

Dec. 10, 1968

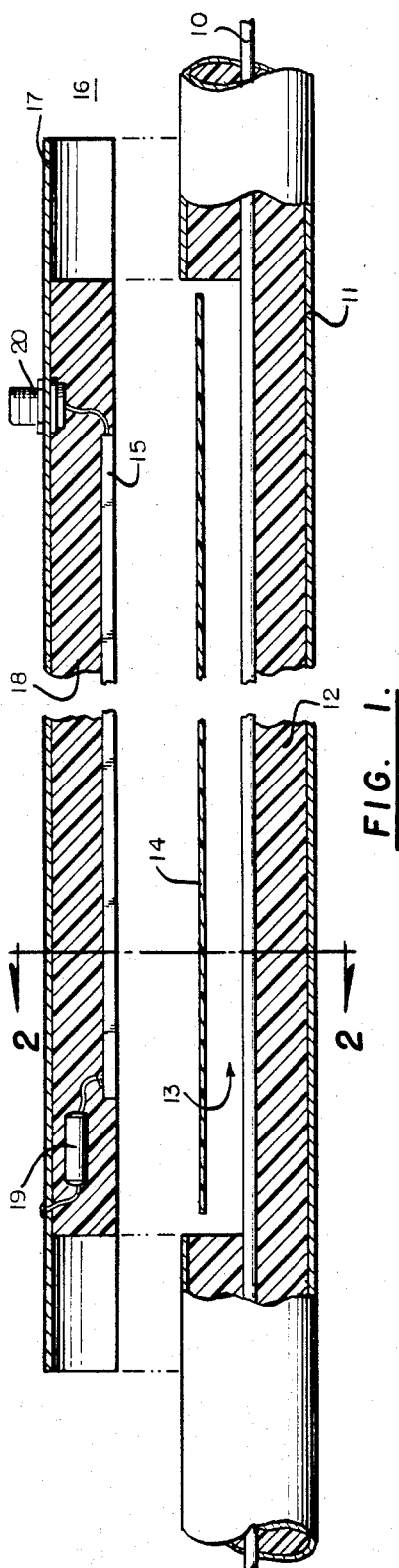
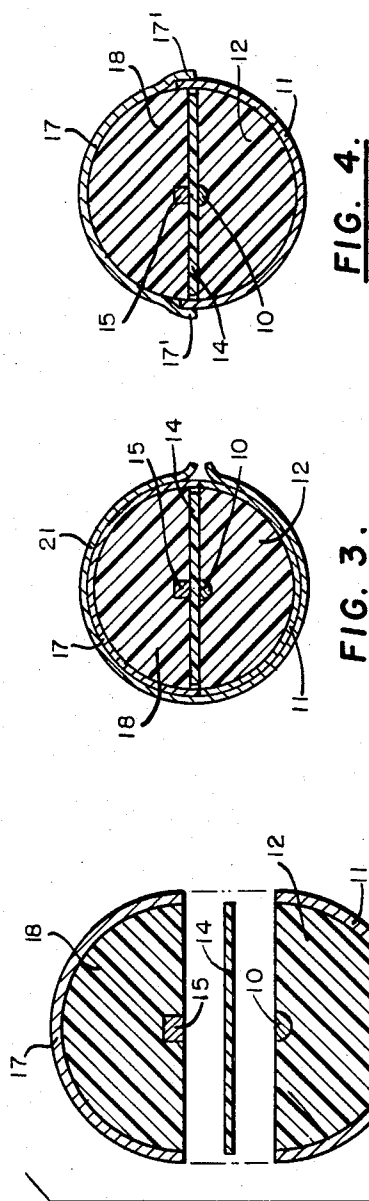
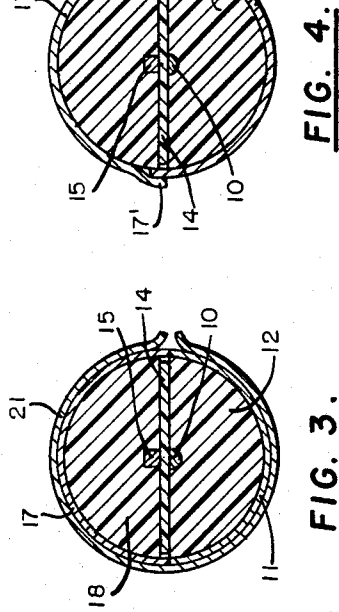
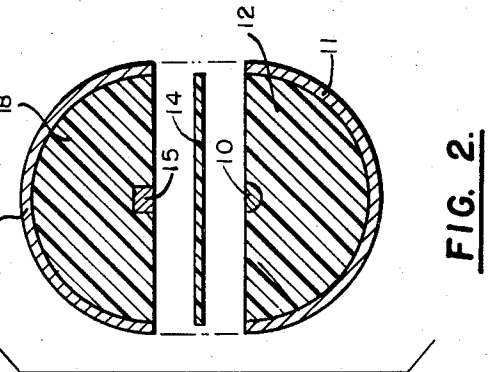
P. D. HAMLIN

3,416,102

METHOD AND APPARATUS FOR TAPPING A COAXIAL CABLE

Filed July 7, 1966

2 Sheets-Sheet 1



INVENTOR

Philip D. Hamlin

BY MOORE and HALL

ATTORNEYS

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P. D. HAMLIN

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METHOD AND APPARATUS FOR TAPPING A COAXIAL CABLE

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**FIG. 5.**

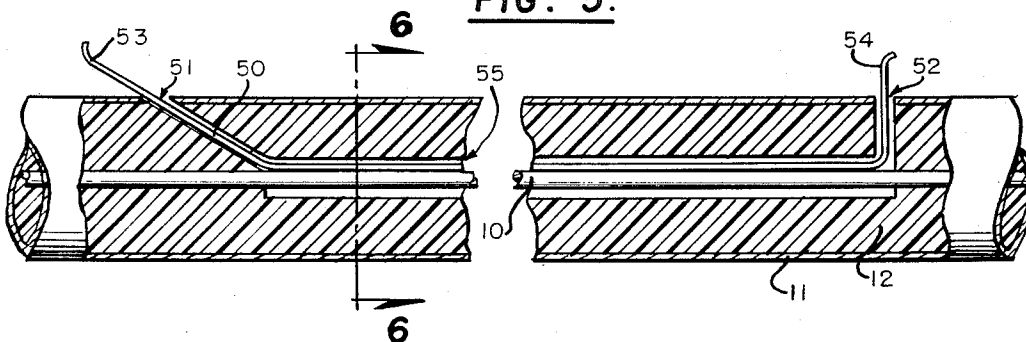


**FIG. 6.**

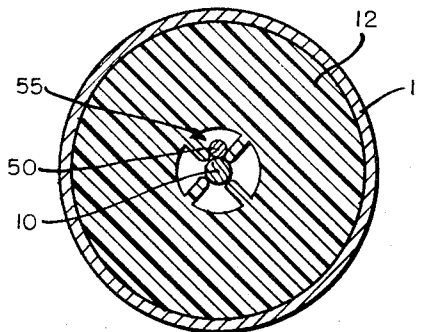


**FIG. 7.**

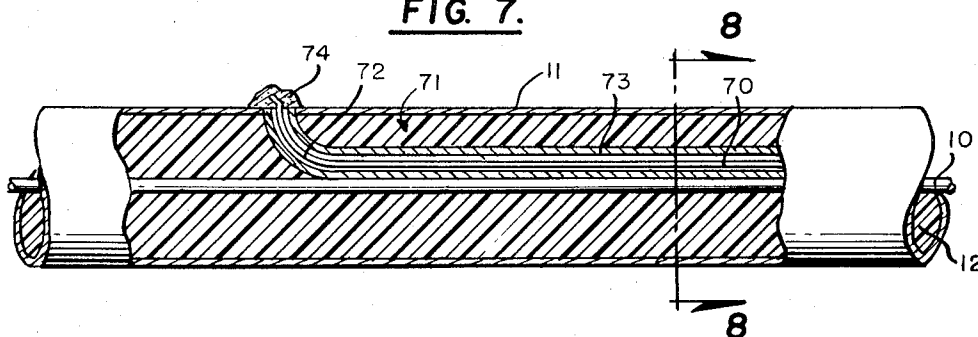
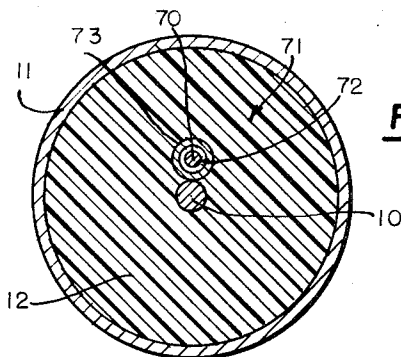


**FIG. 8.**



INVENTOR

Philip D. Hamlin

BY MOORE and HALL

ATTORNEYS

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3,416,102

## METHOD AND APPARATUS FOR TAPPING A COAXIAL CABLE

Philip D. Hamlin, 12611 Standing Lane SW.,  
Seattle, Wash. 98146

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17 Claims. (Cl. 333-10)

This invention relates to a tap for a coaxial cable.

The desirability of tapping a coaxial cable is an old and well known problem, particularly in microwave systems and community antenna systems. In connection with community antenna television work, for example, a coaxial cable passes down the street by a number of houses and it is desirable to be able to tap the cable and run a branch line to each house which desires service.

It is a primary object of this invention to provide a tap for a coaxial cable which is easy to install and low in cost.

Another object of this invention is to provide a tap which is a directional coupler, that is, one in which signals can be transferred in one direction only so that there is protection of the primary coaxial cable from reflections, discontinuities, contaminating signals, voltages or currents of any kind, from the branch conductor. This "non-reciprocity" or "directionality" is highly advantageous where alternating current must be transferred in only one direction.

Numerous directional couplers are currently manufactured but most, if not all, require cutting the coaxial cable, affixing connectors to the cable, and inserting a device between the two severed ends. Regardless of the sophistication with which distributed capacity and inductance are utilized to minimize "reflection," and to reduce the "discontinuity," a traveling wave or waves immediately sense, detect and experience a change in the "propagation media" and the "propagation velocity." This change in media and velocity is due to the substitution of different dielectric and to changes in both capacity and inductance. Many highly sophisticated circuits have been designed to minimize the losses resulting from this by the substitution of circuit elements that slow down, speed up, or shape the traveling energy's waveform to restore the normality that existed prior to the "discontinuity" of the severed cable, the connectors, the passage through the new media of the coupler, and the reinsertion to the output cable via another conductor. However, the best of the prior art have still resulted in prohibitive "insertion" losses—energy loss as measured by the comparison of the output to the input—and have measurable degradation of signals after passage through multiple couplers, one following the other along the line.

Thus it is a further object to provide a directional tap for a coaxial cable which is not plagued by the above indicated problems of the prior art.

Other objects and advantages of the invention will appear as this description proceeds.

According to this invention, in one form, a portion of the coaxial cable including the outer braid and all or part of the dielectric is cut away; and a wire positioned adjacent to, although insulated from, the central conductor of the coaxial cable. This wire may be mounted on a suitable insert which may be inserted into the cable to fill up the portion thereof which was cut away. This insert may include a suitable coaxial connector at one end thereof, and also a piece of outer conductor which takes the place of the portion of the outer conductor of the coaxial cable which was cut away as aforesaid.

In another form of the invention, an extended space is established between the central conductor and the

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solid dielectric at selected places along the coaxial cable when the cable is manufactured. The space at manufacture is filled with air or other suitable gas, or distilled water, oil, or similar substance. When tap-off is desired, a hole is drilled through the cable at both ends of the extended space and a tap-off conductor is inserted in one hole, through the space, and drawn out the other hole. One end of the wire is then connected to a terminating element and the other to a connector element.

In still another form of the invention, there is built into the coaxial cable a suitable cord running in part parallel to, although insulated from, the inner conductor. This cord extends through the outer conductor of the coaxial cable and is available to use, if desired, as a ripcord for easily removing a portion of the coaxial cable and thereafter a tap-off is positioned in the channel formed by said removal.

In the drawings:

FIGURE 1 is an exploded, cross-sectional view of a coaxial cable to which a tap-off is about to be applied.

FIGURE 2 is a cross-sectional view along line 2-2 of FIGURE 1.

FIGURE 3 is a view similar to that of FIGURE 2 in which the tap-off has been assembled with the coaxial cable.

FIGURE 4 is another form of the invention in which the tap-off has been assembled with the coaxial cable.

FIGURE 5 is another form of the invention in which the coaxial cable has been pre-tapped.

FIGURE 6 is a sectional view along line 6-6 of FIGURE 5.

FIGURE 7 is still another form of the invention in which the cable is pre-tapped by having a ripcord built into the coaxial cable.

FIGURE 8 is a sectional view along line 8-8 of FIGURE 7.

FIGURE 1 illustrates a conventional coaxial cable having an inner conductor 10, e.g., of copper, an outer conductor 11, e.g., of aluminum, and suitable insulating material 12, the latter, of course, not being present in the case of coaxial cable using air as the dielectric. The insulating material 12 can be of plastic or plastic foam having a continuous dielectric constant. The conventional coaxial cable is also usually provided with an exterior insulating sheath to thereby insulate outer conductor 11 from its surroundings, however, for simplicity, such an insulating sheath is not illustrated. Of course, when the outer conductor 11 is cut or removed in accordance with the present invention, the corresponding portions of the insulating sheath will likewise be cut or removed.

Before the tapping process began, the cable did not have the cutaway portion 13, but was uniform throughout its length. In order to install applicant's tap-off, part of the outer conductor 11 and the dielectric 12 were cut away as at 13. The cut-away portion may extend clear to the inner conductor 10 or may extend only part way thereto. In event the cut-away portion extends clear to the inner conductor, a piece of plastic or other insulating material 14 having the same dielectric constant as the insulating material 12 is then positioned over the outer conductor so as to insulate the same from the tap-off wire 15 about to be described. A suitable insert 16 including a section of outer conductor 17, e.g., of aluminum, a section of dielectric 18, e.g., of plastic foam, a piece of tap-off wire 15, e.g., of copper, a terminating resistor 19, and a coaxial connector 20, is adapted to feed into and substantially fill up the cavity 13 which was cut away. FIGURE 2 shows the apparatus in a partly assembled or exploded condition. After the insert 16 has been inserted into the cavity 13, and the apparatus assembled as shown in FIGURE 2, a plurality of spring steel clips 21 may be applied about the

insert 16 and the coaxial cable 10-11 at approximately two-inch intervals so that the parts are held firmly together.

Alternatively, a different form of clip as shown in FIGURE 4 may be used. In FIGURE 4 a tap shell 17 has resilient extensions 17' which in cooperation with the remaining portion of the lower part of the outer conductor 11 provides a strong friction grip between the tap-off insert 16 and the coaxial cable 10-11.

While the device shown in FIGURES 1-4 consists of almost evenly proportioned sections or "halves" of coaxial cable, the upper or lower sections can be interchanged, the proportions can be altered, and the methods of cutting or milling the cable can be changed without affecting the basic invention.

One extreme alteration is to eliminate the entire outer piece of cable and to substitute simply the output terminal 20, the conductor 15, and the terminating resistor or device 19.

A rotary saw or narrow milling device then cuts a slit of the necessary width, to the depth required to just expose the cable's center conductor 10. The branch conductor 15 is then lowered into the slit and separated from direct electrical contact either by its own coating of the same dielectric medium or by dropping in a section 14 of this media properly proportioned to fill the bottom of the hole, prevent direct contact, and space the conductors properly, or finally, by sawing in a controlled manner to a depth that still leaves enough dielectric covering the center conductor to act as the "spacer-dielectric." Assuming that of the 360° of outer cable conductor, the slit method cuts through only 1° to 5°, this method can be expanded to take out a more convenient "pie-shaped" wedge of more than 5° but less than 180°. At 180°, the result, of course, is that shown in FIGURES 1-4.

Cutting of the coaxial cable 10-11 can be accomplished in many ways. For example, utilizing a dentist's drill on a curved housing containing a flexible "tachometer" type drive, a curved hole is drilled through an arc entering the cable at 90° to its longitudinal axis and arriving at the center conductor parallel to its axis; then the drill is extended in a straight line along the conductor for the desired length. Finally, a hole is drilled at the termination of the parallel drill cut for the insertion and connection of the terminating device 19. Alternatively, a hole, either straight, curved, or angled, is drilled and an electrically heated device that is self-oriented by its shape to "ride" the center conductor in a straight line is inserted. While heated to a temperature that melts the dielectric, is pushed the desired length. Each of the above cutting methods then permits the insertion of the branch conductor 15.

As a refinement in the above described embodiments, the inner conductor 10, after the plastic insulating sheath 12 has been removed, can be shaped by, e.g., cutting, to better mate with the insert elements 14 and 15. The tap-off or branch conductor 15 should likewise be flat for a better mating fit and better inductive pick-up.

After the tap has been completed, the entire tap area should be enclosed in a weather-proof enclosure, for example, a weather-proof box supported by clamping to the messenger strand.

As an alternative, the coaxial cable when manufactured can be pre-tapped at pre-selected areas along the length of the coaxial cable to facilitate tapping off in accordance with the present invention.

In the pre-tapped form of FIGURE 5, an extended space 55 is provided between the central conductor 10 and the solid dielectric 12 at pre-selected areas along the coaxial cable 10-11 at the time the cable is manufactured. As manufactured the space 55 is filled with air or other suitable insulating gas, or alternatively, distilled water, oil, or other similar substance. When it is desired to provide a tap-off at one of the pre-selected areas, a hole 51 is drilled through the exterior of the cable 10-11 and in communication with one end of the extended space 55. An additional hole 52 is drilled through the exterior of cable 10-11 in communication with the other end of the ex-

tended space 55. A polyinsulated #12-14 copper solid wire is then inserted into the hole 51, caused to move through the extended space 55 and drawn out the hole 52. The ends of the wire 53 and 54 are then attached to a suitable terminating element 19 and connector 20. The first hole 53 is preferably slanted inwardly to facilitate insertion and entrance of the tap-off conductor 50 into the space 55 and the second hole 54 is preferably vertical or radial to facilitate withdrawal of the tap-off conductor 15. Alternatively, both holes 51 and 52 may be slanted.

A modified embodiment of the pre-tapped form is shown in FIGURE 7. In FIGURE 7 the coaxial cable 10-11 at the time of manufacture is provided with a built-in, removable section 71 at pre-selected areas along the length of the cable 10-11. When a tap-off is desired at one of the selected areas, the removable section 71 is pulled out and then replaced with a suitable tap-off conductor. After removal of the section 71, the tap-off conductor is inserted and withdrawn and electrically connected in like manner to that of conductor 50, described above. The removable sections 71 comprise a dielectric layer 72, identical to that of dielectric layer 12, preformed and coated with a lubricant 73 such as, but not limited to, Teflon and then implanted in the cable 10-11 during manufacture. A cord 70 of nylon or any sufficiently strong substance with an appropriate dielectric constant, i.e., a dielectric constant not too upsetting to the cable's standing wave ratio, is centered within the tubular plug section 71. The cord 70 is terminated in a button or "preweakened" section 74 of the outer cable conductor 11. Removal of the button or scribed section 74 permits access to the pull string 70 and the lubrication 73 permits pulling out the cord 70. A channel is then available for the insertion of a suitable branch or tap-off conductor.

The insertion loss for the pre-tapped cable shown in FIGURE 7 is on the order of  $\frac{3}{10}$  of a decibel at American Television VHF Channel 13. Careful manufacture of cable with this basic unit 72 manufactured into the cable, complete with the terminating resistors but without the connector, would permit installation without excessive loss from the non-used taps, which, although adding less than  $\frac{3}{10}$  of a decibel of loss in each instance, would not degrade the pictures due to the high "directionality" and minimal reflection. Cutting the cable and inserting prior art directional couplers causes losses on the order of 1.5 decibels. Pre-tapped cable could, therefore, have from seven to ten "pre-taps" before accumulating comparable losses to one tap which required cutting the cable. At the present state of CATV art, tap-off requirements can be predicted within 50% or less. As a consequence, pre-tapped cable will immediately result in less loss, even if error is maximum, and substantially less loss if errors are accurately predicted, than found in prior art devices.

This new tap-off maintains the normal electrical environment of the coaxial cable since the branch conductor and the inserted piece of cable is nearly identical with that part of the cable which had been cut away. The branch wire 15 is connected to the outer conductor 17 by a resistor 19 which represents the characteristic impedance of the branch conductor and thereby renders the tap-off a directional coupler. However, terminating element 19 can consist of any device capable of termination in satisfaction of the required "characteristic impedance" and is not limited to a resistor, to inductive or capacitive reactance or a combination thereof, nor to so-called "hybrid" circuitry representing resistance, inductance, and capacity. Similarly, the terminating element 19 can consist in single or narrow band circuitry of various configurations of "stubs" in multiples of quarter or half-wave lengths or in open or shorted single sections.

Although the described embodiments show the invention's application to typical foam dielectric, aluminum cable as currently used in community antenna cable distribution for television, closed circuit, and other video distribution systems, the basic principles outlined above

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and shown in the accompanying drawings are applicable to any coaxial cable using solid, semi-solid, or air dielectric between the encircling outer conductor and the center conductor.

I claim to have invented:

1. The method of tapping a coaxial cable having a center conductor and an outer conductor, both conductors being separated by an inner dielectric, which includes removing a limited portion of the outer conductor and placing a tap-off conductor within the area occupied by the inner dielectric adjacent to and in insulating relation to the center conductor.

2. The method of claim 1 in which the said tap-off conductor is terminated at one end in the characteristic impedance of the branch circuit.

3. The method of claim 1 in which a section of outer conductor is applied over the removed portion of the cable substantially flush with the remaining outer conductor.

4. The method of claim 1 in which the tap-off conductor includes means terminating it in the characteristic impedance of the branch circuit comprising an impedance between said tap-off conductor and said outer conductor.

5. The method of claim 1 in which a section of outer conductor is applied over the cut-away portion and the aforesaid tap-off conductor is fed out through said section of outer conductor.

6. The method of claim 1 in which the limited portion is removed by means of a ripcord built into the same.

7. The method of tapping a coaxial cable having an outer conductor, an inner conductor, a dielectric between said conductors and a ripcord built into the cable and extending through the dielectric which includes applying force to the ripcord thereby to remove a portion of the coaxial cable, inserting a branch circuit wire into the coaxial cable to a position adjacent to and insulated from the central conductor.

8. The method of claim 7 in which the branch wire is terminated in its characteristic impedance.

9. A tap for a coaxial cable comprising a branch conductor, a section of outer conductor, and a piece of dielectric connecting the branch conductor to the section of outer conductor; the branch conductor, the section of outer conductor, and the dielectric forming an insert adapted to be positioned in a cavity in the coaxial cable.

10. A tap-off connector for a coaxial cable as defined in claim 9 in which a terminating resistor is connected between one end of the branch conductor and the section of outer conductor.

11. A tap-off for a coaxial cable as defined in claim 10 having a coaxial connector mounted on the section of outer conductor adjacent the other end of the branch conductor, the coaxial connector having an outer sleeve electrically connected to the section of the outer conductor of the tap-off and also having an inner con-

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ductor connected to the end of the branch conductor which is opposite to the end which was terminated as aforesaid.

12. A coaxial cable and a tap therefor comprising an inner conductor, an outer conductor, a dielectric between the inner and outer conductors, an elongated cavity in the coaxial cable running along the length thereof, said cavity extending through the braid and at least part of the dielectric of the coaxial cable but not including the central conductor, an insert positioned in the cavity, said insert comprising a branch conductor, a piece of dielectric, and a section of outer conductor, said section of outer conductor making contact with the outer conductor of the coaxial cable and the branch conductor extending adjacent to but insulated from the central conductor of the coaxial cable.

13. A coaxial cable and a tap therefor as defined in claim 12 including terminating impedance means connected between one end of said branch conductor and the section of outer conductor of the insert.

14. A coaxial cable and a tap-off therefor as defined in claim 13 including a coaxial connector mounted on the outer conductor of the insert, said coaxial connector including an outer sleeve connected to the outer conductor of the insert and also including an inner conductor connected to the end of said branch wire opposite the end which was terminated as aforesaid.

15. A coaxial cable and a tap-off therefor as defined in claim 12, including a clip surrounding the insert and coaxial cable to hold the insert firmly within the coaxial cable.

16. A coaxial cable including an inner conductor, an outer conductor and dielectric between the inner conductor and the outer conductor, and a ripcord embedded in the dielectric for ripping an elongated channel in the dielectric and outer conductor.

17. A coaxial cable as defined in claim 16 in which said ripcord passes adjacent the central conductor for an extended distance so that it cuts an elongated channel in the coaxial cable adjacent the central conductor.

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HERMAN KARL SAALBACH, *Primary Examiner*.

M. NUSSBAUM, *Assistant Examiner*.

U.S. Cl. X.R.

174-10, 74; 333-96, 6