United States Patent [19]

Covill

[11] 3,747,026

[45] July 17, 1973

[54] TWO INPUT COMBINER HAVING USEFUL AND DUMMY LOAD OUTPUTS

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[22] Filed: Nov. 2, 1971

[21] Appl. No.: 194,985

[52] U.S. Cl. 333/6, 333/11, 336/181
[51] Int. Cl. H03h 7/48
[58] Field of Search 333/6, 8, 11; 336/171, 181

[56] References Cited

UNITED STATES PATENTS

3,037,173 5/1962 Ruthroff 333/11

FOREIGN PATENTS OR APPLICATIONS

829,905 1/1952 Germany 333/11

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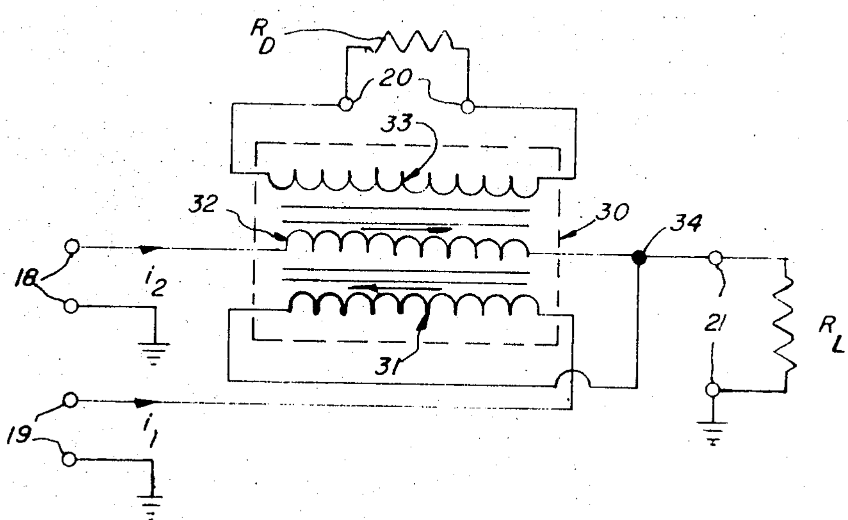
Attorney—Christopher Robinson et al.

[57] ABSTRACT

A four-port combining network which utilizes a single transformer element. The two input ports are supplied with radio frequency signals of the same frequency and phase. One output port is connected to a useful load such as an antenna. The other output port is connected to a dissipative "dummy" load. Under normal operating conditions the two input signals add to provide a single high power output and essentially no signal is fed to the dummy load. In the event of failure of one input signal the remaining operating input signal is divided between the two output ports. Respective isolation under all conditions is maintained between the two inputs ports.

3 Claims, 2 Drawing Figures



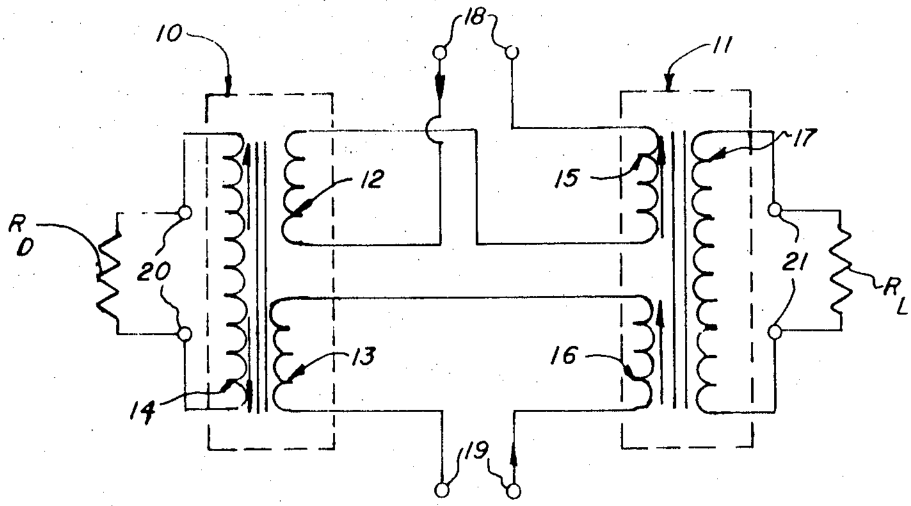


FIG. 1 (PRIOR ART)

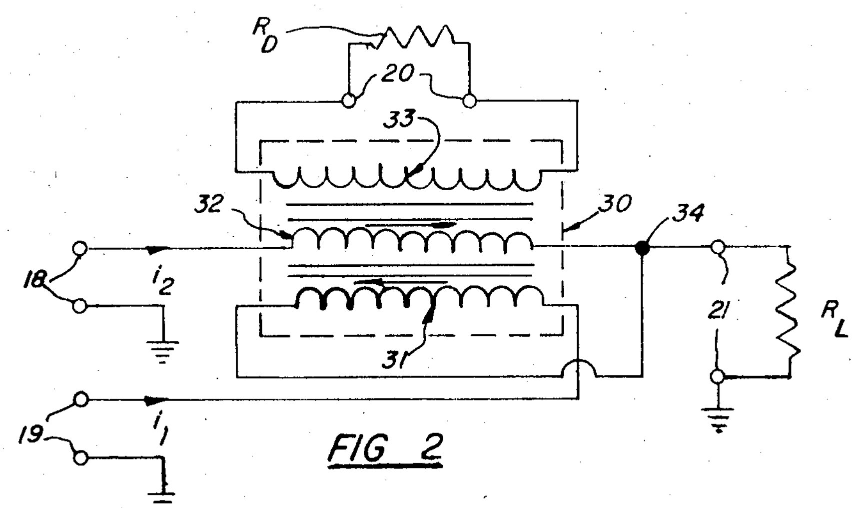


FIG 2

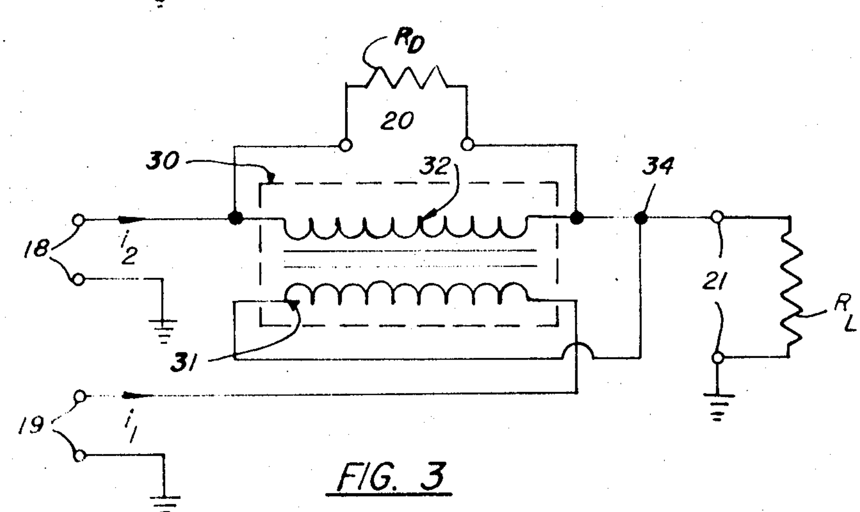


FIG. 3

TWO INPUT COMBINER HAVING USEFUL AND DUMMY LOAD OUTPUTS

FIELD OF THE INVENTION

This invention relates to an improved four-port combiner used to combine two synchronous, coherent AC signals to form a single AC signal.

Known combining networks can be broken down into two categories. The first category contains combiners used to combine narrow band signals and comprises one quarter wave transmission line sections arranged generally in the form of a bridge circuit. The second category of combining network and the category in which the present invention is contained, includes the four-port transformer-wound, broad-band combiner. As in the first category, the transformers are generally arranged in a bridge circuit. An example of the combiners of the second category is described in U.S. Pat. No. 3,503,016, which issued to A.F. PODELL on 24 Mar. 1970.

Known broad-band combining networks have the disadvantage that they are relatively complicated arrangements of a plurality of individual transformers. The individual windings of these transformers must be capable of handling the power output of one of the inputs. In contrast, the combiner of the present invention utilizes a single transformer having three windings and therefore represents a considerable simplification of known prior art devices. The individual windings of the combiner in accordance with the present invention need only be capable of handling a fraction of the power of either input and in fact during normal operating conditions, only a fraction of the power output of an individual source.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a combiner network comprising an output port having a first terminal and a second terminal for supplying a load, a first input port having first and second terminals, a second input port having first and second terminals, the second terminals of the said input ports and the second terminal of the output port being directly connected together; a single transformer having a first winding and a second winding, the first winding being connected between the first terminal of the first input port and the first terminal of the output port, the second winding being connected between the first terminal of the output port and the first terminal of the second input port, said windings being oppositely wound with respect to current flow from the first and second input ports and having a respective turns ratio in inverse proportion to the respective rated input powers of the first and second input ports whereby under rated operating conditions the net flux attributable to current flow through said windings is substantially zero; dissipative impedance means having an impedance selected to balance rated load impedance and connected in a series loop with a third winding of said transformer, said third winding being mutually transformer-coupled with said first and second windings whereby, in response to non-zero net flux in said windings caused by flux imbalance between said windings, said dissipative impedance means is operative to dissipate a portion of the power supplied by said input ports so as to maintain an impedance balance between said input ports.

DESCRIPTION OF THE DRAWINGS

The invention will be described in detail herein below with the aid of the accompanying drawings in which:

FIG. 1 is a schematic diagram of a known broadband, wound transformer combiner; and

FIG. 2 is a schematic diagram of a particular embodiment of a broad-band combiner according to the present invention.

DETAILED DESCRIPTION

The combiner shown in FIG. 1 is comprised of two individual transformers **10** and **11**. Transformer **10** has two primary windings **12** and **13** and a secondary winding **14**. Similarly, transformer **11** has primary windings **15** and **16** and secondary winding **17**. The combiner network is comprised of two input ports **18** and **19** and two output ports **20** and **21**. In operation, two coherent and synchronous AC signals are applied to input ports **18** and **19**. The amplitudes of the signals need not be the same but it is important that the frequency and phase of the two signals be identical. The current sense of the AC signals is indicated by the arrows leading away from input ports **18** and **19** respectively. The currents circulating in the two primary windings **15** and **16** of transformer **11** are wound in aiding sense and produce a net flux circulating in the magnetic core of transformer **11** whose intensity is proportional the sum of the two currents. As a result, there is induced into the secondary winding **17** of transformer **11** a current which is proportional to the sum of the two individual input currents. This summation current is fed to a load R_L via output port **21**. The same input currents which additively combine in transformer **11** exactly oppose one another in transformer **10**. The flux created by the current in winding **12** is opposite in sense to the flux created by the current flowing in winding **13**. It can be seen that if the frequency and phase of the two input signals are identical, and the flux created by the two input ports are identical, there will be no net flux circulating in the magnetic circuit of transformer **10** and as a result, there will be no current induced into the secondary winding **14**.

However, if one of the input signals should fail, the power of the remaining input signal will be divided between the two transformers **10** and **11** and the output signal will appear at both output ports **20** and **21**. At such time, a "dummy load" dissipative impedance element R_D will dissipate a portion of the remaining input signal. In this manner, the two input ports will remain mutually isolated.

A similar action takes place in the combiner according to the present invention, which is shown schematically in FIG. 2. However, it can be readily seen that the complexity of the circuit shown in FIG. 2 is considerably less than that shown in FIG. 1.

Referring to FIG. 2, there are shown input ports **18** and **19** and output ports **20** and **21**. Similar reference numerals are used for similar components throughout the drawings. The combiner network comprises a transformer **30** having three mutually coupled windings **31**, **32** and **33**. Winding **31** is connected with source **19** and winding **32** is connected with source **18** to obtain mutually opposing senses of current flow in transformer **30**. Two coherent and synchronous AC signals are applied to input ports **18** and **19** to produce signal currents whose instantaneous sense is represented by arrows.

The flux created in winding **31** by the current from input port **19** will be opposite in sense to the flux created in winding **32** by the current flowing from input port **18.** If the magnitude of the two fluxes is identical, there will be no net flux circulating in transformer **30.** This criteria is satisfied if:

$$N_{31}\, i_1 = N_{32}\, i_2 \quad (1)$$

where N_{31} represents the number of turns of winding **31**;

N_{32} represents the number of turns of winding **32**; and

i_1 and i_2 represents the two input signal currents.

(Note that by properly selecting the turns ratio, it is possible to produce a zero net magnetic flux in the transformer **30** by applying two input signals which are of the same frequency and phase but of different magnitudes.)

Since no net flux is normally (i.e., under rated operating conditions) present in the magnetic circuit of the transformer **30,** the two input currents add at the connection point **34** to produce an output current substantially equal to the sum of the input currents at the output port **21.** This summation current is then fed to the load R_L.

When one of the input signals fail, the remaining signal produces a net flux in the transformer **30** and a current is induced into winding **33,** which in turn is absorbed by dummy load R_D via the output port **20.** By properly choosing the turns ratios in transformer **30,** the combined effect of the new impedance presented by the dummy load and the impedance created by the load R_L can be arranged to present, at the remaining operating input port, an impedance equal to the impedance presented when both input signals were supplying current. In this manner, input ports **18** and **19** are mutually isolated.

The input impedance of the circuit shown in FIG. **2** for input port **18** is:

$$Z_{18} = Z_L\,(1 + N_{32}/\,N_{31}) \quad (2)$$

and the input impedance for port **19** is:

$$Z_{19} = Z_L\,(1 + N_{31}/\,N_{32}) \quad (3)$$

where Z_L is the impedance of load R_L.

(The turns ratio for N_{31} and N_{32} is determined by the relative input power ratio to the two input ports by equation 1, above.)

The isolation can now be obtained by the correct selection of the number of turns N_{33} for the third winding, and the value Z_D of the dummy load R_D. If it is assumed that transformer **30** is an ideal transformer (i.e. having a unity coupling coefficient and negligible magnetizing current), the voltage transfer coefficient C_{18+19} from input port **18** to input port **19** with input port **19** open-circuited is given as follows:

$$C_{18+19} = (N_{33}^2\, Z_L - N_{32}\, N_{31}\, Z_D)/(N_{33}^2\, Z_L + N_{32}^2\, Z_D) \quad (4)$$

It can be seen from equation **4** that no coupling will be present, (i.e., C_{18+19} will be zero), if $Z_L = Z_D\,(N_{32}\, N_{31}\,/N_{33}^2)$.

The condition for zero coupling from input port **19** to input port **18,** (i.e., $C_{19+18} = 0$), is identical with the above result.

The transformer **11** shown in FIG. **1** must be capable of handling the entire power from the input ports **18** and **19.** However, transformer **10,** will, under the worst conditions only be required to handle one half of the power of the remaining input which has not failed. Under these conditions, the power of the remaining input will be divided between both transformers **11** and **10.** In the combining network according to the present invention, as shown in FIG. **2,** there is no one winding which must be capable of handling the complete power input of the two ports **18** and **19.** As a result, not only has one transformer been eliminated using the combining network according to the present invention but the remaining transformer may be reduced in size.

The embodiment of the present invention described above is concerned with the objective of coupling together a number of coherent RF signal inputs to an antenna (the load). Clearly the frequency range for which the invention is useful will be limited by the operating characteristics of available wire-wound transformers.

What I claim as my invention is:

1. A combiner network comprising an output port having a first terminal and a second terminal for supplying a load, a first input port having first and second terminals, a second input port having first and second terminals, the second terminals of the said input ports and the second terminal of the output port being directly connected together; a single transformer having a first winding and a second winding, the first winding being connected between the first terminal of the first input port and the first terminal of the output port, the second winding being connected between the first terminal of the output port and the first terminal of the second input port, said windings being oppositely wound with respect to current flow from the first and second input ports and having a respective turns ratio in inverse proportion to the respective rated input powers of the first and second input ports whereby under rated operating conditions the net flux attributable to current flow through said windings is substantially zero; dissipative impedance means having an impedance selected to balance rated load impedance and connected in a series loop with a third winding of said transformer, said third winding being mutually transformer-coupled with said first and second windings whereby, in response to non-zero net flux in said windings caused by flux imbalance between said windings, said dissipative impedance means is operative to dissipate a portion of the power supplied by said input ports so as to maintain an impedance balance between said input ports.

2. A combiner network according to claim **1** wherein the rated input powers of the first and second input ports are substantially the same and the said first and second windings have substantially the same number of turns.

3. A combiner network as defined in claim **1,** wherein said transformer and windings are selected for operation at R.F. signal frequencies.

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