Nov. 27, 1962 A. J. FISHER 3,066,266

RADIO FREQUENCY TRANSFORMER

Filed March 17, 1959

FIG. 1

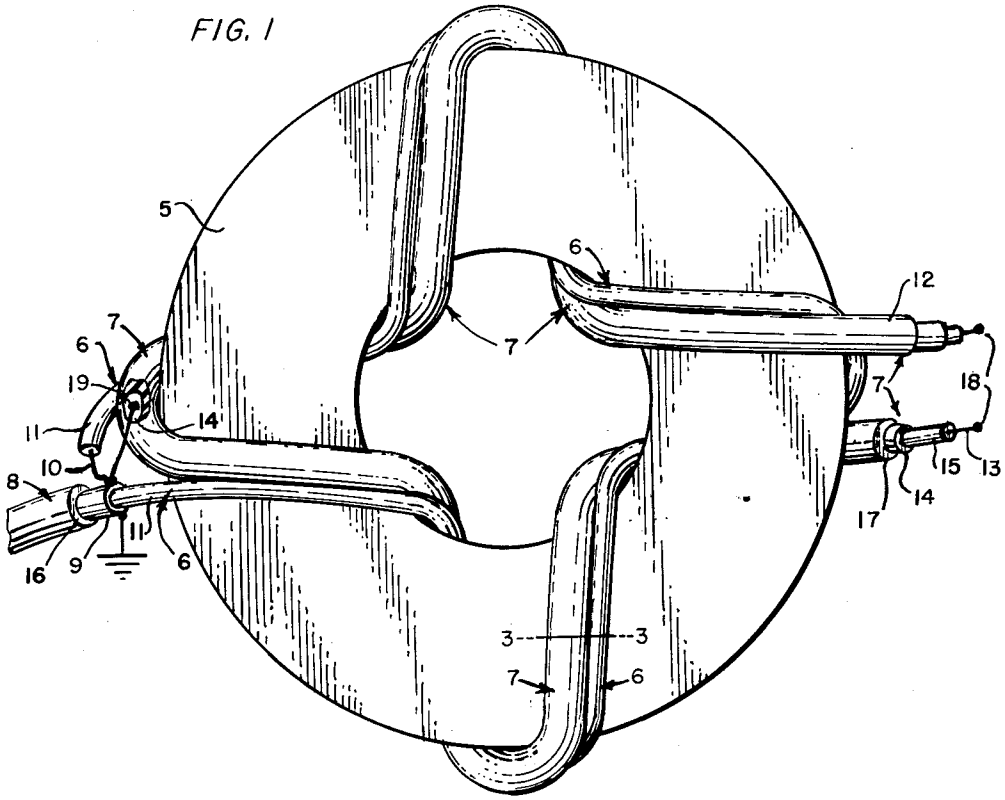



FIG. 2

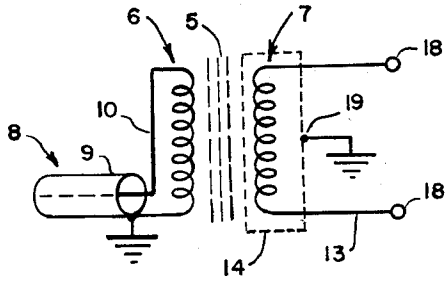
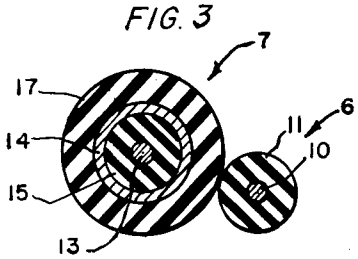



FIG. 3

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# RADIO FREQUENCY TRANSFORMER

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment of any royalty thereon.

This invention relates to radio frequency transformers and particularly to such devices which are capable of providing efficient coupling over a wide band of frequencies.

The invention is exceptionally versatile in those situations wherein two sections of a system must be coupled and the output terminals of one section are electrically unbalanced while the input terminal pair of the other section have identical impedance relations to ground. Such an arrangement is commonly referred to as an unbalance to balance coupling.

As will appear hereinafter the structure of the transformer imparts the qualities of accuracy and uniformity to its operating characteristics. The distributed capacity of the device is held to absolute uniformity throughout the windings.

In radio communication the problem of coupling from unbalanced to balanced circuits is one which is frequently encountered and difficult to efficiently solve. A typical problem of this nature is coupling an antenna to the input of a radio receiver. The invention is ideally adapted to provide such coupling in a highly efficient manner and in addition the transfer of energy is effected over a wide range of frequencies.

The input terminals of the transformer may comprise the outer and the inner conductors of a coaxial line which extends from a point closely adjacent to the transformer to an antenna or other input device. In constructing the device the outer concentric conductor of the cable is removed from a portion of the cable adjacent the transformer thus exposing the inner conductor which is wound upon a suitable core. The free end of this winding is connected to the grounded outer conductor of the input line to form the primary coil.

The secondary coil is wound upon the same core and consists of the inner member of a concentric pair of conductors with insulation therebetween. The primary and secondary coils are wound in closely spaced parallel relation as in bifilar winding. The outer conductor of the secondary winding is left open circuited and connected to ground thus serving as an electrostatic shield between the coils.

The ends of the inner conductor of the secondary winding are connected to a balanced load such as the input circuit of a radio receiver or other device.

It is a primary object of the invention to provide a radio frequency transformer wherein an efficient transfer of energy takes place between an unbalanced terminal pair and a terminal pair wherein the terminals have the same impedance relation to ground.

A further object of the invention is to provide a radio frequency transformer having accurately balanced characteristics.

A still further object of the invention is to provide a radio frequency transformer having the above stated qualities and which functions efficiently over a wide band of frequencies.

A further object of the invention is to provide a radio frequency transformer construction which can readily be physically and electrically adapted for use in a diversified field of applications and in a wide range of band widths.

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A still further object of the invention is to provide a radio frequency transformer having effective isolation against the transfer of undesired energy components between the circuits coupled.

Other objects and features of the invention will appear more fully from the following description and will be particularly pointed out in the claims.

To provide a better understanding of the invention a specific example of a device embodying the principles thereof will now be described and illustrated in the accompanying drawings wherein FIG. 1 is a general view of a transformer constructed in accordance with the invention.

FIG. 2 is a diagrammatic showing of the electrical circuit of the device shown in FIG. 1.

FIG. 3 is a cross section on line 3—3, FIG. 1.

A feature of the invention resides in its small size and compact arrangement of components. Although it is or may be classed as a miniaturized device it may also be designed in larger proportions to meet specific requirements.

The transformer coils are wound upon a suitable core which has high magnetic permeability and low dissipation loss such as the material known as Ferramic Q2 or similar material. Suitable material for this purpose is classed as ferrite which consist of inorganic salts of the formula $MFe_2O_4$ where M represents a bivalent metal.

Desirably but not necessarily the core **5** is ringlike or annular in conformation. Upon the core are wound the primary coil **6** and the secondary coil **7**. The number of turns may be determined in accordance with the requirements and frequency of the system in which the transformer is used. The turns are applied by threading through the aperture in the core.

The primary coil is formed from a cable structure such as a conventional coaxial cable **8**. A portion of the outer conductor **9** of this cable is removed to provide a length of inner conductor sufficient to wind the primary coil **6**. The free end of the primary winding is connected to the outer conductor **9** of the cable. Any point along the outer conductor **9** may be made the ground terminal for example at either end or at both ends. Desirably the inner member of the cable **8** consists of an inner conductor **10** having a concentric insulating cover **11**. The ends of the primary coil are thus connected to the two conductors of the cable **8** which in turn constitutes the channel for input energy such as that being received from an antenna. The ends of the primary coil become the unbalanced terminals of the transformer.

The secondary winding is wound upon the core **5** and its turns are positioned closely adjacent to or in engagement with and parallel to the primary turns. The secondary winding consists of a cable structure **12** having inner and outer concentric insulated conductors **13** and **14** such as are provided in a coaxial cable. A conventional coaxial cable may be used for this purpose. Both cable **8** and cable **12** are provided respectively with outer insulating protective layers **16** and **17** and the cable **12** has a concentric layer of insulation **15** between its outer and inner conductors.

The outer insulation **17** and outer conductor **14** are removed from the cable **12** for a short distance from the ends thereof to expose the inner ends of the inner conductor **13** which become the balanced terminals **18** of the secondary of the transformer and are connected to the load device such as a radio receiver not shown.

The ends of the outer conductor **14** are not interconnected which in effect causes it to function as a shield between the primary and secondary coils. This shield is connected to ground in any desired manner. As shown

the ground connection **19** is made at its mid point where the outer insulating layer **19** is cut away to expose the conductor **14**. By thus grounding the shield its function is accurately balanced with respect to the terminals **18**. Moreover the coaxial structure of the secondary winding insures uniformity of spacing between its components thruout its length and thus insures highly uniform distributed capacity which in turn provides uniform operating characteristics for the transformer. Also uniform accuracy and reproducibility in manufacture are readily achieved. Heretofore such accuracy has been extremely difficult to realize in closely coupled unbalance to balance radio frequency transformers.

It should also be noted that the effective and accurate shielding device **14** provides a barrier against the undesired transfer of energy between the coupled circuits thus adding valuable isolation capability to its other characteristics.

In winding the coils upon the core **5** each turn is passed thru the aperture of the core and encircles the body thereof to form a toroidal winding.

The core may have any suitable conformation such as an elongated rod or bar in which case the coils are wound thereon in helical form and in close parallel relationship turn for turn as shown in FIG. 1. The toroidal or helical turns desirably but not necessarily have a relatively steep pitch.

The input channel to the transformer is described and shown as of coaxial construction and has been found to be highly satisfactory especially where the input energy would naturally require such a channel. In such a construction any ground seeking radio frequency current flowing from the secondary winding inner conductor **13** thru the symmetrical capacity to the shield and thence along the outside surface of the outer conductor of the input channel has no coupling to current in the unbalanced or input channel.

A conventional two wire input may be used however in which case as in the prior case described the terminals would be connected to an unbalanced circuit. The transformer otherwise would have the same structure and would function in the same manner as described above with the exception that the load or generator to which the secondary of the transformer is connected should have ground potential mid-way between the balanced terminal pair **18**.

There are many applications wherein the invention provides high standards of operation such as in push-pull amplifiers, to drive balanced mixer circuits, to couple to bridge circuits and in all radio frequency applications where a well shielded isolation transformer is required.

What is claimed is:

1. A radio frequency transformer comprising a core of material having high magnetic permeability and low dissipation at its operating frequency band, single primary and secondary radio frequency windings wound as a pair in openly spaced helical turns upon the core in closely adjacent parallel relation thruout their length, said primary winding consisting of a metallic conductor insulated from said core and presenting input terminals one end of said primary being grounded, said secondary winding consisting of an inner metallic conductor and an outer concentric metallic conductor insulated from said inner conductor and said core and having its ends open circuited, said inner conductor constituting the secondary coil the ends of said inner conductor presenting balanced output terminals and a ground connection for said outer concentric conductor.



2. A radio frequency transformer according to claim 1 and wherein the ground for said outer conductor of said secondary winding is connected at its mid point.

3. A radio frequency transformer comprising a toroidal core of material having high magnetic permeability and low dissipation at its operating frequency band said core being of annular conformation, single primary and secondary radio frequency windings wound as a pair in toroidal form upon said core in closely adjacent parallel relation thruout their length the turns thereof passing thru the aperture of the core and around the core body, said primary winding consisting of a metallic conductor insulated from said core and said secondary winding one end of said primary being grounded, said secondary winding consisting of an inner metallic conductor and an outer concentric metallic conductor insulated from the inner conductor and said core and having its ends open circuited, said inner conductor constituting the secondary coil the ends of said inner conductor presenting output terminals and a ground connection for said outer concentric conductor.

4. A radio frequency transformer according to claim 3 and wherein the ground for said outer concentric conductor of said secondary winding is connected at its mid point.

5. A radio frequency transformer comprising a core of material having high magnetic permeability and low dissipation at its operating frequency band, single primary and secondary radio frequency windings wound upon said core as a pair in closely adjacent parallel relation thruout their length said primary winding consisting of a metallic conductor insulated from said core and said secondary, a coaxial cable connected to the ends of said primary winding constituting the input terminals to the transformer the outer member of said coaxial cable being connected to ground, said secondary winding consisting of an inner metallic conductor and an outer concentric metallic conductor insulated from the inner conductor and said core and having its ends open circuited, said inner conductor constituting the secondary coil the ends of said inner conductor presenting output terminals and a ground connection for said outer concentric conductor.

6. A radio frequency transformer according to claim 5 and a connection from the outer conductor of said secondary winding to the outer conductor of said input cable.


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