Jan. 4, 1966 W. A. BENTLEY 3,227,969

COAXIAL SWITCH HAVING TOGGLE ACTUATED STRIP CONDUCTOR PLATES

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Fig. 1

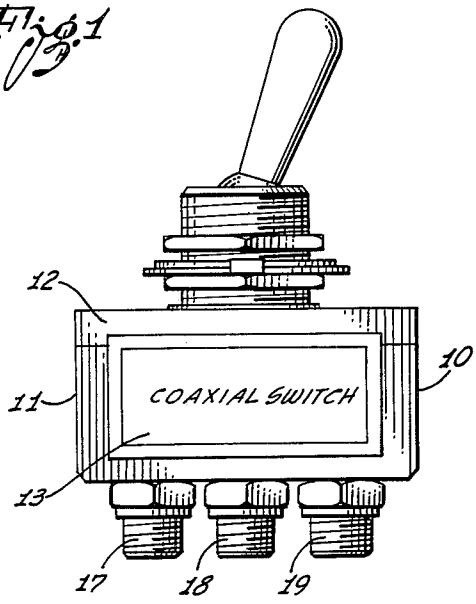


Fig. 2

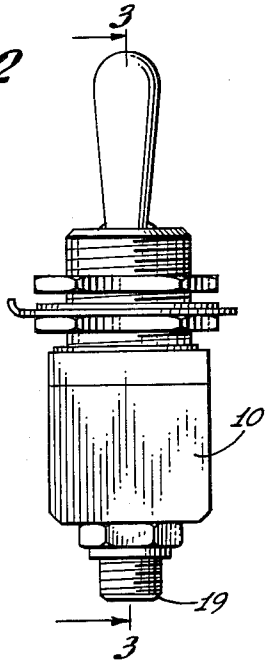


Fig. 5

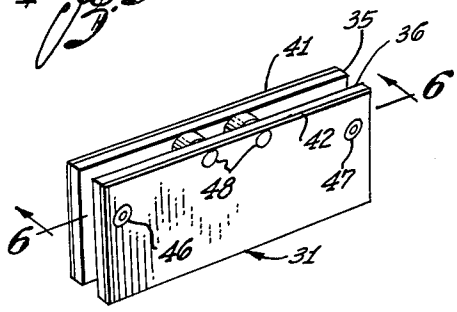


Fig. 6

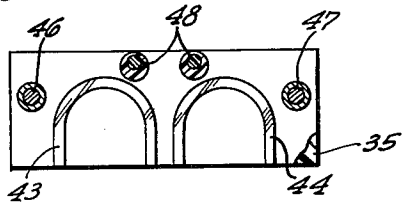


Fig. 10

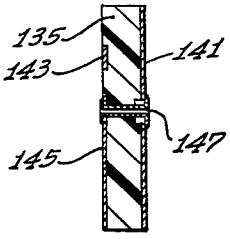
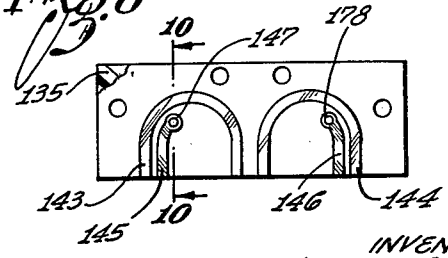


Fig. 8



INVENTOR.
William A. Bentley
By Smyth, Roston & Pavitt
Attorneys.

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COAXIAL SWITCH HAVING TOGGLE ACTUATED STRIP CONDUCTOR PLATES

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Fig. 3

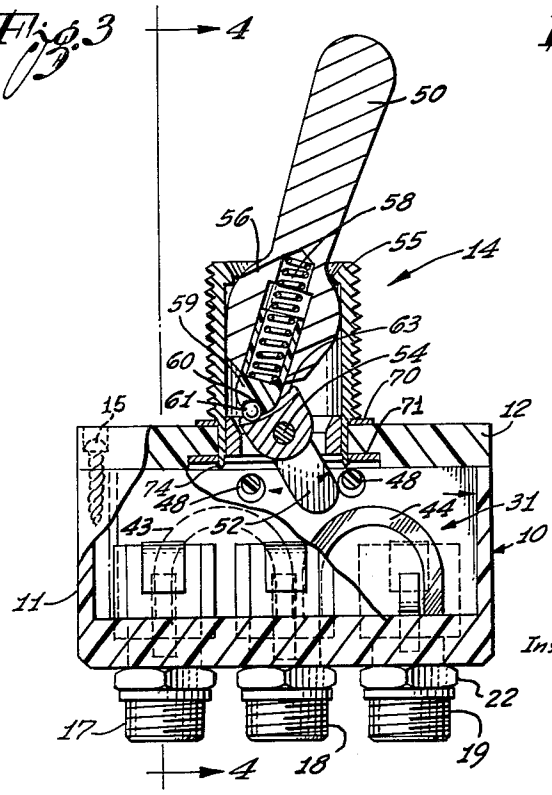


Fig. 4

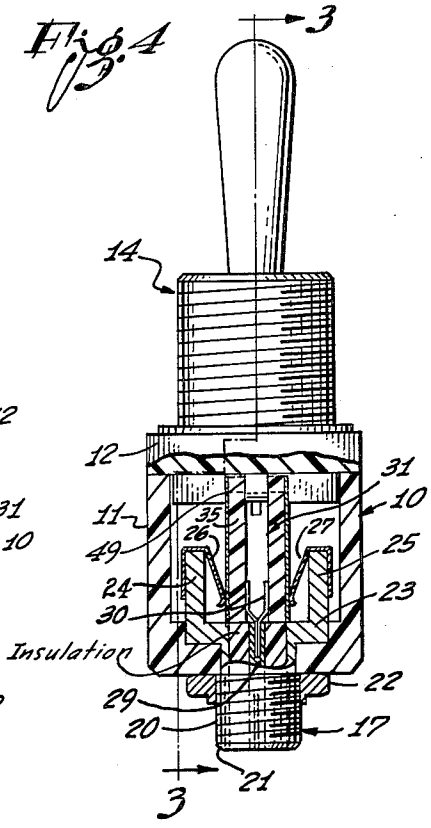


Fig. 7

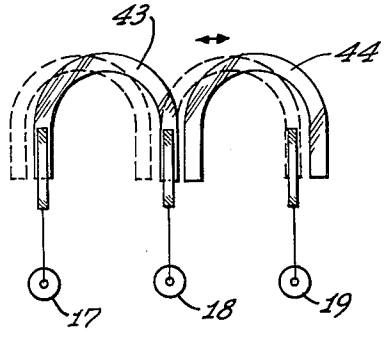
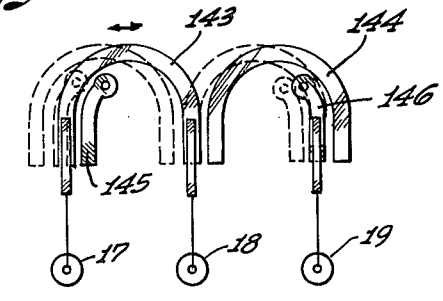


Fig. 9



INVENTOR:
William A. Bentley
By Smyth, Roston & Pavitt
Attorneys.

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Fig. 11

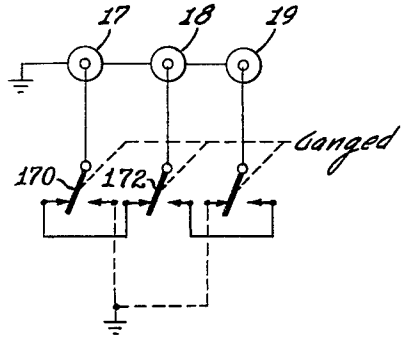


Fig. 12

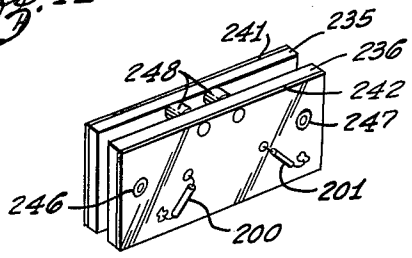


Fig. 13

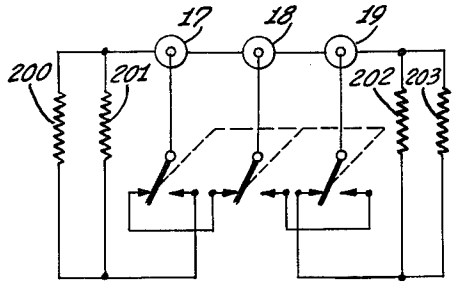


Fig. 14

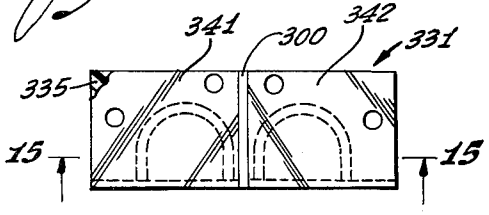


Fig. 15

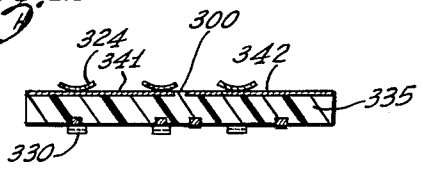
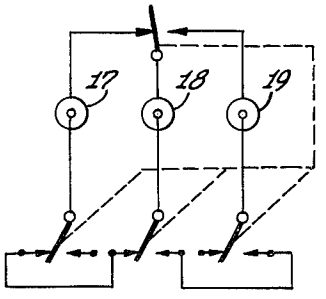


Fig. 16



INVENTOR:
William A. Bentley,
By Smyth, Roston & Pavitt
Attorneys.

United States Patent Office

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COAXIAL SWITCH HAVING TOGGLE ACTUATED STRIP CONDUCTOR PLATES

William A. Bentley, Whittier, Calif., assignor to Microdot Inc., South Pasadena, Calif., a corporation of California

Filed Aug. 15, 1960, Ser. No. 49,467
4 Claims. (Cl. 333—7)

This invention relates to electrical switches and, more particularly, to miniature coaxial switches utilizing strip-line techniques.

It is well known that conduction at very high frequencies does not follow the conventional pattern associated with direct or comparatively low frequency currents. In the region of microwaves this effect becomes so pronounced that connections no longer resemble wiring systems but are more like plumbing systems with provisions made to "pipe" currents from point to point. The present invention is for use in the range where electrical conductors are still utilized but where the problems encountered in handling of such high frequencies in the order of hundreds of megacycles have to be carefully considered.

Conductors which are utilized for the transmission of high frequency waves are generally utilized in pairs spaced relatively close to minimize radiation therefrom. Spacing between such pairs of conductors, the sizes of the individual conductors, and the dielectric between them determine certain transmission characteristics of the transmission line, one of which is known as the surge impedance, or characteristic impedance, Abrupt changes in such impedance along a transmission line generally produce deleterious effects, as is well known in the art. The conductors may be arranged in a coaxial manner with one enveloping the other to further minimize radiation effects. At frequencies that require coaxial conduction, conventional relays and switching means cannot readily be utilized because the current cannot be confined to the usual conducting elements of such devices and the impedance irregularities offered by such elements may be excessively high. Moreover, when high frequency currents are utilized, the impedance mismatch and capacitive coupling in such devices cause standing waves and undesirable crosstalk.

In specific illustrative embodiments of this invention, coaxial switches are provided which maintain the impedance characteristics of the coaxial lines into which they are inserted. The coaxial switches utilize strip-line techniques and are of the type disclosed in the copending patent application Serial No. 810,831 filed by George W. Wedemeyer on May 4, 1959, now U.S. Patent 3,114,887. In the Wedemeyer disclosure, a strip-line board is moved by two pusher rods back and forth between two switching positions. The strip-line board includes conductive members for selectively establishing the connections between the coaxial cables interconnected by the switch. A uniform dielectric field is produced in the switch for maintaining the characteristic impedance of the coaxial lines.

In the specific illustrative embodiments of this invention, pusher rods are not utilized and instead a more convenient and familiar type actuating mechanism is utilized. More specifically, the actuator mechanism is a toggle mechanism which permits conventional mounting and operation techniques. The toggle actuating mechanism is completely removed from the conductive members of the switch and, in fact, is positioned outside the casing

enclosing the conductive members. Features of this invention relate to the provision of a microswitch having a relatively small casing and yet suitable for handling frequencies up to 3,000 or 4,000 megacycles. Only a small actuating tip of the toggle mechanism extends into the casing enclosing the conductive members of the switch. The actuating tip is insulated and does not introduce any material affect to the uniform field established in the casing.

The toggle mechanism includes a partially hollow handle which encloses a spring and a movable plunger. The spring urges the plunger and a steel ball, positioned at the end of the plunger, against a pivoted toggle. The toggle has a tip extending through the casing to engage the strip-line board. The strip-line board has a pair of rivets which are selectively engaged by the tip of the toggle in accordance with the angular position of the handle of the toggle assembly.

Features of this invention relate to the provision of a strip-line board for selectively interconnecting the inner conductor of one coaxial cable to the inner conductor of one or the other of two branch coaxial cables, and for simultaneously grounding the inner conductor of the branch cable which is not interconnected. In another embodiment, a strip-line board is provided including means for terminating the inner conductor of the unconnected cable in a matching terminating impedance. Further features pertain to the provision of strip-line board means for switching the outer as well as the inner conductors of coaxial cables.

Further advantages and features of this invention will become apparent upon consideration of the following description when read in conjunction with the drawing wherein:

FIGURE 1 is a front view of the coaxial switch of this invention;

FIGURE 2 is a side view of the coaxial switch of this invention;

FIGURE 3 is a sectional view of the coaxial switch of this invention taken along lines 3—3 of FIGURE 4 illustrating one embodiment of this invention;

FIGURE 4 is a sectional view of the coaxial switch of this invention taken along lines 4—4 of FIGURE 3;

FIGURE 5 is a pictorial view of the strip-line board utilized in one embodiment of the coaxial switch of this invention;

FIGURE 6 is a sectional view of the strip-line board taken along lines 6—6 in FIGURE 5;

FIGURE 7 is a functional representation illustrating the switching operation of the strip-line board of the first embodiment depicted in FIGURES 5 and 6;

FIGURE 8 is a plan view of a portion of a strip-line board of a second embodiment of a coaxial switch of this invention wherein the unused coaxial cable is grounded;

FIGURE 9 is a functional representation of the switching operation of the strip-line board utilized in the second embodiment of the coaxial switch of this invention;

FIGURE 10 is a sectional view of the strip-line board utilized in the second embodiment of the coaxial switch of this invention taken along lines 10—10 of FIGURE 8;

FIGURE 11 is a circuit representation of the first embodiment of the coaxial switch of this invention in solid lines and also of the second embodiment of the coaxial switch of this invention including the additional dash lines;

FIGURE 12 is a pictorial view of a strip-line board of a third embodiment of the coaxial switch of this inven-

tion wherein the unused coaxial cable is terminated in a matching impedance;

FIGURE 13 is a circuit representation of the third embodiment of the coaxial switch of this invention;

FIGURE 14 is a plan view of a portion of a strip-line board forming part of a fourth embodiment of the coaxial switch of this invention;

FIGURE 15 is a sectional view of the strip-line board of the fourth embodiment of the coaxial switch of this invention taken along lines **15**—**15** of FIGURE 14; and

FIGURE 16 is a circuit representation of the fourth embodiment of the coaxial switch of this invention.

Referring first to FIGURES 1 through 4, a first embodiment of a coaxial switch of this invention is depicted. As is hereinafter described, four different embodiments of the coaxial switch of this invention are disclosed. These embodiments are all similar except for the strip-line boards utilized therein. As is also hereinafter described, the strip-line boards are the movable elements in the coaxial switch which provide for the electrical switching functions. The description of the coaxial switch depicted in FIGURES 1 through 4, accordingly, relates to all four embodiments except for the description of the details of the strip-line board **31**.

As shown in FIGURES 1 through 4, the coaxial switch includes a housing or casing **10** of two-part construction; one part being a hollow box-like rectangular member **11** which is open on one side, and the other part being a closure **12** which seats against the open end of the member **11**. The closure **12** may be provided with a peripheral flange, not shown, so as to form a seal with the hollow member **11**. The closure **12** may be affixed to the hollow member by conventional means such as securing screws **15** shown particularly in FIGURE 3.

The member **11** and the closure **12** forming the casing **10** may be made, illustratively, of black dial plastic which is glass filled, and the two parts may be affixed by a cement, illustratively, (Epoxy) furane 10F and Epocast 951, in addition to the screws **15**. The casing **10**, accordingly, forms a dust and moisture-free enclosure.

On the side of the casing **10** opposite to that of the toggle assembly **14** are three conventional coaxial jack connectors **17**, **18** and **19**. In the illustrative embodiment, the centermost connector **18** may be considered as a common input to one or the other of the connectors **17** and **19**. The coaxial switch is utilized for selectively connecting the cable **18** to the cables **17** and **19**. As shown specifically in FIGURE 4, each of the connectors **17**, **18** and **19** includes a tubular ferrule **20** having a threaded end **21** which extends outwardly from the casing **10**. The ferrule **20** is secured to the casing **10** by means of a nut **22** which coacts with a U-shaped bracket **23** formed at the innermost end of the ferrule **20**. The bracket **23** engages the inside wall of the casing **10**, and the nut **22** engages the outside wall of the casing **10** so that the ferrule **20** is rigidly supported on the casing **10**.

The U-shaped bracket **23** has two substantially rectangularly shaped and spaced apart arms **24** and **25** which carry respectively spring contacts **26** and **27**. The contacts **26** and **27** are mounted on the ends of the arms **24** and **25** and may be secured thereto by welding or other fastening means, not shown. Insulatingly supported in each of the ferrules **20** is a contact **29** for connection with the center conductor of the associated coaxial cable, not shown. The contact **29** is in electrically conductive connection through the ferrule **20** to a pair of spring fingers **30** extending inwardly between the two arms **24** and **25** of the bracket **23**.

Switching is accomplished by means of the movable strip-line board **31**, briefly mentioned above, which is essentially a sandwich structure supported for movement in opposite directions in the casing **10**. The strip-line board **31** of the first embodiment of this invention, as shown particularly in FIGURE 5, includes two boards **35** and **36** made of insulating material which are attached

together by means of two rivets **46** and **47**. On the outer surface of the boards **35** and **36** are positioned respectively conductive plates **41** and **42**. Spacings or bushings, not shown, are supported on the central part of the rivets **46** and **47** for maintaining the boards **35** and **36** in a spaced relation. The rivets **46** and **47** support the four components **35**, **36**, **41** and **42** in the sandwich arrangement with the plate **41** being against the board **35** and the plate **42** being against the board **36**. The strip-line board **31** also includes two pins **48** which are utilized, as is hereinafter described, for moving the board **31** in either one or two opposite directions.

As shown specifically in FIGURE 4, the strip-line board **31** is supported in the casing **10** with the two boards **35** and **36** being on opposite sides of and in engagement with the two spring fingers **30** of the ferrule **20**. The conductive plates **41** and **42** are respectively engaged by the spring contacts **26** and **27** supported on the ends of the arms **24** and **25** of the bracket **23**. In this manner, one end, the lower end in FIGURE 4 of the strip-line board **31**, is positioned between the arms **24** and **25** of the U-shaped bracket **23** while its other end extends into a horizontally extending groove **49** on the inner face of the closure **12**. As shown in FIGURE 3, the strip-line board **31** extends almost the entire inner length of the casing **10** so that it fits into the U-shaped bracket **23** or all three ferrules **20** of the coaxial switch.

The conductive plates **41** and **42** of the strip-line board **31** provide spaced-apart ground or common surfaces which are engaged by all three sets of contacts **26** and **27**. The bracket **23** is made of conductive material as well as the threaded end **21** of the ferrule **20** so that the outer conductors of the coaxial cables, not shown, which are connected to the connectors **17**, **18** and **19**, have a common ground connection. The inner conductors of the three coaxial cables are electrically coupled respectively by the connectors **17** through **19** to the three sets of spring fingers **30** engaging the inner surfaces of the two boards **35** and **36**.

The inner surfaces of the boards **35** and **36**, which may be made of an insulating material such as a plastic, are provided with two U-shaped strip-line conductors **43** and **44** as shown particularly in FIGURE 6. The conductors **43** and **44**, which may be made of copper or other conductive material, may be seated in the board **35** so as to form a smooth flush surface therewith. Similar strip-line conductors **43** and **44** are provided on the inner surface of the board **36**. As is hereinafter described, the strip-line board **31** may be moved back and forth so that the flexible fingers **30** selectively engage the ends of the strip-line conductors **43** and **44**. FIGURE 7 illustrates the two positions of the strip-line board **31** with respect to the connectors **17** through **19**. In one position, the flexible fingers **30** associated with the connector **18** engage the central end of the U-shaped strip strip-line conductor **43** and the other end of the conductor **43** is engaged by the spring fingers **30** associated with the connector **17**. When the strip-line board **31** is moved to the left, the U-shaped conductor **44** is moved to establish an electrical connection between the spring fingers **30** associated with the connectors **18** and **19**. In this manner, depending upon the position of the strip-line board **31**, the inner conductor of the connector **18** is connected to one or the other of the inner conductors of the connectors **17** and **19**. Utilizing the strip-line board **31** of the first embodiment and as shown in FIGURES 5 through 7, one of the inner conductors of the two connectors **17** and **19** is electrically connected to the connector **18**, whereas the other inner conductor is unterminated at the coaxial switch. As is hereinafter described, other embodiments are described wherein the inner conductor of the unused coaxial cable is either grounded or connected to a matching terminating impedance.

The strip-line board **31** is moved back and forth between its two switching positions by means of the toggle mecha-

nism 14 mentioned above. When a handle 50 of the toggle mechanism 14 is moved, it rotates a toggle 52 into engagement with one or the other of the two pins 48 of the strip-line board. The linear distance moved by the toggle 52 due to the rotation of the handle 50 is greater than the distance between the two pins 48 of the strip-line board 31. The distance that the board 31 is moved may be quite small, illustratively, .085 inch because of the utilization of the two U-shaped conductors 43 and 44. In the position shown in FIGURE 3, the handle 50 is at its clockwise position and the toggle 52 has positioned the strip-line board 31 to the right. When the handle 30 is rotated to the left in a counter-clockwise direction, it in turn, as is hereinafter described, rotates the toggle 52 in a clockwise direction about a pivot pin 54 so that the toggle 52 engages the pin 48 of the strip-line board 31. By means of this engagement, the toggle 52 moves the strip-line board 31 to the left. At the position of the board 31 to the right, the inner conductor of the coaxial cable at the connector 18 is connected through the U-shaped conductor 43 to the inner conductor of the coaxial cable at the connector 17. At the position of the board 31 to the left, the inner conductor of the coaxial cable at the connector 18 is connected by the U-shaped conductor 44 to the inner conductor of the coaxial cable at the connector 19.

The handle 50 of the toggle mechanism extends from a threaded ferrule 55, which may be utilized for mounting the coaxial switch in a panel, not shown, so that the handle 50 extends from one side of the panel and the casing 10 extends from the other. The ferrule 55 is supported on the closure 12 by means of two washers 70 and 71, the first at the outer surface of the closure 12 and the second at the inner surface of the closure 12. The ferrule 55 may be bent at 74 to grip the inner washer 71. The handle 50 has a ball shaped portion 56 which functions as a pivot in the ferrule 55. The portion 56 is partially hollow to enclose a spring 58 and a plunger 59. The handle 50 and the toggle 52 may be made of brass having a chrome plate and the plunger 59 may be made of a plastic such as melamine. The plunger 59 is partially hollow for engaging a portion of the coil spring 58 so that the spring 58 urges the plunger 59 out of the handle 50.

The plunger 59 has a depression 60 at its lower end for engaging a ball 61 which may be made of stainless steel. The ball 61 movably engages a ball race 63 of the toggle 52. The ball race 63, which is arcuately shaped and symmetrically aligned with respect to the pivot 54, is on one end of the toggle 52. As the handle 50 is rotated in one direction or the other, the ball 61 is forced along the race 63 of the toggle 52 causing the toggle 52 to rotate about the pivot pin 54. The spring 58 functions to force the plunger 60 and the ball 61 against the ball race 63 of the toggle 52. The spring 58 reaches its maximum compression as the ball 61 reaches the approximate center of the race 63. Illustratively, an additional compression of 0.5 inch may be provided when the ball 61 is at the center of the ball race 63 as compared to when the ball 61 is at either end of the ball race 63.

In this manner, the entire toggle mechanism 14 is removed from the inside of the casing 10 except for the tip of the toggle 52 which is inserted between the two pins 48 of the strip-line board 31. The entire driving mechanism for moving the strip-line board 31, accordingly, does not form part of the casing 10 so that the casing 10 may be relatively small. The toggle 52 does not engage any conductive members throughout its rotation or at either of its stationary positions. The pins 48 of the board 31 may be made of insulating material or consist of two concentric components with the outer being made of insulating material. The tip of the toggle 52 extending into the casing 10 does not affect the electrical characteristics of the coaxial switch. The tip of the toggle 52 may also be made of an insulating material to further reduce any effect of the toggle on the electric field.

Due to the two parallel plates 41 and 42 and the boards 35 and 36 of the strip-line board 31, a substantially uniform dielectric field is provided for maintaining the characteristic impedance of the coaxial lines. Illustratively, characteristic impedance of the coaxial cables may be 50 ohms. The dielectric field in the coaxial switch is mainly in the dielectric material of the boards 35 and 36. The impedance through the switch is not varied at any time by the operation of the switch or the presence of the hand of the operator on the handle 50 partially because the toggle 52 is insulated from the handle 50 and partially because of the uniform dielectric field in the switch.

In the first embodiment of the invention, the strip-line board 31 shown in FIGURES 5 through 7, is utilized to selectively connect the coaxial cable at the connector 18 to one or the other of the branch cables at the connectors 17 and 19. Actually, it is the innermost conductor of these cables which is interconnected, and the unused or unconnected innermost conductor is not terminated by the coaxial switch. In the embodiment depicted in FIGURES 8, 9 and 10, the inner conductor of the unused cable is grounded by the coaxial switch at the same time that the switch establishes a connection between the inner conductors of the other two cables. As shown in these figures, the board 135 includes two U-shaped conductors 143 and 144 and in addition thereto two grounding conductors 145 and 146. The grounding conductors 145 are electrically connected by associated eyelets 147 and 148 to the conductive plate 141 shown in FIGURE 10.

As shown particularly in FIGURE 9, when the U-shaped conductor 143 is positioned for establishing a connection between inner conductors of the connectors 18 and 17, the ground conductor 146 establishes a grounding connection between the inner conductor of the connector 19 and the plate 141. When the strip-line board is moved to the left in FIGURE 9, the U-shaped conductor 144 now establishes a connection between the inner conductors of the connectors 19 and 18 whereas the grounded conductor 145 establishes a grounding connection to the inner conductor of the cable 17. Depending, therefore, upon the position of the strip-line board of the second embodiment of this invention, the inner conductor of the centrally positioned coaxial cable is connected to one of the inner conductors of two branch cables and the inner conductor of the unused branch cable is grounded.

An electrical representation of the first and the second embodiments is depicted in FIGURE 11 wherein the dash lines represent the modification for the second embodiment. As shown in FIGURE 11, the outer sleeves of the two connectors 17 through 19 are grounded; whereas, the inner conductors of these connectors are connected to the armatures 170–172 associated with three sets of transfer contacts. The strip-line board and the fingers 30 are functionally represented by these three sets of transfer contacts.

In the position of the armatures 170–172 to the left, as shown in FIGURE 11, the inner conductors of the two connectors 17 and 18 are connected together, whereas, the inner conductor of the connector 18 is not terminated. In the second embodiment, the dash lines are included so that the inner conductor of the cable 19 is grounded. When the transfer contacts are moved to the right due to the movement of the strip-line board, the reverse situation occurs.

In the embodiment depicted in FIGURES 12 and 13, the unused cable is terminated in a matching impedance instead of being grounded. The terminated impedance is provided by a number of small resistors 200 through 203. These resistors are mounted against the conductive plates 241 and 242 of the strip-line board. Due to the symmetrical arrangement, the fingers 30 of the unused connector are connected to two of the four resistors 200 through 203. The other terminals of these resistors are grounded at the plates 241 and 242. The impedance coupled to the inner conductor of the cable is, accord-

ingly, one-half that of one of the resistors **200** through **203**. Illustratively, the resistors **200** through **203** may each have a resistance of 100 ohms so that the impedance provided to the inner conductor of the unused connector is 50 ohms.

In the fourth embodiment shown in FIGURES 14 through 16, at the same time that the inner conductors of the two cables are interconnected, their outer conductors are also interconnected. As shown in FIGURES 14 and 15, the plates **341** and **342** at the back of the strip-line board **331** are separated by an insulating member **300**. Two plates are, accordingly, provided instead of one. The contacts **326** and **327** (which are similar to the contacts **26** and **27** in FIGURES 3 and 4), accordingly, engage one or the other of the two plates **341** and **342** in accordance with the rectilinear position of the strip-line board **331**. This modification may be provided in conjunction with any of the switching arrangements disclosed above in reference to the three first embodiments of the invention.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

I claim:

1. A high frequency switch for use with cables having inner and outer conductors, including, a pair of spaced apart plates made of insuating material, means defining conducting surfaces on the outer surfaces of said plates; arcuately shaped strip conductors on the inner surfaces of said plates for selectively connecting the inner conductor of the cables in accordance with the position of said plates; a toggle mechanism for moving said plates including a toggle extending between said plates and having a pivotable path; and a pair of insulating pins extending between said plates and supported by said plates for selective engagement by said toggle in accordance with its movement as the toggle mechanism is operated, said toggle having a ball race, said toggle mechanism also having a hollow handle pivotable in a direction opposite to the pivotable path of the toggle, a plunger in said handle, a ball bearing at one end of the plunger and against the ball race of said toggle, and a spring in said handle for urging the plunger to force the ball bearing against said ball race of the toggle.

2. A high frequency switch for use with cables having inner and outer conductors, including, a member movable between first and second positions and having first and second conductive plates spaced from each other, means including a pair of insulating pins interconnecting said two plates, said pair of pins being spaced apart by a particular distance in a direction parallel to the direction of movement of the movable member, contact means connected to the outer conductor of the cables for slidingly engaging said plates, at least one conductor supported on said movable member between said plates for selectively engaging the inner conductors of the cables, means including a toggle member movable in a pivotable path and extending between the pair of pins for moving the movable member between said first and said second positions, a hollow handle actuatable between first and second positions, in a pivotable path occuring at each instant in a direction opposite to the pivotable path of the toggle member, a plunger in said handle, a ball bearing at one end of the plunger and against the toggle member, and a spring in said handle for urging the plunger to force the ball bearing against the toggle member whereby the position of the toggle member is controlled in accordance with the movement of the handle between the first and second positions.

3. In combination, a ferrule having a hollow configuration, a handle having a first portion disposed within the ferrule and having a second portion extending outwardly from the ferrule, the first portion of the handle being provided with a configuration relative to the ferrule to obtain a pivotal disposition of the handle within the ferrule, the handle being provided with a hollow configuration, a plunger having a hollow portion disposed within the ferrule and having a second portion extending from the ferrule in a direction opposite to the second portion of the handle, a spring disposed within the hollow portion of the plunger and within the hollow configuration of the handle and retained under constraint between the handle and the plunger, a toggle pivotable about a first position as a fulcrum in a direction opposite to the pivotal movement of the handle, a member engaging the second portion of the plunger and engaging a first end of the toggle to produce a pivotal movement of the toggle about the fulcrum in accordance with the pivotal movements of the handle but in a direction opposite to the pivotable movements of the handle, and switching means having first and second states of operation and operatively coupled to the toggle at a position displaced from the first end of the toggle to become actuated between the first state of operation and the second state of operation in accordance with pivotal displacement of the toggle, the member engaging the second portion of the plunger and the toggle constituting a ball and the second portion of the plunger being provided with a depression for engaging the ball and the toggle being provided with a race to engage the ball for a transfer of movement from the plunger through the ball to the toggle to obtain a pivotal movement of the toggle in accordance with the pivotal movement of the plunger.

4. In combination for use with transmission lines having inner and outer conductors to transmit electrical energy at high frequencies, first and second conducting members disposed in substantially parallel relationship in a first direction and separated from each other by a substantially uniform distance in a second direction substantially perpendicular to the first direction and movable in the first direction between first and second positions and connected in at least one of the first and second positions to the inner conductors of the transmission lines, third and fourth conducting members disposed in substantially parallel relationship to the first and second conducting members and having lengths greater than those of the first and second conducting members and disposed in overlapping relationship to the first and second members in the first direction and in symmetrical relationship to the first and second conducting members in a second direction substantially perpendicular to the first direction to provide a substantially uniform dielectric field between the first and third conducting members and between the second and fourth conducting members and to respectively form a pair of half-strip line conductors with the first and second conducting members, the third and fourth conducting members being connected to the outer conductors of the transmission lines in at least one of the first and second positions of the first and second conducting members, a pair of insulating pins disposed between the first and second conducting members in a spaced relationship, a toggle made from an insulating material and extending between the first and second pins and pivotable to engage the first and second pins for movement of the first and second conducting members in the first direction without affecting the substantially uniform dielectric field between the first and third conducting members and between the second and fourth conducting members, means operatively coupled to the toggle for obtaining a pivotable movement of the toggle; the means operatively coupled to the toggle for obtaining a pivotable movement of the toggle including a ferrule having a hollow configuration, a handle disposed within the hollow configuration of the ferrule and provided with a configuration to obtain a pivotable movement upon an actuation of the handle, the handle being provided with a hollow configuration, a

plunger having a hollow configuration and disposed within the hollow configuration of the handle and having a portion extending from the handle in engagement with the toggle, a spring disposed within the hollow configuration of the handle and the plunger and retained under constraint between the handle and the plunger to press the plunger against the toggle, and means disposed between the plunger and the toggle to convert the pivotable movements of the plunger into a pivotable movement of the toggle different from the pivotable movement of the plunger and the plunger being provided with a depression and the toggle being provided with a ball race and the means engaging the plunger and the toggle constituting a ball disposed in the depression in the plunger and engaging the ball race of the toggle.

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HERMAN KARL SAALBACH, *Primary Examiner.*

BENNETT G. MILLER, *Examiner.*