March 2, 1948. D. H. RING 2,436,828

COUPLING ARRANGEMENT FOR USE IN WAVE TRANSMISSION SYSTEMS

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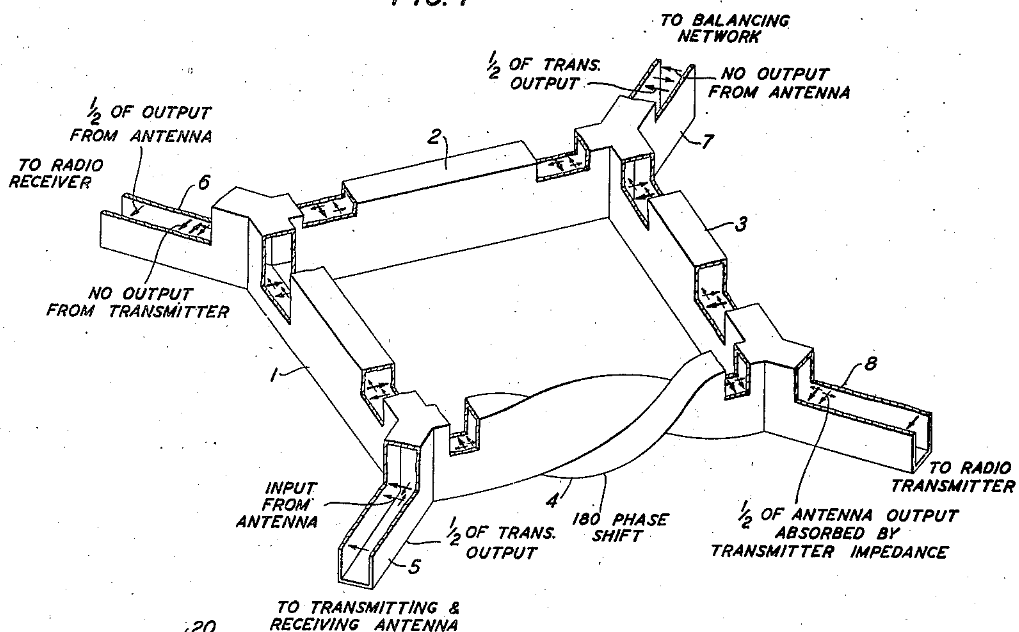
FIG. 1



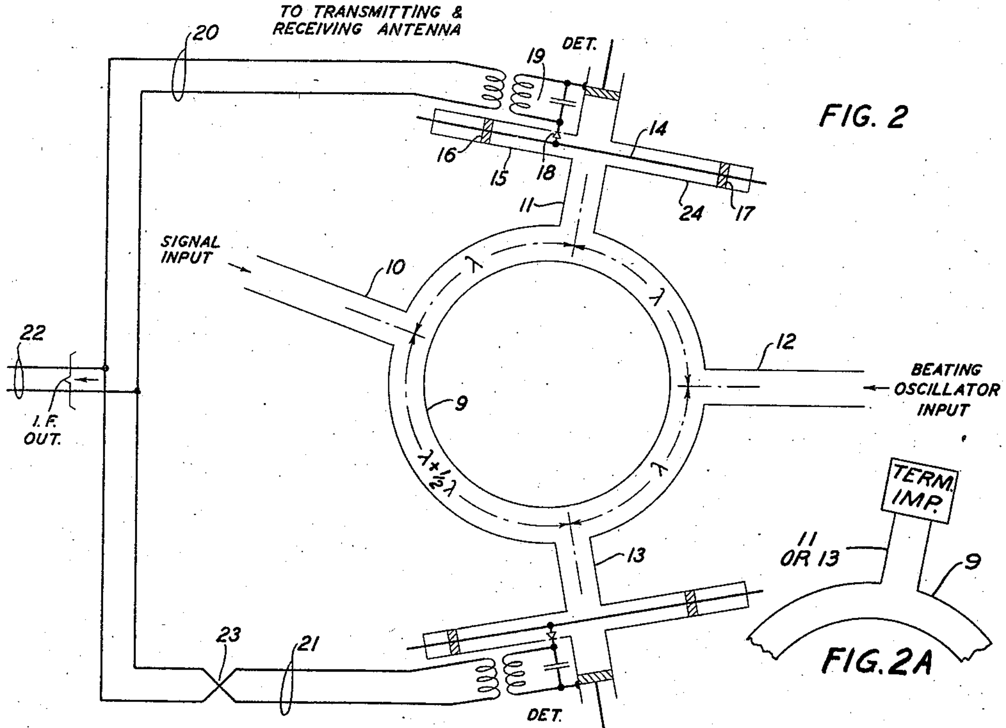


FIG. 2

FIG. 2A

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COUPLING ARRANGEMENT FOR USE IN WAVE TRANSMISSION SYSTEMS

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4 Claims. (Cl. 250—20)

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This invention relates to wave transmission systems and particularly to coupling arrangements for use in such systems.

An object of the invention is to provide efficient transmission of wave power between certain of a plurality of wave transmission lines or circuits in a wave transmission system while substantially preventing transmission of wave power between others of them.

Another object is to provide balance in systems involving wave motion.

A related object is to provide with simple and economical apparatus an extremely accurate electrical balance between certain parts of a wave transmission network so as to prevent wave transmission therebetween at a given frequency, while allowing efficient wave transmission between other parts of the network at that frequency.

A more specific object is to so couple four transmission lines or circuits that when wave power is applied to any one of them, two others of the lines or circuits will receive part of this power while the fourth will receive no power.

These objects are attained in accordance with the invention in the following manner.

A coupling device consisting of a hollow metal wave guide connected in a continuous transmission loop or ring of suitable dimensions is used. The four individual lines or circuits between which wave transmission at a given frequency is to be respectively prevented or allowed, which may be also constructed of hollow metal wave guides, are symmetrically connected as branches to spaced points around the loop or ring in the plane thereof, each by a series electrical connection, i. e., in the electric plane. The electrical characteristics of the portions of the loop or ring connecting each pair of oppositely situated branch circuits are made such that when wave power of a given frequency is applied to the loop from any one of them, the two portions of the wave power transmitted over opposite sides of the loop will be 180 degrees out of phase so as to cancel at the point of connection of the oppositely situated branch circuit, and thereby preventing transmission of any of the wave power into that branch circuit and allowing transmission of only a part of the wave power into each of the two intermediate branch circuits. This is accomplished in accordance with one embodiment of the invention by making the electrical characteristics of the portions of the wave guide loop connecting each pair of adjacent branch circuits equal except for a suitable twist in one of them so as to produce a 180-degree phase shift

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in the wave polarity in that portion of the loop with respect to the wave polarity in the other three portions of the loop, or by introducing an extra one-half wave-length of line in one of the four portions of the loop so as to provide between each two oppositely situated connections of the branch circuits, two electrical paths around the ring or loop which differ geometrically by a half wave-length.

The various objects and features of the invention will be better understood from the following detailed description thereof when read in conjunction with the accompanying drawings in which:

Fig. 1 shows a perspective view of a coupling arrangement embodying one form of the invention applied to one terminal of a two-way radio communication system; and

Fig. 2 shows a sectional view of a coupling arrangement embodying another form of the invention applied to a portion of a double detection or superheterodyne signal receiver and Fig. 2A shows a sectional view of a modification of a portion of the coupling arrangement of Fig. 2 illustrating a third application of the invention.

In Fig. 1 the coupling arrangement of the radio terminal of the invention includes four straight sections 1, 2, 3 and 4 of hollow metal wave guide with rectangular cross-section connected together so as to form a closed transmission loop. Four straight pieces of hollow metal wave guide also with rectangular cross-section, in the same plane as the wave guide loop, are respectively connected to the four junctions between the four wave guide sections in the transmission loop symmetrically, i. e., the axis of each straight wave guide branch passes through the center of the loop. Each wave guide branch is connected electrically in series with the wave guide loop, i. e., in the electric plane or plane parallel to the lines of electric intensity in both joined guides.

As indicated, the branch wave guide 5 connected to the junction between the wave guide sections 1 and 4 of the transmission loop leads to a common antenna for reception and transmission; the branch wave guide 6 connected to the junction between the wave guide sections 1 and 2 of the coupling loop leads to a radio receiver; the branch wave guide 7 connected to the junction between the wave guide sections 2 and 3 of the coupling loop leads to a balancing network or termination; and the branch wave guide 8 connected to the junction between the wave guide sections 3 and 4 of the coupling loop leads to a radio transmitter.

The wave guide branch 4 of the coupling loop is provided with a suitable twist, as shown, to produce 180-degree phase shift in the wave polarity in the guide. Except for this, the opposite wave guide sections of the coupling loop, and the junctions of the opposite sections with the branch wave guides are made to have respectively identical electrical characteristics. The termination of branch wave guide 7 is made such as to match the impedance of the common transmitting and receiving antenna connected to the oppositely situated branch wave guide 5.

The vectors parallel to the short side of the wave guide cross-section, shown in the cut-out portions of each wave guide, represent the electric field polarities for the predominant wave, i. e., the wave of lowest critical frequency propagated through the guide at those points in the system, the heavy line vectors representing the electric field polarities for an outgoing wave applied to the wave guide loop from the transmitter connected to branch wave guide 8, and the light line vectors the electric field polarities for an incoming wave applied to the loop from the antenna connected to wave guide branch 5, acting as a receiving antenna. The direction of travel of the waves represented by the vectors is indicated by the small transverse arrows on the vectors. It will be noted that for the case where a wave is applied by the transmitter to the wave guide loop through the branching wave guide 8, due to the 180-degree phase shift of the wave polarity in the loop branch 4, the wave portions passing in opposite directions around the wave guide loop arrive at the junction of the loop with the branch wave guide 6, 180 degrees out of phase so that they cancel each other which is equivalent to a short circuit at that point. Thus there will be no power flow between sections 2 and 1 of the loop due to excitation from wave guide branch 8 and no wave energy will be applied to the receiver connected to the branch guide 6; whereas the portions of the wave transmitted over the loop via the paths 4 and 3 will be absorbed in the wave guide branch 5 leading to the antenna and the wave guide branch 7 leading to the balancing network, respectively. Similarly, when waves are applied to the wave guide loop through the wave guide branch 5 from the antenna during signal reception, the two portions of the applied wave passing around the wave guide loop in opposite directions, because of the 180-degree relative phase shift in wave polarity produced by the twist in the loop branch 4, arrive at the junction of the transmission loop with the wave guide branch 7 leading to the balancing network in opposite phase relation, so that there is no power flow between sections 2 and 3 of the loop, and no wave energy is transmitted to the balancing network; whereas the portions of the wave transmitted via paths 1 and 4 are absorbed in the wave guide branches 6 and 8 leading to the receiver and the transmitter, respectively.

Fig. 2 shows a modified form of coupling arrangement according to the invention used for the purpose of obtaining conjugacy between the signal and beating oscillator input to a detector circuit in a double detection or superheterodyne radio receiving system. In the figure, the coupling arrangement of the invention comprises a closed ring 9 of hollow metal wave guide, a section along its longitudinal axis being shown, with four straight hollow metal wave guide branches 10, 11, 12 and 13 branching out from it symmetrically, i. e., the axis of each straight guide passes through the center of the ring, at spaced points around its circumference. Each of the four wave guide branches 10, 11, 12 and 13 is connected to the ring by an equivalent electrical series connection, that is, in the electric plane or plane parallel to the lines of electric intensity of both connected guides. The incoming signals are applied to the input of the branch wave guide 10, and the beating oscillator frequency to the input of the branch guide 12, and the inputs of two detectors are fed respectively from the other two branch guides 11 and 13 in the manner which will be described below.

A 180-degree phase shift in the wave polarity in the electrical path around one side of the ring between each pair of oppositely situated branch guides with respect to the wave polarity in the other electrical path around the other side of the ring between the same two branch guides is obtained by making the electrical spacing between two of the adjacent wave guide branches along the mean circumference of the ring, such as the spacing between the wave guide branches 10 and 13, as indicated, one-half wave-length longer than the electrical spacing along the mean circumference of the ring between each two adjacent wave guide branches in the remaining portion of the ring, which are made identical. Thus, the two portions of the signal wave applied to the wave guide branch 10, passing in opposite directions around the two sides of the ring, will be 180 degrees out of phase so as to cancel at the junction of the ring and the wave guide branch 12, and will feed substantially equal power into the junctions of the wave guide ring with the wave guide branches 11 and 13. Also, the two portions of the beat frequency wave applied to the wave guide branch 12 passing around the wave guide ring in opposite directions, will be 180 degrees out of phase so as to cancel at the junction of the ring with the wave guide branch 10 and will feed equally into the junctions of the ring with the wave guide branches 11 and 13. Therefore, none of the signal energy applied to branch 10 will enter the wave guide branch 12 to which the beating oscillator is connected, and none of the energy of the beating oscillator frequency applied to the wave guide branch 12 will enter the wave guide branch 10 to which the signal input is connected, whereas the signal energy and the beating oscillator frequency energy will be equally divided between the wave guide branches 11 and 13. The signal and beating oscillator wave energy entering the wave guide branch 11 is taken off therefrom by means of a transverse section of coaxial line including a conducting wire 14 extending diametrally across the wave guide branch through openings in its side walls, forming the inner conductor of the coaxial conductor pair, and two coaxial extensions 15 and 24 on either side of the wave guide branch at both ends of the diametral wire, each coaxial extension being short-circuited by respective adjustable pistons 16, 17. A crystal detector 18 is connected in shunt across the coaxial line section and is matched into the coaxial circuit by adjusting the position of the detector along the wire 14, the circuit being tuned to resonance at the desired frequency by proper adjustment of the position of the pistons 16, 17. By simultaneous movement of the pistons 16 and 17 in the same direction, the impedance presented to the waves in the guides and thereby the amount of power extracted by the transverse circuit and applied to the detector 18 may be adjusted. The combination products of the beating oscillator frequency and the signal in the output of the detector 18 are impressed upon the filter 19 which selects the intermediate frequency. A similar transverse coaxial line, shunting crystal detector and filter, associated with the branch wave guide 13 provides means for combining the portions of the beating oscillator frequency and the signal diverted into that branch guide to produce waves of intermediate frequency. The intermediate frequency outputs of the two detectors transmitted over the circuits 20 and 21 respectively, are combined in the circuit 22 leading to the second detector stage (not shown) of the receiver in proper phase to add, due to the crossing of the conductors of the circuit 21 at the point 23. The use of the coupling arrangement of the invention in this arrangement has the advantage that the usual signal and beating oscillator filters are eliminated.

In place of the two detectors connected in push-pull, as described, one detector associated with one of the branch wave guides 11, 13 may be used and a suitable matching impedance termination substituted for the detector associated with the opposite wave guide branch 13, 11, as indicated in Fig. 2A. Also, a twist to provide 180-degree phase shift of the wave polarity in one portion of the wave guide ring between adjacent branch circuits, similar to that illustrated for the loop circuit of Fig. 1, may be employed to produce the desired conjugacy of the wave guide branches to which the signal and beating oscillator inputs are applied, in place of employing an extra one-half wave-length of line in one branch as illustrated in Fig. 2.

Various modifications of the coupling arrangements illustrated and described and other applications of them which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In combination in a wave transmission system, a tubular uni-conductor forming a closed transmission loop, four branch transmission circuits connected symmetrically thereto at spaced points around the loop, each by a series electrical connection, one of said branch transmission circuits comprising a source of signal waves of given frequency feeding into said loop, a second branch transmission circuit comprising a source of beating waves of different frequency feeding into said loop, and at least one of the two other branch transmission circuits including means for combining the portions of said signal waves and said beating waves diverted therein from said loop and means for making the relative electrical characteristics of the portions of the looped conductor connecting said four branch transmission circuits such that each of said two other branch circuits will receive part of the wave power impressed on said loop by said one or said second branch circuit and the fourth branch circuit will receive substantially none of this wave power.

2. In combination, in a wave transmission system, four sections of hollow metal wave guide connected to form a continuous transmission loop, and four branch transmission circuits each comprising a straight hollow metal wave guide coplanar with the wave guide loop and respectively joined symmetrically thereto in the electric plane at a different one of the four junctions between the sections of wave guide therein, the opposite junctions of the transmission loop with said branch circuits having identical electrical characteristics and the opposite wave guide sections in said loop having identical electrical characteristics except for the inclusion in one of them of a suitable twist for producing a 180-degree phase shift in the polarity of a wave transmitted thereover with respect to the wave polarity in the other three wave guide sections, so that the two portions of a wave applied to the loop from any branch circuit, passing in opposite directions around the loop will be 180 degrees out of phase when they arrive at the point of connection of the oppositely situated branch circuit thereto.

3. The combination of claim 1, in which each of said two other branch circuits includes a wave detector for combining the applied waves from the two wave sources transmitted around the loop, and means for selecting a combination wave from the output of that detector, the selecting means of said two other branch circuits being coupled in such manner that the selected combination wave outputs of the two detectors are in proper phase relation to produce a maximum amount of wave energy of the combination wave.

4. The combination of claim 2, in which a source of signal oscillations of a given frequency is connected to one of said branch circuits so as to feed therethrough into said loop, a source of beating oscillations of different frequency is connected to another of said branch circuits so as to feed therethrough into said loop, a third one of said branch circuits includes a wave detector for combining the applied oscillations from the two oscillation sources transmitted around said loop and means for selecting a wave of a combination frequency from the output of the detector, and the fourth of said branch circuits is terminated in a suitable matching impedance.

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