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SIGNAL ENERGY TAKE OFF DEVICE

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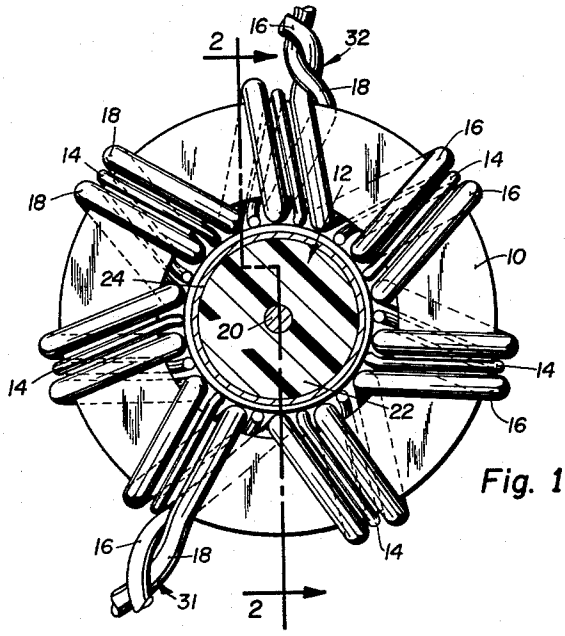


Fig. 1

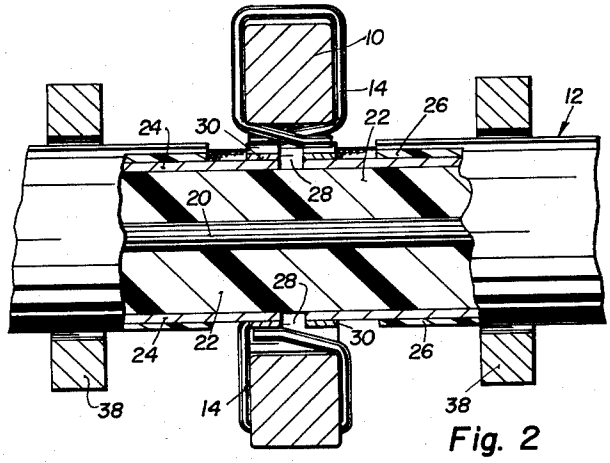


Fig. 2

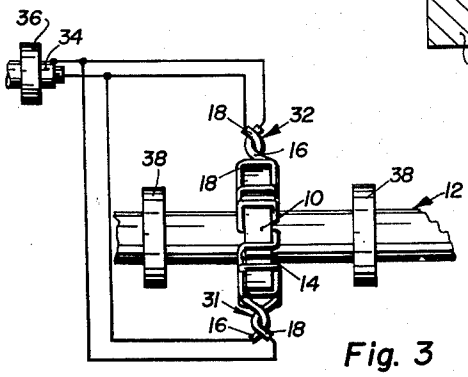


Fig. 3

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SIGNAL ENERGY TAKE OFF DEVICE

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This invention relates to a signal energy take off device and more particularly to a device which will extract a usable small amount of signal energy from a feed through transmission line along which a signal is traveling without materially degrading the quality of the signal in the transmission line and without producing an appreciable amount of discontinuity in the transmission which would cause deleterious reflections, the extraction of signal energy being effective to deliver signal energy through an output transmission line so as to provide an output signal having substantially the same wave form as the signal voltage traveling along the feed through transmission line.

In many cases it is desirable to extract a portion of the signal energy traveling along a transmission line. Such signal energy may, for example, be employed in cathode ray oscilloscopes to actuate a trigger circuit which in turn initiates the actuation of a sweep circuit, the remaining signal energy continuing to travel along such transmission line and being employed to produce a vertical deflection in the oscilloscope after a time delay. Prior devices have employed resistive isolation involving resistance in series with the output cable to minimize reflections in the feed through transmission line resulting in poor efficiency. Recently signal energy take off devices employing transformers capable of being employed with high frequency or pulse signals have been developed and the present invention relates to an improved and simplified but effective transformer type signal energy take off device.

In accordance with the present invention a gap which is short relative to the spacing between the conductors of a feed through transmission line is provided in one of such conductors and a single transformer having an annular core of magnetic material surrounding the feed through transmission is employed. The transformer has a plurality of preferably single turn primary windings circumferentially spaced around the core, each of which extends through and around the core and each of which is connected across the gap referred to. The transformer also has secondary windings extending through and around the core and connected to an output transmission line. Such secondary windings have turns which are parallel to the turns of the primary windings so that a transmission line circuit forming a continuation of the output transmission line and having the same characteristic impedance as such output transmission line is provided.

In a preferred structure the feed through transmission line is a coaxial cable with the gap in its outer conductor and the primary windings are each single turn windings with their ends connected to the outer conductor of the feed through transmission line on opposite sides of the gap. Such preferred structure also includes two separate secondary windings connected in parallel to the output transmission line and each having a number of turns equal to the total number of turns in all of the primary windings. The turns of the two secondary windings are on opposite sides of the primary winding turns. This structure provides two parallel transmission lines each of which may have twice the characteristic impedance of that of the output transmission line, the ends of each of the primary windings being circumferentially spaced around the feed through cable to facilitate the winding arrangement just described. The result is a simple device capable of extracting a usable small amount of signal energy from a feed through transmission line over a wide range of frequencies with very little effect on the signal traveling along the feed through transmission line.

It is therefore an object of the present invention to provide an improved signal energy take off device for extracting a portion of the signal energy traveling along a feed through transmission line in which device the extraction of signal energy is accomplished by employing a single transformer having a core of magnetic material surrounding such transmission line.

Another object of the invention is to provide a signal energy take off device for extracting a portion of the signal energy traveling along a feed through transmission line in which device a single transformer having a core of magnetic material surrounding such line is employed and such transformer has a plurality of primary windings connected across a short gap in one of the conductors of the transmission line to provide a low impedance in series with such transmission line and has secondary windings connected to an output transmission line and arranged to cooperate with the primary windings to produce a transmission line circuit forming a continuation of and having the same characteristic impedance as the output transmission line.

A further object of the invention is to provide an improved signal energy take off device employing a single transformer and capable of being used with high frequency and pulse signals as well as relatively low frequency signals for extracting a small portion of the signal energy traveling along a transmission line without producing substantial distortion or reflection of the signal traveling along such line.

Other objects and advantages of the invention will appear in the following description of a preferred embodiment shown in the attached drawing of which:

FIG. 1 is an end elevation of a transformer forming part of a signal energy take off device in accordance with the present invention with an associated feed through transmission line shown in section;

FIG. 2 is a side elevation of the signal energy take off device of the present invention with parts broken away to show the transformer of FIG. 1 in vertical section and with the secondary windings omitted; and

FIG. 3 is a side elevation of the signal energy take off device with a schematic diagram of the connections to an output transmission line.

Referring to FIGS. 1 and 2, the transformer of the take off device of the present invention includes an annular core 10 of suitable magnetic material having low eddy current and hysteresis losses so as to be usable at high frequency and of relative high permeability. Suitable cores are available commercially and are usually referred to as ferrite cores. A feed through transmission line 12 in the form of a coaxial cable extends through the central aperture in the core 10, which aperture is of sufficiently greater diameter than the external diameter of the cable 12 to provide an annular space for a plurality of primary transformer windings 14, seven in the embodiment shown, and two secondary windings 16 and 18. The feed through cable 12 includes a central conductor 20 surrounded by an annular body of insulating material 22 in turn surrounded by an annular outer conductor 24 which is usually covered by a layer of insulation 26. The insulating cover 26 is shown as being removed adjacent the core 10 and the annular outer conductor 24 as having a gap 28 formed therein. A conducting ring 30, which may be split when applied, is preferably soldered to the ends of the outer conductor on each side of the gap 28.

Each of the primary windings 14 is a single turn of bare wire which extends through the core 10 and around such core and has its opposite ends soldered to the conducting rings 30 on opposite sides of the gap 28. As

shown in FIG. 1, the primary windings 14 are equally spaced circumferentially of the core 10 and the opposite ends of each of the primary windings are also spaced circumferentially of the core to provide for positioning the turns of the secondary windings 16 and 18 so that each turn of such secondary windings is close to and parallel to a primary winding turn. It will be apparent that the primary windings shown in FIGS. 1 and 2 provide a plurality of single turn primary windings, all connected in parallel across the gap 28.

The secondary windings 16 are of insulated wire and can be traced in FIG. 1 from the twisted pair 31 approximately half way around the core 10 to the twisted pair 32. Similarly the secondary windings 18 are of insulated wire and can be traced in the opposite direction from the twisted pair 32 approximately half way around the core 10 and to the twisted pair 31. It will be apparent that each of the secondary windings have seven turns around the core and that each turn extends parallel to and adjacent a primary winding turn.

The secondary windings 16 and 18 constitute balanced transmission lines having a characteristic impedance determined by the wire size employed and the thickness and character of the insulation thereon, which largely determines the spacing between the conductors of the secondary windings and the primary windings. As shown in FIG. 3, the secondary windings 16 and 18 can be connected through the twisted pairs 31 and 32, respectively, to an output transmission line 34. Such output transmission line should have a characteristic impedance approximately one-half of that of each of the secondary windings. It will be apparent that the secondary windings provide a transmission line circuit having the same characteristic impedance as the output transmission line.

The output transmission line 34 is shown as being a coaxial cable and an annular core 36 of magnetic material similar to that of the core 10 and surrounds such cable to electrically isolate the cable from the balanced transmission lines provided by the secondary windings 16 and 18. This enables the outer conductor of the coaxial cable 36 to be grounded to thus provide an unbalanced output transmission line. A similar core 38 is also employed to surround the feed through coaxial cable 12 on at least one side of the gap 28 and preferably on both sides of the gap so as to electrically isolate at least one side of such gap from ground and provide for producing a voltage across such gap which is proportional to the signal traveling along such transmission line even though the outer conductor 24 of such line is grounded in both sides of the gap.

As a specific example, the feed through transmission line 12 may have a characteristic impedance of approximately 125 ohms and the output transmission line may have a characteristic impedance of approximately 50 ohms. By a suitable choice of wire size and insulation thereon each secondary winding may have a characteristic impedance of approximately 100 ohms. It will be found that the twisted pairs 31 and 32 also have a characteristic impedance of approximately 100 ohms so that the secondary windings and twisted pairs in parallel match the impedance of the output transmission line in the direction of signal propagation from such secondary windings toward and along such output transmission line. Since each of the secondary windings 16 and 18 have seven turns on the core 10 and such windings are connected across the 50 ohm characteristic impedance of the output cable 34, the impedance produced across the gap 28 in the outer conductor 24 of the feed through cable is approximately 1 ohm. The voltage across the gap is therefore approximately .8% of that traveling along the 125 ohm feed through transmission line.

The voltage delivered to the output transmission line is approximately 5.7% of the signal voltage because of the 7 to 1 voltage transformation. Such output voltage is obtained at a loss of only approximately .8% of the signal traveling along the feed through transmission line with no more than approximately .4% reflection so that approximately 99.6% of the signal voltage continues along the feed through transmission line. The voltages induced in the various turns of the secondary windings are very closely in phase even at extremely high frequencies so that devices in accordance with the present invention are capable of operating at frequencies of the order of several thousand megacycles as well as at relatively low frequencies and are very useful with pulse for extracting signal energy from signals, particularly from narrow pulses having short rise or fall times.

It will be apparent that the details of the specific device shown may be varied within the scope of the following claims. For example, it is apparent that the structure shown including the number of primary windings connected in parallel as well as the number of secondary windings and the number of turns in each may be varied, and also that the invention may be applied to other type of transmission lines having other values of characteristic impedance.

I claim:

1. A signal energy take off device comprising:
a feed through transmission line having a pair of spaced conductors, one of said conductors having a gap therein,
an output transmission line,
an annular transformer core of magnetic material surrounding said feed through transmission line adjacent said gap,
a primary transformer winding connected across said gap and providing a primary turn extending through and around said core, and
a secondary transformer winding having a turn on said core and connected to said output line.

2. A signal energy take off device comprising:
a feed through transmission line having a pair of spaced conductors, one of said conductors having a gap therein,
an output transmission line,
an annular transformer core of magnetic material surrounding said feed through transmission line adjacent said gap,
a plurality of primary transformer windings spaced circumferentially of said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and
a secondary transformer winding connected to said output line and having a number of turns in series on said core, each of said turns of said secondary winding being adjacent a turn of one of said primary windings to provide a transmission line circuit for delivering signal energy from said feed through transmission line to said output transmission line.

3. A signal energy take off device comprising:
a feed through transmission line having a pair of spaced conductors, one of said conductors having a gap therein which is short relative to the spacing between said conductors,
an output transmission line,
an annular transformer core of magnetic material surrounding said feed through transmission line adjacent said gap,
a plurality of single turn primary transformer windings spaced circumferentially of said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and
secondary transformer windings connected to said output line and having a number of turns in series on said core equal to the total number of turns in all of said primary windings, each of said turns of said secondary windings being adjacent a turn of one of said primary windings to provide a transmission line circuit for delivering signal energy from said

feed through transmission line to said output transmission line.

4. A signal energy take off device comprising:

a feed through transmission line having a pair of spaced conductors, one of said conductors having a gap therein which is short relative to the spacing between said conductors,

an output transmission line,

an annular transformer core of magnetic material surrounding said feed through transmission line adjacent said gap,

a plurality of single turn primary transformer windings spaced circumferentially of said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and

secondary transformer windings connected to said output line and having a number of turns in series on said core equal to the total number of turns in all of said primary windings, each of said turns of said secondary windings being adjacent a turn of one of said primary windings to provide a transmission line circuit for delivering signal energy from said feed through transmission line to said output transmission line, said transmission line circuit having a characteristic impedance substantially equal to that of said output transmission line.

5. A signal energy take off device comprising:

a feed through coaxial cable having inner and outer conductors, said outer conductor having a gap therein,

an output coaxial cable,

an annular transformer core of magnetic material surrounding said feed through coaxial cable,

a plurality of single turn primary transformer windings spaced circumferentially of said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and

secondary transformer windings connected to said output cable and having a number of turns in series on said core, each of said turns of said secondary windings being adjacent a turn of said primary windings.

6. A signal energy take off device comprising:

a feed through transmission line having a pair of spaced conductors, one of said conductors having a gap therein,

an output transmission line,

an annular transformer core of magnetic material surrounding said feed through transmission line adjacent said gap,

a plurality of primary transformer windings spaced circumferentially around said core, said secondary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and

a plurality of secondary transformer windings connected in parallel to said output line, each of said secondary windings having a number of turns in series on said core and each turn of said secondary windings being adjacent a turn of one of said primary windings to provide a transmission line circuit for delivering signal energy from said feed through transmission line to said transmission output line.

7. A signal energy take off device comprising:

a feed through transmission line having a pair of spaced conductors, one of said conductors having a gap therein which is short relative to the spacing between said conductors,

an output transmission line,

an annular transformer core of magnetic material surrounding said transmission line adjacent said gap,

a plurality of single turn primary transformer windings spaced circumferentially around said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and

a pair of secondary transformer windings connected in parallel to said output line, each of said secondary windings having a number of turns in series on said core equal to the total number of said primary turns and each turn of said secondary windings being adjacent a turn of one of said primary windings, the turns of one of said secondary windings being on the opposite sides of said primary turns from the turns of the other of said secondary windings to provide a transmission line circuit for delivering signal energy from said feed through transmission line to said output transmission line.

8. A signal energy take off device comprising:

a feed through coaxial cable having spaced inner and outer conductors said outer conductor having a gap therein which is short relative to the diameter of said outer conductor,

an output coaxial cable,

an annular transformer core of magnetic material surrounding said feed through cable adjacent said gap,

a plurality of single turn primary transformer windings spaced circumferentially around said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and

a pair of secondary winding connected in parallel to said output line, each of said secondary windings having a number of turns in series, each of said turns of said primary windings having their ends spaced circumferentially of said core to provide room between such ends for turns of said secondary windings, each turn of said secondary windings being adjacent a turn of one of said primary windings and the turns of one of said secondary windings being on the opposite sides of said primary turns from the turns of the other of said secondary windings to provide a transmission line circuit for delivering signal energy from said feed through transmission line to said output transmission cable.

9. A signal energy take off device comprising:

a feed through coaxial cable having a pair of spaced conductors, one of said conductors having a gap therein,

an output coaxial cable,

an annular transformer core of magnetic material surrounding said transmission line adjacent said gap,

a plurality of single turn primary transformer windings spaced circumferentially around said core, said primary windings being connected in parallel across said gap and providing primary turns extending through and around said core, and

a pair of secondary transformer windings connected in parallel to said output line, each of said secondary windings having a number of turns in series on said core equal to the total number of said primary turns and each turn of said secondary windings being adjacent a turn of one of said primary windings and having substantially the same characteristic impedance as that of said output cable to provide a transmission line circuit for delivering signal energy from said feed through cable to said output cable.

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