

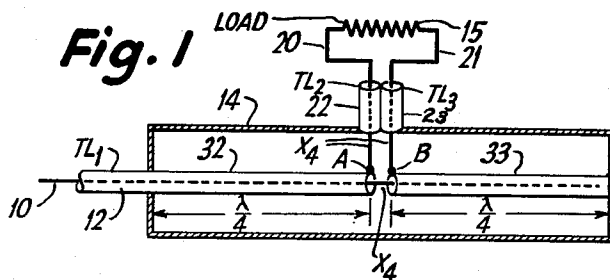
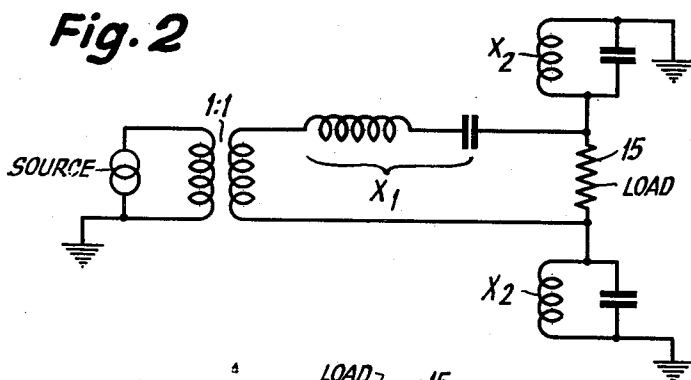
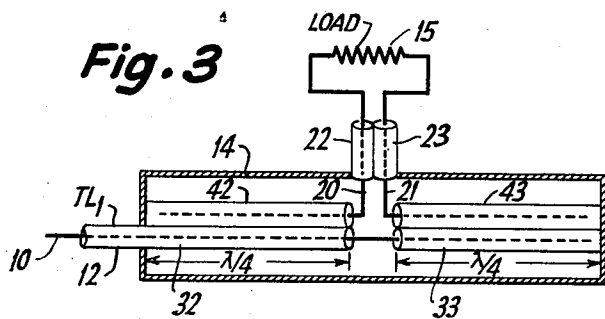
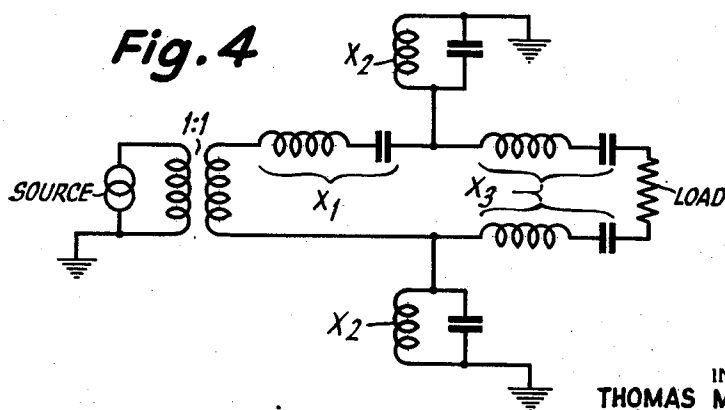
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2,606,964

RADIO FREQUENCY TRANSMISSION LINE CIRCUITS

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RADIO FREQUENCY TRANSMISSION LINE
CIRCUITS

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The present invention relates to radio frequency transmission lines and more particularly to transmission line arrangements for coupling a single ended or unbalanced line to a balanced or push-pull transmission line arrangement.

An object of the present invention is the provision of a wide band balance-to-unbalance coupling device or "balun."

Another object of the present invention is the provision of means for coupling a single ended or unbalanced transmission line to a pair of transmission lines operating in a balanced or push-pull relationship.

A further object of the present invention is the provision of a coupling arrangement as aforesaid which not only is balanced over a wide band of frequencies, but which is also reflectionless over said band.

Still another object of the present invention is the provision of a "balun" operative over a wide band of frequencies.

The foregoing objects and others which may appear from the following detailed description are attained by providing a balance-to-unbalance coupling arrangement in which series reactance are inserted in the balanced line circuit to compensate for the reactive components introduced in the coupling circuit as the frequency departs from the assigned value. The present invention will be more fully understood by reference to the following description which is accompanied by a drawing in which:

Figure 1 illustrates in sectional view, a form of balance-to-unbalance coupling device heretofore known in the prior art; while Figure 2 illustrates in diagrammatic form an equivalent circuit for the "balun" of Figure 1; Figure 3 illustrates in cross-section the application of the present invention to a balance-to-unbalance coupling arrangement; while Figure 4 shows in diagrammatic form, the circuit equivalent of the arrangement of Figure 3.

Referring now to Figure 1, there is shown an unbalanced transmission line TL_1 including an inner conductor 10 and a conductive outer sheath 12 concentrically arranged about conductor 10. The transmission line TL_1 enters a conductive box or outer shell 14 at one end. A further pair of transmission lines TL_2 and TL_3 , operating in a balanced or push-pull relationship, enter one side of the box or shell 14. The shell 14 is entirely closed except where the various transmission lines enter. The transmission line TL_2 includes an inner conductor 20 and a surrounding outer sheath 22, while line TL_3 includes an inner conductor 21 surrounded by another sheath 23.

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The outer sheaths 22 and 23 are shown as extending only a short distance over the inner conductors, but in practice would entirely enclose inner conductors 20 and 21 from the balance converter to the load 15.

The transmission line TL_1 has its outer sheath 12 extending into the shell 14, a distance equal to a one-quarter of the operating wavelength. The inwardly extending portion of sheath 12 is identified by reference character 32.

In a coaxial end-to-end arrangement with extension 32 is a cylindrical conductive member 33, also one-quarter of the operating wavelength long and connected at its end remote from the end of member 32 to outer shell 14. The inner conductor 10 of transmission line TL_1 extends into the tubular member 33, a distance equal to one-quarter of the operating wavelength and is terminated in an electrical open circuit. These members 32 and 33 are electrically inverted images of one another. At the adjacent ends of members 32 and 33, at points A and B, of highest instantaneously equal and opposite potentials, the conductors 20 and 21 of the balanced circuit are connected.

The reactance provided by the tubular conductor 33 and the extension of inner conductor 10 therewithin provides a series reactance element X_1 , shown diagrammatically in Figure 2, which over a reasonably wide band of frequencies nearly cancels the reactive component of the parallel combination formed by the load 15 and the anti-resonant circuits formed by conductors 32 and 33 within the outer shell 14. In Figure 2, these reactances are illustrated in diagrammatic form as reactances X_2 . The added reactance X_1 of Figure 2 representative of the series reactance of tubular conductor 33 and inner conductor 10 also acts to tune out any residual reactance in the circuit such as may be caused by the short unshielded lengths of conductors 10, 20 and 21 within the shell 14. These reactances are indicated in Figure 1 as reactance X_4 .

Now it can be seen that the equivalent circuit shown in Figure 2 is not completely compensated. If the circuit elements indicated by X_2 add susceptance to the load, the input resistance will have a value lower than the load resistance and the source impedance will no longer be matched by the load, thus causing standing waves to be set up in transmission line TL_1 . This is true even though the equivalent series reactance is compensated by X_1 . In order to avoid this undesirable effect, the arrangement, according to my invention, as shown in Figure 3, may be used.

The elements of Figure 3 which correspond to

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those in Figure 1 have similar reference characters and need not be further described. However, in Figure 3 instead of inner conductors 20 and 21 being connected directly to sheath members 32 and 33 these conductors enter the further tubular members 42 and 43 parallel to and connected to the sheaths 32 and 33 respectively. The inner conductor 20 of the balanced TL₂ enters the tubular member 42 a distance equal to one-quarter of the operating wavelength and is open circuited at the inner end thereof. Similarly the conductor 21 enters tubular member 43, a distance equal to one-quarter of the operating wavelength and is open circuited at its inner end. Thus the reactance element formed by conductor 20 and tubular member 42 and the reactance element formed by conductor 21 and tubular member 43 are effectively in series with the load 15. At the operating frequency these open ended quarter wave lines act as though they were short circuited at the mouths of tubular members 42 and 43 and have no effect on the circuit. They are diagrammatically indicated as series resonant elements X₃ in Figure 4.

Now, if at an arbitrary frequency removed from the midband frequency the reactance X₃ is chosen approximately equal in value to the reactance X₁, and the sum of the reactances of X₁ and X₃ is chosen equal in value to the reactance added by susceptance X₂, the input at TL₁ will not only be non-reactive but will have a pure resistance value equal to a resistance of the load 15. Therefore, the network properly terminates the source not only at the midband frequency but also at arbitrary frequencies above and below the mid-band frequency.

Thus the balance transformer of Figure 3 is not only balanced at all frequencies but is substantially non-reactive over a substantial band of frequencies. A band width at least thirty percent greater than obtainable with the structure of Figure 1 is thereby obtained.

What is claimed is:

1. An arrangement for coupling an unbalanced coaxial transmission line having center and sheath conductors to a pair of transmission lines having inner and outer conductors operating in balanced relationship, said unbalanced transmission line having an interruption in the sheath conductor at a point substantially one quarter wavelength at the operating frequency from the end thereof, said arrangement having a conductive shell substantially a half-wave long at said operating frequency surrounding said unbalanced coaxial transmission line at the end thereof and being connected at each end to the sheath conductor thereof, a further section of coaxial transmission line arranged within said shell, said further section of coaxial transmission line having interrupted sheath and center conductors, said interrupted sheath conductor being connected to said shell at the ends thereof and being connected to the interrupted sheath conductor of said unbalanced coaxial transmission line, the interrupted center conductor of said further coaxial transmission line having its adjacent ends connected to the inner conductors of said balanced transmission lines, the outer conductors of said balanced transmission lines being connected to said shell.

2. An arrangement for coupling an unbalanced coaxial transmission line having center and sheath conductors to a pair of transmission lines having inner and outer conductors operating in balanced relationship, said unbalanced transmis-

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sion line having an interruption in the sheath conductor at a point one-quarter wavelength at the operating frequency from the end thereof, said arrangement having a conductive shell substantially a half-wave long at said operating frequency surrounding said unbalanced coaxial transmission line at the end thereof and being connected at each end to the sheath conductor thereof, two further sections of coaxial transmission line each having the sheath conductor connected to said shell at the ends thereof and being connected to the interrupted sheath conductor of said unbalanced coaxial transmission line on each side of the interruption, the other conductors of said further sections having adjacent ends connected to the inner conductors of said balanced transmission lines, the outer conductors of said balanced transmission lines being connected to said shell.

3. An arrangement for coupling an unbalanced transmission line to a balanced transmission line, including a conductive shell member, first, second, third and fourth sections of open-ended transmission line arranged within said shell member, said sections having a length substantially equal to a quarter wavelength at the operating frequency, each of said sections having one end of one conductor thereof connected to said shell member, the other end of said one conductor of said first section being connected to the other end of said one conductor of said third section and the other end of said one conductor of said second section being connected to the other end of said one conductor of said fourth section, the other conductors of said first and said second sections being connected in series, means to connect said unbalanced transmission line to the conductors of said first section at said one end thereof, and means to connect said balanced transmission line to the other conductors of said third and said fourth sections at said other ends thereof.

4. An arrangement for coupling an unbalanced coaxial transmission line to a pair of coaxial transmission lines operating in balanced relationship, said coaxial transmission lines having center and sheath conductors, said arrangement including a conductive shell member, first, second, third and fourth sections of open-ended coaxial transmission line having inner and outer conductors arranged within said shell member, said sections having a length substantially equal to a quarter wavelength at the operating frequency, each of said sections having one end of the outer conductor thereof connected to said shell member, the other end of the outer conductor of said first section being connected to the other end of the outer conductor of said third section and the other end of the outer conductor of said second section being connected to the other end of the outer conductor of said fourth section, the inner conductors of said first and second sections being connected in series, means to connect the sheath conductors of said coaxial transmission lines to said shell member, means to connect the center conductor of said unbalanced transmission line to the inner conductor of said first section at said one end thereof, and means to connect the center conductors of said balanced transmission lines individually to the inner conductors of said third and said fourth sections at said other ends thereof.

5. An arrangement for coupling an unbalanced two-conductor transmission line to a transmission line arrangement having at least two con-

ductors operating in balanced relationship, said arrangement including a conductive shell member, first, second, third and fourth sections of open-ended coaxial transmission line having inner and outer conductors, arranged within said shell member, said transmission line sections having a length substantially equal to a quarter wavelength at the operating frequency, each of said transmission line sections having one end of the outer conductor thereof connected to said shell member, the other end of the outer conductor of said first transmission line section being connected to the other end of the outer conductor of said third transmission line section and the other end of the outer conductor of said second transmission line section being connected to the other end of the outer conductor of said fourth transmission line section, the inner conductors of said first and said second transmission line sections being connected in series, means to connect the conductors of said unbalanced transmission line to the conductors of said first transmission line section at said one end thereof, and means to connect said two balanced conductors of said transmission line arrangement individually to the inner conductors of said third and said fourth transmission line section at said other ends thereof.

6. An arrangement for coupling an unbalanced concentric transmission line to a pair of coaxial transmission lines operating in balanced relationship, said concentric transmission line comprising inner and outer conductors and said coaxial transmission lines comprising central and sheath conductors, said arrangement including a conductive shell connected to said sheath and said outer conductors of said transmission lines, the connection to said outer conductor of said concentric transmission line being made at a distance from the end thereof substantially equal to a quarter wavelength at the operating frequency, a plurality of open-ended transmission line sections having lengths substantially equal to a quarter wavelength at said frequency and comprising tubular conductors and central conductors arranged within said tubular conductors, one of said transmission line sections having the tubular conductor thereof connected to said shell at one end of said section and having the central conductor connected at the other end of said section to the inner conductor of said concentric transmission line, another of said transmission line sections having the tubular conductor thereof connected to the outer conductor of said concentric transmission line and still another transmission line section having the tubular conductor thereof connected to the tubular conductor of said one transmission line section, the central conductors of said coaxial transmission lines being connected to the central conductors of said other transmission line sections.

7. An arrangement for coupling an unbalanced

concentric transmission line to a pair of coaxial transmission lines operating in balanced relationship, said concentric transmission line comprising inner and outer conductors and said coaxial transmission line comprising central and sheath conductors, said arrangement including a conductive shell, connected to said sheath and said outer conductors of said transmission lines, the connection to said outer conductor of said concentric transmission line being made at a distance from the end thereof substantially equal to a quarter wavelength at the operating frequency, a plurality of tubular conductors arranged within said shell, one of said tubular conductors being connected to said shell at one end, the inner conductor of said concentric transmission line extending within said one tubular conductor for a distance substantially equal to a quarter wavelength at the operating frequency, another of said tubular conductors being connected to the outer conductor of said concentric transmission line and still another of said tubular conductors being connected to said one tubular conductor, the central conductors of said coaxial transmission lines extending within said other tubular conductors for a distance substantially equal to a quarter wavelength at said frequency.

8. An arrangement for coupling an unbalanced coaxial transmission line having center and sheath conductors to a pair of transmission lines having inner and outer conductors operating in balanced relationship, including a conductive shell substantially a half-wave long at the operating frequency, two pairs of tubular conductive members arranged within said shell, the members of each pair being arranged in end-to-end relationship relative to each other and the ends of said members remote from the adjacent ends being connected to an end of said shell, the adjacent ends of one pair of said conductive members being connected to the corresponding adjacent ends of the other pair, the sheath conductor of said unbalanced line being connected to said shell to form a continuation of one of said members and the inner conductor thereof being extended into said one member and its complementary member, the inner conductors of said balanced transmission lines being extended individually into the members of the other pair of said members, and the outer conductors of said balanced transmission lines being connected to said shell.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,231,839	Lindenblad	Feb. 11, 1941
2,327,418	Goldmann	Aug. 24, 1943