

July 1, 1969

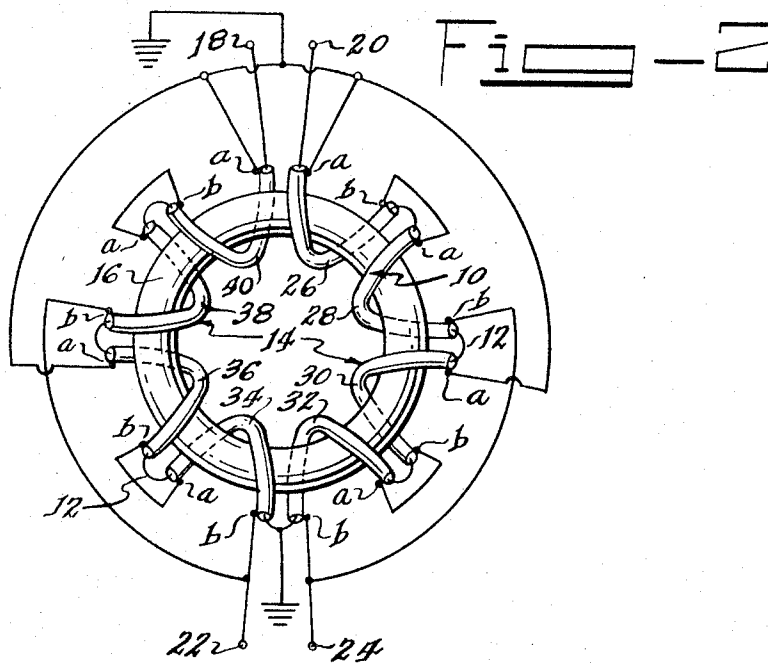
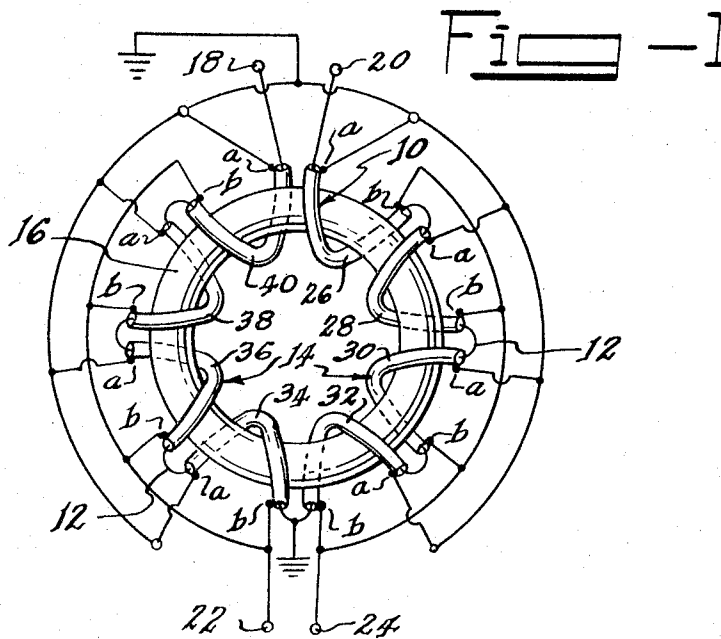
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3,453,574

HIGH-FREQUENCY, WIDE-BAND TRANSFORMER

Filed March 22, 1968

Sheet 1 of 2



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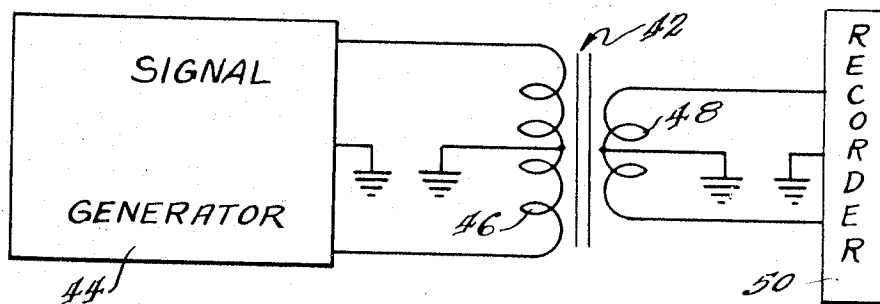


Fig - 3

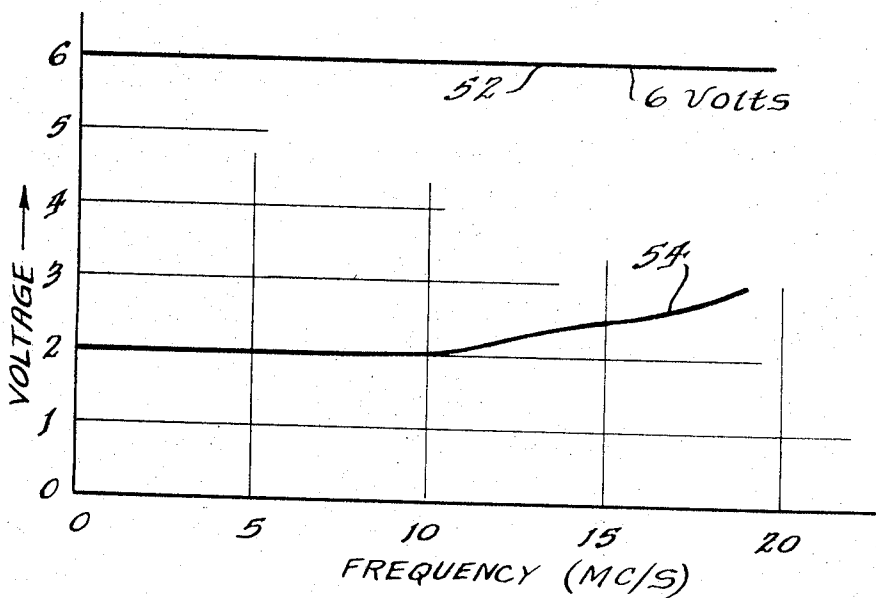


Fig - 4

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3,453,574

## HIGH-FREQUENCY, WIDE-BAND TRANSFORMER

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Filed Mar. 22, 1968, Ser. No. 715,352

Int. Cl. H01f 27/28

U.S. Cl. 336—182

1 Claim

### ABSTRACT OF THE DISCLOSURE

A high-frequency, wide-band transformer includes a toroidal core and a coaxial cable spirally wound around the periphery of this toroidal core. The outer conductor of the coaxial cable is sectionally discontinuous, with each section having a like plurality of turns and a leading and lagging end. The leading ends of the outer conductor sections are electrically interconnected and the lagging ends of the outer conductor sections are electrically interconnected. The inner and outer conductors each form a set of physically separated windings of the transformer.

#### Contractual origin of the invention

The invention described herein was made in the course of, or under, a contract with the United States Atomic Energy Commission.

#### Background of the invention

This invention relates to transformers and more particularly to high-frequency, wide-band transformers having a high turns ratio.

High-frequency, wide-band transformers enjoy a wide usage in the electrical art. For example, application therefor is found in the radiofrequency section of particle accelerators. It is difficult, using the present state of the art, to obtain a high-frequency, wide-band transformer having a high turns ratio, a high coupling coefficient and a flat broad-band response. When the turns ratio is above 2 to 1, it is difficult to obtain efficient coupling in the standard high-frequency transformer. Further, flat broad-band frequency response is not readily available in transformers having high turns ratios.

Accordingly, it is one object of the present invention to provide an improved high-frequency, wide-band transformer.

It is another object of the present invention to provide a high-frequency, wide-band transformer having a high turns ratio.

It is another object of the present invention to provide a high-frequency, wide-band transformer having a high coupling coefficient between the windings thereof.

It is another object of the present invention to provide a high-frequency, wide-band transformer having minimal stray inductance loss.

It is another object of the present invention to provide a high-frequency, wide-band transformer having a flat response and a turns ratio in excess of 2 to 1.

Other objects of the present invention will become more apparent as the detailed description proceeds.

#### Summary of the invention

In general, the transformer of the present invention comprises core means and a cable wound about said core means including an inner conductor and an outer conductor surrounding the inner conductor. The outer conductor of the cable is sectionally discontinuous. Means are provided for electrically interconnecting each of the

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outer conductor sections. The inner and outer conductors each form a winding of the transformer.

#### Brief description of the drawings

Further understanding of the present invention may best be obtained from consideration of the accompanying drawings wherein:

FIG. 1 is a diagram of a transformer constructed according to the present invention.

FIG. 2 is a drawing of the transformer of FIG. 1 having a different turns ratio connection.

FIG. 3 is a schematic of a transformer constructed according to the present invention together with the testing circuit therefor.

FIG. 4 is a graphical representation of the characteristics obtained with the transformer of FIG. 3.

#### Description of the preferred embodiment

In FIG. 1, a coaxial cable 10 comprising an inner conductor 12 and an outer conductor 14 is helically wound about a ferrite toroidal core 16. The inner conductor 12 comprises the primary winding of the transformer having input terminals 18 and 20. The outer conductor 14 comprises the secondary winding of the transformer with output terminals 22 and 24. The transformer of FIG. 1 is shown in a center-tap push-pull configuration having a 4 to 1 step down turns ratio. To obtain this structure, the outer conductor 14 is made sectionally discontinuous and the leading and lagging ends (a and b) of the sections 26 through 40 in each half of the transformer are connected as shown so that the secondary winding is electrically equivalent to a single turn of a conductor about a magnetic core wound with four primary turns. It is to be noted that, though the aforesaid example illustrates a center-tap push-pull transformer configuration, the present invention is not to be limited thereto, nor is the structure limited to a toroidal core configuration. Other core shapes (such as rectangular and H-shaped cores) and other winding configurations may be substituted therefor. Further, it will be appreciated that turns ratios other than that illustrated are obtainable according to the present invention by different interconnection of the sections of the outer conductor 14. For example, a turns ratio of 2 to 1 may be obtained with the transformer of FIG. 1 by interconnecting the leading and lagging ends (26b to 28a, 30b to 32a, 34a to 36b, 38a to 40b) of the sections of outer conductor 14, as shown in FIG. 2.

Turning to FIG. 3, a schematic equivalent is shown for the transformer of FIG. 1. The transformer 42 was constructed according to the structure of the transformer of FIG. 1 in a push-pull center-tap configuration and a 3 to 1 turns ratio (6 turn primary, 2 turn equivalent secondary). A signal generator 44 provided a constant-amplitude signal at a frequency variable between 100 kilohertz and 50 megahertz. This signal was applied across the primary winding 46 of transformer 42. The output voltage from the secondary winding 48 of transformer 42 was measured and recorded by recorder 50. The results obtained with the transformer 42 of FIG. 3 are shown in the graphical plot of FIG. 4. The curve 52 represents the input voltage applied to the primary winding 46 and the curve 54 represents the output voltage from the secondary winding 48. The voltage applied to the primary winding 46, as stated, was maintained at a constant amplitude (6 volts) throughout the frequency spectrum tested. It is to be noted that the transformer 42 exhibited a completely flat response to 10 megacycles and only a 30% deviation therefrom between 10 megacycles and 19 megacycles. The specific performance data of the transformer 42 indicated that the coupling coefficient between the primary and secondary windings 46

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and 48 approached 1 and that stray inductance loss was lowered by the configuration of the transformer. It is to be noted that the amount of coupling and/or stray inductance loss may be varied as a function of the diameters of the two conductors forming the cable 10. Similar results were obtained with the windings 46 and 48 of transformer 42 having turns ratios of 6 to 1 and 10 to 1.

Though the foregoing examples have indicated that the cable 10 from which the transformer is constructed is of a coaxial construction, it is to be understood that for the practice of the present invention it is only necessary that an inner conductor be used which is completely surrounded by an outer conductor. Thus, rectangular conductors may be used provided one is inserted within the other.

Persons skilled in the art will, of course, readily adapt the general teachings of the invention to embodiments far different from the embodiments illustrated. Accordingly, the scope of the protection afforded the invention should not be limited to the particular embodiment illustrated in the drawings and described above, but should be determined only in accordance with the appended claim.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A transformer comprising a toroidal core, first and second like coaxial cables each spirally wound in the same directional sense around the periphery of an associated portion of said toroidal core, the outer conductors of said coaxial cables being sectionally discontinuous, the inner and outer conductors of said coaxial cables each forming windings of said transformer, means for elec-

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trically grounding one pair of adjacent ends of the inner conductors of said coaxial cables, the other pair of adjacent ends of the inner conductors of said coaxial cables being terminals to the transformer windings formed thereby, means for electrically grounding one pair of adjacent ends of the outer conductors of said coaxial cables, and alternate related ends therefrom of said discontinuous sections of said outer conductors, the other pair of adjacent ends of the outer conductors of said coaxial cables being terminals to the transformer windings formed thereby, and means for connecting to an associated one of said other pair of adjacent ends of said outer conductors alternate related ends therefrom of said discontinuous sections of said outer conductor.

#### References Cited

##### UNITED STATES PATENTS

|           |         |          |            |
|-----------|---------|----------|------------|
| 1,827,191 | 10/1931 | Casper   | 336—195 XR |
| 2,348,325 | 5/1944  | Brown    | 336—195 XR |
| 3,005,965 | 10/1961 | Wertanen | 336—195 XR |
| 3,066,266 | 11/1962 | Fisher   | 336—229 XR |
| 3,195,076 | 7/1965  | Morrison | 336—181 XR |
| 3,260,977 | 7/1966  | Coltman  | 336—181    |

##### FOREIGN PATENTS

867,044 4/1961 Great Britain.

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U.S. Cl. X.R.

336—195, 229