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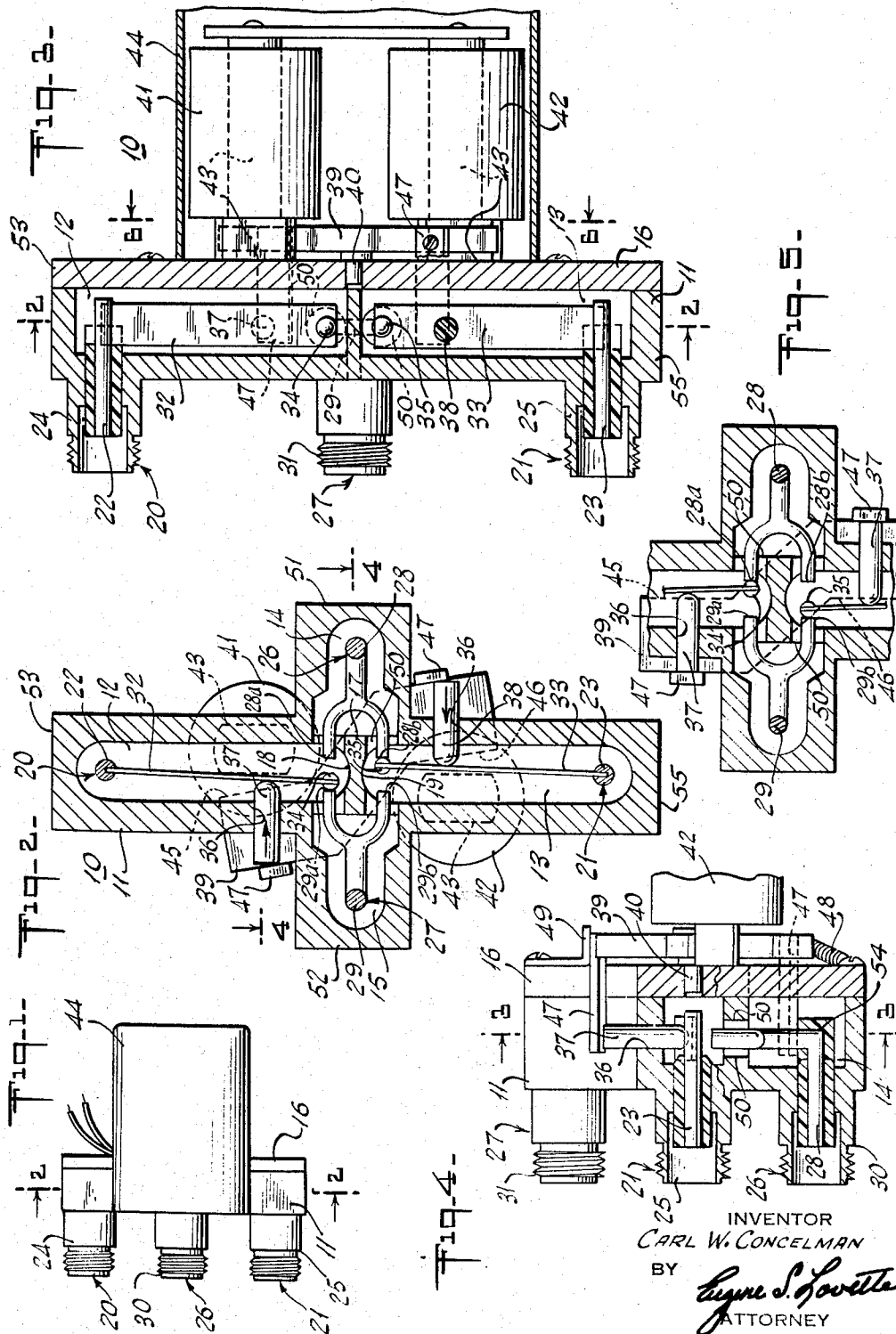
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2,958,053

COAXIAL LINE CROSS-OVER TRANSFER SWITCH

Filed Aug. 14, 1957

2 Sheets-Sheet 1



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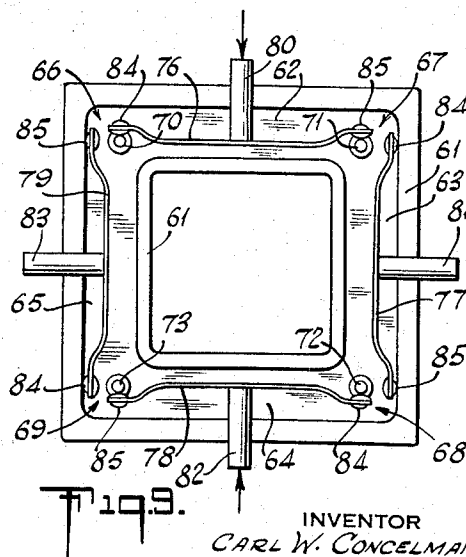
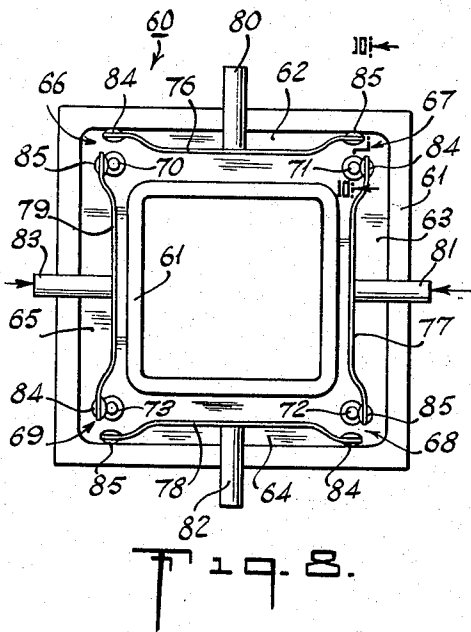
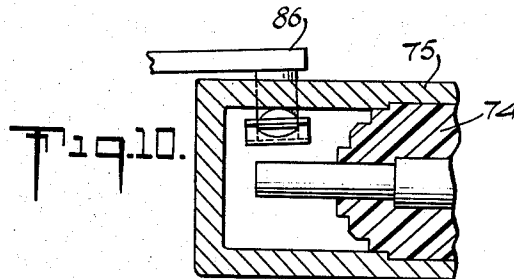
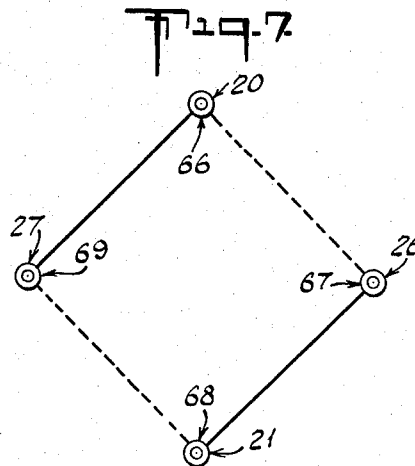
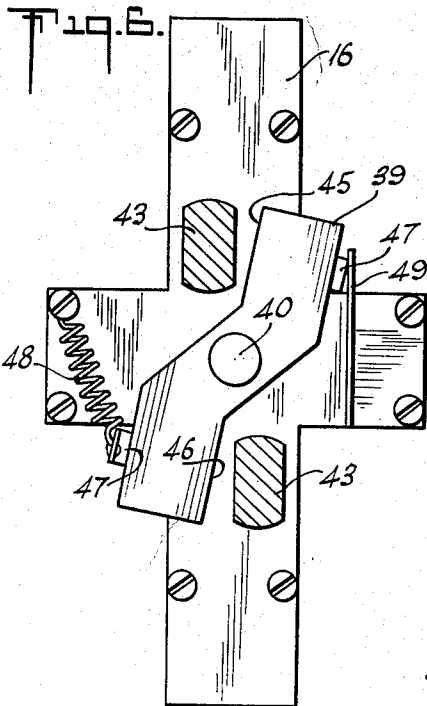
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COAXIAL LINE CROSS-OVER TRANSFER SWITCH

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2 Sheets-Sheet 2



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COAXIAL LINE CROSS-OVER TRANSFER SWITCH

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17 Claims. (Cl. 333-7)

This invention relates to electrical switch relays, and more particularly to coaxial line switch relays adapted to connect and reverse, alternately, a first electromagnetic wave signal source to a first load apparatus and a second signal source to a second load apparatus; the above-described connection is reversed by switching action such that the first signal source is connected to the second load apparatus, whereas the second signal source is connected to the first load apparatus, wherein such switching interconnections are carried out simultaneously.

It is the principal object of the instant invention to provide coaxial line cross-over switches effecting acceptable cross-talk characteristics and acceptable standing wave ratio operation over the range of frequencies up to approximately 1000 mc., which switches are capable of alternately connecting two separate loads with respective ones of two separate sources of electromagnetic wave signals. By means of switch operation, one source is coupled electrically and directly to one load, whereas the second source is coupled directly to the second load and wherein each circuit is substantially isolated electrically from the other. By switching action, the above-described circuit connections are alternated such that the first load is coupled to the second source and the second load is connected to the first source, such alternate interchange of connections being effected solely by the switches and does not require disruption of the interconnected circuits manually or otherwise.

It is a further object of the instant invention to provide a cross-over switch as described hereinbefore, which switch may be produced as a unitary compact block of conducting material provided with internal electrically isolated coaxial line sections, wherein movable means are suspended in each chamber, and a second pair of coaxial line sections having bifurcated inner conductors effecting electrical coupling with respective ones of the first-mentioned sections such that movement of the movable means from one to another of two positions alternately electrically couples each of the first sections with a respective one of the second sections, and wherein each coupled circuit is substantially isolated electrically from the other coupled circuit.

In furtherance of the above-noted objects, it is a further object of the invention to use deflectible returnable arms as the above-described movable means, which arms also serve as inner conductors for the first pair of coaxial line sections and which sections are electrically isolated one from another by a common intervening wall, and wherein the coaxial line sections of the second pair are disposed on opposite sides of the aligned axis of the first-mentioned sections and between the adjacent ends thereof such that a compact switch structure is produced thereby. Conductors extend integrally from the switch block to permit individual electrical coupling to each coaxial line section, and means are provided to deflect the arms, movement of which brings about alternate connection of the circuitry as described hereinbefore.

It is a further object of the instant invention to pro-

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vide a cross-over switch of modified embodiment for the purposes of accomplishing the switching action hereinbefore described, which switch is made up of a four-sided, compact block of conducting material provided with a continuous internal cavity formed by the internal longitudinal chambers of the respective sections of the four-sided block; a connector is coupled to each corner of the block structure and has an inner conductor coupled into and terminating at the merging ends of adjacent chambers; conducting switch members are supported for movement in respective ones of the chambers and adapted to move alternately from a grounded position to an inner conductor connecting position; when each member is maintained in its latter position, the member forms a coaxial line transmission section with its associated chamber and effects electrical connection between the two connectors at the ends of such chamber.

It is a further object of the instant invention with respect to the modified version cross-over switch to actuate simultaneously the conducting switching members, and in particular to move one set of diametrically opposed switching members to inner conductor connecting position as the other set of diametrically opposed conducting switch members are moved to ground position, such that the chambers associated with the grounded members serve to isolate electrically the respective circuits coupled by the respective ones of the first set of diametrically opposed switching members; cross-over switching operation is brought about by reversing the position of the four arms such that the first set of diametrically opposed arms are moved to ground position, whereas the initially grounded arms are moved to inner conductor connection position.

It is a further object of the instant invention with respect to the modified version cross-over switch to employ four longitudinal conducting arms having opposed contact ends to serve as the movable switching members and to move each arm laterally with respect to the longitudinal axis of its associated chamber such that upon bringing the arm to rest centrally in the interior of its associated chamber, the contact ends thereof connect with respective ones of a pair of inner conductors terminating at the corners of the chamber, and upon movement of the arm to its ground position, the contact ends are brought in electrical contact with an interior wall surface of the chamber to effect grounding of the arm.

It is a further object of the instant invention with respect to the modified version cross-over switch to provide effective electrical isolation between respective coupled circuits by reason of the fact that such coupled circuits are connected through diametrically opposed sections of coaxial line formed by diametrically opposed chambers and associated arms therein, which sections of the switch block are separated from each other by chambers in which the arms thereof are grounded. Electrical isolation is further improved by operation in a range of frequencies for which the chambers associated with grounded arms act as wave guides below cut-off.

It is a further object of the instant invention to provide cross-over switches of the type described hereinbefore, capable of being operated effectively by remote control means.

It is a further object of the instant invention to provide compact switches of the type described hereinbefore, which are relatively simple and economical to manufacture and electrically satisfactory for use over a wide range of high frequency operation.

Further objects and advantages will become apparent from the following description of the invention taken in conjunction with the figures, in which

Fig. 1 is a plan elevation of a cross-over switch incorporating the principles of the instant invention, and

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illustrates in particular the feature of having all connectors thereof extending integrally from one side of the switch;

Fig. 2 is a section of the switch block showing the interior thereof taken along line 2—2 of Fig. 1;

Fig. 3 is a section of the switch block showing the interior thereof taken along line 3—3 of Fig. 4;

Fig. 4 is a fragmentary partly cut away section of the switch block taken along line 4—4 of Fig. 2;

Fig. 5 is a fragmentary section of the illustration of Fig. 2 showing the position of the movable arms effecting alternate connection of the switching circuit in comparison to the connection shown in the illustration of Fig. 2;

Fig. 6 is a top plan view, partly in section and taken along line 6—6 of Fig. 3, showing the plan outline of the balanced armature structure for operating the switch of the foregoing figures;

Fig. 7 is a schematic illustration of the circuits provided by cross-over switches incorporating the principles of the instant invention and shows in solid line, the coupled circuit derived by such switches when the switching arms are in one position; the dashed lines show the circuit derived when the switching arms are in its other position. Reference numbers 20, 21, 26, and 27 refer to the embodiment of the cross-over switch illustrated in Figs. 1 through 6; whereas reference numbers 66 through 69 refer to the embodiment of a cross-over switch illustrated in Figs. 8 through 10;

Figs. 8 and 9 are plan views illustrating the interior of another embodiment of a cross-over switch employing the invention. Fig. 8 shows the position of the switching arms for effecting one set of coupled circuits; whereas Fig. 9 indicates the switching arms for the other set of coupled circuits; and

Fig. 10 is a fragmentary and partly sectional view taken along line 10—10 of Fig. 8.

Reference is now made to the drawing, the figures of which illustrate an electrically balanced coaxial line cross-over transfer switch 10 incorporating the principles of the instant invention, which switch is sometimes referred to as a double pole, double throw switch. Switch 10 is made up of a block 11 of electrical conducting material provided with a plurality of internal chambers 12, 13, 14, and 15. Chambers 12 through 15 are formed by suitably shaped interior electrical conducting walls and are enclosed at one side by a cover wall 16 removably secured by suitable means to block 11.

Two of the chambers 12, 13 are formed by elongated opposed interior walls and define longitudinally aligned cavities for supporting electromagnetic travelling waves. In cross section chambers 12, 13 may be substantially rectangular in shape for convenience of fabrication. Chambers 12, 13 are electrically isolated from each other by a common intervening wall 17 wherein the wall faces 18, 19 thereof may be straight, or concave-shaped, as shown herein, for ease of fabrication. Walls 18, 19 face in opposite directions to form the adjacent longitudinal ends of chambers 12, 13. Chambers 12, 13 are made sufficiently long to provide acceptable stress for deflectable spring switching arms 32, 33 supported therein, which arms will be described hereinafter. Electromagnetic wave signals are coupled to or from chambers 12, 13 by respective ones of coaxial connectors 20, 21 made up of inner conductors 22, 23 supported by dielectric means in a well-known manner within respective outer conductors 24, 25. The external ends of connectors 20, 21 are arranged with suitable fittings to permit individual connection with coaxial transmission lines, which lines are in turn coupled to individual sources of electromagnetic signals or to load apparatus not shown herein. Connectors 20, 21 are in effect integral extensions of block 11 such that outer conductors 24, 25 thereof are electrically connected to block 11, whereas inner con-

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ductors 22, 23 terminate in the interior of chambers 12, 13 at the widely separated ends thereof.

A second pair of chambers 14, 15 are disposed on respective sides of the aligned longitudinal axis of chambers 12, 13. Electromagnetic wave signals are coupled to or from chambers 14, 15 by respective ones of coaxial line connectors 26, 27 made up of inner conductors 28, 29 supported by dielectric means in a well-known manner within respective outer conductors 30, 31. The outwardly projecting ends of connectors 26, 27, which connectors are integral extensions of block 11, are provided with suitable fittings to enable connection with individual coaxial transmission lines for coupling chambers 14, 15 to load apparatus or sources of signals not shown.

Inner conductors 28, 29 extend into and through chambers 14, 15. In the illustrated embodiment, conductors 28, 29 bend 90° (shown best in Fig. 4 at 54) and develop into bifurcated sections, which sections pass through respective parallel cylindrical passages 50 in wall portion 17. The bifurcated ends of inner conductors 28, 29 are arranged to terminate in respective ones of chambers 12, 13 such that ends 28a, 28b are juxtaposed correlated ends 29a, 29b in spaced apart planes. In effect, the bifurcated sections of conductors 28, 29 cooperate with bores to form short sections of coaxial transmission line. These short sections are adapted to couple signals from either one of the coaxial sections formed by chambers 14, 15 and conductors 28, 29 to the longitudinal coaxial line sections formed by chambers 12, 13 and arms 32, 33. For the purpose of reducing coupling, the depth of penetration of ends 28a, 28b, 29a, 29b in to the respective chambers 12, 13 is held to a minimum distance.

The parameters of the bifurcated sections of conductors 28, 29 and bores 50 are suitably proportioned to provide an approximate impedance match with the interconnected coaxial line sections and the transmission lines associated therewith so that electromagnetic wave signals are efficiently coupled by switch 10.

As seen from Figs. 2 and 4, the parameters of the interior walls of blocks 11 forming chambers 14, 15 and of inner conductors 28, 29 are suitably proportioned to provide approximate impedance match with the interconnected transmission lines. In furtherance of minimizing impedance discontinuities, cavities 14 and 15, as shown in Fig. 4, are made relatively electrically short. Similarly, arms 32, 33 and the walls of chambers 12, 13 are also suitably proportioned to provide approximate impedance match with the interconnected transmission lines.

Switch arms 32, 33 may be relatively thin in cross-section and are made of deflectable electrical conducting material, such as beryllium copper. Arms 32, 33 are suspended in respective chambers 12, 13 and as noted hereinbefore cooperate therewith to define coaxial line transmission sections. One end of each arm is anchored from and conductively connected to a respective terminating end of inner conductors 22, 23. Each deflectable arm 32, 33 extends longitudinally along its respective chamber and terminates with a contact end 34, 35. Contact ends 34, 35 are adapted to effect electrical contact with the adjacent juxtaposed ends 28a, 28b, 29a, 29b of conductors 28, 29.

The walls of block 11 are provided with through passages 36, in which slidably displaceable dielectric pins 37, 38 are mounted. Arms 32, 33 are suspended from respective inner conductors 22, 23 such that under normal conditions inner conductor 22 is in electrical contact with bifurcated end 29a, whereas inner conductor 23 is connected to 28b, as shown in Fig. 2. Under normal conditions, the interior ends of pins 37, 38 merely rest against respective arms 32, 33 without deflecting same. Upon axial displacement of pins 37, 38 by suitable means in direction of the illustrated arrows, note Fig. 2, each arm

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32, 33 is deflected from its normal position such that the inner conductor 22 now is thrown into contact with end 28a, whereas inner conductor 23 is thrown into contact with end 29b, as shown in Fig. 5. Accordingly, it is seen and illustrated schematically in Fig. 7, that the circuit of switch 10 is normally from connector 20 to connector 27 and connector 21 to connector 26; whereas upon movement of actuating pins 37, 38, the circuit is changed so that connector 20 is coupled to connector 26 and connector 21 to connector 27.

Displacement of pins 37, 38 may be effected by well-known means such as a simple rotary shaft and cam, or a lever device which may be arranged to displace both pins simultaneously to effect cross-over among the four different apparatus connected through transmission lines to the respective connectors 20, 21 and 26, 27. The spring action of arms 32, 33 tends to effect return to the circuit of Fig. 2 when the actuating means release pins 37, 38.

Switch 10 is also especially suited for remote operation, in which case a saw-tooth-shaped balanced armature 39 is pivoted centrally by bearing member 40. Armature 39 is suspended along the outside of cover plate 16 and is caused to turn in a direction to move pins 37, 38 into chambers 12, 13 upon energization of a pair of solenoid coils 41, 42, which coils are provided with respective cores 43 extending integrally from cover plate 16. Upon energization of coils 41, 42, armature 39 turns until armature faces 45, 46 bear against respective and adjacent faces of armature cores. A cover housing 44 on the exterior of cover plate 16 may be used to enclose solenoid coils 41, 42. Armature 39 is provided with a pair of tabs 47, which tabs are disposed to engage the outer ends of pins 37, 38. Upon turning of armature 39, each pin is suitably displaced such that arms 32, 33 deflect to bring about the transfer of circuit connections from normal position to cross-over position. A spring 48, anchored to block 11 and armature 39, assures return of the armature and, in addition, spring 48 helps to suppress undesirable vibrations of the armature structure. A stop 49 on block 11 may be used to limit return travel of armature 39. The balanced armature structure illustrated herein is resistant to vibration and shock and accordingly makes switch 10 especially satisfactory for these environmental conditions.

It will also be observed from the figures, that all connectors 20, 21, 26, and 27 project outwardly from the same side of block 11 which allows the construction of a compact switch 10, which switch may be assembled in a larger piece of apparatus with only one side thereof necessarily accessible for connection and disconnection of transmission lines to connectors 20, 21, 26, and 27. However, it will be understood that the connectors may be adapted to extend from other faces of block 11. For example, connectors 26, 27 may be disposed to extend from sides 51, 52 (Fig. 2) of block 11, in which case the 90° bend along connectors 28, 29 will be eliminated, and as a further example, connectors 20 and 21 may be disposed to extend from ends 53, 55 (Fig. 2) of block 11.

The term "cross-talk" when used herein, refers to signals picked up by reason of imperfect isolation between the section of line formed by chamber 15 and the section of line formed by chamber 14. The coaxial sections defined by chambers 12, 13 and arms 32, 33 respectively, are electrically isolated from one another by wall portion 17. In testing a switch incorporating the principles of the instant invention, it has been found that cross-talk is satisfactorily minimized by the structure disclosed mainly by reason of the small penetration of the bifurcated ends into chambers 12, 13. Tests have also shown that switch 10 provides excellent operation over a frequency range up to 1000 mc. At 300 mc. tests have shown cross-talk between the circuits at approximately 55 db down with a voltage standing wave ratio of 1.1.

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In addition, by maintaining the bifurcated sections electrically short and small, the effect of the impedance discontinuity created thereby on standing wave ratios is not pronounced over the operating range of the switch.

Figs. 8, 9, and 10 illustrate another electrically and mechanically balanced cross-over switch 60 incorporating the principles of the instant invention for the purpose of achieving the objects hereinbefore described. In this instance, switch 60 is made up of a four-sided electrical conducting block 61. Block 61 has opposed pairs of interior wall surfaces providing a continuous internal cavity or passage defined by a plurality of chambers 62, 63, 64 and 65 connected end to end. Each longitudinal chamber corresponds to a correlated side of block 61. Chambers 62 through 65 are uniform in cross-section and for convenience of fabrication are substantially square. The opposed ends of each chamber are located at the corners of block 61. The ends of each chamber merge and communicate with the adjacent ends of a pair of diametrically opposed chambers such that the four chambers define a continuous interior passage.

Four coaxial line connectors 66 through 69 extend integrally from respective corners of block 61. Suitable fittings are provided at the outer ends of connectors 66 through 69, so that respective ones of coaxial transmission lines not shown herein, may be connected to individual connectors 66 to 69. Connectors 66 to 69 are made up of inner conductors 70, 71, 72, 73 supported in a well-known manner by dielectric means 74 within respective outer conductors 75 of the connectors. The inner ends of the inner conductors 70 to 73 extend into and terminate at respective cavity corners formed by correlated pairs of chambers. Consequently, each connector 66 to 69 is adapted to couple electromagnetic wave signals to or from a correlated pair of chambers; for example, connector 66 is adapted to couple energy with respect to either one of chambers 62 or 65.

Switching action is brought about by four movable electrically conducting and resilient arms 76 through 79. Each arm is suspended in a respective chamber 62 through 65 by an attached dielectric pin 80 through 83. Arms 76 through 79 are uniform and substantially thin and rectangular-shaped in cross-section and each extends along the longitudinal axis of its associated chamber. Arms 76 through 79 have turned portions near the opposed terminal ends thereof, which ends are provided with enlarged contacts 84, 85. Pins 80 through 83 are mounted to slide in and out along respective passages in the outer wall surfaces of block 61. Suitable actuating means 86, not completely shown herein, such as relay-lever combination (a fragment of which is shown in Fig. 10) or other motivating mechanism is attached to the ends of pins 80 through 83 projecting outwardly from the interior of the chambers in order to displace arms 76 through 79 laterally with respect to the longitudinal axes thereof. The operation of switch arms such as 76 to 79 are treated more fully in my copending application Serial No. 627,049, filed December 7, 1956, for Coaxial Line switch Apparatus.

It will be understood that the arms are moved in pairs, alternately from a first to a second of two positions in their respective chambers. When occupying one position of the two, the arms are brought to rest adjacent a wall surface of the associated chamber therefor such that the opposed terminal ends 84, 85 of each arm are in conductive contact with portions of the chamber wall, as shown with respect to arms 76 and 78 in Fig. 8. In this position, the arm is grounded. For the other of the two positions, the arms are centralized with respect to the interior of their associated chambers, at which time the opposed terminal ends 84, 85 of each arm are brought into contact with respective pairs of inner conductors, as shown with respect to arms 77 and 79 in Fig. 8. For the second of the two mentioned positions, each arm

and its associated chamber define a section of coaxial transmission line interconnecting the pair of connectors associated with the connected pair of inner conductors. The resiliency and shape of the arms assure a positive electrical contact between the terminal ends 84, 85 of each arm with the juxtaposed inner conductors and with wall surfaces of the associated chambers as each arm is brought to rest at either of its two positions.

For the purpose of the instant invention, suitable actuating means 86 in a well-known manner is synchronized so that as one set of diametrically opposed arms is moved to make the contact with respective pairs of inner conductors, the other set of diametrically opposed arms is moved into contact with the chamber walls as illustrated in Fig. 8. Fig. 8 shows one circuit connection provided by switch 60 wherein one pair of diametrically opposed arms 77, 79, are in contact with inner conductors 71, 72 and 73, 66 respectively; whereas the other pair of diametrically opposed arms 76, 78 are in ground position. In this arrangement, connector 67 is coupled to connector 68, which circuit is electrically isolated from the other circuit coupled through switch 60, the other circuit being defined by connector 69 coupled through chamber 65—arm 79 to connector 66. The circuit arrangements are also shown schematically by solid lines in Fig. 7. Electrical isolation between the respective coupled circuits is effected by grounding the pair of diametrically opposed arms 76, 78 associated with the chambers 62, 64 extending between the two separately coupled circuits. Cross-talk characteristics of switch 60 may be improved by selecting parameters for the chambers such that the chambers operate as wave guides below cut-off for the frequency band of operation.

Cross-over switching action is brought about by reversing the position of each arm, in which case arms 77 and 79 are moved to grounded position, whereas arms 76 and 78 are centralized and brought into conductive contact with respective pairs of inner conductors, as shown in Fig. 9. Connector 66 is now coupled to the connector 67, whereas connector 68 is coupled to the connector 69. This latter circuit is shown schematically by the dashed lines in Fig. 7. It will be understood that switching displacement of the four arms occur simultaneously and in addition, the arms and the chambers therefor are suitably proportioned to provide approximate impedance match with the interconnected connectors and the associated coaxial transmission lines.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An electromagnetic cross-over switch comprising, an electrical conducting block having first and second pairs of internal chambers substantially uniform in shape and for supporting electromagnetic travelling waves therein, the chambers defining said first pair being relatively electrically isolated from each other, the chambers defining said second pair being relatively electrically isolated from one another, each chamber of one pair having common wall means with respect to each chamber of the other pair, said wall means having through passages, inner conductor means supported in each chamber of said second pair and having bifurcated extensions, each bifurcated extension passing through a respective passage in said wall means and having an end terminating in an individual chamber of said first pair, movable inner conductor means in each chamber of said first pair, said movable inner conductor means having a free end alternately connecting with one and then the other of the bifurcated ends terminating in its correlated chamber, means supported by said block for coupling external circuits to

the individual inner conductors of said chambers, said inner conductor means and the correlated chambers thereof having substantially uniform shape to define individual sections of coaxial transmission line characterized by substantially uniform impedance, and means for alternating said movable inner conductor means from one to another of two positions for conductively connecting said movable inner conductor means of each chamber of said first pair with one and then the other of the bifurcated ends terminating therein, said alternating means being characterized to effect conductive connection of the movable inner conductor means in one chamber of said first pair to a bifurcated end therein from one chamber of said second pair as the movable inner conductor means in the other chamber of said first pair conductively connects to the bifurcated end terminating therein from the other chamber of said second pair to cause wave energy signals in either chamber of a pair to be alternately coupled to individual chambers of the other pair.

2. Apparatus as defined in claim 1 wherein, said chambers defining said first pair being longitudinally aligned, and the individual chambers of said second pair being on opposite sides of the aligned longitudinal axis.

3. A cross-over switch comprising, a conductive block having first and second pairs of internal chambers for supporting electromagnetic wave energy therein, the chambers defining said first pair being relatively electrically isolated from each other, the chambers defining said second pair being relatively electrically isolated from each other, connector means for coupling each chamber to an external circuit, each chamber of one pair having common wall means with respect to each chamber of the other pair, said wall means having through passages, each connector means having an inner conductor extension in its correlated chamber, the inner conductor for each chamber of said second pair having bifurcated extensions, each bifurcated extension passing through a respective passage in said wall means and having an end terminating in a respective one of said chambers of said first pair, movable conducting means in each chamber of said first pair, each of said movable conducting means being connected to the inner conductor of its correlated chamber and having a free end alternately connecting with one and then the other of the bifurcated ends terminating such chamber, said movable means and the inner conductors of said second pair of chambers operatively cooperating with their individual chambers to define individual sections of coaxial transmission line, and means for alternating said movable conducting means from one to another of two positions for conductively connecting said movable conducting means of each chamber of said first pair with one and then the other of the bifurcated ends terminating therein, said alternating means conductively connecting the movable conducting means of one chamber of said first pair to the bifurcated end therein from one chamber of said second pair as the movable conducting means in the other chamber of said first pair conductively connects to the bifurcated end therein from the other chamber of the second pair, whereby wave energy signals in either chamber of a pair are alternately coupled to individual chambers of the other pair.

4. Apparatus as defined in claim 3 wherein the chambers of said first pair being in longitudinal alignment and having spaced adjacent ends at said common wall means, respective chambers of said second pair being disposed on opposite sides of the axis of alignment of said chambers of said first pair, said chambers of said second pair also being disposed substantially adjacent said spaced apart ends of said chambers of said first pair.

5. Apparatus as defined in claim 3 wherein, said block having through apertures communicating with the chambers of said first pair, said alternating means comprising, a slidable dielectric member in said apertures and individual ones of said members having an end in the interior of respective ones of said chambers of said

first pair for engaging the movable conducting means therein, and means for slidably displacing said dielectric members to cause simultaneous and selective alternating movement of said movable conducting means.

6. A cross-over switch for interconnecting electromagnetic wave signals comprising, a switch body having internal conductive walls providing an enclosed and continuous passage, said enclosed passage being defined by a plurality of axial chambers connected end to end, each chamber having spaced apart ends and each chamber end communicating with a contiguous end of an adjacent chamber, alternate ones of said chambers defining first and second pairs, connector means supported by said body and each having an inner conductor extending into said enclosed passage at an individual one of the contiguous ends of adjacent chambers for coupling an external circuit thereto, conductive means supported in said first and second pairs of chambers for movement from one to another of two positions, the conductive means in each chamber having axially spaced contact portions conductively connecting respectively to the inner conductors at the spaced ends of its coextending chamber when such conductive means is moved to the first of its positions to define a section of coaxial line for electrically connecting the external circuits coupled to the inner conductors at the ends of such chamber, the contact portions of said conductive means contacting said chamber walls upon movement of such conductive means to the second of its positions for electrically isolating the inner conductors at the ends of its coextending chamber, and means for moving said conductive means of said first pair of chambers from its first position to its second position as the conductive means of said second pair of chambers move from its second position to its first position.

7. Apparatus as defined in claim 6 wherein, the chambers constituting said first pair are diametrically opposite each other.

8. Apparatus as defined in claim 6 wherein, the chambers constituting said first pair are diametrically opposite each other, and the chambers constituting said second pair are diametrically opposite each other.

9. Apparatus as defined in claim 6 wherein, the individual chambers of said first and second pairs are characterized as wave guides operating below cut-off frequency when the conducting means coextending therein is in the second of its positions.

10. Apparatus as defined in claim 6 wherein, the chambers constituting said first pair are in relative parallel relationship, and the chambers constituting said second pair are in relative parallel relationship.

11. Apparatus as defined in claim 10 wherein, the conductive means in said first and second pairs of chambers being longitudinal switch arms which undergo lateral movement through parallel planes when moved from one to the other of their two positions.

12. An electromagnetic travelling wave cross-over switch for interconnecting a plurality of transmission lines comprising, an electrical conducting block having interior conducting walls providing a continuous internal passage defined by a plurality of axial chambers connected end to end, each chamber having an end communicating with an end of an adjacent chamber, coupling means spaced along said block for coupling external circuits to said chambers, each of said coupling means having an inner conductor extending into said passage at an individual one of said connected ends of adjacent chambers, movable conductive means extending through each of said chambers and having terminals adapted to conductively contact the inner conductors at the ends of its coextending chamber, means for moving said conductive means from one to another of two positions, said moving means being characterized so that alternate ones of said movable conductive means move to the first of its positions wherein the terminals thereof make conductive contact with

respective pairs of adjacent inner conductors as the other alternate movable means simultaneously move to the second of its positions wherein the terminals thereof make conductive contact with walls of their coextending chambers.

13. Apparatus as defined in claim 12, said movable means comprising, arms of resilient conductive material, each arm being in centrally disposed operational relationship with respect to the conducting walls of its coextending chamber to define a section of coaxial transmission line when such arm is in the first of its positions wherein the terminals thereof conductively contact the inner conductors at the ends of its coextending chamber.

14. Apparatus as defined in claim 12, said movable means comprising, arms of resilient conductive material, one set of such alternate arms defining a pair, said pair of arms being in centrally disposed operational relationship with respect to the conducting walls of their coextending chambers to define individual sections of coaxial transmission line when such arms are in the first of their positions wherein the terminals thereof conductively contact the inner conductors at the ends of their coextending chambers, whereas a second set of alternate ones of said arms are in their second positions as the terminals thereof conductively contact conducting walls of their coextending chambers.

15. Apparatus as defined in claim 12 wherein, the individual chambers are characterized as wave guides operating below cut-off frequency when the movable conductive means coextending in the chamber is in the second of its positions.

16. An electromagnetic wave cross-over switch interconnecting a plurality of transmission lines and adapted to reverse the aforesaid connections comprising, a multi-sided electrical conducting block having internal walls defining a continuous interior passage defined by a plurality of chambers connected end to end wherein each chamber has spaced apart ends and wherein one end of each chamber communicates with a contiguous end of an adjacent chamber, means at said contiguous ends for coupling external circuits to said chambers an inner conductor extending into said passage at the individual ones of said contiguous ends, movable conducting means extending in each chamber, each of said conducting means having terminals making electrical conductive connection with the inner conductors at the ends of its coextending chamber, and actuating means for operating pairs of said conducting means simultaneously from one to another of two positions, alternate ones of said conducting means defining first and second pairs, said actuating means being characterized so that a first pair of said movable means move to the first of its positions to effect electrical contact with respective pairs of inner conductors at the ends of their respective coextending chambers, whereas a second pair of said alternate ones of said movable means are moved to the second of their two positions such that the terminals thereof are in electrical contact with wall portions of their respective chambers.

17. Apparatus as defined in claim 16 wherein, said movable means comprising, resilient conducting arms extending longitudinally within correlated ones of said chambers, each arm being centrally disposed within its chamber when in the first of its positions to define a section of coaxial transmission line.

References Cited in the file of this patent

UNITED STATES PATENTS

70	2,498,907	Atwood	Feb. 28, 1950
	2,584,901	Miller	Feb. 5, 1952
	2,695,385	Shunemann	Nov. 23, 1954

FOREIGN PATENTS

75	646,510	Great Britain	Nov. 22, 1950
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