United States Patent [19]

Reeder

[11] 3,761,844

[45] Sept. 25, 1973

[54] **IMPEDANCE-MATCHING APPARATUS FOR CONNECTING CO-AXIAL CABLES THROUGH SEPARABLE CONNECTORS OR MULTIPLE PIN TYPE**

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[73] Assignee: **Raychem Corporation**, Menlo Park, Calif.

[22] Filed: **Feb. 2, 1972**

[21] Appl. No.: **222,810**

[52] **U.S. Cl.**............ **333/33**, 174/88 C, 174/DIG. 5, 339/143 R, 339/177 R, 339/275 R

[51] **Int. Cl.**..... **H03h 7/38**, H01r 13/10, H01r 17/18

[58] **Field of Search**..................... 333/33; 174/75 C, 174/88 C, DIG. 5; 339/14 R, 14 P, 143 R, 177 R, 177 E, 275 R

[56] **References Cited**

UNITED STATES PATENTS

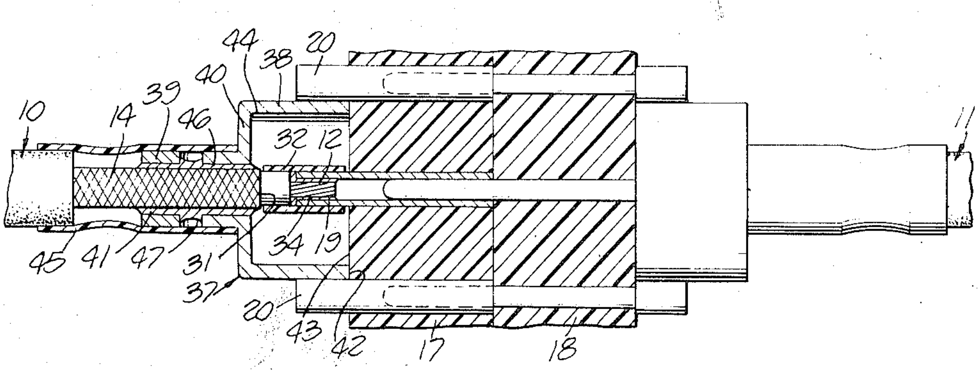
3,076,158	1/1963	Edelman	174/88 C
3,541,495	11/1970	Ellis et al.	174/DIG. 5

Primary Examiner—Rudolph V. Rolinec
Assistant Examiner—Hugh D. Jaeger
Attorney—Charles G. Lyon et al.

[57] **ABSTRACT**

Electrical connector blocks of conventional type each have an array of parallel metal pins. Such connector blocks are rendered suitable for connecting matched impedance co-axial cables, by means of metallic shield-conductors of this invention. The connection of each co-axial cable to its respective connector block employs a first electrical connection between the central conductor of the cable and one of the pins in the array. The shield-conductor employs a second electrical connection between the metal sheath of the cable and employs additional electrical connections to other adjacent pins in the array. A projecting portion of the central conductor extends beyond the end of the metal sheath to its electrical connection with its pin, and the inner surface of a portion of the metallic shield-conductor partially or totally encircles that projecting portion and its joined pin. A dielectric sleeve within said inner surface also encircles the projecting portion of the central conductor and its joined pin. The inner surface of the shield-conductor is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as that of the co-axial cable itself.

16 Claims, 14 Drawing Figures



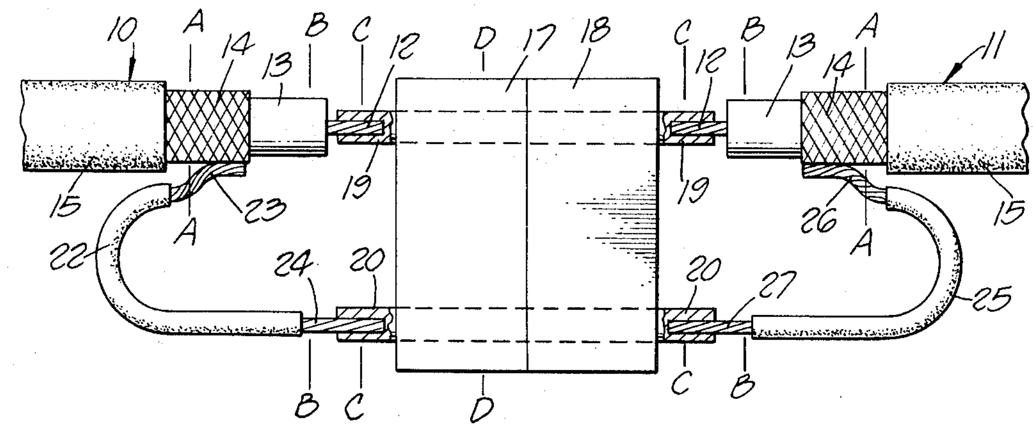


FIG. 1. PRIOR ART

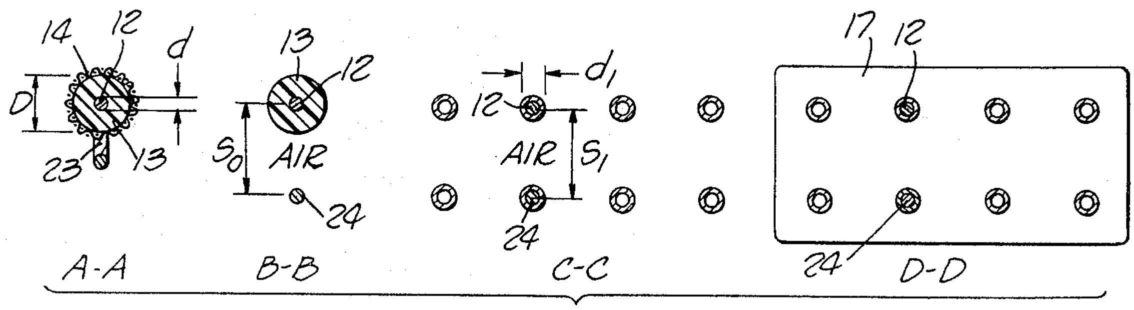


FIG. 2.

FIG. 3.

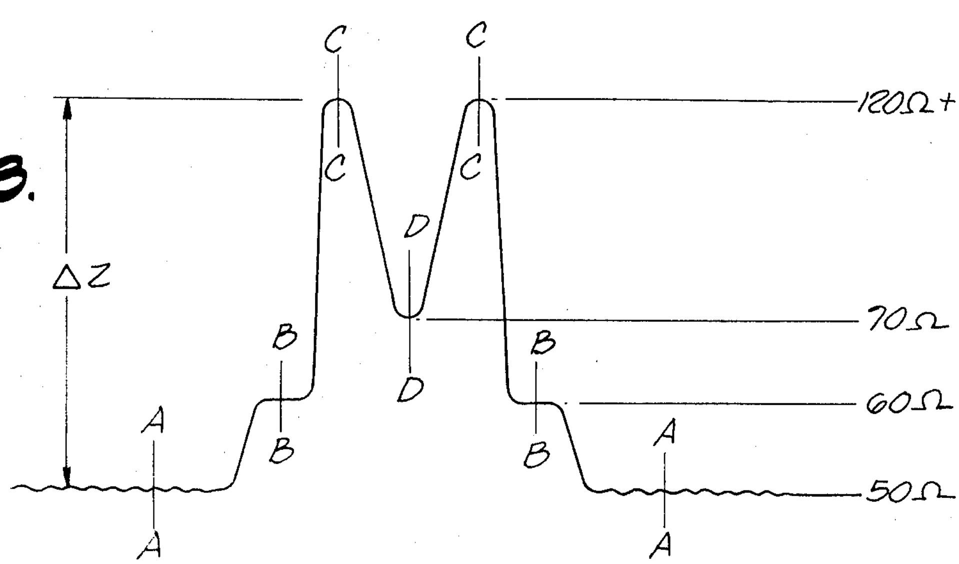
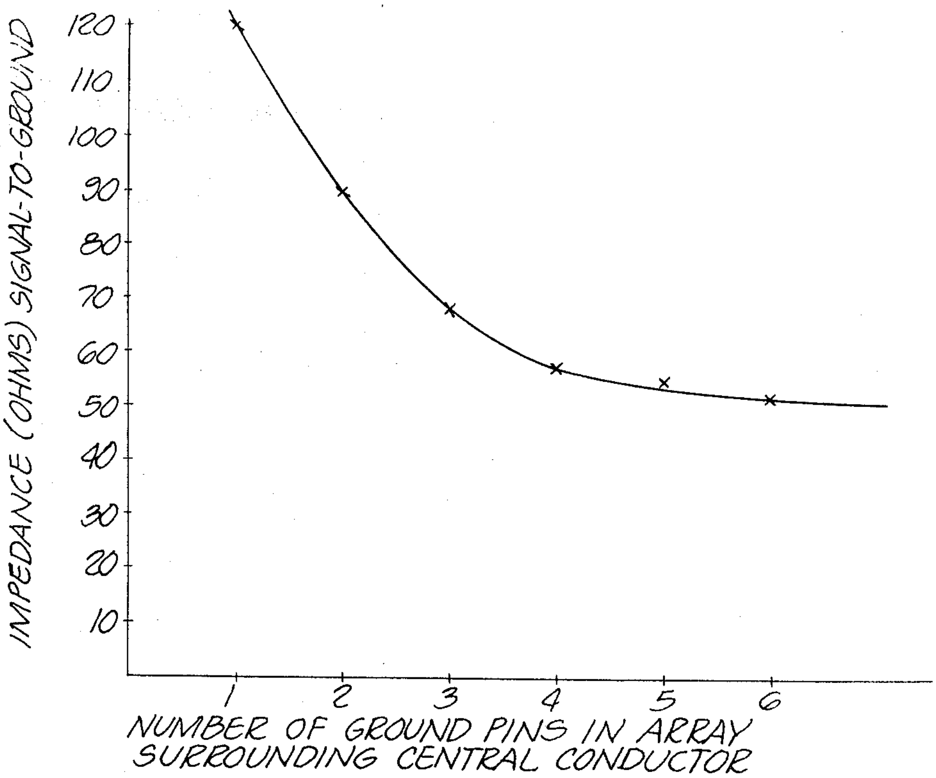


FIG. 4.

X	Y
1	120
2	90
3	68
4	57
5	55
6	52



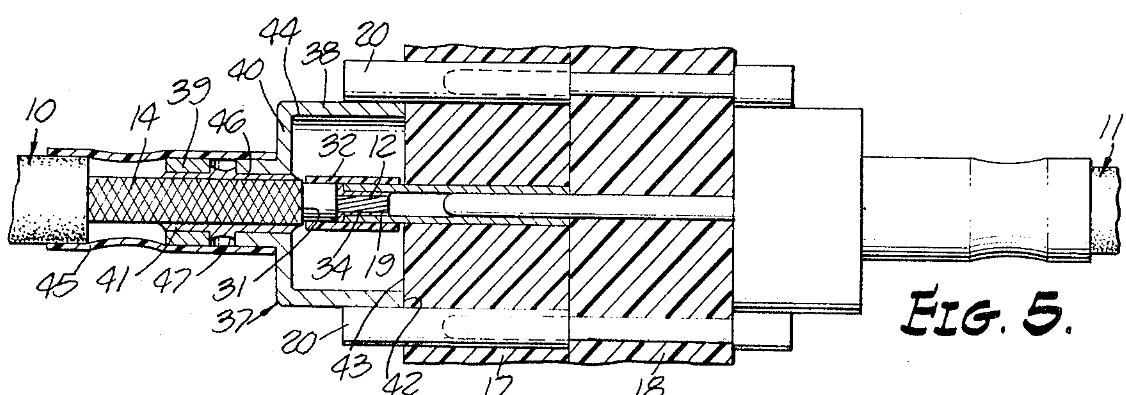


FIG. 5.

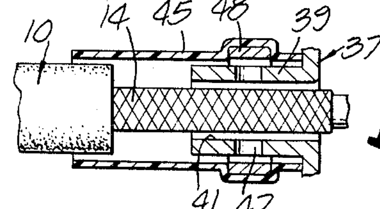


FIG. 7.

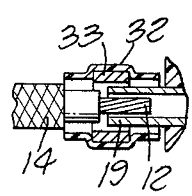


FIG. 6.

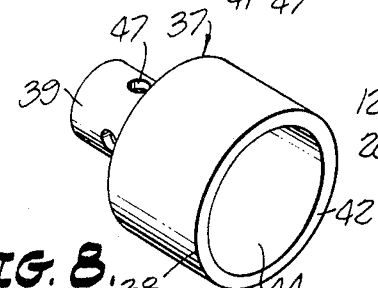


FIG. 8.

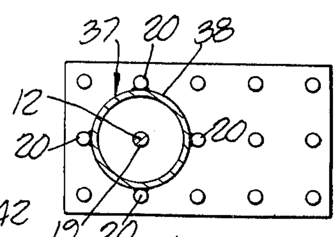


FIG. 9.

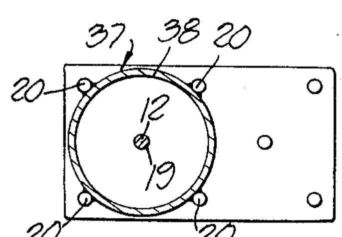
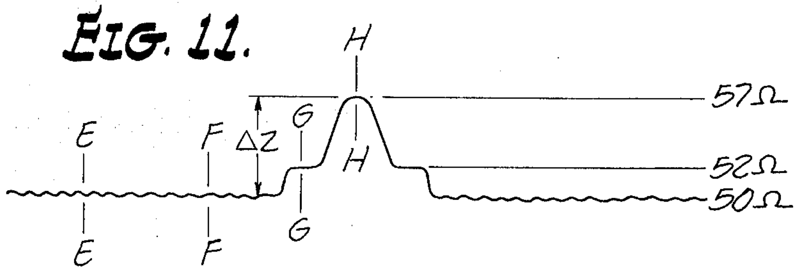


FIG. 10.

FIG. 11.



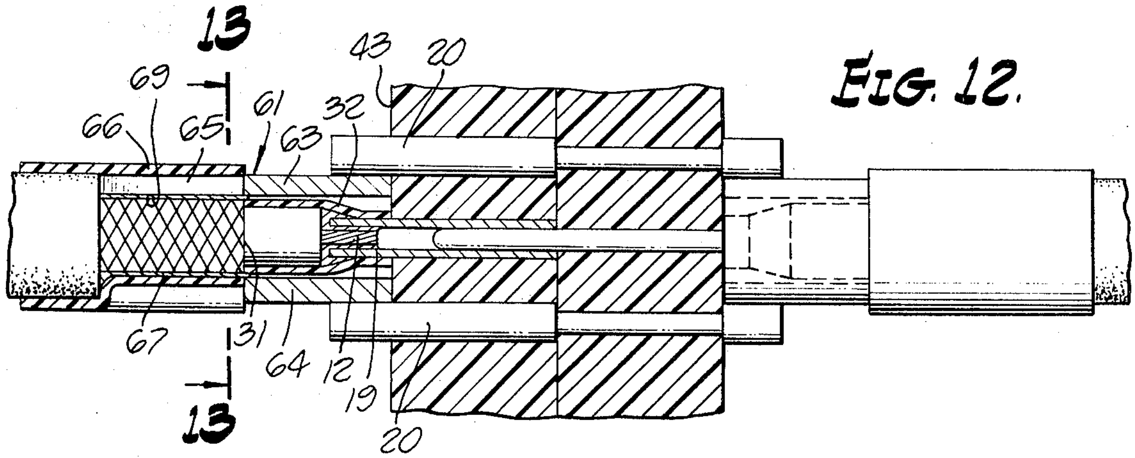


FIG. 12.

FIG. 14.

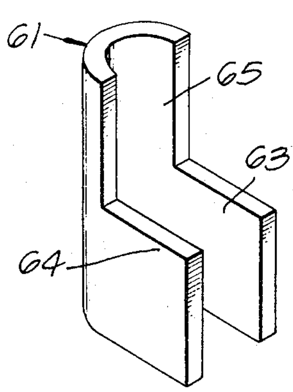
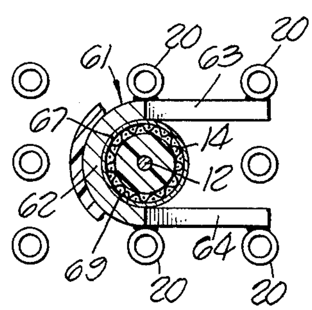


FIG. 13.



IMPEDANCE-MATCHING APPARATUS FOR CONNECTING CO-AXIAL CABLES THROUGH SEPARABLE CONNECTORS OR MULTIPLE PIN TYPE

This invention relates to a capacitance control device which makes it possible to employ mated halves of a conventional electrical connector as an impedance-matching connector for co-axial cables. Inexpensive commercially available discrete wire connectors of various types such as rack and panel, printed circuit board, etc., may thus be employed for connecting co-axial cables instead of requiring a special costly impedance-matching connector useful for no other purpose. Mated halves of a matched impedance co-axial cable connector should have a characteristic impedance which is at least as high as that desired in the matched impedance interconnection. For example, a mated connector having an impedance of 20 ohms would not be acceptable for connecting co-axial cables each having an impedance of 50 ohms. The separable connector device of this invention employing conventional discrete wire connectors has a characteristic impedance which substantially matches the impedance of each of the co-axial cables, when the shield-conductor of this invention is employed with each half of the conventional connector. Each half of the conventional separable connector includes an array of parallel metal pins which are spaced by a dielectric. The central conductors of the two co-axial cables are respectively joined at opposite ends of one separable pin. Shield-conductors of this invention are employed to respectively attach the outer metallic sheaths of the co-axial cables to other adjacent pins, each shield-conductor having an inner surface partially or totally encircling the central conductor from the end of the metal sheath to the connector block. A dielectric sleeve also encircles the same portion of the central conductor and its joined pin. The said inner surface of the shield-conductor is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as the co-axial cable itself.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

FIG. 1 is a diagram showing conventional mated connector blocks used to connect co-axial cables electrically, but the impedance of the mated connector blocks does not match the impedance of the co-axial cables.

FIG. 2 comprises a series of diagrammatic sections at various positions as shown on FIG. 1.

FIG. 3 is a graph of a typical display by a time domain reflectometer showing the impedance at the various positions indicated on FIG. 1.

FIG. 4 is a graph showing the relation between Impedance, signal-to-ground, and the number of ground pins in the array encircling the central conductor, for a typical mated connector.

FIG. 5 is a sectional view showing a preferred embodiment of this invention.

FIG. 6 shows a portion of the apparatus of FIG. 5, the parts being shown prior to the application of heat to the inner solder sleeve.

FIG. 7 shows a portion of the apparatus of FIG. 5, the parts being shown prior to the application of heat to the outer solder sleeve.

FIG. 8 is a perspective view of the shield-conductor of FIG. 5.

FIGS. 9 and 10 are section diagrams showing the application of the device of FIG. 5 to connectors having contact pins arranged on a square grid pattern and on a staggered grid pattern, respectively.

FIG. 11 is a view similar to FIG. 3, showing that the impedance of the connector apparatus embodying this invention is substantially the same for the mated connectors as it is for the co-axial cable itself.

FIG. 12 is a sectional view similar to FIG. 5, showing a modification.

FIG. 13 is a sectional view taken substantially on the lines 13—13 as shown on FIG. 12.

FIG. 14 is a perspective view of the shield-conductor as shown on FIG. 12.

Referring to the drawings, the co-axial cables generally designated 10 and 11 are duplicates and are conventional in form. They have the same impedance, for example, 50 ohms. Each includes a central conductor 12 enclosed within a dielectric tube 13 which in turn is surrounded by a concentric metallic sheath 14. A protective tubular cover 15 encircles the metallic sheath 14.

A conventional connector block assembly of the rack and panel type includes separable blocks 17 and 18 formed of dielectric material and each having two rows of mated metal pins 19 and 20, as shown in FIG. 1.

One end of each co-axial cable is prepared so that the central conductor 12 projects from the dielectric tube 13, which in turn projects from the metallic sheath 14. A portion of the cover 15 is removed to expose and end portion of the metallic sheath 14. If an attempt should be made to use the mated connector blocks 17 and 18 as shown in FIG. 1 to connect the co-axial cables 10 and 11, the central conductors 12 would first be joined to the mated pins 19 in the blocks 17 and 18. A first lead wire 22 would be connected at one end 23 to the metallic sheath 14 of the cable 10 and at the other end 24 to the mated pin 20 on block 17. Similarly, lead wire 25 would be connected at one end 26 to the metallic sheath 14 of the cable 11 and at the other end 27 to the mated pin 20 on the block 18. However, the following analysis shows that the impedance of this assembly as shown in FIG. 1 is quite different for the mated conductor blocks than it is for the co-axial cables themselves. Thus as shown in FIG. 2, section A--A represents a typical cross section of the co-axial cable having a polytetrafluoroethylene dielectric. The inside diameter of the metal sheath 14 is designated "D", and the outside diameter of the central conductor is designated "d", section B—B represents the area where the cable sheath 14 is absent, and the "ground" conductor 22, 25 is at some variable distance S_o from the central conductor 12. Capacitance is further reduced by the presence of the air dielectric along with the solid dielectric 13. The overall capacitance is very low and extremely variable, since S_o is ramdom in nature.

Section C—C represents the location where the conductors are joined to the connector pins 19 and 20. The central conductor diameters designated as "d_1" are larger than the diameter "d" and the only dielectric present is air. S_1 is a fixed dimension dictated by the construction of the connector. Although the increase of the diameter "d_1" tends to raise the capacitance, the air dielectric more than offsets its increase, resulting in overall lower capacitance. The adjacent unused connector pins shown are irrelevant in the apparatus of FIG. 1.

Section D—D is shown in oversimplified form for convenient analysis. The major difference between this section and section C—C is that the dielectric is solid, for example, Diallyl Phthalate (SDG) rather than air. Since this section is internal to the mated connectors **17, 18,** it cannot conveniently be physically altered. Thus, it is the most critical area in the selection of a candidate connector.

FIG. 3 shows a typical time domain reflectometer display of the terminated connector assembly shown in FIG. **1.** Thus, position A—A shows the 50 ohm impedance level of each of the co-axial cables. Position B—B shows the impedance between the end of the metallic sheath **14** and the pins **19** and **20.** Position C—C shows the impedance at the pins **19** and **20,** and, in the typical example shown in FIG. **3,** this impedance reaches a peak of more than 120 ohms, as compared to the 50 ohm impedance of the co-axial cables. Position D—D shows a 70 ohm impedance within the connector blocks themselves.

This variation in impedance of over 100 percent between the 50 ohm impedance of the co-axial cables and over 120 ohm resistance of the mated connector in unacceptable in practice. Apparatus of the present invention, described below, has a characteristic impedance of the mated connector halves which is substantially the same as that of the co-axial cables themselves.

The graph of FIG. **4** shows how the impedance decreases with the number of pins employed as ground pins in the mated conductor blocks. Thus, in a typical example, an impedance of 120 ohms is measured when only one ground pin is employed. Two ground pins produce an impedance of 90 ohms, a considerable improvement. However, as additional ground pins are added, less and less improvement is achieved. Accordingly, as the curve tends to flatten out there is little advantage in employing more ground pins.

Referring to FIG. **5,** showing a preferred embodiment of this invention, the co-axial cables **10** and **11** are connected to pins in their respective blocks **17** and **18.** As shown in FIG. **9,** these pins may comprise a square grid array, or as shown in FIG. **10,** they may comprise a staggered grid array. In either case, the central conductor **12** of each co-axial cable is joined to a pin **19** which constitutes one of the pins in the array. Since the connections between the co-axial cable **10** and the pins of the block **17** are the same as the connections between the co-axial cable **11** and the pins of the blocks **18,** only one such set of connections need be described.

A projecting portion of the central conductor **12** projects beyond the end **31** of the metallic sheath **14.** This projecting portion is soldered to the exposed end of the pin **19** by means of a first solder sleeve **32** which is formed of heat recoverable material having good electrical insulating properties. A solder ring **33** within the sleeve **32** (see FIG. **6**) melts when the sleeve is heated and forms a solder joint **34** between the central conductor **12** and the pin **19.** The heat recoverable sleeve **32** may be formed of polyvinylidene fluoride, and the sleeve and internal solder ring may be of the type shown in the Wetmore U.S. Pat. No. 3,243,211 granted Mar. 29, 1966.

A metallic shield-conductor **37** comprises a large diameter cylinder **38** connected to a small diameter co-axial cylinder **39** by means of integral wall or flange **40.** The inner diameter **41** of the cylinder **39** is large enough to slide over the metallic sheath **14.** The solder joint **34** is accomplished while the shield-conductor **37** is in an inoperative position with the end **42** thereof spaced from the face **43** of the dielectric connector block **17.** After the solder joint **34** is completed, the cylinder **38** is moved to bring its end **42** into contact with the block face **43,** and this brings the outer surface of the cylinder **38** into contact with the exposed portion of the four ground pins **20.** The outer surface of the cylinder **38** is then re-flow soldered to these four ground pins **20.**

A second solder sleeve **45** formed of the same material as the inner solder sleeve **32** is employed to form a solder joint **46** between the metallic cylinder **39** and the metallic sheath **14** of the co-axial cable **10.** Several openings **47** extend radially through the cylinder **39** and a solder ring **48** (see FIG. **7**) within the heat recoverable sleeve **45** encircles these openings **47.** When heat is supplied, the solder **48** melts and the heat recoverable sleeve **45** contracts radially to force the solder through the openings **47** and into the annular space between the parts **14** and **39** to form the solder joint **46.**

It is important that the axially extending metallic cylinder **38** encircle the entire axial length of the portion of the central conductor **12** which projects beyond the end **31** of the metallic sheath **14.** It is also important that the inside surface **44** of the cylinder **38** be of the proper diameter and concentric with the central conductor **12** so that the impedance between the metallic cylinder **38** and the central conductor **12** through the dielectric sleeve **32** is substantially the same as that of the co-axial cable **10.** This desired overall effect is achieved, as shown by the time domain reflectometer display of FIG. **11,** which relates to the impedance at the individual designated cross section as shown in FIG. **5.** Thus, FIG. **11** shows that the 50 ohm impedance of the co-axial cable at E—E is the same as the impedance at section F—F. A small increase to 52 ohms occurs at section G—G and the maximum impedance of 57 ohms occurs at section H—H. This is to be compared with the maximum impedance of over 120 ohms as shown in FIG. **3,** which occurs when this invention is not employed.

In the modified form of the invention shown in FIGS. **12–14,** the shield-conductor **61** is not cylindrical but instead has a semi-cylindrical portion **62** merging with tangent walls **63** and **64** which are parallel. A semi-cylindrical extension **65** of the part **62** projects beyond the parallel walls **63** and **64.**

The connection between the central conductor **12** and the exposed portion of the pin **19** is accomplished by means of the dielectric solder sleeve **32** as described above. The outer solder sleeve **66** is used in the manner described above to form the solder joint **67** between the semi-cylindrical extension **65** and the metallic sheath **14.** The exposed ends of the four ground pins **20** are re-flow soldered to the outer surfaces of the walls **63** and **64.** It is important that the inner semi-cylindrical surface **69** on the shield-conductor **61** be concentric with the central conductor and be sized and shaped so that the impedance between it and the central conductor **12** through the dielectric sleeve **32** is substantially the same as that of the co-axial cable itself.

In the event that more than one pair of co-axial cables are to be terminated on the same pair of conductor blocks **17** and **18**, the shield-conductors **61** should be oriented so that the open spaces between the parallel walls **63** and **64** do not face each other in a manner to permit "line of sight" exposure of the central conductors **12** and joined pins **19** between the ends **31** of the metallic sheaths **14** and the face **43** of the conductor block.

Having fully described my invention, it is to be understood that I am not to be limited to the details herein set forth but that my invention is of the full scope of the appended claims.

I claim:

1. In a separable connector block assembly for joining and matching the impedances of two co-axial cables, each cable having a central conductor and a metal sheath separated by dielectric material, and the central conductor having an end portion projecting beyond an end of the metal sheath, the combination of: a pair of separable connector blocks of dielectric material and each having an array of spaced parallel metal pins, means joining the projecting end portion of the central conductor of each cable to one pin on each of said blocks, respectively, two metallic shield-conductors each having an axially extending part at least partially encircling the projecting portion of a central conductor and its joined metal pin and extending from the end of the metal sheath to the block, respectively, a dielectric sleeve within each axially extending part and encircling the projecting portion of the central conductor and its joined metal pin, said axially extending part of each shield-conductor having an inside surface which is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as that of the co-axial cable itself, means electrically connecting each shield-conductor to one of the cable sheaths, respectively, and means electrically connecting each shield-conductor to a plurality of other pins in the array, respectively.

2. Apparatus as set forth in claim **1** in which the axially extending part of the metallic shield-conductor is at least partially cylindrical and co-axial with respect to the central conductor.

3. Apparatus as set forth in claim **1** in which the axially extending part of the metallic shield-conductor fully encircles the dielectric sleeve and central conductor and its joined metal pin.

4. Apparatus as set forth in claim **1** in which the axially extending part of the metallic shield-conductor is semi-cylindrical and co-axial with respect to the central conductor.

5. Apparatus as set forth in claim **1** in which the axially extending part of the metallic shield-conductor is cylindrical and concentric with said projecting portion of the central conductor.

6. Apparatus as set forth in claim **1** in which each dielectric sleeve is formed of heat recoverable material and contains solder joining the central conductor to its pin.

7. Apparatus as set forth in claim **1** in which an outer dielectric sleeve containing solder encircles a portion of each shield-conductor to connect it to its respective cable sheath.

8. Terminal apparatus for a co-axial cable having a central conductor and a metal sheath separated by dielectric material, the central conductor projecting beyond the end of the metal sheath, comprising in combination: a connector block formed of dielectric material having an array of spaced metal pins, means joining the projecting end portion of the central conductor to one of the pins, a dielectric sleeve encircling the projecting portion of the central conductor and its joined metal pin, a metallic shield-conductor having an axially extending part at least partially encircling said dielectric sleeve, and extending from the end of the metal sheath to the conductor block, said axially extending part of said shield-conductor having an inside surface which is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as that of the co-axial cable itself, means electrically connecting the shield-conductor to the cable sheath, and means electrically connecting the shield-conductor to a plurality of other pins in the array.

9. Apparatus as set forth in claim **8** in which the axially extending part of the metallic shield-conductor fully encircles the dielectric sleeve and central conductor and its joined metal pin.

10. Apparatus as set forth in claim **8** in which the axially extending part of the metallic shield-conductor is semi-cylindrical and co-axial with respect to the central conductor.

11. Apparatus as set forth in claim **8** in which said dielectric sleeve is formed of heat recoverable material and contains solder joining the central conductor to its pin.

12. In a separable connector block assembly for joining and matching the impedances of two co-axial cables, each cable having a central conductor and a metal sheath separated by a dielectric tube, and the central conductor having an end portion projecting beyond an end of the metal sheath, the combination of: a pair of separable connector blocks of dielectric material and each having an array of parallel metal pins, a dielectric sleeve of heat recoverable material encircling the projecting end portion of the central conductor of each cable, respectively, and containing solder to join the central conductor to one pin on each of said blocks, respectively, two metallic shield-conductors each having large and small co-axial cylindrical walls joined by a flange, the large cylindrical wall encircling the projecting portion of a central conductor and its joined metal pin and extending axially from the end of the metal sheath to the block, respectively, said large cylindrical wall of each shield-conductor having an inside surface which is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as that of the co-axial cable itself, means including an outer dielectric sleeve encircling the small cylindrical wall of each shield-conductor, respectively, and containing solder joining it to one of the cable sheaths, respectively, and means electrically connecting said large cylindrical wall of each shield-conductor to a plurality of other pins in the array each equidistant from the pin joined to the central conductor.

13. In a separable connector block assembly for joining and matching the impedances of two co-axial cables, each cable having a central conductor and a metal sheath separated by a dielectric tube, and the central conductor having an end portion projecting beyond an end of the metal sheath, the combination of: a pair of separable connector blocks of dielectric material and each having an array of parallel metal pins, a dielectric sleeve of heat recoverable material encircling the projecting end portion of the central conductor of each cable, respectively, and containing solder to join the central conductor to one pin on each of said blocks, respectively, two metallic shield-conductors each having an axially extending semi-cylindrical part partially encircling the projecting portion of a central conductor and its joined metal pin and extending from the end of the metal sheath to the block, respectively, said axially extending part of each shield-conductor having an inside surface which is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as that of the co-axial cable itself, means including an outer dielectric sleeve encircling a portion of each shield-conductor, respectively, and containing solder joining it to one of the cable sheaths, respectively, each shield-conductor having parallel legs extending tangentially from said semi-cylindrical part, and means electrically connecting said parallel legs of each shield-conductor to a plurality of other pins in the array.

14. Terminal apparatus for use with a co-axial cable and a dielectric member, the cable having a central conductor and a metal sheath separated by dielectric material, the central conductor projecting beyond the end of the metal sheath, the dielectric member having an array of spaced metal pins, comprising in combination: a dielectric sleeve adapted to encircle a projecting portion of the central conductor, a metallic shield-conductor having an axially extending part adapted to at least partially encircle said dielectric sleeve and said projecting portion of the central conductor and extending from the end of the metal sheath to the dielectric member, said axially extending part having an inside surface which is sized and shaped so that the impedance between it and the central conductor through the dielectric sleeve is substantially the same as that of the co-axial cable itself, means joining the projecting end portion of the central conductor to one of the pins, means whereby said shield-conductor may be electrically connected to the cable sheath, said axially extending part of said shield-conductor having an outside surface contacting and electrically connected to a plurality of pins in the dielectric member.

15. Apparatus as set forth in claim **18** in which the axially extending part of the metallic shield-conductor fully encircles the dielectric sleeve and central conductor and its joined metal pin.

16. Apparatus as set forth in claim **18** in which the axially extending part of the metallic shield-conductor is semi-cylindrical and co-axial with respect to the central conductor.

* * * * *