Sept. 13, 1966 GOICHI SAITO 3,273,098

HIGH FREQUENCY MATCHING TRANSFORMER

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FIG. 1.

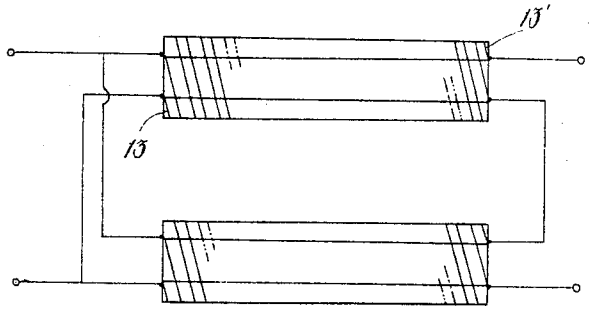


FIG. 2.

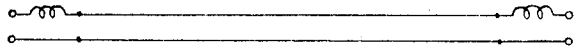
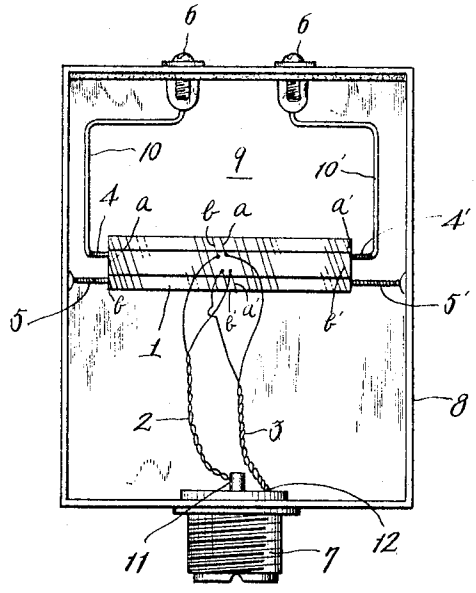


FIG. 3.



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FIG. 4.

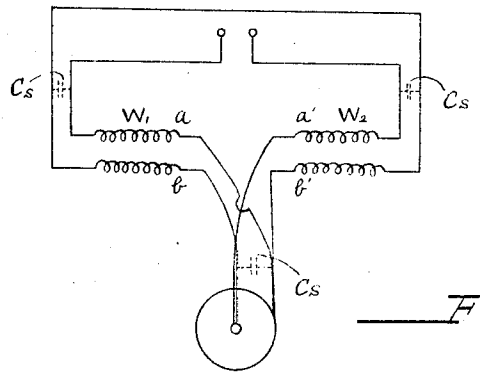


FIG. 5.

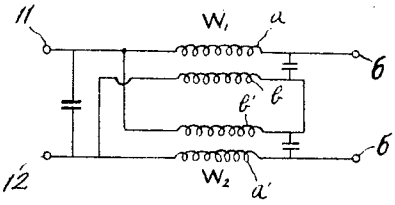


FIG. 6.

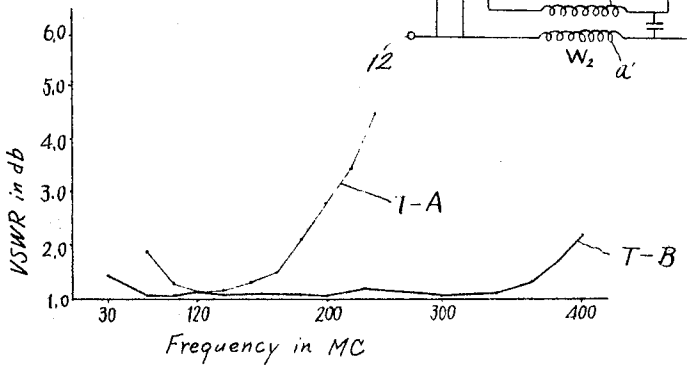
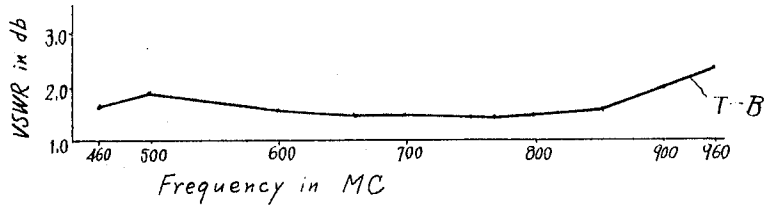


FIG. 7.



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HIGH FREQUENCY MATCHING TRANSFORMER

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2 Claims. (Cl. 336—69)

The present invention relates to improvements in high frequency matching transformer comprising of a pair of bifilar coils which are connected in parallel on one end and in a series on the other end.

The major object of the present invention is to obviate series inductances arising at outermost windings of a bifilar inductor of a high frequency matching transformer.

A further important feature of the present invention is to arrange the VSWR of a high frequency matching transformer by manually intertwining the extension wires.

With these and other objects in view which will become apparent from the following detailed description, the present invention will be clearly understood in connection with the accompanying drawings, in which:

FIGURE 1 is a plan view of a high frequency matching transformer of a well-known type which includes two separate bifilar inductors;

FIG. 2 shows an equivalent circuit of one of the bifilar inductors, as shown in FIG. 1, in which its coils are regarded as two parallel straight wires of the same size;

FIG. 3 is a plan view of a high frequency matching transformer constructed in accordance with the present invention;

FIG. 4 shows an electrical transmission circuit of the transformer illustrated in FIGURE 3;

FIG. 5 shows an equivalent circuit of the transformer illustrated in FIGS. 3 and 4;

FIG. 6 illustrates graphically the frequency characteristic of the transformer of the two types shown in FIGS. 1 and 3, with the VSWR values; and

FIG. 7 shows graphically a frequency characteristic of the transformer by the invention with ultra-high frequency.

A high frequency impedance matching transformer comprises, in general, two or more bifilar inductors. The coils are connected in parallel at one side and in a series at the other side, as shown in FIG. 1. The bifilar inductor is made of a bobbin and two parallel coils, wound around the bobbin with the same pitch.

The balance lines transmission on the bifilar coils is similar to the transmission through two parallel straight wires of the same size. Actually, however, the surge impedance in the bifilar inductor is less than that of two parallel straight wires, because each coil has the other coil on its either side.

Accordingly, a surge impedance Wb of the bifilar coils approximates the amount of:

$$Wb \cong 120 \log eP/\pi d(\Omega)$$

P—Pitch of the coil
d—Diameter of the wire

To complete this formula, it is necessary that the coils have endless length and that the diameter of the wire is large enough in comparison to the pitch. The length of a bifilar inductor, adopted as a circuit unit, is no doubt limited, therefore, it is unavoidable that a disproportion of surge impedance at both ends of the coils will arise. As indicated in FIG. 1, the outermost winding **13** has a single adjacent coil on its inner side. The opposite outermost winding **13'** is the same. Therefore, the electric conditions at both ends of the bobbin are different than that of the center of the bobbin.

The impedance at the outermost winding will be higher than at any other parts of the coils, and the surge impedance of the said bifilar inductor will be equal to that of two parallel straight wires, one of which has series inductances at its both ends as shown in FIG. 2.

In the arrangement of a bifilar coil circuit it is necessary to obviate the series inductances. For the purpose of compensating those series inductances, various changes and improvements have been made by adding some extra coils to the outside of the outermost windings at both ends of a bifilar inductor, or by inserting parallel condensers between the inner and outermost windings of a bifilar inductor.

The present invention will be further described in reference to the accompanied drawings herein:

A bifilar inductor constructed in accordance with the present invention comprises of bobbin **1**, which is made of a low-loss insulating material; a pair of bifilar coils W_1 and W_2, made of enamel insulated copper wires which are wound from the center to both ends of the bobbin **1**; four conductive leads **4**, **5**, **4'**, **5'**, secured and connected to bobbin **1**; lead **4**, connected and secured to the coil *a*, **5** to *b*, **4'** to *a'*, **5'** to *b'* respectively; and two extension wires **2** and **3** connected to bobbin **1**.

The extension twisted wire **2** is extended from coils *a'* and *b* at the center of bobbin **1** and connected to terminal **11** of connector **7**, while extension wire **3** is extended from coils *a* and *b'* and connected to terminal **12**. The edges of the conductive leads **5** and **5'** are rigidly secured to wall **8** of metal box **9**. Conductive lead **4** is connected to arm **10** which extends out along a space parallel to wall **8** and connects to terminal **6**. Lead **4'** is connected to arm **10'** and to terminal **6'**, as shown in FIG. 3.

The bifilar inductor of the present invention has, therefore, a pair of bifilar coils W_1 and W_2 on a single bobbin **1**. As indicated in FIG. 3, coils *a* and *a'* and coils *b* and *b'* are respectively on the same track except for a short intermission at the center. Therefore coil *a* (or *a'*) has coil *b* (or *b'*) on both sides even at the center of the bobbin. Coil *b* (or *b'*) will, therefore, have *a* (or *a'*) on both sides. The series inductance which is negligibly small in the structural characteristic mentioned above, will be obviated by adding a fitting amount of stray capacitance through intertwining extension wires **2** and **3**, respectively, for several times. The parallel capacitance is shown as Cs in FIGS. 3 and 4, between the extension wires 2 and 3. The series inductance arising at both ends of the bifilar inductor will also be obviated by the stray capacities Cs which exist between arms **10**, **10'** an wall **8**. The stray capacities value can be arranged by adjusting the length of arms **10** and **10'**, or by adjusting the distance between arms **10**, **10'** and wall **8**.

Therefore, even at the center of the bobbin where a pair of bifilar coils W_1 and W_2 are connected, coil *a* and coil *a'* are placed between coil *b* and *b'*, and coil *b* and coil *b'* are placed between coil *a* and coil *a'* on the circumferential surface of the bobbin.

The intertwined extension wires **2** and **3**, if necessary, can be twisted together several times to adjust the VSWR by the capacitance of connector **7**.

As shown in FIGS. 6 and 7, a high frequency matching transformer constructed in accordance with the present invention, shown as T–B, will have characteristics suited for broad frequency, while a transformer of a well-known type, shown as T–A, previously mentioned in reference to FIG. 1, has a characteristic suited for limited narrow frequency.

While I have disclosed one embodiment of the present invention, it is to be understood that this embodiment is given by example only and not in a limiting sense, the scope of the present invention being determined by the objects and the claims.

What I claim:

1. A high frequency matching transformer comprising

a bobbin,

a pair of bifilar coils on said bobbin,

one of said bifilar coils extending from the center to a first end of said bobbin,

the other of said bifilar coils extending from the center to a second end of said bobbin,

a metal box having a pair of terminals at one end of said box,

a two-terminal connector at the other end of said box,

first and second conductive leads connecting one coil of each bifilar pair of said metal box,

third and fourth conductive leads connecting the other coil of each bifilar pair to conductive arms, extending parallel to the walls of said box and connecting said terminals on said box, and

two extension wires extending from each coil of said bifilar pair at the center of said bobbin to different terminals of said two-terminal connector.

2. The high frequency matching transformer, as set forth in claim 1, wherein

said two extension wires are, respectively, twisted several times.

References Cited by the Examiner

UNITED STATES PATENTS

3,195,076 7/1965 Morrison ---------- 336—181 X

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