Jan. 5, 1937. J. P. PUTNAM 2,066,945

TUNING UNIT

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Fig. 1

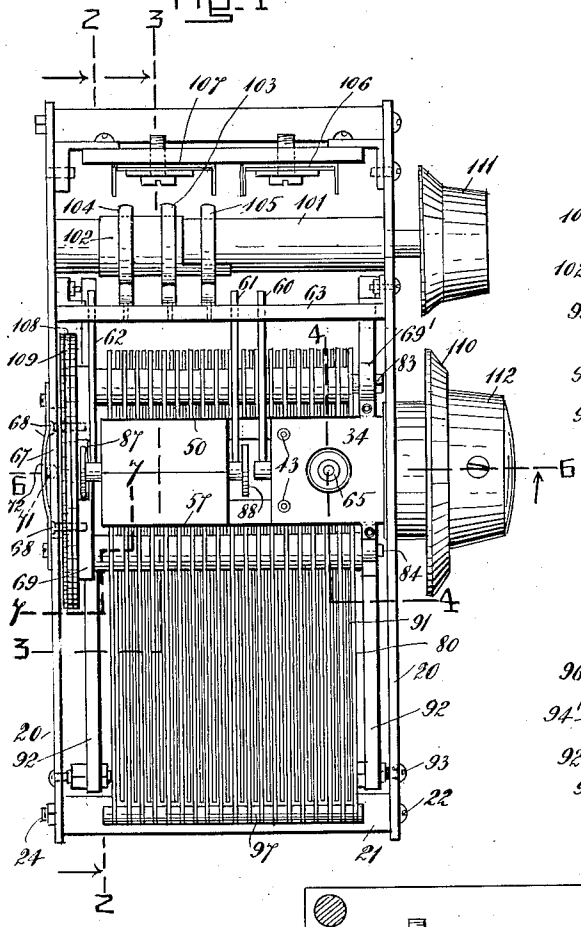


Fig. 2.

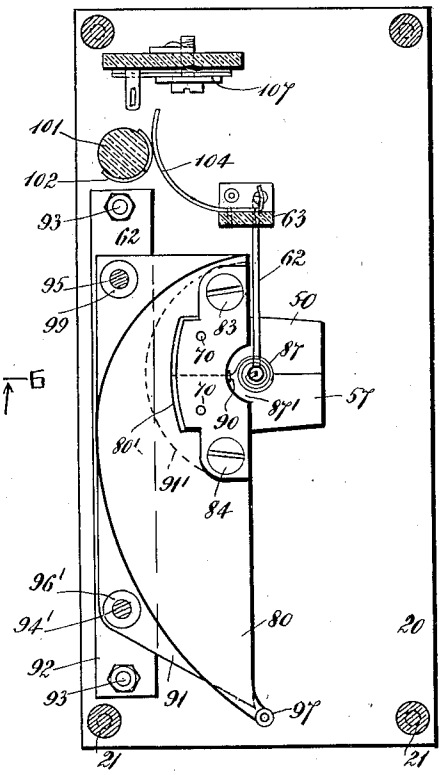


Fig. 4.

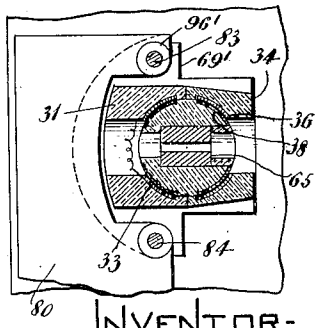


Fig. 3.

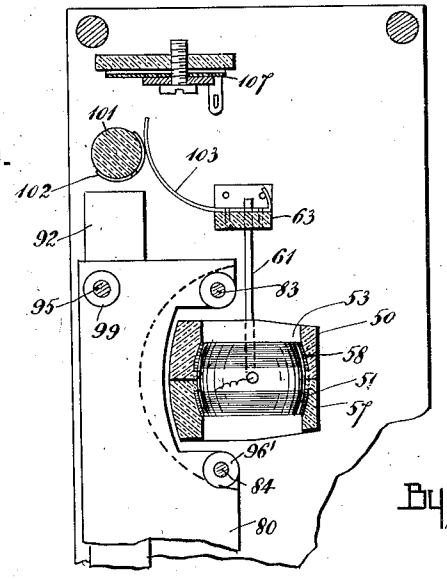
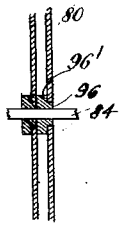


Fig. 7.



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Fig. 5.

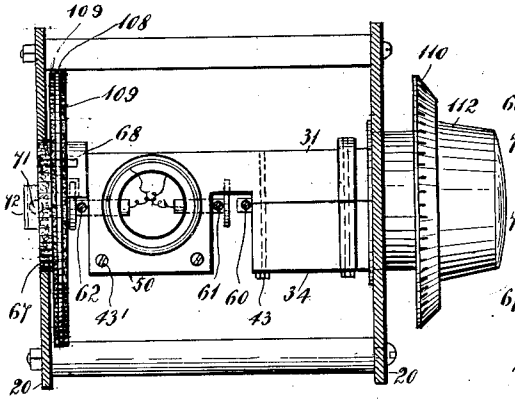


Fig. 6.

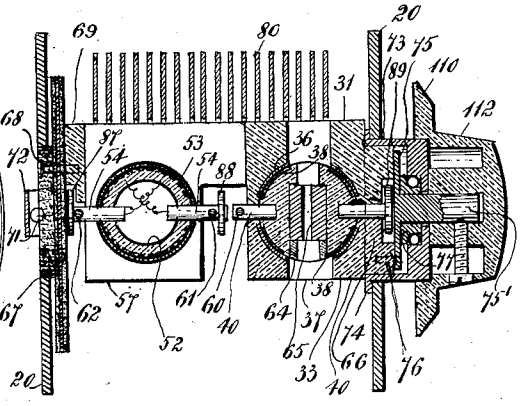


Fig. 10.

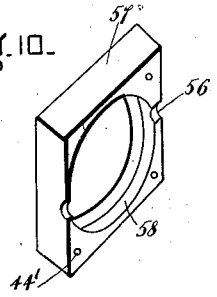
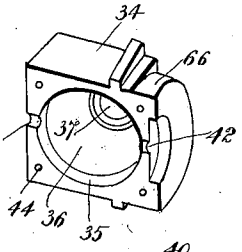


Fig. 9.



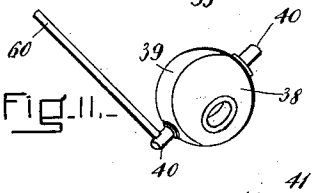


Fig. 11.

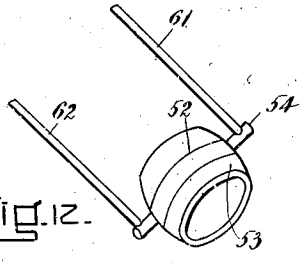


Fig. 12.

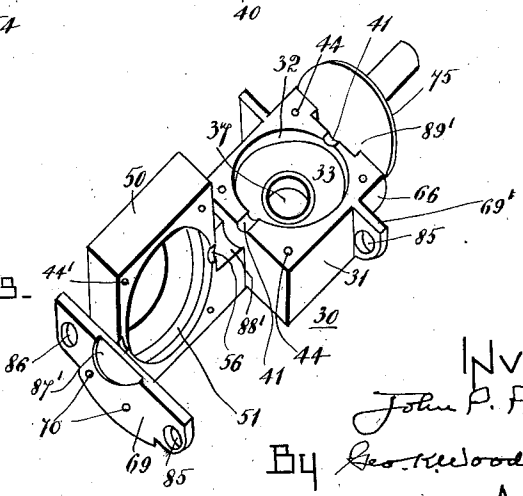


Fig. 8.

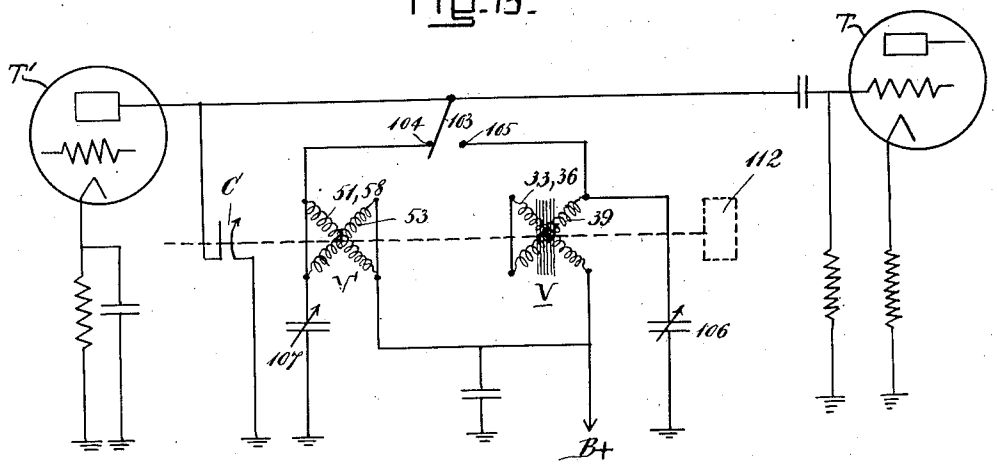
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TUNING UNIT

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Fig. 13.



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UNITED STATES PATENT OFFICE

2,066,945

TUNING UNIT

John P. Putnam, Boston, Mass., assignor to The Reece Button Hole Machine Company, Boston, Mass., a corporation of Maine

Application July 5, 1935, Serial No. 29,866

14 Claims. (Cl. 250—40)

This invention relates to tuning units for electric circuits and is especially adapted, although not limited, to radio receivers of the so-called "all-wave" type.

In receivers having a large frequency coverage it has heretofore been found necessary to employ a relatively large number of tuning elements in each tuning unit or stage and to use an exceedingly complex circuit changing device having a very large number of contact members for switching from one set of tuning elements to another when passing from one frequency band to another.

It is therefore one of the objects of the present invention to provide a tuning unit for a radio receiver whereby a wide frequency range may be covered by a minimum number of tuning elements and such elements selected by an extremely simple circuit-changing device having a minimum number of contact members.

Each tuning unit or stage is self-contained and comprises two variable inductors, preferably in non-inductive relation, and a variable capacitor, together with circuit-changing means for connecting said capacitor in circuit with either inductor at will and means for smoothly and simultaneously varying the capacity of the capacitor and the inductances of the inductors.

The relation between the inductances of said inductors, which preferably are variometers disposed in non-inductive position, and the capacity of said capacitor depends upon the type of receiver in which the tuning unit is to be used; but whatever the type of receiver, the two inductors must have unequal maximum inductance.

In a superheterodyne receiver, the product of the minimum capacity of said capacitor by the minimum inductance of the inductor having the larger maximum inductance, preferably is greater than the product of the maximum capacity of said capacitor by the maximum inductance of the other of said inductors. In such case, the minimum inductance of one inductor preferably is higher than the maximum inductance of the other, and where variometers are employed as inductors this relation conveniently may be attained without unduly increasing the physical bulk of the unit by connecting the windings of one variometer in parallel and those of the other in series, and providing the variometer, the coils of which are serially connected, with a core comprising finely divided paramagnetic material and a binder.

Expressed in terms of frequency, the electromagnetic constants of the tuning unit, when used in a superheterodyne receiver, are such that the maximum frequency of the circuit formed by the capacitor and the inductor having the larger maximum inductance is less than the minimum frequency of the circuit formed by said capacitor and the other inductor.

When the tuning unit is used in a tuned radio frequency receiver, for example, the electromagnetic constants of said unit are such that the maximum frequency of the circuit formed by the capacitor and the inductor having the larger maximum inductance preferably is equal to the minimum frequency of the circuit formed by the capacitor and the other inductor, but I do not wish to be understood as excluding the relation of said constants whereby the frequency of the first named circuit is slightly lower or slightly higher than that of the other.

Another object of my invention is to provide a convenient means for disposing the variometers in noninductive relation, such means comprising a rotary support of insulating material mounted for rotation in the tuning-unit frame and formed of an integral structure having two coil-receiving cavities and two complementary coil-support members detachably secured thereto.

A further object is to provide means for spacing the plates of the condenser and insulating the same from each other at one point, and spacing and electrically connecting the same at another point, thereby to eliminate the formation of the closed circuits in the field of the variometer that would result from conductively connecting said plates at both spacing points.

Still another object is to provide means for eliminating the noises produced by electrical disturbances due to the relative movement of two contacting conducting members only one of which is grounded, this object being effected by mounting the rotor support member for rotation in openings formed in the metallic walls of the tuning-unit frame by means of insulating discs.

Various other objects and advantages of my invention, which is an improvement on the tuning unit disclosed in my application, Serial No. 745,097 filed September 22, 1934, will appear in the detailed description of an embodiment of said invention which has given good results in practice and is illustrated in the accompanying drawings, in which—

Figure 1 is a plan view of a tuning unit embodying my invention.

Fig. 2 is a vertical section taken on the line 2—2 of Fig. 1.

Fig. 3 is a vertical section taken on the line 3—3 of Fig. 1.

Fig. 4 is a vertical section taken on the line 4—4 of Fig. 1.

Fig. 5 is an end view showing the variometer rotor at a position 180° from that of Fig. 1, the condenser being omitted for the sake of clearness.

Fig. 6 is a vertical section taken on the line 6—6 of Fig. 1, the variometer and condenser rotors being at a position 180° from that of Fig. 1.

Fig. 7 is a fragmentary section taken on the line 7—7 of Fig. 1.

Fig. 8 is a perspective view of one portion of the variometer rotors and the support member therefor.

Figs. 9 and 10 are perspective views of the other portions of said variometer rotors and the support members therefor.

Figs. 11 and 12 are perspective views of the variometer stators designed to co-operate with the rotors.

Fig. 13 is a diagram illustrating one type of circuit in which my tuning element may be employed.

In the particular drawings selected for more fully disclosing the principle of my invention, such drawings being illustrative merely and not restrictive, 20, 20 are parallel metallic plates held in spaced position by the studs 21 interposed between the same and secured at one end to one of said plates by screws 22, and at the other by the nuts 23 threaded to the reduced end portion 24 of said studs.

Enclosed within the frame formed by said plates and studs is the self-contained tuning unit comprising the two variable inductors, the common variable capacitor, and the circuit changing means above mentioned. When several units are to be connected in tandem, the threaded ends 24 of the studs of one unit are threaded into the tapped holes in the studs of the next adjacent unit, into which tapped holes the screws 22 are threaded in the case of a single unit.

Referring to Figs. 8 to 12 inclusive, 30 is the frame or support member for the variometer rotors, such member preferably being an integral structure and comprising two portions arranged at right angles to each other. The portion 31 is provided with a spherical interior surface 32 in which the winding 33 is mounted. The complementary portion 34 also is provided with a spherical interior surface 35 in which is disposed the winding 36. The outer faces of the support members 31, 34 are provided with registering circular apertures as indicated at 37. The stator windings 38 which co-operate with the rotor windings 33, 36 are mounted on the stator support 39 which has a spherical exterior surface. By means of the gudgeons 40, which are received in the bearings formed by the complementary grooves 41, 42, formed in the members 31, 34, respectively, the stator support is disposed in the proper position with respect to the rotor support, and is held in such position when said members are secured together by screws 43 which pass through the registering holes 44 in said members.

The rotor support member 50 is arranged in a plane at right angles to that of the member 31 and also has a spherical interior surface in which is mounted the winding 51, the complementary rotor support member 57, which has a spherical interior surface, carrying the winding 58. The stator support 52 has a spherical exterior surface on which are mounted the windings 53 and is provided with gudgeons 54 whereby said stator is properly positioned within its co-operating rotor, said gudgeons being received in the bearings formed by the complementary grooves 55, 56, of the members 50, 57, respectively, and said members being secured together by screws 43' which pass through the registering holes 44' in said members. The pin 60 rigidly secured to one of the gudgeons 40, and the pins 61, 62 rigidly secured to the gudgeons 54, pass through and are held by the insulating bar 63 (Fig. 1) secured to the frame members 20, said pins not only serving to hold the stator supports stationary, but also to afford terminals for connecting the variometer windings in circuit.

The stator windings 38 and the rotor windings 33, 36, are in the present instance connected in series and the stator windings 53 and the rotor windings 51, 58, preferably are connected in parallel, as indicated in Fig. 13.

Enclosed within the central bore of the stator support 39 and held in position by the bushing 64 is a core 65 of paramagnetic material preferably formed by mixing finely divided iron with a binder and compressing the same into the desired shape under extremely high pressure, such cores being well known articles of commerce and requiring no further description.

The variometer rotor support is mounted for rotation in and between the tuning-unit frame by two insulating discs arranged respectively in oppositely disposed circular openings in the plates 20. One of said discs, 66, is shown in the present instance as formed of two semi-circular portions integral respectively with the parts 31 and 34 of the rotor frame, and the other, 67, is secured by screws 68 to the flange 69 which is integral with said frame, said screws passing through the holes 70.

Preferably an antifriction ball 71 is interposed between the disc 67 and the plate spring 72 secured to one of the plates 20. In the particular embodiment of the invention shown in the drawings, the disc 66 has its bearing in the ball-cage 73 which projects into one of the two oppositely disposed circular openings aforesaid in the plates 20, 20, the flange 74 on said cage holding the same in position. The metal disc 75 secured by screws, one of which is shown at 76, to the two-part insulating disc 66, carries the ball cup 77 which projects into a cavity formed in the wall of the ball-cage and with the periphery thereof forms a raceway for the antifriction balls 78. The dial knob 112 is suitably secured to the stud 75' integral with said disc 75, which is of smaller diameter than the interior diameter of the ball cage and does not make rubbing contact therewith.

By mounting the variometer rotor frame for rotation between the plates 20 by means of insulating discs, I eliminate the grinding noises that would be produced by the receiver if said discs were metallic, such noises being caused by electrical disturbances due to the relative movement of two contacting conducting members, only one of which is grounded.

By arranging the variometers at right angles to each other, inductive effects between the two are eliminated, and by providing one of said variometers with a core having greater permeability than air, the magnetic field is concentrated and leakage reduced, thus insuring a greater flux linkage between the coils.

Another result obtained by using a magnetic core is that the "figure of merit" of the variometer, that is, the ratio of the total inductive reactance thereof to its total resistance, known as the "Q" of the variometer, is increased over the greater part of the variometer inductance-range or the ratio of its maximum to its minimum inductance. I have ascertained that the use of such core in a variometer is practically without effect on the Q thereof at and near the lower end of its inductive range where the coils are in or near the position of maximum opposition and minimum inductance.

The minimum inductance of a variometer is equal to the sum of the self inductances of the rotor and stator coils minus twice the mutual inductance thereof. As the rotor is turned toward the position of maximum assistance and maximum inductance, such maximum inductance being equal to the sum of the self inductances of the rotor and stator coils plus twice the mutual inductance thereof, the Q of the variometer is progressively increased and is a maximum at the upper end of the inductance range. It follows therefore that the use of said core results in a marked increase in the variometer inductance range, i. e., the ratio of the maximum inductance of the variometer to the minimum inductance thereof.

In the tuning unit herein particularly described the inductance range of each of the variometers V, V', (Fig. 13) is approximately 10 : 1, as hereinafter more fully set forth, such ratio being specified herein merely by way of example and not as a limitation; and such relatively high inductance range is an important factor in the elimination of the relatively large number of tuning elements heretofore found necessary to be used in each tuning unit and the complex multi-contact switching member required for selecting the same when passing from one band to another.

The condenser rotor plates **80** from each of which a portion has been cut to provide a trough **80'**, extending at right angles to the plane of each plate to accommodate the lower portion of the variometer rotor support, are secured to said rotor support by the bolts **83**, **84** which pass through openings in said plates and the holes **85**, **86**, respectively, in the flanges **69**, **69'** formed integral with the variometer support member **30**.

The variometer rotor and stator windings are connected to each other and to their respective circuits by spiral hair-springs **87**, **88**, and **89**, disposed in the semicircular slots **87'**, **88'**, and **89'**, respectively, formed in the rotor support **30**. One end of each of said springs is connected electrically and mechanically to one of the stator gudgeons, and the other to a pin such as indicated at **90** (Fig. 2) in the body of the variometer rotor support.

The condenser stator plates **91**, from each of which is cut out a semicircular portion forming a trough **91'** for accommodating the lower portion of the variometer rotor, are supported by the rails **92** spaced inwardly from the plates **20** and held in position by the screws **93**. Screws **94**, **95**, pass through the registering apertures near the bottom of the plates **91** and are suitably secured in the rails **92** for supporting said plates.

Means are provided for spacing each set of condenser plates in such manner that they will not form closed circuits acting as transformer secondaries in the field of the variometers, thereby by absorbing and wasting energy. While this result may be effected by a variety of means, I prefer to employ for this purpose a plurality of flanged sleeves **96** (Fig. 7) of insulating material, one for each plate, each sleeve being disposed in the hole in one of the plates and the flange **96'** thereof being interposed between a pair of adjacent plates and serving as a spacer. The bolts **83**, **84**, (in the case of the rotor condenser) pass through the central apertures of the said flanged sleeves. The outer ends of the condenser rotor plates **80** are spaced and electrically connected by the metallic washers **97**.

In the case of the condenser stator, the insulating flanged spacers **96** are carried by the bolt **94** and metallic spacers **99** are carried by the bolt **95**, the insulating spacers in each instance separating the plates at one point and insulating each from the other, and the conducting spacers separating and electrically connecting said plates at another point. In this way the formation of closed loops within the field of the variometers is eliminated.

Passing through the tuning unit frame is an insulating rod **101** on which is disposed an arcuate commutator member **102** the central portion of which is always in contact with the central brush **103** and the end portions of which make contact with the brush **104**, or the brush **105**, according to the angular position thereof. The brush members **103**, **104**, **105**, may, as shown, conveniently be carried by the insulating bar **63**, the ends of which are attached to the plates **20**, **20**.

In the position shown in Fig. 1, there is a metallic connection between the brushes **103**, **104**, as indicated diagrammatically in Fig. 13, and thereby the high frequency variometer V' is connected in circuit with the condenser C. By rotating the rod **101** about 90 degrees, a connec- between the brushes **103**, **105**, is effected whereby the low frequency variometer V is connected in circuit with said condenser C.

Trimmer condensers **106**, **107**, preferably are employed as indicated in Fig. 13. By the term "capacitor" as used herein, it is to be understood that I include both the condenser C and the particular trimmer condensers **106** or **107**, electrically connected thereto by the circuit changing devices **102**, **103**, **104**, and **105**, if such trimmers are used. As shown in Fig. 13, the capacitor C and the inductor V or V' connected thereto constitute a closed resonance circuit connected to the input or output side of the thermionic tube T or T'.

The operation is as follows:

When the brush **103** is connected with brush **105** through the commutator **102** and the dial is at zero position, the circuit including the variometer V and condenser C will be attuned to its lowest frequency, approximately 220 kc, and as the dial is rotated counterclockwise 180° from its zero position, the frequency of said circuit will be varied, without discontinuity, to about 2000 kc at which position the inductance of the low frequency variometer V and the capacity of said condenser are both at their minimum values. Within this frequency coverage are the aircraft radio beacon, maritime code and American broadcast bands, and a portion of the amateur bands. For higher frequency bands, the knob **111** is rotated clockwise about 90°, thereby connecting the brushes **103**, **104** through the commutator member **102** and putting the high frequency variometer V' in circuit

with the condenser C. The dial is then brought to zero position and then turned clockwise to vary the frequency of said circuit between approximately 2600 kc and 27,000 kc, within which frequency coverage is located practically the entire short-wave spectrum, including the police bands, the band allotted for communication from airplanes to ground, the international short-wave broadcast bands, and the greater portion of the amateur bands. It will be understood of course that the frequency values above specified are included herein merely by way of example to facilitate the complete disclosure of one practical embodiment of my invention and that said invention is not limited thereto or to any particular frequency coverage.

When the tuning dial is at its 180° position, the inductance of the low frequency variometer V, which is then at its minimum value, is greater than the inductance of the high frequency variometer V' when the dial is at its zero position, said high frequency variometer having its maximum inductance at such position. The condenser C being common to both variometers it follows that when the tuning unit is used in a superheterodyne receiver the maximum frequency of the circuit formed by the capacitor, i. e., the condenser C and the trimmer **106**, if used, and the low frequency variometer V, preferably must not exceed the minimum frequency of the circuit formed by said capacitor, i. e., said condenser C and the trimmer **107**, if used, and the high frequency variometer V'.

When the tuning unit is used in a tuned radio frequency receiver the maximum frequency of the circuit formed by the capacitor, i. e., the condenser C and the trimmer **106**, if used, and the variometer V preferably is equal to the minimum frequency of the circuit formed by the capacitor, i. e., said condenser and the trimmer **107**, if used, and the high frequency variometer V', although it may differ slightly therefrom,—in other words, there may be a small gap between the maximum frequency of one circuit and the minimum of the other, or else a small overlap of the same without substantial disadvantage.

When trimmer condensers such as **106**, **107**, are used, the tuning unit adapted for use in a superheterodyne receiver and in which there is a substantial gap between the maximum frequency of one circuit and the minimum of the other, may be converted into a tuning unit adapted for use in a tuned radio frequency receiver and in which the maximum frequency of one circuit is substantially equal to the minimum frequency of the other, by merely adjusting said trimmer condensers to secure the substantial equality of said frequencies; but, if no trimmer condensers are employed, the maximum inductance of the high frequency variometer V' must be made larger to reduce the minimum frequency of its circuit to substantial equality with the maximum frequency of the circuit of the low frequency variometer V, if said variometer V remains unchanged, or else the minimum inductance of the low frequency variometer must be made smaller to increase the maximum frequency of its circuit to substantial equality with the minimum frequency of the high frequency variometer V', if said variometer V' remains unchanged.

Preferably a metallic disc **108** of greater diameter than the insulating disc **67**, is interposed between the latter and the flange **69** of the variometer rotor support, being secured to the latter by the screws **68**. The function of said disc **108** is to shield the tuning unit from electrical forces that would otherwise pass through the circular opening in the plate 20 within which the disc **67** is disposed. The disc **108**, is insulated from the adjacent conducting elements by discs **109** of celluloid or other suitable non-conducting material. The opposite opening in the other plate is shielded by the ball-cage **73**.

My improved tuning unit permits the covering of the entire range of frequencies used in radio communication by means of two inductors and a common capacitor connected in circuit with either inductor at will by a switch having three contact members only in contradistinction to the tuning units now in use which require four or five inductors and a common capacitor interconnected at will by circuit-changing means having eighteen or more contact members.

By means of my invention, not only is the construction of a radio receiver greatly simplified and the cost thereof materially lessened, but also the weight and physical bulk of the apparatus is reduced to a minimum.

Having thus disclosed an illustrative embodiment of my invention without however limiting the same thereto, what I claim and desire to secure by Letters Patent is:

1. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor in closed circuit with either of said inductors at will, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors.

2. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, the minimum inductance of one of said inductors being greater than the maximum inductance of the other, a variable capacitor, circuit changing means for connecting said capacitor in closed circuit with either of said inductors at will, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors.

3. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor in closed circuit with either of said inductors at will, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors, the product of the minimum capacity of said capacitor by the minimum inductance of the inductor having the larger maximum inductance being greater than the product of the maximum capacity of said capacitor by the maximum inductance of the other of said inductors.

4. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor in closed circuit with either of said inductors at will, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors, the maximum frequency of the circuit formed by said capacitor and one of said inductors being equal to the minimum frequency

of the circuit formed by said capacitor and the other of said inductors.

5. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor in closed circuit with either of said inductors at will, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors, the maximum frequency of the circuit formed by said capacitor and the inductor having the larger maximum inductance being greater than the minimum frequency of the circuit formed by said capacitor and the other of said inductors.

6. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a capacitor, circuit changing means for connecting said capacitor in closed circuit with either of said inductors at will, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors, the maximum frequency of the circuit formed by said capacitor and the inductor having the larger maximum inductance not exceeding the minimum frequency of the circuit formed by said capacitor and the other of said inductances.

7. A tuning device comprising in combination, two variometers of unequal maximum inductance, a variable capacitor, switch means for connecting said capacitor in closed circuit with either variometer at will, and means connecting the capacitor and the variometers for simultaneous variation of the capacity of said capacitor and the inductances of said variometers.

8. A tuning device comprising in combination, two variometers of unequal maximum inductance, said variometers being disposed in non-inductive relation, a variable capacitor, switch means for connecting said capacitor in closed circuit with either variometer at will, and means connecting the capacitor and the variometers for simultaneous variation of the capacity of said capacitor and the inductances of said variometers.

9. A tuning device comprising in combination, two variometers of unequal maximum inductance, the minimum inductance of one of said variometers being greater than the maximum inductance of the other, a variable capacitor, switch means for connecting said capacitor in closed circuit with either variometer at will, and means connecting the capacitor and the variometers for simultaneous variation of the capacity of said capacitor and the inductances of said variometers.

10. A tuning device comprising in combination, two variometers, one having its windings connected in parallel and the other having its windings connected in series, a variable capacitor, switch means for connecting said capacitor in closed circuit with either variometer at will and means connecting the capacitor and the variometers for simultaneous variation of the capacity of said capacitor and the inductances of said variometers.

11. A tuning device comprising in combination, two variometers, one having its windings connected in parallel and the other having its windings connected in series, a core of paramagnetic material for the variometer the windings of which are connected in series, a variable capacitor, switch means for connecting said capacitor in closed circuit with either variometer at will, and means connecting the capacitor and the variometers for simultaneous variation of the capacity of said capacitor and the inductances of said variometers.

12. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor in circuit with either of said inductors at will, said capacitor and the inductor connected thereto constituting a closed resonance circuit, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors.

13. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor with either of said inductors to form a closed resonance circuit, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors.

14. A tuning unit comprising in combination, two variable inductors of unequal maximum inductance, a variable capacitor, circuit changing means for connecting said capacitor in circuit with either of said inductors at will, said capacitor and the inductor connected thereto constituting a closed resonance circuit, a thermionic tube, means connecting said resonance circuit to said tube, and means connecting the capacitor and the inductors for simultaneous variation of the capacity of said capacitor and the inductances of said inductors.

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