June 20, 1939. J. L. MILLER 2,163,051

SIGNALING SYSTEM

Filed March 21, 1938 2 Sheets-Sheet 1

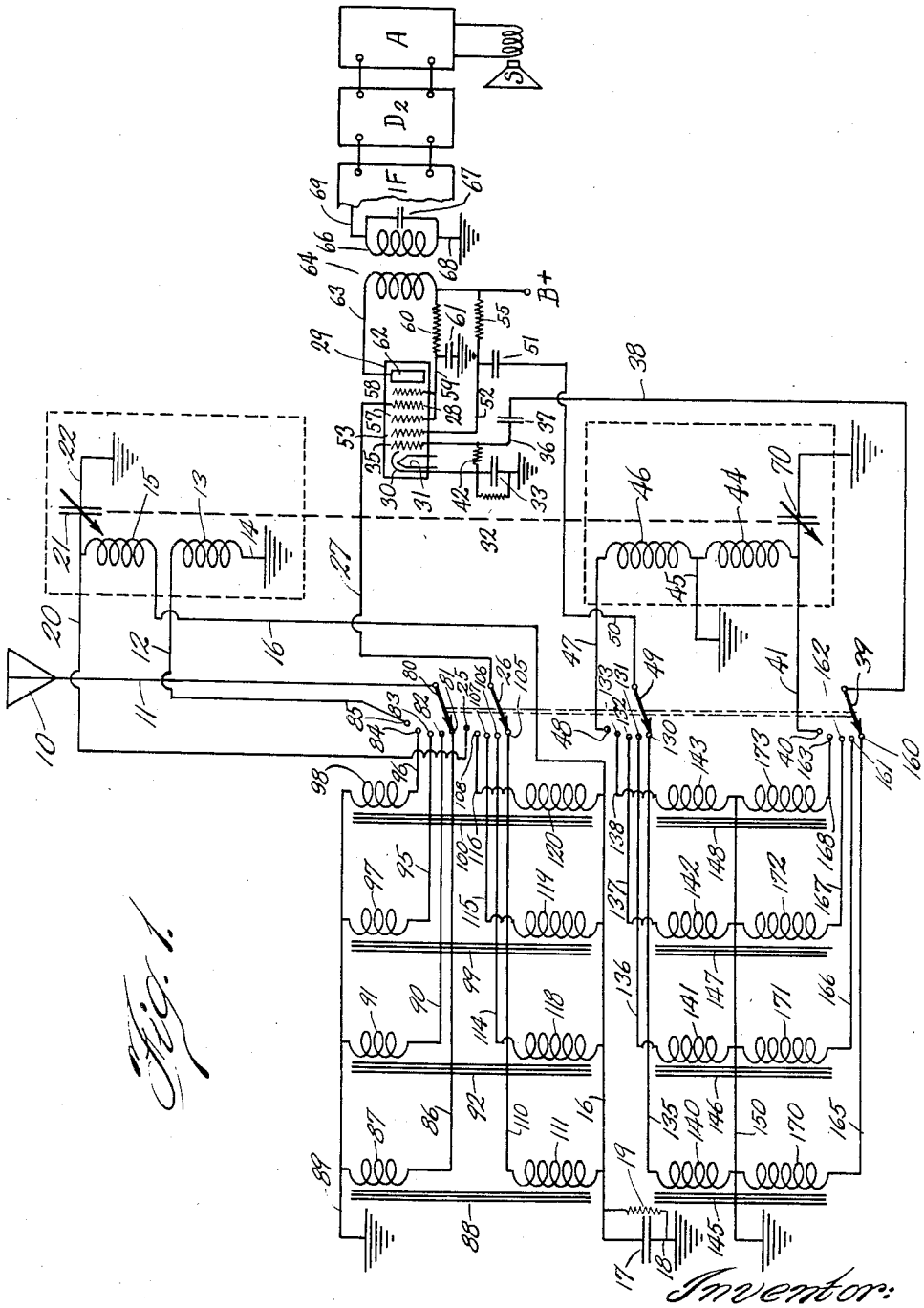



Fig. 1.

Inventor:
Joseph L. Miller
By Robert L. Kahn Attty.

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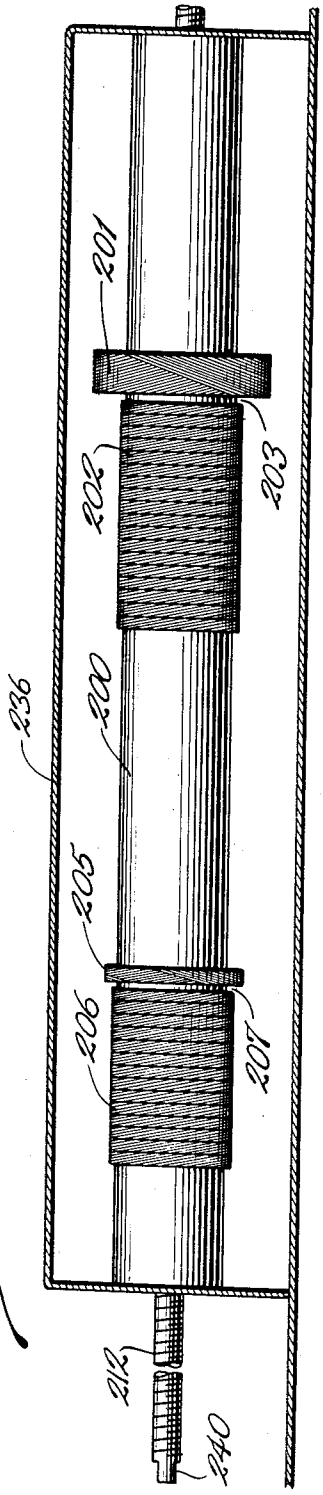



Fig. 2.

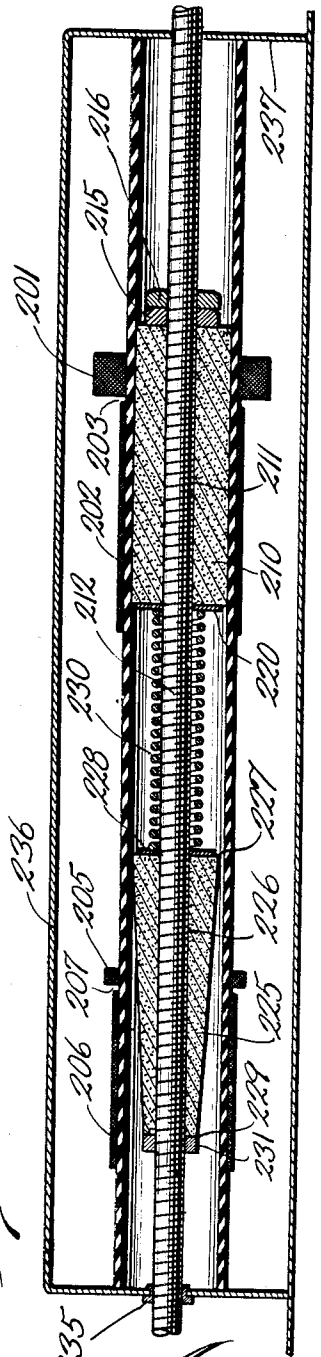



Fig. 3.

Inventor:
Joseph L. Miller
By Robert L. Kahn Atty.

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# UNITED STATES PATENT OFFICE

2,163,051

## SIGNALING SYSTEM

Joseph L. Miller, Oak Park, Ill., assignor to Traveler Radio & Television Corporation, Chicago, Ill., a corporation of Illinois

Application March 21, 1938, Serial No. 197,069

2 Claims. (Cl. 250—20)

This invention relates to a signaling system and has particular application to adjusting a system for making it selectively responsive to one or more signal frequencies. In particular, the invention has special application to radio receivers of the superheterodyne type. In receivers of this character, where the receiver is to operate over a wide frequency spectrum, it has been the custom to tune the receiver by varying the capacitance of circuits. Thus, in receivers of this type, a gang condenser is generally used having sections in the radio frequency amplifier stages and one section in the oscillator circuit. Such receivers as a rule have gang condensers, with each condenser section arranged to track with the remaining sections, and the entire gang continuously movable over the operating range of the receiver. It has been found that in most instances the receiver is tuned to a selected few frequencies representing local broadcasting stations. Hence, it is desirable that simple manual means be provided for quickly and accurately picking out these stations rather than have the operator go through the necessity of tuning the gang condenser manually.

A variety of means have been proposed for accomplishing this. Generally speaking, one system contemplates mechanical means operating on the gang condenser which automatically turns the gang condenser to one or more selected positions. Another means contemplates the disposition of a plurality of padding condensers in place of the gang condenser. The inductances of the receiver are used either in connection with such condensers or with the gang condenser. The disadvantage of these padding condensers lies in the fact that it is impossible in practice to endow each selector unit with enough operating range to cover the entire range of broadcasting. In other words, each padding condenser by itself cannot be adjusted at any one spot over the entire range covered by the gang condenser.

By the invention herein disclosed, a completely alternative circuit including inductance and capacity is obtained, which circuit is alternative to the gang condenser circuits and which alternative circuits may be adjusted to any desired frequency over the entire broadcast range. Each such preselector unit is independent of the others and may therefore be adjusted to any desired frequency within the operating range of the receiver as a whole. In order to make such a preselector unit compact, I preferably provide substantially constant capacitance for each preselector circuit and vary the inductance. To make such units efficient and compact the inductance preferably has as part thereof a core of iron dust.

While cascaded radio frequency stages with tunable inductances have been proposed, such proposals have been restricted to circuits wherein the inductance and capacitance of each circuit are equal. In the present invention it is contemplated to disposed such a tunable inductance in the oscillator circuit as well as the radio frequency circuits. Inasmuch as the frequency difference between these two must remain substantially constant at all times over the operating range of the receiver, it is necessary to adjust the inductance variation of the oscillator with reference to inductance variation of the radio frequency circuit to permit two circuits to track.

At resonance the inductive reactance of a circuit is substantially equal to the capacitative reactance. The latter is proportional to the reciprocal of the capacitance so that in order to keep the inductance values of the circuits up to workable ranges, it is necessary to keep the capacitance to a minimum. This is particularly important at the low frequency end of the broadcast band, namely, 500 kc.

Thus, considering one radio frequency stage and the oscillator circuit as one preselector unit, it is clear that each one of these circuits may be tuned with an inductance variation per unit frequency change which may be considered as normal or standard. The other circuit will therefore have to have its tuning variation so adjusted with reference to the first circuit that both circuits will track to keep a constant frequency differential. Inasmuch as the radio frequency stages are the same, it is clear that any duplication of the radio frequency stages would not change the nature of this problem. It is true that the first stage might have somewhat different constants than the succeeding radio frequency stages as capacity for antenna tuning. However, all such circuits are resonant to the same frequency so that equal variations of inductance could be relied upon to produce equal effects.

In general, the radio frequency stage is provided with an iron core of uniform dimension. By moving this core in and out of the transformer, the inductance of the entire circuit is varied in a predetermined manner. If this is considered as a standard, then the inductance of the oscillator transformer is provided with a core whose shape varies throughout the length thereof. Hence, the

physical movement of the oscillator core may be related in some straight line manner with the movement of the radio frequency transformer core, but the inductance variation of the oscillator circuit will be caused to vary in a different manner so that both transformers will track. Obviously, this may be reversed so that the oscillator transformer core is assumed to be standard and the radio frequency transformer core shaped accordingly. It is also possible to shape both of the transformer cores, although this is more difficult.

The invention will be described in further detail in connection with the drawings wherein:

Figure 1 is a diagrammatic representation of a radio receiver employing the invention.

Figure 2 is an elevation of a preselector unit.

Figure 3 is a section through the preselector unit lengthwise thereof.

Referring to Figure 1, an antenna 10 is provided with a lead-in 11 finally connected through arm 80 and switch point 85 to the terminal 12 of a radio frequency transformer primary 13 whose other end 14 is grounded. Secondary 15 of the transformer has one end connected to a line 16 which is connected to a condenser 17 shunted by a resistance 19 and grounded at 18. The other terminal of secondary 15 is connected to a line 20 which goes to one terminal of a variable condenser 21 grounded at 22.

The output of this radio frequency stage is fed by line 20 through a switch contact 25 and a switch arm 26 of which more will be said later, to line 27. Line 27 is connected to the grid 28 of a vacuum tube 29 which is adapted to function both as an oscillator and first detector. Vacuum tube 29 is provided with a cathode 30 heated by a suitable filament 31. Cathode 30 is grounded through a bias resistor 32 which is shunted by a by-pass condenser 33. A modulating grid 35 is connected by line 36 to a condenser 37 and thence by line 38 through switch arm 39 and contact 40 to line 41 of an oscillator circuit. The modulating grid itself is biased by a resistor 42 connected by line 36 to the cathode lead.

The oscillator comprises a grid coil 44 whose one terminal is connected to line 41 and whose other terminal is grounded by line 45. The plate coil 46 which is in inductive relation to grid coil 44, and together therewith forms a transformer, is connected by line 47 through switch point 48, switch arm 49 and lead 50 to a blocking condenser 51 and thence to lead 52 of oscillator anode 53. Lead 52 is connected through a bias resistor 55 to any suitable source of potential B+. Grids 57 and 58 are connected by a line 59 and bias resistor 60 to B+. Lead 59 is also grounded, as far as radio frequency impulses are concerned, through a by-pass condenser 61. The anode 62 of the vacuum tube 29 is connected by a lead 63 to the primary 64 of an intermediate frequency transformer. Primary 64 has its other terminal connected to the B+ terminal. Secondary 66 of the intermediate frequency transformer may be tuned by a condenser 67 in parallel therewith and both are connected by ground 68 and an input line 69 leading to the remaining intermediate frequency portion of the system. From there on intermediate frequency output is fed to the second detector D2 and thence, if necessary, to a suitable audio frequency amplifier A to be finally reproduced in a speaker S.

The oscillator grid circuit is adjusted by a variable condenser 70 connected by lead 41 and ground. Condensers 70 and 21 are two sections of a gang condenser and may be so shaped and so adjusted as to be susceptible to simultaneous movement. The radio frequency portions of the receiver and oscillator shown as enclosed in dotted lines in connection with the entire receiver as described is conventional. If desired, the single vacuum tube 29 may be broken up into two separate tubes comprising an oscillator and first detector or any other system of mixing may be employed. It is understood, of course, that the switch arms 26, 49 and 39 are adapted to engage the respective switch points in order to complete the circuits. When these switches are in this position, the entire receiver is adapted to be tuned manually by variable condensers 21 and 70.

In order to provide the receiver with preselector units, the remaining transformers, hereinafter described, together with their switching mechanism is provided.

Antenna lead 11 is connected to a switch arm 80 which is adapted to play over switch points 81 to 85 inclusive. Switch point 81 is connected by a line 86 to the primary coil 87 of a transformer 88. Primary 87 has its other terminal connected to a grounded line 89.

Switch point 82 is connected by line 90 to the primary 91 of a transformer 93 whose other terminal is connected to grounded line 89. Similarly, switch points 83 and 84 are connected respectively by lines 95 and 96 to the primaries 97 and 98 of transformers 99 and 100 respectively whose other terminals are connected to grounded line 89.

Switch arm 26 is adapted to play over points 105, 106, 107, 108 and 25. Point 105 is connected by line 110 to the secondary 111 of transformer 88 and the other terminal of this secondary 111 is connected to line 16. Similarly, switch points 106, 107 and 108 are connected respectively by lines 114, 115 and 116 to secondaries 118, 119 and 120 of transformers 93, 99 and 100. All these secondaries are connected through to line 16.

It will be noted that each transformer 88, 93, 99 and 100 forms a complete alternative radio frequency transformer which may be used in place of the radio frequency stage in the dotted rectangle.

Switch arm 49 is adapted to play over switch points 130, 131, 132, 133 and 48. Each of the switch arms 130 to 133 inclusive is connected by lines 135, 136, 137 and 138 to windings 140, 141, 142 and 143 respectively, each of said windings being part of transformers 145, 146, 147 and 148. The other ends of these various windings are all connected to a common line 150 which is grounded.

Switch arm 39 plays over points 160, 161, 162, 163 and 40. Points 160 to 163 inclusive are connected by lines 165, 166, 167 and 168 to windings 170, 171, 172, and 173 respectively, each of these windings forming part of the respective transformers as shown. All these windings are connected to grounded line 150.

Switch arms 39, 49, 26 and 80 are all adapted to be moved together and to assume similar positions with reference to the switch points. When all the switch arms are moved to engage the upper contact points 85, 25, 48 and 40, the receiver is set for manual tuning by means of gang condensers 21 and 70. As shown, however, the switch arms are all contacting the lowermost contact points and in this position, the receiver

is adapted to have the last preselector section, namely, transformers 88 and 145 govern the operation thereof.

Each pair of transformers in vertical alignment of the preselector section is adapted to form a complete unit and since they are all alike, a detailed description of only one will be given. Referring to Figures 2 and 3, a long insulating hollow tube 200 is shown. Disposed at one portion of the tube is a winding 201 which may correspond to antenna coil 87. Disposed in inductive relation to winding 201 is a secondary 202 which may correspond to 111. These two windings are disposed as shown with the primary at the end of the secondary in order to obtain the desired transformer action. It is understood, of course, that the primary coil may be disposed in any other relationship to the secondary, such as directly over the center thereof or even inside thereof. In any event, both of these windings are so wound on that the distributed capacity of of the respective windings is a minimum.

In spaced relation to transformer 203 are windings 205 and 206 forming transformer 207 for the oscillator circuit. Thus, winding 205 may correspond to the grid winding 170 while windings 206 may correspond to the plate winding 140. Again these two windings are so designed that the distributed capacity is at a minimum value.

Disposed within transformer 203 is a core 210 preferably formed of molded iron dust. Inasmuch as such core materials are well known for radio work no further description thereof is necessary. It might be stated, however, that the iron particles are of extremely small size of the order of a few microns and are insulated from each other by the molding composition. Core 210 as shown herein is cylindrical and is adapted to fit within fiber tube 200 and be slidable within said tube. This core has a longitudinal bore 211 through which a long rod 212 passes. This rod is of brass or some non-magnetic material. A pair of lock nuts 215 and 216 are adapted to be disposed on rod 212 which is threaded and these lock nuts, of course, are of some non-magnetic material, such as brass. Disposed against the inside edge of core 210 is a brass washer 220. Cooperating with the oscillator transformer 207 is a core 225 also of molded iron dust. This core is provided with a longitudinal bore 226 through which rod 212 passes. The inside end 227 of core 225 has pressing against it a brass or other non-magnetic washer 228 and between this washer and washer 220 a coil spring 230 is disposed. This coil spring is of non-magnetic material and may be of brass or phosphor bronze. The outer face of core 225 has a nut 231 for adjusting the position of core 225 with reference to core 210. The entire assembly of cores on rod 212 is slidable within fiber tube 200 and may be longitudinally adjustable by turning rod 212 in a threaded bushing 235 carried by a metal container 236 in which the entire assembly is mounted. Rod 212 passes through the rear wall 237 of container 236 and is free to slide therein. It will be noted that the entire assembly of cores on rod 212 may be adjusted longitudinally so that both cores are practically free of the respective transformers to reduce the inductance to a minimum. As rod 212 is turned in bushing 235, both cores are moved longitudinally until in the position shown in Figure 3 the maximum inductive effects are obtained. It will be noted that both of the cores move simultaneously equal distances and in order to have tracking, core 225 is shaped as shown. The inner side 227 has a diameter somewhat smaller than the diameter of core 210. Core 225 drops down to the small end 229.

The transformers and their cores are designed as follows. Each transformer has a winding of not more than three banks or layers and preferably should have a ratio of length to mean turn diameter of at least two. In some cases by using extremely fine wire and carefully winding to keep the distributed capacity low, it may be possible to utilize a somewhat lower ratio. In practice, however, this ratio will be found the lowest workable one. The wires are so wound that the distributed capacity of the entire coil is very low. This may be done by any one of the well-known winding methods and is well-known in the art.

The two transformers are designed so that with air cores they operate at the upper limits of their respective frequency ranges. Thereupon the straight cylindrical core, in this case the radio frequency core, is designed with regard to density of iron and diameter so that when it is within the coil, the lowest frequency limit is reached. The core itself should be as long as the coil and preferably slightly longer by about five or ten per cent of the length of the coil. In this way the entire range will be adequately covered. This core may then be moved outside of the coil and just a short distance beyond to insure that the transformer is operating as an air core. In some cases some slight allowance might be necessary if the core still has some slight effect when moved to the inactive position. As a rule, the core in its inactive position has such a slight effect as to be scarcely measureable.

Assuming that the core above has been obtained for the radio frequency transformer, the same procedure is resorted to for the oscillator transformer. A core for this is designed so that when it is in the full position, the oscillator is operating at its lowest frequency. The oscillator core, which may be of a uniform cylindrical shape, is then moved out to its inactive position to insure that the oscillator is properly working. Thereafter, both cores are disposed in their most active positions with both transformers operating in their lowest frequencies. The radio frequency core is thereupon moved a measured distance out from the core to obtain a measured frequency change. Thus, for example, the radio frequency core might be moved a measured distance to obtain a change of 10 kilocycles. Thereafter the oscillator core is moved a distance sufficient to change the oscillator frequency by the same amount, in this case 10 kilocycles. This procedure is resorted to to cover the entire range so that the ratio of oscillator core displacement to radio frequency core displacement is plotted for predetermined frequency increments. This procedure gives the ratio of effective core masses necessary in the two transformers. In other words, if the oscillator core must be moved half the distance between two frequencies in comparison to the radio frequency core, it is clear that the rate of change of the oscillator core volume at that particular frequency is half as great as for the radio frequency core. From this table the core shape of the oscillator may be plotted, it being merely necessary to keep the original oscillator cylindrical core volume and translate the irregular (with respect to the radio frequency core) displacements into irregular volume changes.

In this connection, the effectiveness of the core varies as a square of the ratio of the mean coil diameter to the core diameter. To that extent, therefore, the transposition of irregular displacement to irregular diameter of the oscillator core is not strictly accurate. However, it is found that other factors tend to compensate. Thus, for example, the increase in inductance with frequency tends to off-set the decrease in inductance due to reduction in the average diameter of the oscillator core. Another factor which is helpful is the relative shapes of the resonance curves for the oscillator and radio frequency transformer. The resonance curve for the oscillator is extremely sharp while the resonance curve for the radio frequency transformer is, by comparison, much broader. Hence it is clear that some relative displacement between the two resonance curves is possible without any appreciable harm. It is found that the above method of obtaining the core shape is sufficiently accurate so that within the limits of the two resonance curves as present in commercial radio receivers satisfactory tracking may be easily obtained.

In the transformer as illustrated in the drawings, the taper is straight. In some instances, however, the taper may be concave or convex with respect to the straight taper shown here depending upon the manner in which the coils are wound, the average turn diameter, the magnetic density of the core, and how near the core diameter is to the average turn diameter. In practice, any slight curvature may be disregarded so that satisfactory tracking with a frustum of a cone for the core shape is readily possible.

It is understood, of course, that in practice the two transformers are mounted sufficiently far apart so that the oscillator core has no appreciable effect upon the radio frequency transformer.

As the ratio of coil length to mean turn diameter increases, a greater frequency range may be covered. Throughout this discussion, only the secondaries have been considered. The primaries are designed in the usual fashion and may be disposed in any suitable position, depending upon the degree of coupling desired.

In this connection, it might be pointed out that a uniform iron particle size and distribution throughout the core is assumed. Obviously, the physical shape of both cores may be the same and the tracking secured by controlling the size and density of iron particles in the molding material. Thus, rings of different kinds of cores may be so combined that uniform physical dimensions may result. It is understood that such changes are considered within the scope of this invention and that the shape of the core as claimed is deemed to refer not merely to the physical core shape but to include such variations as above to change the effective magnetizing core shape.

Assuming that the respective cores have been designed, it is only necessary in production to adjust the relative distance between the two cores to insure tracking. In order to do this, oscillator core **225** may be disposed in the transformer to produce a predetermined oscillator frequency. Nut **231**, which in practice need not be adjustable with respect to rod **212**, functions as one fixed point on the rod. Thereafter, core **210** is adjusted by means of lock nuts **215** and **216** so that the correct frequency may pass through the corresponding transformer. Thereafter, spring **230** will maintain the two cores in their adjusted positions so that any friction between the inside of tube **200** and the cores will have no effect upon the relative positions of these cores.

After this factory adjustment has been made, the entire core system may be adjusted with reference to both transformers by turning rod **212** in bushing **235** to slide the cores in or out of their respective transformers. This may be accomplished by operating upon the square nut **240** of rod **212**. No necessity for touching the lock nuts **215** and **216** or the fixed nut **231** is present and, since these are disposed inside of container **236**, the entire unit will be protected against any unauthorized tampering. By sliding the two coils simultaneously, both transformers will track and may be adjusted over the entire broadcasting range. Hence, each one of the tuning units may be adjusted independently of the other.

What is claimed is:

1. In an electrical system having a plurality of circuits tunable by inductance variation, an inductance coil for each circuit, a magnetizable core for each inductance coil, means for mounting said inductance coils axially in fixed relation to each other, means for loosely mounting said cores in alignment on a common operating rod threaded through said cores, means for adjusting the position for each core with respect to said rod longitudinally thereof including a spring between each of said aligned cores to maintain the spacing therebetween, said cores being differently shaped whereby upon movement of said rod all said cores are simultaneously moved with respect to their coils to change tuning of said circuits by equal frequency increments.

2. In a superheterodyne receiver, a radio frequency transformer comprising two coils in fixed relation to each other, an oscillating circuit transformer comprising two coils in fixed relationship to each other, means for mounting said two pairs of transformers on one insulating tube in fixed relation to each other, a core for each transformer movable longitudinally, a rod passing through said cores with said cores loosely disposed thereon, a fixed stop in said rod for one of said cores, a movable stop in said rod for the other core, a spring between said cores tending to maintain said cores separated to their extreme positions, and means for moving said rod longitudinally within said tube to move said cores, said two cores being differentially shaped whereby said circuits will track over the tunable ranges thereof.

JOSEPH L. MILLER.