Oct. 18, 1938. Y. DELBORD 2,133,849

MEANS FOR TUNING RECEIVING SYSTEMS

Filed May 17, 1935

Fig.1.

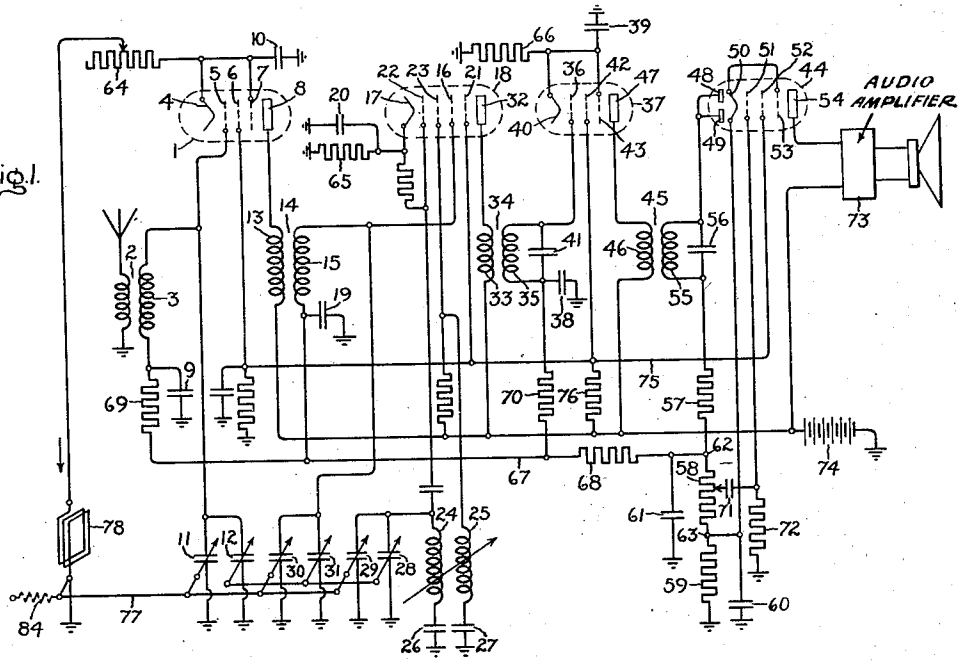


Fig.3.

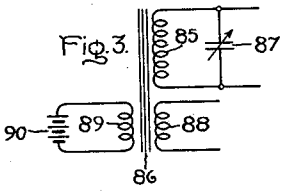


Fig.5.

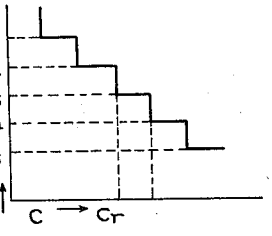


Fig.2.

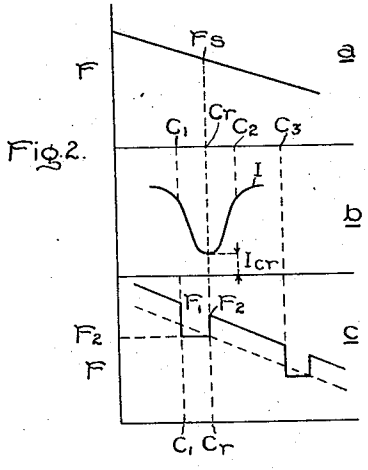


Fig.6.

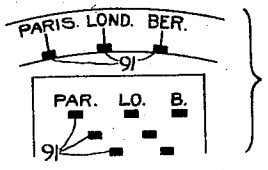
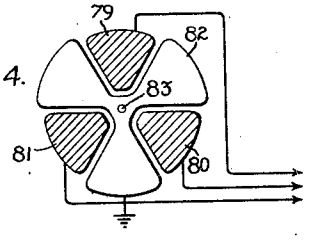


Fig.4.



Inventor:
Yvon Delbord
by Harry E. Dunham
His Attorney

Patented Oct. 18, 1938

2,133,849

UNITED STATES PATENT OFFICE

2,133,849

MEANS FOR TUNING RECEIVING SYSTEMS

Yvon Delbord, Paris, France, assignor to General Electric Company, a corporation of New York

Application May 17, 1935, Serial No. 22,069
In France June 7, 1934

9 Claims. (Cl. 250—20)

My invention relates to means for tuning receiving systems for the reception of signals of various frequencies, and more particularly to means for automatically tuning the various oscillating circuits of a receiving system to a point of exact response to a selected signal frequency after the system has been manually tuned to a condition roughly responsive to the selected signal frequency.

My invention is applicable to the so-called tuned radio frequency systems in which the resonating circuits are all tuned to the signal frequency; as well as to systems involving a frequency change which comprise, in addition to the circuits tuned to the signal frequency, a local oscillating circuit so tuned that its output frequency differs from that of the signal frequency by a constant quantity. Regulation of the above types of systems is usually performed manually by adjusting variable condensers connected in the oscillating circuits of the receiving system. However, it is rather difficult to adjust the condenser control member with sufficient accuracy to tune the circuits to the exact center of the carrier signal current which it is desired to receive. This detracts from the efficiency of the system and faithful reproduction of the received signal.

In accordance with my invention the above-noted disadvantages are obviated by the provision of a tuning device arranged automatically to tune the system to exact resonance with the frequency of a selected signal current which it is desired to receive. To accomplish the automatic tuning I provide means responsive to the variations in the anode current of a control tube of the system which is subjected to the control of an automatic volume control circuit, for influencing the tuning of the system.

It is an object of my invention to provide in a radio receiving system equipped with an automatic volume control circuit, an improved tuning device for automatically tuning the system to a selected carrier signal frequency, which is responsive to variations in the direct component of current flowing in the anode circuit of one branch of the system.

It is a further object of my invention to provide in a radio receiving system a tuning arrangement comprising manually controlled tuning means for roughly tuning the system to respond to a signal carrier current of a selected frequency and automatic tuning means responsive to variations in the direct component of current flowing in an anode circuit of the system for tuning the system to exact resonance with the carrier signal current after the approximate manual tuning operation has been effected.

It is an additional object of my invention to provide in a radio receiving system an automatic auxiliary tuning means of simple and economical construction, which is extremely positive and accurate in operation.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and the method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawing in which Fig. 1 illustrates a receiving system having my automatic tuning device embodied therein; Fig. 2 shows the operating curves of certain elements of the circuit of Fig. 1; Fig. 3 shows my invention in slightly modified form; Fig. 4 illustrates one form of condenser which may conveniently be employed in the circuit of Fig. 1; Fig. 5 illustrates a regulation curve applying to a particular case; and Fig. 6 shows one form of tuning dial which may be incorporated in a receiving set having my invention embodied therein.

Referring to Fig. 1 of the drawing I have shown my invention embodied in a receiving system of the well known superheterodyne, or local oscillator, type which is provided with an automatic volume control circuit. As shown, the incoming signal currents from the antenna circuit are impressed on the input circuit of a radio frequency amplifier tube 1 by the coupling transformer 2 having a secondary 3. The tube 1 is of the pentode type having an indirectly heated cathode 4, a control grid 5 connected to the secondary 3, a screen grid 6, a secondary electron emission suppressor grid 7 and an anode 8. The input circuit to the tube 1 is completed through the radio frequency by-pass condensers 9 and 10 connected between one end of the transformer secondary 3 and the cathode 4. This input circuit is tuned by the relatively large manually controlled variable condenser 11 and the comparatively small variable condenser 12; the two condensers being connected in parallel across the series circuit consisting of the condenser 9 and the transformer secondary 3. The operation of the condensers 11 and 12 to tune the input circuit to resonate at a particular selected frequency is described in detail hereinafter.

The output from the amplifier tube 1 is im-

pressed on the primary 13 of a coupling device 14 having a secondary 15 connected across the control grid 16 and cathode 17 of a frequency changer, or mixer tube 18 in series with radio frequency by-pass condensers 19 and 20. The mixer tube 18 includes a screen grid 21 and a pair of additional grids 22 and 23 which are connected to a local oscillatory circuit comprising the coupled inductances 24 and 25, condensers 26 and 27, and the variable condensers 28 and 29 shunting the inductance 24. The radio frequency input circuit of the tube 18 is tuned by the relatively large manually controlled condenser 30 and the comparatively small variable condenser 31 which are connected in parallel across the series connected secondary 15 and the condenser 19. The function of the local oscillator in this type of circuit is well understood in the art. Briefly, its action is to modulate the electron stream between the cathode 17 and the control grid 16 in accordance with the locally generated oscillating control current, the frequency of which is determined by the coupling between the inductances 24 and 25 and the capacity settings of the condensers 28 and 29.

The output circuit of the tube 18 includes the anode 32 thereof and the primary 33 of a coupling transformer 34 having a secondary 35 connected to the control grid 36 of an intermediate frequency amplifier tube 37. The input circuit to the tube 37 is completed by the intermediate frequency by-pass condensers 38 and 39 connected in series between the remaining end of the secondary 35 and the cathode 40 of the tube 37. A fixed tuning condenser 41 is shunted across the secondary 35 for tuning the input circuit to resonate at the selected intermediate frequency. The tube 37 includes a screen grid 42 and a suppressor grid 43 for suppressing secondary electron emission due to bombardment of the cathode.

The output from the intermediate frequency amplifier is coupled to the input of a duplex diode pentode detector and automatic volume control tube 44 by means of the transformer 45 having its primary 46 connected in the output circuit including the cathode 40 and anode 47 of the amplifier tube 37. The tube 44 includes a pair of diodes 48 and 49, a cathode 50, a control grid 51, a screen grid 52, a suppressor grid 53 and an anode 54. The two diodes 48 and 49 are included in the input circuit of the tube 44 and are connected to one end of the secondary 55 of the coupling transformer 45. The secondary 55 is tuned to resonate at the intermediate frequency by a condenser 56 shunting its leads. A source of automatic volume grid biasing control is derived from a resistance circuit which includes the series connected resistors 57, 58 and 59 connected between the remaining end of the secondary 55 and ground.

Briefly described, the automatic volume control potential is, under signal conditions, derived in the following manner: The rectified and modulated signal current which varies in accordance with the intensity of the received carrier, flows from diodes 48 and 49 to cathode 50 through resistors 57 and 58, the secondary 55, and back to the diodes. Intermediate frequency current smoothing condensers 60 and 61 are provided which are connected in series across the resistor 58. From the above it will be seen that the end 62 of the resistor 58 will be at negative potential with respect to the end 63 thereof, which in turn is maintained at a predetermined potential with respect to the cathodes 4, 17 and 40 respectively of the tubes 1, 18 and 37 by means of the resistance 59 and resistances 64, 65 and 66 connected in the respective cathode leads of the tubes 1, 18 and 37. The point 62 is connected by means of the lead 67 and resistance 68 to impress the varying negative control potential on the control electrodes 5, 16 and 36 of the tubes 1, 18 and 37. Resistances 69 and 70 are interposed respectively between the lead 67 and the control electrodes 5 and 36 to control the biasing effect of the potential existing at the point 62. The value of the negative potential at point 62 varies in accordance with the amplitude of the intermediate frequency current and since this potential is connected to exert a controlling effect on the tubes 1, 18 and 37, automatic volume control is achieved in a manner well known in the art.

The control potential for the control grid 51 of the tube 44 is derived from the resistance 58 by means of a condenser 71 and a resistance 72. The derived potential follows the audio frequency envelope and controls in a well known manner the current flowing in the anode output circuit which includes the input circuit of an audio frequency amplifier indicated diagrammatically at 73. The output from the audio amplifier 73 is impressed on a reproducing instrument such as a loud speaker in the manner illustrated.

A suitable source of high voltage potential 74 is provided for supplying the anode circuits of the respective tubes in the manner shown. A screen grid circuit is also provided which includes the lead 75 to which the screen grids of each of the tubes are connected and this circuit is maintained at a positive potential slightly below that of the anodes by connecting it to the positive side of the plate potential source through the resistor 76.

In the operation of the above described system the input and local oscillator circuits are manually tuned by means of the variable condensers 12, 31 and 28 approximately to the desired signal current frequency to be received. As shown diagrammatically, these condensers are connected to be operated by a common control member. The received signal current is amplified in the tube 1 and heterodyned with the output from the local oscillator in the tube 18. The intermediate frequency output from the tube 18 is amplified in the tube 37, rectified in the tube 44 and the audio frequency currents are finally amplified in the amplifier 73. The volume of the received signal is maintained substantially constant by the automatic volume control circuit in the manner described above.

In accordance with my invention I employ the varying anode current flowing in one branch of the system to energize a driving means coupled to an auxiliary tuning means thereby to effect an automatic accurate tuning of the system. To accomplish this automatic tuning, the auxiliary tuning condensers 11, 29 and 30 are connected by a common mechanical connection 77 to the movable coil 78 of a galvanometer which is electrically connected in the anode circuit of the radio frequency amplifier tube 1. A convenient form of triple condenser which may be used as the auxiliary condensers 11, 29 and 30 is shown in Fig. 4 wherein the stationary electrodes 79, 80 and 81 cooperate with the movable sectionalized electrode 82 which is mounted on the shaft 83. It will be understood that the shaft 83 is connected to be rotated by the movable element of the galvanometer in any suitable manner. The movable coil 78 is provided with a suitable mechanical

biasing means such as a spring 84 for retaining the condensers 11, 29 and 30 in a position of maximum capacity when no current is flowing through the galvanometer.

The operation of the above-described arrangement for obtaining automatic accurate tuning will best be understood by reference to Fig. 2 in which *a* represents the resonant frequency of the high frequency amplifier input circuit as a function of the value of tuning capacitance, which function is assumed to be a straight line over a small range of frequencies. The curve I illustrates the direct component of the output current of the high frequency amplifier tube as a function of the tuning of the input circuit of the tube when the resonant frequency of the input circuit is varied on either side of a frequency equal to a selected signal current frequency. The curve I may be explained by referring again to the action of the automatic volume control circuit in response to variation in intensity of the received signal current. As the input circuit of the tube 1 is manually tuned by the condenser 12 to approach resonance with a selected signal current the amplitude of the current in the input circuit increases and thus brings about an increase in the biasing potential on the control electrode 5 derived from the automatic volume control resistor 58. This increase in turn lowers the value of the direct component of current flowing in the anode circuit. The action is cumulative and continues until the input circuit of the tube 1 is in exact resonance with the signal current of the selected frequency which it is desired to receive. It will be observed that the value of the direct component of current varies as a function of the difference between the resonant frequency of the input circuit and the frequency of the signal current when the frequency difference between the two is within a certain range. Thus, the current decreases only when the input circuit is tuned to a frequency within a frequency range corresponding to a condenser setting between C_1 and C_r and increases only when the input circuit is tuned to a frequency within the range corresponding to a condenser setting between C_r and C_2.

To initiate the automatic tuning the set of condensers 12, 28 and 31 are first manually adjusted until the system is approximately responsive to the selected signal to be received, having a frequency which may be assumed to be equal to F_s. From the curves of Fig. 2 it will be seen that when the total capacitance of condensers 11 and 12 has attained the value C_1, the anode current of tube 1 begins to decrease and, since this current flows through the mechanically biased galvanometer coil 78, rotation thereof results which changes the settings of the condensers 11, 29 and 30 to increase the capacitance thereof. This increase in the capacitance of condenser 11 shunting the condenser 12 brings about in turn a new decrease of the current I, which causes a new change in the settings of the condensers 11, 29 and 30. This mutual effect between the tuning and variations in the anode current continues until the anode current of amplifier 1 has attained its minimum value I_{cr}, that is; until the input circuits including the secondaries 3 and 15 of the transformers 2 and 14 are tuned exactly to the frequency of the preselected signal F_s, and the oscillatory circuit including the inductances 24 and 25 is tuned to a frequency F_s+MF, MF being the intermediate frequency obtained by heterodyning the incoming radio frequency with the output frequency of the local oscillator.

From the foregoing description of the operation it will be seen that I have provided an arrangement wherein the various tuned circuits of a radio receiving system are automatically tuned to the correct frequencies corresponding to resonant condition of the input circuit with the signal current frequency after the system has been roughly tuned manually. It will further be seen that the direct component of the anode current of one of the tubes subjected to control of the automatic volume control circuit is employed as the electrical quantity which varies as a function of the input circuit tuning.

As shown in Fig. 1, the desired automatic tuning is effected by variation of the capacitance of the different tuned circuits. It will be understood, however, that my invention is not limited thereto, and that the desired tuning may be effected by varying the inductance of the tuned circuits as well. One convenient means whereby this may be effected is indicated in Fig. 3 in which the inductance of any one of the tuned circuits is shown as the coil 85 on the permalloy core 86 and shunted by the variable tuning condenser 87. A change in the inductance is effected automatically by means of the coil 88 which is connected in the anode circuit of a tube included in the system having an amplification factor which is controlled by the automatic volume control circuit as, for example, the tube 1 of the circuit shown in Fig. 1. Preferably this arrangement should include a third coil 89 which is excited from a direct current source 90 in opposition to the coil 88 and at a value equal to the minimum current flowing in the anode circuit in which the coil 88 is connected. With this arrangement it will be seen that as the anode current in the coil 88 varies in response to a rough manual tuning of the system, the inductance of the coil 85 will be varied to initiate the automatic accurate tuning, following which the change in inductance is cumulative until a resonant condition of the system obtains. An obvious modification of this arrangement is that of causing the anode current to mechanically influence the relative positions of a sectionalized tuning inductance having one or more movable sections.

While I have described my invention as applied to a system of the frequency changing type wherein the constants of the oscillating circuit are influenced, it will of course be understood that the operating conditions of the oscillator tube may be influenced to accomplish the desired automatic variations in the oscillator frequency. Thus, for example, the variation of the direct component of one of the tubes controlled by the automatic volume control circuit may be utilized to regulate the voltage bias of the control grid of the oscillator tube, the space charge of the tube, the tube heating circuit, or its plate voltage, to accomplish the desired automatic adjustment of the circuit. Furthermore, it will be obvious to those skilled in the art that my invention may be applied to a system of the tuned radio frequency type which comprises one or more cascade connected tubes coupled together by several circuits tuned to the signal frequency; the same system of regulation being used to tune the several circuits automatically and exactly to the selected signal frequency.

From the foregoing description it will be seen that I have devised an extremely simple and positive acting arrangement for overcoming the disadvantages and inaccuracies attendant with manual tuning. Thus, in the practical operation

of a system equipped with my automatic tuning means it is only necessary to adjust the indicating pointer of the main tuning means to a point such that the natural frequencies of the tuned circuits are within certain ranges and the automatic tuning means then completes the tuning operation. In Fig. 6 I have shown two convenient forms of a tuning dial which may be used to indicate when the main tuning means are set to tune the circuits to frequencies within the ranges necessary to initiate the automatic tuning action. On the indicating dials shown, marks 91 are arranged to cooperate with a pointer mounted on the main tuning control member to give the desired indication. These marks are made a certain length corresponding to the condenser play C_1—C_r (Fig. 2) and the adjustment is such that when the pointer intersects the mark corresponding to a selected station, the automatic tuning operation is initiated and the manual tuning operation is complete. The marks 91 may be distributed in either of the two ways shown, or in any other manner suitable to a particular system.

It will be readily understood from the previous description that if a plurality of transmitting stations to be received have carrier wave frequencies increasing in arithmetic progression, and separated by a definite frequency band as, for example, by 9 kc. per second, and further; if the receiving circuit which is to be tuned is so designed that the band corresponding to the positions C_1—C_r is precisely equal to 4½ kc. per second; the tuning curve of the set will be as shown in Fig. 5. When the above conditions are satisfied and provided the auxiliary tuning means has a range capable of varying the tuning over a frequency range equal to 4½ kilocycles, movement of the main tuning means causes the receiving system to automatically change over from a transmitting station having the frequency F_1 (for example) to the immediately following station having a frequency F_2, or from F_2 to F_3 and so on. With such an arrangement the automatically controlled auxiliary tuning means maintains the receiving means in tune with one selected signal current frequency during the preliminary movement of the main tuning means over a certain capacity range and immediately snaps the system to resonance with a different and succeeding signal current frequency when the range is slightly exceeded due to the restricted range of the auxiliary tuning means. Thus, if the auxiliary condenser 11 of Fig. 1 has a capacity range sufficient to increase the total capacity in the input circuit of tube 1 from C_1 to C_r, it will maintain the system in tune when the main tuning condenser 12 is increased from a value C_1 to a value C_2, since increases in the capacitance of the condenser 12 between the values C_r and C_2 will be compensated by decreases in the capacitance of the condenser 11. However, as the capacitance of condenser 12 is increased above C_2 the condenser 11 is ineffective until the next succeeding lower signal current frequency resonance curve is approached, when the condenser 11 again automatically influences the tuning of the system until a point of exact resonance with the lower signal frequency is reached. It should be noted that if the condenser 12 is set at a value C_3, for example, which is outside the resonance curve of the signal frequency F_s it is desired to receive, and the capacitance of the condenser 12 is decreased to tune the system to the signal frequency F_s, the automatically controlled condenser 11 is ineffective to automatically tune the system to the frequency F_s until the total capacitance is decreased to a value less than C_r. This follows from the fact that the total capacitance of condensers 11 and 12 must be decreased, and the additional fact that the condenser 11 is at a position of minimum capacitance when the decrease in capacitance is started. This slight disadvantage is of no importance if a graduated indicating dial of the type shown in Fig. 5 is employed.

The above described automatic tuning means is simple and positive in operation and of economical construction. Very few parts are necessary and, consequently, it may be readily adapted to any type of receiving system without unduly complicating the circuit thereof.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications in the structure may be made, and I contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination, in a radio receiving system of a variably tuned input circuit including a main tuning condenser and an auxiliary tuning condenser, an output circuit in said system carrying current which assumes a normal value when no carrier wave is being received and which varies as said input circuit is tuned to resonance with a received carrier wave, the variation of said current from said normal value being maximum when said circuit is in resonance with a received carrier wave, means responsive to said current variations to actuate said auxiliary tuning condenser to tune said input circuit to exact resonance with a received carrier wave after said main tuning condenser has been varied to tune said input circuit to approximate resonance with said carrier wave.

2. The combination in a radio receiving system of an amplifier having input electrodes, an input circuit connected to said electrodes, means for manually tuning said input circuit to resonance with selected carrier waves, an output circuit connected to said amplifier, means for varying the current in said output circuit in accordance with the tuning of said input circuit, and means electrically connected to said output circuit and responsive to said current variations produced by manual operation of said first named tuning means to tune said input circuit to exact resonance with the received carrier wave after said input circuit has been tuned to approximate resonance with said carrier wave.

3. The combination in a radio receiving system of an amplifier having input electrodes, an input circuit connected to said electrodes, means for manually tuning said input circuit to resonance with selected carrier waves, an output circuit connected to said amplifier, means including an automatic volume control circuit for impressing on one of said input electrodes a control voltage which decreases the current in said output circuit as said input circuit is tuned to approximate resonance with a received carrier wave, and means controlled by current in said output circuit and responsive to operation of said manual tuning means for automatically tuning said input circuit to exact resonance with said carrier wave.

4. The combination, of a manually tunable radio receiver, automatic volume control means therefor, and means actuated by the operation of

said automatic volume control means to control the tuning of said receiver, said means being responsive to manual tuning of said receiver toward and approximately to resonance with a received carrier wave to tune said receiver to exact resonance with the received carrier wave.

5. The combination, in a radio receiver, of manual tuning means therefor, automatic volume control means to maintain the output from said receiver substantially constant over a range of variation of the tuning of said receiver on either side of exact resonance at a frequency corresponding to a desired signal, and means actuated by the operation of said last named means in response to the manual operation of said first named means to increase the accuracy of tuning of said receiver to exact resonance at said frequency when said manual means is varied approximately to tune said receiver to resonance at said frequency.

6. The combination, in a radio receiver, of an input circuit manually tunable to currents to be received, an electron discharge amplifier, having a grid, an anode, and a cathode, an anode circuit including said anode, means to supply oscillations varying in strength in accordance with the tuning of said input circuit to said grid, means responsive to the strength of said oscillations to supply to said grid a negative unidirectional potential with respect to said cathode to control the amplification of said amplifier, said last named means effecting changes of direct current in said anode circuit, and means controlled by the direct current in said anode circuit to vary the tuning of said input circuit, said last named means being responsive to manual tuning of said input circuit approximately to resonance with said carrier wave to tune said input circuit to exact resonance with said carrier wave.

7. The combination, in a radio receiver having a manually tunable input circuit, of a high frequency amplifier for received currents, an output circuit therefor, means to vary the amplification of said amplifier in response to the intensity of oscillations received through said input circuit, thereby to reduce the variations in intensity of currents in said output circuit produced by variations in intensity of currents received in said input circuit, and means actuated by said last named means in response to manual tuning of said input circuit approximately to resonance with received oscillations to tune said input for maximum intensity of said oscillations.

8. The combination, in a radio receiver, of a manually tuned input circuit, an output circuit, an amplifier between said input circuit and said output circuit, means responsive to the intensity of current received through said input circuit to control the amplification of said amplifier to reduce variations in intensity of currents in said output circuit, manual means to vary the tuning of said input circuit through a range of frequencies, and means actuated by said first named means additionally to vary the tuning of said input circuit to exact resonance with a received carrier wave in response to the tuning by said second named means of said input circuit to approximate resonance with said carrier wave.

9. The combination, in a superheterodyne radio receiver, of a local oscillator, an output circuit, means to produce currents having a constant beat frequency between received oscillations and oscillations produced by said local oscillator, and to supply said currents to said output circuit, manual means to vary the tuning of said local oscillator through a range of frequencies, means to reduce variations in intensity of currents in said output circuit relative to variations of the intensity of received currents, and means actuated by said last means in response to the operation of said means to vary the tuning of said local oscillator to produce beat currents of said constant frequency throughout variation of said first tuning varying means through a range of frequencies approximating a frequency different from the frequency of received oscillations by said fixed frequency.

YVON DELBORD.

DISCLAIMER

2,133,849.—*Yvon Delbord*, Paris, France. MEANS FOR TUNING RECEIVING SYSTEMS. Patent dated October 18, 1938. Disclaimer filed March 22, 1939, by the assignee, *General Electric Company*.

Hereby disclaims from the scope of claim 2 all means for varying the current in said output circuit in accordance with the tuning of said input circuit except where said means comprises means for varying the gain of said amplifier in response to the tuning of said input circuit to a selected station.

[*Official Gazette April 18, 1939.*]