June 13, 1967 C. G. SONTHEIMER 3,325,587

ELECTRICAL CONNECTOR FOR TRANSMISSION LINES AND THE LIKE

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FIG. 2

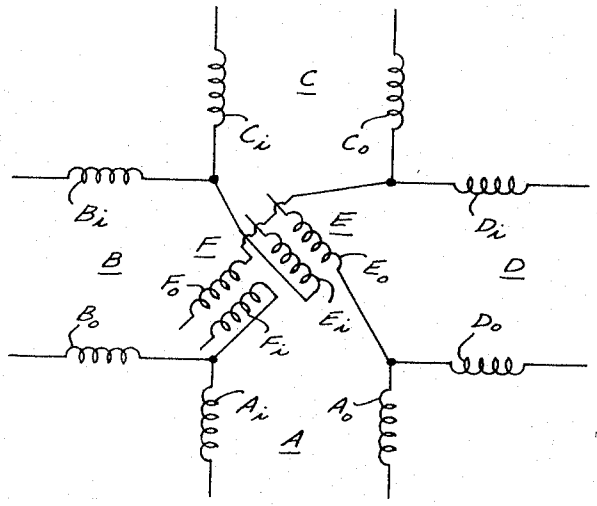
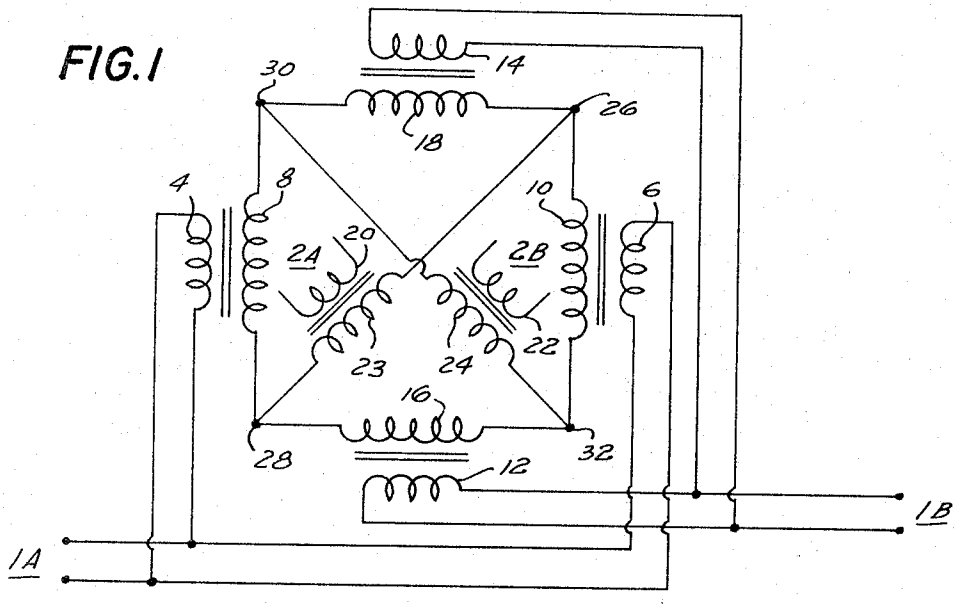


FIG. 1



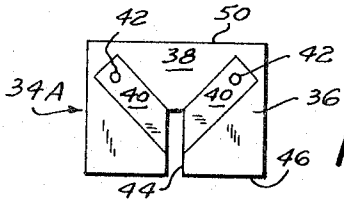


FIG. 4

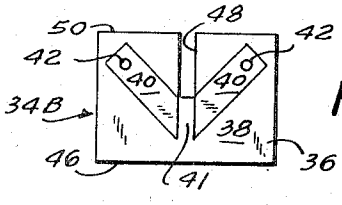
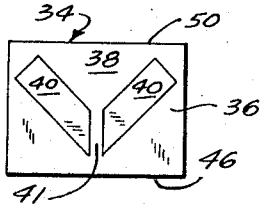


FIG. 5

FIG. 3



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FIG.6

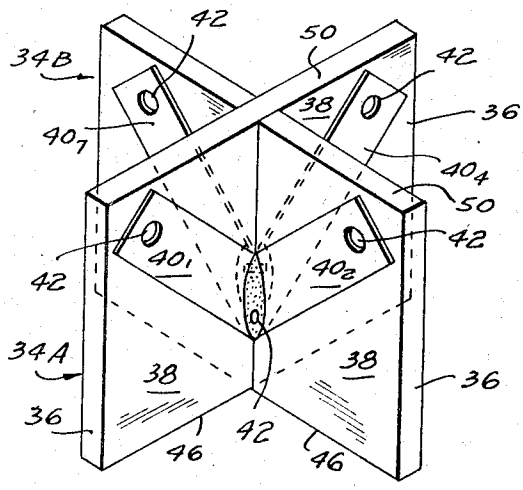


FIG.7

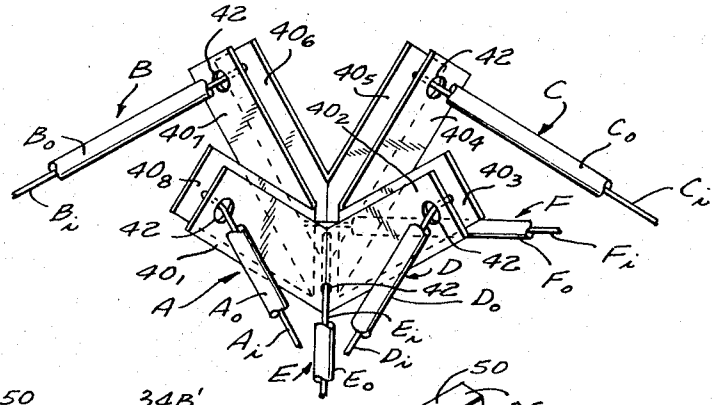
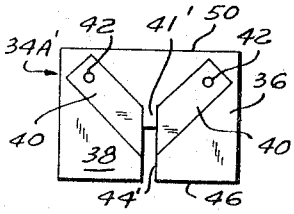


FIG.8



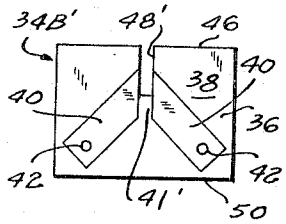


FIG.9

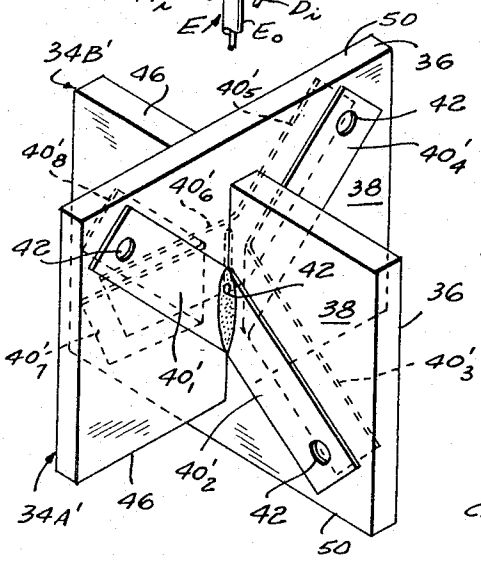


FIG.10

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United States Patent Office 3,325,587
Patented June 13, 1967

3,325,587

ELECTRICAL CONNECTOR FOR TRANSMISSION LINES AND THE LIKE

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Filed July 16, 1965, Ser. No. 472,466
28 Claims. (Cl. 174—72)

The present invention relates to the construction of an electrical connector specially adapted to effect interconnection of the conductors of a plurality of transmission lines.

Many circuits exist in which a plurality of conductors must be interconnected in various more or less complex fashions. Typical of such circuits are so-called "hybrid" circuits, in which a plurality of conductors, often of transmission line form, are connected to produce a desired degree of isolation between certain of the ports to which the outer ends of the conductors are connected and to produce a desired type of power distribution between others of the ports to which others of the conductors are connected. When operating at high frequencies the physical geometry of the circuit structure plays an important part in the electrical functioning thereof, and hence the structure and arrangement of the connecting means and the conductors are important factors in the overall design of a piece of equipment provided for a given purpose. Specifically, twists and bends in transmission lines are to be avoided, and the connections between the conductors of the transmission lines should be as direct as possible. The more lines which must be interconnected, the greater are the problems involved.

Not only does simplified geometry of the overall structure improve the operating characteristics thereof, but it also reduces the cost of manufacture of circuit installations by reducing the number of manufacturing operations which must be performed on the conductors and by facilitating the making of the appropriate electrical connections, thus minimizing labor costs and reducing the number of rejects.

One type of hybrid circuit which presents particularly troublesome problems in these regards is that disclosed in French Patent No. 810,300 and French patent of Addition 48,362. This type of hybrid comprises a four-sided bridge with inputs made to opposite pairs of sides of the bridge, the outputs from the bridge being derived from diagonal connections thereacross. If, as is desirable in high frequency work, the bridge sides and the diagonal connections be formed at least in part of transmission lines, six transmission lines must be connected to one another in a fairly complicated manner. To make these connections directly would be troublesome and time-consuming, would involve a mare's nest of wiring which would greatly detract from the proper functioning of the overall circuit, and would also constitute a source of potential trouble and malfunction.

It is the prime object of the present invention to devise a connector structure by means of which the above problems can be solved, and by means of which a large number of conductors, particularly when in transmission line relation, may be interconnected in different fashions simply, effectively, neatly, and without causing any physical interference between the transmission lines.

It is a further prime object of the present invention to provide such a connector structure which may be easily and inexpensively manufactured and which will permit the interconnection of a plurality of transmission lines as aforesaid in a reliable fashion even by relatively unskilled personnel.

It is a further object of the present invention to devise a connector structure which will accommodate and make

electrical connections to a plurality of transmission lines led to the connector structure at different levels and/or from different directions so as to be non-interfering with one another, and to permit different electrical connections to be made to the individual conductors of the line.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to the construction and arrangement of a connector, and to the connection thereto of transmission lines, as defined in the appended claims and as described in this specification, taken together with the accompanying drawings, in which:

FIG. 1 is a circuit diagram of a bridge type of hybrid circuit of the prior art in connection with which the connector structure of the present invention is particularly useful;

FIG. 2 is a circuit diagram of the transmission line connections to be made in connection with the hybrid circuit of FIG. 1;

FIG. 3 is a front plan view of a typical member from which the connectors of the present invention are constructed;

FIGS. 4 and 5 represent modifications of the member of FIG. 3 which are designed to be assembled to form one embodiment of the connector structure of the present invention;

FIG. 6 is a three-quarter perspective view, on an enlarged scale, showing the members of FIGS. 4 and 5 assembled together;

FIG. 7 is a three-quarter perspective diagrammatic view (the insulating sheets of the connector of FIG. 6 being eliminated for illustrative purposes) showing the manner in which the structure is used to accomplish the interconnections required in FIG. 2;

FIGS. 8 and 9 represent other modifications of the member of FIG. 3 which are designed to be assembled to form another embodiment of the present invention; and

FIG. 10 is a three-quarter perspective view on an enlarged scale showing the embodiment produced by the assembly of the members of FIGS. 8 and 9.

Solely for purposes of illustration, the connector structure of the present invention is here specifically disclosed as accomplishing the required electrical connections for a hybrid circuit of the type generally shown in FIG. 1. This circuit has been selected because of the relative complexity of the transmission line interconnections required and because of the relatively large number (six) of such lines which must be interconnected. It will be understood, however, that the invention has applicability in many other specific areas.

The hybrid circuit of FIG. 1 comprises a first pair of opposed ports 1A and 1B and a second pair of opposed ports 2A and 2B. The ports of each pair are designed to be isolated from one another when either one of those ports is used as an input port, the input power equally dividing between and appearing at the ports of the other pair. The port A is electrically connected to a pair of primary windings 4 and 6, connected in parallel, those windings being electromagnetically associated with secondary windings 8 and 10 respectively. The port 1B is electrically connected to a pair of primary windings 12 and 14 connected in parallel, those windings being electromagnetically associated with secondary windings 16 and 18 respectively. The secondary windings 8, 16, 10 and 18 are connected together sequentially to define the sides of a bridge circuit. The ports 2A and 2B are electrically connected to primary windings 20 and 22 respectively, those windings being electromagnetically associated with secondary windings 23 and 24 respectively, the winding 23 being connected diagonally across the bridge between corner points 26 and 28, and the winding 24 being connected diagonally across the bridge between

corner points **30** and **32**. (The designation of particular windings as "primary" or "secondary" are purely arbitrary.)

FIG. 2 is a circuit diagram of a transmission line embodiment of the hybrid circuit generally disclosed in FIG. 1. It comprises transmission lines A, B, C and D, corresponding respectively to the windings **16**, **8**, **18** and **10** of FIG. 1, and transmission lines E and F corresponding respectively to the windings **23** and **24** of the circuit of FIG. 1. Each of these transmission lines comprises a pair of conductors, differentiated by being termed "inner" and "outer" conductors, this terminology corresponding to the structure of a concentric transmission line. (In the case of a parallel transmission line, the terms "inner" and "outer" would not be literally applicable, but it should be understood that within the context of this application the specific nature of the transmission line is not significant.) The conductors are identified as A_i and A_o, representing the inner conductor of line A and the outer conductor of line A respectively, with the conductors of the other lines B–F being correspondingly identified. It will be noted that the following connections must be made: B_i with C_i; C_o with D_i; D_o with A_o; A_i with B_o; E_i with B_i and C_i; E_o with D_o and A_o; F_i with B_o and A_i; and F_o with C_o and D_i.

To accomplish these connections in conventional fashion would be troublesome, difficult and unreliable, and would involve such convolutions of conductors as to adversely affect the high frequency operation of the circuitry. The connector structure of the present invention, which will now be described, is designed to permit the effectuation of these and comparable electrical interconnections, particularly between the conductors of transmission lines, without those disadvantages.

The connector structure, in the form here specifically disclosed, is made up of a pair of connector members generally designated **34**, all of which are of similar construction. They comprise, as may be seen from FIG. 3, a sheet or plate **36** of appropriate insulating material having opposite side surfaces **38** on each of which a pair of conductive sections **40** are mounted. Those conductive sections **40** may be formed in any appropriate manner, as through the use of conventionel "printed circuit" techniques or through the affixation to the surfaces **38** of discrete strips of conductive material. The conductive sections **40** on the side surface **38** not visible in FIG. 3 are preferably in registration with the conductive sections **40** on the visible side surface **38** in FIG. 3. Moreover, the sections **40** on each side surface **38** are angularly related to one another so as to define an essentially V-shape, but with the sections **40** terminating short of the vertex of the V so as to define a non-conductive area **41** therebetween.

In the first disclosed embodiment two of the insulating members **34**, designated **34A** and **34B** and illustrated respectively in FIGS. 4 and 5, are employed. The member **34A** is provided with an edge notch **44** extending up into the body of the member **34A** from the edge **46** toward which the vertex of the V is directed, the notch **44** extending into and substantially through the area **41**. The member **34B** is provided with an edge notch **48** which extends inwardly from the edge **50** away from which the V points, the notch **48** being in line with the vertex of the V and terminating short of the area **42**. The members **34A** and **34B** are assembled in egg-crate fashion by interfitting those edge notches **44** and **48**, thereby to produce the structure shown in FIG. 6. When the members **34A** and **34B** are thus assembled each conductive section **40** carried by a given member **34A** or **34B** will substantially meet a conductive section carried by the other member, and electrical connections between those sections can be simply effected through the use of solder. Thus, as may perhaps best be seen from FIG. 7, which is a diagrammatic representation of the embodiment of FIG. 6 with the insulating sheets **36** eliminated to show the nature of the electrical connections, a conductive section 40_1 carried by the member **34A** is electrically connected to the section 40_2 carried by the member **34B**. The section 40_4 which forms a V with the section 40_1 on one surface **38** of member **34A** is electrically connected to the section 40_3 carried by the member **34B** opposite the section 40_2. The section 40_5 carried by the member **34A** opposite the section 40_4 is electrically connected to the section 40_6 carried by the member **34B** and forming a V with section 40_3. Section 40_7 carried by the member **34B** opposite the member 40_6 is electrically connected to section 40_8 carried by the member **34A** opposite the member 40_1. Thus sections 40_1 and 40_2 define sections of a first conductive length, sections 40_3 and 40_4 comprise sections of a second conductive length, sections 40_5 and 40_6 comprise sections of a third conductive length, and sections 40_7 and 40_8 comprise sections of a fourth conductive length, each of those conductive lengths being insulated from all of the others. Because of the orientation of those lengths and their various sections, it will be apparent that connections may be made thereto at different levels, and hence transmission lines or other conductors can be brought to the connector structure, and directly affixed thereto, at those different levels, therefore solving the problem of possible physical interference of between conductors without requiring special conductor configuration.

In FIG. 7 transmission lines corresponding to the lines A–F of FIG. 2 are disclosed in electrical connection, and the various conductors thereof are identified by the same reference numerals as are used in FIG. 2. The transmission lines A–D are connected to their appropriate conductive sections adjacent the ends of those sections, which are at the same level but which face in different directions. The transmission lines E and F engage the connector at different levels at the vertices of the V's formed by each electrically connected pair of conductive sections. At the connection points the appropriate sections are provided with apertures **42** through which the inner conductors of the appropriate transmission lines pass. Thus the outer conductor of a transmission line engages that surface of the appropriate conductive section **40** toward which the transmission line is directed, and the inner conductor of that transmission line passes through the opening **42** to the other side of the member **34**, thereby not making electrical connection with the same conductive section **40** as its outer conductor part but instead making electrical connection with the conductive section **40** opposite the one to which its associated outer conductor is electrically connected. The actual electrical connection can be made in any appropriate manner, as through the use of solder.

It will be noted that the connected portions of the transmission lines E and F constitute physically diagonal connections between the V's defined by the electrically connected conductive sections as well as defining electrically diagonal connections as indicated in FIGS. 1 and 2.

A second embodiment of the present invention is disclosed in FIGS. 8–10. It, like the embodiment of FIGS. 4–6, comprises a pair of assembled sections **34**, but in the embodiment of FIGS. 8–10 the sections **34A'** and **34B'** differ from the sections **34A** and **34B** in that the edge notch **44'** of the member **34A'** is not as deep as the edge notch **44** in the member **34A**, and in that the member **34B'** is a substantial duplicate of **34A'** and has its edge notch **48'** extending from the edge **46** instead of from the edge **50**, and to substantially the same depth as the edge notch **44'** in member **34A'**. As a result, when the members **34A'** and **34B'** are assembled, and as may be seen from FIG. 10, the sections $40_1'$ and $40_2'$ carried respectively by the members **34A'** and **34B'** will not form a V, as in the embodiment of FIGS. 4–7, but will instead constitute substantial prolongations of one another bent, however, about the vertical axis of the assembly. The same will be true of the other pairs of electrically connected conductive sections $40_3'$–$40_4'$, $40_5'$–$40_6'$ and $40_7'$–$40_8'$. As a result, when four transmission

lines are adapted to be connected to the ends of the conductive sections, they will not only meet differently facing surfaces, as in the embodiment of FIGS. 4–7, but will also, in pairs, be at different levels, the lines electrically meeting conductive sections $40_4'$ and $40_1'$ (e.g. lines C and A) being at an upper level and the lines meeting the conductive sections $40_2'$ and $40_7'$ (e.g. lines D and B) being at a lower level, with the lines adapted to meet the electrically connected sections near their joint (e.g. lines E and F) being at an intermediate level.

From the above it will be seen that the connector structure is made from a plurality of identical or substantially identical elements 34, is readily assembly, and when thus assembled constitutes an efficient interconnecting device for effecting complex circuit interconnections, particularly when transmission lines are involved. The use of solder or other means to electrically connect the conductive sections defining each conductive length also serves to physically secure the two members **34** in assembled condition, and when diagonal electrical connections are effected, as through the use of transmission lines E and F, the soldering or the like which electrically connects such transmission lines to the appropriate conductive sections also connects those sections together to define the individual conductive lengths and secures the members **34** in assembled condition. The nature of the electrical connections produced is one which is conducive to efficient high frequency applications, and the external conductors may be connected in a simple manner, without interference, and without requiring complex pre-shaping.

While but a limited number of embodiments of the present invention are here specifically disclosed, it will be apparent that many variations may be made therein, all within the scope of the invention as defined in the following claims.

I claim:

1. A connector comprising first, second, third and fourth conductive lengths each having A and B sections angularly disposed relative to one another about a first axis, said lengths being arranged with the A section of each length positioned opposite and spaced from the B section of another length to define four sets of opposed length sections, and insulation between the opposed length sections of each set.

2. The connector of claim **1**, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces.

3. In combination with the connector of claim **2**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

4. In combination with the connector of claim **2**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

5. The connector of claim **1**, in which said sections of each length make an acute angle with one another about

a second axis substantially perpendicular to said first axis.

6. In combination with the connector of claim **5**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

7. In combination with the connector of claim **5**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

8. The connector of claim **5**, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces.

9. The connector of claim **5**, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces, and in combination therewith, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

10. The connector of claim **5**, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces, and in combination therewith, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

11. The connector of claim **1**, in which said sections of each length constitute elongations of one another in the general direction of said first axis.

12. In combination with the connector of claim **11**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a

given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

13. In combination with the connector of claim 11, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

14. The connector of claim 11, in which said insulation comprises a pair of insulating member having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces.

15. The connector of claim 11, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces, and in combination therewith, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

16. The connector of claim 11, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces, and in combination therewith, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

17. In combination with the connector of claim 1, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

18. In combination with the connector of claim 1, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the section thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the section of said other length meet.

19. A connector comprising first, second, third and fourth conductive lengths each having conductively connected A and B sections angularly disposed relative to one another about a first axis, said lengths being arranged with the A section of each length positioned opposite and spaced from the B section of another length to define four sets of opposed length sections, and insulation between the opposed length sections of each set.

20. The connector of claim 19, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces.

21. A connector comprising first, second, third and fourth conductive lengths each having A and B sections substantially right-angularly disposed relative to one another about a first axis, said lengths being arranged with the A section of each length positioned opposite and spaced from the B section of another length to define four sets of opposed length sections, and insulation between the opposed length sections of each set.

22. The connector of claim 21, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said edge notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces.

23. A connector comprising first, second, third and fourth conductive lengths each having conductively connected A and B sections substantially right-angularly disposed relative to one another about a first axis, said lengths being arranged with the A section of each length positioned opposite and spaced from the B section of another length to define four sets of opposed length sections, and insulation between the opposed length sections of each set.

24. The connector of claim 23, in which said insulation comprises a pair of insulating members having opposite side surfaces and each being provided with an edge notch adapted to interfit with the edge notch of the other member upon assembly of said members, each member carrying on its opposite side surfaces, and extending up close to but not across an area in line with said notch, two sets of opposed A and B length sections, each of said sections comprising part of a different length, side surfaces of said members facing one another in pairs when said members are assembled with their edge notches interfitted, and electrical connecting means between the strip sections carried by said pairs of side surfaces.

25. In combination with the connector of claim 24, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length

section and being electrically connected to the length section thereopposite.

26. In combination with the connector of claim **24**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

27. In combination with the connector of claim **23**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length section and the other of said conductors passing through and being insulated from said given length section and being electrically connected to the length section thereopposite.

28. In combination with the connector of claim **23**, a transmission line comprising first and second conductors, one of said conductors being electrically connected to a given length at a point adjacent the region where the sections thereof meet, the other of said conductors passing through and being insulated from said length and being electrically connected to another length at a point adjacent the region where the sections of said other length meet.

No references cited.

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