April 24, 1962 W. S. KRAKAU ETAL 3,031,632

TUNED H.-F. TRANSFORMER WITH IMPROVED BALANCED OUTPUT

Filed June 25, 1959

FIG. 1

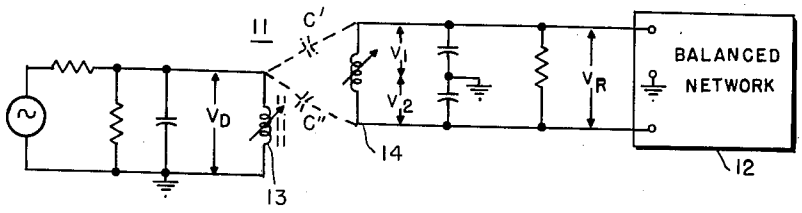
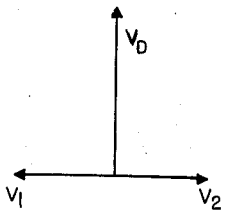
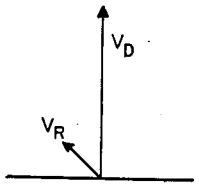


FIG. 2A



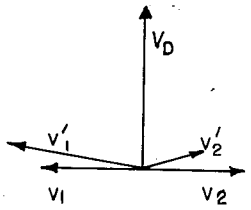
INDUCTIVE COUPLED VOLTAGE

FIG. 2B



CAPACITIVE COUPLED VOLTAGE

FIG. 2C



OUTPUT VOLTAGES

FIG. 3

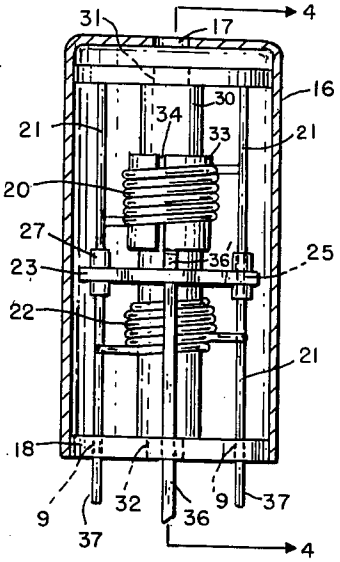


FIG. 4

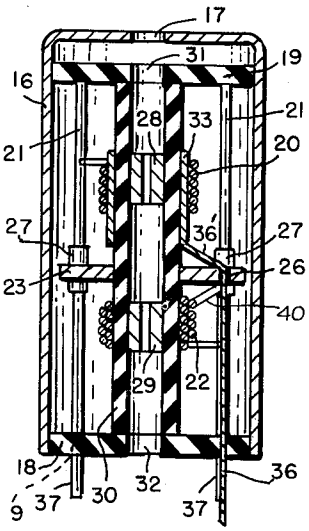
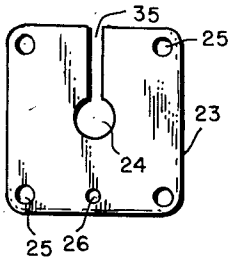


FIG. 5



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TUNED H.-F. TRANSFORMER WITH IMPROVED BALANCED OUTPUT

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The present invention relates to a tuned high-frequency transformer with balanced output, and more particularly to a transformer of this type utilizing a novel arrangement of electrostatic shields to reduce undesired capacitive coupling.

In utilizing such a high-frequency transformer, it is frequently desired that the coupling between the input and output windings be essentially inductive. To accomplish this, it becomes necessary to minimize the capacitive coupling between these windings. The reduction of capacitive coupling is of particular importance in the design of a transformer to operate as an input to a symmetrical or balanced circuit such as a balanced mixer, discriminator, or push-pull amplifier.

Accordingly, it is an object of the present invention to provide a tuned high-frequency transformer having a minimum of capacitive coupling between the input and output windings.

It is a further object of the present invention to provide a high-frequency transformer capable of a high degree of balance in the induced voltages of the separate portions of the secondary winding.

It is still another object of the present invention to provide a compact high-frequency transformer that is easy to manufacture and small in size.

The transformer of this invention accomplishes this and other objects by a novel arrangement of electrostatic shields. More specifically, a first electrostatic shield is placed so that it is surrounded by the primary winding, and a second electrostatic shield, shaped to fit the transformer can, is placed between the primary and secondary windings, perpendicular to the transformer axis. The secondary winding comprises two halves wound symmetrically to the second electrostatic shield.

The exact nature of this invention as well as its advantages will be readily apparent from consideration of the following specification taken in connection with the annexed drawings in which:

FIGURE 1 is a schematic circuit showing of inductive and capacitive coupling in a double-tuned high-frequency transformer connected to a balanced network;

FIGURES 2A, 2B and 2C are vector diagrams of voltages developed in the circuit of FIGURE 1;

FIGURE 3 is an elevational view, partially in section, of the present invention;

FIGURE 4 is a section of the invention taken on line 4—4 of FIGURE 3 looking in the direction of the arrows; and

FIGURE 5 is a detail showing of the center electrostatic shielding plate forming a part of the structure of FIGURES 3 and 4.

Referring now to FIGURE 1, there is shown a circuit in which a transformer **11** serves as an input to a balanced network **12**. In actual practice it is desirable that the coupling between input winding **13** and output winding **14** of transformer **11** be essentially inductive so that the voltages V_1 and V_2 will be equal in magnitude and opposite in phase. This is generally not achieved because of the capacitive coupling, C′ and C″, between the two windings.

The vector diagrams of FIGURES 2A, 2B, and 2C are helpful in illustrating the unbalance in the circuit of FIGURE 1 caused by the coupling capacitance. FIGURE

2A shows the vector relationship between the output voltages V_1 and V_2 and the input voltage V_D when purely inductive coupling exists between the input (primary) and output (secondary) windings. This relationship, in which the output voltage is in phase quadrature with the input voltage, follows a well known principle and is due to the fact that the field producing inductive current is in phase quadrature with the current producing input voltage. FIGURE 2B shows the relationship between output voltage V_R and the input voltage V_D when capacitive coupling exists in addition to the inductive coupling. The superposition of the vector diagrams shown in FIGURES 2A and 2B results in the vector diagram of FIGURE 2C in which V_1' and V_2' are the resultant vector output voltages. This latter figure illustrates how the capacitive coupling causes unbalance in an inductively coupled transformer. It should be understood that this presentation is simplified since in an actual transformer the coupling capacities are distributed, making an exact calculation almost impossible.

The foregoing discussion shows how important it is that the capacitive coupling, as far as possible, be eliminated when a transformer is to be used as an input to a balanced circuit.

The transformer structure in accordance with this invention serves as a tuned high-frequency input to a balanced mixer having a center frequency of 10 mc. and a bandwidth of 1 mc. Its preferred embodiment, as shown in FIGURES 3 and 4, comprises a transformer shield can **16** having an opening **17** in its upper end. Its bottom end is closed by a bottom insulating board **18**. A top insulating board **19** lies in the upper portion of shield can **16** substantially parallel to bottom insulating board **18**.

The shield can **16** contains a transformer comprising primary winding **20** and secondary winding **22** wound upon a hollow cylindrical coil form **30** having top and bottom ends affixed to top insulating board **19** and bottom insulating board **18**, respectively. Powdered iron cores **28** and **29** are located within the hollow portion of coil form **30** and are surrounded by primary winding **20** and secondary winding **22**, respectively. Apertures **31** and **32** are provided in the top and bottom insulating boards, respectively, to permit access to these cores.

The ends of the primary and secondary windings of the transformer are connected to respective conductive supporting rods **21**. As shown, there are four of these rods, each having one end **37** passing through an opening **9** in the bottom insulating board **18**, to form terminals for mounting the transformer structure upon a chassis or other support and as electrical connections to external circuit components. The other end of each supporting rod **21** is anchored in top insulating board **19**.

To prevent electrostatic coupling between primary winding **20** and secondary winding **22**, without interfering with the magnetic coupling, electrostatic shielding members are provided. More specifically, a center electrostatic shielding plate **23** is interposed between the primary winding and secondary windings perpendicularly to the longitudinal axes of those windings to eliminate the electrostatic coupling between them; and an electrostatic shield collar **33** is placed underneath the primary winding, between it and coil form **30**, to avoid the electrostatic coupling through the cores inside of the coil form.

As shown in FIGURE 5, shielding plate **23** has a large opening **24** through which coil form **30** passes, four small holes **25** through which rods **21** pass, a slot **35** for preventing the shielding plate from acting as a shorted turn, and a ground terminal **26** serving as a common ground for the transformer structure. Insulating sleeves **27** fit in holes **25** to prevent electrical contact between shielding plate **23** and rods **21**.

Electrostatic shield collar 33 has a longitudinal slot 34 for preventing it from acting as a shorted turn, and a tab 36' for connecting it to common ground terminal 26.

An external ground lead 36 passes through bottom insulating board 18 and is connected to common ground terminal 26. The center-tap 40 of secondary winding 22 is also connected to this common ground terminal.

To further improve the balance characteristics of the transformer, the secondary winding is formed of two halves wound symmetrically to the center shielding plate 23, one of said two halves being wound upon the other, so that the two halves are equally spaced from the center shield, thus equalizing the stray distributed capacities to ground of each half.

In summary, the presently disclosed high-frequency transformer, by achieving a high degree of balance in the induced voltages in the two halves of its secondary winding, provides a definite advancement in the transformer art. This advancement is primarily attained by the novel arrangement of electrostatic shielding members and by the symmetrical placement of the halves of the secondary winding with respect to the center electrostatic shielding plate. More specifically, the placement of the halves of the secondary winding permits the stray distributed capacities to ground of each half to be equalized, and the arrangement of the shielding members prevents electrostatic coupling between the primary and secondary winding, both through space and through the cores within the coil form.

The foregoing disclosure relates to a preferred embodiment of the invention. Numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention set forth in the appended claims.

What is claimed is:

1. In a tuned high-frequency transformer with balanced output: an outer shielding housing, a coil form supported within said housing, a primary winding wound upon a portion of said coil form, a secondary winding formed of two substantially identical halves wound upon a second portion of said coil form, one of said two halves being wound upon the other, said secondary winding being axially aligned with said primary winding so that the two halves of said secondary winding are substantially symmetrical with respect to said primary winding, an electrostatic shielding plate interposed between said primary and secondary windings, said two halves of said secondary winding being wound symmetrically to said shielding plate and being equally spaced therefrom, and a shielding collar positioned underneath said primary winding between it and said coil form, a common ground terminal, said shielding collar and said shielding plate connected to said ground terminal.

2. The high frequency transformer of claim 1 further comprising first and second powdered-iron cores positioned within said coil form and surrounded by said primary and secondary windings, respectively.

3. The high frequency transformer of claim 2 further comprising a plurality of conductive rods, each of said rods having an end passing through the bottom portion of said housing, the other end of each rod being supported in said housing, said rods being connected individually to terminals of said primary and secondary windings.

4. In a tuned high-frequency transformer with balanced output: a transformer shield can; a bottom insulating board closing off the bottom portion of said can; a top insulating board positioned within the upper portion of said can substantially parallel to said bottom board; a hollow cylindrical coil form having top and bottom ends affixed to said top and bottom boards, respectively; a primary winding wound upon the upper portion of said coil form; a secondary winding formed of two halves wound upon the lower portion of said coil form, one of said two halves being wound upon the other in a bifilar manner; first and second powdered iron cores positioned within the hollow portion of said coil form and surrounded by said primary and secondary windings, respectively; supporting conductive rods, each of said rods having an end passing through said bottom board, the other end of each rod being anchored in said top board, said primary and secondary windings having ends connected to respective rods; an electrostatic shielding plate interposed between said primary and secondary windings and having a common ground terminal, said two halves of said secondary winding being wound symmetrically to said shielding plate and being equally spaced therefrom; and a shielding collar coaxial with said primary winding and positioned between it and said coil form, said shielding collar having a tab for connection to said common ground terminal, said secondary winding having a center-tap connected to said common ground terminal.

5. A tuned high-frequency transformer with balanced output comprising a transformer shield can having an opening in its upper end; a bottom insulating board closing off the bottom portion of said can and having openings therein; a top insulating board having similar openings and positioned within the upper portion of said can substantially parallel to said bottom board; a hollow cylindrical coil form having top and bottom ends affixed to said top and bottom boards, respectively; a primary winding wound upon the upper portion of said coil form; a secondary winding wound upon the lower portion of said coil form; first and second powdered iron cores positioned within the hollow portion of said coil form and surrounded by said primary and secondary windings, respectively; said top and bottom boards having apertures to permit access to said cores; four supporting conductive rods, each of said rods having an end passing through one of said openings in said bottom board, the other end of each rod being anchored in said top board, said primary and secondary windings having ends connected to respective rods; a center electrostatic shielding plate interposed between said primary and secondary windings perpendicularly to the longitudinal axes of these windings, said shielding plate having a large opening through which said coil form passes, four small holes through which said rods pass, a radial slot for preventing said plate from acting as a shorted turn, and a ground terminal serving as a common ground; insulating sleeves fitting in said holes in said plate to prevent electrical contact between said shielding plate and said rods; an electrostatic shielding collar positioned underneath said primary winding between it and said coil form, said shielding collar having a longitudinal slot for preventing it from acting as a shorted turn and a tab for connecting it to said common ground terminal; an external ground lead passing through said bottom board and connected to said common ground terminal, said secondary winding having a center-tap connected to said common ground terminal, said secondary winding being formed of two halves wound symmetrically to said shielding plate, one of said two halves being wound upon the other, said two halves being equally spaced from said shielding plate.

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