Feb. 6, 1940. W. R. KOCH 2,189,317

DIVERSITY ANTENNA SYSTEM

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Fig. 1.

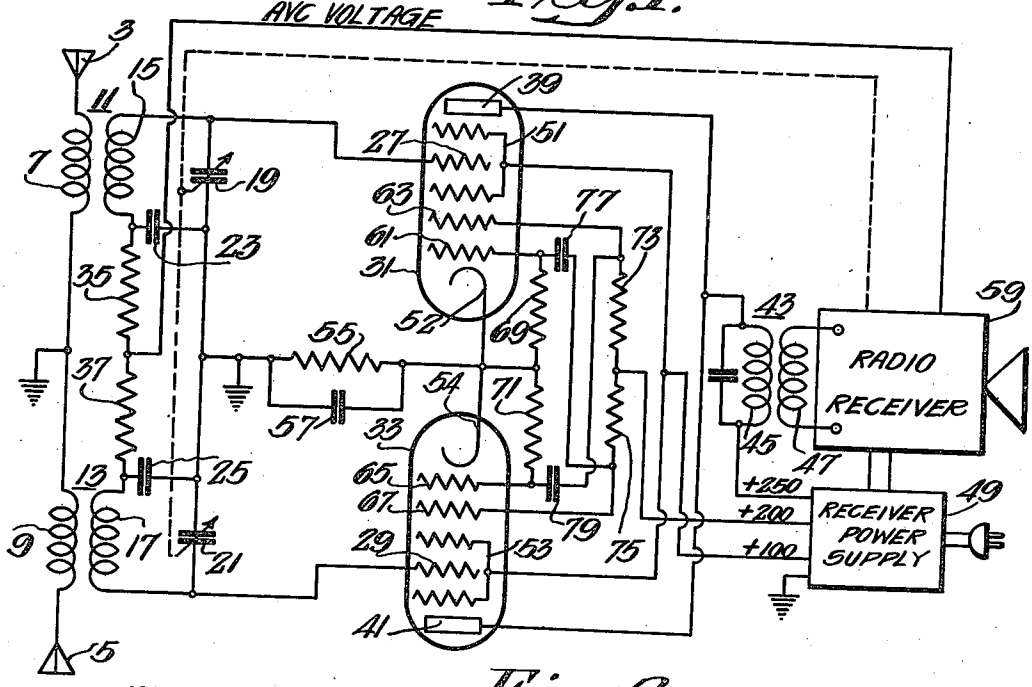
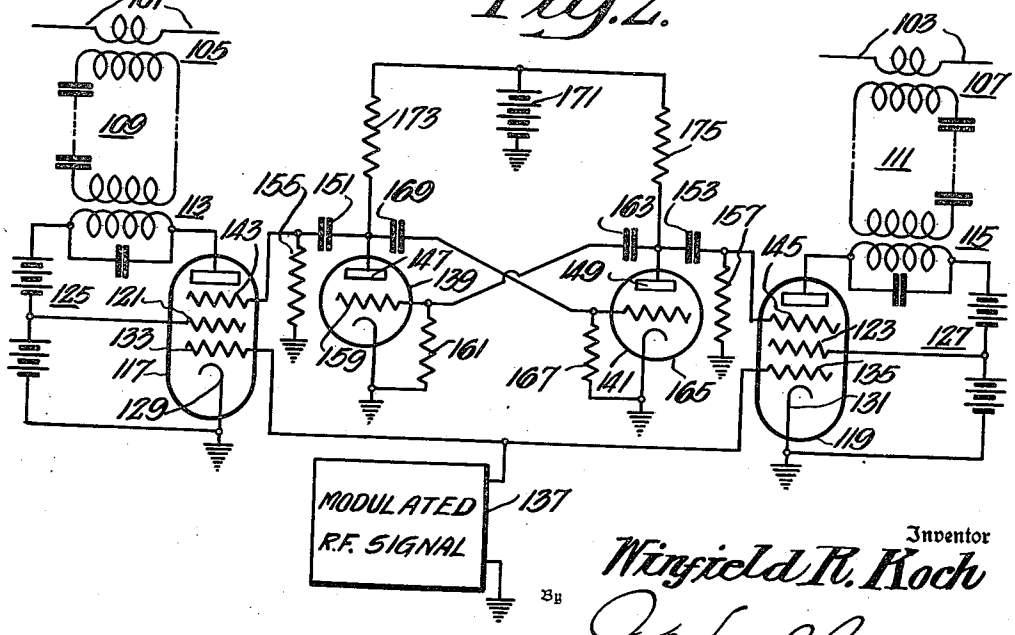


Fig. 2.



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DIVERSITY ANTENNA SYSTEM

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2 Claims. (Cl. 250—20)

My invention relates to a method of and means for reducing fading in radio reception, and more particularly to an electronic switching means by which a pair of spaced antennas are alternately utilized at a receiving or transmitting station.

It is well known that radio reception is subject to periodic fading, especially at high frequencies. It is also known that the signal strength of a given station may vary widely between antennas located at different points which are relatively close together. It is impractical to connect several antennas located in different positions to one receiver, because the currents in one are frequently out of phase with the currents in the other. The result is that the signal at the receiver is actually decreased and the fading made worse.

One solution of this problem involves the use of several receivers, each having a separate antenna, and means for automatically bringing the receiver into operation which is providing the best signal. This system, known as a diversity reception system, involves more apparatus than the usual broadcast listener can afford.

I propose to provide an effective diversity reception system which uses but one receiver, and yet which is automatically receptive to signals from the one of two antennas which provides the best signal strength.

Alternately I propose to apply the same system to the transmitter in such a manner that fading is reduced for receivers having but one antenna.

It is an object of my invention to provide an automatically operated device for reducing fading in radio reception.

It is a further object of my invention to provide means for utilizing more than one antenna with a radio receiver to reduce fading.

A further object of my invention is to provide a simple and inexpensive device for obtaining the benefits of diversity reception.

A still further object of my invention is to reduce fading at a radio receiver by transmitting alternately from two antennas which are at different locations.

A still further object of my invention is to connect alternately two antennas to a transmitter or receiver at a supersonic rate.

A still further object is to provide an electronic switching means to accomplish the above-named objects.

My invention will be better understood from the following description when considered in connection with the accompanying drawing. Its scope is indicated by the appended claims.

Referring to the drawing:

Figure 1 is a schematic diagram of one embodiment of my invention as applied to a radio receiver, and

Figure 2 is a schematic diagram of an alternative embodiment of my invention as applied to a radio transmitter.

Referring to Fig. 1, a pair of antennas 3 and 5 are provided which are located at suitably remote locations, and which are preferably separated by a distance which is greater than one wave length at the lowest desired operating frequency. The antennas are respectively connected to ground through the primaries 7 and 9 of a pair of input transformers 11 and 13. Input transformers 11 and 13 are similar to those commonly used in radio receivers. Their secondary windings 15 and 17 are respectively shunt tuned by a pair of variable capacitors 19 and 21, which may be ganged together for unitary operation.

One terminal of each secondary windings 15, 17 is connected to respective by-pass capacitors 23 and 25, and also through respective resistors 35, 37 to an AVC voltage source will be subsequently described. The remaining terminal of each secondary winding 15, 17 is connected to the respective capacitors 19 and 21 and to the control grids 27 and 29 of a pair of thermionic tubes 31 and 33. Tubes 31 and 33 are preferably multi-grid tubes such as are commonly used as the first detector-oscillator in a superheterodyne receiver.

The anode electrodes 39 and 41 are connected together and to one terminal of the primary 45 of a coupling transformer 43. The remaining terminal of the primary 45 is connected to any convenient source of high voltage D. C. 49. Each tube is provided with a screen grid electrode 51, 53 which is likewise connected to the positive potential source 49. The cathode 52, 54 may be grounded directly, or through a common bias resistor-capacitor combination 55, 57.

The secondary 47 is connected to the first detector or radio frequency amplifier of a standard radio receiver 59, which is not shown in detail. The capacitors 19, 21 are preferably ganged together with the amplifier and oscillator tuning capacitors of the receiver.

It is to be noted that the circuit which has been described includes a pair of radio frequency amplifiers fed from a pair of antennas and connected to a single radio receiver. The amplifiers may be an addition to the standard receiver, or may be substituted for the usual first stage of radio frequency amplification. It is evident, however, that the device would be inoperative unless the

currents from the two antennas were in proper phase, or unless some means were provided for making one-half of the system inoperative. Manual selection is undesirable and therefore I propose to accomplish the desired result by making the tubes 31, 33 alternately non-conductive at a rate which is high enough so as not to cause any interruption in the signal reception. The first and second grids 61, 63 and 65, 67 of the respective tubes are therefore interconnected and constitute an impulse oscillator which alternately biases off the tubes.

A pair of grid resistors 69 and 71 are respectively connected between grids 61 and 65 and the cathodes 52, 54. A pair of resistors 73, 75 are respectively connected between grids 63 and 67 and a tap on the positive potential power supply 49. A coupling capacitor 77 is connected from grid 61 to grid 67, and a similar coupling capacitor 79 is connected between grid 65 and grid 63.

The values of the resistors and capacitors which constitute this oscillator are suitably selected so that the resultant impulse oscillation is of the desired supersonic frequency. In such a case the receiver 59 will effectively be connected first to one antenna and then to the other. If the signal from one antenna fades out, and the signal from the other antenna is still usable, the usable signal will operate the receiver. The possibility of simultaneous fading of the signal from both antennas is reduced by placing the antennas at different locations which are some distance apart.

The two tubes 31 and 33 are automatically biased according to the signal having the greatest intensity by applying the receiver AVC voltage to the control grids 27 and 29. It is to be noted that this AVC voltage is applied to both tubes. Consequently, when the signal fades out from the first antenna, there will be enough time lag in the AVC voltage to prevent the first amplifier from amplifying static and other noises at maximum amplification. The overall receiver sensitivity is thus automatically adjusted by the signal having the greatest intensity.

The system described above can be applied to a standard receiver as additional apparatus, or can be incorporated within the receiver itself. In either case a minimum of parts is required.

This system is particularly useful in conjunction with ultra high frequency receivers on police cars and the like. The fading effects at ultra high frequencies are intensified, probably due to "shadows" cast by buildings in certain localities, and to cancellation of one wave by a second wave travelling a different and longer path. Frequently, a change in the position of the antenna of only a few feet is sufficient to restore reception to normal. By equipping police cars with two antennas and an electronic switching system of the type herein disclosed, greatly improved reception can be obtained.

It is possible to obtain effectively the same result without modifying the receiver or adding anything to it. This is accomplished by applying the principle of my invention to the transmitter insead of to the receiver. A device of this nature is shown in Fig. 2.

Referring to Fig. 2, a pair of dipole antennas 101 and 103, or the like, are provided. These antennas are placed at different locations and are respectively coupled through coupling transformers 105, 107 and transmission lines 109, 111, to a pair of output transformers 113 and 115. The output transformers are respectively connected in the anode circuits of a pair of radio frequency power amplifiers 117 and 119.

Potential for the screen grids 121 and 123 is respectively obtained from a suitable tap on two batteries 125 and 127, or the like. The negative terminals of the batteries are connected to cathodes 129, 131 and grounded. The control grids 133, 135 of the power tubes are connected in parallel and energized from a source of modulated, or unmodulated, radio frequency energy which is indicated by reference numeral 137.

The transmitting system thus described includes a transmitter which has two output systems connected in parallel, driving separate antennas. It would be unsatisfactory to operate in this manner, however, as in certain locations the signals from the two antennas would be out of phase and reception would be impossible. As before, therefore, an electronic commutator is utilized to cause the output tubes to become alternately operative at a supersonic rate. If at any given point reception from one antenna is poor, the signal from the other antenna may be usable.

Switching is accomplished by interconnecting a pair of triodes 139 and 141 so as to obtain impulse oscillation and alternately biasing off one of the output tubes. The output amplifiers 117 and 119 are respectively provided with suppressor grids 143 and 145. These grids are respectively connected to the anodes 147, 149 of the triodes through coupling capacitors 151 and 153. Grids 143 and 145 are also respectively grounded through resistors 155 and 157.

The grid 159 of triode 139 is grounded through a resistor 161 and coupled by a capacitor 163 to the anode 149 of triode 141. The grid 165 of triode 141 is similarly grounded through resistor 167 and coupled to the anode 147 of triode 139 by capacitor 169. Anode potential is supplied by a battery 171, or the like, which is respectively connected to the anodes 147 and 149 through resistors 173 and 175.

The operation of this device may be explained as follows: As the triodes oscillate in the well known manner, a biasing potential is alternately impressed on the grids 143 and 145 by capacitors 151 and 153 due to the decrease in anode potential as each tube becomes conductive. Consequently the radio frequency output is transferred from one antenna to the other at a rate which is determined by the frequency of oscillation of the two triodes. As before this is preferably at a supersonic frequency.

I have thus described a system of diversity reception which may be applied either to a receiver or to a transmitter.

I claim as my invention:

1. In a device of the character described, a pair of antennas positioned in spaced relationship, a pair of thermionic tubes having input and output circuits, means respectively coupling said antennas to said input circuits, a utilization device, means coupling said utilization device to said output circuits, means for simultaneously limiting the sensitivity of both of said thermionic tubes in proportion to the signal intensity from one of said antennas and means for causing said thermionic tubes to become alternately conductive, whereby currents from said antennas are alternately impressed on said utilization device.

2. In a device of the character described, a pair of antennas positioned in spaced relation-

ship, a pair of thermionic tubes having input, output, and auxiliary electrodes, means respectively coupling said antennas to said input electrodes, a utilization device, means coupling said utilization device to said output electrodes, means including said auxiliary electrodes for generating supersonic oscillatory currents which cause said tubes to become alternatively conductive, and means for simultaneously and equally limiting the sensitivity of said thermionic tubes in proportion to the amplitude of the received signal having the greatest intensity.

WINFIELD R. KOCH.