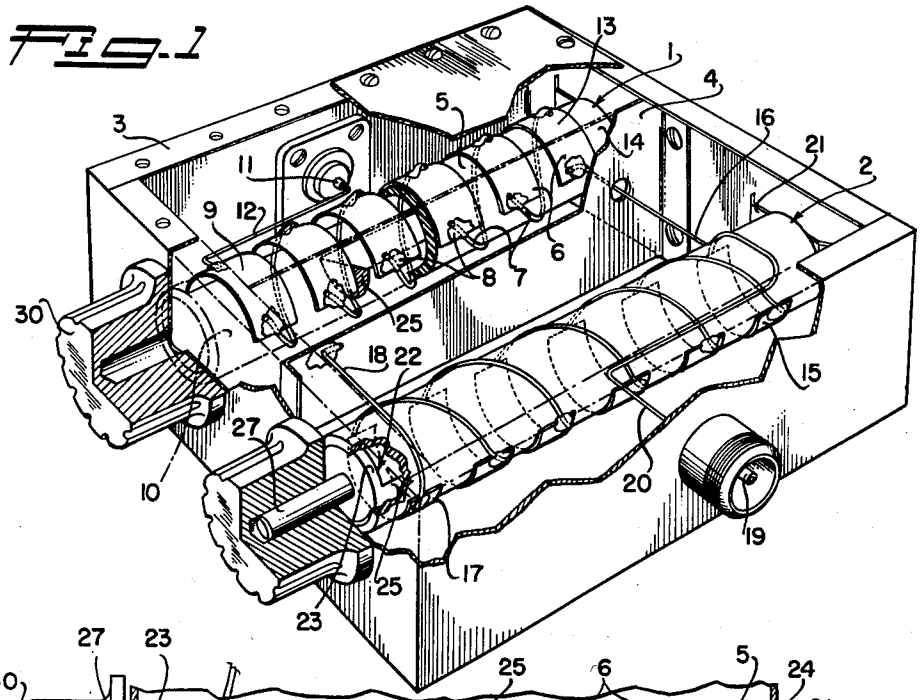
June 28, 1960 E. LOVICK, JR 2,943,276

VARIABLE ARTIFICIAL TRANSMISSION LINES

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Fig. 1



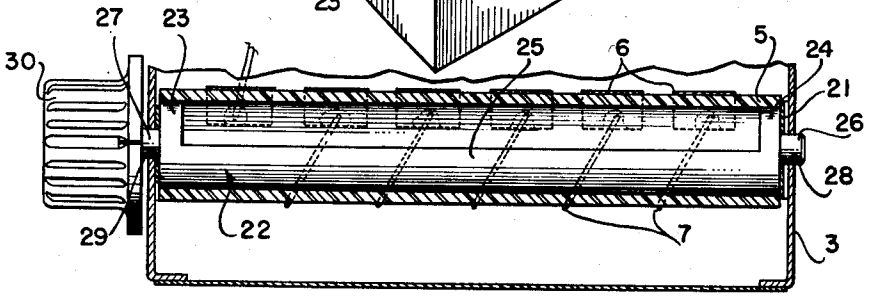


Fig. 2

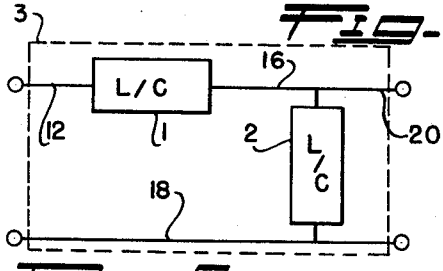


Fig. 3

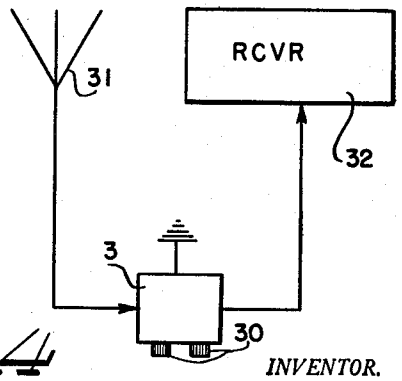


Fig. 4

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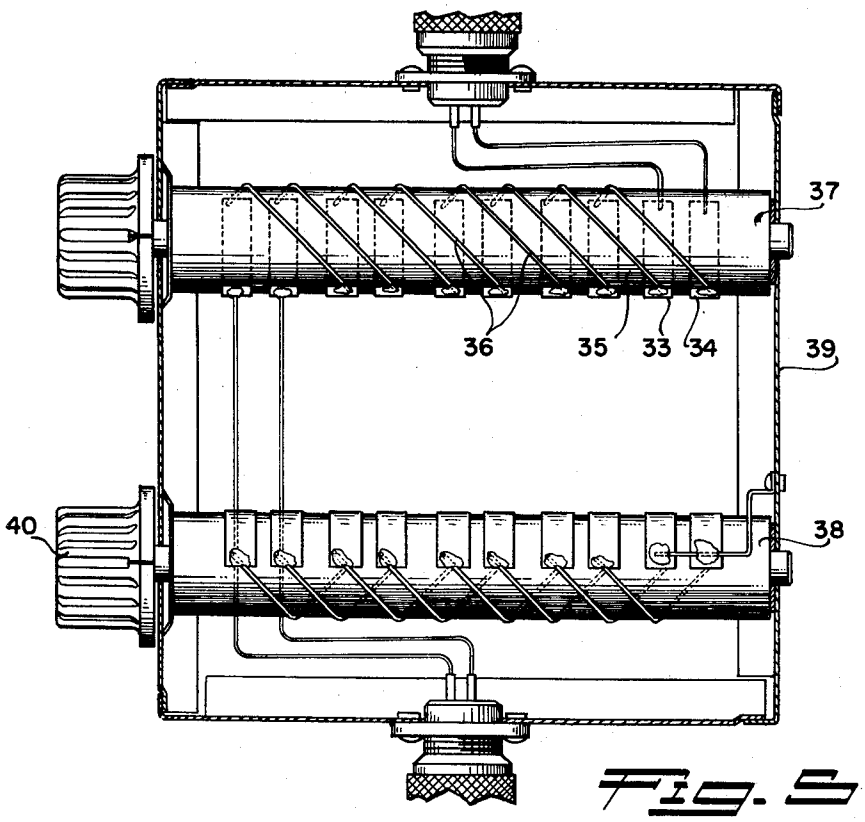


Fig. 5

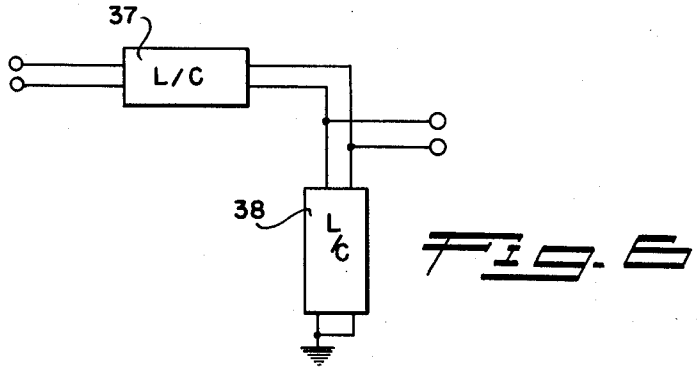


Fig. 6

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VARIABLE ARTIFICIAL TRANSMISSION LINES

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3 Claims. (Cl. 333—29)

This invention relates to variable electrical four-terminal networks and more particularly to a variable artificial transmission line element which simulates, within wide limits, any combination of inductance and capacitance for phase shifting or impedance matching purposes. Basically, the artificial line includes two elements each having a dielectric insulating tube with a number of conducting patches or plates mounted on the outer surface thereof. The conductive patches serve as one plate of a variable capacitor. Conductive wires or strips connect adjacent conductive patches and form a series inductance circuit which spirals around the outside of the dielectric tube. A cam-like semi-cylindrical conductive rotor is slidably carried within the dielectric tube for independent rotational movement causing a simultaneous increase in shunt capacitance and series inductance depending upon the direction of rotor rotation from an intermediate position.

The transmission line element may be designed so that the ratio between inductance and capacitance is constant and, therefore, the characteristic impedance may be specified and made independent of rotor position.

An object of this invention is to provide a variable artificial transmission line element which may be used as a variable phase shifter by matching the input impedance with the characteristic impedance of the element.

Another object of this invention is to provide a variable artificial transmission line element which may be used as a coupling device for impedance matching an antenna or the like with microwave transmitting or receiving equipment.

Another object of this invention is to provide a variable artificial transmission line element which may be used as a piece of test apparatus to determine the optimum transmission line electrical characteristics for communications equipment.

Another object of this invention is to provide a variable artificial transmission line element for either balanced or unbalanced lines which has negligible power losses and which is substantially unaffected by extreme environmental conditions or aging.

Still another object of this invention is to provide a variable artificial transmission line element which is rugged in construction and economical to manufacture.

Further and other objects will become apparent from a reading of the following detailed description especially when considered in combination with the accompanying drawing wherein like numerals refer to like parts.

In the drawing:

Figure 1 is a fragmentary perspective view showing the construction details of the unbalanced line version of the variable artificial transmission line;

Figure 2 is a sectional side view of one of the variable artificial transmission line elements shown in Figure 1;

Figure 3 is a schematic block diagram showing the electrical four-terminal coupling network for the variable artificial transmission line elements of Figure 1;

Figure 4 is a schematic block diagram showing a typical application of the variable artificial transmission line element;

Figure 5 is a sectional plan view showing the construction of the balanced line version of the variable artificial transmission line; and

Figure 6 is a schematic block diagram showing the electrical coupling network for the variable artificial transmission line elements of Figure 5.

Referring to Figure 1 a pair of variable artificial transmission line elements **1** and **2** are carried within a shielding, box-like container **3**. Elements **1** and **2** are electrically isolated from one another by a partition **4** which is suitably secured to the walls of the container.

Each variable artificial transmission line element **1** and **2** includes a tubular member **5** of dielectric material as shown in Figures 1 and 2 and a plurality of curved or semi-cylindrically shaped conductive plates **6** secured to the outer surface of the dielectric tube such as by bonding with an adhesive. The plates are equally spaced axially of the tube on a longitudinal segment thereof and in alignment with one another. A plurality of conductive wires or straps **7** are connected at each end to adjacent plates **6** by wrapping the wire around the outside of tube **5** as best shown in Figure 1 to form a spiralling series circuit. Solder **8** or other suitable means may be used to provide the electrical connection between plates **6** and wires **7**. Plate **9** at one end **10** of tube **5** connects with a terminal socket **11** through lead **12**. Terminal socket **11** is carried by housing **3** for electrically connecting the variable artificial transmission line with an external circuit such as is schematically illustrated in Figure 4. Plate **13** adjacent the opposite end **14** of tube **5** connects with the corresponding plate **15** on the other variable artificial transmission line element **2** through lead **16**. Plate **17**, the last in the element **2** plate assembly is connected with ground through lead **18** by securing the lead onto partition **4** within container **3**.

A second terminal post **19** carried by container **3** connects with lead **16** joining variable artificial transmission line element **1** with variable artificial transmission line element **2** through lead **20** to provide a parallel circuit arrangement for the two transmission line elements as schematically indicated in Figure 3. The resulting circuit, hereinafter referred to as the variable artificial transmission line as distinguished from the variable artificial transmission line elements, provides a wide range of inductance and capacitance in a versatile four-terminal or L network for accomplishing any of a number of functions such as those enumerated in the statement of the objects.

Dielectric tube **5** of each variable artificial transmission line element **1** and **2** is suitably restrained against rotation relative to container **3** by connections with terminal posts **11** and **19** as well as by spring-like brackets **21** carried on the inside of the container.

A core or rotor **22** having a pair of cylindrically shaped end portions **23** and **24** and a semi-cylindrically shaped center portion **25**, as most clearly shown in Figure 2, is provided for each variable artificial transmission line element. Rotor **22** is slidably received within dielectric tube **5**. Cylindrically shaped end portions **23** and **24** of rotor **22** serve to support and align the rotor with respect to the dielectric tube and position the curved surface of the rotor closely adjacent a longitudinal segment of the inner surface of the dielectric tube. While center portion **25** of the rotor is shown and described herein as being semi-cylindrical, it should be understood that any cross-sectional shape may be employed so long as a cam-like action is effectively obtained to provide means for varying the inductance and capacitance of the external circuit.

Shafts **26** and **27**, one at each end of rotor **22** extends

through openings such as openings 28 and 29 in container 3 to provide the primary means of support for each variable artificial transmission line element. A knob 30 secured to shaft 27 exteriorly of container 3 provides a convenient means for positioning rotor 22 relative to plates 6 and wires 7.

Rotor 22 serves to control both the inductance and capacitance of the plate and wire arrangement surrounding the outside of dielectric tubes 5. When semi-cylindrical center portion 25 of the rotor is moved by rotor rotation to a position adjacent plate 6 and spaced from wire 7 both a high capacitance and high inductance will be obtained. When rotor 22 is rotated to the opposite position wherein the semi-cylindrical center portion 25 is spaced a maximum distance from plates 6 and adjacent wires 7 both the capacitance and inductance of the circuit will be at a minimum. Intermediate rotational positions of rotor 22 will result in providing inductance and capacitance values which are between the maximum and minimum values obtained by the two extreme rotor positions described above. Both the inductance and capacitance vary directly and simultaneously so that the ratio therebetween may be made constant for all rotor positions wherein the variable artificial transmission line elements may be designed having a fixed characteristic impedance.

The upper and lower limits of capacitance and inductance of each transmission line element will depend upon the size and number of plates 6, the diameter and thickness of dielectric tube 5 and upon the length of wires 7 as well as upon the particular type of materials used. All of these factors should be considered when designing an element to meet the performance requirements of a given case.

Figure 4 schematically illustrates a typical application of the variable artificial transmission line described above wherein the unit shown in Figure 1 is connected in series with an antenna 31 and receiver 32 for impedance matching purposes. By simply rotating rotors 22 through knobs 30 to introduce the desired amount of inductance and capacitance into the circuit the impedance of the antenna may be matched with that of the receiver to increase the effective signal strength and thereby improve receiver operation. As previously set forth the artificial transmission line may also be used as a phase shifter or as a piece of test apparatus to determine the optimum impedance for a coupling network.

The variable artificial transmission line element configuration shown by Figures 1 through 3 is applicable to unbalanced transmission lines only. Where the device is to be used with balanced transmission lines a slight modification of the circuitry is required as shown in Figure 5 wherein a pair of plates 33 and 34 are substituted for each of the plurality of plates 6 in the Figure 1 configuration. Thus in the balanced line version of the transmission line elements, two separate circuits may be provided on the outside of dielectric tubes 35. Induction wires or straps 36 connect the corresponding plates together to furnish the twin lead type of coupling illustrated in Figure 6. The construction of container 39 and the means for supporting elements 37 and 38 is substantially identical to the construction shown and described in connection with Figure 1.

The balance line version of the variable artificial transmission line elements as shown in Figures 5 and 6 operates to provide a wide range of inductance and capacitance through rotation of knobs 40 in the same manner as was described for the unbalanced line version of Figure 1. It is particularly useful as an impedance matching device for television receiving or transmitting equipment where balanced line circuitry is commonly employed.

It is to be understood that certain alterations, modifications and substitutions may be made to the instant disclosure without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A variable artificial transmission line having a substantially constant characteristic impedance comprising, a pair of tubular dielectric members, a series of semi-cylindrical conductive plates secured to one semi-cylindrical portion of the outer wall of each said dielectric member, said conductive plates being spaced apart and axially aligned with one another, a plurality of helical inductive wire segments confined to the other longitudinal semi-cylindrical portion of the outer wall of each said dielectric member and having their opposite ends electrically connecting adjacent conductive plates forming a single continuous electrical circuit spiralling around each said dielectric member, a conductive core, generally semi-circular in cross section, rotatably carried within each dielectric member, means for rotating each conductive core, and means electrically connecting the continuous electrical circuits formed on said tubular members in parallel whereby the inductance and capacitance of the circuit may be varied in a direct relationship over a wide range by rotation of the conductive cores.

2. A variable artificial transmission line element comprising, a tubular dielectric member, a plurality of spaced, semi-cylindrical conductive plates secured to one longitudinal semi-cylindrical portion of the outer wall of said dielectric member and aligned with each other axially of the dielectric member to serve as one side of a variable capacitor, a plurality of inductive wire segments confined to the other longitudinal semi-cylindrical portion of said dielectric member and having their opposite ends electrically connecting adjacent conductive plates and forming with said plates a continuous circuit spiralling around said tubular dielectric member for conducting electrical energy, and a conductive semi-cylindrical core rotatably carried within said tubular dielectric member and closely adjacent the inner wall of said member whereby to simultaneously vary the inductance and capacitance of the circuit while maintaining a nearly constant characteristic impedance.

3. A variable artificial transmission line element comprising, a tubular dielectric member, a plurality of pairs of spaced semi-cylindrical conductive plates secured to one longitudinal semi-cylindrical portion of the outer wall of said dielectric member and aligned with each other axially of the dielectric member to serve as one side of a variable capacitor, a plurality of inductive wire segments confined to the other longitudinal semi-cylindrical portion of said dielectric member and electrically connecting alternate conductive plates together to form a pair of continuous electrical circuits spiralling around said tubular dielectric member for conducting electrical energy, and a conductive semi-cylindrical core rotatably carried within said tubular dielectric member and closely adjacent the inner wall of said member whereby to simultaneously vary the inductance and capacitance of the electrical circuits while maintaining a nearly constant characteristic impedance.

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