May 12, 1942. E. W. KENEFAKE 2,282,968

COUPLING APPARATUS

Filed Sept. 18, 1940

Fig. 1.

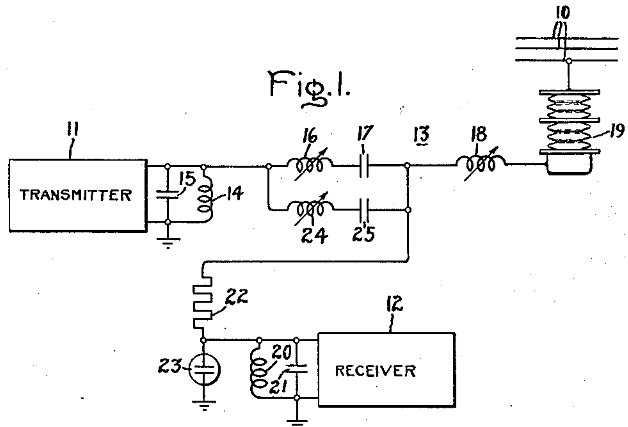


Fig. 2.

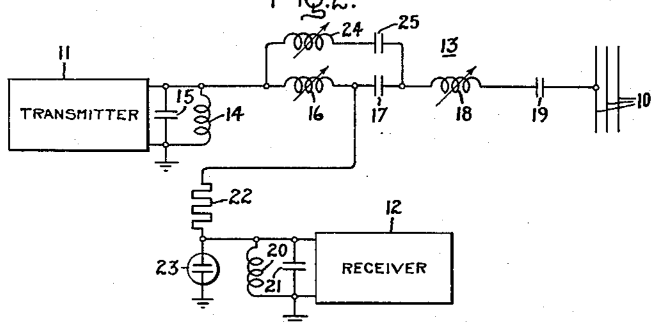
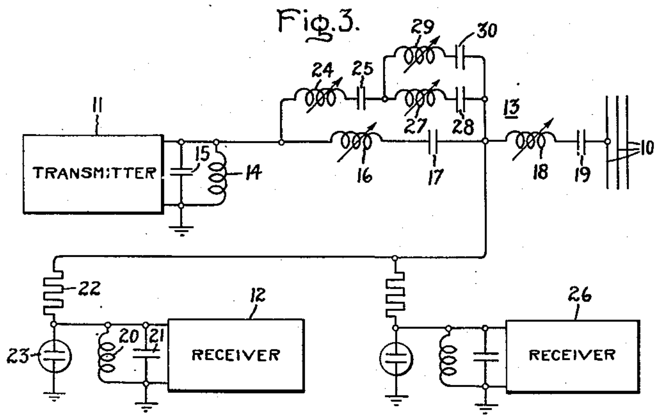


Fig. 3.



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2,282,968

COUPLING APPARATUS

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7 Claims. (Cl. 179—2.5)

This invention relates to coupling apparatus and has for an object to provide a more efficient coupling apparatus for coupling a carrier wave transmitting and receiving device to a carrier wave transmission channel.

It is a further object of my invention to provide such coupling apparatus which applies a greater proportion of the desired carrier wave in the transmission channel to the carrier wave receiver coupled to the channel by the coupling apparatus, while it does not increase the voltage applied to the receiver when the transmitter operates.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates an embodiment of my invention and Figs 2 and 3 illustrate modifications thereof.

Fig. 1 shows a power transmission line 10 upon which a signal modulated carrier wave is impressed from a transmitter 11 and from which a receiver 12 is energized by a carrier wave of different frequency to reproduce a signal modulated thereon. The transmitter 11 and receiver 12 are both coupled to the same conductor of the transmission line 10 through coupling apparatus 13. The circuit through one conductor of the line 10 and ground forms a transmission channel. The transmitter 11 includes a tuned output circuit comprising an inductance 14 and a condenser 15. One side of the tuned circuit 14, 15 is grounded and carrier wave voltage from the other side is transmitted serially through a variable inductance 16, a condenser 17, a second variable inductance 18, and a high voltage condenser 19 to the transmission line 10. The output of the transmitter 11 may be applied through any suitable coupling device to the inductance 16.

The adjustable inductance 16 is adjusted so that it resonates in series with the condenser 17 at the transmitter frequency. Similarly the adjustable inductance 18 is adjusted to resonate serially with the high voltage condenser 19 at the transmitter frequency. Therefore, at the transmitter frequency no voltage exists across the inductance 16 and condenser 17 and likewise no voltage exists across the inductance 18 and condenser 19.

The coupling system 13 acts effectively to exclude from the transmitter 11 and receiver 12 voltage of power frequency on the transmission line 10. This power frequency is very much lower than either the transmitter frequency or the receiver frequency. The reactances of the condensers 17 and 19 are therefore very high at the power frequency and very little power frequency voltage is transmitted to the transmitter 11, or to the receiver 12

The receiver 12 includes a tuned input circuit comprising an inductance 20 and a condenser 21, which circuit is resonant at a frequency different from the transmitter frequency (at which the tuned circuit 14, 15 is resonant). One side of the tuned circuit 20, 21 is grounded and the other side is connected through a protective resistor 22 to a point between condenser 17 and inductance 18. A gas or vapor discharge device 23 is connected in shunt to the tuned circuit 20, 21 and has the characteristic that it conducts substantially no current when voltages below a critical value are impressed thereacross, but when voltages greater than this critical value are impressed thereacross it tends to carry so much current that a large voltage drop is produced in the circuit through which the voltage is supplied. The protective resistor 22 is in the circuit through which voltage is supplied across the device 23 and if voltages greater than a critical value are impressed across the device 23 a large drop occurs through the resistor 22 so that the receiver 12 is protected therefrom.

In order to apply a larger proportion of the carrier wave of the received frequency in the transmission line 10 to the receiver 12, means is provided to make the circuit including the elements 14, 15, 16, 17, 18, and 19 series resonant at the received frequency and to provide that the elements 14, 15, 16 and 17 exhibit the opposite type of reactance to the elements 18 and 19. To accomplish this result a series combination comprising an adjustable inductance 24 and a condenser 25 is connected in shunt to the inductance 16 and condenser 17. If the received frequency is higher than the frequency of current transmitted by the transmitter the tuned circuit 14, 15 has capacitive reactance and the tuned circuits 16, 17 and 18, 19 each have inductive reactance. The capacitive reactance of the tuned circuit 14, 15 is substantially less than the inductive reactance of the tuned circuit 16, 17. In order to produce the series resonance desired, the inductance 24 is reduced until the effect of the condenser 25 is sufficient, in shunt to the tuned circuit 16, 17 to make the elements 14, 15, 16, 17, 24 and 25 altogether have a capacitive reactance at the frequency at which the receiver operates equal to the inductive reactance of the elements 18 and 19. Under such conditions of adjustment the coupling device acts as an inductance connected from the receiver to the transmission line 10 and a capacity connected from the receiver to ground, the inductance and the capacity being tuned at the frequency of the receiver so that the transmission line 10 tends to transmit a large voltage of the frequency at which the receiver operates to the receiver 12.

If the received frequency is lower than the transmitted frequency the adjustment differs in some details. The tuned circuit 14, 15 appears to have inductive reactance and the circuits 16, 17 and 18, 19 appear to have capacitive reactance. The adjustable inductance 24 is therefore increased until the overall reactance of the elements 14, 15, 16, 17, 24, and 25 is inductive in the proper amount to resonate with the capacitive reactance of the elements 18 and 19 at the received frequency. Under these conditions of adjustment, the coupling device acts as a condenser connected between the receiver 12 and transmission line 10 and an inductance connected from the receiver 12 to ground, so that the condenser and inductance resonate at the received frequency and tend to transmit a large voltage of received frequency from the line 10 to the receiver 12.

By this connection of the receiver 12 to the coupling device 13 a large voltage of the received frequency is supplied to the receiver 12, where in former practice the receiver 12 was energized in parallel to the tuned circuit 14, 15 of the transmitter 11 and received a relatively much smaller voltage. Increased selectivity provided by the connection of the receiver as disclosed herein, which might result in poor transmission of high frequencies of the signal modulated on the carrier wave, may be offset by introducing resistance into the tuned circuit 20, 21 to reduce its selectivity and broaden its frequency response.

In Fig. 2 the parts are identical with those illustrated in Fig. 1 and are given like reference characters. The receiver 12 is, however, connected to the coupling apparatus 13 between the inductance 16 and the condenser 17. The coupling apparatus 13 is also adjusted somewhat differently. The inductance 18 is adjusted to resonate with the condenser 19 at the received frequency, and the inductance 16 is likewise adjusted to resonate with the condenser 17 at the received frequency. At the received frequency there is, therefore, no voltage across the inductance 18 and condenser 19 or across the inductance 16 and condenser 17. Since the inductance 16 and condenser 17 are series resonant at the received frequency, a point between them tends to reach a very high voltage at the received frequency.

At the transmitted frequency the combination of inductance 16 and condenser 17 and the combination of the inductance 18 and condenser 19 are either inductive or capacitive as the transmitted frequency is higher or lower than the received frequency. If they are inductive at the transmitted frequency, the inductance 24 is decreased so that the condenser 25 makes the combination of elements 16, 17, 24 and 25 appear as a capacitance equal in reactance to the inductive reactance of elements 18 and 19 at the transmitted frequency.

If the combination of elements 16 and 17 acts as a capacitance, the inductance 24 is increased so that the combination of elements 16, 17, 24 and 25 is inductive and so that its reactance is equal to the capacitive reactance of the elements 18 and 19 of the transmitted frequency.

While this type of connection and adjustment of the elements is not so advantageous as that illustrated by Fig. 1 it possesses advantages over prior systems. While the carrier wave is transmitted from the line 10 to the receiver 12 with greater intensity than if the receiver were connected to a point between the transmitter 11 and inductance 16, the transmitted carrier wave from the transmitter 11 is applied with greater intensity to the receiver 12 in the connection of Fig. 2 than with the connections of Fig. 1. It is, however, of more advantage to connect the receiver 12 as shown in Fig. 2 than to connect it in parallel to the transmitter 11.

In Fig. 3 many of the elements are like those illustrated in Figs. 1 and 2 and are given like reference characters. The coupling apparatus 13, however, serves to connect an additional receiver 26 to the lines 10 and for that purpose it is constructed so that it can be tuned to three different frequencies, namely the transmitted frequency, the frequency of the receiver 12, and the frequency of the receiver 26.

The coupling device 13 is adjusted as explained above to transmit the carrier wave from the transmitter 11 to the line 10.

The inductance 16 is adjusted to resonate with the condenser 17 at the transmitted frequency and the inductance 18 is adjusted to resonate with the condenser 19 at the transmitted frequency. There is, therefore, no voltage of the transmitted frequency across the combination of inductance 16 and condenser 17. Circuit elements of the coupling device 13 which are connected in shunt with the combination of inductance 16 and condenser 17 are therefore unaffected by the carrier wave transmitted from the transmitter 11, and carry substantially no current therefrom.

The coupling device 13 also acts to transmit the carrier wave of the frequency of the receiver 12 from the line 10 to that receiver as follows: The inductance 24 and the condenser 25, connected serially with an adjustable inductance 27 and a condenser 28 are connected in shunt to the inductance 16 and condenser 17. The inductance 27 is adjusted to resonate with the condenser 28 at the frequency of the receiver 12. The combination of the inductance 24 and condenser 25 may therefore be adjusted to exhibit capacitive or inductive reactance to tune the coupling device 13 to the frequency of the receiver 12 depending on whether this frequency is higher or lower than the transmitted frequency.

The coupling device 13 is also adjusted and arranged to transmit a carrier wave from the line 10 to the receiver 26 at its independent frequency. A series combination of an adjustable inductance 29 and a condenser 30 is connected in shunt to the inductance 27 and the condenser 28. If the frequency of the receiver 26 is higher than that of the receiver 12, the combination of the inductance 27 and condenser 28 appears inductive. Assuming that the frequency of the receiver 12 is higher than the frequency of the transmitter 11, the combination of inductance 16 and condenser 17 and also the combination of the inductance 18 and condenser 19 also appear inductive. The inductance 29 may therefore be reduced until the combination of inductance 29 and condenser 30 is sufficiently capacitively reactive so that the elements 14, 15, 16, 17, 24, 25, 27, 28, 29, and 30 altogether act as a capacitance and the elements 18 and 19 act as an inductance resonant with the capacitance at the frequency of the receiver 26.

The inductance 29 and the condenser 30 do not interfere with the action of the coupling device 13 in transmitting a carrier wave from the line 10 to the receiver 12, because the combination of inductance 27 and condenser 28 is series resonant at the frequency of the receiver 12. The combination of inductance 27 and condenser 28 is therefore substantially a short circuit across the inductance 29 and condenser 30.

It is of course clear that additional receivers may be energized from the line 10 through the coupling device 13 if additional elements be added thereto so as to allow its being tuned to additional received frequencies. By the use of the coupling device 13 for each receiver energized therefrom there is the same advantage in that the ratio of the carrier wave intensity from the line 10 to the carrier wave intensity from the transmitter 11 is increased.

The coupling device 13 is very flexible and is easily adjusted to couple a transmitter and one or more receivers to a transmission line. The transmitter and each receiver so coupled may be adjusted to operate at any frequency in a wide frequency band and the receiver sensitivity to line signals is increased without increasing the amount of transmitter voltage applied to the receiver.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto, since different modifications may be made both in the circuit arrangement and instrumentalities employed, and I aim by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Carrier wave apparatus comprising a transmitter and a receiver operating at different frequencies, an electrical path serially including said transmitter, and means to connect said receiver in shunt to a portion of said path including said transmitter, the reactance of the portion of said path in shunt to said receiver being of opposite character to the reactance of the remainder of said path at the frequency at which said receiver operates, and said path having minimum reactance to a wave from the output of said transmitter at the frequency at which said transmitter operates.

2. Carrier wave apparatus comprising a transmitter and a receiver operating at different frequencies, an electrical path serially including said transmitter and a plurality of serially connected impedance elements, and means to connect said receiver in shunt to a portion of said path including said transmitter and at least one of said elements, the reactance of the portion of said path in shunt to said receiver being of opposite character to the reactance of the remainder of said path at the frequency at which the receiver operates, and said elements having minimum reactance at the frequency at which said transmitter operates.

3. Carrier wave apparatus comprising a transmitter and a receiver operating at different frequencies, an electrical path serially including said transmitter and a plurality of serially connected groups of reactance elements, each of said groups having minimum reactance at the frequency at which said transmitter operates, and means to connect said receiver in shunt to said transmitter and at least one of said groups, the reactance of said path in shunt to said receiver being of opposite character to the reactance of the remainder of said path at the frequency at which said receiver operates.

4. Carrier wave apparatus comprising a parallel resonant path connected in series with two series resonant paths, said paths all being resonant at a predetermined frequency, and apparatus responsive to a wave of a frequency different from said predetermined frequency connected in shunt to said parallel resonant path and the adjacent one of said series resonant paths, the algebraic sum of the reactances of said parallel resonant path and the adjacent series resonant path being of opposite character to the reactance of the remaining series resonant path at said different frequency.

5. In a carrier communication system, a power line, a carrier wave transmitter and a receiver, a coupling condenser connected from said line serially through a tuning coil and a second condenser and second coil to the output of said transmitter, said coupling condenser and first coil, and similarly said second condenser and second coil, being series resonant with each other at the operating frequency of said transmitter, a reactance element connected in shunt to said second condenser and second coil having such a value that the combined reactance of said second condenser, second coil, the output of said transmitter, and said reactance element is equal in value and of opposite character to the combined reactance of said coupling condenser and said first coil at the operating frequency of said receiver, and means connecting said receiver in shunt to said second condenser and coil and said transmitter, whereby a carrier wave on said power line of the frequency to which said receiver responds is impressed at high voltage on said receiver.

6. Carrier wave apparatus comprising a transmitter and a plurality of receivers operating at different frequencies, an electrical path serially including said transmitter, and means to connect said receivers together in shunt to a portion of said path including said transmitter, the reactance of the portion of said path in shunt to said receivers being of opposite character to the reactance of the remainder of said path at each frequency at which a respective receiver operates, and said path having minimum reactance to a wave from the output of said transmitter at the frequency at which said transmitter operates.

7. In a carrier communication system, a power line, a carrier wave transmitter and a receiver, a coupling condenser connected from said line serially through a tuning coil and a second condenser and second coil to the output of said transmitter, said coupling condenser and first coil, and similarly said second condenser and second coil, being series resonant with each other at the operating frequency of said receiver, a reactance connected in shunt to said second condenser and second coil having such a value that the combined reactance of said second condenser, second coil, and said reactance is equal in value and of opposite character to the combined reactance of said coupling condenser and first coil at the operating frequency of said transmitter, and means connecting said receiver in shunt to said second coil and said transmitter, whereby a carrier wave on said power line of the frequency to which said receiver responds is impressed at high voltage on said receiver.

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