Nov. 25, 1941. W. H. CONRON 2,263,613

UNICONTROL VARIABLE INDUCTANCE TUNING SYSTEM

Filed March 31, 1939 2 Sheets-Sheet 1

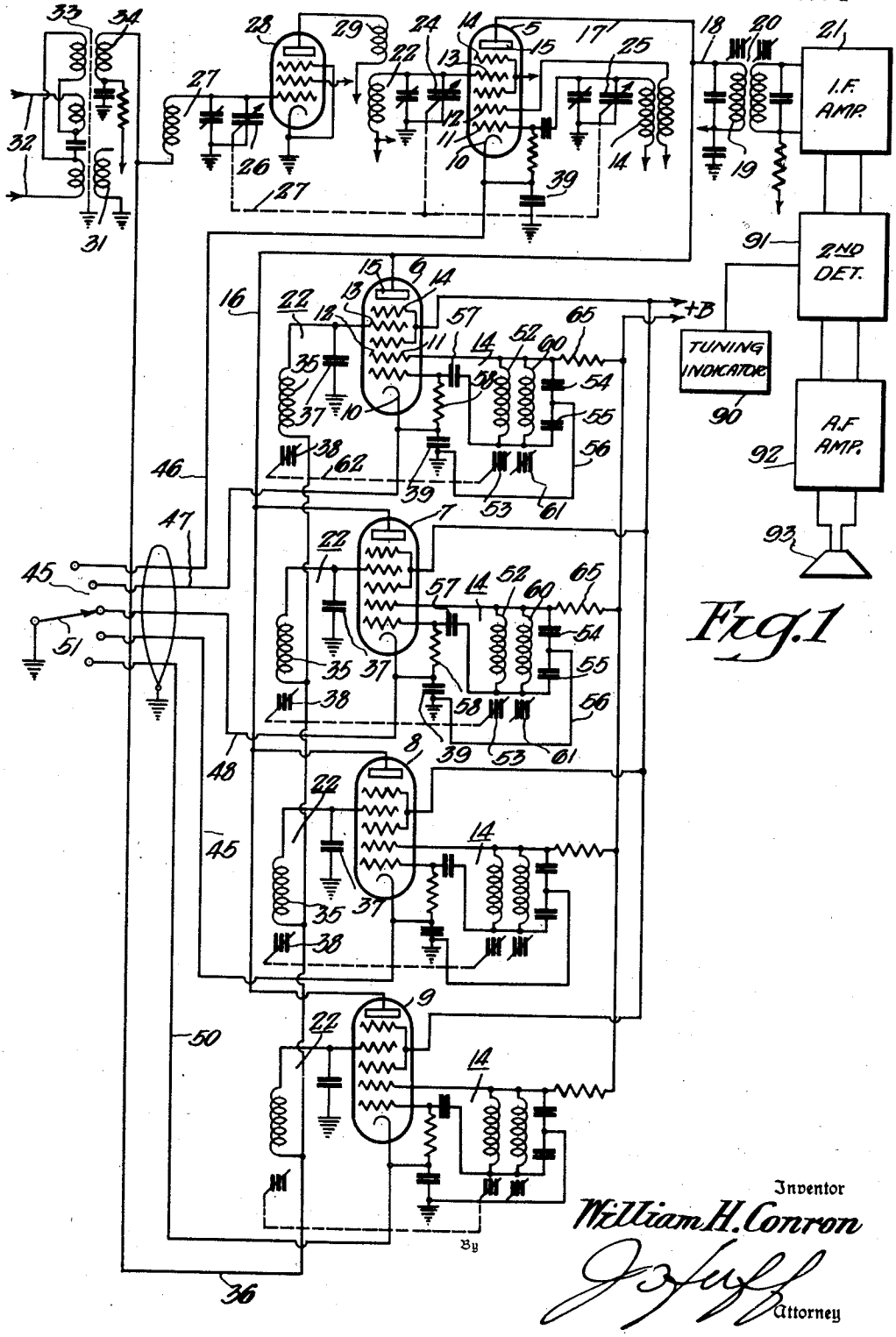


Fig. 1

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Fig. 2.

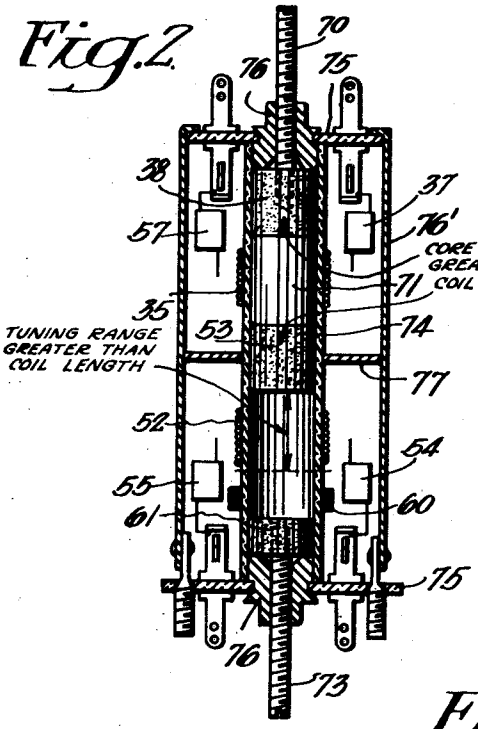


Fig. 3.

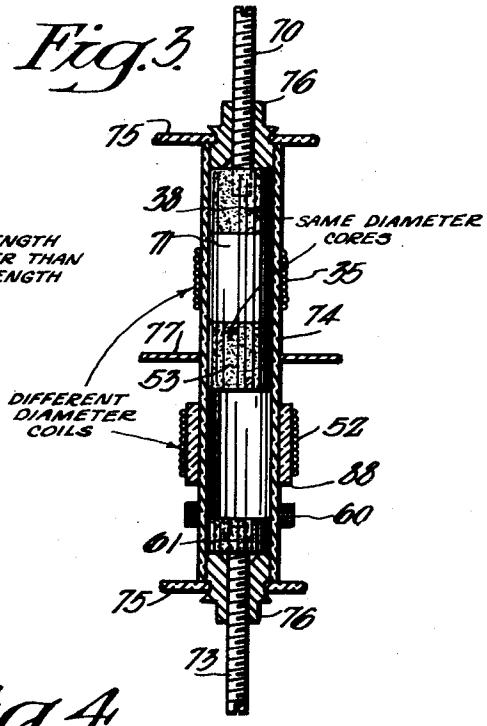
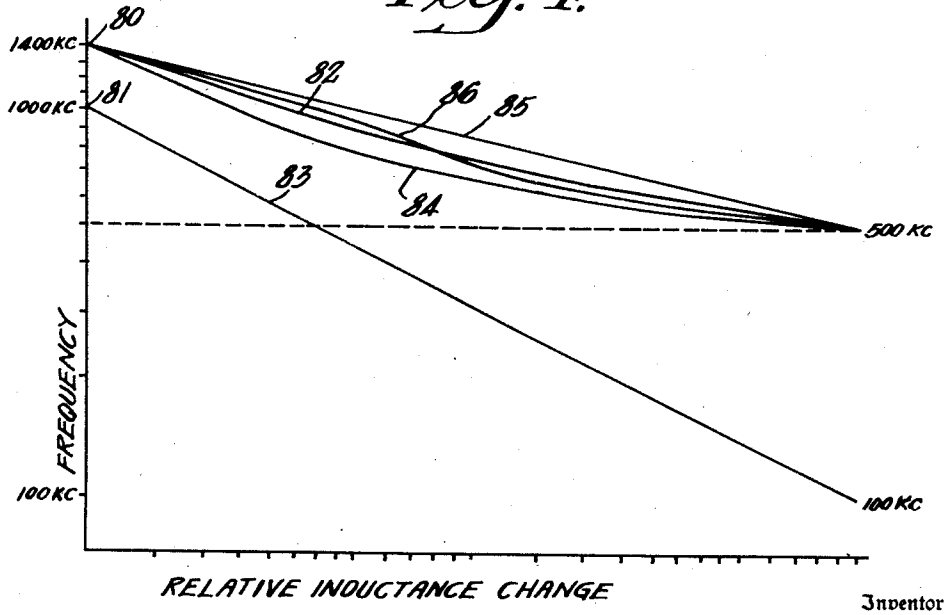


Fig. 4.



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Patented Nov. 25, 1941

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UNITED STATES PATENT OFFICE

2,263,613

UNICONTROL VARIABLE INDUCTANCE TUNING SYSTEM

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Application March 31, 1939, Serial No. 265,280

5 Claims. (Cl. 250—40)

The present invention relates to unicontrol variable inductance tuning systems of the type shown generally in United States patents to Roberts 2,034,773 and Beers 2,037,754, for maintaining substantially a constant frequency relation between two or more tunable signal circuits when tuning said circuits through predetermined frequency ranges. The circuits are tuned by unicontrol means comprising variable inductances having movable core elements connected for simultaneous movement and adjustment.

The present invention is more particularly adapted for unicontrol tuning, of the type referred to, for radio frequency and oscillator circuits of a superheterodyne receiver, whereby substantially a constant frequency difference between the two circuits may be maintained throughout a predetermined tuning range to provide a desired intermediate frequency, and has for its primary object to provide an improved unicontrol tuning means of the variable inductance, movable core type for that purpose.

It is also a further object of the present invention to provide an improved variable inductance tuning means for a plurality of circuits of the unicontrol movable core type, which may provide a relatively wide inductance variation by reason of a predetermined optimum relation between the core length, inductance coil size, and the length of travel of the core in tuning.

It is a still further object of the present invention to provide an improved unicontrol variable inductance tuning means for a superheterodyne receiver of relatively small size, that may be manufactured at low cost, and may provide more accurate tracking between two tunable circuits whereby the said tunable circuits may be tuned at all times to substantially the same frequency or to frequencies differing from one another by substantially the same amount, throughout a predetermined tuning range.

The invention is further particularly adapted for aligning the preselection tuning circuits of a superheterodyne receiver of the type shown in my U. S. Patent 2,173,898 with W. L. Carlson, for Signal radio receiving systems, filed March 31, 1938, Serial No. 199,086, and assigned to the same assignee as this application.

In the application referred to, a system for preselection tuning is shown, described and claimed, wherein each one of a plurality of separately tunable converter stages feeding into a common I. F. amplifier is selectively energized to provide signal response at one of a plurality of differing selectable frequencies in a predetermined frequency band, the frequency response being determined by the tuning of the oscillator and R. F. grid circuits of the respective converter stages.

In the said application, more specifically, the first detector and oscillator or converter stages, selectively operable by energizing the respective cathode circuits, are each provided with tunable oscillator and signal circuits having movable magnetite cores for variable inductance tuning to differing signal frequencies in a relatively wide frequency band.

In a radio receiver of that type, it is a further object of the present invention to provide an improved tuning system whereby preselection tuning by said movable cores may be simplified and adapted for accurate unicontrol adjustment.

The present invention is particularly adapted for tuning the oscillator and detector grid circuits for each selector stage, and has for its further and more specific object to provide improved means whereby both grid circuits in each stage may conjointly be tuned through predetermined frequency ranges with substantially a constant frequency difference, thereby facilitating setting up the system for the reception of preselected signals or broadcasting stations.

It is also a further object of the present invention to provide an improved variable inductance tuning system wherein an improved R. F. transformer having adjustable magnetite or movable core tuning which may be utilized in both R. F. and oscillator circuits, and which is adapted for combining said circuits in one shielded unit, with the cores ganged for unicontrol adjustment.

The invention will be described herein in connection with a receiving system of the type above referred to, and its scope will be pointed out in the appended claims. For a further consideration of the invention, attention is now directed to the following description in connection with the accompanying drawings, in which

Figure 1 is a schematic circuit diagram of a radio receiving system provided with tuning means embodying the invention;

Figure 2 is substantially a full-size view partly in cross-section, of a unicontrol variable inductance tuning device in certain of the circuits of Fig. 1, and embodying the invention;

Figure 3 is a similar cross-sectional view of the device of Fig. 2 showing a modification of a portion thereof; and

Figure 4 is a series of curves illustrating certain tuning characteristics of the circuits shown

in Fig. 1 and of the tuning devices shown in Figs. 2 and 3.

Referring to Fig. 1, a superheterodyne radio receiving system comprises a plurality of first detector or converter tubes 5–9, inclusive, each comprising a cathode 10, an oscillator grid 11, an oscillator anode electrode 12, a signal input grid 13, a screen 14 therefor, and an output anode 15.

The system is arranged for remote control and preselection tuning through a plurality of tuned signal channels or stages containing the several converter tubes and suitable individually tunable input and oscillator circuits therefor, as hereinafter described. The anodes 15 of the converter tubes are connected in parallel through circuit leads 16 and 17 with a common output circuit 18 including the primary 19 of a tuned intermediate frequency coupling transformer 20 for an intermediate frequency amplifier indicated at 21.

The converter tubes are provided with separate tuned input circuits indicated at 22, for the signal input grids 13 and with separate tuned oscillator circuits 14. In the case of the converter 5, the signal input circuit 22 and the oscillator circuit 14 therefor are tuned by variable capacitors indicated at 24 and 25, respectively. The latter are connected for unicontrol operation with a third variable capacitor 26, as indicated by the dotted connection line 27, and provide for variably tuning the receiving system throughout a predetermined frequency range such as the broadcast band. The capacitor 26 tunes an R. F. input circuit 27 in connection with an R. F. amplifier tube 28 which is coupled as indicated at 29, to the detector input circuit 22.

The R. F. amplifier 28 and the converter 5 are those normally provided in a superheterodyne receiver, forming the main signal channel thereof and being variably tunable throughout the tuning range of the receiving system. The R. F. input circuit 27 is coupled to a signal source in any suitable manner. In the present example, it is coupled with a signal input circuit 32 through a coupling transformer indicated at 33. The winding 31 is one of the secondaries of the transformer 33 for short wave reception and, since this does not concern the present invention, the connections therefor are not shown or described.

A secondary 34 of the transformer 33, however, provides a low impedance series connection to ground for the R. F. circuit 27 and the inductance elements 35 of the signal input circuits 22 of the additional converter tube 6–9, inclusive. These inductance elements are connected at their low impedance ends through a lead 36, to the coupling winding 34. The windings 35 are each tuned within a predetermined frequency band by a shunt capacitor 37 connected between the high potential grid end of each winding and ground whereby the winding 34 is included in common with each tuned circuit.

The inductances 35 are also adjustably tuned within each band by movable core elements indicated at 38.

The converters 6–9, inclusive, together with the main converter 5 are arranged so that any one of the cathodes 10 may be grounded through extended selector leads 46–50, inclusive, and a selector switch 45 having a grounded selector contact 51, to select and energize a converter and cause it to operate to receive signals at the frequency to which its input circuit is tuned, thereby providing a plurality of selective circuits tuned to differing signals through the converter stages 6–9, inclusive, and to any signal within the broadcast band by means of the variably tunable converter 5.

In order to maintain the cost of a preselector tuning system, of the type shown, at a minimum, the oscillator as well as the input circuits are arranged and designed so that they may be tuned over the limited ranges referred to, by moving the core elements of the tuning inductances therein. The tuning range for each unit is made as wide as possible in order to reduce the number of units that may be required to cover a given frequency range such as the broadcast band, for example. It has been found that four units are sufficient to cover the said band from 540 to 1600 kc. with sufficient overlap.

In the oscillator circuits for the converters 6–9, inclusive, the tuning is accomplished by means of variable inductors 52, each having a movable core element 53 by which it is adjustably tunable, and shunt tuning capacity provided in the present example by two series-connected capacitors indicated at 54 and 55. By connecting the cathodes to the midpoints between the capacitors through ground leads 56 and the by-pass capacitors 39, and by connecting the oscillator grids and anodes to opposite ends of the respective inductances 52, Colpitts type oscillator circuits are provided without requiring cathode taps on the tuning inductances. It will be noted that the oscillator grids are provided with the usual grid capacitor and leak connection indicated at 57 and 58.

The oscillator circuits 6–9, inclusive, are also provided with shunt trimmer inductances 60 for the inductances 52, which are also of the movable core, adjustably-tunable type, the cores being indicated at 61. For the purpose of tuning the oscillator and input circuits of each converter tube conjointly by a single control element, the variable or movable cores 38 and 53 are interconnected as indicated by the dotted line 62, for unicontrol adjustment.

Referring now to Fig. 2 along with Fig. 1, the same reference numerals are used to indicate like parts throughout, with particular reference to the oscillator and signal input circuits of the converter tube 6–9, inclusive.

As indicated in Fig. 2, it has been found to be practicable to make the signal input and oscillator inductances 35, 52 and 60 conform in size to the usual intermediate frequency transformer, whereby the same size shield may be provided in connection with them. Furthermore, it has been found that a greater range of tuning adjustment may be obtained in the same space and with the same size movable core if the windings are provided in the form of single layer solenoids, as shown, instead of the usual multi-section universal winding. The solenoid winding is also less costly to manufacture and is less subject to production variations.

In regard to the relation between the core length, the inductance core size and the length of travel of the core in tuning, it has been found that with a core of magnetite material, the maximum range for a given core is obtained when the coil length is substantially 80 percent of the core length and the travel of the core axially into the coil is substantially equal to the length of the core. Therefore, the choice of length of core, the approximate size of the coil or inductance winding, and the travel of the core resolves it-

self into a consideration of the space available, and for modern receiving systems and the like this is preferably reduced to a minimum.

For the tuning capacitors used in connection with the type of coils or inductance windings shown, it is preferable to utilize standard value fixed capacitors in the positions, for example, as indicated at **37**, **54** and **55**. While a tuning range of over 1.7 to 1 in frequency change may be obtained with the construction shown in Fig. 2, for example, the standard fixed capacitors available are held only to a certain limit on either side of their nominal value, such as plus or minus 10 percent, so that the maximum range which may be depended upon from a tuned circuit may be reduced to substantially 1.54 to 1 and possible variations in the coil and core may reduce this range to substantially 1.46 to 1. However, it has been found that four channels or converter stages, such as indicated at **6–9**, inclusive, are sufficient to cover the present broadcast band.

The design of the oscillator coils and circuits involve a consideration of frequency stability. It has been found that the effect of line voltage variations on the oscillator stability may be reduced appreciably by providing resistance means in the order of 100,000 ohms in the plate supply leads of the various oscillator circuits, as indicated by the resistors at **65**. With this arrangement the oscillators were found to shift less than .1 percent with a shift in line voltage of from 130 to 90 volts.

Since the oscillator circuits are normally tuned above the signal input circuits by the amount of the intermediate frequency, such as 400 to 460 kc., for example, any design that may cover the tuning range as an input inductance may also cover the tuning range as an oscillator coil.

In order to simplify the procedure in adjusting the signal input and oscillator circuits of the various converted tubes for the reception of signals at differing predetermined frequencies and to simplify the construction of the apparatus and to lower its cost, the signal input and oscillator circuits for each channel or each converter tube are placed in the same container or shield and arranged to be adjusted by the movement of a single control element as further shown in Fig. 2.

In the complete tuning unit for one tube as shown in Fig. 2, both the cores **38** and **53** are operated by the same adjusting screw **70**. The adjusting screw is secured to or molded into the end of one of the core elements and extends axially therefrom as shown and the other core is joined with the first core in axially spaced relation thereto, by an insulating body or core element **71** which is moulded between the main core elements. This insulating member may be constructed of moulded insulating material and the core elements may be of moulded magnetite material, whereby both the cores and the insulating member may be moulded preferably in one cylindrical form or body, as shown, and all being substantially the same diameter to slide freely in the coil form **74**.

In the preferred embodiment shown, the two magnetite cores **38** and **53** are substantially ½ inch long, separated by the insulating member **71** which is substantially ¾ inch long. The magnetite cores are shown in their extreme withdrawn position from the coils **35** and **52** with which they are associated respectively. The coils may consist of 80 turns of No. 36 enamel covered wire. This arrangement and design provides for tuning in the broadcast band with the maximum possible tuning variation range.

In order to make the tuning units better adapted for testing and production and easier to adapt to different receivers, the variable portions of the signal input and oscillator coils are made substantially alike. Also with the view to lowering cost and reducing the number of different units required, the same size coils for all of the channels for both the oscillator and signal input circuits is provided and the difference in frequency established for the various circuits is initially determined by changing the value of the fixed capacitors used in conjunction therewith, for example at **37** and **54—55** in the circuit of Fig. 1. As previously noted, the use of the series capacitors **54—55** on the oscillator coil eliminates the necessity for tapping the coil to provide the cathode connection.

Furthermore, the tracking of the oscillator with the signal input circuit is made to be exact at only two points in the tuning range instead of the usual three points because of the small range that is required to be covered with each unit, that is, substantially one-fourth of the broadcast range, in the present example. The method for causing the oscillator and signal input circuits to track properly for each converter tube with the gang or unicontrol tuning arrangement for the two cores, consisted in using a fixed or adjustable inductance **60** shunted directly across the variable inductance of the oscillator and a suitable fixed capacity **54—55** which is sufficiently large to make up for the loss in inductance to bring the circuit into the desired frequency range. With this arrangement the maximum deviation of the oscillator between the two line-up points was less than 2 kc. below the correct oscillator frequency.

It will be noted that the shunt inductance **60** is included in the tuning unit at the opposite end from the adjustable element **70** and that the movable core member **61** therefor is provided in a similar manner to the other cores, with an adjusting screw **73**.

In the construction shown in Fig. 2, the inductance windings **35** and **52** are wound on the common tubular coil form **74** which is secured to insulating end plates **75** by end plugs **76** tapped axially to provide bearings for the adjusting screws **70** and **73**.

The shunt inductance **60** is also mounted on the coil form and may be of the multi-layer type, as indicated, and since it is connected in parallel with the inductance winding **52** it may be placed adjacent thereto. The casing **76'** for the unit is of metal and is provided with a central shield ring **77** surrounding the coil form **74** between the windings **35** and **52** to prevent radiation of oscillations from the oscillator section of the tube through the signal input circuit to the antenna circuit.

The capacitors **54** and **55** and the capacitors **37** and **57** may also be included within the tuning unit as indicated in Fig. 2, so that both the oscillator and input circuits are included substantially wholly within the shield casing.

Assuming a predetermined frequency difference between the two circuits of any one of the converter tubes, such as 400 kc. for example, as a desired intermediate frequency, the windings are tuned initially to this frequency difference at 1400 kc., for the oscillator and 1000 kc. for the signal input circuit, as indicated in Fig. 4 at the

points **80** and **81**, respectively, on the curves **82** and **83**, which indicate the ideal tracking of the oscillator at **82** with the signal input circuit at **83** in tuning over the range of from 100 to 1000 kc. These curves are plotted between frequency and relative inductance change. It will be noted that substantially a constant frequency difference of 400 kc. is maintained throughout the range.

The ideal tracking curve **82** for the oscillator is approximated in the response curve **84** which indicates the result obtained when a shunt trimmer inductance **60** is employed in conjunction with the main oscillator winding **52** in the arrangement shown in Fig. 2 when incorporated in the circuit of Fig. 1.

If the oscillator variable tuning inductance **52** is spaced from its core, by reducing the core diameter or by winding the inductance **52** on a slightly greater diameter than the signal input winding **35**, as indicated in the modification shown in Fig. 3, the rate of change of inductance of the oscillator will be less than that of the input circuit and the response curve **85** of Fig. 4 will result. The curves **84** and **85** fall on opposite sides of the ideal curve **82**. The use of a greater diameter coil of the same length as the R. F. coil, causes the oscillator tuning curve to be slightly too high between the two line-up points at the low and high frequency ends of the tuning range, while the use of the shunt coil tends to make the oscillator tuning curve too low between the two line-up points, although in either case the line-up may be kept within practical limits of satisfactory operation. The curves **84** and **85** are drawn with the departure from the ideal curve somewhat exaggerated in order to show the tendency of the change more clearly.

In providing the method for tracking as shown in the unit of Fig. 3, the oscillator inductance **52** is wound on a sleeve **88** placed between it and the coil form, and the tracking or shunt inductance **60** is also provided. The tracking curve for the oscillator assumes a form somewhat as shown at **86** in Fig. 4 and more closely approximates the ideal curve **82** by crossing this curve, so that the departure therefrom is only slightly higher over a certain portion of the tuning range and only slightly lower over the remaining portion of the tuning range, than the desired frequency characteristic **82**.

The shunt tracking coil **60** for the oscillator is made relatively high in inductance value with respect to the main oscillator tuning inductance, and the lowering of the overall inductance of the circuit is compensated by the shunt capacitance in each circuit.

In one embodiment of the invention, the tuning bands within the broadcast range as provided by the converter stages 6–9, inclusive, and the values of the shunt capacitors for the R. F. or signal input and the oscillator circuits may be as shown below:

Frequency band	R. F. or signal input coil	Oscillator coil (each capacitor)
Kilocycles	*Micromicrofarads*	*Micromicrofarads*
530- 770	835	874
690- 970	464	651
880-1280	276	435
1135-1640	162	245

The four control units are preferably placed in the front portion of the receiver chassis or other apparatus in which they are employed in such a manner as to make them readily accessible for adjustment and are preferably mounted vertically as shown in the drawings. It will be noted that the coil length in the devices of Figs. 2 and 3 in each case is substantially 80 percent of the core length, and the travel of the core in each case in fully entering the winding is made substantially equal to the length of the core, which has been found to provide a maximum change of inductance or tuning range. Also, the longer the core used under those conditions, the greater the range obtained.

By retaining the normal variable capacitor tuned input circuits as a fifth channel, any broadcasting station or desired signal may be tuned in by the variable capacitors **24**, **25** and **26** when the cathode of the converter tube **5** is energized. Any selected converter stage may then be tuned to the same station after energizing the proper tube. After tuning, the same signal or station may be selected at will thereafter by the selector switch **45**.

Each channel may similarly be preset to a different station or signal and thereafter any one of the selected signals may be received by operation of the selector switch **45**. In order to facilitate tuning in of the preselected signals, a suitable tuning indicator **90** may be included in the receiving system. In the present example this is indicated in connection with the second detector at **91**, following the intermediate frequency amplifier **21**.

The receiving system is provided with the usual audio frequency amplifier **92** and output device such as the loudspeaker **93**. Since the main signal channel through the tubes **28** and **5** and the amplifier **21** is variably tunable throughout the broadcast band, it is possible to preset two broadcasting stations or signals 10 kc. apart at any point in the broadcast band.

By utilizing a unitary tuning device for the R. F. input and oscillator circuits of each converter tube for the additional channels, as shown in Figs. 2 and 3, for example, the addition of preselection remote control to an existing radio receiver or the incorporation of such control in a production receiver is greatly facilitated and simplified since, as pointed out, the main tuning inductances are all wound to the same value and adjusted initially by differing fixed shunt capacitors. The tracking of the circuits is then maintained substantially uniform as described, by the combination of the difference in diameter of the two windings in the main tuning circuits for any one stage and the operation of the shunt trimmer inductance for each oscillator circuit. In any case, however, the two circuits which are to be aligned for unicontrol operation are each provided with a tuning inductance having a movable core and a third inductance of relatively high inductance value is placed in parallel with one of the tuning inductances for maintaining substantially a constant frequency difference in the tuning of the two circuits.

I claim as my invention:

1. A unicontrol tuning system for high frequency signal circuits comprising in combination, a plurality of solenoid tuning inductances for said circuits, two of said inductances being of different diameters, means providing substantially equal movable magnetic core elements associated therewith for varying said inductances, said elements being connected for simultaneous movement and adjustment, each having a length greater than that of the solenoid inductance associated therewith, means for moving said core

elements with respect to said inductances with a range of movement substantially equal to the length of one of said core elements, and means providing fixed capacitance and a fixed inductance directly in parallel with the larger diameter one of said two tuning inductances and fixed capacitance in shunt with another of said tuning inductances for improving the tracking relation in the tuning of said circuits.

2. A unicontrol tuning system for high frequency signal circuits comprising in combination, a plurality of variable inductances comprising solenoid windings and movable magnetic core elements for said windings, said elements being connected for simultaneous movement and adjustment with respect to said windings, the length of the solenoid windings being substantially equal to each other and of the order of 80 percent of the length of said core elements, and the length of travel of the core elements with respect to said windings being at least equal to the length of one of said core elements.

3. A variable inductance tuning system for two high frequency signal circuits, comprising in combination, two different diameter solenoid windings, tuning core means movable with respect to said solenoid windings and including spaced sections of magnetic material, the length of said sections being somewhat greater than the length of said windings and substantially equal to the length of travel of the core in tuning, whereby a relatively wide inductance variation of said windings is provided by movement of the core means, a high inductance winding connected directly in parallel with the larger diameter one of said first named windings, movable magnetic core means for adjusting said last named inductance winding to adjust the relative frequency response of said first-named windings at one end of a predetermined tuning range, and means providing a shunt capacity across said one winding for compensating the inductance loss due to said parallel winding connection.

4. A frequency converter tuning system comprising in combination, oscillator and signal circuits, an oscillator circuit tuning inductance and a signal circuit tuning inductance of the solenoid type, the oscillator inductance being of larger diameter, two movable substantially equal magnetic tuning core elements associated with said inductances in spaced relation to each other, said core elements each being longer than the inductance associated therewith means for moving said core elements relative to said inductances substantially the length of said core elements to provide a predetermined tuning range, and means for causing the tuning of said oscillator and signal circuits to track throughout said predetermined tuning range comprising a third inductance connected directly in parallel with said oscillator circuit tuning inductance, means for adjusting said third inductance comprising a movable core element therefor, and means providing a fixed capacity connected directly in parallel with each of said first named inductances for adjusting the initial frequency relation in the tuning of said circuits.

5. Unicontrol tuning means for radio signal circuits comprising in combination, two variable inductances of the solenoid type, one being of larger diameter than the other, means providing substantially equal movable magnetic core elements for said inductances, said elements being connected for simultaneous unitary movements and adjustment, an inductance element connected directly in parallel with the larger diameter inductance, and movable core means for adjusting said last-named inductance element to adjust the relative frequency response of said windings at one end of a predetermined tuning range.

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