United States Patent

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[73] Assignee **The United States of America as represented by the United States Atomic Energy Commission**

[54] **COAXIAL CABLE HIGH-VOLTAGE PULSE ISOLATION TRANSFORMER**
6 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **336/174,** 333/26, 336/175, 336/195
[51] **Int. Cl.** **H01f 17/06**
[50] **Field of Search** 336/173, 174, 175, 195, 221; 333/11, 24, 25, 26, 78

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ABSTRACT: A one-to-one high-voltage nanosecond pulse isolation transformer formed from a single length of solid dielectric coaxial cable bent into a U-shape with the outer sheath separated at the midpoint of the "U" and with the outer ends of the sheath electrically interconnected. Input connections are made to the separated sheaths at the midpoint of the "U" and output connections are made across the ends of the center conductor at the ends of the "U." Ferrite cores are stacked over the sheath on each leg of the "U" to prevent input pulses from flowing in the sheaths and being shorted by the connection between the sheaths.

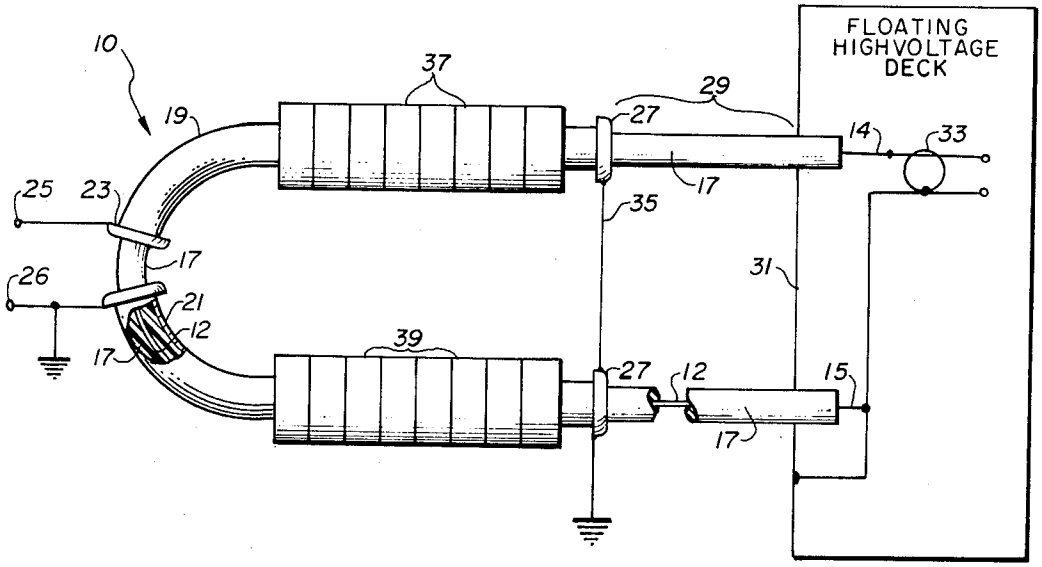


Fig. 1.

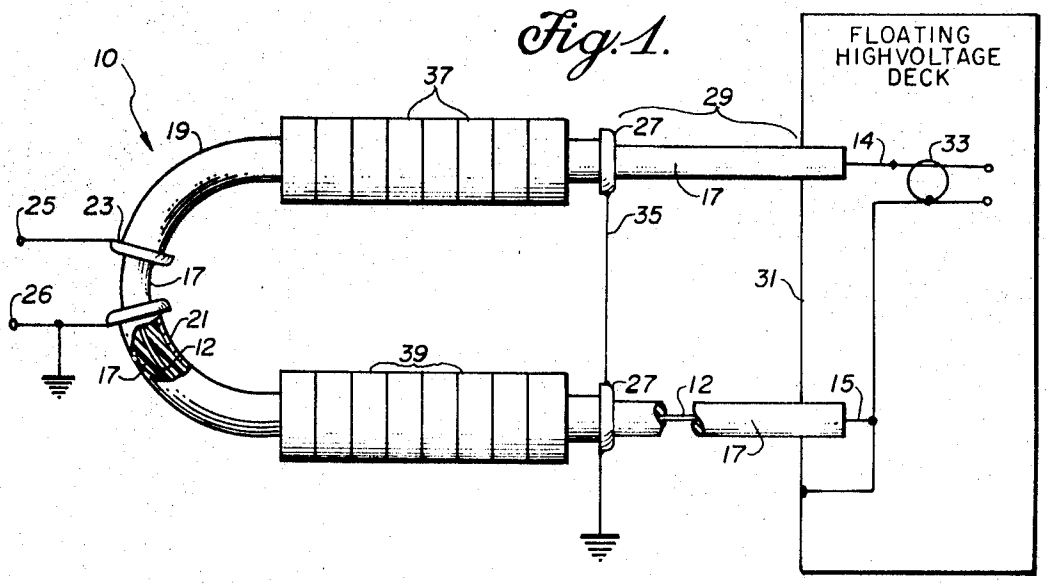
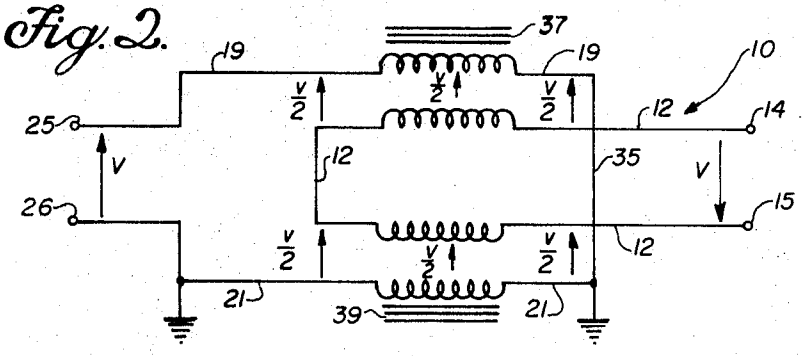


Fig. 2.



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COAXIAL CABLE HIGH-VOLTAGE PULSE ISOLATION TRANSFORMER

BACKGROUND OF THE INVENTION

The present invention relates to a high-voltage pulse isolation transformer, more particularly it relates to a transmission line type of transformer constructed from a single integral length of transmission line.

In transmission line transformers for high-voltage pulses one persistent problem is the elimination of impedance discontinuities such as arise in making electrical connections between conductors or in providing insulation or spacing for the conductors. Such discontinuities cause pulse degradation, spurious pulse reflections, and difficulty in matching load and source impedances to the transformer. Known techniques to minimize these discontinuities are complex and expensive and involve intricate mechanical connections and special potting techniques.

SUMMARY OF THE INVENTION

In brief, the invention pertains to a transmission line pulse transformer that is made from an integral unit of standard transmission line so as to take advantage of the inherently high degree of freedom from impedance discontinuities that a length of such line normally possesses. In particular, a pulse transformer may be constructed according to the invention from a single length of coaxial cable of the type having a center conductor, an outer sheath and a solid dielectric between the center conductor and sheath. The sheath is electrically separated into two lengths at the midpoint of the cable but the solid dielectric and center conductor are left intact along the entire length. The separated ends of the sheath constitute a pair of input terminals and a balanced center point for application of an input pulse. Inductive means such as ferrite cores are provided around each of the sheaths for preventing high-frequency currents from flowing through the sheaths. This permits one-half of the input signal to be launched between each center conductor and sheath at the input terminals. Since the signal flow is completely within the coaxial cable, the ferrite cores do not impede the signal; however, the cores do prevent signals from propagating through the sheaths to a short circuit at the connection between the ends of the sheath. The particular construction of the transformer results in a transmission line transformer in which the mechanical connections are minimal and the uniformity of the dielectric is preserved, thereby minimizing impedance discontinuities. Such an arrangement provides superior electrical characteristics, is simple to construct, provides convenient connections, and is inexpensive.

It is an object of the invention to maximize the DC isolation capability of a pulse transformer.

Another object is to minimize impedance discontinuities in transmission line transformers.

Another object is to construct a pulse transformer from a single length of coaxial cable.

Another object is to minimize the mechanical connections in a transmission line pulse transformer.

Another object is to effectively, simply, conveniently and inexpensively construct a transmission line pulse transformer.

Other objects and advantageous features of the invention will be apparent in a description of a specific embodiment thereof, given by way of example only, to enable one skilled in the art to readily practice the invention, and described hereinafter with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a pictorial diagram of a coaxial cable high-voltage pulse isolation transformer according to the invention.

FIG. 2 is a schematic diagram of the transformer of FIG. 1.

DESCRIPTION OF AN EMBODIMENT

Referring to FIG. 1 of the drawing, a coaxial cable high-voltage pulse isolation transformer **10** is shown which is constructed from a single length of coaxial cable having a center conductor **12** with ends that terminate at a pair of output terminals **14** and **15**. The conductor **12** is uniformly surrounded with a solid dielectric **17** having a constant thickness over the entire length of the conductor. The dielectric **17** is surrounded with a conducting sheath that is separated into first and second sheaths **19** and **21** at the midpoint of the cable length. Near their separation, the sheaths **19** and **21** are terminated with corona rings **23** which are connected to input terminals **25** and **26**. The opposite ends of the sheaths **19** and **21** are terminated in a second pair of corona rings **27** that are interconnected electrically with a connection **35**. A length of center conductor and dielectric extends beyond each corona ring **27** across a high-voltage gap **29** to a floating high-voltage deck **31** for connection at the output terminals **14** and **15** to a coaxial cable **33** which may for example conduct high-voltage pulses to the grid of an electron gun of a high-energy linear accelerator. A first group of ferrite cores **37** are stacked around the sheath **19** while a second group of ferrite cores **39** are stacked around the sheath **21**. These cores are inductive means for preventing pulses that are applied across the input terminals **25** and **26** from being conducted over the sheaths **19** and **21** through the direct current short established by the connection **35**.

It will be noted that the mechanical connections to the transformer **10** are minimal, that transmission lines of various types may be easily and conveniently connected to both the input and output terminals, that the center conductor **12** is uniform throughout its length and free from mechanical connections, that the solid dielectric **17** is uniform throughout its length, that there are no sharp bends in the coaxial cable and that it is generally free of any impedance discontinuities.

The transformer **10** of FIG. 1 is shown schematically in FIG. 2 for the purpose of a brief explanation of the operation of the transformer **10**. Application of an input pulse having a peak voltage V across the input terminals **25** and **26** and rising in the direction of the arrow from terminal **26** towards terminal **25** causes the voltage V to divide equally so that a first voltage of ½ V appears across the sheath **21** and the center conductor **12** and a second voltage of ½V appears across the center conductor **12** and the sheath **19**, the two voltage pulses of ½V being launched thereby towards the output terminals **14** and **15**. The inductance of the ferrite cores **37** and **39** prevents signal current from moving down one sheath and up the other through the connection **35**. Thus, the first and second input voltage of ½ V are propagated to the respective output ends of the cable entirely within the sheaths, i.e., there is no signal field that is external to the sheath. The propagation of the pulses within the sheath, therefore, is not impeded by the ferrite cores. By virtue of the connection **35** between the sheaths, the two signals add across the output terminals **14** and **15** to form an output signal having a peak amplitude of V. The direction and amplitude of the peak output voltage appearing between the terminals **14** and **15** may be ascertained by examination of a path starting at the terminal **14** and moving from the conductor **12** towards the sheath **19** for a first voltage rise of ½V, and then moving over the connection **35** to the sheath **21** for a second voltage rise of ½V from the sheath **21** to the end of the conductor **12**. The two voltage rises of ½V are additive and in phase and thereby constitute a voltage rise of V from the terminal **14** towards the terminal **15**. Since the center conductor **12** is electrically isolated from the sheath, the resulting output signal is independent in ground reference from the input signal. This permits the transformer to be used in systems requiring DC isolation where the output signal is to be used at a different reference potential from the input signal. The isolation between the center conductor and sheaths also permits the transformer to be used with either polarity at ground, thus permitting the transformer to be used as an inversion transformer.

A coaxial cable high-voltage pulse isolation transformer exemplifying the invention was constructed of a 6 ft. length of 50 ohm coaxial cable having an outside diameter of ⅜ in. Twenty ferrite cores were mounted on each leg of the coaxial cable. The transformer was used to drive the grid of an electron gun for a long linear accelerator. The gun was mounted on a high-voltage deck having a potential of 80 kv. with a gap of 10 inches between the deck and the transformer output. Pulses having a peak voltage of 1 kv., a peak current of 10 amps and a risetime of 3 nanoseconds were applied to the input terminals **25** and **26**, resulting in output pulses of the same specifications.

While an embodiment of the invention has been shown and described, further embodiments or combinations of those described herein will be apparent to those skilled in the art without departing from the spirit of the invention.

I claim:

1. A coaxial cable high-voltage pulse isolation transformer, comprising:

a single length of coaxial cable having a center conductor, an outer sheath, and a dielectric between said center conductor and sheath, said dielectric being solid and continuous and uniformly covering said center conductor at a constant thickness along the entire length of said cable, said sheath being electrically separated transversely at one section along said length, said separated sheath constituting first and second legs, the portions of said legs adjacent said separation constituting input terminals for application of an electrical pulse, said single length of coaxial cable being bent to have a "U" shape in which said first and second legs are equal, said dielectric being solid, continuous and uniformly covering said center conductor at said constant thickness throughout the portion of said cable that is bent into a "U" shape; and

inductive means mounted around each of said legs for blocking the flow of high-frequency currents in said sheath, said transformer being operable in response to application of said pulse across said input terminals to produce an output signal between the center conductor and the surrounding sheath at the end of each leg opposite said separation.

2. The transformer of claim **1** wherein the separation of said sheath is at the balanced center point of said length of coaxial cable.

3. The transformer of claim **1** wherein said center conductor and sheath of said first leg are connected in phase addition with said center conductor and sheath of said second leg.

4. The transformer of claim **1** further including an electrical connection between the ends of said sheath at the ends of said cable on said first and second legs, the ends of said center conductor constituting first and second output terminals.

5. The transformer of claim **1** further including four corona rings, each of said rings terminating one of the ends of the sheaths of said first and second legs.

6. The transformer of claim **1** wherein said inductive means is a plurality of ferrite cores stacked around said first and second legs.