April 5, 1966 W. BUSCHBECK 3,245,009

UNBALANCED TO BALANCED BROADBAND IMPEDANCE TRANSFORMER

Filed March 21, 1962 4 Sheets-Sheet 1

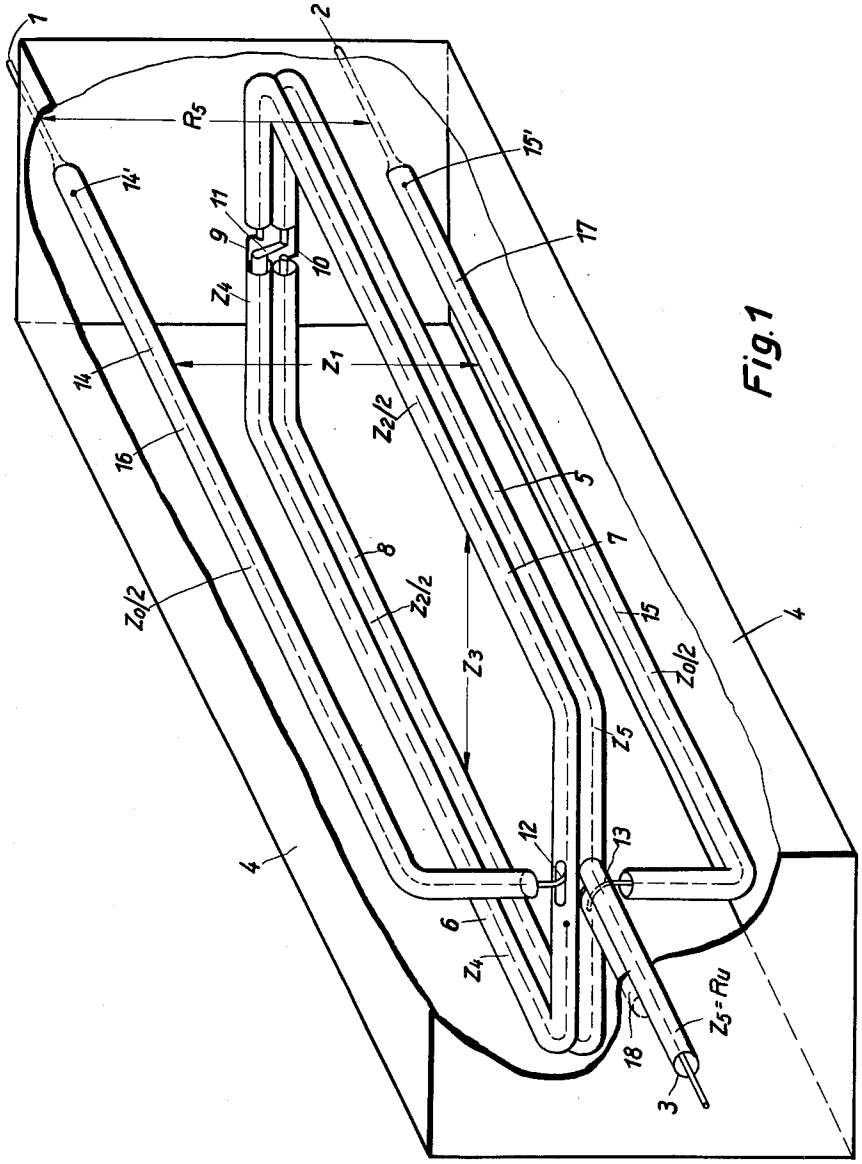


Fig.1

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Filed March 21, 1962 4 Sheets-Sheet 2

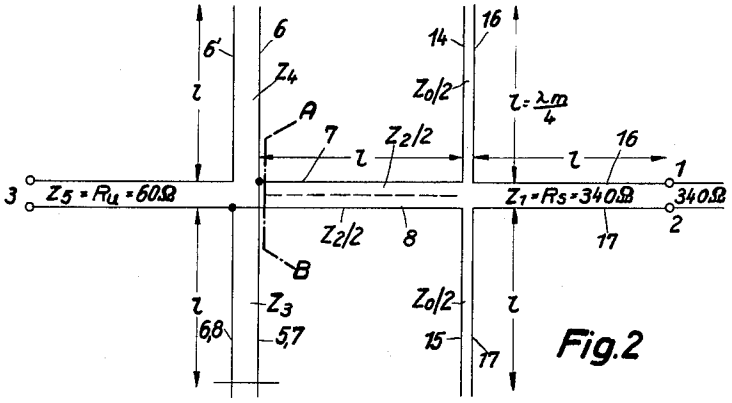


Fig.2

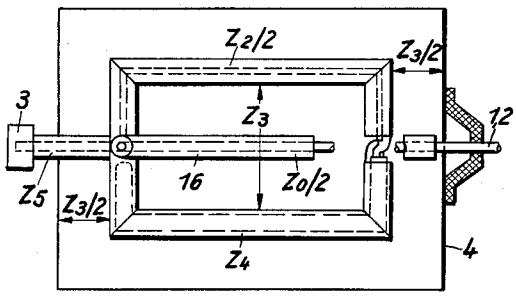


Fig. 3a

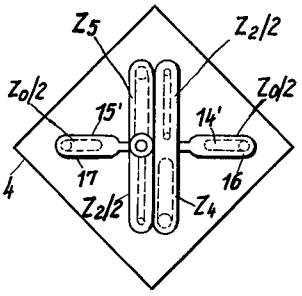


Fig. 3b

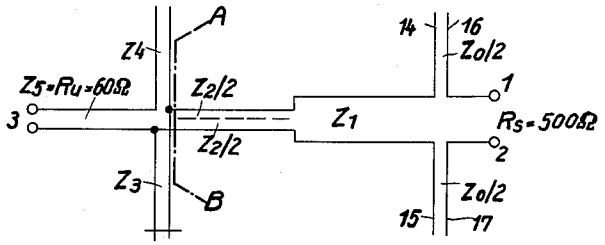


Fig. 4

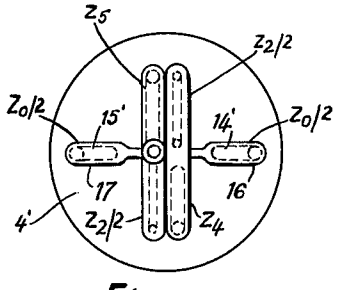


Fig. 3c

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UNBALANCED TO BALANCED BROADBAND IMPEDANCE TRANSFORMER

Filed March 21, 1962 4 Sheets-Sheet 3

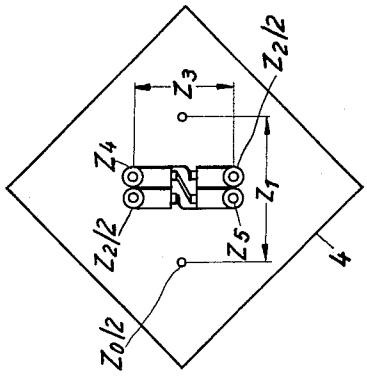


Fig. 5b

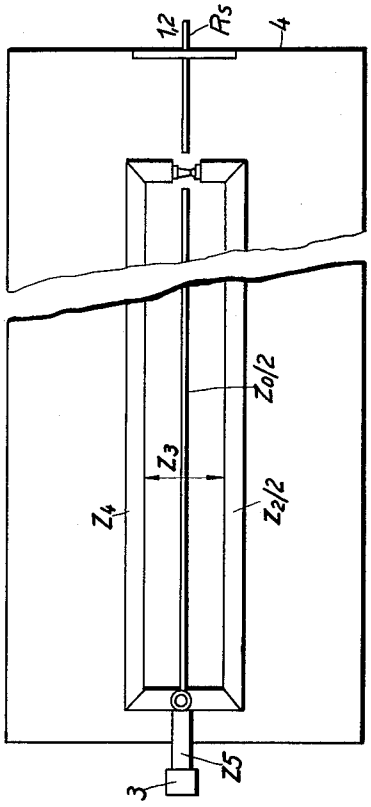


Fig. 5a

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April 5, 1966 W. BUSCHBECK 3,245,009

UNBALANCED TO BALANCED BROADBAND IMPEDANCE TRANSFORMER

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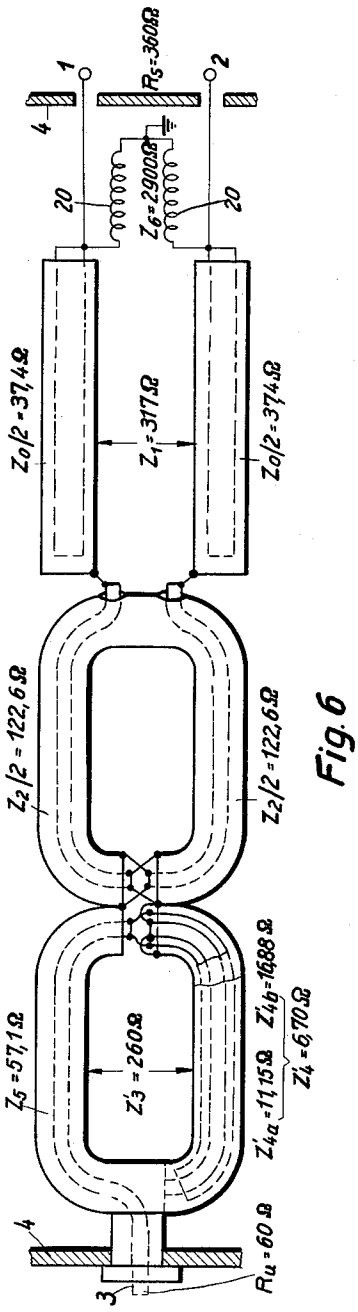


Fig. 6

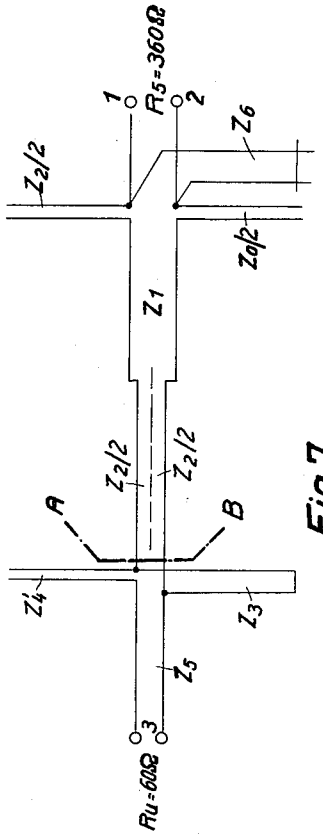


Fig. 7

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United States Patent Office 3,245,009 Patented Apr. 5, 1966

3,245,009

UNBALANCED TO BALANCED BROADBAND IMPEDANCE TRANSFORMER

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Filed Mar. 21, 1962, Ser. No. 181,355
Claims priority, application Germany, Mar. 22, 1961, T 19,834
16 Claims. (Cl. 333—26)

The present invention relates generally to the high frequency art, and, more particularly, to a device for connecting a coxial line with a balanced line having a higher characteristic impedance and for eliminating the pulse which would otherwise occur. Such devices are known as balancing-transformer devices or matching balun devices.

The known balancing loop may be used for rebalancing, i.e., in the transition from a coaxial unbalanced line to a balanced line, without a simultaneous transformation to another impedance. Furthermore, it is taught in German Patent No. 743,669 that the symmetric or balanced terminals of such a balancing loop may be connected by means of compensating members, with the low resistance balancing terminals of a transformer loop acting as an ideal transformer having a transformer resistance ratio of 1:4. This transformation is provided by a special arrangement of the transformer loop wherein two halves of the outer conductor are connected in parallel and they thus provide a resulting characteristic impedance Z. The two halves of the inner conductor are connected in series providing a resulting characteristic impedance of 4Z and thus four times the value of Z. It was thus possible to change or have a transition from a coaxial unbalanced line having the characteristic impedance Z to a balanced line having the characteristic impedance 4Z by using the device taught in the afore-mentioned German patent.

However, a device which produces transformer ratios of 1:4 between coaxial and balanced lines in a simple manner frequently does not satisfy practical requirements. For example, it is frequently necessary to have a transition from the standard coaxial line resistance of 60 ohms to a resistance of 340 ohms for a balanced four-wire line, or the still higher resistance of 500 ohms for a balanced two-wire line. In these cases the transformer ratio is as high as 1:5.5 through 1:7.5.

German Patent No. 806,446 teaches a device for the transition from a high frequency unbalanced device, i.e., one which is asymmetrical with respect to ground, to a high frequency balanced device, i.e., one which is symmetrical relative to ground, with simultaneous resistance matching or transformation wherein ratios are provided which are different from the value of 1:4. This device has an unbalanced line divided into a number of branches which, when viewed from the branching point, are connected in parallel and with the free ends of the branches connected in series. In this device means are used to prevent voltage equalization between the free ends via the outer covering of the lines. However, in using this device, only transformer ratios having a value of $1:X$, where X is the square of an integral number, may be produced.

In order to solve the problem it is also known to use a balancing loop or coil in connection with a quarter wavelength transformer or a staggering of such transformers in the form of a stepped line or an exponential line (German Patents No. 845,967 and No. 955,065). However, with these devices, resistance ratios of from 1:5 through 1:8 can be matched only by having a great number of steps in the stepped line or with an exponential line of a considerable length, if the device is to be used for a frequency band having a substantial band width. Therefore, these devices generally require an undesirably large amount of equipment and are accordingly expensive to produce and occupy a great deal of space.

In all of the balancing-transformer devices mentioned above, it is fundamentally necessary to provide additional compensating members if the device is to operate within a large frequency range without undesired or inadmissible changes of the transformer ratio. The design of such compensating members is basically known and several of these members may be provided at each end of the device. It is also known to enclose several coaxial line portions each into one another to provide for their structural housing (German Patent No. 944,615), or, for example, the otherwise free leg of the balancing loop may be used for housing a coaxial line portion of suitable characteristic impedance which is open at one end and is a quarter wave in length. Further, it is also known to use the balancing loop itself as a compensating member by providing it with a suitable characteristic impedance (German Patent No. 738,664).

With these defects of the prior art in mind, it is a main object of this invention to provide a balancing-transformer device which may be used in a range of transformer ratios of 1:4 through 1:10 and which possesses good performance and simplicity of design.

Another object of this invention is to provide a device of the character described which reduces the amount of space required for the device.

A further object of the present invention is to adapt such a device to have its members for multiple compensation housed within the loop device without requiring substantially more circuitry and without involving further expense.

Still another object of this invention is to provide a device of the type described which is extremely compact and is disposed in its entirety within a common housing.

These objects and others ancillary thereto are accomplished according to preferred embodiments of the invention wherein a device is developed from a known combination (German Patent No. 743,669, particularly FIGURE 3) of the balancing loop with a 1:4 transformer loop. It is possible to construct the device so that the transformer ratio within the mentioned limits may deviate from the value 1:4. A combination of a one stage or multiple stage quarter wavelength transformer will suit this purpose very well. The invention uses a device for the transition from a coaxial line to a balanced line of higher characteristic impedance.

This device has a balancing loop and a transformer loop, with the transformer loop connected to connection points of the balancing loop by means of compensating elements for a resistance or impedance ratio of 1:4. The device is preferably provided with an open quarter wavelength line housed in the interior of the otherwise free leg of the balancing loop, and serves as compensating element. Preferably, it is also provided with an open quarter wavelength line housed in the interior of tubular ini-

tial portions of the conductors of the balanced line and serving as compensating member.

According to the present invention, the balancing loop and the transformer loop are substantially equal in size and closely adjacent each other. They are disposed in a mirror image position relative to a plane of symmetry which is parallel to the planes of the loops, as determined by the line axes of the loop portions belonging in the same loop plane. However, in each case, one leg is coordinated with the balancing loop, and the other leg is coordinated with the transformer loop. Also, outlets which are disposed on the side of the coaxial connection of the balancing loop for the initial portions of the conductors of the balancing line are defined by apertures in the outer conductors. These apertures also have a mirror image position relative to the plane of symmetry mentioned above, and are disposed in the electrical center of the loops. Moreover, the two initial portions are disposed remote from these outlets at right angles to the plane of symmetry, and are bent in a direction parallel to the plane of symmetry, at a distance which results in the desired characteristic impedance. They are led to connections to the balanced line and the initial portions mentioned have a mirror image position relative to the plane of symmetry and its axes, and is disposed within the equipotential plane of the loops.

By combining the two loops which act as an ideal transformer of the transformer ratio 1:4, the characteristic impedances of the compensating members on the input side are reduced to one-fourth of the otherwise necessary value, and thereby obtain practical, usable values with little expenditures.

It must be noted that the point of the transformation begins directly at the open end of the balancing loop where the inputs of the two sides of the transformer loop are fed. However, while, as stated above, the quarter wavelength compensation line which is open at the input side, can easily be accommodated in the leg of the balancing loop which is readily accessible at that point and is otherwise free, the 1:4 impedance transformation occurs only at the short-circuited end of the loop where the two outer conductors—whose input sides are fed in phase opposition—can be connected together with inverse polarity so that the output voltage is, independently of its relative phase position with respect to the input voltage, just exactly doubled with respect to the value applied through a single line.

This combination of the loops provides a reduction in the volume required as compared to the known devices according to German Patent No. 743,669. There is a special coordination of the individual legs of the loop according to which the spatially correlated loops disposed on both sides of the plane of symmetry mentioned above, each receives one leg of the balancing loop and one leg of the transformer loop. This provides the possibility of designing the initial portions which leave or exit from the mentioned apertures of the outer conductor loop and which are initial portions of the balanced line, in a manner which allows them to be likewise spatially exactly symmetrical relative to the plane of symmetry mentioned above and allows them to be led into the equipotential plane of the loop device and thus in the electrically neutral plane. This is particularly important in view of the necessary decoupling of the balanced line from the field of the loop device. Thus, the present invention provides the feature that the total construction is extremely compact and all of the parts may be housed within a common housing.

Additional objects and advantages of the instant invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a perspective view of the balancing-transformer device with the housing thereof broken away for clarity.

FIGURE 2 is a schematic circuit diagram illustrating the equivalent circuit of the device of FIGURE 1.

FIGURE 3*a* is a schematic elevational side view of another embodiment similar to that of FIGURE 1.

FIGURE 3*b* is a front elevational view of the device illustrated in FIGURE 3*a* having a rectangular housing.

FIGURE 3*c* is a front elevational view similar to that of FIGURE 3*b* but showing a cylindrical housing.

FIGURE 4 is a schematic circuit diagram of the equivalent circuit of the device of FIGURES 3.

FIGURE 5*a* is a schematic elevational side view of another embodiment of the invention illustrating a two stage arrangement.

FIGURE 5*b* Illustrates a front elevational view of the embodiment of FIGURE 5*a*.

FIGURE 6 is a schematic view illustrating a device constructed in accordance with the present invention.

FIGURE 7 is a circuit diagram illustrating the equivalent circuit of FIGURE 6.

With more particular reference to the drawings, FIGURE 1 illustrates a first embodiment of a balancing-transformer device designed in accordance with the present invention. Terminals or connections **1** and **2** of the balanced line proper are provided on one side of housing **4**, while a connection or terminal **3** for the coaxial line is disposed on the other side thereof. The characteristic impedance of coaxial line terminal **3** have a value Z_5 and is equal to the matching resistance R_u. This matching resistance value may correspond to one which occurs in actual practice and may be, for example, 60 ohms.

In FIGURE 1, two loops are shown disposed one above the other with the outer conductors **5** and **6** for the balancing loop and the outer conductors **7** and **8** for the transformer loop. The inner conductors of the transformer loop are connected with the outer conductors of the opposite legs by means of the connecting bridges **9** and **10**. The connecting bridge **11** forms a connection between the inner conductor of the balancing loop and the outer conductor of the opposite leg of this loop. However, a compensating element or line which is a quarter wave in length is inserted, is open at its end, has a characteristic impedance Z_4, and is disposed within the interior of outer conductor **6**.

This device will be even clearer if the current path is traced from the coaxial line connection or terminal **3** to the connections **1** and **2** for the balanced line proper. Beginning with the connection **3**, the inner conductor thereof first turns into the leg which is disposed at the lower right and is a leg of the balancing loop, the outer conductor of which is designated **5**. This leg of the balancing loop has the characteristic impedance Z_5 and is thus equal to the characteristic impedance of the coaxial line terminal **3**. At the separation point of this loop device, the connection continues, via the connecting member **11**, from the inner conductor to the compensating line which has the characteristic impedance Z_4. By the insertion of this compensating line section, the connection of the inner conductor to the outer conductor of the opposite leg, which is required anyway, is thus established.

The two ends of the outer conductor at the separating point now form the connection points of the balancing loop. The high frequency current arrives, via the connections **9** and **10**, at the inner conductors of the legs of the transformer loop from these balanced connection points and thus at the leg which is located at the upper right and the leg in the lower left of the drawing. These legs are designed to have the characteristic impedance $Z_2/2$, the importance of which will be discussed below in connection with the equivalent circuit.

The inner conductors of the transformer loop are bent at **12** and **13** and they pass from the interior to the exterior of the outer conductors through corresponding apertures and are disposed perpendicular to the central plane of the loop device. These conductors immediately

enter tubular outer conductors **16** and **17** and form the inner conductors **14** and **15** thereof. The outer conductors form the beginning or initial portions of the balanced line which is symmetrical with respect to ground. They are chosen to be of such thickness that the beginning portions which they form are provided with the desired characteristic impedance Z_1. Inner conductors **14** and **15** and the associated outer conductors **16** and **17** form portions which are a quarter wave in length and are open at the end and act as compensating members having a characteristic impedance of $Z_0/2$.

These inner conductors **14** and **15** end at the points **14'**, **15'**. In order to improve the spatial symmetry of the device which is disturbed somewhat due to the eccentric position of the coaxial line for terminal **3**, a dummy socket **18** is provided. This dummy socket has no other electrical function to fulfill except as mentioned above.

From FIGURE 1, it may be seen that the initial portions **16** and **17** of the balanced line, which are parallel to the symmetrical plane, spatially, enclose two loops between them. The terminals of the balanced line are disposed on the side of the device which is opposite to that of the coaxial terminal **3**. Thus, all parts of the device are housed relatively close to each other without mutually disturbing one another in an electrical sense. The entire device requires little volume and has excellent mechanical and electrical properties. This device may be placed in positions where it is subject to the elements without any protective casing, if the openings in the outer conductors are protected, in a manner which is known per se, to prevent penetration by moisture.

FIGURE 2 illustrates an equivalent circuit wherein the coaxial line portions are indicated as Lecher wires in order to clarify the drawing. Tracing the path of the high frequency energy from terminal **3** to the terminals **1** and **2** will more clearly demonstrate the effect of the compensating members and the transforming elements.

It will be assumed that the characteristic impedance of the terminal **3** Z_5 is equal to 60 ohms and that it corresponds to the value of the matching resistance R_u. The transformation in the 1:4 ratio takes place at the separating phantom line A–B. Therefore, it may be imagined that an ideal transformer is disposed at this point having a resistance transformer ratio of 1:4. The compensating elements on the input side are formed by the line section which is open at the end and has the length l and the characteristic impedance Z_4 and includes outer conductor **6** and inner conductor **6'**. Also comprising the compensating element is the line section which is short-circuited at the end and has the length l and a characteristic impedance Z_3, and these elements are disposed on the low resistance side of the transformer.

The short-circuited line section is formed by the outer conductors **5** and **7** of the double loop which are disposed one upon the other as well as the outer conductors **6** and **8** on the other side. The transmission lines having the characteristic impedance $Z_2/2$ and formed by the two legs of the transformer loop are connected on the high resistance side of the transformation point A–B. These line sections also have a length l which is approximately equal to $\lambda m/4$, and thus to a quarter wavelength with respect to a mean frequency of the range to be covered. The outer conductors **7** and **8** of these transmission line sections are housed in the legs of the transformer loop.

In order to provide a matching of a value which deviates from the fourfold of the impedance match on the unbalanced side and preferably to a higher value in the case of an embodiment according to FIGURES 1 and 2, the two legs of the transformer loop are designed as a $\lambda/4$ transformer having the characteristic impedance $Z_2/2$. Z_2 at least substantially corresponds to the geometric mean between the fourfold value mentioned above and the desired deviating value. In FIGURE 2, it is assumed that the transformation is to be carried out for a resistance R_s of 340 ohms on the balanced side which corresponds to the characteristic impedance of a conventional four-wire line.

Uunder these assumed conditions, a value of 260 ohms is provided for Z_2 so that $Z_2/2$ is 130 ohms. The design of these line portions in legs **7** and **8** of the transformer loop having the characteristic impedance $Z_2/2$ may be found when it is considered that, as seen from the balanced side, the characteristic impedances of these two line portions appear to be connected in series.

In FIGURE 1, a balanced line is shown which has a characteristic impedance Z_1 which is equal to 340 ohms and which is connected at the points **12** and **13**. Using distances between the two conductors which are still technologically feasible, this characteristic impedance results in the conductors being relatively large in diameter. Therefore, the initial portions **16** and **17** of the balanced lines are of tubular form and contain inner conductors **14** and **15** interiorly thereof. Together, the inner conductors and outer conductors form compensating members which are open at the end, have the characteristic impedance $Z_0/2$, and are of a length l.

The characteristic impedances of the compensationg members Z_3, Z_4, and Z_0, may be determined according to known formulas and therefore there is no need for a further discussion thereof. However, it should be noted that when considered from the balanced side of the characteristic impedance $Z_0/2$ of the intial portions **16** and **17** appears to be connected in series, and this explains the value of being $Z_0/2$. As shown in FIGURES 1 and 2, the invention provides not only an exceedingly simple and space-saving balancing and transforming device, but also provides a transformer ratio which deviates from the value 1:4 without any additional expense.

With reference now to FIGURES 3*a* and 3*b*, a device is illustrated which is similar to FIGURE 1 with different diameters of the conductors of the coaxial line sections being indicated. If the housing **4**, which covers the device, is of a conductive material, then there are certain conditions which must be met as to its spacing from the outer conductors in order to assure that the desired characteristic impedances are provided. These characteristic impedances are: (1) Z_1 of the intial portions of the balanced line; and (2) Z_3 of the loop section. In order to determine the proper design and dimensions for the housing, known calculations are required, such as those which are taught in Telefunken-Zeitung, March, 1961, Issue 131: "Der Wellenwiderstand zylindrischer Leiter gegen verschiedenartig angeordnete ebene Schirmwände" (The Characteristic Impedance of Cylindrical Conductors Against Differently Arranged Plane Screens), by W. Buschbeck. The housing **4** is shown in FIGURE 3*b* as having a square cross section with the plane of symmetry of the loops forming a diagonal thereof, but this may be replaced by an electrically equivalent housing **4'** which is of cylindrical form, as shown in FIGURE 3*c*.

The embodiments of FIGURES 3 are somewhat different from that of FIGURE 1 in the compensating section of the initial portions **16** and **17** of the balanced line. The inner conductors of the transformer loop pass through outlets or apertures in the outer conductors of the transformer loop and pass through the thicker outer conductors **16** and **17** and into the intial portions of the balanced line. These outer conductors now terminate while open at the point where in FIGURE 1 they directly change over to the connecting conductors or terminals **1** and **2**. Thus, the terminal points **14'** and **15'** of the inner conductors **14** and **15** of the compensating members are now disposed near the exit points of the inner conductors of the transformer loop.

Due to this interchange of the terminals of the compensating members **14**, **16**, and **15**, **17**, between the conductors **1** and **2**, which are symmetrical with respect to ground and the inner conductors leaving the transformer loop, the switch-in points of these line sections having the

characteristic impedance $Z_0/2$ are shifted to the terminal points of the balanced line conductors **1** and **2** as shall be discussed below in connection with FIGURE 4. This displacement of the compensating members directly to the output of the device advantageously provides the possibility of designing the intial portion, formed by the outer conductors **16**, **17**, of the line symmetric to ground as a quarter wavelength transformer stage, and of designing the corresponding characteristic impedance Z_1 accordingly.

The impedance match on the asymmetrical side may be transformed to a value which deviates from the fourfold value and preferably to a higher value. This may be achieved because the two initial portions **16** and **17** of the balanced conductors are arranged as a quarter wavelength transformer having the characteristic impedance Z_1. The impedance Z_1 at least substantially coresponds to the geometrical mean between the matching impedance prevailing at the connections of the initial portions mentioned to the inner conductors of the transformer loop and the desired deviation value.

This feature will now be discussed with reference to the equivalent circuit of FIGURE 4. It will be assumed, for purposes of explanation, that the transformation is to be effected from a coaxial input resistance R_u of 60 ohms to a balanced output resistance R_s of 500 ohms. The intial portion of this circuit of FIGURE 4 is identical with that of FIGURE 2 up to the right side of the legs of the transformer loop having the characteristic impedance $Z_2/2$.

The two portions having the characteristic impedance $Z_2/2$ form a first stage of a quarter wavelength transformer. An output resistance of 340 ohms could be connected to their ends without a voltage surge, in the circuit of FIGURE 2. In the circuit of FIGURE 4, the transformer stage would be too large to connect the output resistance of 500 ohms, and it would no longer be possible to obtain favorable wide band characteristics. Therefore, the second quarter wavelength transformer stage having a characteristic impedance Z_1 is provided by the initial portions of the balanced line. Under these conditions, $Z_2/2$ has a value of 146.5 ohms, while Z_1 is 424 ohms. As mentioned above, the connection points for the compensating open quarter wavelength line members **14**, **16**, and **15**, **17**, have characteristic impedances $Z_0/2$ and are now disposed between the end of the line section having the characteristic impedance Z_1 and the 500 ohm terminal.

FIGURES 5 illustrate the spatial arrangement of a balancing-matching device with a two stage quarter wavelength transformer which follows the transformer loop. Parts which correspond to those of FIGURE 1 are provided with the same reference numerals and a detailed description of these portions will be omitted. The initial portions of the balanced line are considerably thinner in design in accordance with the increase of the characteristic impedance Z_1. Calculations have proven that in spite of this the compensating lines which are open at the output side and have the characteristic impedance $Z_0/2$ may still be disposed within these conductors. Thus, the expense for providing a device having an additional twofold quarter wavelength transformation is not greater than in a device having a one stage quarter wavelength transformation. The characteristic impedances of the consecutive line sections in the multistage transformer at least substantially form a geometric series in a known manner.

FIGURE 6 illustrates an embodiment for matching a 60 ohm unbalanced line to a 360 ohm balanced line, such as the type of device which is needed for high power transmitters where two wire Lecher lines cannot be used, but where four wire Lecher lines must be used because of the magnitude of the power to be transmitted. FIGURE 7 illustrates the equivalent electrical circuit of the device according to FIGURE 6.

In FIGURE 6, parts which are similar to those of preceding figures are given corresponding reference numerals. A terminal **3** is provided for the unbalanced line and has an input resistance R_u of 60 ohms on the left side and connected to this is the balancing loop, the transformer loop, which is on the right side next to the balancing loop, and the compensating members on the output side which are connected to terminals **1** and **2** on the balanced line and which provide an output resistance R_s of 360 ohms. It should be understood that these loops are folded or coiled one on the other similar to the devices of FIGURES 1 and 3.

If the mentioned ratio of input to output resistance is used, the transformer ratio which is provided, if a loop having a transforming ratio 1:4 is used, is so small that by using a fourfold compensated double quarter wavelength transformation, a very large wave range of about 1:20 may be included. Calculation indicates that with an input resistance of 60 ohms the characteristic impedance Z'_3—providing compensation—of the combined loop is still somewhat too large to provide a device which is in a practically useful form. However, by lowering the input resistance a little to 54 ohms, a usable design can be provided. Therefore, this step has been used in the embodiment of FIGURE 6 and the 60 ohms is first lowered to a usable resistance by a transformer. This is provided by using the first leg of the balancing loop which is directly connected with the input terminal **3**. This leg is used as a quarter wavelength transformer section and is designed to have a characteristic impedance Z_5 which is smaller than the input resistance R_u to be connected with the terminal.

In the embodiment of FIGURE 6, specific characteristic impedances of a practical embodiment are indicated. However, it should be realized that the present invention is by no means restricted to this particular example. The characteristic impedance Z_5 of the above-mentioned leg of the balancing loop has a value of 57.1 ohms. Due to this reduction of the characteristic impedance, even in the compensating members, it is possible to use the loop device itself as a compensating member with the characteristic impedance Z'_3, as has been discussed above. The equivalent circuit illustrated in FIGURE 7 shows the connection of the line on the low resistance side of the device which line is formed by the loop, short-circuited at the end, and has a characteristic impedance Z'_3.

When a great deal of power is involved, there are difficulties in housing the compensating quarter wavelength line sections, which are open at the end and have the characteristic impedance Z'_4 in the balancing loop because by using such a small characteristic impedance the dielectric strength is no longer sufficient. Accordingly, in FIGURE 6 the open quarter wavelength compensating line in the otherwise free leg of the balancing loop is replaced by two line portions which are connected in parallel. The inner conductor of one line is disposed in a tubular inner conductor of the other line. The characteristic impedance of the one line portion is Z'_{4a} and that of the other line portion is Z'_{4b}. From these lines, and due to the parallel connection, the resulting characteristic impedance is Z'_4.

The remainder of this embodiment is similar to the embodiment of FIGURES 3. However, on the output side a second compensating element is provided in the form of a coil **20** which has a central tap connected to ground. This arrangement has the desirable effect of removing to ground static charges on the four-wire line connected to terminals **1** and **2**. The characteristic impedance Z_6 of the compensating element formed by the coil is so large that it can be provided only in the form of a coil winding.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A device for connecting a coaxial line having a low characteristic impedance to a balanced line having a higher characteristic impedance, said device comprising, in combination:

(a) a balancing loop having a hollow outer conductor;

(b) a transformer loop producing a 1:4 transformation ratio having a hollow outer conductor;

(c) at least one compensating section connecting said loops thereby to form a loop assembly;

(d) means for connecting a coaxial line with one electrical end of said loop assembly; and

(e) means for connecting a balanced line with the other electrical end of said loop assembly and including initial portions of a balanced line and a connection assembly including terminal portions for connecting said initial portions with a balanced line proper; and

wherein said device is arranged with

(1) said balancing and transformer loops being of substantially the same size and arranged closely together in mirror image relationship with respect to a plane of symmetry parallel to the loop planes as determined by the loop axes through the sections of the loops,

(2) one leg of a loop in a plane being a portion of the balancing loop and the other leg of such loop being a portion of the transformer loop,

(3) the end of said loop assembly disposed adjacent the coaxial line connecting means having outlets formed therein for passage therethrough of said initial portions which are connected to said loop assembly, said outlets being defined by openings in said outer conductors and which are disposed in mirror image relationship with respect to said plane of symmetry,

(4) said initial portions of said outlet projecting away from each other at right angles to said plane of symmetry, said initial portions being bent parallel to said plane of symmetry at a distance which produces the desired characteristic impedance and leading to the balanced line connection assembly, and

(5) said initial portions being disposed in mirror image relationship with respect to said plane of symmetry with the axes thereof disposed within the equipotential plane of said loops.

2. A device as defined in claim 1 wherein said compensating section includes a quarter wavelength open line disposed interiorly of the otherwise free leg of the balancing loop.

3. A device as defined in claim 1 wherein said initial portions are tubular, and further comprising compensating members connecting said loop assembly with said connection assembly and including a quarter wavelength open line disposed interiorly of each tubular initial portion.

4. A device as defined in claim 1 wherein said initial portions spatially enclose said loop assembly between them, and said connection assembly is disposed on the opposite end of said device from said coaxial line connecting means.

5. A device as defined in claim 1 wherein the two legs of said transformer loop are a quarter wavelength transformer having the characteristic impedance $Z_2/2$ for transforming to a value deviating from the fourfold matching impedance on the coaxial or unbalanced side and preferably to a higher value, and wherein Z_2 at least substantially corresponds to the geometric mean between this fourfold value and the desired deviating value.

6. A device as defined in claim 1 wherein said initial portions are a quarter wavelength transformer having a characteristic impedance at least substantially corresponding to the geometric mean between the matching impedance at the point where the initial portions are connected to the loop assembly and a desired value deviating from the fourfold matching impedance on the coaxial or unbalanced side and preferably to a higher value.

7. A device as defined in claim 1 wherein the legs of the loops are a quarter wave in length and the two consecutive outer conductors of the loops have such a characteristic impedance (Z_3) that they form a compensating element in the form of a short-circuited quarter wavelength line.

8. A device as defined in claim 1 comprising a housing enclosing all of said loop assembly and said initial portions.

9. A device as defined in claim 8 wherein said housing is formed of an electrically conductive material.

10. A device as defined in claim 8 wherein said housing is formed of an insulating material.

11. A device as defined in claim 1 comprising a second compensating element connected between said terminal portions, said second compensating element being a coil having a grounded central tap.

12. A device as defined in claim 1 wherein a balancing loop leg is connected to said coaxial line connecting means and is a quarter wavelength transformation line having a characteristic impedance which is smaller than the input resistance to be connected to said coaxial line connecting means.

13. A device as defined in claim 2 wherein the open quarter wavelength compensating section is formed of two line sections connected in parallel with an inner conductor of one line section disposed in a hollow inner conductor of the other line section.

14. In a device for connecting a coaxial line having a low characteristic impedance to a balanced line having a higher characteristic impedance, and including a balancing loop having a hollow outer conductor, a transformer loop producing a 1:4 transformation ratio, at least one compensating member connecting said loops to form a loop assembly, means for connecting a coaxial line with one electrical end of said loop assembly, and means for connecting a balanced line with the other electrical end of said loop assembly and including initial portions of a balanced line and a connection assembly for connecting said initial portions with a balanced line proper, the improvement that said balancing and transformer loops are of substantially the same size and arranged closely together in mirror image relationship with respect to a plane of symmetry parallel to the loop planes as determined by the loop axes through the sections of the loops, one leg of a loop in a plane is a portion of the balancing loop and the other leg of such loop is a portion of the transformer loop, the end of said balancing loop disposed adjacent the coaxial line connecting means has outlets formed therein for passage therethrough of said initial portions, said outlets are defined by openings in the outer conductor and which are disposed in mirror image relationship with respect to said plane of symmetry, said initial portions of said outlet project away from each other at right angles to said plane of symmetry, said initial portions are bent parallel to said plane of symmetry at a distance which produces the desired characteristic impedance and lead to the balanced line connection assembly, and said initial portions are disposed in mirror image relationship with respect to said plane of symmetry with the axes thereof disposed within the equipotential plane of said loops.

15. A device as defined in claim 1 wherein said transformer loop is formed of two coaxial conductors which are of substantially the same length and the ends of whose corresponding outer conductors are connected,

on the low ohmic side of the loop, with the ground symmetry terminal points of the balancing loop, and, on the high ohmic side of the loop, with each other, the ends of the inner conductors are connected, on the low ohmic side over a cross with the ends of the outer conductors and, on the high, ohmic side, with the connections of a conductor that is symmetrical with respect to ground.

16. A device as defined in claim 1 wherein said balancing and transformer loops are arranged in contact with each other in mirror image relationship.

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