Dec. 8, 1931. W. SCHEPPMANN 1,834,975

RADIO CIRCUIT

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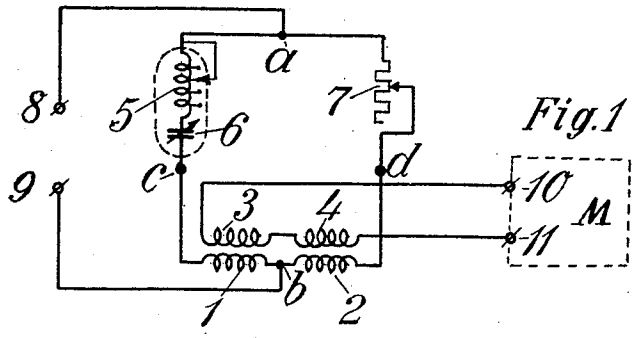


Fig.1

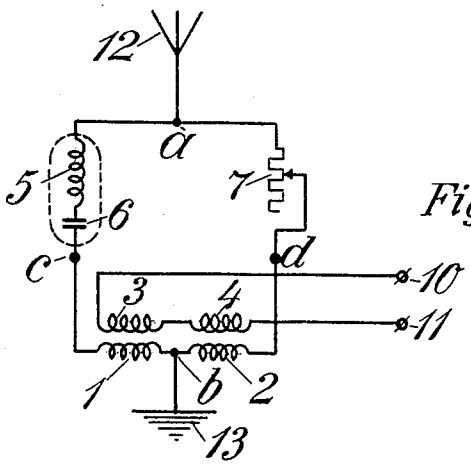


Fig.2

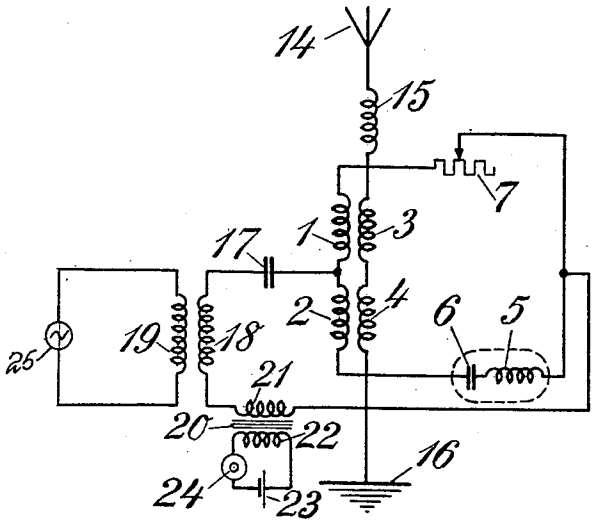


Fig.3

Inventor
Wilhelm Scheppmann
By Paul Schilling
Attorney.

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UNITED STATES PATENT OFFICE

WILHELM SCHEPPMANN, OF BERLIN-TEMPELHOF, GERMANY

RADIO CIRCUIT

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This invention relates broadly to the art of radio engineering and more particularly to all cases where a compensating circuit arrangement is required such as is in use for the suppression of an interfering signal in the reception of radio signals, or for any other circuit systems in which a differential or compensating action of currents of a distinct frequency is to take place.

In carrying out my invention I provide a circuit arrangement embodying two circuit paths in order to transmit currents from an input circuit to an output circuit and I render these circuit paths transparent to the currents of the frequency which is to be neutralized in the associated output circuit preferably by introducing into one of these circuit paths an "acceptor" circuit tuned to such particular frequency and therefore presenting zero impedance for same, so that currents of this frequency will be delivered at substantially equal magnitude to the output circuit associated equally with both circuit paths. By virtue of this relation of the circuit paths to the associated output circuit being so arranged as to have the currents in the latter oppose each other the resulting effect in the associated circuit for currents of such frequency will be zero. It follows, therefore, that for all currents of a frequency other than that to which the mentioned acceptor circuit is tuned to, the latter presents an effect equivalent to that of a large impedance and consequently prevents currents of all frequencies other than the resonant frequency of the acceptor circuit to pass thru only one of said circuit paths. The neutralizing effect of these frequencies in the associated common circuit is therefore rendered ineffective, only the resonant frequency of the acceptor circuit being substantially neutralized in the associated output circuit.

The circuit arrangement according to my invention presents special advantages more fully hereinafter explained.

When effecting a compensating or neutralizing action with direct currents, such as is the case e. g. with differentially wound relays and the like it is only necessary for the two currents flowing thru the two differentially wound windings to have the same magnitude i. e. the same number of amperes in order to neutralize their actions upon a current sensitive device e. g. the armature of the relay. When dealing with alternating or oscillating currents in compensating circuits a further condition is to be fulfilled to satisfy to this end in that, to obtain complete neutralizing effect, the two compensating currents besides having equal amplitudes, must always have a phase difference of 180°. There are known means to change the phase of radio currents and so satisfy this condition, but these means are troublesome and in most cases inaccurate and they make necessary readjustments when passing from one working wave length to another one. This method, therefore, can not be used in radio circuits, in which a constant change of frequency or tuning is required. It is, therefore, a special advantage of the novel circuit arrangement in accordance with my invention, that phase adjustments may be entirely dispensed with. For, the acceptor circuit introduced into one of the compensating circuit paths presents zero impedance to the current of its resonant frequency, it being therefore not necessary to introduce a phase shifting device into the other circuit path for balancing purposes. The currents have only to be adjusted to equal amplitudes as is the case when dealing with direct current systems.

My invention finds particular application in radio receiving systems, where it is desired to suppress one or more undesired interfering signal frequencies, but it may be of use too in transmitting systems, e. g. for suppressing undesired harmonics and thus preventing them from being radiated and causing interference in receivers. It may be employed too for the suppression of the carrier frequency in so-called single side band wireless telephone transmission systems with carrier suppression. Another application of the circuit arrangement according to my invention is to serve in a wave meter acting by a so-called "null" method as will be hereinafter more fully set forth.

My invention will be better understood by the following detailed description taken with

reference to the accompanying drawings of which Fig. 1 is a wiring diagram showing the general principle of the subject matter of the invention, and of which,

Fig. 2 is a schematic diagram showing a radio receiving system intended to eliminate an interfering signal and having for this purpose the circuit arrangement of my invention incorporated in it, and

Fig. 3 shows another embodiment of my invention in a transmitting system with the circuit arrangement of my invention associated therewith for the suppression of the carrier frequency for single side-band telephone systems with carrier suppression.

Referring more particularly to the diagram illustrated in Fig. 1, 8 and 9 are the input and 10 and 11 the output terminals of a radio circuit system of any kind in which it is desired to prevent currents of a distinct frequency to be transmitted from the input circuit at 8, 9 to the output circuit at 10, 11. For this purpose two compensating circuit paths are provided each containing a self-inductance 1 and 2 respectively symmetrically arranged which are coupled in opposite relationship by coils 3 and 4 respectively to the associated output circuit connected at the output terminals 10 and 11 so as to produce opposite effects therein. Into one of the current paths there is introduced an "acceptor" circuit consisting of a self-induction coil 5 in series with a capacity 6 and tuned to the frequency of the current which is to be suppressed. As this acceptor circuit has for the currents of its resonant frequency an effect equivalent to zero impedance, the balancing conditions for such current are maintained and the neutralizing effect in the associated circuit rendered effective. The circuit path containing the acceptor circuit 5, 6 presents to the current of its resonant frequency a short-circuit whereas for currents of differing frequencies the effect of it is that of a comparatively large impedance. The balancing conditions of such frequencies are, therefore, annulled so that they are transmitted to the output circuit with normal strength.

When dealing with practical circuits the acceptor circuit does not present complete zero resistance to its resonant frequency, but there is always left its ohmic resistance and according to another feature of my invention I compensate for this residual resistance by introducing into the other circuit path a variable resistance 7, whose value is so adjusted as to be equal to the resistance caused by the losses in the acceptor circuit 5, 6. It is thus possible to obtain a complete neutralizing effect with respect to currents of the undesired frequency, all other frequencies being transferred into the associated circuit. As the acceptor circuit 5, 6 presents only ohmic resistance to its resonant frequency, only a balancing by an ohmic resistance 7 is necessary such as is the case with direct current systems and laborious phase-shifting operations are avoided.

Referring to Fig. 2 of the drawings the novel feature of my invention is shown incorporated in a radio receiving system, in which an interfering signal is to be prevented from entering the receiver, such as is the case with radio plants on ships, where sending and receiving aerials are necessarily arranged close together and where for simultaneous transmitting and receiving the receiver must be protected against the strong interfering signals of the transmitter. The circuit arrangement forming the subject matter of my invention may be of use too when receiving distant broadcasting stations in the neighborhood of a local station and in other like cases. The wiring diagram represented by Figure 2 only differs from Figure 1 in that at the branching points *a* and *b* a receiving antenna-earth system 12, 13 is connected forming thus an input circuit. All other reference characters similar to that used in Figure 1 refer to equivalent elements. At the output terminals 10, 11 a well-known amplifying or detecting system for the signal frequency may be connected, e. g. there may be associated an oscillatory circuit tuned to the signal frequency which influences the grid of a three-electrode discharge device acting as detector or amplifier in combination with further devices to obtain an amplified signal which is finally supplied to a translating device. But as this is out of the scope of the present invention a further description may be dispensed with.

When employing a system according to Figure 2 also simultaneous transmitting and receiving with the same aerial may be carried out, it being only necessary to connect the transmitting apparatus outside the compensating circuit i. e. outside the points *a* and *b*. If two or more undesired frequencies are to be suppressed, the compensating circuit arrangement just described may be employed in successive stages. In this case, instead of a receiver, there is to be connected at the output terminals 10 and 11 a second compensating arrangement analogous to the first one and having its individual acceptor circuit tuned to another frequency which is to be prevented from being transmitted to the receiver.

When carrying into practice a circuit arrangement in accordance with my invention the coils 1, 2, 3 and 4 are preferably to be constructed in the form of a differential transformer. The coils 3 and 4 may also be dispensed with and the output or receiving circuit may then be connected at the points *c* and *d* instead of at the terminals 10 and 11. The latter method is equivalent to a conductive coupling of the output circuit in-

stead of an inductive one as is the case in Figs. 1 and 2. The effect is in both cases the same.

Referring to Fig. 3 of the drawings a transmitting wiring diagram is shown intended for the suppression of the carrier frequency in radio telephony and having to this end the circuit arrangement of my invention incorporated in it. It has already been proposed when transmitting modulated radio frequency currents particularly in carrier telephony with or without a wire in which besides the carrier frequency there exist two frequency bands more or less large and lying symmetrically with respect to the carrier frequency, to prevent the latter from being transmitted and thus transmit only the two or only one of the side-frequency bands. This makes it necessary to add at the receiving end the carrier frequency afresh by means of a small local oscillator in order to obtain an intelligible signal. One advantage of this method consists in that by the suppression of the carrier frequency its energy is applied on the side bands, and the secrecy of the signal with respect to unauthorized persons is increased it being only possible to get an intelligible signal for the person who is able to add the right carrier frequency. A further advantage when working with one side band only is the possibility of more stations being allowed to work within one given range of wave lengths, and especially when working on longer waves, of the farthest side frequencies not being chopped off in the sharply tuned receiver. By employing a circuit arrangement as proposed by my invention the carrier frequency may be suppressed in an effective and very easy way. Reference characters in Fig. 3 the same as those in Figs. 1 and 2 refer to equivalent elements. The circuit is shown with an antenna-earth system comprising the antenna 14, a loading coil 15, the differential coils 3 and 4 in accordance with the invention and the earth connection 16, the antenna circuit forming thus the output system of the compensating circuit arrangement. The input circuit is an intermediate circuit consisting of a capacity 17 and a coil 18 coupled to an oscillation generating apparatus 25 of any kind connected to the terminal of the coupling coil 19. 20 is a magnetic amplifier with its high-frequency winding 21 inserted into the input circuit 17, 18. The controlling winding 22 is supplied by a local direct current source 23 in series with a microphone 24 to modulate the radio currents in accordance with speech oscillations.

The acceptor circuit 5, 6 in this case is tuned to the frequency of the carrier currents, other operating details being substantially equal to those underlying the operation according to Figures 1 and 2.

In order to render the neutralizing arrangement very selective the damping factor of the acceptor circuit is to be given a value as low as possible which may be accomplished by making the self-inductance 5 quite large and by making the capacity 6 small.

Another application of the compensating circuit arrangement of my invention is that of serving as a wave meter as will be described more fully hereinafter it being sufficient for simplicity's sake to refer to Fig. 1.

The method ordinarily used in wireless engineering for indicating or measuring wave lengths is based on the well-known resonance phenomena in oscillating current circuits. In order to indicate the wave length of an oscillation produced by a generator or transmitted by an antenna, an oscillatory circuit having as low a damping coefficient as possible is coupled loosely to the generator or to the antenna respectively. If the natural frequency of this oscillatory measuring circuit is rendered resonant to the frequency to be measured by means of adjustable tuning means, a maximum of current flow is established in it. When observing this maximum current by means of a suitable voltmeter or ampere-meter the wave length may be calculated and if the measuring circuit is calibrated in advance the wave length may be read instantly. For an accurate determination of the wave length according to this resonance principle which as for accuracy depends upon the sharpness of the peak of the resonance curve, it is necessary for the measuring circuit to have as low a damping factor as possible and to be in loose coupling with the circuit whose current is to be measured. These conditions, in practice may only be fulfilled to a certain extent.

In employing the circuit arrangement of my invention I may obviate these inconveniences by connecting the circuit containing the current whose frequency is to be determined at the input terminals 8, 9 of the circuit arrangement and by connecting at the output terminal 10 and 11 a current indicating device M. Then I change the natural frequency of the acceptor circuit 5, 6 gradually by making the variable condenser 6 and tapping the inductance at several points such as shown at 5, till the indicating device at 10, 11 does not show any reading and remains at zero. As will be readily seen the natural frequency of the acceptor circuit 5, 6 is then equal to the frequency of the current to be measured. The condenser may be calibrated directly in wave lengths so that a direct reading may be carried out. As is seen this method is a so-called "null" method possessing as every "null" method the advantage of high sensitiveness, it being possible to employ very highly sensitive indicating instruments. The resistance 7 has not to be adjusted afresh for each new position of the condenser, but is only to be given several constant values cor-

responding to the tapped portions of the self-inductance 5. For, the ohmic resistance, of the acceptor circuit, when employing an air condenser, is mainly constituted by the resistance of the self-inductance. This method has a further advantage over the above mentioned resonance method in that the coupling between measuring circuit and the generator, whose wave length is to be determined, may be rendered close at will. The indicating circuit is to be protected against being directly influenced by the generator circuit, e. g. by shielding it electrostatically.

As the current in the indicating circuit assumes a considerable value by the slightest detuning of the frequency to be indicated with respect to the frequency to which the acceptor circuit is tuned, the arrangement may serve as a control device of a wave length which is to be held at a constant value, e. g. that of the wave length transmitted by an aerial in a transmitting station.

According to another feature of my invention it enables the determination and measuring of higher harmonics in wireless circuits to be readily carried out. The known radio frequency generating systems such as vacuum tube transmitters, Poulsen arc transmitter or machine transmitters produce besides the fundamental signaling frequency other frequencies being more or less distant from the signaling frequency and having considerably smaller magnitude. These frequencies are known as higher harmonics and side frequencies. They are in most cases very undesired and present difficulties in the determination of their magnitude and wave length. When using an ordinary wavemeter in the neighborhood of a strong transmitter, it would absorb such a quantity of current of the fundamental frequency that it would be impossible to discern the weaker higher harmonics and a resonance curve plotted in accordance with readings would only show the conditions of the fundamental and would not show the considerably weaker higher harmonics. Only by very accurately measuring and plotting the curve would the higher harmonics be indicated in the resonance by small elevations. But in this case, too, there could not be obtained a direct and exact measuring of their magnitude the influence of the fundamental being so strong as to allow only a rough appreciation of their relative strength. When employing an arrangement according to my invention the disturbing fundamental frequency may be neutralized and prevented from passing into the wavemeter, whereby the measuring of the harmonics in the latter may now be easily carried out. Referring to the general wiring diagram of Fig. 1, the circuit containing the higher harmonics to be measured is connected at the input terminals 8 and 9, whereas the output terminals 10, 11 lead to a normal wavemeter. The rejector circuit 5, 6 is tuned to the fundamental frequency which is accordingly neutralized in the wavemeter circuit, thereby only the higher harmonics to be allowed to pass into the wavemeter circuit where they can now easily be indicated.

The principle of operation of my invention has been already discussed, but it might be pointed out that the broad operating principle is that I provide two compensating circuit paths equally and oppositely associated with a circuit to produce opposite effects therein and I introduce into one of these circuit paths an acceptor circuit tuned to the frequency of the current which is to be neutralized. A balancing ohmic resistance equal to the resistance caused by the losses in the acceptor circuit is inserted into the other circuit path. Thereby a neutralization of currents of undesired frequencies may be carried out entirely independent of phase adjustments.

While I have described my invention in certain specific embodiments, it will be understood that I intend no limitations other than are imposed by the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent of the United States is:

1. The combination in a radio circuit arrangement of the character described of an output circuit, an input circuit having two circuit paths that are in equal and opposite coupling relationship to said output circuit to produce opposite effects therein, only one of said circuits being a tuned circuit and comprising an acceptor circuit introduced into one of said circuit paths and tuned to the frequency of the current to be neutralized in the output circuit.

2. The combination in a radio circuit arrangement of the character described of an output circuit, an input circuit having two circuit paths that are in equal and opposite coupling relationship to the output circuit to produce opposite effects therein, an acceptor circuit introduced into one of said circuit paths and tuned to the frequency of the current to be neutralized in the output circuit, and an ohmic resistance equivalent to the resistance caused by losses of said acceptor circuit introduced into the other one of said circuit paths.

3. The combination in a radio circuit arrangement of the character described of an output circuit, an input circuit having two circuit paths that are in equal and opposite coupling relationship to the output circuit to produce opposite effects therein, only one of said circuits being a tuned circuit and comprising an acceptor circuit having a comparatively small capacity and a relatively large inductance introduced into one of said circuit paths and tuned to the frequency of

the current it is desired to be neutralized in the output circuit.

4. The combination in a radio circuit arrangement of the character described of an output circuit, an input circuit having two circuit paths that are in equal and opposite coupling relationship to said output circuit to produce opposite effects therein, an acceptor circuit having a comparatively small capacity and a relatively large inductance introduced into one of said circuit paths and tuned to the frequency of the current it is desired to be neutralized in the output circuit, and an ohmic resistance equivalent to the resistance caused by losses of said acceptor circuit introduced into the other of said circuit paths.

5. The combination in a radio circuit arrangement of the character described of an output circuit having an induction coil therein, an input circuit having two circuit paths containing symmetrically arranged coupling coils coupled oppositely to said induction coil to produce opposite effects in the output circuit, an acceptor circuit introduced into one of said circuit paths and tuned to the frequency of the current to be neutralized in the output circuit, and an ohmic resistance equivalent to the resistance caused by losses of said acceptor circuit introduced into the other one of said circuit paths.

6. The combination in a radio circuit arrangement of the character described of an input circuit having two circuit paths, an output circuit connected at points of equal potential of said circuit paths to have produced opposite effects in it by current flowing thru said circuit paths, an acceptor circuit introduced into one of said circuit paths and tuned to the frequency of the current to be neutralized in the output circuit, and an ohmic resistance equivalent to the resistance caused by losses of said acceptor circuit introduced into the other one of said circuit paths.

7. The combination in a radio telephone transmission system with carrier suppression of an antenna circuit, an input circuit that is supplied by high-frequency oscillations modulated in accordance with speech currents to be transmitted and having two circuit paths in equal and opposite coupling relationship to said antenna circuit to produce opposite effects therein, an acceptor circuit introduced into one of said circuit paths and tuned to the carrier frequency employed for the transmission, and an ohmic resistance equivalent to the resistance caused by losses of said acceptor circuit introduced into the other one of said circuit paths.

8. The combination in an electric carrier suppression communication system of a transmitting circuit, an input circuit, means for applying carrier current oscillations modulated in accordance with signal currents to be transmitted to said input circuit, two circuit paths connected to said input circuit and coupled in equal and opposite relationship to said transmitting circuit, to produce opposite effects therein and an acceptor circuit connected in the first of said circuit paths and tuned to the frequency of said carrier currents employed for the transmission.

9. The combination in an electric carrier suppression communication system of a transmitting circuit, an input circuit means for applying carrier current oscillations modulated in accordance with signal currents to be transmitted to said input circuit, two circuit paths connected to said input circuit and coupled in equal and opposite relationship to said transmitting circuit to produce opposite effects therein, an acceptor circuit connected in the first of said circuit paths and tuned to the frequency of said carrier currents employed for the transmission, and an ohmic resistance equivalent to the resistance of said acceptor circuit connected into the other one of said circuit paths.

10. The combination with a carrier suppression communication system of the character described of a transmitting circuit, an input circuit, means for applying carrier current modulated in accordance with signal currents to be transmitted to said input circuit, two circuit paths connected to said input circuit and coupled in equal and opposite relationship to said transmitting circuit, such transmission system being connected at points of equal potential in said circuit paths to have produced opposite effects in it by currents flowing through said circuit paths, and an acceptor circuit connected in one of said circuit paths and tuned to the carrier frequency employed for the transmission.

11. The combination with a carrier suppression communication system of the character described, of a transmitting circuit, an input circuit, means for applying carrier currents modulated in accordance with signal currents to be transmitted to said input circuit, two circuit paths, said transmission system being connected at points of equal potential in said circuit paths whereby opposite effects are produced in said system by currents flowing through said circuit path, an acceptor circuit connected in one of said circuit paths and tuned to the carrier frequency employed for the transmission and an ohmic resistance equivalent to the resistance caused by loss of such acceptor circuit connected in the other one of said circuit paths.

12. Means for eliminating undesired frequencies in a radio transmitting system comprising a source of modulated currents, an acceptor circuit connected to said source which is resonant to the frequency of said undesired frequency to be eliminated, a second circuit connected to said source, an antenna circuit and means for impressing upon

the antenna electromotive forces derived from both of said circuits to produce opposite effects therein.

13. Means for eliminating disturbing effects in a radio transmitting system comprising a source of modulated carrier currents, an acceptor circuit connected to said source which is resonant to the frequency of the disturbing effect to be eliminated, a second circuit connected to said source, the resistance of the acceptor circuit being substantially equal to the resistance of the second circuit, an antenna circuit and means for impressing upon the antenna electromotive forces derived from both of said circuits to produce opposite effects therein.

14. A transmitting system for radio signals comprising a source of modulated carrier currents, and means for deriving from said source and impressing upon a transmitting circuit two radio frequency electromotive forces of equal intensity and opposite sign produced by undesired waves of definite frequency in said modulated currents, said means being arranged to impress upon the transmitting circuit two electromotive forces produced in said source by desired signaling currents and which will add in the transmitting circuit.

15. Means for eliminating undesired frequencies in a radio transmitting system comprising a source of modulated currents, an acceptor circuit connected to said source which is resonant to the undesired frequency to be eliminated, a second circuit connected to said source which comprises pure ohmic resistance, an antenna circuit and means for impressing upon the antenna electromotive forces derived from both of said circuits to produce opposite effects therein.

16. Means for eliminating undesired frequencies in a radio transmitting system comprising a source of modulated carrier currents, an acceptor circuit connected to said source which is resonant to the undesired frequency to be eliminated, a second circuit which comprises pure ohmic resistance connected to said source, the resistance of the acceptor circuit being substantially equal to the resistance of the second circuit, an antenna circuit and means for impressing upon the antenna electromotive forces derived from both of said circuits.

In testimony whereof I have affixed my signature.

WILHELM SCHEPPMANN.