Aug. 30, 1966 W. E. STAPF 3,270,299
COAXIAL SWITCHING APPARATUS FOR CONNECTING SELECTED SOURCES TO SELECTED LOADS
Filed Jan. 8, 1964 4 Sheets-Sheet 1

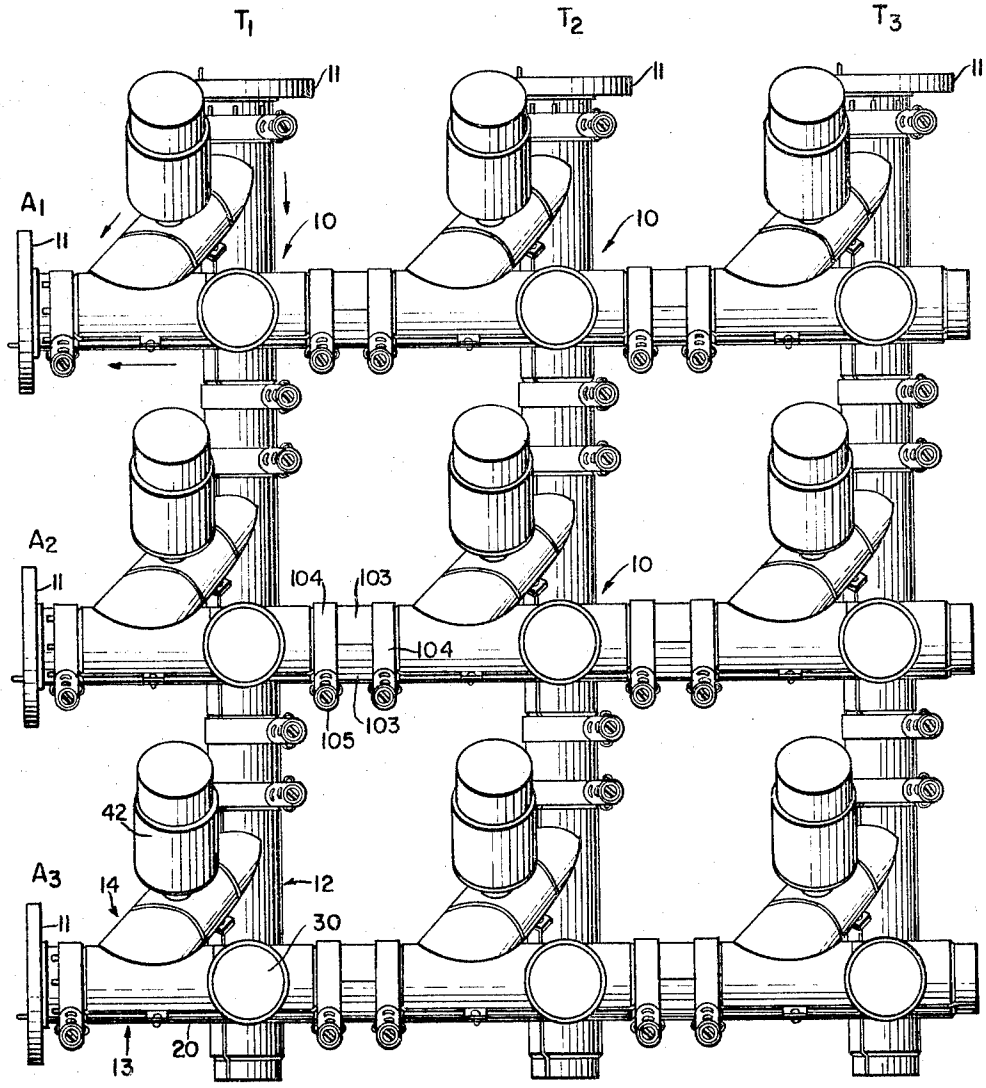


FIG. 1.

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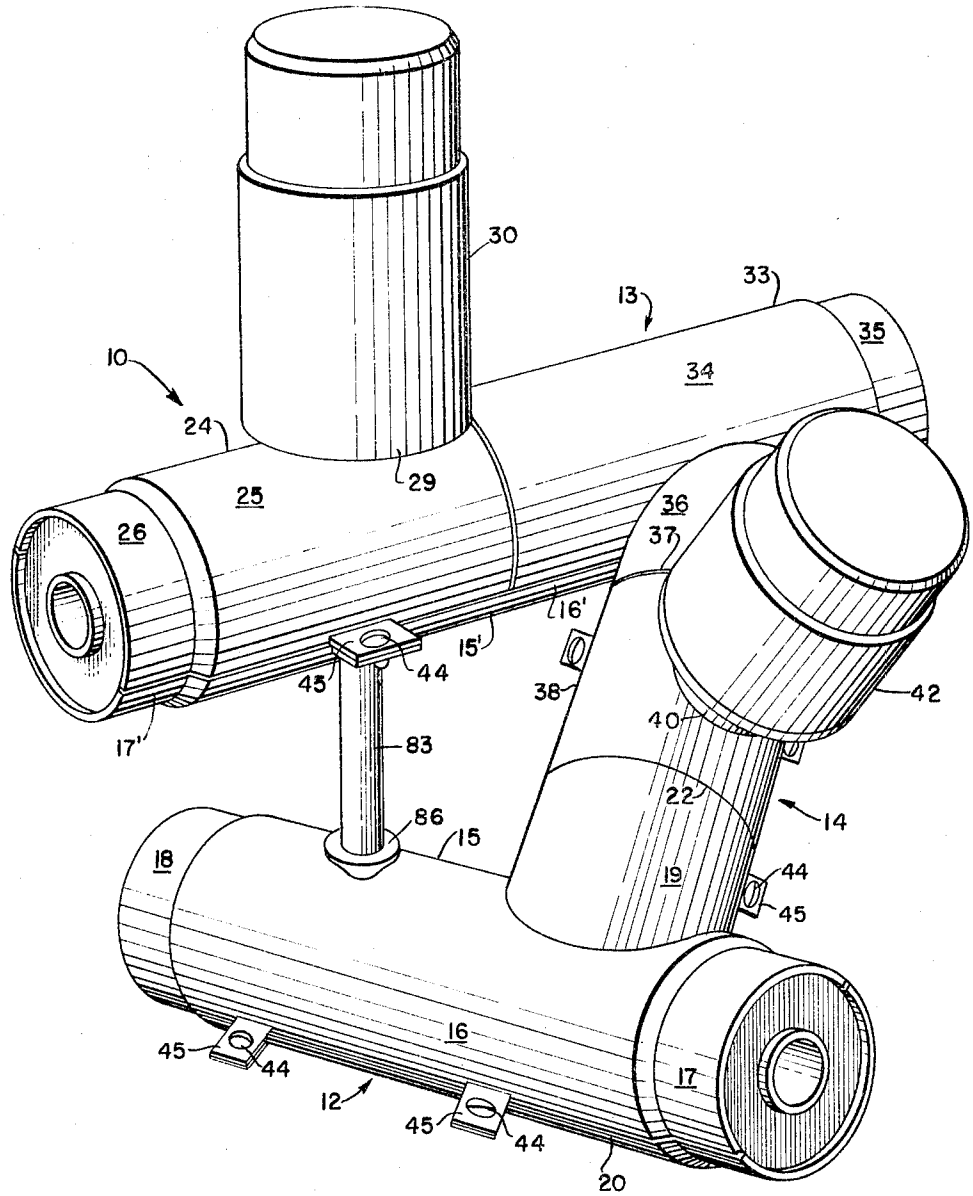


FIG. 2.

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COAXIAL SWITCHING APPARATUS FOR CONNECTING SELECTED SOURCES TO SELECTED LOADS
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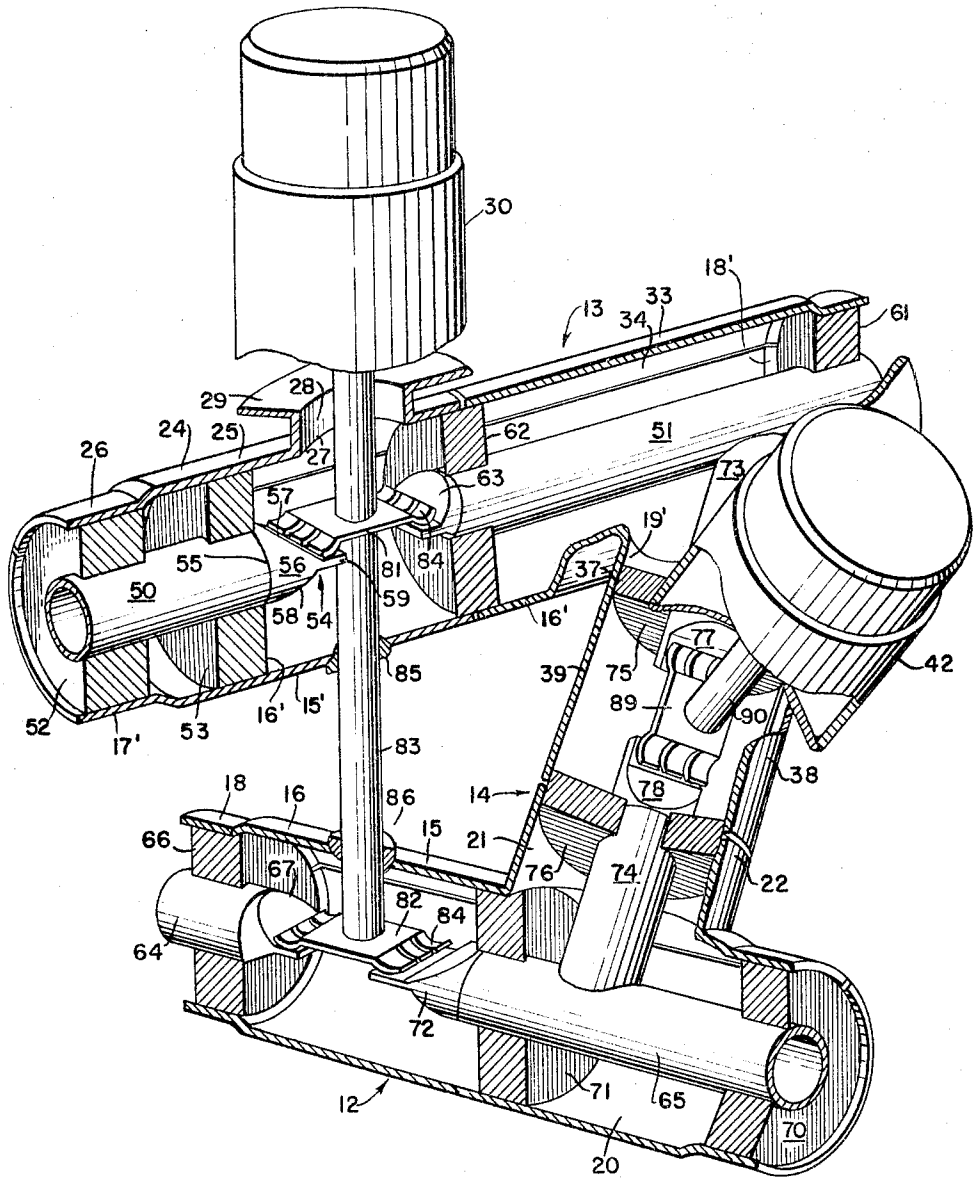


FIG. 3.

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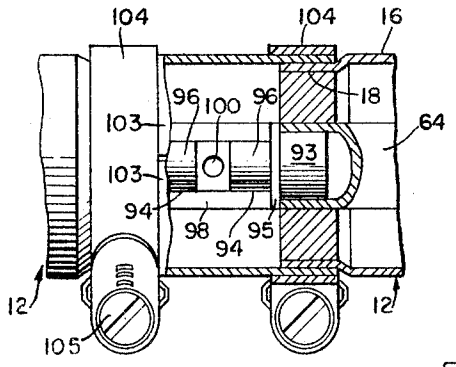


FIG. 4.

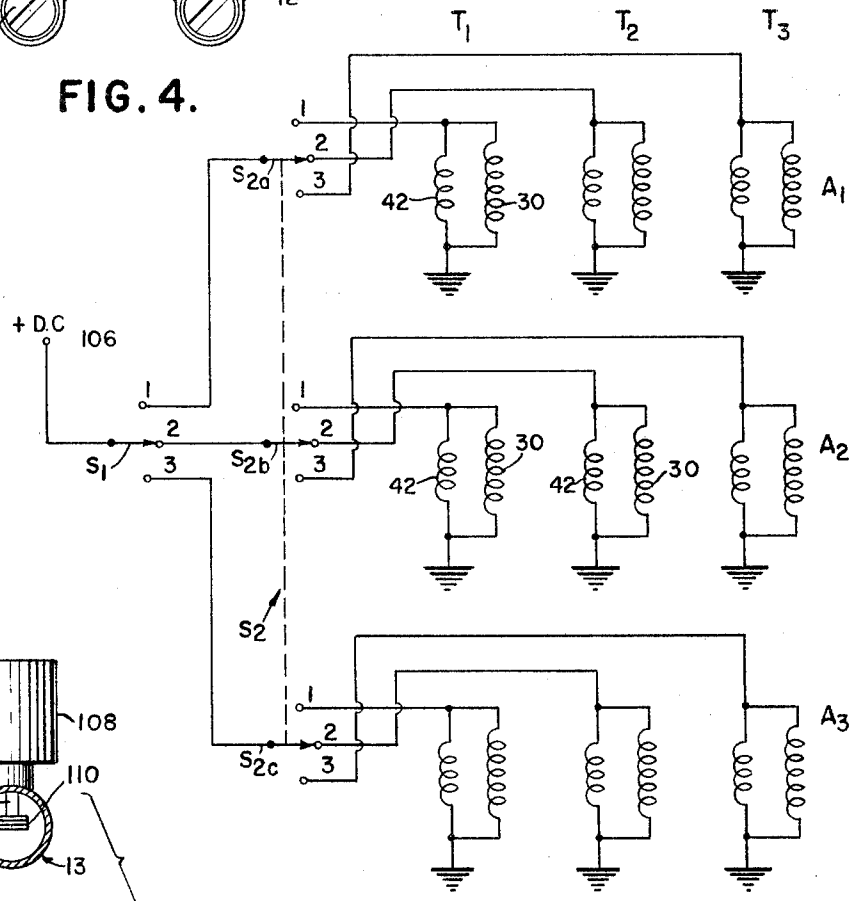


FIG. 5.

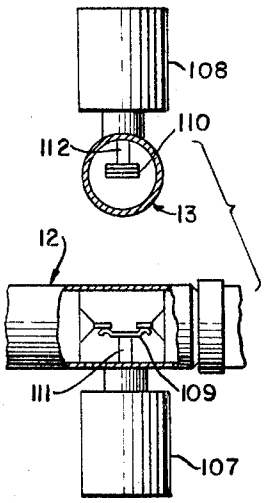


FIG. 6.

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United States Patent Office 3,270,299 Patented August 30, 1966

3,270,299

COAXIAL SWITCHING APPARATUS FOR CONNECTING SELECTED SOURCES TO SELECTED LOADS

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Filed Jan. 8, 1964, Ser. No. 336,596
9 Claims. (Cl. 333—7)

This invention relates to switching of high frequency systems and specifically to switchng apparatus for selectively connecting one of a plurality of high frequency sources to one of a plurality of load devices via coaxial lines.

The most usual application for coaxial line switching devices of the type described herein is in selectively connecting a desired one of a number of high frequency transmitters to a particular one of a number of available antennas, and the invention will be discussed in terms of such an application, although it is not limited thereto.

Conventionally such a switching system comprises a matrix formed in part of two orthogonal sets of coaxial transmission lines. A separate transmitter is connected to the input end of each line of one of these sets, and a separate antenna is connected to the output end of each end of each line of the other set. Each line of the transmitter set must be capable of being selectively connected to each line of the antenna set. This requires a bridging coaxial line to connect each line of the transmitter set to each line of the antenna set. At each such area of possible connection, or "crossover point," there are three coaxial switches normally required to effect selective connection: One switch in the bridging line section, one switch in the transmitter line to open that line between the crossover point and the output end, and one switch in the antenna line to open that line between the input end and the crossover point. Coaxial vacuum switches are expensive, and since, for M transmitters and N antennas, a conventional switching system of the type described will require 3MN coaxial switches, it is obvious that such a system is extremely costly. The principal cost of these coaxial switches is in the solenoid, and vacuum sealed contacts.

It is an object of this invention to provide a non-vacuum coaxial line switching matrix of a unique configuration requiring fewer coaxial switch solenoids, which may consequently be constructed at greatly reduced cost, with non-vacuum sealed contacts.

Conventional coaxial switching matrices are custom designed and built for a particular application. For this reason they are not easily adaptable for use with quantities of transmitters and antennas differing from those for which they are designed.

It is therefore another object of this invention to provide a coaxial switching matrix which may be easily and conveniently altered to switch varying numbers of transmitters and antennas.

The coaxial switch is the element most likely to fail in a switching matrix. In a conventional type of matrix, the entire surrounding connections must be removed and disassembled in order to replace a defective switch, requiring the expenditure of a considerable amount of time, and, what is worse, resulting in a long "down" time for the transmitter antenna system complex.

It is therefore a further object of this invention to provide a coaxial switching matrix in which the switch elements may be quickly and easily replaced with a minimum of disassembly being required.

The switching matrix of this invention, in its preferred embodiment, comprises a plurality of identical modules that may be quickly and easily assembled into a complete switching matrix, and, that, by the addition or removal of the appropriate number of modules, the matrix may be quickly converted to adapt to any change in the number of transmitters or antennas, or both, that are to be switched. Each module comprises a transmitter section of coaxial line, an antenna section, and a bridging section diagonally connecting the two. The diagonal arrangement permits both the transmitter and receiver lines to be switched by a single solenoid driving two switch actuators, one in each line, thus requiring one less solenoid per module than would be required by the conventional construction wherein a separate solenoid and actuator are used to switch each line. A separate switch, including both solenoid and actuator, is used to switch the bridging section.

The outer conductor of the coaxial module is formed of a plurality of shell portions that are easily assembled and disassembled. The solenoids of the coaxial switches are mounted externally of the sectionalized outer conductor structure, and are connected to the internally positioned switch actuators by linkage means extending through one or more holes in the appropriate outer shell portions. To remove a coaxial switch, the appropriate outer conductor shell portion or portions are merely removed from the module assembly and the switch may be lifted free.

Therefore, a still further object of this invention is to provide a coaxial switching matrix in which the principal elements are a plurality of identical modules, the modules being so constructed as to permit relatively simple assembly procedures in forming the matrix.

Correspondingly, the use of a plurality of identical modules substantially reduces the per unit cost of each module, since at least some of the elements of each module can be produced by mass production methods, and hence, an additional object is a coaxial switching matrix of substantially reduced cost.

By a unique arrangement of elements of each module applicant has discovered that several of the module elements can be identical, and hence, costs of tooling are also reduced. Therefore, a still further object of this invention is to provide a module for a switching matrix in which several of the module elements are identical.

The manner in which the modules which form the matrix of this invention fulfill the above and other objectives may be more clearly understood by reference to the following detailed description of certain embodiments of the invention taken in conjunction with the drawings, which form a part of the specification, and in which:

FIG. 1 is an elevational view of a coaxial switching matrix in accordance with the preferred embodiment of this invention;

FIG. 2 is a perspective view of a single module of the preferred embodiment shown in FIG. 1;

FIG. 3 is a perspective view similar to FIG. 2, but with a large portion of the outer conductor cut away to reveal the structure of the inner conductor, spacers, and switches;

FIG. 4 is a fragmentary view of the connection between the ends of two adjacent modules in the matrix of FIG. 1, with a portion cut away to show internal connector details;

FIG. 5 is an electrical schematic diagram of the control circuit for the coaxial switches of the matrix of FIG. 1; and

FIG. 6 is a fragmentary view, partially in section, of another embodiment of this invention in which separate switches, each comprising a solenoid and switch actuator, as used to switch the transmitter and antenna section of each module.

FIG. 1 shows a switching matrix for selectively connecting any one of three transmitters to any one of

three antennas. The matrix comprises nine identical and hence, interchangeable crosspoint modules **10**, which, when connected together as shown, define a set of straight parallel transmitter coaxial lines T_1, T_2 and T_3, and an orthogonally arranged set of straight parallel antenna coaxial lines A_1, A_2 and A_3 spaced from the transmitter lines with appropriate switching means interconnected between the two sets.

The modules are connected together to form the matrix by various interconnecting elements which will be described below. At the same end of each of the three transmitting coaxial lines T_1, T_2 and T_3, and at the same end of each of the antenna coaxial lines A_1, A_2 and A_3, there are attached identical flanges **11** for connection of the respective coaxial lines to a transmitter or antenna as the case may be.

The end of each transmitter line to which the flange **11** is attached is referred to as the "input" end, and the other end is correspondingly the "output" end. The ends of the transmitter line section of the modules are correspondingly designated; that end of each section which will face toward the transmitter in the assembled matrix is the "input" end and the other is the "output" end. Similarly, for the antenna coaxial lines, the ends of the lines which are to be attached to the antennas comprise the "output" ends, and the other ends are referred to as the "input" ends. The modules have their antenna coaxial sections correspondingly designated.

Each module, as may be seen more clearly in FIGS. 2 and 3, comprises a transmitting coaxial line section **12**, an antenna coaxial line section **13**, spaecd from an orthogonal with the transmitting coaxial line section, and a bridging coaxial line section **14** connecting sections **12** and **13** on a diagonal.

A plurality of removably connected diametrically mating shell members define, when connected, the electrically continuous outer coaxial conductor structure of the three connecting coaxial sections in each module.

A thin walled shell section **15** forms half of the outer conductor structure of transmitting section **12**. Shell section **15** has a central portion **16** that is semicircular in cross sectional configuration, central portion **16** having two similarly shaped semicircular ends **17** and **18** of reduced diameter. Near end **17** of central portion **16** is an integral semicircular portion **19** that projects at an angle from central portion **16**. The other half of the outer conductor structure of transmitting section **12** is a thin wall shell section **20** which is the mirror image of shell section **15** and mates with shell section **15** to form a diametrically split complete outer conductor for transmitting section **12**. Shell section **20** has a semicircular projecting wall **21** that mates with semicircular portion **19** to form a projecting cylindrical wall having a flat annular end edge **22**, the axis of this cylindrical wall intersecting the axis of transmission section **12** and antenna section **13**.

One half of antenna coaxial line section **13** is formed by a shell section **15'** that is identical to shell section **15**, having a central portion **16'** of semicircular section and end portions **17'** and **18'** of reduced diameter semicircular section, as well as an integral projecting portion **19'** that is semicircular in section. (The similarity between shell section **15** and shell section **15'** can be best visualized by inverting shell section **15** and turning same 90° toward antenna section **13**, whereupon, it is evident that these shell sections are identical.)

The antenna coaxial line section outer conductor structure is completed by two additional shell sections. One section **24** has a main portion **25** and a reduced diameter end portion **26**, portions **25** and **26** being of semicircular section and mating with the main central portion **16'** and the reduced diameter end portion **17'**, respectively, of shell section **15'**. As may be seen in FIG. 3, the main portion **25** of section **24** has an opening **27** from which a cylindrical wall **28** projects in a direction normal to the axis of antenna section **13**, and an annular flange **29** that opens radially from cylindrical wall **28** to form a seat for a solenoid **30**, shown partially cut away.

Antenna section **13** is completed by a shell section **33** which has a main portion **34** of semicircular section and an end portion **35** of reduced diameter semicircular section. Projecting from main portion **34** at an angle is a semicircular wall **36** which mates with the corresponding projecting portion **19'** of section **15'** to form a cylindrical wall that is aligned with the cylindrical wall formed by portions **19** and **21**.

The cylindrical wall formed by wall **36** and projecting portion **19'** terminates at a flat annular end edge **37**.

The cylindrical walls that terminate respectively at flat annular end edges **22** and **37** form the ends of the outer conductor portion of bridging coaxial line section **14**.

The outer conductor of bridging coaxial line section **14** is completed by two additional shell sections that form a thin walled right circular cylinder of a length equal to the distance between end edges **22** and **37**, and of the same diameter. These shell sections **38** and **39** are each semicircular in section. Shell section **38** has a solenoid supporting structure **40** for supporting solenoid **42**, that is identical to the solenoid support for mounting solenoid **30**. Shell section **39** mates with shell section **38** to complete the outer conductor portion of bridging section **14**.

All of the various shell sections are formed so that their side edges abut the mating shell sections. The mating sections are connected by passing bolts **44** through openings in tabs **45** that project radially from the edges of the shell sections in aligned relation. The particular locations of the various tabs is not critical. It is to be understood however that the tabs should be located, and a sufficient number used to provide adequate mechanical strength for the assembled unit. The mode of connection, using bolts **44**, is apparent from FIGS. 2 and 3.

The interior structure of a module **10** may be seen in FIG. 3, where large portions of the outer conductor shell structure are cut away. Broadly speaking the inner structure comprises hollow cylindrical inner conductors spaced from the outer conductor shell structures by annular insulators, and switching means for selectively connecting and disconnecting the inner conductor in each module section.

The inner conductor of antenna coaxial line section **13** comprises two hollow cylindrical inner conductor sections of suitably electrically conducting material, such as copper. A relatively short section **50** is located at one end of the coaxial section, which is the input end; and a longer section **51** extends to the other, or output end, of the antenna section. Inner conductor section **50** is spaced from the outer conductor shell by two annular insulators **52** and **53**, which may be of any suitable electrically insulating material, and which are preferably of Teflon. Insulator **52** fits over the inner conductor section and its outer periphery fits within the two mating outer shell portions of reduced diameter, **17'** and **26**. Insulator **53** has an inner diameter identical to that of insulator **52** and likewise fits over inner conductor section **50**. However, it has a larger outer diameter than insulator **52**, and its periphery fits within mating outer conductor shell portions **16'** and **25**. Insulators **52** and **53** may make a press fit with inner conductor section **50**, or they may be suitably bonded thereto by any appropriate means. The outer conductor shell portions are pressed tightly against the outer periphery of the insulators by the force of bolts **44**, through tabs **45**, pulling together the mating sections.

The inner end of inner conductor section **50** is fitted with a contact **54**. Contact **54** is preferably of a solid copper construction. It has a cylindrical portion **55** of reduced diameter that fits into the open end of inner conductor **50** and is fastened thereto by soldering or other appropriate means. The main body portion **56** of

contact 54 has a cylindrical periphery at one end that is flush with the outer surface of section 50, and then tapers along two converging surfaces 57 and 58 to a flat axial portion 59 which forms a stationary contact.

Inner conductor section 51 is similarly maintained in coaxial relation to the outer conductor shell by spacers 61 and 62 that are identical to spacers 52 and 53. The inner end of inner conductor section 51 is provided with a contact 63 that is identical to contact 54 and is attached to the inner conductor in an identical manner.

Transmitter section 12 has two hollow cylindrical inner conductor sections 64 and 65, relatively shorter and longer respectively, positioned near the output and input ends, respectively, of the transmitting section. Inner conductor 64 is spaced from the reduced diameter end portion of the outer conductor shell by a Teflon spacer 66 identical to spacer 52 and attached in an identical manner, and the inner conductor section is fitted with a contact 67 identical to contacts 54 and 63 already described, and attached to the inner conductor in an identical manner. Inner conductor section 65 is spaced from the reduced diameter end portion and the main central portion of the outer conductor shell by insulators 70 and 71 respectively and is fitted at its inner end with a contact 72 identical to the contacts described previously.

The inner conductor structure of bridging section 14 is formed by hollow cylindrical sections 73 and 74 that project angularly from, and are rigidly attached to, center conductor sections 51 and 65 respectively. The inner ends of sections 73 and 74 are fitted with contacts 77 and 78 that are identical to the other contacts and connected to the inner conductor structure in an identical manner. Annular insulators 75 and 76 space inner conductor sections 73 and 74, respectively, from the outer conductor shell, and they are identical to annular spacers 53, 62 and 71 previously described.

Simultaneous switching of the inner conductors of antenna section 13 and transmitter section 12 is accomplished by movable switching members 81 and 82, respectively. Switching members 81 and 82 are fixed in spaced apart relation to a rod-like linkage element 83. Switching elements 81 and 82 are identical, being in the shape of slightly elongated rectangles of electrically conductive metal, and having a series of curved spring fingers 84 at two opposite sides of the rectangular portion. The curved spring fingers of switching member 81 bow slightly toward the stationary contacts 54 and 63 at the inner ends of conductor sections 50 and 51. Likewise, spring fingers 84 of switching member 82 bow slightly toward the contacts 67 and 72 of conductor sections 64 and 65. Switching members 81 and 82 are fixed to rod 83 so that spring fingers 84 of switching member 81 overlap the flat spaced apart ends of contacts 54 and 63 of antenna section 13, and the spring fingers of switching member 82 overlap the flat spaced apart ends of contacts 67 and 72 of transmitter section 12. Since these two sections have their axes spaced apart at right angles to each other the spring fingers of switching members 81 project in a direction at right angles to the spring fingers of switching member 82.

Linkage rod 83 is formed of suitable insulating material such as Teflon and is secured to the armature (not shown) of solenoid 30. The armature of solenoid 30 is spring biased to move switching members 81 and 82 into engagement with the contacts on inner conductors of the antenna and transmitter sections when the solenoid 30 is unenergized. When solenoid 30 is energized, linkage rod 83 is moved in a straight line toward solenoid 30 to disengage movable switching members 81 and 82 from the stationary contacts of the inner conductors of both the transmitter and antenna sections. The stroke of rod 83 is sufficient to move switching members 81 and 82 into engagement with the outer conductor portions of transmitter and antenna sections 13 and 15. This engagement in effect short circuits the movable switching members with the outer conductors to positively prevent conduction between the contacts of the inner conductors, and the switching members.

As seen in FIG. 3 rod 83 extends at right angles to the axes of both transmitter section 12 and antenna section 13. Rod 83 extends through antenna section 13 via opening 27 in outer conductor shell section 24, and via bushing 85 positioned in an opening in shell section 15'. Rod 83 extends into transmitter section 12 through bushing 86 positioned in an opening in shell section 15. Since rod 83 is straight it follows that the various openings are axially aligned. Bushings 85 and 86 are formed of Teflon or other insulating material having good bearing properties.

It will be noted that while switching members 81 and 82 are too large to pass through any of the openings through which rod linkage 83 passes, the entire switch assembly of solenoid, linkage rod and switching members may be removed by removing the bolts 44 from the tabs 45 attaching both shell sections 15 and shell section 15', and then lifting these shell sections and the switch assembly away from the remainder of the module.

Switching member 89, identical to switching members 81 and 82 already described, switches the inner conductor of bridging coaxial section 14 by alternately connecting and disconnecting spaced apart contacts 77 and 78. Switching member 89 is fixedly attached to linkage rod 90 which is similar in construction and configuration to linkage rod 83, although shorter in length. Linkage rod 90 is attached, by means not shown, to the armature of solenoid 42. When the solenoid is energized, switching member 89 is moved into engagement with contacts 77 and 78. When unenergized, the solenoid moves switching member 89 into engagement with the outer conductor section formed by shell section 38. Linkage rod 90 extends through a bushing (not shown) in a suitable opening in the top of shell section 38 in a manner analogous to linkage rod 83 extending through bushings 85 and 86; and although switching member 89 is larger than the opening, the entire switch assembly may be easily and quickly removed from the module by removing bolts 44 from the tabs 45 of shell section 38, and lifting the shell section and the switch assembly from the remainder of the module.

The modules are connected to form a switching matrix as shown in FIG. 1, with the details of the connections shown in FIG. 4. One module is required for each desired crosspoint connection of a transmitter line to an antenna line. Thus, if it is desired to be able to connect any of M transmitters to any of N antennas, the switching matrix will be composed of MN modules. For the configuration shown in FIG. 1, where it is desired to be able to selectively connect one of three antennas, A_1, A_2 or A_3, nine crosspoint modules 10 are required for the switching matrix.

In forming the switching matrix, the modules 10 are connected to each other so that the antenna coaxial section 13 of each module becomes a part of one of the antenna coaxial lines of the matrix, and so that the transmitter coaxial section 12 of each module becomes a portion of one of the transmitter coaxial lines of the matrix. This is accomplished by connecting the input end of each module coaxial section to the output end of a corresponding section of an adjacent module, and by connecting the output end of the same module section to the input end of a corresponding section in another adjacent module on the other side. In this manner, the three horizontal antenna coaxial lines and three vertical transmitter coaxial lines of the switching matrix of FIG. 1 are formed. A flange 11 is attached to the input end of each transmitter coaxial line and to the output end of each antenna coaxial line. Three transmitters (not shown), numbered for convenience T_1, T_2, and T_3

are adapted to be attached to flanges **11** of the transmitter coaxial lines, and each transmitter line in FIG. 1 is designated by the corresponding transmitter designation. Similarly, the three horizontally disposed antenna coaxial lines of FIG. 1 are designated A_1, A_2 and A_3, to correspond to the three antennas (not shown) which are adapted to be attached to flanges **11** at their output ends.

The manner in which the inner and outer conductors of the module coaxial sections are connected to those of adjacent sections is shown in FIGS. 1 and 4. FIG. 4 shows the connection of the output and input ends of two transmitter coaxial sections **12**. The cylindrical end **93** of a solid inner conductor extension **94** of copper or similar conducting material is inserted in the open end of cylindrical inner conductor section **64** until flange **95** abuts the end of the inner conductor. Cylindrical end **93** preferably makes a press fit with the interior surface of inner conductor **64**, although it may be soldered thereto. A reduced diameter portion **96** extends from the other side of flange **95**. Another inner conductor extension **94** is similarly inserted in the open end of adjacent inner conductor section **65**, which is hidden from view in FIG. 4 by the outer conductor shell. The two reduced diameter portions **96** of the inner conductor extensions **94** are joined by two mating halves **98** of an inner conductor connector fabricated of some conducting metal such as copper. Each mating half **98** comprises a half cylindrical wall portion having a circular opening **100** at its center. The opening in one mating half **98** is threaded to receive a bolt end, and the other opening may be countersunk on the outer surface of the mating half to receive a flat bolt head. The two halves **98** are placed around the facing reduced diameter extensions **96** of inner conductor extensions **94**, and a bolt (not shown) is passed through the untapped one of the openings **100** and screwed tightly into the registering tapped hole **100**. As the bolt is drawn up tight, the mating halves **98** tightly clamp together the ends of the inner conductors.

The outer conductors are connected by means of two semicircular mating shells **103** of an outer conductor connector. These mating shells, which are preferably of the same material as the outer conductor shell, are placed over the facing reduced diameter end portions **18** and **17** (not visible in FIG. 4) of the outer conductor. Two circumferential strap clamps **104** of conventional design, are placed about the outside of mating shells **103** and drawn up tight by screws **105**, thus tightly clamping the ends of the outer conductor shell within the outer conductor connector shells.

All of the coaxial connections are formed in an identical manner to the particular connection shown in FIG. 4 and described above. Thus it will be seen that the various modules may be easily and quickly connected and disconnected, facilitating modification of the matrix and replacement of any modules that may be defective.

The switching matrix is susceptible to being switched by a variety of types of electrical circuitry, and a relatively simple electrical control circuit suitable for performing the required switching as shown in schematic form in FIG. 5. Each pair of solenoids **30** and **42** corresponding to a particular crosspoint module is parallel connected and positioned according to the position of the corresponding module in FIG. 1. The pairs of solenoids, and the modules to which they correspond, are identified by the number of the transmitter and antenna which they switch; as T_1–A_2 identifies the module at the left-center of FIG. 1 that switches the coaxial lines corresponding to transmitter T_1 and antenna A_2, and the same designation identifies the solenoid pair at the left center of FIG. 6 that forms a part of this particular module.

While either A.C. or D.C. actuated solenoids are usable in this invention, in the preferred embodiment both solenoids **30** and **42** are D.C. actuated. The appropriate positive D.C. voltage is applied to terminal **106** and fed from there to the movable switch arm of antenna switch S_1. This is a single pole, three position switch whose three numbered positions correspond to the numbers given to the three antennas. Each of the three stationary contacts **1**, **2** and **3** of antenna switch S_1 is connected to a different one of the three movable center arms of the ganged three pole, three position transmitter switch S_2, with terminal **1** of switch S_1 connnected to the center arm of wafer S_{2a}, terminal **2** of switch S_1 connected to the center arm of wafer S_{2b}, and terminal **3** of switch S_1 connected to the center arm of wafer S_{2c}. The center arm of each wafer of switch S_2 is switched between three contacts, numbered in accordance with the transmitter numbers. Each of these contacts of switch S_2 is then connected to one end of the parallel connected pair of solenoids **30** and **42** that correspond to the crossover module adapted to switch the coaxial lines of the transmitter and antenna bearing the numbers of the particular S_2 wafer contact and the particular S_1 contact connected to that particular S_2 wafer, respectively. The other end of each parallel connected solenoid pair is grounded.

Thus, by moving the center arms of switches S_1 and S_2 to the appropriately numbered positions, the solenoids belonging to any desired crosspoint module may be energized. For instance, in FIG. 5 switches S_1 and S_2 are both placed on position number **2**, thus energizing the solenoids **30** and **42** in the T_2–A_2 crosspoint module.

In operation, with the appropriate transmitters and antennas connected to flanges **11** of the switching matrix, the switches S_1 and S_2 are set to actuate the crosspoint module corresponding to the particular transmitter and antenna that it is desired to connect. Let us assume that it is desired to connect transmitter T_2 to antenna A_2, so that the switches are set as shown in FIG. 5. Then the solenoids **30** and **42** of crosspoint module T_2–A_2 (center of FIG. 1) are energized.

As described above, energization of solenoid **42** establishes continuity in bridging section **14** and energization of solenoid **30** breaks continuity in both transmitting section **12** and antenna section **13**. With the switches in the positions shown in FIG. 5, bridging section **14** of module T_2–A_2 connects the T_2 transmitter coaxial line to the A_2 antenna coaxial line, and the transmitter and antenna coaxial lines are interrupted in the T_2–A_2 module.

Transmitter T_2 is then turned on. The transmission from transmitter T_2 proceeds through the transmitter section **12** of the T_2–A_1 module (since solenoid **30** of this module is deenergized) and proceeds through the bridging section **14** of the T_2–A_2 module to the A_2 coaxial line. The transmission does not proceed further down the T_2 transmitter coaxial line because that line is interrupted on the output side of the T_2–A_2 module bridging section. When the transmission enters the A_2 antenna coaxial line, it proceeds to the left through the antenna section of module T_1–A_2, since solenoid **30** of that module is deenergized, and thence reaches antenna A_2. The transmission cannot proceed to the right along the A_2 transmission line since that line is interrupted in the T_2–A_2 module on the input side of the bridging section.

It is obvious that additional transmitters or antennas may be added by connecting additional columns or rows, respectively, of crosspoint modules to the matrix configuration of FIG. 1.

FIG. 6 is a fragmentary view of an alternative embodiment in which the single solenoid double switching assembly of the preferred embodiment is replaced with two separate switch assemblies each including a solenoid **107**, **108** that independently operate the contacts for transmitter section **12** and antenna section **13**. Note that the resulting switch assemblies are each identical to the switching assemblies for bridging section **14** as described for the preferred embodiment of the coaxial switch assembly. Note that solenoid **107** projects below transmitter section **12** whereas solenoid **108** projects above antenna section **13**. In each instance movable contacts **109** and **110** are connected to the respective solenoid by operating rods

111 and 112 that extend through the outer conductor of the respective coaxial line sections.

Various changes and modifications in the embodiments of the invention shown and described are contemplated as being within the scope of this invention. For example, the orientation of the transmitting and antenna line section although shown in parallel sets at right angles to each other could be slightly angled without departing from the spirit of this invention. Also, the various line sections and modules could be oriented in any desired direction without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In a module for a switching matrix, the combination comprising

a first coaxial line section having input and output ends;

a second coaxial line section having input and output ends, said second section being spaced from and orthogonal with said first section;

a bridging coaxial line section connecting said first and second sections;

each of said line sections including a substantially straight inner conductor, and an outer conductor concentric with said inner conductor and comprised of a plurality of removable shell sections;

each of said inner conductors being discontinuous and defining a pair of spaced contacts thereby;

electrically insulating spacer means disposed between said inner and outer conductors of each of said line sections for maintaining their coaxial relationship; and

each of said line sections including switching means, each of said switching means comprising:

actuating means disposed externally of said outer conductor thereof;

a switching member disposed within said outer conductor thereof for connecting and disconnecting one of said contact pairs of said inner conductor;

linkage means extending through one of said shell sections and being connected between said actuating means and said switching member for positioning said switching member to connect or disconnect said contact pairs in response to said actuating means;

said contact member, actuating means, and mechanical linkage for each of said line sections being removable as a unit by removing selected ones of said shell sections in which openings are located, whereby replacement of selected ones of said switching means is facilitated.

2. A switching matrix for selectively connecting any one of a plurality of high frequency energy sources to any one of a plurality of loads, comprising

a first set of spaced, parallel, coaxial lines;

a second set of spaced, parallel, coaxial lines orthogonal with and spaced from, said first set;

said first and second sets defining a plurality of crossover points where straight lines orthogonal to both said sets intersect one coaxial line of each said set;

a plurality of first switching means, one located adjacent each said crossover point, each of said first switching means comprising

a switch actuator,

linkage means disposed substantially along an axis comprising the straight orthogonal line intersecting said coaxial lines, and connected to said switch actuator to be displaced thereby along the axis, and

first and second switching members connected in spaced apart relation to said linkage means and adapted to simultaneously interrupt conduction in said coaxial lines of said first and second sets, respectively, upon displacement of said linkage means along its axis; and

a plurality of second switching means selectively connecting each coaxial line in said first set to any coaxial line in said second set.

3. A switching matrix in accordance with claim 2 and comprising further

a plurality of bridging coaxial sections diagonally disposed so that each said bridging section connects a separate one of said first set of parallel coaxial lines to a separate one of said second set of parallel coaxial lines;

a separate one of said plurality of second switching means being disposed in and adapted to interrupt conduction in each of said bridging coaxial sections.

4. In a switching matrix for selectively connecting any one of a plurality of high frequency energy sources to any one of a plurality of loads, the combination comprising

a plurality of identical interchangeable crosspoint modules each comprising

a first coaxial line section having input and output ends,

a second coaxial line section having input and output ends, said second section being spaced from and orthogonal with said first section, and

a bridging coaxial line section connecting said first and second sections;

first section switching means including a movable contact member adapted to interrupt conduction in said first coaxial line section between said output end and the point of connection with said bridging section;

second section switching means including a movable contact member adapted to interrupt conduction in said second coaxial line section between said input end and the point of connection with said bridging section;

bridging section switching means including a movable contact member adapted to interrupt conduction in said bridging coaxial line section;

linkage means interconnecting said movable contact members of said first and second switching means; and

first switch actuating means connected to said linkage means;

whereby operation of said switch actuating means is effective to simultaneously interrupt conduction in both said first and second coaxial line sections.

5. A switching matrix in accordance with claim 4 in which

said first and second sections of each of said modules define a crossover point where a straight line orthogonal with both said sections intersects said sections, and

each of said bridging coaxial line sections extends diagonally to connect with said first section, at a point between its input end and said crossover point, and with said second section, at a point between its output end and said crossover point, of the same module.

6. A switching matrix in accordance with claim 4 which further includes

second switch actuating means for operating said switch means of said bridging section,

said first and second actuating means being so arranged and electrically controlled that said first actuating means is operated to interrupt conduction in said first and second coaxial line sections at the same time that said second actuating means is operated to complete conduction in said bridging section.

7. A switching matrix in accordance with claim 6 in which

each of said coaxial line sections is comprised of

an inner conductor structure, and

an outer conductor structure;

said outer conductor structure including a plurality of removable connected shell members in concentric relation with said inner conductor structure;

said second switch actuating means is mounted on the outer conductor of said bridging section; and

said first switch actuating means is mounted on the outer conductor of one of the other coaxial line sections.

8. In a module for a switching matrix, the combination comprising

a first coaxial line section having input and output ends;

a second coaxial line section having input and output ends, said second section being spaced from and orthogonal with said first section;

a bridging coaxial line section connecting said first and second sections;

each of said line sections including a substantially straight inner conductor, and an outer conductor concentric with said inner conductor;

said outer conductor of each of said line sections being comprised of a plurality of removable shell sections, one of said shell sections having an opening therein spaced from the edges thereof;

each of said line sections including switching means, each of said switching means comprising:

a movable contact member within said outer conductor thereof; and

a mechanical linkage connected to said contact member and extending through said opening in said one of said shell sections of said outer conductor;

actuating means disposed outside said outer conductor and connected to said linkage means for operating said switch means; and

said contact member, actuating means, and mechanical linkage for each of said line sections being removable as a unit by removing selected ones of said shell sections in which openings are located, whereby replacement of selected ones of said switching means is facilitated.

9. In a module for a switching matrix, the combination comprising

a first coaxial line section having input and output ends;

a second coaxial line section having input and output ends, said second section being spaced from and orthogonal with said first section;

a bridging coaxial line section connecting said first and second sections;

each of said line sections including a substantially straight inner conductor, and an outer conductor concentric with said inner conductor;

said outer conductor of each of said line sections being comprised of a plurality of removable shell sections;

each of said line sections including switching means, each of said switching means comprising:

a movable contact member within said outer conductor thereof; and

a mechanical linkage connected to said contact member and extending through said outer conductor;

actuating means disposed outside said outer conductor and connected to said linkage means for operating said switch means;

said mechanical linkage of the switching means for said first and second line sections is a first shaft;

said mechanical linkage of the switching means for said bridging line section is a second shaft;

said actuating means includes

a first switch actuator connected to said first shaft to operate said switching members of said first and second line sections; and

a second switch actuator connected to said second shaft to operate said switching member of said bridging section; said first switch actuator, first shaft, and switching members for said first and second line sections being removable as an assembled unit by removing selected ones of said removable shell sections of said first and second line sections; said second switch actuator, second shaft, and switching member for said bridging line section being removable as an assembled unit by removing selected ones of said removable shell sections of said bridging line section;

whereby replacement of any portion of either of said assembled units can be quickly effected by removing an entire assembled unit and replacing same with an identical previously assembled unit.

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