RADIO RECEIVER

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Fig. 1.

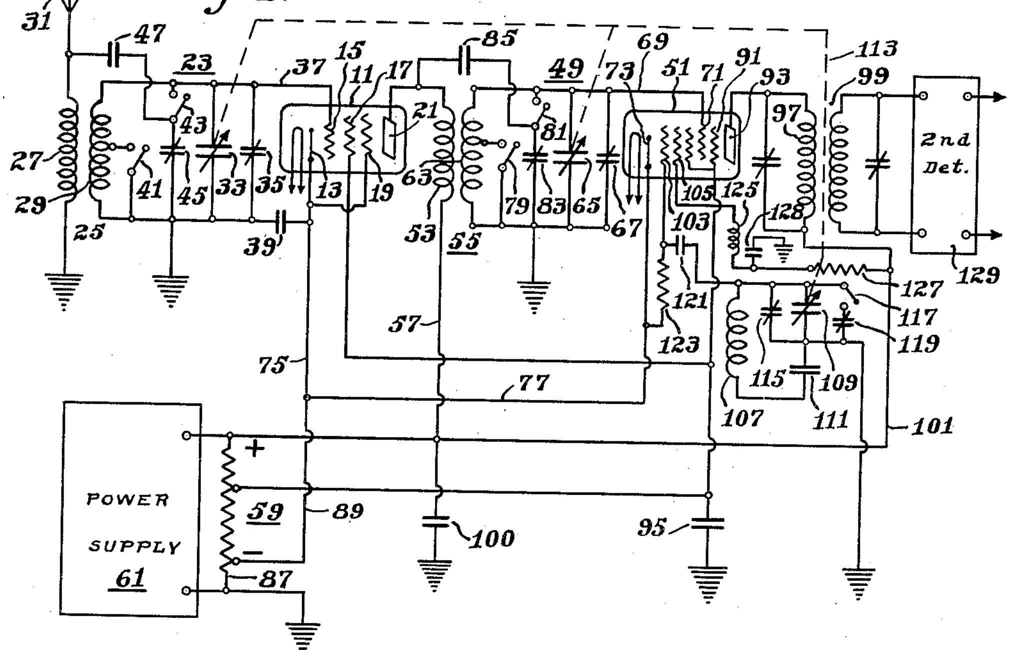


Fig. 5.

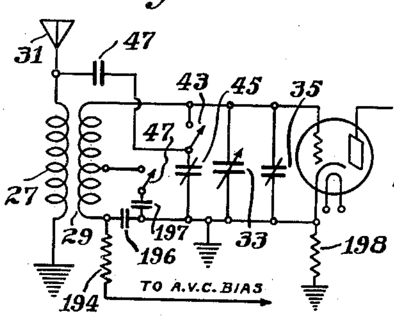


Fig. 3.

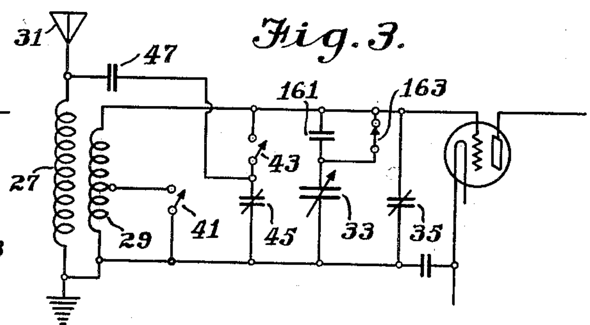
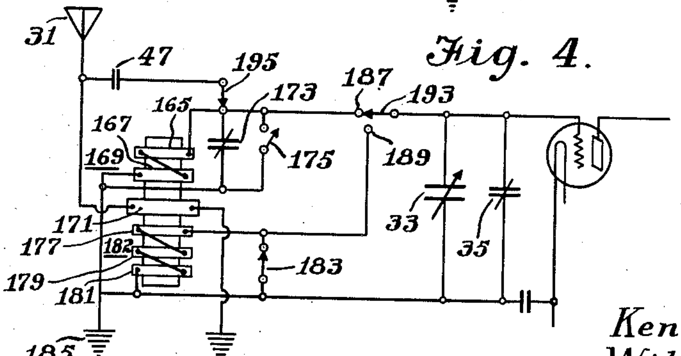


Fig. 4.



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Feb. 2, 1937. K. A. CHITTICK ET AL 2,069,518
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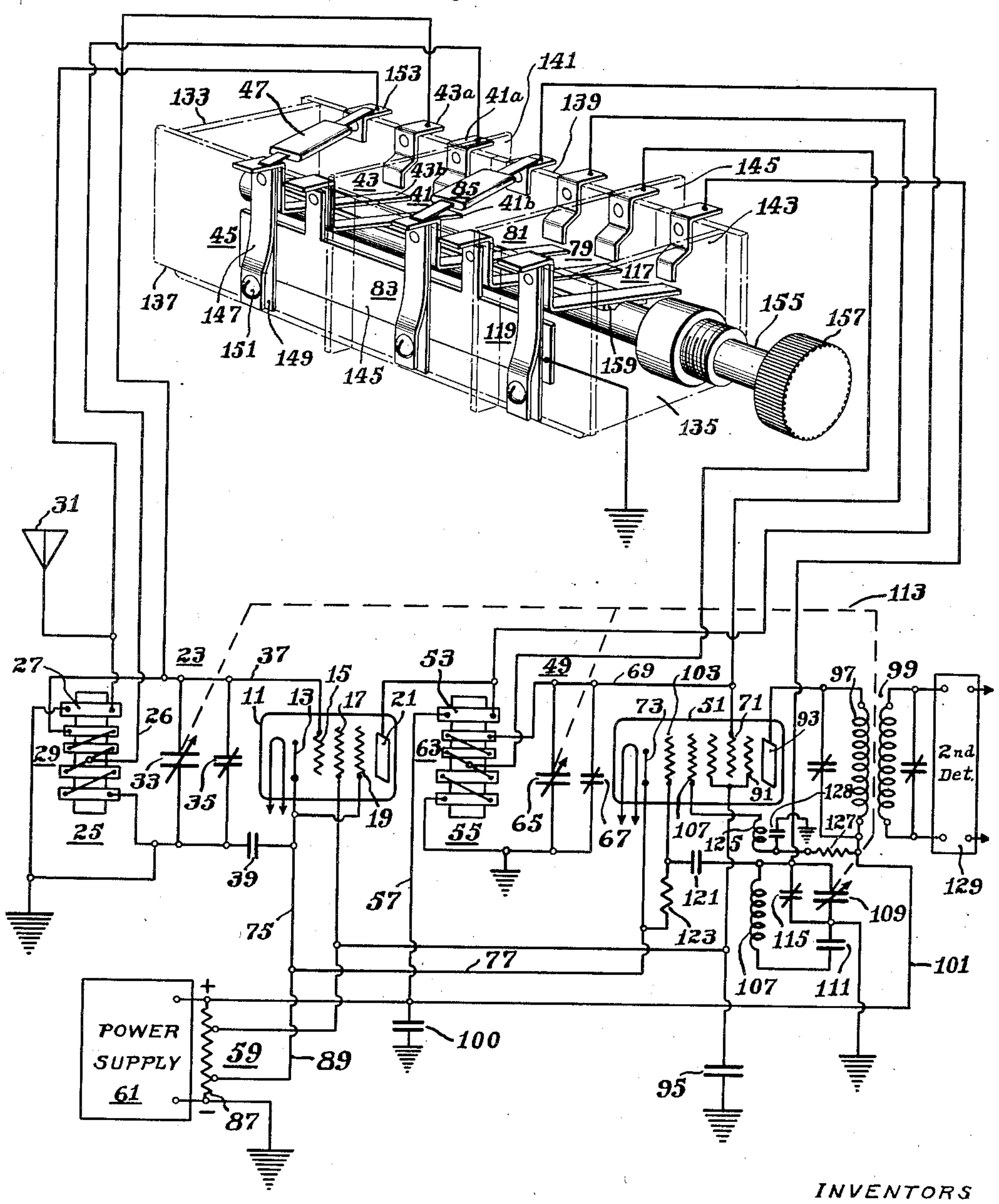
Fig. 2.



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UNITED STATES PATENT OFFICE

2,069,518

RADIO RECEIVER

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Application September 30, 1933, Serial No. 691,590

5 Claims. (Cl. 250—20)

Our invention relates to radio receivers, and more particularly to radio receivers of the multiwave type adapted to receive radio signals over a plurality of wave bands or frequency ranges.

In providing for multi-wave reception, and notably for broadcast and short wave reception, various circuits have been utilized for adapting a radio receiver, designed primarily for reception within the broadcast band, to receive signals within the different frequency or wave band, such as a short wave band or bands. One such circuit for adapting an existing broadcast receiver for short wave reception is represented by the well known "short-wave converter" ordinarily comprising an oscillator and one or more tuned radio-frequency circuits in connection with a detector which may be connected to a conventional broadcast receiver at the proper point in the circuit. In connection with the present popular superheterodyne type of radio receiver, the high frequency or short-wave signals are converted to either the radio or to the intermediate frequency for which the broadcast receiver is designed.

The "converter" type of circuit, while generally satisfactory in operation, with a certain required degree of understanding and skill on the part of the operator of the apparatus in which it is included involves considerable extra apparatus and cost together with extra tuning controls, thereby limiting its commercial use.

Another type of circuit involves switching or plugging into circuit, one or more sets of coils for differing wave band reception. In a superheterodyne receiver this may involve such changes in three different circuits, the radio-frequency, the detector, and the oscillator circuits, for the different frequency ranges or wave bands to be received. The objectionable features of this type of circuit are well known.

It is a primary object of our invention, therefore, to provide a simplified, unitary receiver for operation over a plurality of frequency or wave bands which obviates the above named and other disadvantages inherent in prior receivers of that type.

A further object of our invention is to provide a receiver of the above-mentioned type which is tunable over a wide frequency range within said frequency bands.

A further object of our invention is to provide a superheterodyne receiver of the above-mentioned type, and one which does not require a major change in the fundamental circuit constants of the oscillator when switching from one frequency range to another, whereby the "lining-up" of the oscillator and the tuned radio-frequency circuits is facilitated.

A still further object of our invention is to provide an improved method and means for "lining-up" the tuned radio-frequency circuits and the oscillator circuit in the different frequency ranges of a multirange superheterodyne receiver.

In practicing one embodiment of our invention we design the receiver to receive signals both within a band from 540 kilocycles to 1500 kilocycles, which will be referred to as the broadcast band, and within a band from 1255 kilocycles to 3000 kilocycles, which will be referred to as the police band.

Reception within the police band is accomplished by utilizing the second harmonic of the superheterodyne oscillator and by short-circuiting a portion of the inductance coil in each tuned radio-frequency circuit to make the circuit tunable over the police band with the same variable tuning means.

Other features and advantages of our invention will appear from the following description taken in connection with the accompanying drawings in which

Fig. 1 is a circuit diagram of a radio receiver embodying our invention;

Fig. 2 is a similar circuit diagram of the receiver of Fig. 1, showing in perspective a preferred form of switching mechanism, and tuning coil units for the tuned circuits thereof; and

Figs. 3, 4 and 5 are circuit diagrams showing modifications of certain of the tuned circuits of Figs. 1 and 2, and illustrating modifications of the invention.

Referring to Fig. 1, one embodiment of our invention comprises a tuned radio frequency amplifier which includes a vacuum tube **11** having an indirectly heated cathode **13**, a control grid **15**, a screen grid **17**, a suppressor grid **19**, and an anode **21**. The tuned input or selecting circuit **23** for the vacuum tube **11** comprises a radio frequency transformer **25** having a primary winding **27** and a secondary winding **29**. The upper end of the primary winding **27** is connected to an antenna **31**, while the lower end of the winding is connected to ground.

The secondary winding **29** is shunted by a variable condenser **33** which is one unit of a gang condenser. Condenser **33** is shunted by a trimmer condenser **35** for use in "lining-up" the several tuned circuits in the usual manner. The tuned circuit thus formed is connected across the input electrodes of the vacuum tube **11** by means of a conductor 37 connecting the upper end of the secondary winding 29 to the control grid 15, and a condenser 39 connecting the grounded lower end of the secondary winding 29 to the cathode 13.

The circuit as above described is tunable over the broadcast band. In order to make the radio frequency circuit 23 tunable over a higher frequency range, in this case the above mentioned police band, a switch 41 is provided for shorting a portion of the secondary winding 29. Another switch 43 is provided for shunting a second trimmer condenser 45 across the tuning condenser 33 at the same time that the secondary portion 29 is shorted, the condenser 45 being for the purpose of "lining-up" the tuned circuits in the police band.

The switch 43 performs an additional function in that, when closed, it connects a small coupling condenser 47 between the upper end of the primary winding 27 and the upper end of the secondary winding 29, the coupling condenser 47 being for the purpose of maintaining the transfer of energy from the primary winding to the tuned circuit 23 at the desired value in the high frequency or police band.

The output circuit of the amplifier tube 11 is coupled to the tuned input circuit 49 of the combined detector and oscillator tube 51.

The output circuit of tube 11 may be traced from the anode 21 through the primary winding 53 of a radio frequency transformer 55, and through a conductor 57 to a point of positive potential on the voltage divider 59 of the power supply 61.

The tuned input or selecting circuit 49 for the first detector is similar to the tuned radio frequency circuit 23 above described, and comprises the secondary winding 63 of the radio frequency transformer 55 shunted by a variable condenser 65, which is one unit of the above-mentioned gang condenser. The tuning condenser 65 is shunted by the usual trimmer condenser 67.

The tuned input circuit 49 is coupled to the input electrodes of the detector by means of a conductor 69 which connects the upper terminal of the secondary winding 63 to the control grid 71, and by means of the coupling condenser 39 which connects the lower end of the secondary winding 63 to the cathode 73. The connection through the coupling capacity 39 may be traced from the lower end of the secondary winding 63 through ground, through the condenser 39 and through the conductors 75 and 77 to the cathode 73.

A switch 79 is provided for short circuiting the lower portion of the secondary winding 63 for the purpose of making the input circuit 49 tunable over the high frequency range. Another switch 81 is provided for shunting another trimmer condenser 83 across the tuning condenser 65 at the same time that the short circuiting switch 79 is closed.

Also, when the switch 81 is closed, a small coupling capacity 85 is connected between the upper end of the primary winding 53 and the upper end of the secondary winding 63 for providing the desired transfer of energy at the high frequencies.

The proper negative bias is supplied to the grids 15 and 71 of the amplifier and detector tubes, respectively, by means of the lower section 87 of the voltage divider 59, the cathodes 13 and 73 being connected through conductors 75 and 77 and a conductor 89 to a positive point near the lower end of the voltage divider and the grids 15 and 71 being connected through ground to the lower end of the voltage divider.

The detector electrodes, which are enclosed in the same container with the oscillator electrodes, comprise the cathode 73 and control grid 71, above referred to, a screen grid 91 and an anode 93. Both the screen grid 91 and the screen grid 17 of the radio frequency amplifier tube 11 are supplied with positive potential from a point on the voltage divider 59. They have a radio frequency connection to ground through a bypass condenser 95.

The anode 93 is connected to the upper end of the primary 97 of a tuned intermediate frequency transformer 99, the lower end of which is connected to a positive point on the voltage divider 59 through a conductor 101. The primary winding 97 and the primary winding 53 both have a radio frequency connection to ground through the bypass condenser 100.

The oscillator electrodes consist of a control grid 103, an anode 105, and the cathode 73 which is common to the detector and oscillator. By utilizing a common cathode, the detector and oscillator are coupled through the common electron stream.

The frequency determining circuit of the oscillator comprises an inductance coil 107 which is shunted by a variable condenser 109 and a fixed condenser 111 connected in series, the fixed condenser 111 having a larger capacity than the maximum capacity of the variable condenser 109. The variable condenser 109 is one unit of the above-mentioned gang condenser, and is variable simultaneously with the condensers 33 and 65 by means of a common tuning control, as indicated by the dotted line 113.

The fixed condenser 111 is employed in series with the variable condenser 109 for the purpose of making the oscillator "track" with the tuned radio frequency circuits, as described in Carlson Patent No. 1,740,331, and forms no part of our invention. By "tracking" the oscillator with the tuned radio frequency circuits is meant so adjusting the oscillator that its oscillations always have a constant frequency difference from that to which the radio frequency circuits are tuned.

The variable condenser 109 is shunted by a trimmer condenser 115 for lining-up the oscillator with the tuned radio frequency circuits 23 and 49 in the broadcast band. A switch 117 is provided for shunting another trimmer condenser 119 across the variable condenser 109 when the receiver is set to receive signals in the higher frequency band.

The upper end of the inductance coil 107 is coupled to the oscillator control grid 103 through a coupling capacity 121, while the point between the fixed condenser 111 and the variable condenser 109 is connected to the cathode 73 through ground, the bypass condenser 39, and the conductors 75 and 77.

An oscillator grid leak resistor 123 is connected between the grid 103 and the cathode 73.

The plate circuit of the oscillator is coupled to the tuned grid circuit for producing sustained oscillations by means of an inductance coil 125. The plate circuit of the oscillator may be traced from the plate 105 through the inductance coil 125, and through a voltage reducing resistor 127 through conductor 101 to the voltage divider 59. A radio frequency connection from the lower end of coil 125 to ground is provided by a bypass condenser 128.

The oscillator tuned circuit and tuned radio frequency circuits **23** and **49** are so adjusted with respect to each other that in the broadcast band, the incoming signal beats with the fundamental frequency of the oscillator to produce a signal at an intermediate frequency, which in a preferred embodiment is 175 kilocycles. This intermediate frequency output is transferred to the second detector **129** by means of the tuned intermediate frequency transformer **99**.

When receiving within the police band, all of the above-mentioned switches are closed, whereby the radio frequency circuits are tunable over the police band range and properly lined-up with the oscilllator. When receiving within this frequency range, the second harmonic of the oscillator is utilized.

The relation between the tuned radio frequency circuits **23** and **49** and the oscillator, with the switches closed, is such that the incoming signals beat with the second harmonic of the oscillator to produce the same intermediate frequency as produced in broadcast reception.

In the particular embodiment being described, the second harmonic frequency of the oscillator is always 175 kilocycles higher than the frequency to which the radio-frequency circuits **23** and **49** are tuned when the switches are closed. With the switches open, the fundamental frequency of the oscillator is always 175 kilocycles higher than the frequency to which said circuits **23** and **49** are tuned.

In accordance with another embodiment of our invention, the selecting circuit is so adjusted with respect to the oscillator that in the broadcast band the oscillator frequency is 175 kilocycles above the frequency of the selected signal, while in the police band the harmonic frequency of the oscillator is 175 kilocycles below the selected signal. This extends the range for police band reception while retaining, at the same time, the advantages of having the oscillator frequency higher than the signal frequency in the broadcast band.

That the above-described adjustment permits the reception of signals at a higher frequency than permitted by the first-described adjustment is obvious since in the one case the signal received is 175 kilocycles above the harmonic frequency, while in the other case the signal is 175 kilocycles below it. As to the adjustment in the broadcast band, it is well known that, when employing a high intermediate frequency, it is difficult to make the oscillator cover the desired frequency range if it is adjusted to oscillate at a frequency lower than that of the incoming signal.

The circuit shown in Fig. 2 is the same as that shown in Fig. 1, with the present preferred form of radio frequency coil structure and switch and trimmer condenser construction included therein. In the two figures, like reference numerals indicate like parts.

Referring to Fig. 2, the radio frequency transformer **25** comprises a universal wound coil **27** which forms the primary of the transformer. The secondary **29** of the transformer consists of four universal wound coils connected in series and mounted below the primary coil **27**. A tap connection **26** extends from a connection between two of the coils to permit short circuiting the two lower universal wound coils when receiving in the police band range.

The radio frequency transformer **55** is identical in construction with the transformer **25** above described.

The switch structure for switching from one frequency range to another comprises a base plate **131** having two end plates **133** and **135**. Side members **137** and **139** of insulating material are fastened to the end plates **133** and **135** for supporting the switches and police band trimmer condensers.

In order to prevent undesired capacity coupling, the switch structure is divided into sections by means of shielding plates **141** and **143** which are supported from the base member **131** and electrically connected thereto. They are also electrically connected to a grounded metal plate **145** on the outside of the side member **137**.

The first section includes the short circuiting switch **41** and the trimmer condenser switch **43** of the first tuned radio-frequency circuit. The contact points **41*a*** and **43*a*** of the switches **41** and **43**, respectively, comprise strip elements riveted to the side member **139**. The switch arm **416** of the short circuiting switch **416** of the short circuiting switch **41** comprises a strip of springy metal riveted to the side member **137** and electrically connected to the grounded metal plate **145**. The switch arm **436** of the trimmer condenser switch **43** comprises a strip of springy metal riveted to the side member **137**.

The trimmer condenser **45** is mounted on the side member **137** and comprises a condenser plate of flexible spring metal **147** positioned over the grounded plate **145** (which forms the other condenser plate) and insulated therefrom by means of a piece of mica **149**. The upper end of the trimmer condenser plate **147** is riveted to the side member **137** and electrically connected to the switch arm **436**. The spacing between the trimmer condenser plate **147** and the grounded plate **145** is made adjustable by means of a screw bolt **151** which is threaded into the side member **137** whereby the head of the screw bolt can be made to engage the condenser plate **147**.

The coupling condenser **47** is supported from the side members **137** and **139** and has one terminal electrically connected to the switch arm **436** and the other terminal electrically connected to a piece of strip metal **153** riveted to the side member **139**.

It will be noted that the switch contact point **43*a*** is a small piece of metal so that although it is connected to the grid **15** at all times, it has no detrimental effect since the capacity to ground is very small.

The construction of the short circuiting switch **79**, the trimmer condenser switch **81**, and the coupling condenser **85** in the second switch section is the same as the corresponding elements in the first section.

The third section includes only a trimmer condenser **119** which is connected in the oscillator circuit, and its switch **117**. The construction of the trimmer condenser **119** and the switch **117** is the same as that of the trimmer condensers and switches in the other sections.

All of the switch arms are moved upwardly to close the switches simultaneously when a shaft **155** is rotated. A knob **157** is provided for rotating the shaft. Shaft **155** is journaled in the end plates **133** and **135** and has a flat strip **159** of insulating material fastened thereon and so positioned with respect to the switch arms that when the switches are open, the switch arms are resting against the flat side of the strip. When the shaft **155** is given a quarter turn, the edge of the strip **159** is brought into contact with the switch arms to force them upwardly and close all the switches.

It will be evident that, since the rotors of condensers 33, 65 and 109 are units of a gang condenser and mounted upon a common shaft for simultaneous rotation, the radio-frequency and oscillator circuits must be "lined-up" for both of the frequency ranges. That is, in both frequency ranges the radio-frequency circuits 23 and 49 must always be tuned to the same frequency; in the broadcast band, the fundamental frequency of the oscillator must always be 175 kilocycles above the frequency to which circuits 23 and 49 are tuned, and in the police band the second harmonic of the oscillator must always be 175 kilocycles above the frequency to which circuits 23 and 49 are tuned.

The method by which the circuits are "lined-up" is as follows: Before the receiver is assembled the condensers 33, 65 and 109 are adjusted in the usual manner to make them of equal capacity at all settings of the rotors. The transformer secondaries 29 and 65 are compared with a standard coil before assembly and so adjusted that they will have the same inductance values.

In accordance with one feature of our invention, the secondary coils 29 and 63 are adjusted as follows: Taking secondary 29 as an example, the two lower universal wound coils are short-circuited and the two upper universal wound coils of secondary 29 are compared with the standard inductance coil for the police band and the combined inductance of these two coils brought to the correct value by adjusting the spacing between them.

Next the short-circuit is removed from the two lower coils and the four coils of secondary 29 are compared with the standard inductance coil for the broadcast band. The combined inductance of the four coils is brought to the correct value by adjusting the spacing between the two lower coils by moving the lowest coil, the spacing of the previously adjusted two upper coils remaining unchanged.

It will be seen that by following the above-described procedure, the second adjustment of the secondary coil inductance does not materially affect the first or police band adjustment because the coils involved in the second adjustment are short-circuited during operation over the police band. While the procedure has been described as applied to coils having concentrated windings, it will be understood that it may be applied equally well to solenoid coils where sections of a coil winding are spaced apart to permit adjustment of the inductance.

The "line-up" is completed after the receiver is assembled by opening all the switches and setting the tuning condensers 33, 65, and 109 near the minimum capacity position, adjusting the trimmer condensers 35 and 67 until the radio frequency circuits 23 and 49 are tuned to the same frequency, and adjusting trimmer condenser 115 until the oscillator frequency is 175 kilocycles above the frequency to which circuits 23 and 49 are tuned. This completes the "line-up" for the broadcast band.

Next the "line-up" for the police band is completed by closing all the switches (by giving knob 157 a quarter turn) and adjusting the trimmer condensers 45 and 83 until circuits 23 and 49 are tuned to the same frequency. The trimmer condenser 119 is then adjusted until the second harmonic of the oscillator is 175 kilocycles above the frequency to which circuits 23 and 49 are tuned.

From the foregoing, it will be apparent that the receiver may be "lined-up" accurately for both frequency bands and that the "lining-up" operation for one frequency band does not affect the "line-up" for the other frequency band.

Referring to Fig. 3, there is shown a modified tuned radio frequency circuit which may be utilized in place of the circuit shown in Figs. 1 and 2, for obtaining a more exact line-up between the oscillator and radio frequency circuits at the higher frequencies. The circuit is the same as that shown in Fig. 1, (like reference numerals indicating like parts), except that a fixed condenser 161 is connected in series with the tuning condenser 33 and shunted by a switch 163, which is closed when receiving within the broadcast band and open when receiving within the police or high frequency band.

The condenser 161 preferably is given a capacity which is larger than the maximum capacity of the tuning condenser (approximately twice as large, for example) and is utilized to provide more exact line-up of the radio frequency circuits with the second harmonic of the oscillator at the lower frequency end of the police band.

Another form of tuned radio frequency circuit which may be utilized in place of the one shown in Figs. 1 and 2 is the circuit shown in Fig. 4. In these figures the same reference numerals indicate like parts. In Fig. 4, the circuit includes a separate set of secondary windings for each frequency range. The secondary coils 165 and 167, which comprise the secondary winding 169 for the police band, are mounted above the primary coil 171 and shunted by a trimmer condenser 173 and a short circuiting switch 175.

The secondary coils 177, 179 and 181, which comprise the secondary winding 182 for the broadcast range, are located below the primary winding 171 and are shunted by a short circuiting switch 183.

The lower ends of secondary windings 169 and 182 are connected to ground as indicated by the conventional symbol 185. The upper ends of the secondary windings 169 and 182 are connected to the switch points 187 and 189, respectively, so that a tuning condenser 33, shunted by the usual trimmer condenser 35, may be connected across either one of the secondary windings by means of the switch arm 193. In order to prevent undesirable absorption of energy, the switches are so arranged that when one secondary winding is in use, the other secondary winding is short circuited.

In order to provide the desired transfer of energy when receiving in the high frequency range, a coupling condenser 41 is connected between the antenna 31 and the upper end of the secondary winding 169, by means of a switch 195.

The above-described circuit, and, in particular, the circuit shown in Figs. 1 and 2, may be modified to permit both more exact tracking of the oscillator and the radio frequency circuits, and the utilization of automatic volume control as shown in Fig. 5. In these figures, like reference numerals indicate like parts.

Referring to Fig. 5 it will be seen that the tuned radio frequency amplifier circuit of the receiver differs from that shown in Fig. 1 in that a blocking condenser 196 is inserted in the connection between the lower end of the coil 29 and the connection to ground to permit application of a volume control bias to the grid of the tube.

The volume control bias is applied to the grid through a resistor 194 which is connected to any suitable source of automatic volume control bias as indicated by the legend. A suitable constant bias for the grid is supplied in a conventional manner by means of the resistor 198 in the cathode circuit.

Instead of shorting the lower portion of coil 29 directly through the switch 47, it is shorted with respect to radio frequency energy through the condenser 196 and a series tracking condenser 197. When the switch 47 is closed, the condenser 196 is in series with the tuning condenser 33 and functions the same as condenser 161 in Fig. 3 and condenser 111 in Fig. 1.

By connecting the series tracking condenser in series with the short-circuiting switch as shown in Fig. 5, the addition of an extra switch is avoided. This will be seen from a comparison of Figs. 3 and 5.

By employing our invention, a small receiver may be made tunable over a wide range in a high frequency band as well as tunable over the usual broadcast band, merely by the addition of a few small condensers and switches. Because of the small size and the small number of the additional parts required, such a multi-range receiver is compact and only slightly more expensive to manufacture than a receiver tunable over the broadcast band only.

Also, our invention makes it possible to "line-up" the tuned radio frequency circuits and the oscillator over the different frequency bands just as easily as the several circuits are "lined-up" for one frequency band. This feature is of great importance in obtaining economical assembly of the receivers.

Various modifications, other than those described, may be made in our invention without departing from the spirit and scope thereof, and we desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art, and set forth in the appended claims.

We claim as our invention:

1. The method of adjusting the tunable circuits of a radio receiver for simultaneous tuning adjustment by a tuning control means common to said circuits, one of said circuits including an inductance coil wound in at least four sections, said method including the steps of short-circuiting two of said sections and adjusting the inductive relation between the remaining two sections until they have a combined predetermined inductance value, and removing said short-circuit and adjusting the inductive relation between said two remaining coil sections until all the sections of said coil have a second combined predetermined value.

2. The method of adjusting the tunable circuits of a radio receiver for simultaneous tuning control, one of said circuits including an inductance coil wound in at least four spaced sections, said method including the steps of short-circuiting two of said sections and adjusting the spacing between the remaining two coil sections until they have a combined predetermined inductance value, and removing said short-circuit and adjusting the spacing between said remaining two coil sections until all of the sections of said coil have a second combined predetermined inductance value.

3. In a superheterodyne receiver having a tunable radio-frequency circuit and an oscillator having a tunable circuit, said radio-frequency circuit including an inductance coil, means for short-circuiting a section thereof, and a trimmer condenser, the method of lining-up said tunable circuits for obtaining a desired intermediate frequency throughout two frequency ranges by the operation of a single tuning control common to said tunable circuits, which method comprises the steps of lining-up said tunable circuits for one of said frequency ranges with all of said inductance coil included in said radio-frequency circuit, and then short-circuiting said coil section, connecting said trimmer condenser across said inductance coil, and lining-up said tunable circuit for the other of said frequency ranges by adjusting said trimmer condenser.

4. In a radio receiver, a plurality of tunable selecting circuits connected in cascade, each selecting circuit comprising an inductance coil shunted by a variable tuning condenser, a trimmer condenser connected in parallel with each tuning condenser, additional trimmer condensers, one for each of said tuning condensers, a coupling condenser associated with each selecting circuit, and a simultaneous control means for short-circuiting a portion of each of said inductance coils, for connecting said additional trimmer condensers across said tuning condensers and for connecting said coupling condensers to said selecting circuits.

5. A radio receiver according to claim 4 characterized in that said simultaneous control means comprises a unitary switch structure consisting of a plurality of electrostatically shielded switch sections, each section including the switches and the additional trimmer condenser for one of said selecting circuits, said additional trimmer condenser being an integral part of said switch structure.

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