

Jan. 1, 1946.

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2,391,880

COUPLING CIRCUIT

Filed Jan. 31, 1944

Fig. 1.

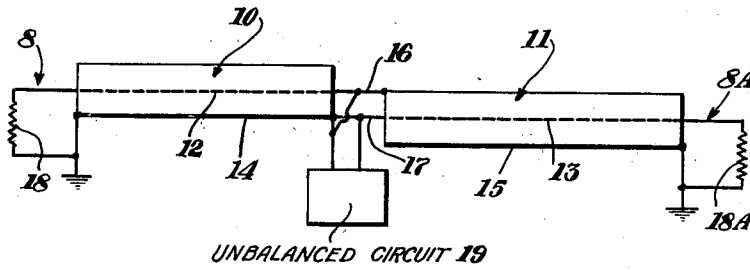


Fig. 2.

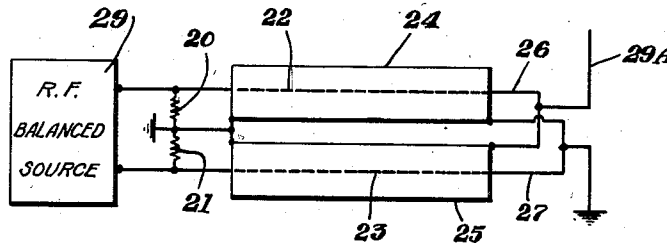
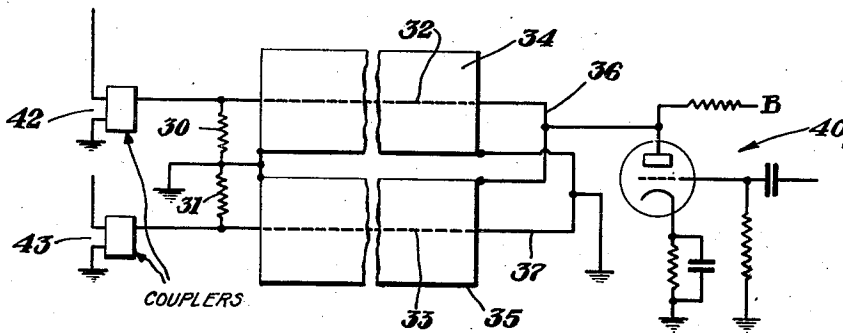


Fig. 3.



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COUPLING CIRCUIT

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Application January 31, 1944, Serial No. 520,403

5 Claims. (Cl. 178—44)

This invention relates to coupling circuits and more particularly to coupling circuits designed to intercouple balanced and unbalanced circuits.

In proposed prior systems coupling circuits for coupling together balanced and unbalanced sources and loads at a particular frequency have been proposed. Such circuits, to operate satisfactorily over a wide frequency band, are generally quite complicated. Simpler couplers of coaxial line sections have been provided with certain inter-connections between the inner conductors and the shields of the coaxial line sections. However, in these relatively simple systems, the coupling circuit is generally made in the form of a loop which is tuned to the operating frequency. As a consequence, the couplers are useful only for a particular frequency or an extremely narrow frequency band.

It is an object of my invention to provide a relatively simple coupler for coupling together radio frequency circuits operating over a wide band of radio frequencies.

It is a further object of my invention to provide a simple coupler which will couple together balanced and unbalanced circuits without producing any substantial disturbance of the balanced or unbalanced condition of the circuits so coupled.

According to a feature of my invention, I provide a coupler consisting of two short sections of coaxial line. These line sections are preferably made short with respect to a quarter wavelength at the operating frequency so that they will be substantially untuned over the entire frequency band used, and are arranged physically in substantially parallel relationship. At one end of the section a balanced circuit is coupled to the inner conductors of the coaxial lines and at the other end of the sections the inner conductor of each is connected to the outer conductor of the other and a circuit which may be completely unbalanced is coupled to these connections.

A better understanding of my invention and the objects and features thereof may be had by reference to the accompanying drawing, in which:

Fig. 1 is a diagram used in explaining the principle of operation of a coupler in accordance with my invention;

Fig. 2 is a simple circuit diagram illustrating a practical construction of my invention; and

Fig. 3 is a further circuit diagram illustrating another application of a coupler in accordance with my invention.

In providing a coupler between circuits, a coaxial cable represents the closest approach to a unity coupled system. Accordingly, a system such as shown in Fig. 1 may be used for providing a coupling between balanced and unbalanced circuits. In this figure there are provided two sections of coaxial transmission line 10 and 11 comprising inner conductors 12 and 13 and outer

conductors 14, 15, respectively. Inner conductor 12 is connected by connection 16 to outer conductor 15 and inner conductor 13 is connected by connection 17 to outer conductor 14.

At the other end of section 10 is provided a circuit 8 represented by resistance 18 and at one end of conductor 11 is provided a circuit 9A represented by resistance 18A. These two circuits are presumed to be equal in value so as to present equal impedances to line sections 10 and 11. If a circuit, such as illustrated by block 19, is connected to connectors 16, 17, the impedance presented to circuit 19 will be the parallel value of the impedance of coaxial line sections 10 and 11 and the impedance of the outer conductors of these lines.

Since the impedances of line sections 10 and 11 are equal and the loads are equal, any unbalance in circuit 19 will not be spread to the loads 8 and 9A but these loads will be balanced with respect to one another, regardless of the amount of unbalance of circuit 19.

The arrangement shown in Fig. 1, however, is not entirely practical since there will be considerable radiation from the outer conductors of line sections 10 and 11. A practical structural arrangement of my invention is illustrated in Fig. 2. In this arrangement, two coaxial conductor line sections comprising inner conductor 22, outer conductor 24 and inner conductor 23, outer conductor 25, respectively, are arranged side by side in physically parallel relationship. The two outer conductors are placed as close to one another as practical, in general, not further apart than a tenth of the length of the sections, and preferably less than one-seventieth of this length. By this proximity radiation from the outer conductors is substantially eliminated. These sections are made less than one quarter of a wavelength long at the operating frequencies of the band over which the circuit is intended to work.

At one end of the sections, conductor 22 is connected to conductor 25 by connector 26 and conductor 24 is connected to conductor 23 by connector 27. Connected substantially to the center points of connectors 26 and 27 is provided an unbalanced circuit which may, for example, be an antenna, as shown at 29A. At the other end of the section inner conductors 22 and 23 are coupled to a circuit 29 which may, for example, be a balanced radio frequency source serving to feed energy to the unbalanced antenna 29A. Preferably, at this end of the sections the outer conductors 24 and 25 are interconnected and grounded and the inner conductors 22, 23 are connected by means of equal resistance units 20, 21 to ground. These resistances may be eliminated when a single balanced circuit is provided, but permits the coupling of individual loads to the

separate conductors 22 and 23 of the transmission line system.

Coupling devices of the form shown in Fig. 2 have been used in practice. In a particular arrangement in which the coaxial sections were made four feet in length and spaced apart one half inch (.002-1.25 of the section length), it was found that a completely unbalanced circuit could be connected to a balanced circuit operated over a frequency range of from 1 to 30 megacycles with a better than 400 to 1 maintenance of balance. By this is meant that the amount of unbalance introduced into the balance circuit was less than one part in 400.

A similar circuit tested over a frequency range of from 60 to 300 megacycles using only four inch lengths of coaxial conductor was found to give a balance ratio of better than 200 to 1. In this latter construction, the spacing between the coaxial sections was made one-sixteenth of an inch (.04-1.01 of the section length). Because of the close spacing of the sections one to another, substantially any tendency to radiate was completely overcome.

These results are readily reproducible and may be obtained by the use of commercial coaxial cable. In special units made with great care and selected conductors of uniform characteristics, tests failed to show any unbalance that could be read on the available instrument.

Other tests indicate that, without the extraordinary precautions in construction, the coupling circuit, in accordance with my invention, over a range of from 5 to 30 megacycles provided a coupling efficiency of from 85 to 90 percent of the ideal unity coupling.

In Fig. 3 is illustrated another application of my invention in which a coupler of two lines consisting of inner conductors 32, 33 and other conductors 34, 35, respectively, is used for interconnecting two separate loads 42, 43, balanced with respect to one another, and an unbalanced circuit 40. As illustrated, loads 42 and 43 are shown as monopole antennas coupled respectively to inner conductors 32 and 33. These inner conductors are coupled through resistors 30, 31, respectively, to ground and outer conductors 34, 35 are also inter-connected and grounded at the same point. At the other end of the coupler inner conductor 32 is connected by connector 36 to outer conductor 35 and inner conductor 33 is connected by connector 37 to outer conductor 34. Connector 37 is grounded while connector 36 is coupled to the anode circuit of a vacuum tube representing the unbalanced supply circuit 40.

It should be distinctly understood that, in each of the illustrations shown in Figs. 2 and 3, the sources and loads may be interchanged in position without affecting the operation of my system. For example, in Fig. 3, antennas 42 and 43 may be considered as receiving antennas supplying energy to a common unbalanced load circuit at 40.

It is seen that, in accordance with the principles of my invention, a coupler is provided which serves ideally as a balanced to unbalanced or an unbalanced to balanced coupler. The coupler is extremely simple in construction and small in dimensions but provides a much better coupling ratio than is provided by most of the more elaborate, known circuits of the prior art. Furthermore, the system operates over a wide band of frequencies with a very high degree of efficiency.

While I have described my invention in con-

junction with certain modifications and embodiments thereof, it should be distinctly understood that these embodiments are given merely by way of example and are not intended to be limits on my invention, as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A device for coupling two circuits together to prevent unbalanced currents or voltages in one from spreading to the other of said two circuits, comprising two substantially equal length sections of coaxial transmission line arranged longitudinally side by side in substantially physically parallel relation one to the other and spaced apart a distance not greater than one tenth of the length of a section, means at one end of said conductor sections for coupling the center conductors of the coaxial lines to a balanced circuit, connections at the other end of said sections between the center conductor of each section and the outer conductor of the other section, and means for coupling an unbalanced circuit between said connections.

2. A device according to claim 1, further comprising resistance means connected between said central conductors at said one end of said section and the outer conductors of said sections, whereby said balanced circuit may comprise two separate loads balanced with respect to one another.

3. A device for coupling two circuits together to prevent unbalanced currents or voltages in one from spreading to the other of said two circuits, comprising two substantially equal length sections of coaxial transmission line arranged side by side in substantially physically parallel relation one to the other and spaced apart a distance not greater than one tenth of the length of a section, each section being relatively short with respect to a quarter wavelength of the energy to be transmitted between said circuits, means at one end of said conductor sections for coupling the center conductors of the coaxial lines to a balanced circuit, connections at the other end of said sections between the center conductor of each section and the outer conductor of the other section, and means for coupling an unbalanced circuit between said connections.

4. A device in accordance with claim 3, wherein said sections are made of a length between .004 and .125 of a wavelength at the operating frequencies.

5. A device for coupling two circuits together to prevent unbalanced currents or voltages in one from spreading to the other of said two circuits over a wide frequency band, comprising two substantially equal length sections of coaxial transmission line arranged side by side in substantially physically parallel relation one to the other and spaced apart a distance not greater than one-seventieth of the length of a section, each section being electrically not more than one-eighth of a wavelength long at the shortest wavelength to be transmitted between said circuits, means at one end of said conductor sections for coupling the center conductors of the coaxial lines to a balanced circuit, connections at the other end of said sections between the center conductor of each section and the outer conductor of the other section, and means for coupling an unbalanced circuit between said connections.

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