Feb. 13, 1940. W. J. POLYDOROFF 2,190,082

PERMEABILITY-TUNED SUPERHETERODYNE RECEIVER

Original Filed April 22, 1933 2 Sheets-Sheet 1

Fig. 1,

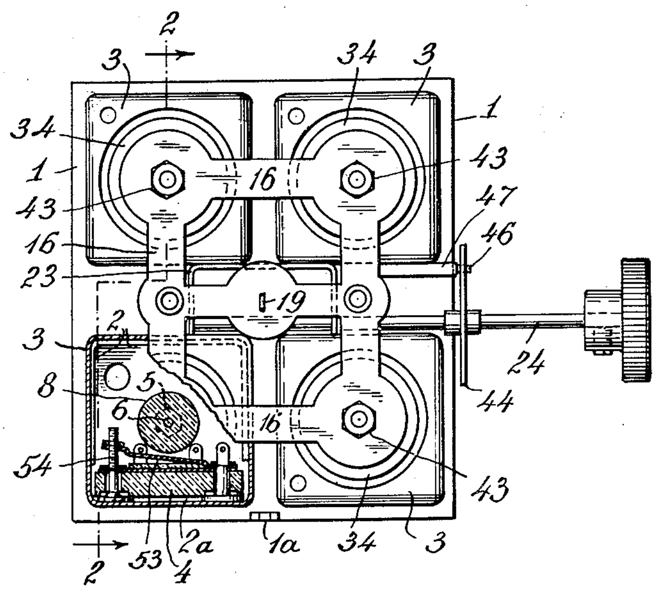
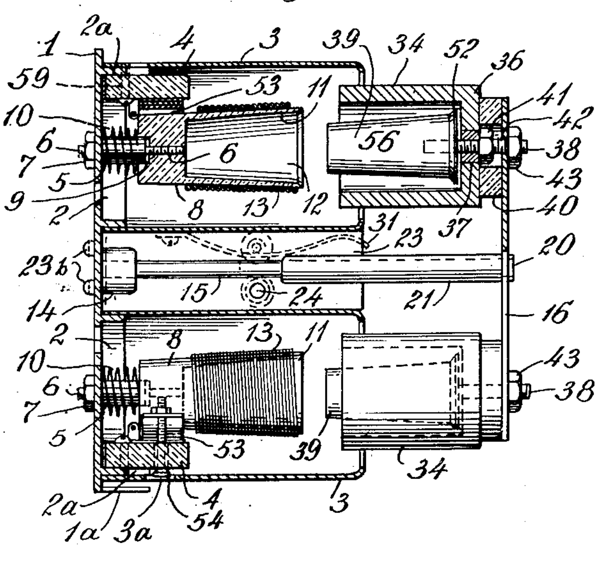


Fig. 2,



INVENTOR
WLADIMIR J. POLYDOROFF,
BY
Willis H. Taylor Jr.
ATTORNEY

Feb. 13, 1940. W. J. POLYDOROFF 2,190,082

PERMEABILITY-TUNED SUPERHETERODYNE RECEIVER

Original Filed April 22, 1933 2 Sheets-Sheet 2

Fig. 3,

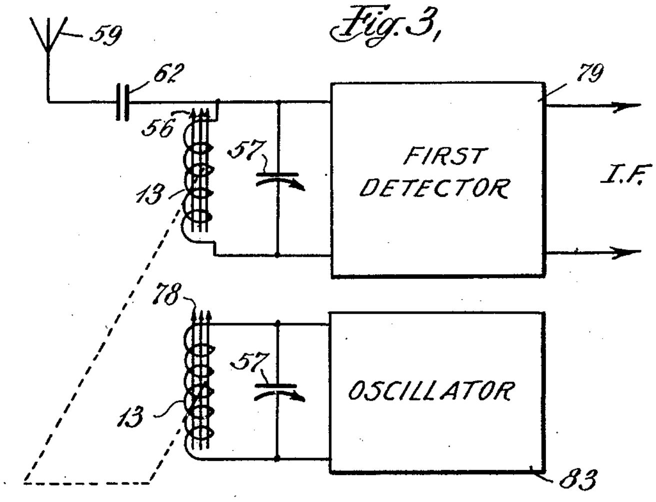


Fig. 4,

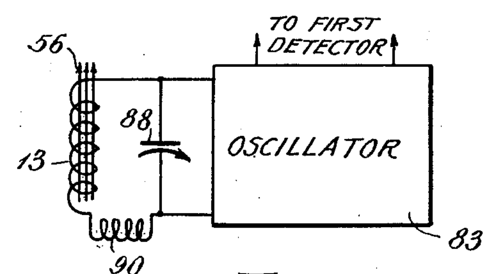
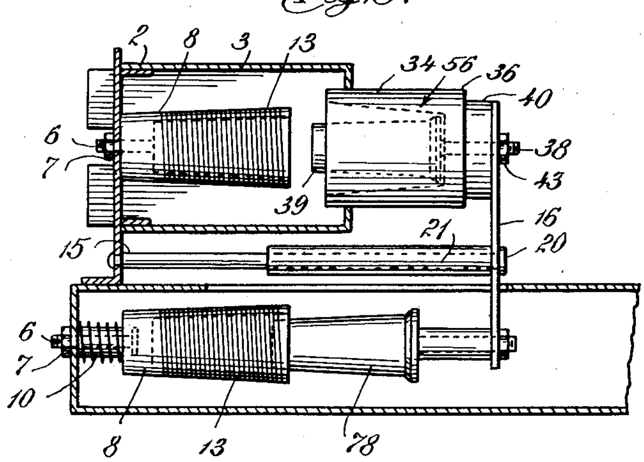


Fig. 5.



INVENTOR
WLADIMIR J. POLYDOROFF
BY
Willis H. Taylor Jr.
ATTORNEY

Patented Feb. 13, 1940

2,190,082

UNITED STATES PATENT OFFICE

2,190,082

PERMEABILITY-TUNED SUPERHETERODYNE RECEIVER

Wladimir J. Polydoroff, Wilmette, Ill., assignor to Johnson Laboratories, Inc., Chicago, Ill., a corporation of Illinois

Original application April 22, 1933, Serial No. 667,368. Divided and this application January 21, 1937, Serial No. 121,460

14 Claims. (Cl. 250—20)

The invention relates to radio receiving apparatus in which compressed ferromagnetic cores are utilized as the tuning means. In such apparatus, the ferromagnetic cores are arranged to be movable with respect to the inductance coils, and the variation of the inductance which produces the variable tuning is brought about by varying the effective permeability of the space surrounding the coils. This method is therefore conveniently called "permeability tuning" to distinguish it from other methods of inductance variation, and from methods in which the capacitance is varied.

The several comminuted compressed ferromagnetic cores and inductance devices which are described in this specification are disclosed in my United States Patent No. 1,982,689 for Magnetic core material, and in my United States Patent No. 2,113,603, High-frequency inductance device; hence no claims covering such improvements per se are herein included.

In permeability-tuned systems containing several tuned circuits and intended to be tuned by a single control handle, there arises the problem of so designing and constructing the tuning unit that each of the circuits will be tuned very closely to the correct frequency for each setting of the single control. This is accomplished partly by designing and constructing the magnetic cores and the inductance coils so that they will be closely of the correct values, partly by providing a mechanism which will insure that the cores (or the coils) will move in unison, and partly by providing adjusting means so that any unavoidable discrepancies in the cores, the coils, or the operating mechanism can be compensated for.

This application is a division of my application, Serial No. 667,368, now Patent No. 2,158,252 for Inductive tuning system, in which it is a principal object not only to provide suitable gang or multiple tuning means for permeability-tuned systems, but also to provide, as a part of the complete mechanism, those essential adjustments by which the ganged units may be definitely aligned, so that they will be in substantial agreement throughout the range of adjustability The present application is addressed to the adaptation of the arrangements disclosed to circuits of the superheterodyne type.

As has been indicated, the first essential in a multiple tuning unit of the permeability-tuned type is that the inductance coils shall be closely of the correct values. This same requirement has existed in other and earlier multiple tuning units, and it is well known that by properly choosing the materials used and by adopting a suitable technic in the manufacture of such coils, they may be satisfactorily produced. It is recognized, however, that even with all reasonable precautions the coils will not be exactly correct, and that, in general, some means for compensating for those slight unavoidable discrepancies which will exist must be employed.

It is equally desirable to so design and produce the ferromagnetic cores that they also will have the required values of effective permeability. Here again, however, in spite of every reasonable precaution, slight discrepancies will remain and adjustments must be provided by which these discrepancies can be compensated. Methods which may be employed to make the cores of the desired values are described in my United States patent for Magnetic core material above referred to, and additional means are disclosed in this specification.

In mechanisms for permeability tuning, the cores move in a straight line into and out of the coils, and the requirement that they shall move in unison and shall be actuated by the single driving means is met by mounting the several cores on a rigid gang-plate and by providing suitable guide means so that the only motion which the gang-plate can have is one of pure translation. There are, of course, many ways of arranging mechanically for this single translatory motion of the gang-plate and its associated cores. There are also many ways of arranging to produce this translatory motion by simple driving means.

The tuning function is accomplished by the relative motion of the cores and the coils, and it is essential that each coil shall be placed in a correct position with respect to its cooperating core, in order that each core may have the correct effect on its coil, so that each of the circuits will be tuned to the desired frequency for each setting of the cores. Because of the difficulty of establishing this precise relation by merely mounting the coils on an appropriately designed rigid foundation plate, it is advisable to provide adjusting means by which the position of each coil may be adjusted with respect to its cooperating core independently of the relation established by the common mounting means.

Each resonant circuit consists of a coil with its cooperating core and a capacitor which, in so far as the tuning operation is concerned, is fixed in value but which, for the purpose of establishing the initial conditions in the several tuned circuits, is preferably made so that its capacitance is adjustable over a limited range.

In order to secure proper performance of the cores themselves, it is desirable to arrange in the design of the core bodies an adjustment by which slight discrepancies in the effective permeabilities of the cores can be compensated. This adjustment is available after the cores have been completely fabricated and is preferably carried out before they are assembled on the gang-plate. It avoids the necessity for selecting a group of cores which are sufficiently close to the correct values without adjustment, and insures exact agreement of the several circuits at the low-frequency end of the tuning range.

In order to secure the full advantage of the several adjustments which have been described, and in order to secure the best possible agreement of the several circuits over the tuning range, it is preferable to carry out the adjustments in a prescribed order so that each adjustment will be made at that portion of the tuning range where it is most effective, and so that one adjustment will not affect another. Thus, assuming that the cores have already been adjusted to have the correct effective permeability, it is preferable to adjust the capacitances in the several tuned circuits with the cores at the position of their minimum effect on the inductance of the coils. This adjustment is conveniently carried out at or near the highest frequency in the range for which the receiver is designed, and consists in tuning each of the several circuits to the desired frequency by the adjustment of the capacitors. This takes care of any differences which may exist in the capacitances in the wiring of the several circuits.

In the superheterodyne method of radio reception, the signal passes through one or more circuits which are tuned to the signal frequency, is heterodyned with locally produced oscillations, is demodulated and then further amplified at an intermediate frequency, and is finally demodulated to produce an audio-frequency current which is then rendered audible. In a superheterodyne radio receiver, that portion of the system through which the signal passes without a change in frequency usually includes an antenna circuit and one or more variably tuned circuits with or without a thermionic amplifier tube, and is commonly called the "preselector." The locally produced oscillations, above referred to, are produced by a local oscillator the frequency of which differs by the intermediate frequency of the receiver from the signal frequency. Since the intermediate frequency remains fixed, the frequency of the oscillator must be varied as the signal frequency is changed. Although the oscillator frequency might be made lower than the signal frequency by an amount equal to the intermediate frequency, it is customary to operate the oscillator at a frequency equal to the sum of the signal frequency and the intermediate frequency. If this frequency difference is maintained throughout the range of signal frequencies, the oscillator is said to be in "track" with the preselector.

To the extent to which the self-inductances of the coils in the preselector are precisely alike, the capacitors need only to be adjusted to make the capacitance values in these several circuits also alike. However, to the extent to which the inductance values are not alike, the adjustment of the capacitors will also compensate for the inductance differences, so that at the starting point, corresponding to the minimum inductance and the highest frequency, the preselector circuits will be in exact alignment.

The relatively movable ferromagnetic cores act only upon the inductances themselves. However, each core acts to multiply the inductance value of its associated coil by a definite factor, no matter what the inductance value may be. If, therefore, the inductance value in a particular circuit is low, and if that circuit has been brought into desired alignment with the others by adjusting its capacitance to a slightly higher value, at an initial setting corresponding to the highest frequency, then the core will operate to tune that circuit over the desired range of frequencies, and finally to the correct minimum frequency, in proper agreement with the other circuits. It remains only to adjust the positions of the coils with respect to their cooperating cores, so that each coil is suitably affected by its core. This adjustment is preferably carried out at a frequency intermediate the two ends of the tuning range, in order to establish proper agreement of the several circuits at this third or intermediate point.

To summarize, therefore, agreement at the highest frequency is secured by adjustment of the capacitor, agreement at the lowest frequency is secured by adjustment of the core, and agreement at a frequency approximately midway between the highest and the lowest frequency is secured by adjustment of the position of the coil. With exact agreement established at these three frequencies, substantial agreement is secured throughout the tuning range.

The invention will be better understood if reference is made to the accompanying drawings, which are illustrative of preferred embodiments, and wherein:

Figure 1 is a plan view of an assembly of several high-frequency devices, in one unit, parts being broken away to reveal subjacent elements;

Figure 2 is a sectional view of said unit taken on the line 2—2 of Figure 1;

Figure 3 shows diagrammatically a portion of a receiving circuit employing one of the new high-frequency units, this circuit being of the superheterodyne type;

Figure 4 shows diagrammatically an alternate form of oscillator suitable for use in the receiver of Figure 3; and

Figure 5 shows a modification of the high-frequency device.

The unit disclosed in Figures 1 and 2 has four shielded variable inductance devices arranged to operate simultaneously. This unit has a foundation plate 1 that is provided with flanges 2 to which rectangular shields 3 are removably secured by friction or by other means, and with ribs 2*a* which serve as mountings for the semi-adjustable capacitors 4. A perforated lug 1*a* rising from an edge of said plate enables said unit to be connected with a suitable support.

The foundation plate 1 also is provided with hexagonal tubular thimbles 5 through each of which extends a longitudinally movable screw-threaded rod 6 which terminates outside of the foundation plate 1, where it is provided with an adjusting nut 7. Fixed to the inner end of each of the rods 6 is a coil form 8 having a hexagonal cavity 9 into which the hexagonal thimble 5 extends, the depth of this cavity being such as to permit the coil form to move longitudinally relatively to the thimble, but without disengagement therewith, the coil form while thus moving being prevented from rotating by its hexagonal engagement with said thimble. A helical spring 10 is disposed between said foundation plate 1 and each of the coil forms 8, in order to maintain the coil forms in their adjusted positions. Each of the coil forms 8 has a flared wall 11 and is open at the end 12, and carries an inductance coil 13. The mechanism just described constitutes means for adjusting the positions of each of the coils 13 individually with reference to the core portions 34, 39.

The foundation plate 1, furthermore, is provided with tubular sockets 14 for guide rods 15 which are parts of the mechanism for relative motion in unison between the several coils and cores of the unit.

The flanges 2, the hexagonal tubular thimbles 5 and the tubular sockets 14 may be made integral with the plate 1, as by die casting, or may be separately produced and secured to the plate in any suitable manner.

Associated with and movable toward and from the foundation plate 1 is a preferably integral rectangular gang-plate 16, to which a jointed actuating rod 19 is attached. The gang-plate 16 has holes 20 in which the ends of guide tubes 21 are fixedly secured. The guide rods 15, carried by the foundation plate 1, telescope with and accurately fit these guide tubes.

Carried by the gang-plate 16 are compressed ferromagnetic cores 56, which may be of the type having variable magnetic density along the magnetic path, as described in my above-mentioned United States Patent No. 1,982,689. These ferromagnetic cores cooperate with the inductance coils 13 in such a way as to vary the effective permeability of the space surrounding the coils. Each ferromagnetic core has a cup-shaped shell 34 open at one end to receive the coil 13 and having, in its head 36, an internally threaded bushing 37 through which a screw-threaded rod 38 extends, and in which said rod is longitudinally adjustable.

Each core 56 also includes a plug 39 which is tapered so as to conform with the inner wall 11 of the coil form 8, and into which is moulded the inner end of the rod 38. The cup-shaped shell 34 may be spaced from the rectangular gang-plate 16 by an insulating washer 40 to exclude undesired influences of the metal gang-plate on the core, and to leave room for a lock nut 41 which engages the screw threads of the rod 38 and, by contract with the head 36 of the shell 34, locks the plug 39 in any chosen position.

The aforesaid construction allows both the plug 39 and the shell 34 to be made separately and assembled by simply screwing the rod 38 into the bushing 37 of the outer shell, and then tightening the nut 41 until it locks the parts together. The core may thus be matched with other cores of the same unit so as to insure proper maximum values of inductance in all of the variable inductance devices. This is accomplished by appropriately regulating the air gap 52 between the plug 39 and the head 36 of the shell 34, and then locking these parts together by the nut 41. The arrangement just described constitutes means whereby the core portions 34, 39 may be adjusted so that the cores will have the correct effective permeability values.

The rectangular gang-plate 16 is provided with holes 42 through which the outer ends of the screw-threaded rods 38 may be passed when the core portions 34, 39 are placed in position, nuts 43 being screwed onto those ends to thereby firmly unite the gang-plate 16, the core portions 34, 39, and the insulating washer 40.

When the cores and coils are assembled, as hereinbefore described, it is necessary to so adjust their relative positions that all the cores and coils, however positioned, will produce substantially correct inductance variations. These results may be secured by the adjustment of the nuts 7 and consequent linear movement of each coil form 8 with its coil 13.

The capacitors 4 may be of the semi-adjustable type, each having at least two plates 53 spaced by an insulator and resiliently held at any desired separation by a screw 54. The adjustable capacitors constitute the means whereby the several tuned circuits may be tuned to the correct frequency at the high-frequency end of the tuning range.

Each of these capacitors is desirably disposed within one of the shields 3, whereby individual circuits are shielded from external influences and from each other. Hence, the problem of shielding inter-connecting wires between component parts of the same circuit is eliminated. The shields have holes 3a affording access to the adjusting screws 54.

In my United States Patents Nos. 2,005,203 and 2,113,603, an improved variable inductance device consisting, for example, of a core 34, 39, a coil 13 and shield 3, is adequately described, and it is there pointed out that such a device is capable of maintaining a substantially constant ratio between the inductance and the radio-frequency resistance. This property is secured by the appropriate design and construction of the core and by so designing the coil that the inductance-to-resistance ratio of the coil itself will have any desired value. It will be apparent that the use of such a variable inductance device in the preselector portion of a superheterodyne radio receiver, therefore, provides a preselector which is capable of substantially uniform selectance and uniform gain over a wide range of signal frequencies. Furthermore, by properly designing the oscillator employing the type of variable inductance device herein contemplated, the oscillator output voltage will remain substantially constant with changes in its frequency. Thus a superheterodyne radio receiver in accordance with the invention is capable of providing substantially uniform performance over a wide range of signal frequencies.

Figure 3 shows a conventional superheterodyne circuit arrangement having a plurality of resonant circuits but the tuning is accomplished by variable inductance devices such for example as those of Figs. 1 and 2, preferably having the three adjustments above described for securing alignment between the several circuits. The core 56 may have provision for adjustment of its effective permeability, the capacitors 57 will have means for the adjustment of their capacitance values, and means may be provided for the adjustment of the relative position of core 56 with respect to its coil 13. In a preferred embodiment of the circuit of Fig. 3, these adjustments will have the form described in connection with Figs. 1, 2 and 5. The motion of the several cores relative to the coils 13, to tune the system over the proper ranges of frequencies, may be secured by employing the drive arrangements described in connection with Figs. 1 and 2. It will be understood that equivalent arrangements for the adjustments and the drive may be employed without departing from the scope of my invention.

Referring to Figure 3, the signal is received on the antenna or signal-collecting means 59 and fed to the first tuned circuit through capacitor 62. The first tuned circuit includes an inductance coil 13 and a capacitor 57. Block 79 represents the first detector. The local oscillator is represented by block 83, and has associated with it a tuned circuit including inductance coil 13 and capacitor 57.

In operation, first detector 79 combines the incoming signal and the output of the local oscillator 83 in the well-known manner to produce a signal of intermediate frequency. The preselector is tuned to the signal frequency by means of a movable core 56 which cooperates with inductance coil 13 associated with first detector 79. The oscillator is maintained at a frequency higher than the signal frequency by an amount equal to the intermediate frequency of the receiver, the oscillator frequency being determined by the position of a movable core 78 relative to inductance coil 13 in the input circuit of the oscillator 83. The cores are ganged for simultaneous motion, as indicated by the broken lines.

Figure 4 shows an alternate form of oscillator arrangement for use in the superheterodyne radio receiver of Figure 3. Both the inductance coil 13 and the core 56 of the oscillator variable inductance device may be substantially identical with those employed in the preselector portion of the receiver. The oscillator inductance coil 13 is preferably so mounted as to permit of a slight axial adjustment. An additional inductor 90 is connected in series with oscillator inductance coil 13. The use of this inductor 90 narrows the frequency range over which the oscillator is tuned by the variable inductance device, and its inductance value is so chosen as to insure the maintenance of the oscillator approximately in track with the preselector. Capacitor 88 is suitably chosen to provide the desired limits for the oscillator frequency range.

The high-frequency tuning device of Figure 5 includes two variable inductance devices. The inductance coils 13 wound on forms 8 may be substantially identical. The core 56 of the upper variable inductance device includes a shell portion 34 and a plug portion 39, the two portions being secured in a desired relation by means of screw-threaded rod 38, and the core is attached to gang-plate 16 by nut 43 and spacer 40. The upper device is enclosed in an individual shield can 3, and is suitable for use in the preselector portion of the superheterodyne receiver of Figure 3. The lower variable inductance device includes a core having a plug portion 78 only. Plug 78 is attached to gang-plate 16 for simultaneous operation with core 56. Inductance coil 13 associated with plug 78 may be arranged to be axially adjustable in position with respect to gang-plate 16 as shown by means of screw-threaded rod 6, adjusting nut 7 and spring 10, the lower variable inductance device being adapted for use in the oscillator portion of the superheterodyne receiver of Figure 3.

In superheterodyne circuits, it is necessary to have one tuned circuit cover a different range of frequencies from the other tuned circuits, although the two ranges may overlap to some extent. In such a superheterodyne circuit, the preselector may be designed to cover the range from 550 to 1500 kilocycles, and this will require an inductance variation of $(1500)^2/(550)^2$, or 7.45. If the intermediate-frequency amplifier is designed for a frequency of 175 kilocycles, the oscillator circuit will require to be tuned from 1500+175 kilocycles to 550+175 kilocycles, which requires an inductance variation of only 5.35. To obtain this range with a variable inductance device of the same type as used in the preselector, an additional fixed inductance coil, not acted upon by the moving core, may be inserted in the circuit in series with the coil of the variable inductance device.

When a sufficiently high intermediate frequency is employed in superheterodyne circuits, such for example as 450 or 500 kilocycles, the inductance variation necessary in the oscillator is only of the order of 4 and may easily be accomplished by the use of the inner plug alone. In this case, similar coils may be employed for the preselector and for the oscillator, as shown in Figure 5, the plug 78, which is used to tune the oscillator circuit, being given a suitable shape to produce the desired variations throughout the range of frequencies to be covered by the oscillator. In accordance with the invention, therefore, the oscillator is kept properly in track with the preselector by suitably shaping the oscillator core 78 to produce desired variations in the oscillator frequency throughout the range.

Having thus described my invention, what I claim is:

1. A plurality of resonant circuits tunable over a range of frequencies by tuning means which simultaneously varies the effective values of the inductance in each of said circuits, electrical means for adjusting said circuits to substantially the same maximum frequency, magnetic means for adjusting said circuits to substantially the same minimum frequency, mechanical means for adjusting said circuits to substantially the same frequency intermediate said maximum and minimum frequencies, and an additional resonant circuit having inductance, capacitance and tuning means of such values that said additional circuit is tuned over a range of frequencies differing from that covered by the remaining resonant circuits but having a definite and desired relation thereto.

2. A plurality of resonant circuits each having inductance coils and capacitance, and tuning means including ferromagnetic cores movable relatively to said coils which simultaneously varies the effective value of the inductance in each of said circuits, said ferromagnetic cores being similarly shaped and being of such values of effective permeability that one of said circuits is tuned over a range of frequencies differing from that covered by the remaining circuits but having a definite and desired relation thereto.

3. A plurality of resonant circuits each having inductance and capacitance, and tuning means which simultaneously varies the effective value of the inductance in each of said circuits, said inductances, capacitances and tuning means being of such values that one of said circuits is tuned over a range of frequencies differing from that covered by the remaining circuits but having a definite and desired relation thereto, electrical means for adjusting said circuits substantially to the desired maximum frequencies, magnetic means for adjusting said circuits substantially to the desired minimum frequencies, and mechanical means for adjusting said circuits substantially to the desired frequencies at a setting intermediate said maximum and minimum frequencies.

4. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and

said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits having first and second inductance coils respectively and comminuted ferromagnetic cores movable with respect thereto and each having a capacitor, a third inductance coil in series in said last-mentioned circuit, and a uni-control means for tuning said circuits by relative movement between said first and second coils and said cores simultaneously, said third inductance coil being so related to the inductance-varying effect of said cores that over said frequency range the frequency of the oscillator output always differs from the tuning of said first-mentioned circuit by an amount substantially equal to said intermediate frequency.

5. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits having substantially identical first and second inductance coils respectively and substantially identical comminuted ferromagnetic cores movable with respect thereto and each having a capacitor, a third inductance coil in series in said last-mentioned circuit, and a uni-control means for tuning said circuits by relative movement between said first and second coils and said cores simultaneously, said third inductance coil being so related to the inductance-varying effect of said cores that over said frequency range the frequency of the oscillator output always differs from the tuning of said first-mentioned circuit by an amount substantially equal to said intermediate frequency.

6. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a first circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, said circuit including a first inductance coil, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a second tunable circuit comprising a second inductance coil having a comminuted ferromagnetic core which is movable with respect thereto, and a uni-control means for tuning said first circuit and for causing relative movement between said second coil and said core simultaneously whereby the tuning of said first circuit and the frequency of the oscillator output may be varied simultaneously, and means whereby the relation between said core and said second coil may be adjusted, said core being so shaped that over said frequency range the frequency of the oscillator output always differs from the tuning of said first circuit by an amount substantially equal to said intermediate frequency.

7. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a first circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, said circuit including a first inductance coil, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a second tunable circuit comprising a second inductance coil substantially identical with said first inductance coil and having a comminuted ferromagnetic core which is movable with respect thereto, and a uni-control means for tuning said first circuit and for causing relative movement between said second coil and said core simultaneously whereby the tuning of said first circuit and the frequency of the oscillator output may be varied simultaneously, and means for adjusting the relation between said core and said second coil, said core being so shaped that over said frequency range the frequency of the oscillator output always differs from the tuning of said first circuit by an amount substantially equal to said intermediate frequency.

8. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a pretermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits each having an inductance coil, a capacitor and a comminuted ferromagnetic core which is movable with respect to said coil, a uni-control means for tuning said circuit by relative movement between said coils and said cores simultaneously, means for adjusting the capacitance of one of said capacitors, means for adjusting the relation between one of said cores and one of said coils, and means for adjusting the effective permeability of one of said cores, whereby over said frequency range the frequency of the oscillator output always differs from the tuning of said first-mentioned circuit by an amount substantially equal to said intermediate frequency.

9. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits having substantially identical inductance coils and each having a capacitor and a comminuted ferromagnetic core which is movable with respect to said coil, a uni-control means for tuning said circuits by relative movement between said coils and said cores simultaneously, means for adjusting the capacitance of one of said capacitors, means for adjusting the relation between one of said cores and one of said coils, and means for adjusting the effective permeability of one of said cores, whereby over said frequency range the frequency of the oscillator output always differs from the tuning of said first-mentioned circuit by an amount substantially equal to said intermediate frequency.

10. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits each having an inductance coil, a capacitor and a comminuted ferromagnetic core which is movable with respect to said coil, a uni-control means for tuning said circuits by relative movement between said coils and said cores simultaneously, means for adjusting the capacitance of one of said capacitors, means for adjusting the relation

between one of said cores and one of said coils, and means for adjusting the effective permeability of one of said cores, whereby respectively at high-frequency, middle-frequency and low-frequency points within said frequency range the frequency of the oscillator output differs from the tuning of said first-mentioned circuit by an amount equal to said intermediate frequency.

11. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits having substantially identical inductance coils and each having a capacitor and a comminuted ferromagnetic core which is movable with respect to said coil, a unicontrol means for tuning said circuits by relative movement between said coils and said cores simultaneously, means for adjusting the capacitance of one of said capacitors, means for adjusting the relation between one of said cores and one of said coils, and means for adjusting the effective permeability of one of said cores, whereby respectively at high-frequency, middle-frequency and low-frequency points within said frequency range the frequency of the oscillator output differs from the tuning of said first-mentioned circuit by an amount equal to said intermediate frequency.

12. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit comprising an inductance coil having a comminuted ferromagnetic core which is movable with respect thereto, a uni-control means for tuning said first circuit and for causing relative movement between said coil and said core simultaneously whereby the tuning of said circuit and the frequency of the oscillator output may be varied simultaneously, and independent means for adjusting the rate of change of inductance in one of said circuits, said core being so shaped that over said frequency range the frequency of the oscillator output always differs from the tuning of said first circuit by an amount substantially equal to said intermediate frequency.

13. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits each having an inductance coil, a capacitor and a comminuted ferromagnetic core which is movable with respect to said coil, a third inductance coil in series in said last-mentioned circuit, a uni-control means for tuning said circuits by relative movement between said coils and said cores simultaneously, and independent means for adjusting the rate of change of inductance in one of said circuits, said third inductance coil being so related to the inductance-varying effect of said cores that over said frequency range the frequency of the oscillator output always differs from the tuning of said first-mentioned circuit by an amount substantially equal to said intermediate frequency.

14. In a radio receiver of the superheterodyne type, a signal collecting means, a first detector, a circuit tunable over a predetermined frequency range coupling said signal collecting means and said detector, an oscillator coupled to said first detector for heterodyning an incoming signal to a signal having an intermediate frequency, said oscillator including a tunable circuit, said circuits having substantially identical first and second inductance coils respectively and substantially identical comminuted ferromagnetic cores movable with respect thereto and each having a capacitor, a third inductance coil in series in said last-mentioned circuit, a uni-control means for tuning said circuits by relative movement between said coils and said cores simultaneously, and independent means for adjusting the rate of change of inductance in one of said circuits, said third inductance coil being so related to the inductance-varying effect of said cores that over said frequency range the frequency of the oscillator output always differs from the tuning of said first-mentioned circuit by an amount substantially equal to said intermediate frequency.

WLADIMIR J. POLYDOROFF.