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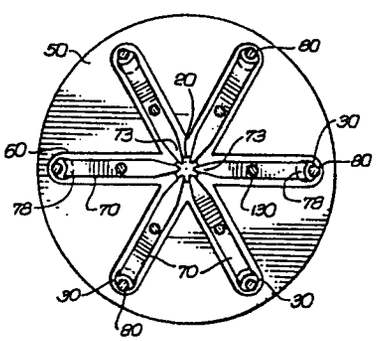
(54) **Self terminating coaxial switch.**

(57) A self-terminating coaxial microwave switch is provided having a moving termination resistor (80). The microwave switch is provided in a multi-position coaxial microwave switching device (10) having a plurality of peripheral coaxial terminals (30) distributed about a central coaxial terminal. A movable termination resistor is provided for each peripheral coaxial terminal. A conductor reed (70) is also provided for each peripheral coaxial terminal, connecting a selected peripheral coaxial terminal to the central coaxial terminal. For each peripheral coaxial terminal, the corresponding termination resistor and conductor reed physically contact different portions of the same peripheral coaxial terminal.

Fig. 2



EP 0 211 541 A2

SELF TERMINATING COAXIAL SWITCH

This invention relates to a self-terminating coaxial switch.

In the field of cable switching devices generally, and more specifically of switches incorporated in multi-position coaxial microwave switching devices, it is is generally known that it is advantageous to provide a coaxial microwave switch for use in a multi-position switching device with a termination resistance provided at each position for each coaxial terminal such that any terminal not being used for transmission of a signal ends in a termination resistance. This termination resistance is typically a 50 ohm resistor. Various means of providing switches with such features have been shown, generally using thin, narrow conductor reeds. For example, a conductor reed may be selectively placed in contact between the common coaxial terminal of a multi-position switching device and a selected one of many coaxial terminals, providing a microwave signal path between the common terminal and the selected terminal. Alternatively, a termination reed may be selectively placed in contact between the selected coaxial terminal and a termination resistance. In this way, any signal path not being used for transmission may be provided with a termination resistor. For example, see U.S. Patent No. 4,298,847 to Hoffman, the inventor herein.

Such reeds must be made to operate in alternating engagement, which generally requires the use of rocker arms and solenoids. This is because, for a selected coaxial terminal, either the common coaxial terminal or the termination resistor is connected to the coaxial terminal at any given time. Such switches require many moving parts and careful assembly. For example, conductor reeds for the signal path and for the

termination resistor are required, as well as springs for each such reed. These reeds may be placed in a "dog-leg" arrangement, where the signal path reed is positioned adjacent to, but at an angle from, the termination resistor reed, both reeds terminating at one end at a common coaxial terminal. Thus, when a plurality of such switches are used to construct a multi-position microwave switching device, the number of coaxial terminals is limited by the geometry required to accommodate the switches within a housing.

An object of the present invention is to provide a more compact, self-terminating, coaxial switch for use in a multi-position coaxial microwave switching device, with fewer moving parts. This results in a more economical switch, with increased reliability, and allows for more coaxial terminals in a multi-position coaxial microwave switching device of a given size.

According to one aspect of the present invention, there is provided in a self-terminating coaxial microwave switch having a first terminal that is selectively connectable to a second terminal by a reed conductor and that has a termination resistor, the improvement wherein:

said reed conductor and said termination resistor alternately directly and mechanically contact said first terminal.

Preferred embodiments of the present invention provide a self-terminating microwave switch that is a less complicated mechanism that those currently in use, for added reliability, compact dimension, and easier production. Principally, in one embodiment the termination resistor is allowed to physically move into and out of contact with a coaxial connector. A conductor reed is provided for connecting a selected coaxial terminal to the common coaxial terminal. One end of the termination resistor and one end of the conductor reed physically contact the same coaxial terminal. In this way, termination resistor reeds are not required, resulting in a simpler, more compact switch.

A rocker arm may be provided, where one end of the rocker arm moves the termination resistor and the other end moves the conductor reed, the rocker arm being actuated by either a solenoid or by a magnetic latch. In one embodiment of the invention, springs are provided at both ends of the termination resistor such that an "at-rest" or "power-off" position is established and so that the resistor does not tend to stay at either end of its travel when the rocker arm is moved.

In another aspect, the invention provides a multi-position microwave switching device having a common coaxial terminal and a plurality of peripheral coaxial terminals ~~is provided~~, wherein each position of the multi-position switching device includes a switch in accordance with said one aspect of the present invention.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a perspective view of the multi-position coaxial microwave switching device with a cutaway showing one of the microwave switches used;

Figure 2 is a view of the body of the multi-position coaxial microwave switching device along section line 2;

Figure 3 is a view of a self-terminating microwave switch for one of the coaxial connectors along section line 3;

Figure 4 is a view of a self-terminating microwave switch of an alternative embodiment utilizing a magnetic latch to actuate the rocker arm.

A multi-position microwave switching device 10 is shown in Figure 1, at an angle showing the underside of the switch with the central coaxial terminal 20 and the peripheral coaxial terminals 30. In the cutaway portion of the multi-position microwave switching device 10 is shown a single self-terminating microwave switch 40, which is shown in further detail in Figure 3.

Figure 2 is a view of the base of the multi-position switching device 10 along section line 2, wherein the base 50 is shown with the cavity 60 having a central portion and radial portions extending therefrom. In the base 50 is also shown the central coaxial terminal 20 and the peripheral coaxial terminals 30. The conductor reeds 70 are shown in the radial portions of the cavity 60, where it can be seen that the conductor reeds connect the central coaxial terminal 20 with any one of the peripheral coaxial terminals 30. Also shown are the termination resistors 80, located above the peripheral coaxial terminals 30. Each peripheral coaxial terminal has an associated conductor reed and termination resistor. The conductor reed and termination resistor corresponding to a peripheral coaxial terminal both contact the same terminal. It can also be seen that the conductor reeds have a pointed end 73 adjacent the central coaxial terminal 20 and an opposite end 78 shaped to substantially conform to the shape of the termination resistors 80.

A self-terminating microwave switch is shown in further detail in Figure 3. The central coaxial terminal 20 and a peripheral coaxial terminal 30 are shown extending through the body housing 50. A conductor reed 70 is shown positioned above the coaxial terminals, with the termination resistor 80 in contact with the peripheral coaxial terminal 30. A rocker arm

90 performs the function of alternately moving the termination resistor 80 and conductor reed 70 into contact with the same peripheral coaxial terminal. A solenoid 100 is positioned above one end of the rocker arm 90, with a plunger 110 forcing down the rocker arm 90 whenever the solenoid 100 is actuated. When the solenoid plunger 110 acts on the rocker arm 90, a conductor spring 120 is compressed and a shaft 130 connected to the conductor reed 70 is forced in a downward movement until the conductor reed 70 contacts the central coaxial terminal 20 and peripheral coaxial terminal 30. When the solenoid 100 is not actuated, the termination spring 140 is compressed by the force of the fail-safe spring 150, and the conductor spring 120 is allowed to expand, thereby moving the rocker arm 90 into the position shown in Figure 3, and forcing the termination resistor 80 into contact with the peripheral coaxial terminal 30. An adjustment screw 160 is provided for adjusting the tension on the fail-safe spring 150 and termination spring 140.

Also shown in Figure 3 are the relative shapes and locations of the conductor reed 70, the termination resistor 80, the central coaxial terminal 20, and the peripheral coaxial terminal 30. The flat, narrow conductor reed 70, which is movable toward and away from the common plane containing the surface of the central coaxial terminal 20 and peripheral coaxial terminal 30, is shown moved away from the coaxial terminals. The termination resistor 80, which is movable toward and away from the peripheral coaxial terminal 30, is shown contacting the terminal. As may be seen from Figure 3, the end of the conductor reed 70 and the termination resistor 80 come into contact with different portions of the peripheral coaxial terminal 30. Also illustrated is the convex, semi-circular shape of one end 78 of the conductor reed 70, which contacts the peripheral coaxial connector 30, and the

pointed end 73 of the opposite end, both illustrated earlier in Figure 2.

Figure 4 illustrates an alternative embodiment of the present invention. A central coaxial terminal 20 and peripheral coaxial terminal 30 are again shown extending through a body portion 50. A conductor reed 70 is allowed to complete a microwave signal path between the central coaxial terminal 20 and peripheral coaxial terminal 30, with a termination resistor 80 allowed to contact the peripheral coaxial terminal 30. Once again, the conductor reed and termination resistor physically contact the same peripheral coaxial terminal. A rocker arm 170 is used to act upon a conductor reed shaft 130 in compressing the conductor reed spring 120, thereby forcing the conductor reed 70 into contact with the coaxial terminals. In this embodiment, however, a solenoid is not used. Rather, a magnetic latch is used to act upon the rocker arm 170.

The magnetic latch includes two coils 180, 190 that have windings that are wound in opposite directions so that their respective magnetic forces act in opposite directions. A permanent magnet 200 is positioned between the coils 180, 190, a magnet cover plate 210 constructed of a magnetically susceptible material being placed above the coils 180, 190 and the permanent magnet 200. The rocker arm 170 is allowed to move between a first position and a second position. When the rocker arm 170 is in either position, a magnetic path is completed, comprising the permanent magnet 200, the magnet cover plate 210, one of the coils 180, 190, and a portion of the rocker arm 170. In this way, the rocker arm 170 is held or latched in position by the permanent magnet 200.

When one of the coils 180, 190 is energized with an electrical signal of predetermined polarity, that coil will attract the end of the rocker arm 170 nearest the coil. The other coil will repel the opposite end

of the rocker arm. The rocker arm 170 is thereby made to change its position with respect to the coils 180, 190. Once the rocker arm 170 has been moved into the appropriate position, the aforesaid magnetic path will operate to keep the rocker arm 170 in that position. When a change in the rocker arm position is desired, the polarity of the electrical signal is reversed from the previous polarity, and the other coil attracts the opposite end of the rocker arm 170 toward itself, while the coil previously in contact with the rocker arm 170 repels the rocker arm 170. Once this movement of the rocker arm is completed, the magnetic path described above will again maintain the rocker arm in its position.

A cap 220 is located at the end of the termination resistor adjacent to the rocker arm 170, with a termination spring 140 located underneath the cap 220. In this way, when the conductor spring 120 is compressed, the termination spring 140 is allowed to expand, thus lifting the termination resistor 80 out of contact with the peripheral coaxial terminal 30.

Claims:

1. In a self-terminating coaxial microwave switch having a first terminal that is selectively connectable to a second terminal by a reed conductor and that has a termination resistor, the improvement wherein:

said reed conductor and said termination resistor alternately directly and mechanically contact said first terminal.

2. The self-terminating coaxial microwave switch claimed in claim 1 wherein the reed conductor and termination resistor respectively contact different parts of the first terminal.

3. The self-terminating coaxial microwave switch claimed in claim 2 wherein the end of the reed conductor contacting the first terminal is shaped to conform to the end of the termination resistor contacting the first terminal and is spaced apart from the termination resistor.

4. The self-terminating coaxial microwave switch claimed in claim 1 further having a rocker arm means for moving the reed conductor and termination resistor into and out of contact with the first terminal.

5. The self-terminating coaxial microwave switch claimed in claim 1 further having a first and second springs disposed adjacent to each end of the termination resistor for ensuring that the termination resistor moves in direct response to movement of the rocker arm.

6. Switching means for use in a self-terminating coaxial microwave switching device comprising:

a switch housing;

a rocker arm connected to the housing by a pivot means for allowing the rocker arm to move between a first signal transmission position and a second termination position;

a reed conductor for allowing transmission of a microwave signal;

a reed conductor spring disposed in the switch housing adjacent a first coaxial terminal and first end of the rocker arm and connected to the reed conductor such that the force of the reed conductor spring places the conductor reed in the first signal transmission position;

a termination resistor having a predetermined impedance for terminating a position of the self-terminating multi-position coaxial microwave switching device, said termination resistor being vertically disposed in the switch housing adjacent a second coaxial terminal and a second end of the rocker arm such that the termination resistor may be moved vertically in the switch housing in response to movement of the rocker arm;

a termination spring disposed in the switch housing adjacent the bottom end of the termination resistor such that the force of the termination spring moves the termination resistor upward in the switch housing;

a fail-safe spring disposed in the housing proximate to the top end of the termination resistor such that the force of the fail-safe spring tends to move the termination resistor downward in the switch housing; and

a switch activating means for moving the rocker arm between the first signal transmission position and the second termination position;

wherein the relative spring forces of the reed conductor spring, termination spring, and fail-safe spring when expanded are such that the rocker arm tends to remain in the second termination position when the switch activating means is not actuated, the fail-safe spring thereby moving the termination resistor downward in the switch housing into contact with the second coaxial terminal, while actuating the switch activating means moves the rocker arm into the first signal transmission position, thereby moving the termination resistor upward in the switch housing and compressing the reed conductor spring, completing the signal path.

7. A self-terminating multi-position coaxial microwave switching device having a plurality of switches as claimed in claim 1 and including:

a housing having a body and body cover plate, wherein the body has a cavity comprising a central portion and a plurality of radial portions extending from the central portion;

a central coaxial terminal disposed in the body with its inner conductor extending coaxially into the central portion of the body;

a plurality of peripheral coaxial terminals disposed in the body at the end points of the radial portions of the body located near the periphery of the body;

a plurality of reed conductors of the same number as the peripheral coaxial terminals suspended from the body cover plate over each of the radial portions and having a configuration such that the reed conductors may be placed into the radial portions of the body cavity;

said body cover plate having a plurality of self-terminating coaxial microwave switches of the type as claimed in claim 1, one for each radial portion of the body cavity, for selectively coupling the central coaxial terminal with a peripheral coaxial terminal, wherein:

each reed conductor is connected to an associated reed conductor spring through the body cover plate such that compressing the reed conductor spring thereby brings one end of the reed conductor into contact with the central coaxial terminal and brings the other end into contact with a peripheral coaxial terminal; whereas allowing the reed conductor spring to expand pulls the reed conductor out of contact with the central coaxial terminal and peripheral coaxial terminal, allows the fail-safe spring to

expand, and thereby brings the termination resistor into contact with the peripheral coaxial terminal.

8. A switching means for use in a self-terminating multi-position coaxial microwave switching device comprising:

a substantially flat body portion, having a cavity comprising a channel in a top surface of the body portion;

a body cover portion coupled to the body portion at the surface having the channel;

a rocker arm connected to the body cover portion by a pivot means for moving the rocker arm between a first position and a second position;

first and second coils mutually excited by a current source and wound about an axis such that the magnetic forces generated by the respective coils are in opposite directions along the axis;

a substantially flat magnet plate;

a permanent magnet disposed between the first and second coils, beneath the magnet plate and above the rocker arm such that, when the rocker arm is in the first position, a magnetic circuit is completed comprising the permanent magnet, a first portion of the magnet plate, the core of the first coil, and a first end portion of the rocker arm and, when the rocker arm is in the second position, a magnetic circuit is completed comprising the permanent magnet, a second portion of the magnet plate, the core of the second coil, and a second end portion of the rocker arm;

a first coaxial terminal disposed in the body portion with its inner conductor extending into a first end of the channel;

a second coaxial terminal disposed in the body portion with its inner conductor extending into a second end of the channel;

a termination resistor having a predetermined impedance;

a reed connector having an upwardly extending shaft, the shaft extending through the body cover

portion and suspended therefrom by a reed spring, the shaft and spring being disposed beneath the rocker arm and above the channel;

wherein placing the rocker arm in a first position compresses the reed spring, thereby displacing the reed connector in a downward position into contact with the first and second coaxial terminals so that a microwave signal may travel from the first coaxial terminal to the second coaxial terminal, and placing the rocker arm in the second position moves the termination means downward into contact with the second coaxial terminal.

9. A self-terminating multi-position coaxial microwave switching device including:

a housing containing a base plate with a plurality of switching means as claimed in claim 8.

10. In a self-terminating coaxial switch of the type wherein a common terminal is selectively connectable to another coaxial terminal by a reed movable in a transmission cavity, said reed being movable in a direction toward and away from a common plane containing the surface of said common terminal and the surface of said other common terminal, the improvement comprising:

a termination resistor situated above a portion of said other terminal surface, said termination resistor being movable toward and away from said common terminal surface, and

means for concurrently moving (a) said reed towards said common plane to bring one end of said reed into contact with said common terminal surface and the other end of said reed into contact with said other terminal surface so as to provide a microwave path between said one terminal and said other terminal, and (b) said termination resistor away from said other terminal surface, and alternately moving (a) said reed away from said terminal surfaces to open said microwave path and (b) said termination resistor toward and into contact with said portion of said other terminal surface so as to provide a resistive termination for that other terminal,

said reed other end being configured to contact only a part of said other terminal surface different from said position contacted by said termination resistor.

11. The improvement of claim 10 wherein said termination resistor end is generally circular and said reed other end is of convex semicircular shape, said reed other end being spaced laterally from said termination resistor end.

12. The improvement of claim 10 wherein said means for moving comprises a magnetically latched rocker arm, said reed and said termination resistor being respectively operatively connected to different portions of said rocker arm.

Fig. 1

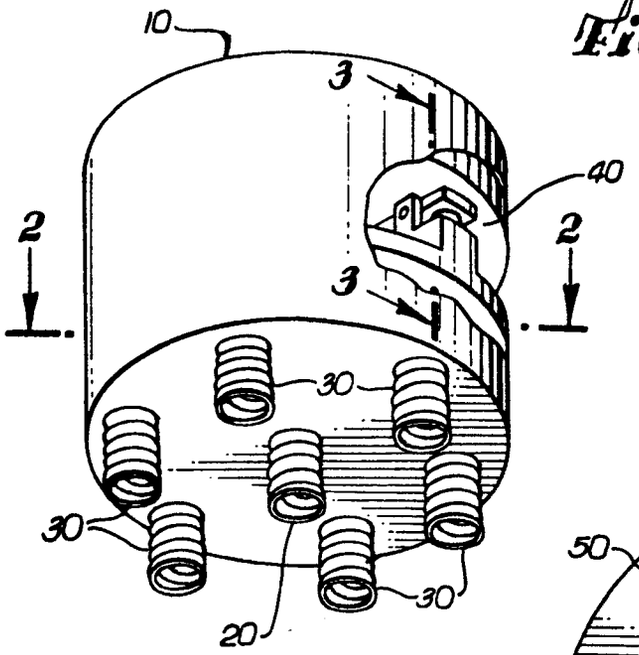


Fig. 2

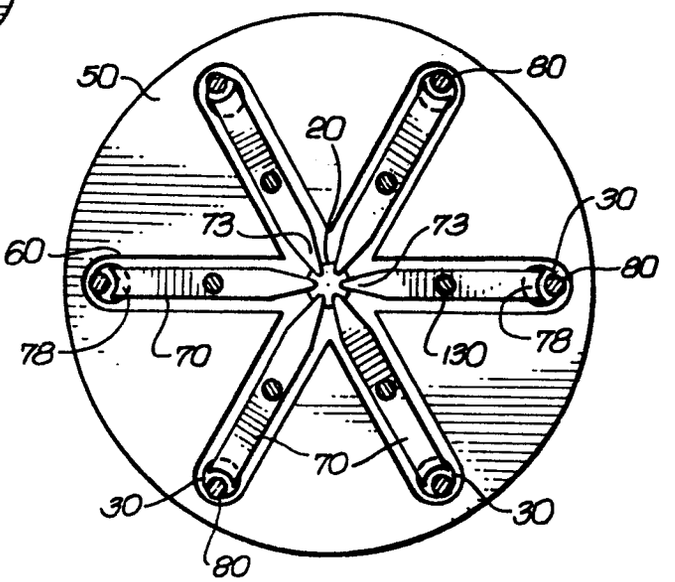


Fig. 4

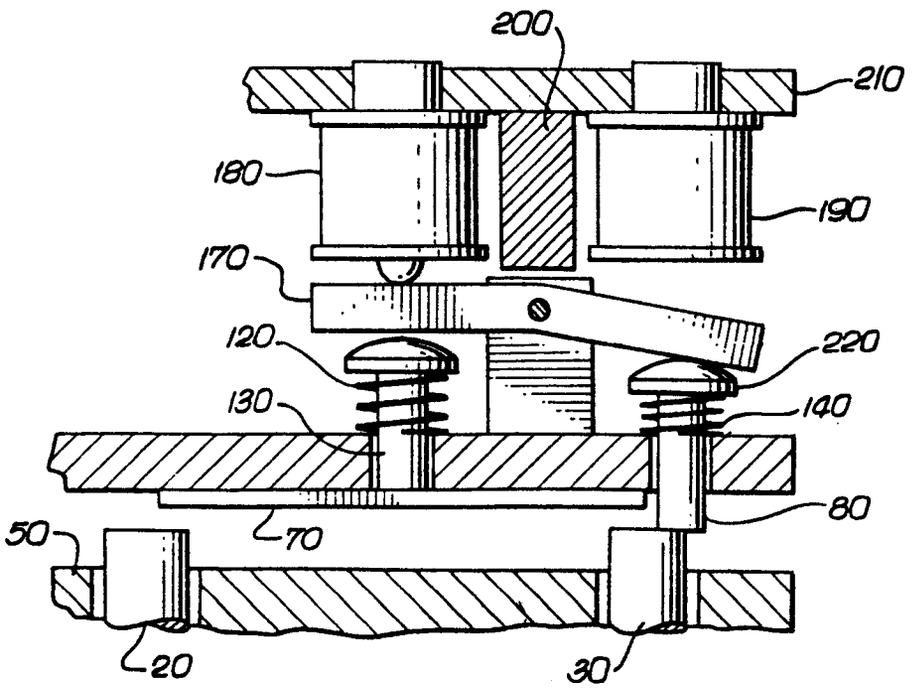


Fig. 3