June 6, 1967 YUKIO FUJIMOTO 3,324,421

IMPEDANCE MATCHING TAP-OFF COUPLER FOR COAXIAL TRANSMISSION LINES, HAVING INTEGRAL VARIABLE CAPACITANCE

Filed Oct. 19, 1964 2 Sheets-Sheet 1

FIG. 1.

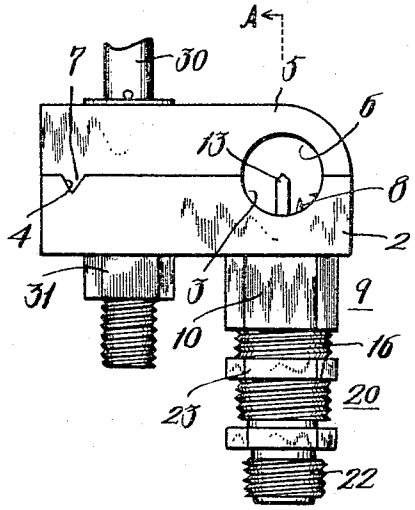


FIG. 2.

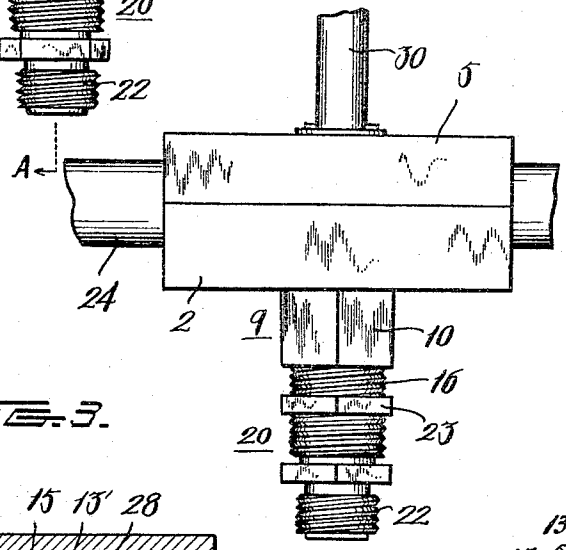
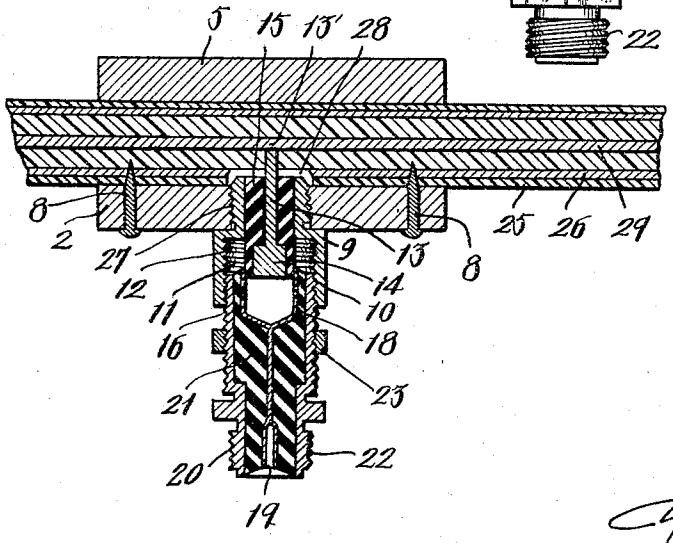


FIG. 3.



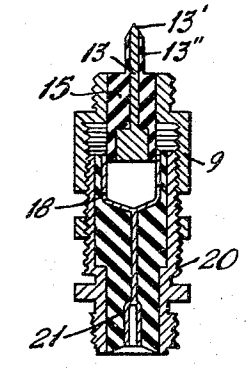


FIG. 3a.

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Filed Oct. 19, 1964 2 Sheets-Sheet 2

FIG. 4

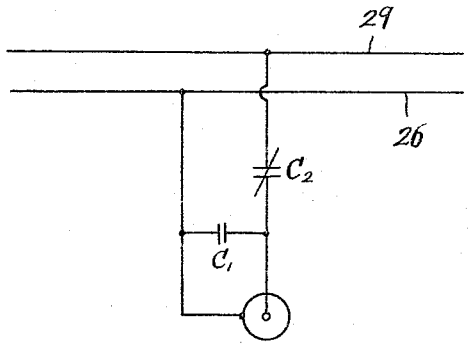


FIG. 5 I

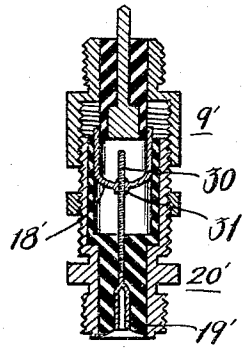


FIG. 5 II

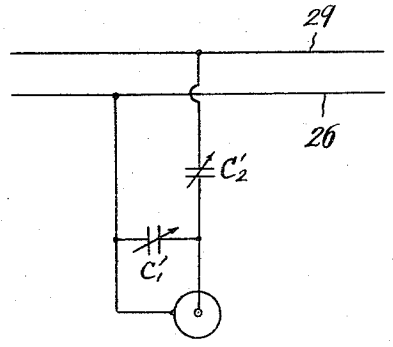


FIG. 6 I

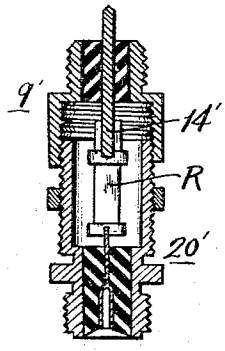
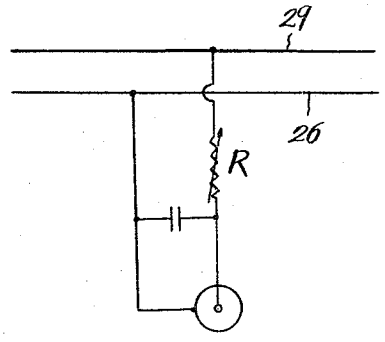


FIG. 6 II



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IMPEDANCE MATCHING TAP-OFF COUPLER FOR COAXIAL TRANSMISSION LINES, HAVING INTEGRAL VARIABLE CAPACITANCE

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6 Claims. (Cl. 333—9)

ABSTRACT OF THE DISCLOSURE

A tap-off coupler for coaxial transmission lines with electrical connections through piercing pins and having a cylindrically shaped metal capacitor plate in one adjustable part into which the rear end of one of the piercing pins is adjustably moved axially therein to vary the impedance for matching.

The present invention relates to an impedance matching tap-off coupled for coaxial transmission lines, comprising an inner conductor and an outer conductor, the two being separated by suitable insulation.

Heretofore, in the reception of television transmission, especially with a multiple outlet system, a tap was made on the main coaxial line to transfer energy to the branch lines.

Experiments conducted to achieve desirable results in the adjustment of the coupler's impedance have usually been unsuccessful.

It is one object of the present invention to provide an impedance matching highly efficient tap-off coupler for coaxial transmission lines which can easily and quickly be installed onto a coaxial cable, and impedance of which can be adjusted.

It is another object of the present invention to provide an impedance matching tap-off coupler for coaxial transmission lines comprising four separate parts; the upper two conductor parts are designed to encircle and firmly grip the main coaxial cable. Two short pins in the lower conductor part pierce the outer insulating coating of the coaxial cable, thereby making connection with the outer conductor of the cable. The lower conductor is formed with an internally threaded opening in which is connected an externally threaded member which constitutes the third part and which is comprised of an outer conducting portion and an inner conductor which includes a piercing pin. The outer conducting portion and the inner conductor are fully insulated from each other, and are firmly held together with the insulation. The lower portion of the inner conductor of the third part projects into an aperture in the lower portion of the third part into which a cartridge (the fourth part) is fitted. The cartridge has an insulated outer conducting portion and an inner conductor which forms an impedance element. The inner conductor of the cartridge comprises a cylindrical metal part (or a variable resistor). The cylindrical metal part and the outer conducting portion of the cartridge constitute a capacitor. The third part is fitted onto the fourth part and the lower portion of the inner conductor of the third part is fitted into the cylindrical metal part and the upper portion of the cartridge. The cylindrical metal part of the cartridge is located inside of the outer conducting portion of the third part, and the degree

of insertion of the lower portion of the inner conductor of the third part into the cylindrical metal part of the inner conductor of the cartridge constitutes a variable capacitor. The impedance of the coupler is adjusted by the changes in the capacitance.

When a variable resistor is used for the impedance element, the degree of insertion of the cartridge into the third part determines the resistance value, providing the means for adjusting the impedance.

With these and other objects in view which will become apparent in the following detailed description, the present invention will be clearly understood in connection with the accompanying drawings, in which:

FIGURE 1 is a front elevation of an impedance matching tap-off coupler according to the present invention;

FIG. 2 is an end elevation of the tap-off coupler of FIG. 1 with a main coaxial cable attached thereto;

FIG. 3 is a section along the lines A—A of FIG. 1;

FIG. 3*a* is an axial sectional view of the third part and the cartridge of the tap-off coupler showing an insulated piercing pin;

FIG. 4 is an electrical transmission circuit of the tap-off coupler illustrated in FIGS. 1–3;

FIG. 5–I is an axial sectional view of a third part and a cartridge, showing a modified construction;

FIG. 5–II is an electrical transmission circuit of the coupler illustrated in FIG. 5–I;

FIG. 6–I is an axial sectional view of a third part and a cartridge, showing another modified construction; and

FIG. 6–II is an electrical transmission circuit of the coupler illustrated in FIG. 6–I.

Referring now to the drawings, and more particularly to FIG. 1–3, an impedance matching tap-off coupler according to the present invention comprises a lower conductor **2** having a semi-circular groove **3** and an indented V-shaped recess **4** on the inside.

The diameter of the groove **3** matches the diameter of a coaxial main cable **24**. The tap-off coupler further comprises an upper conductor **5** having a semi-circular groove **6** and a V-shaped protruding part **7** on the inside.

The protruding part **7** fits snugly in the V-shaped recess **4**, and the coaxial cable **24** fits snugly inside the semi-circular grooves **3** and **6**, which form a cylindrical opening when the two conductors **2** and **5** are fitted together. When the coaxial cable **24** is inserted into the cylindrical grooves (**3** and **6**), pins **8** protruding out into the groove **3** from the lower conductor **2** (FIG. 3) pierce through the outer insulating coating **25** of the coaxial cable **24** and connect with outer conductor **26** of the coaxial cable.

The lower conductor **2** has an opening **28** having internal threads **27** which receive an externally threaded third part **9**. The lower conductor **2** and the third part **9** are made of conducting materials to obtain an electrical connection between the outer conductor **26** of the coaxial cable **24** and the conducting material of the third part **9**, through the piercing pins **8** and the body of the lower conductor **2**. The lower outside portion of the third part **9** is formed into the shape of a nut **10** and has an annular aperture **11** having internal threads **12**. A piercing pin **13** having an inner protruding metal end **14** is disposed in the interior of the third part **9**, which is covered tightly with insulation **15**. The inner protruding metal end **14** is fitted and positioned into the aperture **11**.

The piercing pin **13** has an outer extending portion of length slightly longer than the radius of the cable **24**.

As illustrated in FIG. 3, the outer conductor **26** is cut away at its outer coating at the desired position of the cable to be engaged before the third part **9** is engaged into the opening **28**, and the head **13'** of the piercing pin pierces the inner insulation and connects with the inner conductor **29** of the cable **24**. As shown in FIG. 3*a* where the piercing pin **13** has an insulation covering **13''** around its extending portion (except the pointed head **13'**), it may be unnecessary to cut away a portion of the outer conductor of the cable.

A cartridge **20** with an external thread **16** is placed in the internally threaded aperture **11** of the third part **9**. The cartridge **20** also includes a cylindrical metal part **18** and a connector **19** tightly covered with insulation **21**. The connector **19** has a slit on the end opposite the metal part **18**. The lower portion of the cartridge **20** has external threads **22**, which are attached to a branch cable (not shown) in a conventional way. The cartridge **20** possesses a predetermined capacitance between the metal part **18** and the outer conducting portion of the cartridge **20**. When the cartridge **20** is fitted into the aperture **11** of the third part **9**, the cylindrical metal part **18** encircles the inner protruding metal end **14** together with its outer insulation **15**, whereby a further capacitance arises between the two metal parts **14** and **18**.

The capacitance between parts **14** and **18** can be adjusted according to the degree of insertion of the inner protruding metal end **14** into the cylindrical opening of the metal part **18**. That is, as indicated in FIG. 4, the cylindrical metal part **18** of the cartridge **20** possesses a capacitance C_1 between the metal part **18** and the outer conducting portion of the cartridge **20** and by placing the cartridge **20** in the aperture **11** of the third part **9**; and by placing the inner protruding metal end **14** inside the cylindrical opening of the metal part **18**, a variable capacitor C_2 is formed.

On the external threads **16** on the upper portion of the cartridge **20**, a suitable stop, such as a nut **23**, is located to secure the cartridge **20**. For attaching the coupler to the cable **24** and securing it at the desired position, a bolt **30** and a nut **31** are provided, as illustrated in FIG. 1.

As clearly illustrated in FIG. 3, the pointed short pins **8** protrude slightly into the groove **3** of the lower conductor **2** to pierce through the outer insulation **25** of the cable **24** and connect with the outer conductor **26** of the cable **24**. These pins are intended to provide a good electrical connection between the lower conductor **2** and the outer conductor **26** of the cable **24** as well as to firmly secure the cable in the grooves **3** and **6**. The piercing pin **13** extends through the cut in the cable **24**, and pierces the inner insulation and connects with the inner conductor **29** of the cable **24** when the third part **9** is threadedly engaged in the opening **28** of the lower conductor **2**.

When the piercing pin **13** includes an insulation covering **13''** (FIG. 3*a*) about its outer projecting portion (except at the pointed head **13'**), the pin **13** may be pierced into the cable without any cut formed therein, because electrical connection between the pin **13** and the outer conductor **26** of the cable **24** cannot occur and a short circuit cannot result.

The tap-off coupler constructed according to the present invention with operations as described above, may be adjusted by adjustably securing the cartridge **20** relative the third part **9** in a suitable position where the desired value of the capacitance is obtained. The capacitance value, as shown at C_2 in FIG. 4, depends upon the degree of insertion of the cartridge **20** into the third part **9**. Accordingly, this tap-off coupler contains two impedance elements C_1 and C_2, when in use. Therefore, a coupling loss suitable for a tap-off point on the cable to which the coupler is attached may be selected by adjusting the proper values of the elements.

With an increase in the coupling loss of the tap-off coupler, the difference of loss in the lower and high frequency

TV band decreases, and with a decrease in the coupling loss of the tap-off coupler, the difference of loss in the low and high frequency TV band increases. It is one of the special characteristics of the present invention to utilize this frequency quality.

In the past, impedance elements such as capacitance or resistors were invariable. However, the tap-off coupler of the present invention has two capacitances, one or both of which are variable, as described herein. Capacitance between the cylindrical metal part **18** (containing an inner conductor of the cartridge **2**) and the inner protruding metal end **14** (constituting an inner conductor of the third part **9**) is changed in proportion to the degree of insertion of the cartridge **20** into the third part **9**. Deep insertion makes the capacitance large, because the coupling loss is small, whereas a slight insertion makes the capacitance small, because the coupling loss is large.

Referring now again to the drawings, and more particularly to FIGS. 5–6, there are illustrated modified embodiments of the cartridge of the present invention. FIG. 5–I shows a cartridge **20'** comprising a cylindrical metal part **18'** as an inner conductor, the metal part **18'** being held with a threaded shaft **30** in an aperture of the cartridge **20'**. The shaft **30** may be rotated by a suitable tool such as a screw-driver, the position of the metal part **18'** thereby being axially changed. The electrical circuit diagram of this embodiment is illustrated in FIG. 5–II, where two variable capacitors are established as impedance elements. In this case the value of the capacitance C_1' is also variable because of the relationship between the metal part **18'** and the outer conducting portion of the cartridge **20'**.

FIGS. 6–I and 6–II show another embodiment where the capacitance of the impedance elements is changed and a variable resistor R is used. This is accomplished by using the inner protruding metal end **14** of the third part **9'** as a variable terminal. By the degree of insertion of the cartridge **20'** into the third part **9'**, the resistance value of the variable resistor R is adjusted.

While I have disclosed several embodiments of the present invention, it is to be understood that these embodiments are given by example only and not in a limiting sense, the scope of the present invention being determined by the objects and the claims.

I claim:

1. An impedance matching tap-off coupler for transmitting electrical energy from a main coaxial cable having an inner conductor, an outer conductor, and an inner insulation therebetween and an outer insulating coating about the outer conductor, comprising

two clamping conductors, each having a semi-circular groove for together firmly engaging in said grooves said main coaxial cable,

short pins for piercing through said outer insulating coating of said cable so as to connect with said outer conductor of said cable,

said short pins protruding out from one of said clamping conductors into one of said semi-circular grooves,

said one of said clamping conductors having an internally threaded opening axially intersecting said one of said semi-circular grooves,

a third part having an outer conducting portion and having first external threads engaging with said one of said clamping means at said threaded opening,

said third part including an inner conductor spaced from said outer conducting portion and comprising a piercing pin extending from an inner protruding metal end to an outer extending portion,

said outer extending portion of a length being slightly more than the radius of said cable and piercing said cable and said inner insulation and adapted to connect to said inner conductor of said cable,

insulation material disposed between said piercing pin and said outer conducting portion of said third part,

and spaced from said outer conducting portion about said inner protruding metal end to define thereat an annular aperture,

a cartridge adjustably fitting into said annular aperture,

said cartridge comprising a second outer conducting portion having second external threads and adapted for adjustable attachment to said outer conducting portion of said third part in said annular aperture,

said cartridge adapted for attachment with a branch cable,

said cartridge including a second inner conductor insulated from said second outer conducting portion,

said second inner conductor comprising a cylindrical metal part and a connector,

said second outer conducting portion and said cylindrical metal part constituting a capacitor,

said inner protruding metal end disposed inside said cylindrical metal part constituting a variable capacitor, and

the degree of insertion of said inner protruding metal end into said cylindrical metal part being adjustable by said adjustable attachment of said cartridge to said outer conducting portion of said third part, thereby determining the value of the capacity of said variable capacitor.

2. An impedance matching tap-off coupler for transmitting electrical energy from a main coaxial cable having an inner conductor, an outer conductor, an inner insulation therebetween and an outer insulating coating about the outer conductor, comprising

two clamping conductors, each having a semi-circular groove for together firmly engaging in said grooves said main coaxial cable,

short pins for piercing through said outer insulating coating of said cable so as to connect with said outer conductor of said cable,

said short pins protruding out from one of said clamping conductors into one of said semi-circular grooves,

said one of said clamping conductors having an internally threaded opening axially intersecting said one of said semi-circular grooves,

a third part having an outer conducting portion and having first external threads engaging with said one of said clamping means at said threaded opening,

said third part including an inner conductor spaced from said outer conducting portion and comprising a piercing pin extending from an inner protruding metal end to an outer extending portion terminating with a pointed head,

said outer extending portion of a length slightly more than the radius of said cable and piercing said cable and said inner insulation and adapted to connect to said inner conductor of said cable,

insulation material disposed between said piercing pin and said outer conducting portion of said third part and spaced from said outer conducting portion about said inner protruding metal end to define thereat an annular aperture,

said annular aperture being internally threaded on said outer conducting portion,

a cartridge comprising a second outer conducting portion having second external threads,

said cartridge adjustably engaging with said second external threads, said internally threaded outer conducting portion of said third part thereby adjustably fitting into said annular aperture,

said cartridge including third external threads for attachment with a branch cable,

said cartridge including a second inner conductor insulated from said second outer conducting portion,

said second inner conductor comprising a cylindrical metal part and a connector,

said second outer conducting portion and said cylindrical metal part constituting a capacitor,

said inner protruding metal end disposed inside said cylindrical metal part constituting a variable capacitor, and

the degree of insertion of said inner protruding metal end into said cylindrical metal part being adjustable by said adjustable attachment of said cartridge to said outer conducting portion of said third part, thereby determining the value of the capacity of said variable capacitor.

3. The coupler, as set forth in claim 2, further comprising

stop means mounted on said second external threads of said cartridge to secure said cartridge at any desired position for obtaining a desirable capacitance between said third part and said cartridge.

4. The coupler, as set forth in claim 2, wherein

said piercing pin is insulated at said outer extending portion except at said pointed head.

5. The coupler, as set forth in claim 2, wherein

said second inner conductor comprises a threaded shaft,

said cylindrical metal part having a threaded opening and being threadedly engaged therein by said threaded shaft,

said cartridge defining a cartridge aperture,

said cylindrical metal part disposed in said cartridge aperture, and

said shaft adapted for rotation whereby the position of said cylindrical metal part is axially adjusted.

6. A tap-off coupler for transmitting electrical energy from a main coaxial cable having an inner conductor, an outer conductor, an inner insulation therebetween and an outer insulating coating about the outer conductor, comprising

two clamping conductors, each having a semi-circular groove for together firmly engaging in said grooves said main coaxial cable,

short pins for piercing through said outer insulating coating of said cable so as to connect with said outer conductor of said cable,

said short pins protruding out from one of said clamping conductors into one of said semi-circular grooves,

said one of said clamping conductors having an internally threaded opening axially intersecting said one of said semi-circular grooves,

a third part having an outer conducting portion and having first external threads engaging with said one of said clamping means at said threaded opening,

said third part including an inner conductor spaced from said outer conducting portion and comprising a piercing pin extending from an inner protruding metal end to an outer extending portion.

said outer extending portion of a length slightly more than the radius of said cable and piercing said cable and said inner insulation and adapted to connect to said inner conductor of said cable,

insulation material disposed between said piercing pin and said outer conducting portion of said third part, and spaced from said outer conducting portion about said inner protruding metal end to define thereat an annular aperture,

a cartridge adjustably fitting into said annular aperture,

said cartridge comprising a second outer conducting portion having second external threads and adapted for adjustable attachment to said outer conducting portion of said third part in said annular aperture,

said cartridge adapted for attachment with a branch cable,

said cartridge including a second inner conductor insulated from said second outer conducting portion,

said second inner conductor comprising a resistor and a connector,

said second outer conducting portion and said connector constituting a capacitor,

said inner protruding metal end slidably connected to said resistor constituting therewith a variable resistor, and

the connecting position of said resistor with said inner protruding metal end being adjustable with the degree of insertion by said adjustable attachment of said cartridge into said outer conducting portion of said third part, thereby determining the value of the resistance of said variable resistor.

References Cited

UNITED STATES PATENTS

2,188,389	1/1940	Cork et al.	333—33 X
2,207,690	7/1940	Cork et al.	333—33 X
2,694,182	11/1954	Edlen et al.	333—97 X
2,694,183	11/1954	Edlen et al.	333—97 X
2,745,065	5/1956	Maher	333—97 X

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