April 12, 1955 R. J. JACOBI 2,706,277

TUNABLE RESONANT STRUCTURE

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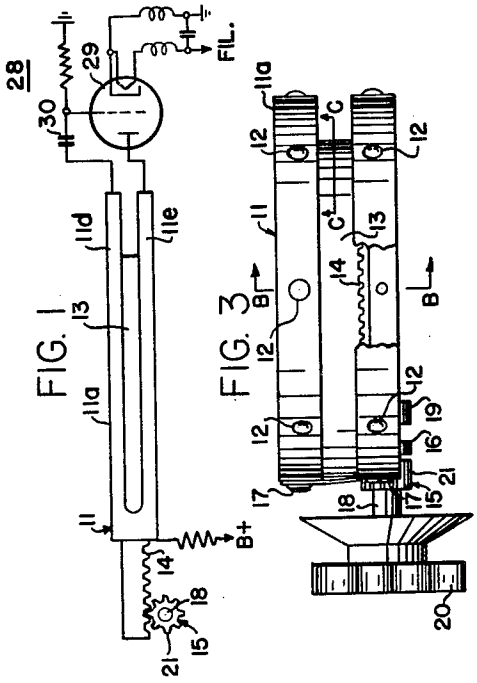


FIG. 1

FIG. 3

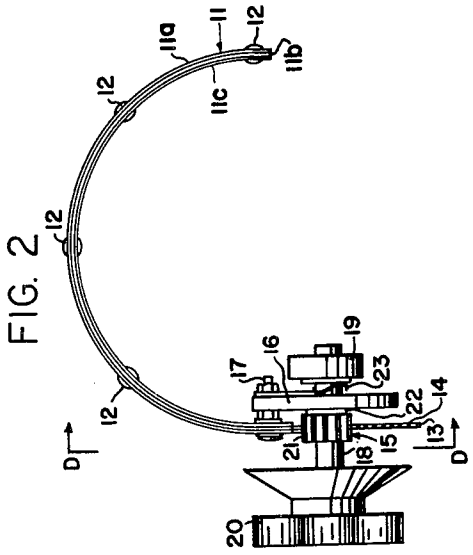


FIG. 2

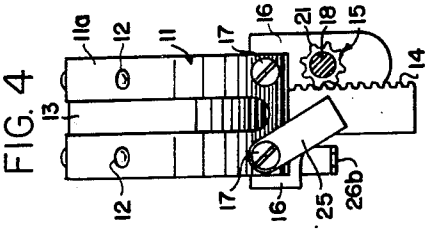


FIG. 4

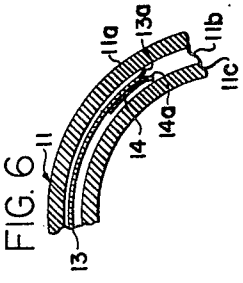


FIG. 6

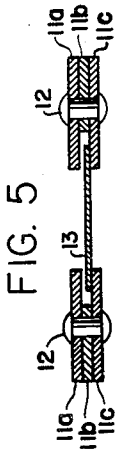


FIG. 5

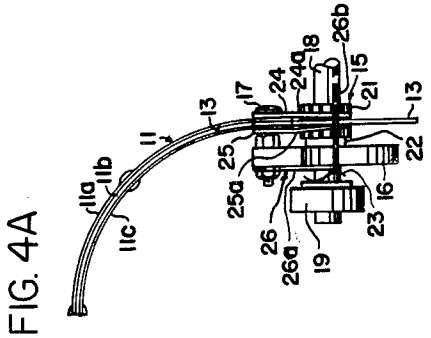


FIG. 4A

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TUNABLE RESONANT STRUCTURE

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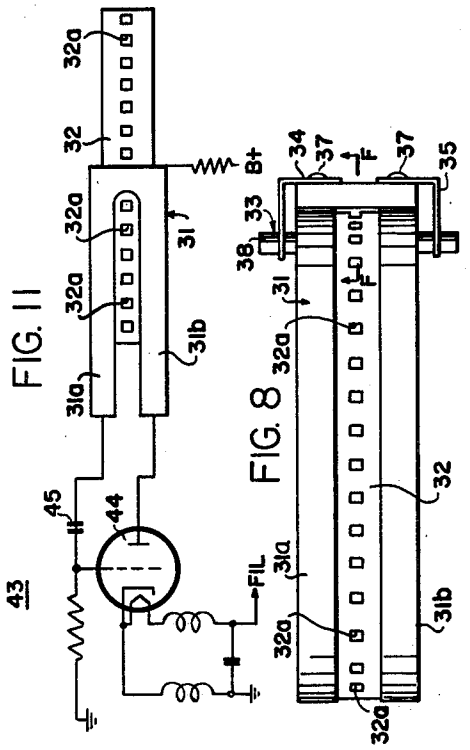


FIG. 11

FIG. 8

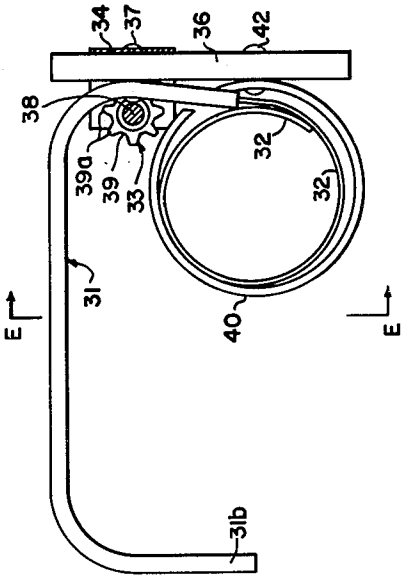


FIG. 7

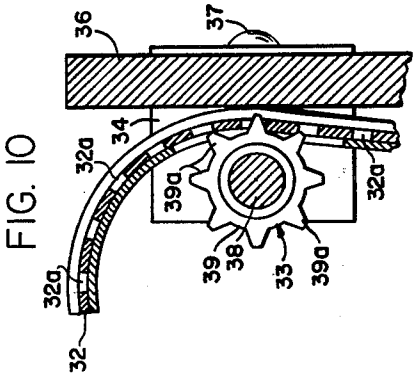


FIG. 10

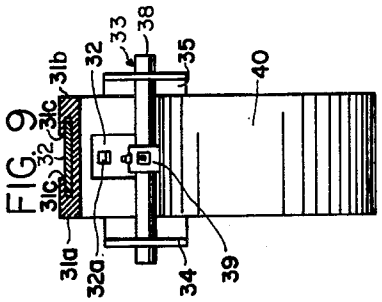


FIG. 9

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TUNABLE RESONANT STRUCTURE

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Application November 27, 1951, Serial No. 258,445

6 Claims. (Cl. 333—82)

The present invention relates in general to resonant tuning systems, and more particularly to a tunable resonant structure adaptable for use in a distributed constant radio frequency tunable resonant circuit.

In tunable resonant structures, having a wide range to cover in the ultra-high frequency band, movable shorting bars have been used for selecting the resonant frequency by controlling the electrical characteristic length of the conductors. However, such shorting bars provided an open line section behind the resonant section. Therefore, an open section is provided with the shorting bar somewhere in the electrical center. Such a condition hinders the operation of an oscillator when both open sections have approximately the same resonant frequency, by dissipating the energy therein in both sections, thereby cutting off the oscillatory state. Further, the shorting bars heretofore used have never been adaptable for accurate micromatic tuning.

Accordingly, an important object of the present invention is to provide a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit wherein there is no open section behind the resonant portion thereof by providing a ribbon shorting member.

Another object of the present invention is to provide a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit wherein accurate tuning is provided by having a variably positioned shorting member driven by a gear mechanism.

Another object of the present invention is to provide a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit wherein accurate tuning is provided by having a variably positioned shorting member sprocket driven.

Another object of the present invention is to provide a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit wherein improved oscillatory characteristics and accurate tuning are provided by having a ribbon shorting member sprocket driven.

Another object of the present invention is to provide a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit wherein improved oscillatory characteristics and accurate tuning are provided by having a ribbon shorting member driven by a gear mechanism.

Another object of the present invention is to provide a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit that occupies a minimum of space by providing therein an arcuate shaped conductor and a contour conforming flexible ribbon shorting member.

Another object of the present invention is to provide a durable tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit by providing a U-shaped channel conductor for receiving the ribbon shorting member.

Other objects will appear upon further perusal of the detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a partial schematic diagram illustrating an oscillatory circuit utilizing the tunable resonant structure embodying the present invention;

Figure 2 is a front elevational view illustrating the novel tunable resonant structure embodying the present invention;

Figure 3 is a plan view of the tunable resonant structure;

Figure 4 is a sectional view taken substantially along the line D, D, of Figure 2 and particularly illustrating the tooth edge of the ribbon shorting member and the sprocket gear wheel.

Figure 4A is a partial rear view particularly illustrating the guide members for the flexible ribbon shorting member of the tunable resonant structure;

Figure 5 is an enlarged sectional view taken substantially along the line B, B, of Figure 3 and particularly illustrating the structure of the U-shaped channel conductor;

Figure 6 is an enlarged sectional view taken substantially along the line C, C, of Figure 3 and particularly illustrating the shorting contact structure of the ribbon shorting member;

Figure 7 is a front elevational view of a modification of the tunable resonant structure embodying the present invention;

Figure 8 is a top view of the modification of the tunable resonant structure;

Figure 9 is a sectional view taken substantially along the line E, E, of Figure 7 and particularly illustrating the structure of the U-shaped channel conductor;

Figure 10 is an enlarged sectional view taken substantially along the line F, F, of Figure 8 and particularly illustrating the sprocket driving mechanism and the ribbon shorting member; and

Figure 11 is a partial schematic diagram illustrating an oscillatory circuit utilizing a modification of the novel tunable resonant structure embodying the present invention.

Briefly described, a tunable resonant structure is herein provided adaptable for use in a distributed constant tunable resonant circuit. The tunable resonant structure functions on a transmission line theory and is basically a quarter wave length section.

In one embodiment, the tunable resonant structure comprises a U-shaped channel conductor made of suitable conducting material, such as brass. For controlling the electrical characteristic length of the U-shaped channel conductor, a flexible ribbon shorting member or tape made of suitable conducting material, such as Phosphor bronze, is provided. The flexible ribbon shorting member is suitably received by the U-shaped channel and cooperatively engages the conductor for establishing the electrical characteristic length thereof.

For variably positioning the flexible ribbon shorting member relative to the conductor, one embodiment of the present invention provides a suitable gear driving mechanism which intermeshes with the tooth edge of the flexible ribbon shorting member for imparting lateral movement thereto relative to the U-shaped channel conductor. Another embodiment of the present invention provides a suitable sprocket driving mechanism which is suitably received by the apertures in the flexible ribbon shorting member for imparting lateral movement thereto relative to the conductor.

In more detail, tunable resonant structures are herein provided to cover the UHF television band. Lump circuit perameters are both impractical and impossible to use to cover the range between 470 megacycles and 900 megacycles.

Referring now to Figures 1–6, inclusive, one embodiment of the novel tunable resonant structure comprises a U-shaped channel conductor **11** made of suitable conducting material, such as three separate conducting strips **11*a***, **11*b*** and **11*c***, as shown in Figure 5. It is to be noted that the U-shaped conductor **11** may be integrally formed from a single piece, as shown in Figure 9. For securing the strips **11*a***, **11*b*** and **11*c***, suitable means are provided, such as rivets **12**. Each conductor strip, such as **11*a*** and **11*c***, is a stamping, having spaced-apart portions **11*d*** and **11*e***.

For controlling the electrical characteristic length of the U-shaped channel conductor **11**, thereby selecting the resonant frequency of the tunable resonant structure, a flexible ribbon shorting member **13**, or tape, is provided, made of suitable conducting material, such as Phosphor bronze. The shorting member **13** is an elon-

gated flexible ribbon having teeth **14** at one edge thereof. The conductor **11** has the strips **11***a* and **11***c* suitably spaced by the strip **11***b* so as to receive the flexible ribbon shorting member **13** to provide lateral movement therebetween and still cooperatively engage the flexible ribbon shorting member **13** for establishing electrical contact engagement.

For providing improved contact engagement between the conductor strips **11***a* and **11***c* and the shorting member **13**, one end of the ribbon shorting member facing the open end of the tunable resonant structure is provided with an outwardly extending flange **13***a*, as shown in Figure 6. In addition thereto, a flexible ribbon strip **14** made of suitable conducting material, such as Phosphor bronze, is secured to the flexible ribbon shorting member **13**, as shown in Figure 6, by suitable means, such as solder. The flexible ribbon strip **14** has an outwardly extending flange **14***a* for further improving the contact engagement between the shorting member **13** and the conductor **11**.

It is to be particularly noted that it is a feature of the present invention to prevent two open line sections in the tunable resonant structure by providing a ribbon shorting member that is elongated and extends to the shorted end of the tunable resonant structure. Noteworthy is the advantage gained by this feature; in the event two open end line sections are present with a short in the middle thereof, the energy is dissipated in both sections, thereby hindering the oscillatory state and at times preventing continuous oscillations. This is particularly noticeable in the event both sections have approximately equal wave length.

In order to provide a tunable resonant structure that would occupy a minimum of space, another feature of the present invention is to provide an arcuate configuration for the U-shaped conductor **11**, which in the preferred embodiment is semi-circular, as shown in Figure 2. The flexible ribbon conductor **13** has a configuration which is also substantially semi-circular and conforms to the contour of conductor **11**. It is to be understood that the conductor **11** and the ribbon shorting member **13** can be straight pieces.

For variably positioning the flexible ribbon conductor **13** relative to the U-shaped conductor **11** in order to select the resonant frequency of the tunable resonant structure, a gear driving mechanism **15** is provided.

Suitable means, such as bracket **16**, is provided for mounting the gear mechanism **15** to the tunable resonant structure and is secured to the conductor **11** by suitable means, such as a screw and nut arrangement **17**.

A rotatable shaft **18** is suitably received by an aperture in the bracket **16**. At one end of the shaft **18** is suitably positioned a collar **19** fixedly secured thereto for preventing excessive lateral displacement of the shaft **18**. For rotating the shaft **18** suitable means are provided, such as knob **20**, made of suitable insulating material, such as hard rubber or plastic. For driving the variably positioned ribbon shorting member **13**, a spur gear wheel **21** is provided which is fixedly secured to the shaft **18** and suitably positioned thereon to cooperatively engage the tooth edge **14** of the flexible ribbon shorting member **13**. Washer **22** is positioned between the spur gear wheel **21** and the bracket **16**, and spring washer **23** is positioned between collar **19** and bracket **16** to further prevent excessive lateral movement of the shaft **18**.

For guiding the movement of the flexible ribbon shorting member **13** at the open end of the tunable resonant structure, guide members **24** and **25** are provided. The guide members **24** and **25** are secured to the conductor **11** by suitable means, such as the screw and nut arrangement **17**. The guide members **24** and **25** have inturned portions **24***a* and **25***a*, respectively, facing one another so as to provide a narrow guiding passageway for the portion of the shorting member **13** protruding out of conductor **11** at the open end of the tunable resonant structure. For retaining the ribbon member **13** so that the tooth edge **14** constantly engages the spur gear wheel **21**, retaining member **26** is provided. The retaining member **26** is a right angle piece suitably secured to the bracket **16** at the straight portion **26***a* by the screw and nut arrangement **17**. The bent portion **26***b* of the retaining member **26** at one edge thereof abuts against the edge of the shorting member **13**.

In operation, an operator rotates the knob **20** to rotate the shaft **18** which in turn rotates the spur gear wheel **21** secured thereto. The movement of the spur gear wheel **21** imparts lateral movement to the flexible ribbon shorting member **13** relative to the U-shaped channel conductor **11** by having the spur gear wheel **21** intermesh with the teeth **14** of the shorting member **13**.

Referring now to Figure 1, for a preferred line tuned oscillatory circuit **28** utilizing the novel structure of the present invention, the oscillatory circuit **28** comprises a suitable triode tube **29** having the plate thereof suitably connected to the spaced portion **11***e* of the U-shaped channel conductor **11** at the open end of the tunable resonant structure. The plate of the tube **29** is suitably connected to B+ potential by conductor **11**. The grid of the tube **29** is suitably connected to the spaced portion **11***d* of the conductor **11** through a blocking condenser **30** at the open end of the transmission line.

The operation of the oscillatory circuit **28** is conventional in that a quarter wave length section is variably tuned to select the oscillatory frequency for the line tuned oscillator **28**.

Referring now to Figures 8–10, inclusive, another embodiment of the novel tunable resonant structure comprises a U-shaped channel conductor **31** made of suitable conducting material, such as brass. As shown in Figure 9, the U-shaped channel conductor **31** is an integrally formed piece. The U-shaped channel conductor **31** has spaced-apart portions **31***a* and **31***b*. The spaced-apart portions **31***a* and **31***b* have included therein grooves **31***c*, as shown in Figure 9, to provide a channel or passageway for suitably receiving a ribbon shorting member or tape **32**. The grooves **31***c* are suitably spaced so as to enable the ribbon shorting member **32** to have lateral movement therethrough and still enable the ribbon shorting member **32** to cooperatively engage the U-shaped conductor **31** for establishing electrical contact engagement.

For controlling the electrical characteristic length of the U-shaped channel conductor **31**, thereby selecting the resonant frequency of the tunable resonant structure, the flexible ribbon shorting member **32** is provided and is made of suitable conducting material, such as Phosphor bronze. The shorting member **32** is an elongated flexible ribbon having a series of suitably spaced and shaped apertures **32***a* at the central portion thereof. The flexible shorting ribbon **32** is suitably received by the grooves **32***c* so as to enable lateral movement therethrough relative to the U-shaped conductor **31** and still cooperatively engage the U-shaped conductor **31** for establishing electrical contact engagement therewith. The flexible ribbon shorting member conforms to the contour of the U-shaped channel conductor **31**.

For variably positioning the flexible ribbon shorting member **32** relative to the U-shaped conductor **31** in order to select the resonant frequency of the tunable resonant structure, a sprocket driving mechanism **33** is provided.

Suitable means, such as brackets **34** and **35**, are provided for mounting the sprocket driving mechanism **33** to a support means, such as an insulated terminal strip **36** of the tunable resonant structure. The sprocket driving mechanism **33** and the U-shaped conductor **31** are secured to the terminal strip **36** by suitable means, such as a screw and nut arrangement **37**.

Rotatable shaft **38** made of suitable insulating material is suitably received by apertures in the brackets **34** and **35**. For driving the variably positioned ribbon shorting member **32**, a sprocket wheel **39** is provided which is fixedly secured to the shaft **38** and has projections **39***a* thereon which are suitably received by the apertures **32***a* for cooperative engagement with the flexible ribbon shorting member **32** for imparting lateral movement thereto, relative to the U-shaped conductor **31**.

For guiding the movement of the flexible ribbon shorting member **32** protruding out of the portion of the conductor **31**, an arcuate guide member **40** is provided and in the preferred embodiment is substantially circular. The guide member **40** is secured to the terminal strip **36** by suitable means, such as a nut and screw arrangement **42**. The flexible ribbon shorting member **32** engages the inner surface thereof and winds in a spiral configuration, as shown in Figure 7.

In operation, an operator rotates the shaft **38** which in turn rotates the sprocket wheel **39** secured thereto. The movement of the sprocket wheel **39** imparts lateral movement to the flexible ribbon shorting member **32** relative to the U-shaped channel conductor **31** by having

the projections 39*a* of the sprocket wheel 39 engaging the shorting member 32 by extending through the apertures 32*a*.

Referring now to Figure 11, for a preferred line tuned oscillatory circuit 43 utilizing the novel tuning structure of the present invention, the oscillatory circuit 43 comprises a suitable triode tube 44 having the plate thereof suitably connected to the spaced portion 31*b* of the U-shaped channel conductor 31 at the open end of the tunable resonant structure. Through the conductor 31, the plate of the triode tube 44 is connected to B+ potential. The grid of the triode tube 44 is suitably connected to the spaced portion 31*a* of the conductor 11 through a blocking condenser 45 at the open end of the transmission line.

The operation of the oscillatory circuit 43 is conventional in that a quarter wave length section is variably tuned to select the oscillatory frequency for the line tuned oscillatory circuit.

It is to be understood that variations and modifications may be effected without departing from the scope of the appended claims.

I claim:

1. In a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit, a source of ultra high frequency energy, a distributed constant transmission line comprising two conductors connected to said source of energy, a ribbon shorting member of conductive material conductively engaging both conductors of said transmission line along a length thereof extending from the end of said transmission line remote from the connection of said transmission line to said source for controlling the electrical characteristic length of said transmission line, and means variably controlling the length of said ribbon shorting member engaging said transmission line for varying the length of said transmission line engaged by said shorting member and thus selecting the resonant frequency of said tunable resonant structure.

2. In a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit, a source of ultra high frequency energy, a distributed constant transmission line comprising two conductors each of which is in the form of a U-shaped channel, said conductors being connected to said source of energy, a ribbon shorting member of conductive material movable in said U-shaped channel conductors and conductively engaging both of said U-shaped channel conductors along a length thereof extending from the end of said transmission line remote from the connection of said transmission line to said source for controlling the electrical characteristic length of said transmission line, and means variably controlling the length of said ribbon shorting member engaging said U-shaped channel conductors for varying the length of the transmission line engaged by said ribbon shorting member and thus selecting a resonant frequency of said tunable resonant structure.

3. In a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit, a source of high frequency energy, a distributed constant transmission line comprising two conductors, said transmission line having an arcuate configuration for conserving space and connected to said source of energy, a flexible ribbon shorting member of conductive material having a contour conforming to the configuration of said transmission line and conductively engaging both conductors of said transmission line along a length thereof extending from the end of said transmission line remote from the connection of said transmission line to said source for controlling the electrical characteristic length of said transmission line, and means variably controlling the length of said ribbon shorting member engaging said transmission line for varying the length of the transmission line engaged by said ribbon shorting member and thus selecting the resonant frequency of said tunable resonant structure.

4. In a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit, a source of ultra high frequency energy, a distributed constant transmission line comprising two conductors connected to said source of energy, a ribbon shorting member of conductive material conductively engaging both conductors of said transmission line along a length thereof extending from the end of said transmission line remote from the connection of said transmission line to said source for controlling the electrical characteristic length of said transmission line, and a gear driving mechanism variably controlling the length of said ribbon shorting member engaging said transmission line for varying the length of the transmission line engaged by said ribbon shorting member and thus selecting the resonant frequency of said tunable resonant structure.

5. In a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit, a source of radio frequency energy, a distributed constant transmission line comprising two conductors connected to said source of energy, a ribbon shorting member of conductive material conductively engaging both conductors of said transmission line along a length thereof extending from the end of said transmission line remote from the connection of said transmission line to said source for controlling the electrical characteristic length of said transmission line, and a sprocket driving mechanism variably controlling the length of said ribbon shorting member engaging said transmission line for varying the length of the transmission line engaged by said ribbon shorting member and thus selecting the resonant frequency of said tunable resonant structure.

6. In a tunable resonant structure adaptable for use in a distributed constant tunable resonant circuit, a source of ultra high frequency energy, a distributed constant transmission line having a support means, said transmission line comprising two channel conductors attached to said support means and connected to said source of energy, a flexible ribbon shorting member of conductive material conductively engaging and variably positioned in both of said channel conductors for controlling the electrical characteristic length of said conductors and having a portion thereof extending out of said conductors from the ends of said conductors remote from the connection thereof to said source of energy, a ribbon guiding member having a circular configuration attached to said support means and having the inner peripheral surface thereof engaged by the portion of said flexible ribbon shorting member extending out of said conductors for guiding said ribbon shorting member, and means variably positioning said flexible ribbon shorting member in said channel conductors, whereby the portion of said flexible ribbon shorting member extending out of said conductors engages the inner peripheral surface of said guiding member for providing a spiral configuration.

References Cited in the file of this patent

UNITED STATES PATENTS

2,159,782	Conklin et al.	May 23, 1939
2,246,928	Schick	June 24, 1941
2,292,254	Van Beuren	Aug. 4, 1942
2,405,229	Mueller et al.	Aug. 6, 1946
2,468,147	Vonada	Apr. 26, 1949
2,516,990	Herold	Aug. 1, 1950
2,523,725	Schmidt	Sept. 26, 1950
2,581,680	Martenot	Jan. 8, 1952