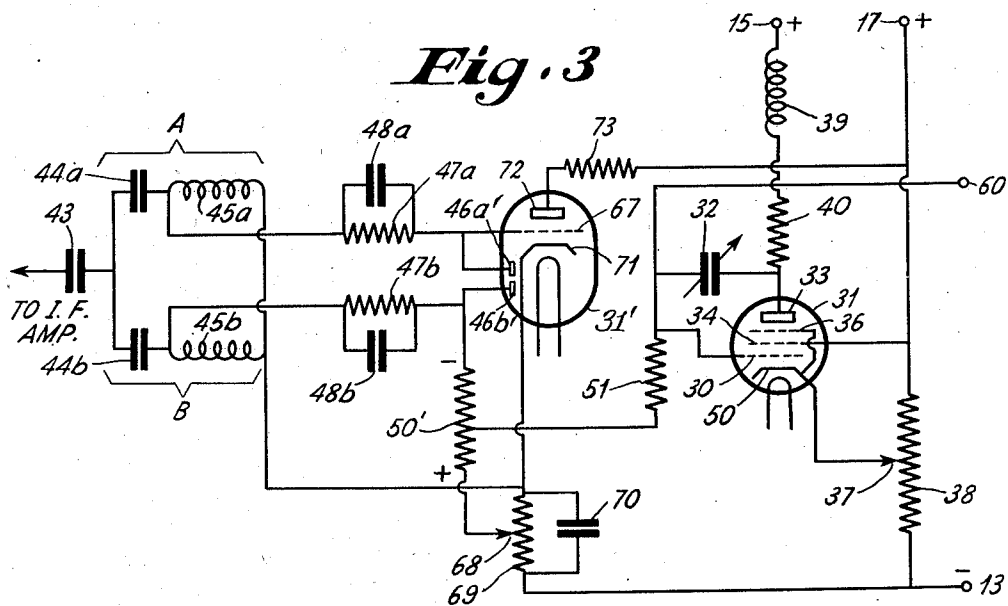


Fig. 3



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HIGH FREQUENCY OSCILLATING CIRCUIT

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1 Claim. (Cl. 250—20)

This invention relates to electrical high frequency oscillating circuit arrangements and has for its object to provide improved means whereby the tuning or natural frequency of a high frequency electrical oscillating circuit may be automatically varied in dependence upon departures from predetermined desired results in such manner as to correct for such departures.

The principal applications of the invention are

- (1) to so-called "homodyne" receivers, i. e. receivers wherein a received modulated carrier wave is mixed with a locally generated carrier wave of like frequency for reception purposes, and
- (2) to what are sometimes termed "self-tuning"

receivers, i. e. receivers wherein a tuning instrumentality is caused automatically to be varied in such manner as to maintain the receiver accurately tuned to a desired signal even if said signal "drifts" i. e. varies slightly, in frequency.

The invention is based upon the fact that by virtue of so-called Miller effect the space between the electrodes of an electron discharge device may be arranged to present a substantially pure reactance of a magnitude which can be varied by varying the operating constants of the device, and in carrying out this invention a reactance so presented is utilized as a variable reactance in a high frequency tuned circuit to be automatically controlled; the operating constants of said device being varied in dependence upon departures from results desired to be obtained, such variations being such as to produce variations in tuning in a sense to compensate for the departures.

The invention is illustrated in the accompanying drawings which show diagrammatically different embodiments thereof. Fig. 1 shows a homodyne circuit embodying the invention; Fig. 2 shows a portion of a superheterodyne receiver embodying the invention in an oscillator frequency control circuit; Fig. 3 illustrates a modification of Fig. 2.

Referring to Figure 1 which shows one arrangement in accordance with the invention as applied to a so-called homodyne receiver the local oscillator of the said receiver in the particular embodiment illustrated includes certain of the electrodes of a so-called heptode valve 1, i. e. a valve having a cathode 2, an anode 3 and five grids 4, 5, 6, 7, 8, in succession between cathode and anode. In the description which follows valve grids will, for the sake of brevity, be described in reference to their order as counted from the cathode; for example, the first grid is the grid 4 nearest the cathode, the second grid is the next grid 5 and so on. The first grid 4

is connected to the cathode 2 through a leak resistance 9 and is also connected through a coupling condenser 10 and a parallel tuned circuit consisting of an inductance 11 shunted by a variable condenser 12 to the negative terminal 13 of the anode potential source (not shown). The second grid 5 is connected through a coil 14 which is adjustably coupled to the coil 11 to a source of positive potential (not shown) connected at 15, the cathode 2 and the first and second grids 4 and 5 accordingly constituting the electrode system of a local oscillator which is utilized as the local oscillator of a homodyne receiver. A third coil 16 coupled to the coil 11 is utilized to take off local oscillatory energy to the homodyne detector (not shown). The third and fifth grids 6, 8, are connected together and to a suitable source of positive potential connected at 17. The fourth grid 7 is coupled through a coupling condenser 18 to a point (not shown) of the receiver from which received high frequency signal voltage (for "locking" purposes) is obtainable, the said grid 7 being also connected through a resistance 19 to a variable tapping point 20 upon a potentiometer resistance 21 one end of which is connected to the negative terminal 22 of a suitable bias source and the other end of which is connected to the cathode 2. The said cathode is connected through a milliammeter 23 in series with a choke 24 and a second potentiometer resistance 25 to the terminal 13. The potentiometer resistance 25 is shunted by a condenser 26 and a second condenser 27 is shunted across the series connected choke 24 and resistance 25 the said choke and two condensers constituting a low pass filter across which is effectively shunted the resistance 25. An adjustable tapping point 28 upon the resistance 25 is connected through a further resistance 29 to the control grid 30 of a valve 31 which is utilized as a variable reactance device, the grid 30 being also connected directly to the junction point between the parallel tuned circuit 11, 12 and the condenser 10.

In the embodiment illustrated a pentode valve is utilized as the variable reactance device and the control grid 30 is connected to the anode 33 thereof through a variable condenser 32 which serves to increase the anode-grid capacity of the valve and which can be varied to adjust the value of the apparent input reactance of the valve 31.

The second grid 34 of the valve 31 receives positive bias from any convenient source (as shown it is connected to terminal 17) and the cathode 35 of the valve 31 is connected as in

the usual way to the third grid 36 thereof and also to an adjustable tapping point 37 on a resistance 38 shunted between the positive and negative terminals 17 and 13 respectively. The anode 33 of the valve 31 is connected through a choke 39 and resistance 40 in series to a suitable source of anode potential (as shown it is connected to terminal 15). The low pass filter above referred to is of such design as only to pass frequencies below the lowest modulation frequency expected to be present and desired to be received.

Now it will be appreciated that with this arrangement the grid cathode circuit 30-35 of the valve 31 is effectively in shunt across the parallel tuned circuit 11, 12, in the circuit of the first grid 4 of the heptode, and accordingly, the capacitive reactance presented by the control grid circuit of the valve 31 will form a small condenser in shunt across the normal condenser of the said tuned circuit.

The low pass filter will pass on to the second potentiometer 25, 28 (from which potential for the control grid of the valve 31 is obtained) either slow beats due to the interaction between the local oscillations and "locking" signal oscillations or—if the local oscillator is operating accurately at signal frequency—a resultant direct current depending for its magnitude upon the relative phase between the local oscillations and the "locking" signal oscillations. This resultant—slow beats or direct current—will be indicated by the milliammeter 23 and because of the fact that a desired proportion of the said resultant is fed to the control grid 30 of valve 31, it is possible so to adjust the apparatus that the tuning of the local oscillator will be automatically varied so as to maintain it automatically substantially at the same frequency as the received "locking" signal frequency and in a predetermined phase relationship therewith. In other words, the arrangement effectively interlocks the local oscillation frequency with received signal oscillation frequency. It is found in practice possible so to make the adjustments as to secure any relative phase relationship required between local oscillations and received signal oscillations, such adjustments being made either by varying the position of the tapping point 28 or by manually adjusting the frequency of the parallel tuned circuit 11, 12. Where the received signals are weak the adjustments become more delicate and it is found better to move the slider 28 in such direction as to give maximum controlling action upon the pentode and then to adjust the tuning of the parallel tuned circuit 11, 12.

An important advantage of the above described arrangement is to be found in the fact that not only is an easily adjustable and satisfactory locking action obtained between received signal oscillations and local oscillations, but the local oscillations are only very weakly if at all modulated by modulation energy from the received signals, and this, of course, is of considerable importance in homodyne receivers. The plate circuit of the heptode may be used for any purpose—for example it may be connected to an arrangement for indicating beats so as to facilitate adjustment of the circuit. In Figure 1 such an arrangement is illustrated, and comprises a valve 41 coupled as shown to the plate circuit of the heptode and giving an indicating output which may be taken from terminals 42.

Figure 2 shows another embodiment of the invention as applied to a superheterodyne re-

ceiver wherein self-tuning is resorted to. Here a point (not shown) in the intermediate frequency amplifier of the receiver and from which intermediate frequency voltage is obtainable, is coupled through a condenser 43 to one end of a two-branch tuned circuit, the branches being designated A and B. Branch A consists of a capacity 44a in series with an inductance 45a, and branch B which is in parallel with branch A likewise comprises series elements 44b and 45b. The two branch circuit is tuned as a whole to the operating intermediate frequency, but one branch is arranged to be an acceptor circuit for a frequency above the operating intermediate frequency and the other to be an acceptor circuit for a frequency a corresponding amount below the intermediate frequency. For example, if the intermediate frequency is 100 kilocycles one branch may be tuned to 110 kilocycles and the other to 90 kilocycles. The junction of the inductance 45a and the capacity 44a in branch A is connected through a rectifier 46a—for example a copper oxide rectifier in series with a condenser shunted resistance combination 47a 48a—to that end of the two branch circuit remote from the coupling condenser 43, and in a similar manner the junction point of inductance 45b with capacity 44b is connected through a second rectifier 46b and a second capacity shunted resistance combination 47b 48b to the same end of the two branch circuit. Adjustable tapping points 49a and 49b upon the resistance 47a 47b respectively, are connected together through a further resistance 50, and the mid-point of this further resistance is connected through a still further resistance 51 to the first grid 30 of a valve 31 which is again a pentode and which acts as a variable reactance device. The rectifiers are connected in opposite sense so that one of the two adjustable tapping points 49a or 49b will be positive and the other negative as a result of uni-directional currents obtained from rectification. The end of the two branch circuit remote from the intermediate frequency amplifier is connected to an adjustable tapping point 37 upon the potentiometer resistance 38, which as in the previously described embodiment is shunted between the negative and positive terminals 13, 17, respectively, of a source of potential (not shown); the positive terminal of this source being connected to the second grid 34 of the pentode and the tapping point 37 being connected to the cathode 35 of the pentode. The cathode 35 is also connected as in the usual way to the third or suppressor grid 36 of the pentode. The anode 33 of the pentode is, as before, connected through a resistance 40 in series with a choke 39 to the positive terminal 15 of a source of anode potential and a variable condenser 32 is connected between the control grid 30 and the anode 33. The control grid-cathode space of the valve 31 is connected by means of terminals 13, 60, across the normally provided coil (not shown) in the adjustable frequency determining circuit of the local oscillator of the receiver.

In practice the local oscillator is manually adjusted as in the usual way, so as to beat with received signals to produce as nearly as possible the desired operating intermediate frequency, but in a circuit as just described, owing to the interconnection of the pentode with the local oscillator of the receiver, if this manual adjustment is not accurately made, or if the received signal "drifts" somewhat in frequency, the local oscillator tuning will be automatically varied in such manner

as to produce the correct operating intermediate frequency. In this connection it will be appreciated that so long as the intermediate frequency is accurately obtained at the point from which it is taken off to the two branch circuit, the potentials set up by the two rectifiers will be equal and the bias upon the first grid of the pentode will not be changed. If, however, either by reason of faulty manual tuning or by reason of drift in the received signal frequency, the proper beat frequency is not obtained, the bias upon the pentode will be changed and this change will produce a variation in the effective reactance in the frequency determining circuit of the local oscillator in such direction as to rectify the fault. In this way the action of the signal itself is utilized to correct for frequency drift or for tuning inaccuracies. Accordingly, the invention enables a relatively narrow band pass intermediate frequency amplifier to be employed since accurate local oscillator tuning is automatically obtained, while furthermore, in receivers having automatic gain control the tuning indicator means usually deemed necessary to assist accurate manual tuning, can be omitted.

The last described embodiment is satisfactory so long as a normal fairly low intermediate or beat frequency is employed e. g. an intermediate frequency of the order of 100 kilocycles, but where very high beat frequencies are employed copper oxide rectifiers are not satisfactory and the modification illustrated in Figure 3 is preferably employed. In this figure, in which parts corresponding to like parts in Figure 2 are indicated by like characters, a two branch circuit is used as before and, also as before, one branch is tuned slightly above and the other slightly below the operating beat frequency which is now presumed to be of a high value of, for example, 2,000,000 cycles per second. For 2,000,000 cycles per second one branch might be tuned to 2,020,000 cycles and the other to 1,980,000 cycles. One end of this two-branch circuit is, as before, connected through a coupling condenser to the beat frequency amplifier; and the other end is connected to the cathode of a double diode triode 31'. A point between the inductance and capacity in one branch of the two-branch circuit is connected through a capacity shunted resistance combination 47a 48a to one diode anode 46a' of the double-diode-triode tube 31'—this anode 46a' is also connected to the grid 67 of the double-diode-triode—while a corresponding point on the other branch of the two-branch circuit is connected through a capacity shunted resistance combination 47b 48b to the second diode anode 46b', this second diode anode being connected through a resistance 50' to an

adjustable tapping point 68 upon a further capacity shunted resistance combination 69, 70, which is in series between the cathode 71 of the double-diode-triode and the negative terminal 13 of an anode potential source. The anode 72 of the double-diode-triode is connected through a resistance 73 to the positive terminal 17 of the source of anode potential, and the mid-point of the resistance 50' is connected through a further resistance 51 to the control grid 30 of the valve 31 which acts as a variable reactance valve. The cathode 50 of this valve is connected as before to an adjustable tapping point 37 upon a resistance 38 shunted between the terminals 13, 17, the remaining connections being similar to those of Figure 2.

The invention is not limited to its application to heterodyne receivers and the principles embodied in the self-tuning super-heterodyne receivers described are applicable in like manner to securing self-tuning action against slight inaccuracies of tuning or slight signal frequency "drifts" in other types of receivers—for example, receivers embodying ordinary radio frequency tuned amplifiers.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

In a superheterodyne receiver of the type provided with an intermediate frequency energy circuit and a tunable local oscillator circuit whose frequency is to be automatically controlled, the improvement which consists of a network comprising a pair of resonant circuits, each resonant circuit including a rectifier, means for impressing the intermediate frequency energy upon said resonant circuits, one of the resonant circuits being tuned to a frequency differing from the intermediate frequency by a predetermined frequency value, the other resonant circuit being tuned to a frequency differing from the intermediate frequency by the same frequency value but in an opposite direction, an electron discharge tube, means, responsive to the current flow in one of said rectifier circuits, for varying the space current flow of said tube, an impedance in the space current circuit of said tube, and tube means connected to said impedance and the second of said rectifier circuits, and whose gain is responsive to direct current voltage developed across said impedance by the space current flow therethrough and the current flow in said second rectifier circuit, for providing a reactance of variable magnitude.

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