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E. DÖLLE ET AL
ARRANGEMENT FOR THE AUTOMATIC TUNING
OF A TRANSMITTER ANTENNA
Filed Nov. 1, 1940

Serial No.
363,862
2 Sheets-Sheet 1

Fig. 1

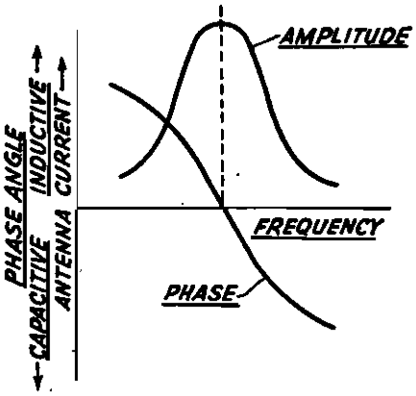

Fig. 3

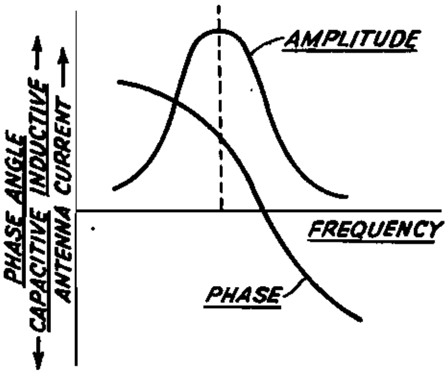

Fig. 2

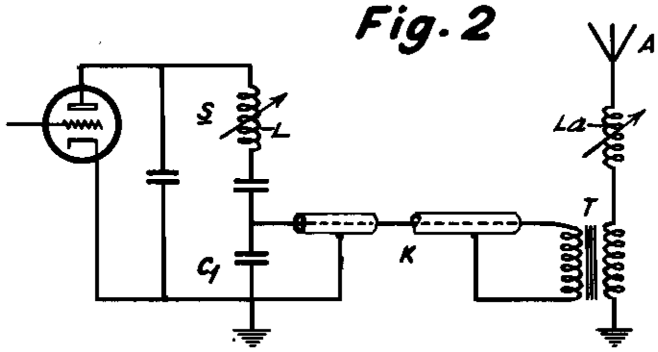

Fig. 5

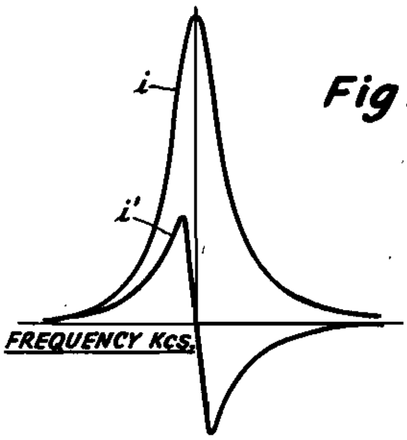

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Fig. 4

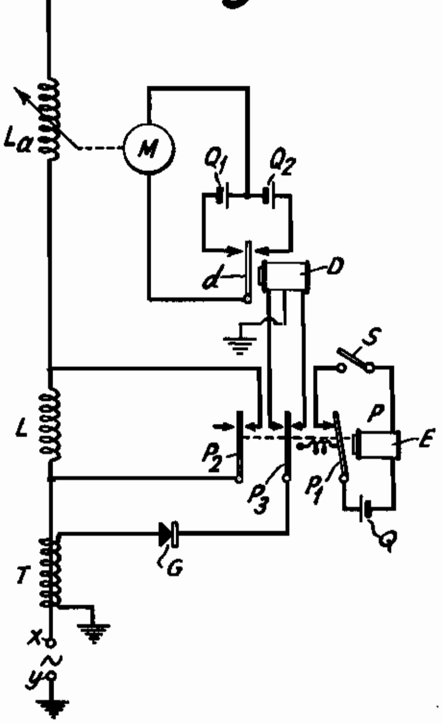


Fig. 6

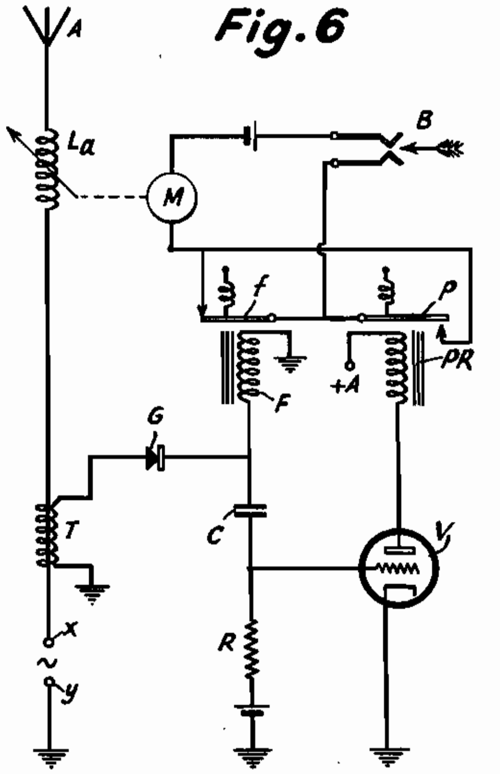
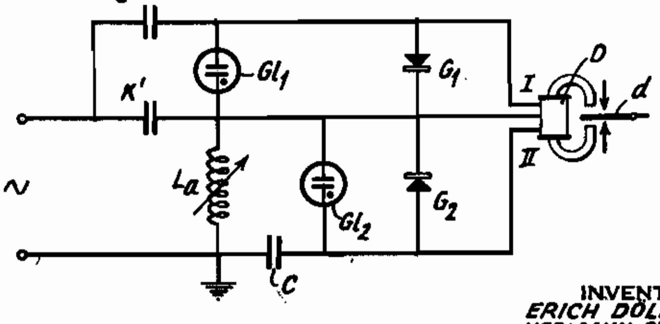


Fig. 7



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ALIEN PROPERTY CUSTODIAN

ARRANGEMENT FOR THE AUTOMATIC TUNING OF A TRANSMITTER ANTENNA

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For the automatic tuning of an electric structure capable of producing oscillations such as, for instance, a receiver an entire series of arrangements are known. The majority of these arrangements utilize as the criterion for the attained resonance the phase equality of current and voltage in the respective resonance circuit, since for even a slight detuning there exists a considerable phase difference between current and voltage. This type of control of the automatic tuning is termed "phase jump" method.

Arrangements are also known in which the resonance curve is scanned and the tuning is varied until the amplitude of the current, or of the voltage has reached its maximum. Since the latter arrangements are more complicated as to structure and furnish at their best no better setting possibilities and usually a less accurate setting due to the flat slope of the resonance curve in the immediate vicinity of the maximum, arrangements are usually employed which operate in accordance with the "phase jump" method.

In accordance with the present invention in such an arrangement for the automatic tuning of a transmitter antenna, to the frequency of the coupled transmitter there serves as criterion for the exact tuning the maximum of the antenna current, or of the antenna voltage. More especially, there is provided in a manner known as such a tuning variation means which oscillates periodically only within a narrow range and which is responsive to only difference of the current values, or voltage values which disappear at resonance, and which values exist in the border points of the oscillatory tuning, for the purpose of controlling a constant variation of the tuning. A further method may also be employed in which there serves for the control of the remaining tuning variation a differential quotient with respect to time which disappears at resonance. The quotient taken may be based on the effective antenna power of the detected antenna current or of the detected antenna voltage. Each of these values vary with the tuning.

The present invention will be more clearly understood by reference to the following detailed description which is accompanied by a drawing in which Figures 1 and 3 are curves useful in explaining the principle of the invention as applied to the antenna circuit of Figure 2, while Figure 4 illustrates an application of one modification of the invention to the circuit of Figure 2, Figure 5 shows further curves illustrative of the operation of the invention and Figures 6 and 7 show further modifications of the invention.

The advantage of the present invention can be recognized from the following considerations: In an ordinary oscillatory circuit the maximum of the amplitude-resonance curve coincides with the passing through zero of the phase resonance curve as shown in Figure 1. However, a different condition exists in the case of a transmitter antenna having a circuit as shown, for instance, in Figure 2. Herein S is the final amplification circuit of a transmitter, said circuit being tuned by means of the variable inductance L. A part C_1 of the capacity of the circuit is connected through the shielded transmission line or cable K across the antenna transformer T which is coupled to the antenna A. The latter can be tuned by means of the inductance L_A.

When plotting for such an arrangement the phase difference between the antenna current and antenna voltage on the one hand and the amplitude of the antenna current on the other hand, as a function of the tuning of the antenna circuit comprising substantially the antenna capacity and L_A, the resonance curves according to Figure 3 will be obtained. According to this figure the passing through zero of the phase curve and the maximum of the amplitude curve do not coincide with each other. This is explained by the fact when the impedance of the antenna is purely ohmic the condenser C_1 is shorted to a greater or lesser degree and the output circuit of the transmitter is so detuned that the latter and, therefore, also, the antenna cannot conduct the maximum current possible. The fact is rather that the location of the strongest antenna current corresponds with an inductive state of the antenna.

Consequently, such arrangements which bring about an automatic tuning to the zero phase directly at the antenna offer in use, in general, but a very poor degree of efficiency. Such arrangements could be utilized with a more favorable degree of efficiency only if according to a proposal already made, the arrangement is so adapted by the insertion of a coil tuned with the transmitter in the lead from the condenser C_1 to the cable K that the influence of the detuning of the output circuit of the transmitter caused by the ohmic state of the antenna is eliminated or compensated for.

The present invention, however, renders possible a correct automatic tuning of the antenna arrangement in each case, irrespective as to whether or not the transmitter is provided with the said compensation device. The antenna device hence can be connected to the automatic tuning arrangement at any desired transmitter. An example of construction according to the present invention is shown in Figure 4.

The transmitter antenna A is connected to ground through a series circuit comprising the tuning coil L_a, a fixed additional coil L, the primary coil of a current converter T and the terminals x, y to which the alternating voltage is applied which comes from the transmitter, The vibrating switch P has an exciter coil E which is placed in series to the voltage source Q, a switch S and the exciter contact p_1. A further contact p_2 is placed in parallel to the coil L and a third reversing contact p_3 of the vibrating converter is so connected that the moved contact pole lies in series with the secondary coil of the transformer T and a detector G, while the two fixed contact poles are connected to the coil ends of the differential relay D. The coil center is grounded as is the end of the secondary coil of the transformer T which is not connected to the detector G. The switching contact *d* of the differential relay D energizes the terminals of the reversible motor M in accordance with the sense of the excitation of the winding by either the voltage of the direct voltage source Q_1 or the voltage of the source Q_2 with opposite polarity. This motor is mechanically coupled in any suitable manner with the tuning device of the coil L_a.

As soon as the vibrating switch P is actuated by closing the contact S_1 the impedance L in the antenna circuit is periodically short-circuited by the contact p_2. The switch p_3 operating simultaneously with p_2 supplies the coils of the differential relay D which act against each other with current pulses which are proportional to the antenna currents which flow in the antenna circuit in the conditions of open or short-circuit of self inductance L. Depending on whether the operation takes place on the left side, or right side of the resonance curve, the difference current in the coil of the relay has a different direction so that the contact *d* engages different fixed contacts. The direction of rotation of the motor M thus is always so determined that the variation of the tuning impedance L_a takes place in the direction towards resonance. When the resonance point is reached, the vibratory tuning takes place symmetrically with respect to the resonance position so that the current pulses in the two coils of the relay are identical in value. The armature of the relay hence, assumes the neutral center position and disconnects the motor M.

Figure 6 shows an example of construction according to the present invention in which the differential quotient in respect to time, which disappears at resonance, of the antenna power varied with the tuning, serves for controlling the variation of the tuning. Figure 5 shows a resonance curve *i* and its differential quotient *i'* in respect to time for a transit of the tuning operation, i. e. the figure shows the steepness of the resonance curve.

In the circuit according to Figure 6 by pressing down the key B the circuit of the motor M is closed across the contacts *a* and *p*. An impedance of the antenna circuit, for instance, the variable self inductance L_a, is continuously varied by the motor in a certain direction. If the current starts flowing in the antenna circuit in the proximity of the resonance, a current is obtained through the condenser C and through the resistance R which current is almost proportional to the differential quotient *i'* in regard to time, of the resonance curve of Figure 5 if care is taken that the apparent resistance of the condenser C is sufficiently high against the resistance R.

The amplifier tube V is blocked in the state of rest and thus no plate current flows. Owing to the potential drop through the resistance R the grid biasing potential will be less negative so that a plate current pulse will be given across the coil of the polarized relay PR. The contact *p* will thus next be closed.

The sensitivity of the further relay F must be so regulated that it only begins to operate and opens its contact *f* after *p* is closed. The control of the motor M thus takes place solely across the contact *p*. In the state of resonance proper the current passes through zero. PR has then no current thus severing the circuit of the motor. The tuning of the transmitter antenna is thus reached.

Furthermore, it is advisable to utilize in conjunction with the circuit according to the present invention, additional arrangements which in the case of a wider detuning permit of first a rough automatic tuning in the shortest direction because the described devices normally operate reliably only if the initial detuning is not too excessive. An example of construction for such an arrangement is shown in Figure 7.

Now, when applying a voltage to the series resonant circuit comprising the capacity of the transmitter antenna, the self inductance L_a, the antenna tuning coil whereby the said voltage (transmitter potential) has a frequency that is lower than the resonance frequency of the circuit, the voltage at the condenser K' is higher than that at the self inductance L_a. The current at the coil I of the different relay D hence predominates and moves the contact *d* upwards, for instance. If the frequency is higher than the circuit frequency, the voltage on across L_a will be higher so that therefore the current at the coil II of the differential relay D predominates. The contact *d* therefore moves down. The arrangement can be so adapted that across the contact *d* a motor will be controlled as in Figure 4 which through the variation of L_a so changes the tuning of the transmitter circuit that the latter passes to the resonance point on the shortest way.

In the case of resonance the two potentials at K' and L_a would have the same value and opposite senses. The contact *d* would thus assume the central position and would disconnect the drive motor.

In all practical cases the resonant voltages at K' and at L_a have such high values that the detectors G_1 and G_2 would be destroyed. These detectors must necessarily be very sensitive since the potentials serving for the control of D are, outside the resonance point, higher than at the resonance point, by two to three orders of magnitude. For the protection of these detectors glow discharge paths Gl_1 and Gl_2 are employed which short circuit the detector as soon as the voltage at the detector exceeds the potential of the glow discharge. Hence, the tuning of the circuit consisting of K' and L_a can only be brought near the resonance point by the use of the arrangements according to Figure 7. The accurate setting must then be done by means of another arrangement such as, for instance, that shown in Figure 4.

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