Nov. 3, 1936. F. H. DRAKE 2,059,321

HETERODYNE RECEIVER

Filed May 3, 1935

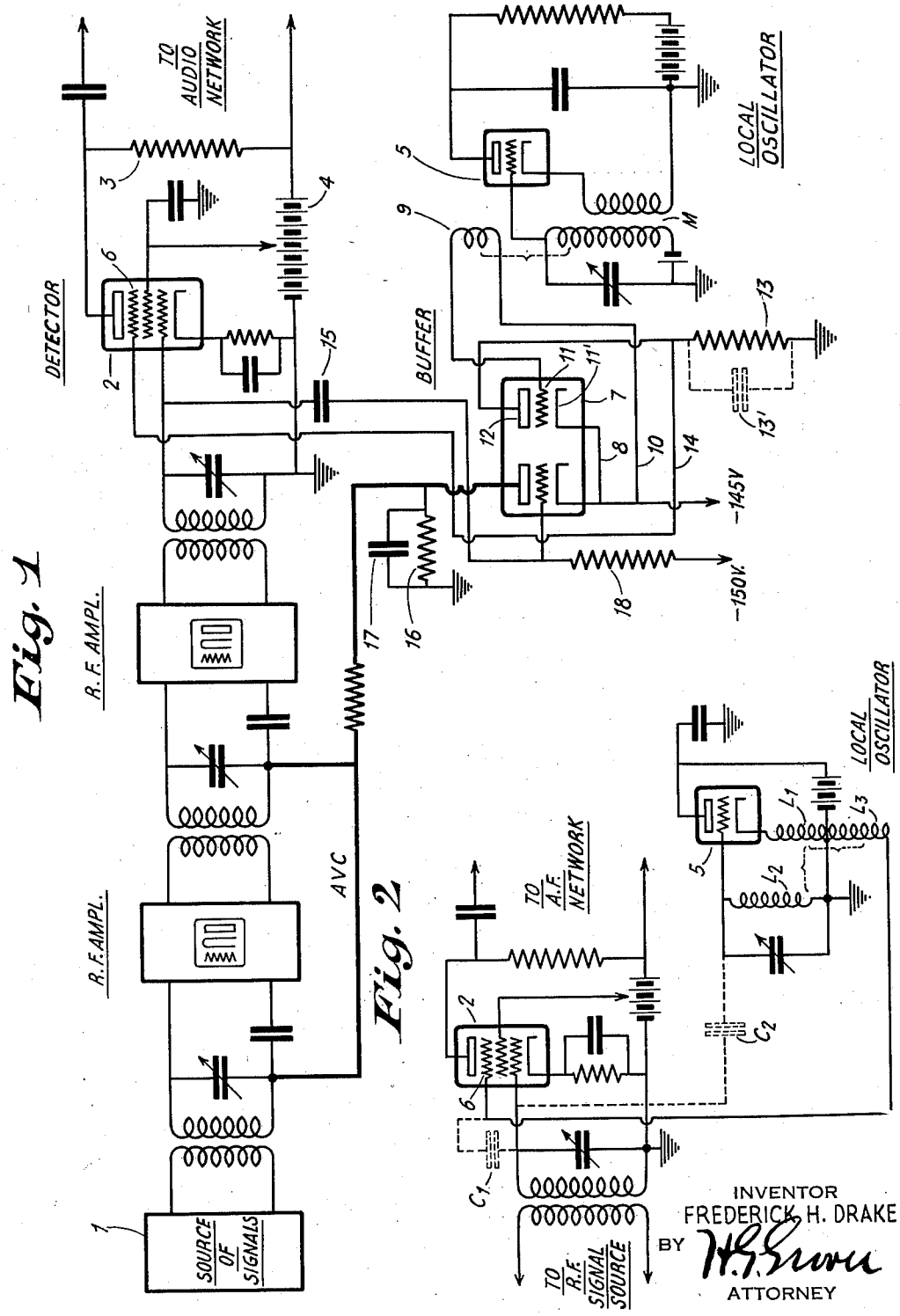


Fig. 1

Fig. 2

INVENTOR
FREDERICK H. DRAKE
BY H. H. Drake
ATTORNEY

Patented Nov. 3, 1936 2,059,321

UNITED STATES PATENT OFFICE

2,059,321

HETERODYNE RECEIVER

Frederick H. Drake, Boonton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application May 3, 1935, Serial No. 19,575

5 Claims. (Cl. 250—8)

My present invention relates to heterodyne receiving systems, and more particularly to heterodyne receivers of the audible beat type.

There are various factors which must be considered in the design of heterodyne receiving systems of the audible beat type. As is well known, such a receiving system usually employs in addition to amplifiers operating at super-audible frequency, and an audio amplifying system, a detector which has impressed thereupon locally produced oscillations. The frequency of the latter oscillations differ from the desired signal frequency by a beat note in the audible frequency range. In the utilization of such a receiving system it is not only desired that the beat note be produced with maximum loudness and with minimum use of tubes, but, also, with minimum of regenerative reaction in the heterodyning circuits in order to prevent the production of spurious whistles. Another operating defect which commonly occurs in receiving systems of this type may be termed "locking", or "sucking-in", of the oscillator frequency by the signal frequency. Such "sucking-in" action arises because the signal frequency draws the oscillator frequency into synchronization with itself. When it is remembered that the two frequencies are very close to each other, and only differ by a frequency of the order of a tone such as 1000 cycles, it is readily appreciated why such synchronization action is undesired. This "locking" action manifests itself chiefly by a ragged note above a certain audio frequency limit. Below this limit the note disappears. The more the "sucking-in" the higher the minimum audio beat frequency which can be heard. If this action is too bad, it may be impossible to hear a beat as low as 1000 cycles.

Accordingly, it may be stated that it is one of the primary objects of the present invention to provide a heterodyne receiving system of the audible beat type which not only effectively prevents the "sucking-in" action of the impressed signal on the local oscillator, but also results in the production of an audible beat with high gain and with a minimum of apparatus, the method utilized in the present invention briefly involving the impression of the locally produced oscillations upon the suppressor grid of the receiver detector through a "buffer" amplifier.

Another important object of the invention is to provide a heterodyne receiving system which includes, in addition to a detector, a super-audible frequency amplifier, the system further including a local oscillator, and the detector being of the pentode type, the locally produced oscillations being impressed upon the suppressor grid through an electron discharge amplifier functioning as a buffer stage, while the signals are impressed upon the signal grid of the detector, the receiving system further including an automatic volume control tube whose electrodes are disposed in the same tube envelope as the electrodes of the buffer amplifier.

Another object of the present invention may be stated to involve a coupling arrangement between the suppressor grid of a pentode tube detector and a local oscillator, the coupling being designed to permit the balancing out of the suppressor grid to signal control grid capacity existing in the detector tube.

Still other objects of the invention are to improve generally the efficiency of heterodyne receivers, and more especially to provide an improved heterodyne receiving system of the audible beat type which is not only reliable and efficient in operation, but readily and economically constructed.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:—

Fig. 1 diagrammatically shows a heterodyne receiving system embodying the present invention,

Fig. 2 shows the detector and local oscillator circuits of a heterodyne receiving system embodying a modification of the invention.

Referring now to the accompanying drawing, wherein like reference characters in the two figures designate similar circuit elements, it will be noted that there is shown in Fig. 1 a heterodyne receiving system whose networks, in general, follow a conventional pattern. The numeral 1 designates a source of signals, and this source may be the usual grounded antenna circuit, a loop antenna, an airplane antenna, or any other device for collecting radiated C. W. signals. The detector tube 2 which is a pentode tube of the 77 type, has its signal input electrodes coupled to the source of signals 1 through an amplifier network. The amplifier network operates at super-audible frequency, and may comprise one, or more stages of amplification. The input circuits

of the super-audible frequency amplifiers, which are designated as "R. F. amplifiers" and the detector have their input circuits tuned. The various tuning condensers of the receiving system are to be uni-controlled; such uni-control devices are well known to those skilled in the art.

The detector tube 2 includes in its anode circuit a load resistor 3, and the beat voltage developed across resistor 3 is impressed upon an audio network (not shown). The latter may comprise one, or more, stages of amplification followed by a reproducer of any desired type. The desired signal energy is impressed between the signal control grid and cathode of the tube 2, and the cathode circuit of the tube includes the usual grid bias resistor-shunt condenser network. The screen grid electrode of the tube is connected to a desired point of positive potential on the B voltage supply source 4, the screen grid circuit being by-passed to ground through a radio frequency by-pass condenser.

The local oscillator of the receiving system comprises an electron discharge tube 5 which is of the 85 type. It will be recognized that the oscillator involves a purely conventional circuit arrangement, and for this reason it is not believed necessary to describe the elements thereof. It is believed sufficient to point out that the tuning condenser thereof tunes the local oscillator network to a frequency differing from the signal frequency by a frequency of the beat note which is desired. The local oscillator network produces local oscillations by virtue of the regenerative coupling M between the cathode circuit of tube 5 and the tuned grid circuit thereof. The locally produced oscillations are impressed upon the suppressor grid 6 of the pentode tube 2. However, they are not directly impressed upon the suppressor grid, but are transmitted thereto through the agency of a buffer amplifier. This is done in order to prevent "sucking-in" action of the impressed signal frequency on the oscillator frequency.

The electrodes of the buffer tube are housed within the envelope 7 of a tube of the 79 type. Such a tube is well known to those skilled in the art at the present time, and comprises a pair of independent triodes disposed within a common tube envelope. The cathodes of the two triode systems are connected together, as by means of lead 8, and are at a common potential. The grid 11 of the buffer triode of tube 7 is connected to the cathode 11' thereof through a path which includes coil 9, the latter being magnetically coupled to the tuned grid circuit of the local oscillator, and lead 10. The output electrode 12 of the buffer triode is connected to ground through a resistor 13. The suppressor grid 6 of detector tube 2 is connected to the anode side of resistor 13 through a lead 14.

The remaining triode system of tube 7 functions as an automatic amplification control tube, and the grid thereof is connected to the signal input grid of detector tube 2 through a condenser 15 which passes signals to the first named grid. The plate, or output electrode, of the second triode system is connected to ground through a resistor 16, the latter being by-passed for radio frequencies by condenser 17, and a gain control connection, designated "AVC", is connected between the plate side of resistor 16 and the signal grid circuits of the super-audible amplifiers whose amplification is to be regulated in response to variations in amplitude of incoming signals. The sensitivity of these gain-controlled amplifiers is a maximum for weak signal reception, and, as the received signal amplitude increases, the function of the automatic gain control triode and its associated circuit is to reduce the sensitivity, or gain, of each of the super-audible amplifiers.

By way of illustration, it is shown that the common cathode lead of tube 7 is connected to a point which is at —145 volts with respect to ground, whereas the signal input grid of the automatic gain control triode section of tube 7 is connected to a point at —150 volts with respect to ground through resistor 18. It will be understood that the usual common voltage supply bleeder resistor may be used for the circuits of tube 7.

It will now be observed that the locally produced oscillations are impressed upon the input electrodes of the buffer triode section of tube 7, and that the output of the buffer section is impressed upon the suppressor grid of the detector tube 2. The resistor 13 is used as the impedance in the plate circuit of the buffer stage to provide substantially equal amplification at the various frequency ranges of the receiver. If this resistance 13 is given a value of between 750 to 1000 ohms the effect of the varying capacity reactance 13', shown in dotted lines, in parallel with it will be relatively slight, and approximately as much voltage will be available in the plate as is applied to the grid 11. The AVC triode section of tube 7 is capable of functioning during the operation of the buffer section; the electrodes of the two sections are disposed within a common tube envelope and this is a very desirable form of construction since it enables the designer to dispense with separate tubes for these two functions.

An additional advantage of the arrangement shown in Fig. 1 resides in the fact that there is provided a method of giving negative bias to the suppressor grid 6 of the detector tube 2 conveniently, the bias increasing the suppressor modulation of the detector. In other words the buffer stage, and its impedance in the plate circuit thereof, not only functions to prevent the "sucking-in" action of the impressed signal on the oscillator when the heterodyning voltage is introduced on the detector, but it also functions to provide the suppressor grid bias which increases the efficiency of suppressor modulation action in the detector tube. The arrangement disclosed results in much less "sucking-in" action over all frequency ranges when the stray capacity couplings across the structure of the tube 7 do not produce too much voltage on the control grid of the AVC section of tube 7, and hence the detector. The buffer section of tube 7 may employ a screen grid between plate 12 and grid 11 to improve the action of the invention.

With efficient shielding in the tube 7, or rather shielding between the "metal cap" electrode (this electrode being the signal input grid of the AVC triode section) and the other tube elements, this arrangement functions in a satisfactory manner. Although for a multi-range frequency receiver the value of resistance 13 is chosen so low that practically no amplification is obtained, the "sucking-in" action is almost entirely eliminated. Of course, those skilled in the art are fully acquainted with the manner of providing the switching arrangements to have the receiving system shown functioning in more than one frequency range, and it is to be clearly understood that the present invention is readily applicable to such type of multi-range receiver.

In Fig. 2 there is shown a novel alternative

method of reducing the "sucking-in" action. In this method the local oscillator network, which includes tube 5, is coupled to the suppressor grid of the detector tube 2. The purpose of this arrangement is to permit balancing out the small suppressor grid to signal control grid capacity which exists in the electrode structure of tube 2. This inter-electrode capacity is designated in dotted lines, and is represented by the symbol C_1. The capacity C_1 may be balanced out provided the stray capacity between the local oscillator grid and the signal input grid of tube 2 is properly proportioned. This stray capacity is shown in dotted lines, and is designated by the symbol C_2. A balance of these capacity effects can be secured if the ratio of coupling between coils L_2 and L_3 to the inductance of coil L_2 is made equal to the ratio of the capacity C_1 to the capacity of C_2.

It will be noted that the oscillator network in Fig. 2 provides local oscillations by means of the regenerative coupling between the coils L_2 and L_1. The coil L_3 may be a portion of the coil section L_1, and coil L_3 is magnetically coupled to coil L_2. If the magnitude of the inter-electrode capacity C_1 is as low as 0.15 micromicrofarad the balancing arrangement shown in Fig. 2 can be dispensed with, since by proper choice of biases enough heterodyne action can be developed through the suppressor, in the absence of any such balance, without producing more than about 0.3 volt (R. F.) on the detector signal control grid.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination with a detector tube of the pentode type, the latter including a suppressor grid disposed between the output electrode thereof and a positive screen electrode, means for impressing desired signals upon the input electrodes of the detector tube, a separate vacuum tube oscillator for producing local oscillations differing in frequency from the signal frequency by an audible frequency, a path coupled between said local oscillation means and the suppressor grid of said detector tube for impressing the locally produced oscillations upon said suppressor grid, said path including an electron discharge tube having its input electrodes coupled to said oscillator, and its output circuit conductively connected to said suppressor grid.

2. In combination with a detector tube of the pentode type, the latter including a suppressor grid disposed between the output electrodes thereof and a positive screen electrode, means for impressing desired signals upon the input electrodes of the detector tube, a separate vacuum tube oscillator for producing local oscillations differing in frequency from the signal frequency by an audible frequency, a path coupled between said local oscillator and the suppressor grid of said detector tube for impressing the locally produced oscillations upon said suppressor grid, said path including an electron discharge device having an impedance in its space current path, the input electrodes of said device being coupled to said oscillator, and a direct current connection connecting the suppressor grid of the detector tube to one side of said impedance.

3. In combination with a detector tube including at least a cathode, signal grid and a suppressor grid disposed between the output electrodes thereof and a positive screen electrode, means for impressing desired signals upon the signal grid of the detector tube, means for maintaining said signal grid at a substantially constant negative bias voltage with reference to said cathode, means for producing local oscillations differing in frequency from the signal frequency by an audible frequency, a path coupled between said local oscillation means and the suppressor grid of said detector tube for impressing the locally produced oscillations upon said suppressor grid, said signal impressing means including at least one stage of signal amplification, means for automatically regulating the degree of amplification of the latter in accordance with the strength of the desired signals, and said path and last named means including electron discharge devices whose electrodes are disposed within a common tube envelope.

4. In combination with a signal detector of the pentode tube type, a local oscillator including a tube provided with regeneratively coupled input and output circuits, said pentode tube including a spurious capacity coupling between the signal input grid and suppressor grid thereof, a coil connected to said suppressor grid, and means coupled to said detector and local oscillator for balancing out the effect of said spurious coupling, said balancing means comprising properly proportioned stray capacity coupling between the signal control grid of the detector tube and local oscillator grid, and magnetic coupling between the oscillator input circuit and said coil connected to the detector suppressor grid.

5. In combination with a detector tube of the pentode type including a suppressor grid disposed between the output electrodes thereof, and a positive screen electrode, means for impressing desired signals on the input electrodes of said tube, a separate vacuum tube oscillator for producing local oscillations differing in frequency from the signal frequency by an audible frequency, a path coupled between said local oscillator and said suppressor grid for impressing the locally produced oscillations upon said suppressor grid, said path comprising a vacuum tube having a cathode, control grid and plate, an input circuit connecting said control grid and cathode, means coupling said input circuit to said oscillator tube source, a resistor connected to said plate and in the space current path of said tube, and a direct current connection between the low potential end of said resistor and said suppressor grid.

FREDERICK H. DRAKE.