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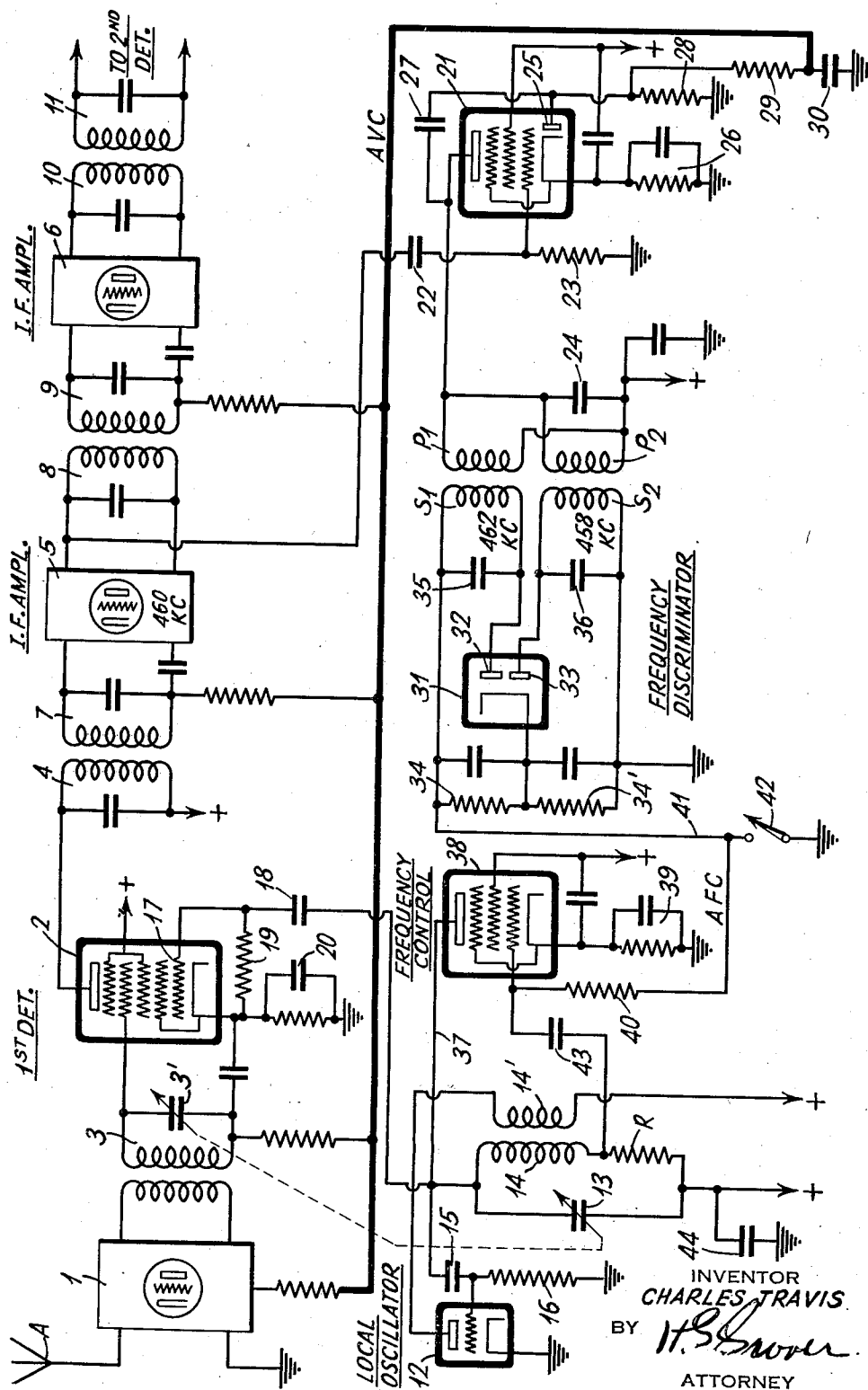
C. TRAVIS

2,155,208

AUTOMATIC FREQUENCY CONTROL SYSTEM

Original Filed May 3, 1935

2 Sheets-Sheet 1



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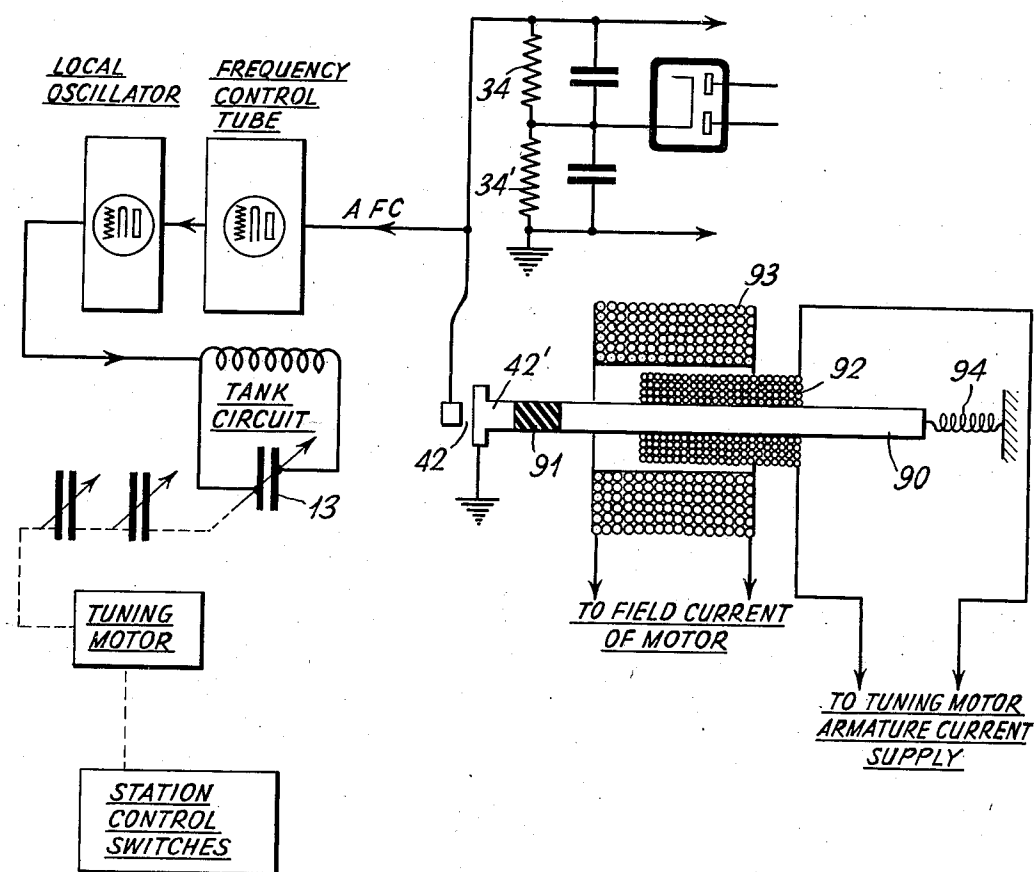
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Fig. 2



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2,155,208

AUTOMATIC FREQUENCY CONTROL
SYSTEM

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Original application May 3, 1935, Serial No.
19,563. Divided and this application Septem-
ber 3, 1937, Serial No. 162,229

9 Claims. (Cl. 250—40)

My present invention relates to frequency control systems, and more particularly to improvements in automatic frequency control networks; this application is a division of my application, Serial No. 19,563, filed May 3, 1935.

There has been disclosed in my copending application Serial No. 4,793, filed February 4th, 1935, various circuits for automatically varying the tuning of a resonant circuit independently of the normal tuning device. In these previous systems the result sought to be accomplished have in general been attained. However, additional investigation and experimentation has resulted in the development of further improvements in automatic frequency control systems.

The automatic frequency control systems to be explained in detail in a later portion of this specification involve in general two distinct units. One of these units is a frequency discriminator, or frequency sensitive detector, that generates a bias varying with changes of the intermediate frequency signal carrier. The other unit is a control that is acted upon by the aforementioned bias, and whose function it is to vary the local oscillator frequency in a desired sense. The two units are so coordinated that if the intermediate frequency carrier tends to shift from the mid-band position, the oscillator frequency changes sufficiently to restore proper alignment.

The automatic frequency control systems which comprise the subject matter of the present application are not only useful in facilitating the manual tuning operation of a superheterodyne receiver, but are also highly useful in maintaining the local oscillator frequency at a desired carrier setting for a long period of time, and throughout operation of the receiver during this period.

In addition to its aid and benefit in connection with the manual tuning of superheterodyne receivers, the presently disclosed frequency control systems can be used with benefit in connection with the automatic tuning of radio receivers of the superheterodyne type. In such instances the frequency control network functions as a vernier device accurately to tune the oscillator circuit after the automatic tuning mechanism has adjusted the tuning device to its generally desired station position.

Accordingly, it may be stated that it is one of the primary objects of the present invention to provide improved automatic frequency control networks which are not only capable of usage in such a manner as to secure the aforementioned

results, but are also constructed so as to function in a positive and reliable manner.

Another object of the present invention may be said to reside in the provision of a tunable oscillation circuit which is capable of being automatically tuned to different frequencies in a predetermined frequency range, there being an automatic frequency control system operatively associated with the oscillation circuit in such a manner that the oscillation circuit is accurately and automatically tuned to resonance with a desired signal carrier when the tuning means of the oscillation circuit is adjusted to a predetermined frequency, there being provided additional means for rendering the frequency control operative as soon as the oscillation circuit has been tuned to approximate resonance with said predetermined frequency.

Still other objects of the invention are to improve generally the simplicity and efficiency of automatic frequency control systems for radio receivers, and more especially to provide such systems in an economical and practical manner; the control systems of the present invention being particularly characterized by their reliability and accuracy in operation.

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, both as to its organization and method of operation, will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:—

Fig. 1 diagrammatically shows a superheterodyne receiving system embodying one form of the present invention.

Fig. 2 schematically illustrates the present invention applied to an automatic tuning device for a radio receiver.

Referring now to the accompanying drawings wherein like reference characters in the different figures designate similar circuit elements, the receiving system shown in Fig. 1 is of the superheterodyne type, and is shown as embodying an automatic frequency control network whose general organization is similar to that disclosed by me, and claimed, in my aforesaid copending application.

The receiving system embodies generally a grounded antenna circuit A which feeds a radio frequency amplifier 1 having a tunable input

which is resonated to the desired signal frequency; the output of the amplifier 1 is impressed upon the tunable input 3 of a first detector tube 2, the latter being of the 6A7 type.

5 The plate circuit of the tube 2 includes a tuned circuit 4 which is resonated to the operating intermediate frequency of the system, and the latter may be chosen to have a value, for example of the order of 460 kilocycles. The intermediate frequency energy produced in the circuit 4 may then be amplified in one or more stages of intermediate frequency amplification, and by way of example two such cascaded amplifier stages 5 and 6 are shown. The numeral 7 denotes the tuned input circuit of the amplifier 5, whereas the numeral 8 denotes the tuned output circuit of the amplifier.

The intermediate frequency amplifier 6 is provided with a tuned input circuit 9 and a tuned output circuit 10, it being pointed out that the circuits 4, 7, 8, 9 and 10, as well as the input circuit 11 to the second detector, are each resonated to the operating intermediate frequency of the system. The second detector, or demodulator of the system may be of any well known type, and may follow the construction, for example, shown in my above mentioned copending application. The local oscillator network comprises a tube 12 which is provided with a tunable oscillator tank circuit; the tank circuit includes the tuning condenser 13, and the coil 14 and resistance R connected in shunt with the condenser 13. The high potential side of the tank circuit is connected to the control grid of tube 12 through a condenser 15, the usual grid leak resistor 16 being connected to ground from the grid side of condenser 15.

The cathode of oscillator tube 12 is grounded, and the plate thereof is regeneratively coupled to the tank circuit by means of a coil 14' which is magnetically coupled to coil 14. The positive potential required for the plate of oscillator tube 12 is fed to the plate through the feedback coil 14', and the low alternating potential side of the tank circuit is connected to a source of positive potential. This latter positive potential is provided for the plate of the frequency control tube to be described in further detail at a later point. The locally produced oscillations are impressed upon the grid 17, which is the nearest to the cathode of tube 2. The grid 17 is connected to the high alternating potential side of the tank circuit through a condenser 18, the grid side of condenser 18 being connected to the cathode side of the grounded signal grid bias network 20 through a resistor 19.

It will be observed that a dotted line denotes the mechanical uni-control device usually employed for operating the rotors of the variable tuning condensers of the signal and local oscillator circuits. It is to be clearly understood that the dotted line signifies the mechanical coupling between the rotors of condensers 13 and 3', and also with the rotors of the variable condenser usually employed in the input of amplifier 1. The frequency changing function in tube 2 is accomplished by means of the electronic coupling, and this action is so well known to those skilled in the art at the present time that a mere reference thereto is believed sufficient.

The signal carrier amplitude at the demodulator input circuit 11 is maintained substantially constant over a wide range of carrier amplitude variation at the signal collector A by means of an automatic volume control arrangement, the

latter being denoted as "AVC" in Fig. 1. The varying negative bias for securing the automatic amplification regulation is derived from the diode network operatively associated with the driver tube 21. The latter tube may be of the 78 or 6D6 type, and has its control-grid coupled for the impression of intermediate frequency currents to the high alternating potential side of the tuned output circuit 3 of amplifier 5. The signal path connected to the control grid of tube 21 includes a condenser 22, the control grid being connected to ground through a resistor 23.

The plate of tube 21 is connected to a source of positive potential through two paths; one of these paths includes the coil P₁, while the other path includes the coil P₂. The coil P₂ is shunted by a condenser 24. The diode network comprises the auxiliary anode 25 which is disposed adjacent a portion of the cathode of tube 21 outside the main electrode stream to the plate of tube 21. The grounded cathode lead of tube 21 includes the control grid bias network 26; the resistor 23 acting as a conducting path for the grid bias of the control grid of the driver tube. Intermediate frequency energy is impressed upon the diode anode 25 through the condenser 27 which is connected between the plate of tube 21 and the diode anode 25. The anode 25 is also connected to ground through a resistor 28, the latter developing the direct current bias voltage across it when the intermediate frequency carrier amplitude attains a magnitude above a predetermined intensity level.

The anode side of resistor 28 is connected to the gain control electrodes of the controlled signal transmission tubes. In the present case the signal grids may act as the gain control electrodes, and the AVC lead is to be understood as being connected to the various grid circuits of the controlled transmission tubes. The AVC lead is connected to the anode side of resistor 28 through a resistor 29 which acts to suppress pulsating components of rectified intermediate frequency energy; the condenser 30 connected to ground cooperating with resistor 29 to provide the well known time constant network for the AVC arrangement.

Those skilled in the art will recognize that the system described to this point is in general of a well known type. Assuming that the signal range is in the broadcast band and covers a range of frequencies from 550 to 1500 k. c., then the local oscillator frequency range will be from 1010 k. c. to 1960 k. c. if the operating intermediate frequency is to be 460 k. c. As the intermediate frequency carrier amplitude in circuit 8 increases the negative bias applied to the control grids of the regulated tubes by the AVC network increases, and in this way the signal amplitude at the demodulator input circuit 11 is maintained substantially uniform regardless of the signal amplitude variation at collector A.

The discriminator network comprises the double diode tube 31, and the latter may be of the 85 type with the triode section thereof unused. The anodes of tube 31, these anodes being designated by numerals 32 and 33, are connected to opposite sides of a resistor which develops the automatic frequency control bias. This resistor has the cathode of tube 31 connected to the midpoint thereof, and therefore a single resistor may be employed or a pair of resistors of equal magnitude may be connected if desired. In any event the numeral 34 designates the resistor section between the cathode of tube 31 and the anode 32.

The resistor section 34' designates the load between the cathode of tube 31 and the diode anode 33. Each of the resistor sections 34 and 34' are shunted by a condenser, and the anode side of resistor 34' is grounded. The coil S₁, which is magnetically coupled to primary P₁, is connected between anode 32 and resistor section 34; the secondary coil S₂ is magnetically coupled to primary P₂, and the secondary is connected between the anode 33 and the grounded side of resistor section 34'. A condenser 35 is connected in shunt with coil S₁ and tunes the latter to a frequency on one side of the intermediate frequency, whereas condenser 36 is in shunt with coil S₂, and tunes the latter to a frequency on the other side of the intermediate frequency.

The frequency control tube is of the pentode type, and its plate is connected by lead 37 to the high alternating potential side of the oscillator tank circuit; the cathode of control tube 38 is grounded through a grid bias network 39, and the control grid of tube 38 is connected to the anode side of resistor 34 through a path which includes the resistor 40 and a lead 41. The lead 41 is designated by the letters AFC and is to be understood as denoting the automatic frequency control bias path. The lead 41 is adapted to be connected to ground by a switch 42, and it will be understood that the bias path for tube 38 is operative only when switch 42 is open. When the switch 42 is closed, then the AFC path is short circuited to ground, and is inoperative. The control grid of tube 38 is connected to the coil side of resistor R in the tank circuit of the local oscillator through a condenser 43, a condenser 44 being connected between the low alternating potential side of the tank circuit and ground.

In considering the operation of the AFC system of the receiver shown in Fig. 1 it is first pointed out that a high degree of selectivity in a superheterodyne receiver is of no great use unless it is possible to tune the receiver with a corresponding degree of accuracy, and thereafter to maintain this accuracy. As is well known if the tuning of a superheterodyne receiver is inadequate the high selectivity may actually become a detriment. For example, in the all-wave sets, selectivity has been effectively increased 15 to 20 times over that usual for broadcast reception, merely because the received frequencies have been increased by that amount without changing the intermediate frequency band width, i. e., at 20 mc. the nominal 10 k. c. I. F. band is only 0.05% of the base frequency. To meet this increase in selectivity in present day receivers manual tuning means have been improved by the employment of more smoothly working speed reducing mechanical movements to operate the variable gang condenser.

Nevertheless the maintenance of proper tuning after the station signal has once been correctly brought in, is a problem that requires a reliable and accurate solution. Local oscillator drift, if not corrected by more or less frequent manual readjustment, is capable of mistuning the signal by many channels in the course of a few hours run. In the broadcast band conditions are quite as serious if quality of reproduction is a consideration. The average broadcast set user does not tune the receiver well enough to obtain the best quality it is capable of giving; this is due not only to negligence, but to a great extent because of the lack of necessary skill, and in the latter case the mechanical design of the set is a contributing factor. These considerations show the need for

supplementing the accuracy of manual or automatic tuning by an automatic frequency control device.

It will therefore be seen that it is the essential object of the frequency discriminator and frequency control tube to cooperate to bring the signal carrier precisely to the center of its I. F. band, and anchor it there in spite of small original maladjustments of tuning, or other causes, that subsequently arise from thermal changes and the like. It will now be seen that the frequency discriminator network generates a bias, flowing through lead 41, which varies with changes of the I. F. carrier; the control unit 38 has its gain varied by the AFC bias, and the control unit functions to vary the local oscillator tank circuit in frequency. The two units are so inter-related that if the I. F. carrier tends to move away from the mid-band position, then the oscillator frequency changes sufficiently to restore the proper alignment. Such units and their construction for performing these functions, are generally disclosed in my aforementioned application.

The two similar I. F. transformers, between tube 21 and tube 31, have their primaries P₁ and P₂ connected in parallel in the plate circuit of the driver tube 21. This composite primary is tuned to the mid-band frequency of the I. F. band; in other words the composite primary is tuned to 460 k. c. The secondaries S₁ and S₂ are loosely coupled to their respective primaries and are tuned to different frequencies lying above and below the mid-band frequency by equal amounts. Thus, the secondary S₁ is tuned to 462 k. c., and the secondary S₂ is tuned to 458 k. c. The AVC diode is driven from the composite primary associated with the driver tube 21, and the diode load 28 not only functions as such, but also acts to damp the composite primary in order to aid in de-coupling the secondaries from each other and so to cause them to act like isolated single tuned circuits.

The secondaries S₁ and S₂ are each connected into one of the plates of the double diode tube 31, and the cathode of this tube is "floating" for direct current voltage. One of the diode returns to ground, and the AFC bias output is taken from the other diode return. The output of the discriminator is the algebraic difference between the rectified outputs of the two diodes. If the I. F. carrier is off center frequency towards the resonance of coil S, then diode 32 will produce the greater output of the two diodes, and the generated AFC bias will be negative with respect to the initial value. Conversely, if the carrier is off in the other direction the reverse will be true. When the carrier is exactly aligned the bias will equal the initial value.

It will be noted that the AVC diode is driven from the driver tube which feeds the discriminator network. This mode of generating AVC bias is employed, in preference to deriving AVC input energy from the circuit 11, because there is thus obtained a higher carrier input into the AVC rectifier than into that for AFC; this is desirable, and a considerable voltage delay may be used on the AVC diode. Another advantage of taking off the AVC bias in this manner is that the signal modulation into the second detector is not distorted by the demodulation produced by the AVC diode.

If the AFC driver also drives the AVC rectifier its output is automatically held nearly constant no matter where it is connected. Therefore, the grid of the driver tube may be connected at the

primary or secondary of the transformer preceding the last I. F. amplifier tube. This has the merit of giving a broader channel for the AFC and the AVC than for the audio detector. The gain of the last I. F. stage should be considerably decreased to avoid second detector overload.

As clearly explained in my aforementioned application maximum AFC sensitivity is obtained when the discriminator characteristic has the greatest slope. This occurs when the two secondaries S_1 and S_2 are so tuned that points of maximum slope on their individual resonance curves are made to coincide. Before explaining in detail the construction and functioning of the frequency control unit the manner in which the system operates as a whole will be described. The control circuit acts to vary the oscillator frequency and this variation may be thought of as if due to a variation in capacity, or of an inductance. The total tank circuit reactance may be considered to consist of two parts. That part physically present as in the variable tuning condenser, or the tuning coil, and that part reflected by the control circuit. The latter is a function of the I. F. carrier frequency, and its magnitude varies with the shift from I. F. mid-band frequency.

In my aforementioned application the control tube has been shown as reflecting capacity into the tank circuit, or the plate resistance of the control tube has been connected in series with a reactive element in the tank circuit. Additional investigation and experimentation has revealed frequency control circuits which make use of a different principle. It will be noted that the plate of control tube 38 is coupled into the high potential side of the tank circuit, and that the grid of the control tube is excited by a voltage which is 90° out of phase with that appearing across the tank circuit. The plate current in the control tube is then likewise out of phase with the tank voltage, and accordingly the control tube 38 looks like a reactance to the tank circuit.

The sign of the reactance presented to the tank circuit by the control tube depends upon the nature of the impedance across which is developed a voltage to be fed to the input electrodes of the control tube. The magnitude of the reflected reactance depends upon the AFC bias impressed upon the control grid of control tube 38, as this varies the mutual conductance, and proportionately the magnitude of the plate current, of the control tube. In Fig. 1 there is shown one method of obtaining the out-of-phase excitation for the grid of the control tube, and it will be noted that this is accomplished by taking the voltage across resistance R in series with the tank coil and tuning condenser. The effect of this arrangement is to produce an inductive effect across the tank coil 14. As the plate current of tube 38 is decreased the shunting effect of the reflected inductance is decreased, and the effective inductance of the tank circuit will therefore increase. This results in a rise of oscillator frequency.

A specific example will be given to illustrate the operation of the control tube 38. Assume that the set is to be tuned to a signal of 600 k. c.; the local oscillator frequency will have to be 1060 k. c. to produce an I. F. of 460 k. c. As the tuner device is adjusted from 500 to 600 k. c., the oscillator condenser 13 tunes the tank circuit from 960 to 1060 k. c. When the tank circuit is within 2 k. c., for example, of 1060 k. c. (1058 k. c.), the I. F. value is 458 k. c. Since this is the frequency of the circuit S_2 , voltage will

be developed across resistor 34'. The control grid of tube 38 will, therefore, become less negative with respect to ground due to its connection through lead 41 and resistor 34 to the cathode side of resistor 34'. The plate current flow of tube 38 increases; this will result in an increase in the inductive reactance reflected across coil 14. Thus, the effective inductance in the tank circuit decreases; the oscillator frequency, therefore, increases.

The increase in frequency of the tank circuit will be such as to bring the local oscillation frequency to 1060 k. c. Then the proper I. F. of 460 k. c. is secured, and the set sounds "tuned-in" to the listener. The reverse action takes place, of course, when the set is tuned away from the desired setting of 600 k. c. Within 2 k. c. on either side of 600 k. c. the AFC system will act to "anchor" the tuning of the receiver. When the receiver is tuned beyond the permissible limits of a carrier setting the AFC action is suspended until the limit of the adjacent channel is reached. In this way the normally highly selective superheterodyne receiver is rendered easily tunable; a range of some 4 k. c., for example, is provided within which the set may be tuned and yet distortionless reproduction be secured. The same operation is secured when the local oscillator circuit constants vary due to thermal, or other, effects. The AFC acts to bring the oscillator frequency back to the desired operating value so as to produce the operating I. F.

There are numerous methods of obtaining the out-of-phase grid voltage for the control tube 38. In order to make it clear to those skilled in the art how such different modes of procedure may be achieved, the following analysis of the operation of tube 38 and its circuits is furnished. It is to be clearly understood however, that the analysis is theoretical in nature, and in no way affects the demonstrated operation of the reactance control network.

It can be shown, in general, for a network of the type illustrated in Fig. 1 (that is, the tank circuit and the tube 38 with its circuits) that the combination of the control tube 38 and the oscillator presents to the tank circuit an effective impedance which is the negative reciprocal of the control tube impedance with respect to the resistance product of both oscillator and control tubes. For example, a capacity is the reciprocal of an inductance with respect to a resistance product; the reciprocal of a shunt combination is a series combination.

A practical value for R in Fig. 1, for a broadcast local oscillator, is about 100 ohms. With the G_m of tube 38 equal to 1000 microhms, the frequency change is about 5 percent. This permits a variation of plus or minus 25 k. c. at 1 mc., which seems ample for the purpose. The tuned impedance of the tank circuit is unaffected by the control action. Constant oscillator amplitude with frequency change is one of the advantages of the present arrangement.

In Fig. 2 is shown, in schematic manner, the application of the invention to an automatic tuner device. The automatic tuner mechanism is that shown by C. R. Garrett in U. S. P. 1,956,419 granted April 24, 1934. The tuning condensers are automatically varied by the tuning motor to a desired position when a station control switch is depressed. The condenser 13 is that in the oscillator tank circuit. The AFC system is to be understood as being that of Fig. 1. In fact, the entire system may be that of Fig. 1. The

switch 42 is the switch of Fig. 1 which is capable of short-circuiting the AFC line when closed. The movable element 42' of switch 42 is coupled to the armature 90 of a solenoid; an insulation spacer 91 is provided between 42' and 90.

The armature 90 carries a winding 92 which is connected to the tuning motor armature current supply. A fixed field current winding 93 causes the element 42' to contact the other element of switch 42 whenever the tuning motor is operating and varying the condensers. When the tuning motor ceases to run, the armature 90 is pulled back by spring 94; this opens switch 42 and the AFC is operative.

Thus, in Fig. 2 is shown a system capable of vernier tuning after rough tuning by an automatic tuner. The AFC here operates to bring the tank circuit into exact tune after the tuning motor has stopped running. As long as the motor is turning the condenser rotors, the switch 42 is closed. This renders the AFC inoperative because the switch 42 short-circuits the AFC system. The flexibility of the present invention in so far as variety of uses is concerned will now be seen.

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 the local oscillator tank circuit of a superheterodyne receiver, a motor for varying the tuning device of the tank circuit, an automatic frequency control circuit responsive to signal frequency variation for supplementally adjusting the tank circuit frequency at different frequency settings of the tuning device, station selector control switches connected with said motor for energizing the latter to adjust the tuning device to said settings, and means responsive to energization of the motor for automatically rendering inefficient said control circuit.

2. In combination with the local oscillator tank circuit of a superheterodyne receiver, a motor for varying the tuning device of the tank circuit, an automatic frequency control circuit responsive to signal frequency variation for supplementally adjusting the tank circuit frequency at different frequency settings of the tuning device, station selector control switches connected with said motor for energizing the latter to adjust the tuning device to said settings, and short-circuiting switch means responsive to energization of the motor for automatically rendering inefficient said control circuit.

3. In combination with the local oscillator tank circuit of a superheterodyne receiver, a motor for varying the tuning device of the tank circuit, an automatic frequency control circuit responsive to signal frequency variation for supplementally adjusting the tank circuit frequency at different frequency settings of the tuning device, station selector control switches connected with said motor for energizing the latter to adjust the tuning device to said settings, means responsive to energization of the motor for automatically rendering inefficient said control circuit, said last means comprising a switch for disabling the control circuit, and an adjustable element adapted to close said switch when electrically energized.

4. In combination with the local oscillator tank

circuit of a superheterodyne receiver, a motor for varying the tuning device of the tank circuit, an automatic frequency control circuit for supplementally adjusting the tank circuit frequency at different frequency settings of the tuning device in response to predetermined changes in intermediate frequency, station selector control switches connected with said motor for energizing the latter to adjust the tuning device to said settings, and means responsive to energization of the motor for automatically rendering inefficient said control circuit.

5. In a radio receiver of the type including a main tuning device, an electrically energizable means for adjusting said device through a range of station frequencies, a plurality of station selector elements, corresponding to desired station frequencies of said range, adapted to effect energization of said means thereby to secure adjustment of said main device, a supplemental tuning device constructed and arranged accurately to tune said receiver at selected adjustments of said main device in response to signal frequency variations, and means, operative upon energization of said electrical means, for rendering the supplemental device ineffective.

6. In a radio receiver of the type including a main tuning device, an electrically energizable means for adjusting said device through a range of station frequencies, a plurality of station selector elements, corresponding to desired station frequencies of said range, adapted to effect energization of said means thereby to secure adjustment of said main device, a supplemental tuning device constructed and arranged accurately to tune said receiver at selected adjustments of said main device in response to signal frequency variations, and a second electrically energizable means, operative upon energization of said first electrical means, for rendering the supplemental device ineffective.

7. In a radio receiver of the type including a main tuning device, an electrically energizable means for adjusting said device through a range of station frequencies, a plurality of station selector elements, corresponding to desired station frequencies of said range, adapted to effect energization of said means thereby to secure adjustment of said main device, a supplemental tuning device constructed and arranged accurately to tune said receiver at selected adjustments of said main device in response to signal frequency variations, and means, operative upon energization of said electrical means, for rendering the supplemental device ineffective, said last means comprising a short-circuiting switch adapted to be actuated upon energization of said first means.

8. In combination, an automatic receiver tuner of the type employing a motor-driven tuning device and a plurality of station-representative motor control switches, an accuracy tuning mechanism responsive solely to signal frequency variations and operative at adjustments of the tuning device corresponding to said stations, and means, operative upon actuation of a control switch, for rendering said accuracy mechanism ineffective.

9. In combination with the tunable local oscillator network of a superheterodyne receiver, a frequency control tube operatively associated with the network to reflect a reactance of predetermined sign thereacross, accuracy tuning means responsive to shifts in signal energy from desired frequencies for actuating said tube to ad-

just the said reactance value in a sense to correct the oscillator network frequency, means for automatically changing the frequency of the oscillator network to different values with respect to
5 said desired signal frequencies, and means responsive to operation of the automatic means for

rendering said accuracy tuning means ineffective, said accuracy tuning means being rendered effective upon the automatic means ceasing operation.

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