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# CROSS REFERENCE

EXAMINEE

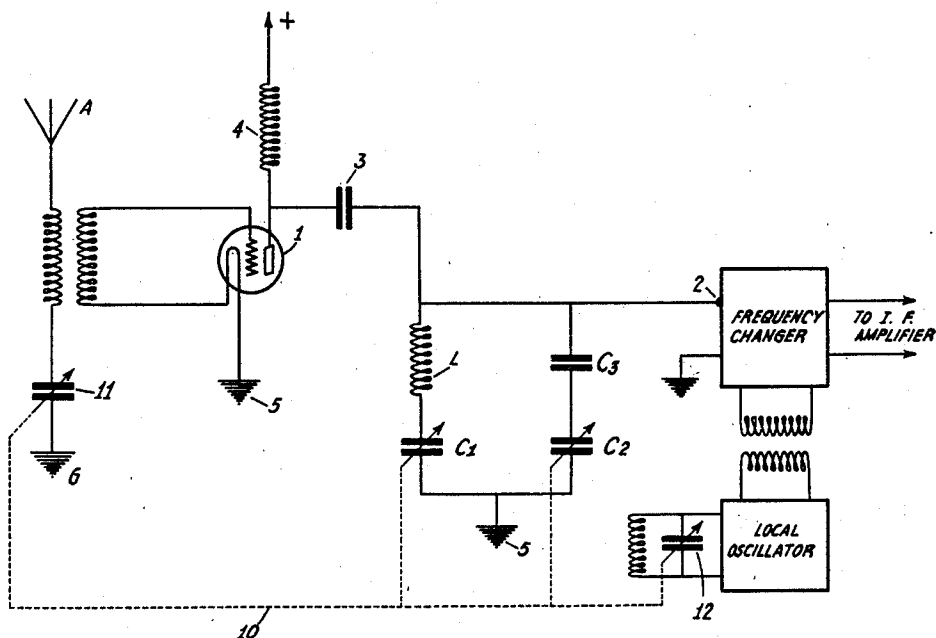
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H. CHIREIX

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HETERODYNE RECEIVER

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INVENTOR  
HENRI CHIREIX  
BY *H. B. Brown*  
ATTORNEY

## UNITED STATES PATENT OFFICE

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## HETERODYNE RECEIVER

Henri Chireix, Paris, France, assignor to Compagnie Generale de Telegraphie Sans Fil, a corporation of France

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7 Claims. (Cl. 250—20)

The present invention relates to improvements in receiver apparatus based upon the heterodyne principle, and more particularly to superheterodyne receivers.

One of the serious inconveniences associated with frequency change receivers, or heterodyne receivers, resides in the interference to which they may lead, and is known as "second beat" or "image frequencies". For instance, if the local oscillator is regulated to a frequency of about 1000 kilocycles, and if the intermediate frequency is chosen to be 50 kilocycles, the receiver is able to receive signal frequencies of 1050 and of 950. It is only by means of tuning to the desired signal frequency that it is possible to rid reception of the undesirable "image" wave. Such attenuation, or suppression, however, is often inadequate, and the object of the present invention is to remedy this condition while preserving the uni-control, or regulation with one knob or dial, if this is desired, with the attendant advantages.

The present invention consists essentially in causing the current having the frequency to be received, prior to the change in frequency or beat action, to flow through a special tuned circuit having a cut-off frequency whose value varies with the regulation of the resonance frequency so as to differ a constant value from the resonance frequency.

Further objects of this invention are to provide various means and ways of carrying the invention into practice, and more particularly means adapting the same to uni-control systems. The invention will be more clearly understood by the following description and by reference to the accompanying drawing.

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 one arrangement whereby my invention may be carried into effect.

The illustration shows a circuit including a multi-electrode tube provided below the point where a frequency change, or the heterodyning action, is to take place, this tube, for instance, coupling the antenna circuit with the heterodyne circuit.  $C_1$ ,  $C_2$ ,  $C_3$  and  $L$  constitute elements included in a complex circuit inserted in the plate circuit of the tube 1. The potential to be fed to the stage next above is derived between points 2 and 5 (or at a point of zero radio frequency potential, such as the ground, or casing of the apparatus, feed source, etc.), while 3 and 4 represent the coupling condenser and the choke coil respectively usually provided, the coil 4 being

connected to the anode potential source (not shown).

With the variable condensers  $C_1$  and  $C_2$  being mechanically united, for instance by having the rotors mounted upon a common spindle 10, the essential feature of the invention consists in insuring at the same time the tuning of the circuit  $LC_1$  to the signal image frequency to be eliminated, and the tuning of the entire circuit assembly to the desired signal frequency. It follows from the disposition of the various elements that the frequency to be eliminated will be the lowest wave-length, in the present instance of 950 kilocycles. The desired result will be attained if the difference of the tuning frequencies will be maintained constant and equal to twice the intermediate frequency that has been chosen.

A simple examination of the diagram will make it clear that by virtue of this arrangement the elimination of the second beat will be very effective, the overvoltage of the circuit being equal to the second power. It is easy to demonstrate that these conditions are satisfied in the following manner. The fixed capacity is so proportioned as to insure resonance with inductance  $L$  to the difference in frequency to be realized, and there must moreover be fulfilled the following condition:

$$C_3 = \frac{1}{2\sqrt{C_2 C_1}} = \sqrt{\frac{C_2}{2}} \sqrt{\frac{1}{C_1}} \quad 30$$

In other words, the capacity of the variable condenser  $C_2$  should vary with the square of the capacity of the variable condenser  $C_1$  or else in a particular instance, if

$$\sqrt{C_1}$$

satisfies a linear law ("square-law" condenser so-called, or of linear variation of wave length)  $C_2$  is a simple condenser based upon a linear variation of the capacity.

Supposing that  $\omega_2$  and  $\omega_1$  are the two pulsations to be received and to be discarded, there will be:

$$\omega_2 - \omega_1 = \frac{1}{\sqrt{L}} \left( \sqrt{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} - \sqrt{\frac{1}{C_1}} \right) \quad 45$$

and on the other hand since  $C_3$  has been chosen as a consequence

$$\omega_2 - \omega_1 = \frac{1}{\sqrt{L}} \frac{1}{\sqrt{C_3}} \quad 50$$

By "identifying" we get

$$\sqrt{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} = \sqrt{\frac{1}{C_3}} + \sqrt{\frac{1}{C_1}} \quad 55$$

Raising to the second power and by simplification the relation before referred to is obtained.

It is to be understood that the variation of  $C_1$  as a function of the angle of rotation may obey any desired law at all, with the law of variation

of  $C_2$  being then well defined; but the square-law contour or profile for  $C_1$  is particularly advantageous.

A heterodyne receiver embodying the basic idea of this invention, for example, could comprise four variable condensers seated upon one and the same spindle, to wit:

(1) the condenser 11 adapted to insure tuning of the antenna circuit A, G to wave  $\omega_2$  to be received; (2) condenser  $C_1$  regulating the tuning of the shunt circuit  $LC_1$  to wave  $\omega_1$  to be eliminated; (3) condenser  $C_2$  which while being associated with condenser  $C_1$  and to the fixed condenser  $C_3$  regulates the anti-resonant circuit to wave  $\omega_2$  to be received; and (4) the condenser 12 insuring the local generator, or the heterodyne, to the mean pulsation

$$\frac{\omega_1 + \omega_2}{2}$$

The cross-sectional shape, or contour, of the condenser (1) and (4) before enumerated may be the same as that of  $C_1$  provided that there are used on condensers (1) and (4) means consisting essentially in the addition to the variable condenser of two fixed condensers, one thereof being small compared with its minimum value and in parallel therewith, and the other large compared with its maximum capacity and arranged in series.

An example may be cited in order to make conditions clearer. Suppose that the intermediate frequency is fixed at 50 kilocycles, and that the range to be received is between 500 and 1500 kilocycles. The condenser  $C_1$  associated with the inductance L should cover the range between 400 and 1400 kilocycles, the ratio between its liminal frequencies being thus as  $1400:400=3.5$ . The condenser regulating the local oscillator should be designed to cover the range between 450 and 1450 kilocycles; hence, the relationship between its limiting frequencies is  $1450:450=3.22$ . The condenser regulating the antenna or the aerial loop should be capable of covering the range between 500 and 1500 kilocycles, so that the ratio between its liminal frequencies will be  $1500:500=3$ .

These three condensers, for instance, could be of the type insuring linear variation of wave length designed for the ratio 3.5 (the fourth condenser, as has been indicated, a condenser designed for linear capacity variation); the ratios of 3.22 and 3 being obtained by the addition of fixed condensers as mentioned in the before-mentioned arrangements. It is also feasible to use for the three condensers a contour as the one corresponding to linear variation of the frequency by calculating the profile of the plates of condenser  $C_2$  correspondingly.

While I have indicated and described one arrangement 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 organization 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. A heterodyne receiver comprising an oscillation circuit for collecting signal frequencies, a frequency changer, an oscillation circuit, between the collecting circuit and the changer, including a reactive couple consisting of a coil and a variable condenser resonant to an undesired signal image frequency, said second oscillation circuit addi-

tionally including a second variable condenser and a fixed condenser both in shunt with said couple, said second condenser being adapted to resonate the entire second oscillation circuit to a desired signal frequency.

2. In a superheterodyne receiver, a source of signal frequency energy and undesired image frequency energy, a frequency changer, an oscillation circuit between the source and changer, said circuit comprising an inductance coil, a tuning condenser in said circuit in shunt with the coil, and additional means in the circuit for simultaneous selection of the signal frequency and rejection of the image frequency, said means including a second variable condenser in series with said coil, a fixed condenser in series with said tuning condenser, and means for simultaneously and similarly varying said tuning and variable condensers.

3. An electric wave receiving circuit comprising an inductance coil and at least two variable condensers, one of the condensers cooperating with said coil to tune the path including them to a predetermined undesired frequency, the other condenser being adapted to tune the entire circuit to a frequency within a range of desired frequencies, means for simultaneously adjusting both condensers, and an additional fixed condenser in series with the said second variable condenser in said circuit, and means comprising predetermined plate shapes of both variable condensers for maintaining a constant difference between the said undesired and desired frequencies throughout the range of adjustment of the variable condensers.

4. An electric wave receiving circuit comprising an inductance coil and at least two variable condensers, one of the condensers cooperating with said coil to tune the path including them to a predetermined undesired frequency, the other condenser being adapted to tune the entire circuit to a frequency within a range of desired frequencies, means for simultaneously adjusting both condensers, and an additional fixed condenser in said circuit, said three condensers being in series with each other and said coil in said circuit, and means comprising predetermined plate shapes of both variable condensers for maintaining a constant difference between the said undesired and desired frequencies throughout the range of adjustment of the variable condensers.

5. An electric wave receiving circuit comprising an inductance coil and at least two variable condensers, one of the condensers having a linear capacity variation characteristic and cooperating with said coil to tune the path including them through a range of undesired frequencies, the other condenser having a linear wave length variation characteristic and being adapted to tune the entire circuit through a range of desired frequencies, means for simultaneously adjusting both condensers, and an additional condenser in said circuit for maintaining the difference between said ranges a constant throughout the range of adjustment of the variable condensers.

6. In a superheterodyne receiver, a tunable radio frequency circuit including a variable tuning condenser, a frequency changer provided with a resonant input circuit and an output circuit resonant to an intermediate frequency, a local oscillation circuit including a variable tuning condenser, said resonant input circuit including a coil and a shunt variable tuning condenser, a uni-control tuning means mechanically coupled to the rotors of said variable condensers, said

control means being adapted to vary the first and third condensers to tune their respective circuits to the same desired signal frequency and the second condenser to tune the oscillation circuit to a frequency different from the signal frequency by said intermediate frequency, a fourth variable condenser in said resonant input circuit, having its rotor arranged for adjustment by said uni-control means, for resonating said coil to an undesired image of said signal frequency.

7. In a superheterodyne receiver, a tunable radio frequency circuit including a variable tuning condenser, a frequency changer provided with a resonant input circuit and an output circuit resonant to an intermediate frequency, a local oscillation circuit including a variable tuning condenser, said resonant input circuit including a coil and a shunt variable tuning condenser, a uni-

control tuning means mechanically coupled to the rotors of said variable condensers, said control means being adapted to vary the first and third condensers to tune their respective circuits to the same desired signal frequency and the second condenser to tune the oscillation circuit to a frequency different from the signal frequency by said intermediate frequency, a fourth variable condenser in said resonant input circuit, having its rotor arranged for adjustment by said uni-control means, for resonating said coil to an undesired image of said signal frequency and a fixed condenser in series with the said third condenser for maintaining the image frequency tuning range of the fourth condenser different by a constant amount from the desired signal frequency range.

HENRI CHIREIX.