Feb. 20, 1940. D. V. SINNINGER 2,190,850

INTERFERENCE REJECTION RECEIVER

Filed April 26, 1939

Fig. 1,

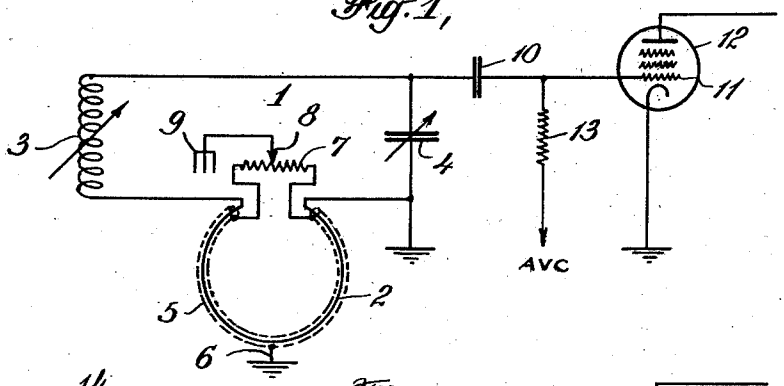


Fig. 2,

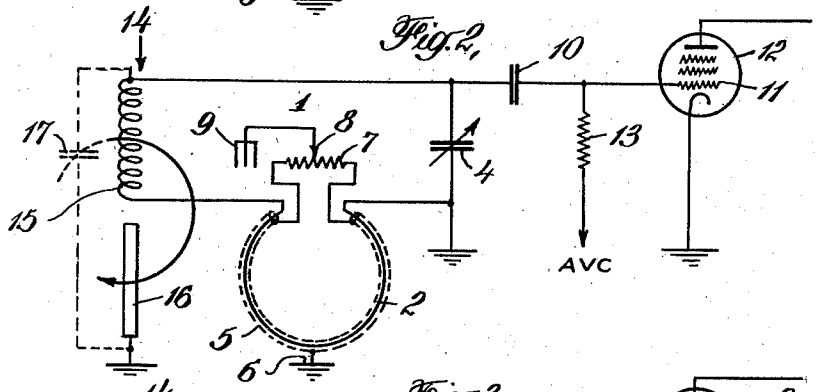


Fig. 3,

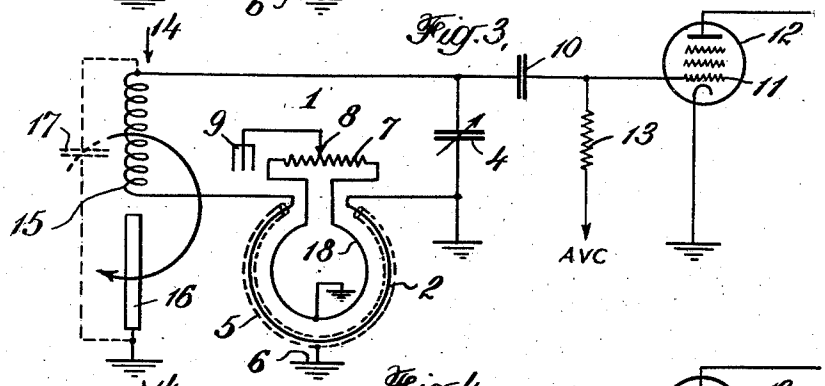
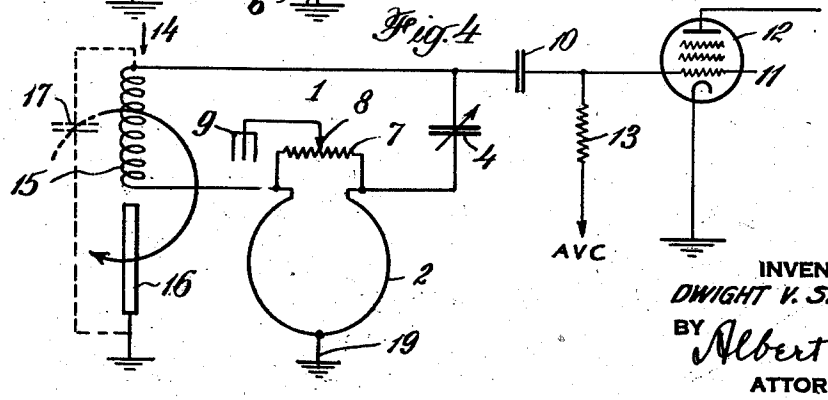


Fig. 4



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2,190,850

INTERFERENCE REJECTION RECEIVER

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6 Claims. (Cl. 250—20)

This invention relates to high-frequency circuits and more particularly to those employed in radio receiving systems. Such systems include means for collecting the high-frequency signals which are radiated from relatively distant transmitting stations. Such a collecting means is of the capacitive or inductive type. The improved collecting means incorporated in the present invention is of the inductive type.

In radio receivers, and more particularly those intended for the reception of broadcasting, it is very important that the signal-to-noise ratio at the input to the first vacuum tube be as high as possible. This ratio may be increased either by increasing the amount of signal pick-up or by decreasing the noise pick-up, or by both simultaneously. The signal pick-up may be improved by increasing the physical dimensions of the signal-collecting means or by tuning the circuit including the signal-collecting means to resonance with the desired signal or both. The noise pick-up may be reduced by preventing the signal-collecting means from picking up certain forms of interference or by supplying to the input circuit of the first vacuum tube of the receiver a voltage equal in amplitude but opposite in phase to the noise which is picked up by the signal-collecting means.

In accordance with my invention, I employ an electro-statically shielded loop antenna as a signal-collecting means and arrange to tune the circuit in which it is connected to resonance with the desired signal. Additionally, I provide means for introducing into the input circuit of the first vacuum tube a voltage which tends to overcome the voltage there present due to noise pick-up by the signal-collecting means. My invention provides, therefore, in compact and inexpensive form, a system having a signal-to-noise ratio comparable with that formerly obtainable only by the use of a relatively large capacitive antenna, or by the use of a bulky loop antenna of the type which must be rotated for satisfactory results with various signals originating in geographically different locations.

In an article entitled "A shielded loop for noise reduction in broadcast reception" appearing at page 20 of the October 1938 issue of "Electronics" magazine, Goldman describes the use of a pivotally mounted electrostatically shielded loop antenna which is tuned to resonance with the desired signal by capacitance variation, noise reduction being realized by properly orienting the loop with respect to the noise source. This arrangement, however, differs in important respects from that of my invention, as will become apparent from my specification.

My invention is particularly adapted for use in connection with resonant circuits which are tuned over a range of frequencies by inductance variation. Such a system is the one disclosed by Polydoroff in United States Patent No. 1,940,228, in which a resonant circuit having an inductance coil and capacitor is adjusted over a range of frequencies by movement of a compressed comminuted ferromagnetic core relative to the inductance coil. This method of tuning is commonly called permeability tuning. An improved form of such a system is disclosed by Schaper in United States Patent No. 2,051,012. Both Polydoroff's original system and Schaper's improved system readily cover an adequate range of frequencies and may easily be ganged to provide multiple unit systems. It will be understood, however, that my invention is equally useful in capacitively tuned systems.

An object of my invention is to provide an improved signal-collecting means for radio receivers.

An additional object is to improve the signal-to-noise ratio which may be obtained with a compact signal-collecting means.

Still another object is to provide a tuned input circuit for radio receivers which is capable of providing an improved signal-to-noise ratio.

These and other objects are realized in accordance with my invention in a manner which will be more readily understood by reference to the accompanying drawing, in which:

Fig. 1 shows schematically an input system embodying my invention;

Fig. 2 shows a preferred arrangement according to the invention; and

Figs. 3 and 4 show modifications of the arrangement of Fig. 2.

In the input system of Fig. 1, which is suitable for use in radio receivers or the like, the resonant circuit which is designated generally by the reference numeral 1 includes a signal-collecting loop 2, an inductor 3, and a capacitor 4. Loop 2 is housed in a conductive shield or sheathing 5 the electrical center of which is grounded at 6 and the ends of which are respectively connected to the end terminals of a potentiometer 7. The movable arm or slider 8 of the potentiometer is connected to counterpoise 9. Loop 2, sheathing 5, potentiometer 7 and counterpoise 9 in combination constitute means for introducing into resonant circuit 1 potentials picked up by counterpoise 9. The phase of these potentials with

respect to that of the noise potentials in circuit 1 is determined by the direction in which slider 8 is moved, and their amplitude by the amount of such movement.

Thus it will be seen that my improved input system comprises a resonant circuit 1 including a loop 2, an inductor 3, and a capacitor 4, and the system is connected to supply voltage through capacitor 10 to control-grid 11 of vacuum tube 12, direct-current bias voltage being supplied to control-grid 11 from any suitable source through resistor 13.

It will be understood that loop 2, although shown diagrammatically as a single turn, actually consists of several turns. Loop 2 will ordinarily be mounted in such a way as to permit it to be rotated about a vertical axis, since by this means maximum signal pick-up is secured, but this is not an essential requirement for the successful operation of my invention. Counterpoise 9, shown by the conventional symbol, may in practice have any one of a number of different forms, as for example a few feet of wire attached to the cabinet housing the receiver employing the invention. Vacuum tube 12 is the first tube of a radio receiver or the like, and may function either as an amplifier or otherwise, for example as the first detector of a superheterodyne radio receiver, without affecting the mode of operation of the invention.

In operation, resonant circuit 1 is tuned to resonance with the desired signal. The two halves of loop sheathing 5 with potentiometer 7 comprise a bridge circuit by means of which the amplitude and phase of the voltage which is supplied to resonant circuit 1 from counterpoise 9 may be varied as desired. Thus electrostatically introduced interference may be bucked out by the introduction of a voltage of equal amplitude but of opposite phase. This is done merely by adjustment of potentiometer 7 to the null point. By means of this adjustment, it is also possible to substantially offset electromagnetically introduced interference arising with random orientations of the loop. In this manner, a very substantial reduction of noise is realized without the necessity for changing the orientation of loop 2. This is an important feature of my invention and greatly simplifies the construction and operation of the receiver utilizing my system. Thus, in accordance with my invention, I realize most of the advantages of the loop type of antenna without the requirement of rotating it for minimum noise. The system described by Goldman, mentioned above, is incapable of providing this highly desirable result. Still further noise reduction may be obtained, however, by rotating loop 2 to the bearing providing the least pick-up from the interference source.

Another feature of my invention is that, in quiet locations, the signal pick-up of counterpoise 9 may be made to supplement that of loop 2 merely by moving slider 8 of potentiometer 7 to either extremity. Where maximum sensitivity is required, an ordinary antenna may be connected to counterpoise 9 or in place of it, thus rendering the receiver incorporating my invention suitable for use in so-called "dead spots" or other locations of relatively poor signal strength, and in any locations for the reception of very weak signals.

Referring now to Fig. 2, which shows a preferred embodiment of the invention and in which like reference numerals are used to designate like components, it will be seen that the inductor 3 of Fig. 1 is replaced by a variable inductance device 14 comprising an inductance coil 15 and a relatively movable ferromagnetic core 16. Inductance device 14 is used for tuning resonant circuit 1 over a range of frequencies, and capacitor 4, which is adjustable, may be employed for adjusting the resonant frequency near the high-frequency end of the tuning range. Core 16 has appreciable surface conductivity and is effectively grounded, either conductively or through a low-impedance resistive or capacitive path. The capacitance between the core 16 and the high-potential portion of coil 15 is represented by dotted capacitor 17, and this capacitance varies as core 16 moves relatively to coil 15, as indicated by the curved arrow passing through it. The arrangement and mode of operation of the embodiment shown in Fig. 2 is otherwise similar to that of the system of Fig. 1.

In Figs. 1 and 2, sheathing 5 serves simultaneously as an electrostatic shield for loop 2 and as a primary winding for applying signals originating in counterpoise 9 to resonant circuit 1. This is a preferable arrangement and one of the features of my invention, but it is within the scope of the invention to employ a separate primary winding. This modification is shown in Fig. 3, in which like components are designated by like reference numerals. Potentiometer 7, instead of being connected to the ends of sheathing 5, as in Figs. 1 and 2, is connected between the ends of a primary winding 18 which is inductively coupled to loop 2 and the approximate electrical center of which is grounded. In other respects, the arrangement and operation of the modification of Fig. 3 is the same as in the case of the systems of Figs. 1 and 2.

Where the interference encountered is of the resonant type, i. e., such as to undergo an increase in a resonant circuit, good results may be obtained by employing a loop which is not shielded electrostatically. Fig. 4 shows such a modification in which like reference numerals are used to designate like components. In contrast with Figs. 1, 2 and 3, loop 2 of Fig. 4 is unshielded and potentiometer 7 is connected between its ends. The low-potential terminal of capacitor 4 is not grounded, resonant circuit 1 being grounded by means of the connection 19 near the electrical center of loop 2. Although effective in overcoming resonant interference, the system of Fig. 4 is inferior to those of Figs. 1, 2 and 3 in cancelling non-resonant interference.

In Figs. 2, 3 and 4, tuning of resonant circuit 1 over a range of frequencies is accomplished by movement of core 16 with respect to coil 15. With the core withdrawn, the resonant frequency is adjusted to the desired value by means of capacitor 4. Core 16 may be ganged with other cores in the receiver for single-control operation if desired. Since the proportion of loop inductance to total inductance in resonant circuit 1 varies over the frequency range, the amount of signal pick-up tends to decrease at the low-frequency end of the tuning range. This tendency is partially overcome by the fact that core-to-coil capacitance 17 increases as the resonant frequency decreases, so that more current flows through loop 2 at the lower frequencies. This is one of the features of my invention. It will be understood, however, that forms of inductance tuning other than permeability tuning may be employed in the systems of Figs. 2, 3 and 4 without departing from the scope of my invention. In Figs. 2 and 3, the use of inductance tuning prevents the inherent capacitance between loop 2

and sheathing 5 from curtailing the frequency range over which resonant circuit 1 is tunable.

In one successful embodiment in accordance with Fig. 2, loop 2 consists of five turns of No. 22 insulated wire enclosed in shield 5 consisting of a split copper tube with an inside diameter of 0.3125 inch and an outside diameter of 0.375 inch. Loop 2 is 12.5 inches in diameter, and is preferably mounted so as to rotate freely about a vertical axis. Potentiometer 7 has a resistance of 5000 ohms. Counterpoise 9 consists of about ten feet of insulated wire. Inductance coil 15 comprises 277 turns of No. 36 enamelled wire forming a winding 1.6875 inches long on a form having an outside diameter of 0.340 inch, and the coil has an inductance of approximately 125 microhenries. Core 16 has a length of 1.875 inches and a diameter of 0.3125 inch. Capacitors 4 and 10 have capacitances of 37 and 500 micromicrofarads, respectively. Resistor 13 has a resistance of 0.5 megohm. This embodiment is intended for use over the frequency range from 540 to 1600 kilocycles.

Although suitable for use in any type of radio receiver, my invention is particularly applicable in portable battery-operated receivers of the so-called suitcase type, where the maximum signal pick-up consistent with extreme compactness is essential and where it may or may not be convenient to orient the self-contained loop for minimum interference. Other uses will readily occur to those skilled in the art.

Having thus described my invention, what I claim is:

1. An input system for use in radio receivers and the like, comprising a resonant circuit including a signal-collecting loop, a counterpoise, and means for introducing into said circuit potentials of opposite phase but otherwise substantially identical to noise potentials occurring in said circuit comprising a potentiometer coupled to said loop and having its movable arm connected to said counterpoise, whereby said noise potentials may be effectively cancelled with resultant improvement in the signal-to-noise ratio of said circuit.

2. An input system for use in radio receivers and the like, comprising a resonant circuit including a signal-collecting loop having a conductive sheathing grounded at approximately its electrical center, a counterpoise, and means for inducing into said circuit potentials of opposite phase but otherwise substantially identical to noise potentials occurring in said circuit comprising a potentiometer having its end terminals connected respectively to the ends of said sheathing and having its movable arm connected to said counterpoise, whereby said noise potentials may be effectively cancelled with resultant improvement in the signal-to-noise ratio of said circuit.

3. An input system for use in radio receivers and the like, comprising a resonant circuit including an electrostatically shielded signal-collecting loop; a counterpoise; and means for inducing into said circuit potentials of opposite phase but otherwise substantially identical to noise potentials occurring in said circuit comprising a winding inductively coupled to said loop and being grounded at approximately its electrical center, and a potentiometer having its end terminals connected respectively to the ends of said winding and having its movable arm connected to said counterpoise; whereby said noise potentials may be effectively cancelled with resultant improvement in the signal-to-noise ratio of said circuit.

4. An input system for use in radio receivers and the like, comprising a resonant circuit including an unshielded signal-collecting loop having its approximate electrical center grounded, a counterpoise, and means for introducing into said circuit potentials of opposite phase but otherwise substantially identical to noise potentials occurring in said circuit comprising a potentiometer having its end terminals connected respectively to the ends of said loop and having its movable arm connected to said counterpoise, whereby said noise potentials may be effectively cancelled with resultant improvement in the signal-to-noise ratio of said circuit.

5. An input system for use in radio receivers and the like, comprising a resonant circuit including a signal-collecting loop, a variable inductance device for tuning said circuit over a range of frequencies comprising an inductance coil and a relatively movable ferromagnetic core of appreciable surface conductivity and effectively grounded, and an adjustable capacitor for adjusting the resonant frequency of said circuit near the high-frequency end of said range; and means for introducing into said circuit potentials of opposite phase but otherwise substantially identical to noise potentials occurring in said circuit; whereby the capacitance between said core and said inductance coil tends to maintain substantially constant the effective signal pick-up of said signal-collecting means, and whereby said noise potentials may be effectively cancelled with resultant improvement in the signal-to-noise ratio of said circuit.

6. An input system for use in radio receivers and the like, comprising a resonant circuit including a signal-collecting loop having a conductive sheathing grounded at approximately its electrical center, an inductor, and a variable capacitor for tuning said circuit over a range of frequencies; a counterpoise; and means for inducing into said circuit potentials of opposite phase but otherwise substantially identical to noise potentials occurring in said circuit comprising a potentiometer having its end terminals connected respectively to the ends of said sheathing and having its movable arm connected to said counterpoise; whereby said noise potentials may be effectively cancelled with resultant improvement in the signal-to-noise ratio of said circuit.

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