United States Patent

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[54] **APPARATUS FOR TERMINATING ELECTRICAL RIBBON CABLE**
14 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **339/17 F,** 339/176 MF
[51] **Int. Cl.** **H01r 13/50,** H05k 1/04, H05k 3/34
[50] **Field of Search** 339/17

[56] **References Cited**

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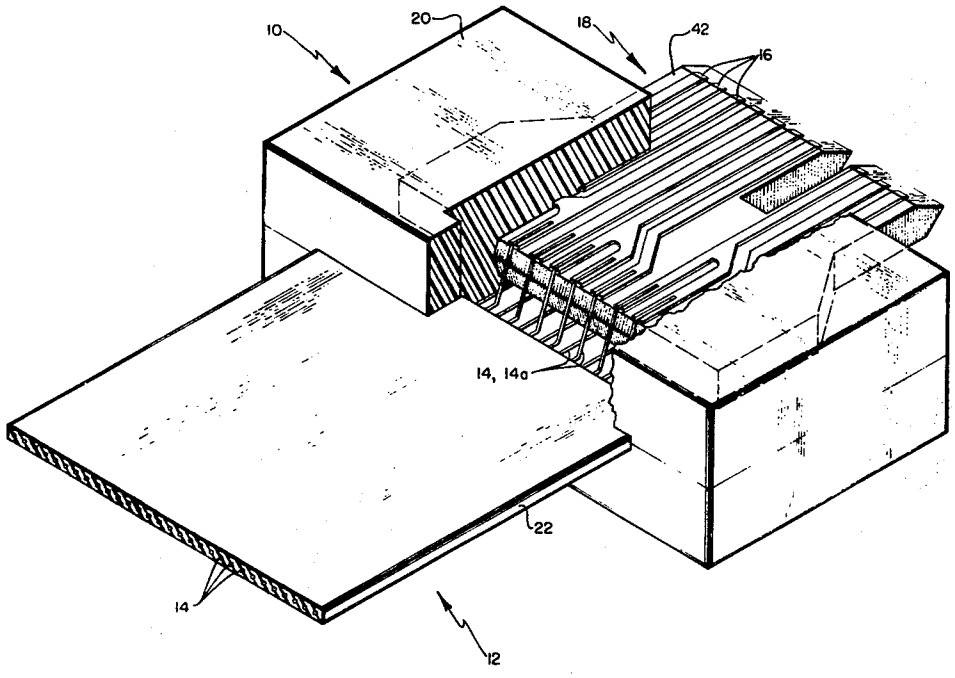
ABSTRACT: A new termination, with which a miniature ribbon cable can be connected readily to other electrical devices, has adjacent cable conductors connected without fan-out to a connector plate having contacts on opposite sides of a boardlike insulator. The cable insulation is removed from the conductors, prior to assembly of the cable with the connector plate, preferably along the entire conductor length that overlies the insulator.



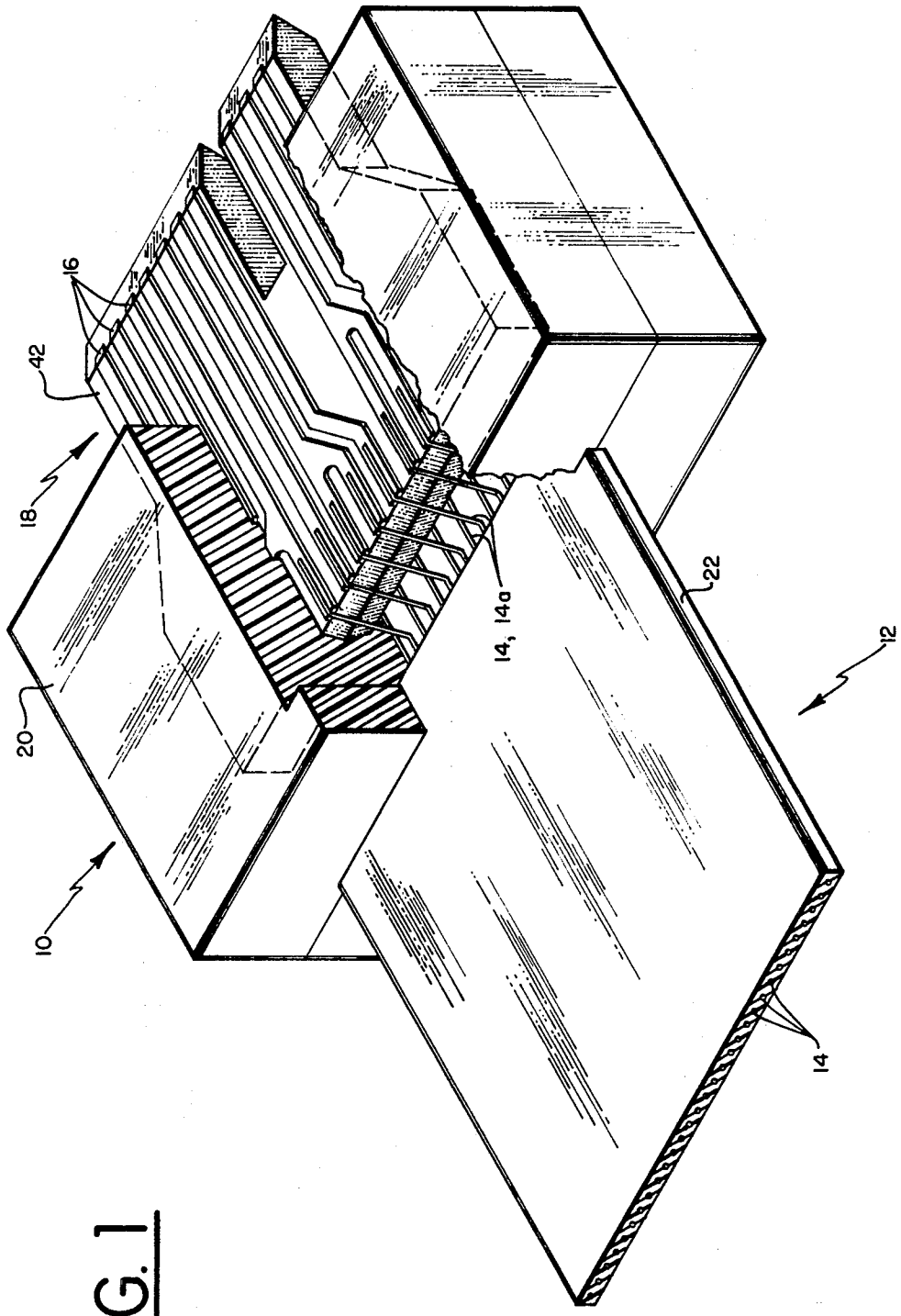


FIG. 1

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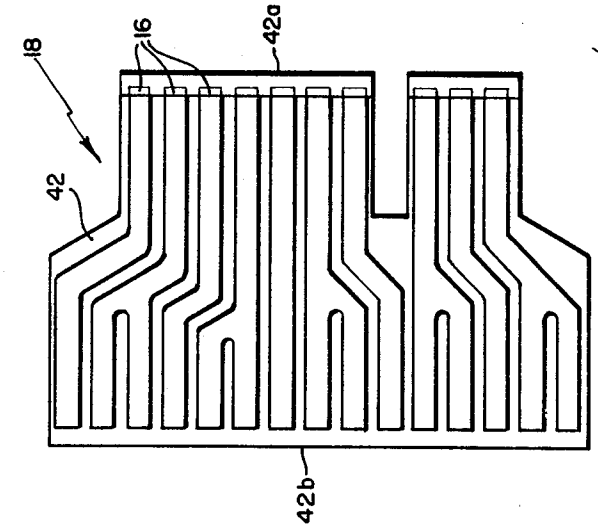
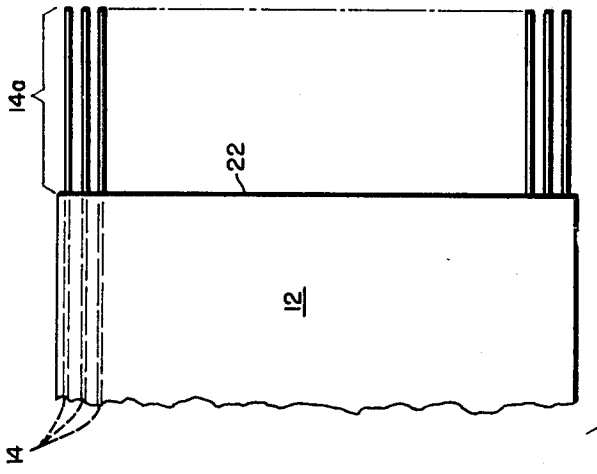


FIG. 3



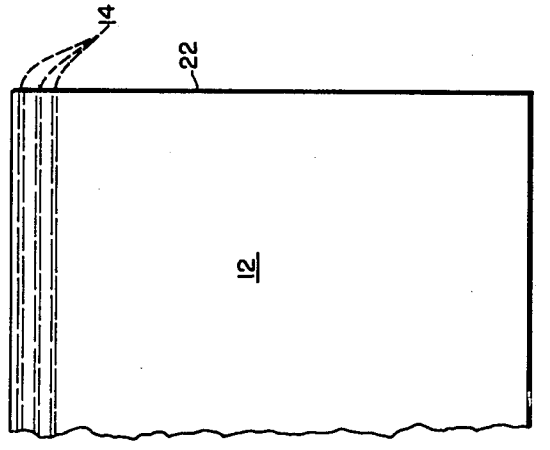


FIG. 2

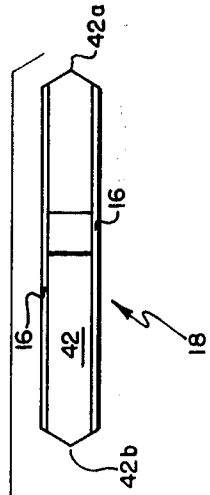


FIG. 4

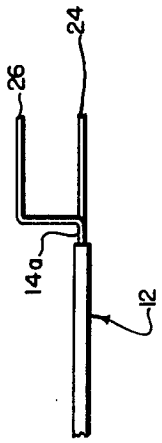


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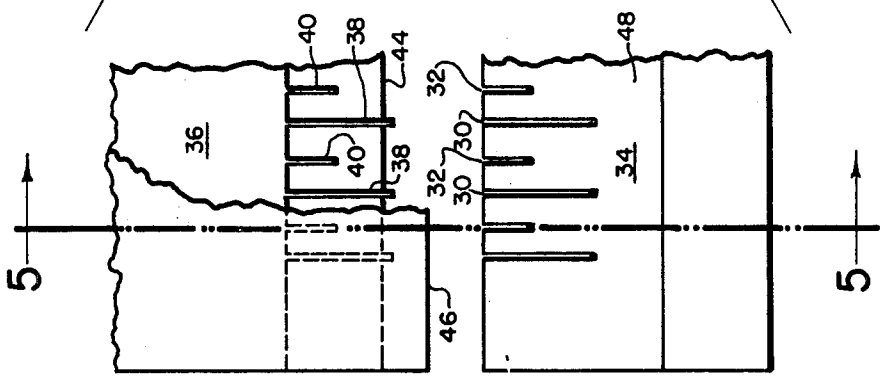
FIG. 6



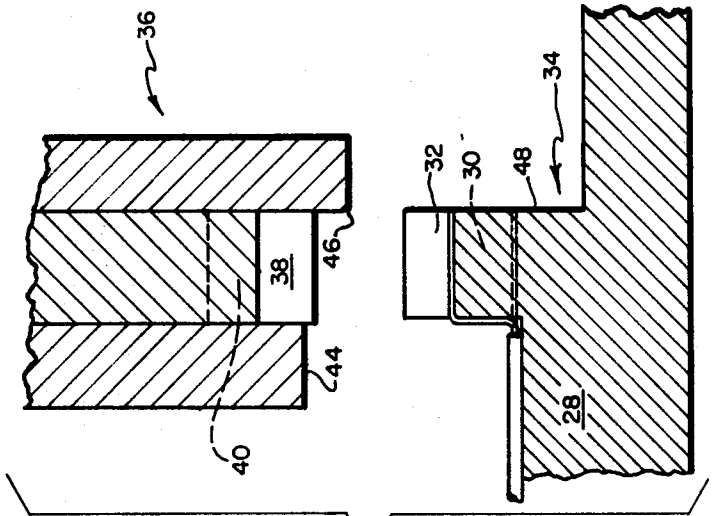


FIG. 5

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APPARATUS FOR TERMINATING ELECTRICAL RIBBON CABLE

BACKGROUND

This invention relates to the connection of a miniature electrical ribbon cable to other electrical elements. More particularly the invention provides a ribbon cable with a new termination to which other electrical devices can readily be connected. The invention also provides a new method for terminating a miniature ribbon cable. The termination and the method of preparing it provide a new degree of cost saving and compactness for terminations for ribbon cable having miniature fragile conductors in such close proximity to each other that separate connection to each conductor has heretofore been relatively impractical.

A ribbon cable is terminated, within the context of this invention, by electrically and mechanically attaching the cable conductors to an assemblage of contacts to which further connection can readily be made. The further connection can be by plug-in or other readily effected, removable connection and, alternatively, can be more permanent as by soldering or welding.

Ribbon cable is electrical cable in which many conductors are embedded in a flat ribbonlike insulator. The conductors are generally arranged side by side in a single layer. Recently ribbon cable of miniature dimensions, and further, miniature cable dimensioned to operate as open wire transmission line, have been desired for electrical equipment, such as for interconnecting elements of a computer. However, use of such cables has been severely restricted by difficulty in terminating the cable at reasonable cost with a compact structure to which further connection can be effected with ease. A further problem is to terminate transmission line ribbon cable without introducing excessive impedance discontinuities.

One reason miniature ribbon cable is difficult to terminate is that there is little space between adjacent conductors, typically there are 30 conductors in a cable three-quarter inch wide. Further, the small size (typically less than 10-mil diameter) and hence fragility of each conductor introduces mechanical problems, particularly problems in positioning and supporting the individual conductors during automatic machine or manual manipulation. This latter problem has generally been skirted in the prior art by leaving the conductor ends embedded in the cable insulation until the final steps in the termination process, or by requiring that extensions of the conductor—beyond the point of termination—remain on the cable until the terminating connections are secure. These and other prior techniques such as are disclosed in U.S. Pats. Nos. 3,004,237, 3,355,699, 3,221,286, 3,149,897, 3,189,864 and 3,017,602 are not satisfactory, especially with miniature cables of rodlike transmission line conductors, as distinguished from older, cables having relatively widely spaced ribbonlike conductors.

Accordingly, it is an object of this invention to provide a new cable termination suited for economical use with miniature ribbon cables, with ribbon cables operated as transmission lines, and with ribbon cables of rodlike conductors.

Another object is to provide a termination for cable of the foregoing types which is compact, and, further, which can be attached with relatively simple and low-cost equipment by relatively unskilled labor.

Another object is to provide a cable termination of the above character to which further connection can be made readily, including by plug-in connector, by soldering, and by welding.

A further object is to provide such a cable termination that does not require conductor fan-out, that is compact, and that introduces relatively small impedance discontinuities into transmission line cables.

It is also an object of the invention to provide an economically practical method for terminating miniature ribbon cable, transmission line ribbon cable, and ribbon cable having rodlike conductors.

A particular further object is to provide such a method in which surplus conductor insulation, or surplus conductor length, is not required during fabrication of the termination.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

SUMMARY OF INVENTION

In general, the cable termination of this invention is formed by removing the ribbon insulation from the end of the ribbon cable to expose, uninsulated, the ends of the cable conductors. Alternate ones of the uninsulated conductor ends are displaced relative to each other in opposite directions in the direction of the cable thickness. This forms the uninsulated conductor ends into two rows spaced apart in the direction of the cable thickness with the ends of adjacent conductors being in different rows.

A connector plate, illustratively in the form of a small printed circuit board, is fitted on the cable end with the edge of the plate seated between the two rows of preformed conductor ends. The connector plate has contacts on both plate surfaces, with a contact under each conductor end. The conductor ends are then soldered or otherwise secured to the contacts. The termination can be encapsulated or otherwise packaged as desired.

Connection to the cable is now easily effected by the use of conventional connector structure contacting the contacts on the connector plate.

The resultant termination is characterized, particularly when compared to the ribbon cable termination of the above-noted Cole et al. U.S. Pat. No. 3,004,237, by having the cable insulation terminate sufficiently short of the cable end so that the conductors extend without insulation to, and along, the connector board. Further, the termination is easily used on cables having conductors so close together, or so otherwise arranged, that one cannot readily "weave" the connector plate between the cable conductors, whether insulated or not; such weaving is disclosed in the Cole patent.

The present cable termination is well suited for use with ribbon cable having cylindrical or other rodlike conductors, as used in recently introduced ribbon cable constructed to operate as open wire transmission line. The invention generally requires that the uninsulated conductor ends be self-supporting in the sense that the uninsulated conductor ends maintain the position of being preformed into two rows as described above.

The invention accordingly comprises an article of manufacture possessing features, properties and the relation of elements exemplified in the article hereinafter described and further comprises the several steps for making the article and the relation of one or more of such steps with respect to each of the others thereof, all as exemplified in the method hereinafter disclosed, and the scope of the invention is indicated in the claims.

BRIEF DESCRIPTION OF DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which

FIG. 1 is a perspective view, partly broken away, of a cable termination embodying features of the invention;

FIG. 2 is a plan view of a ribbon cable illustrative of those with which the invention can be practiced;

FIG. 3 is a plan view of the cable of FIG. 2 with the insulation removed from an end thereof and, further, of a connector plate for use in making the termination of FIG. 1;

FIG. 4 is a side elevation view of the cable end and connector plate of FIG. 3 with the uninsulated conductor ends formed into two rows illustrative of the practice of the invention; and

FIGS. 5 and 6 show respectively side elevation and end views of processing equipment for forming the conductor ends into two rows as shown in FIG. 4.

DESCRIPTION OF ILLUSTRATED EMBODIMENT

In FIG. 1, the termination 10 on ribbon cable 12 has the cable conductors 14 soldered to contacts 16 carried on a connector plate 18. An insulating encapsulation 20 is molded over the adjacent ends of cable 12 and plate 18 to secure these elements together mechanically and thereby minimize stress applied to the conductor ends 14*a* that interconnect the plate and cable. The encapsulation also facilitates attaching a conventional connector to the connector plate 18 to effect further connection to the cable 12.

The cable 12 has a substantial number of conductors 14 disposed side by side embedded in a ribbon of insulation 22. It is the general practice that this is a unitary insulation formed over all the conductors simultaneously; the individual conductors normally do not have, in addition, individual insulating jackets. On the other hand, the conductors alternatively could be individually insulated and bonded side by side to provide the cable configuration. The illustrated conductors 14 are cylindrical and the illustrated cable is designed so that adjacent conductors operate as open wire transmission line. The illustrated cable also has miniature dimensions. For example, in one embodiment, the conductors have 8-mil diameters, are spaced apart on 25-mil centers, and are embedded in insulation 33 mils thick. The insulation 22 is typically a synthetic resin of high loss and low electric permittivity; polytetrafluoroethylene (commercially available under the trademark Teflon) is a preferred insulator although it has such a high melting point that it cannot be melted away with conventional soldering equipment.

As shown in FIGS. 2 and 3, the first step in fabricating the FIG. 1 termination 10 with a trimmed cable 12 as shown in FIG. 2 is to remove the insulation 22 from the conductor ends 14*a*, as shown in FIG. 3. This can be done with conventional skills, as by thermally softening the insulation to be removed and then removing it from the end of the cable 12. The technique selected often depends on the nature of the insulation 22.

In the event the conductor ends 14*a* are bent or otherwise misaligned after having the insulation stripped therefrom, they are next straightened by pulling them through a comblike structure or with equivalent techniques so that the conductor ends are straight and aligned as in FIG. 3.

The conductor ends are next formed into two rows 24 and 26 as shown in FIG. 4 with adjacent conductor ends being in different rows, as shown also in FIG. 1. The two rows 24 and 26 are spaced apart, in the direction of the thickness of the cable 12, sufficiently to receive between them the connector plate 18 shown in FIGS. 1, 3 and 4 and described further below. As indicated, the rows 24 and 26 are essentially parallel to the side-by-side arrangement of the conductors 14 in the cable 12. It should be noted that the illustrated conductors are not fanned apart in the plane of FIG. 3; on the contrary, in this plane and in the plane parallel to the cabled conductors and transverse to the plane of the ribbon cable, the conductor ends remain in line with the cabled conductors.

The cable ends can be staggered to form the two rows 24 and 26 by laying the cable on a flat support bed 28 shown in FIG. 5. The conductor ends 14 lie in slots 30 and 32 of a stamping form 34. The slots 30 and 32 are aligned parallel to each other in line with the cabled conductors 14 but, as shown in FIG. 6, the alternate slots 32 are shallower than the intervening alternate slots 30 by the amount of offset desired between the conductor rows 24 and 26 (FIG. 4). The bases of the slots 30 are substantially in the same plane as the support bed 28, and the bases of slots 32 are above this level.

As also shown in FIGS. 5 and 6, with the cable thus disposed, a stamping die 36 having alternate long and short forming teeth 38 and 40, respectively, is pressed against the stamping form 34 with the teeth 38 and 40 respectively meshing into the slots 30 and 32 to press alternate ones of the conductor ends 14*a* into the slots 30 and the other alternate conductor ends into the slots 32. The teeth 38 on stamping die 36 are dimensioned to position the conductor ends at the bases of the deep slots 30 on the stamping form 34, and similarly, the stamping die teeth 40 are dimensioned to press the conductor ends lying in slots 32 to the bases of these slots.

The stamping die 36 also has a platen 44 that overlies the support bed 28 and presses the cable 12 to the bed 28 as the teeth 38 push conductor ends down into slots 30. Further, the illustrated die 36 has a cutting edge 46 that moves down closely spaced from the forward face 48 of the stamping form to trim off excess conductor lengths extending forward, out of the slots 30, 32 beyond the face 48.

With further reference to FIGS. 3 and 4, which show the alignment of the connector plate 18 relative to staggered conductor ends 14*a* prior to assembly of the plate with the cable, the illustrated connector plate is a dielectric board 42 having contacts 16 secured to the opposite "plate" surfaces thereof. The board 42 and contacts 16 are conveniently of conventional printed circuit construction and the board 42 generally can have the same width as the cable 12. The contacts extend across the length of the board 42 from its forward end 42*a* to the back end 42*b* that is adjacent to the cable insulator 22 in the assembled termination. Further, the contacts 16 are so spaced apart on each side of the board 42 that each contact is aligned under a different conductor end when the connector plate is assembled with the cable, as shown in FIG. 1.

The connector plate 18 and cable 12 are assembled simply by inserting the back end 42*b* of the board between the two rows of conductor ends so that the end 42*b* is closely spaced from the edge of the cable insulation 22, FIG. 1. This assembly is conveniently carried out by placing the cable on a support plate in order to fix the position of the rows 24 and 26 of conductor ends. The connector plate is slide, toward the cable and between the rows of conductor ends, guided on rails that position the plate with respect to the width and thickness dimensions of the cable and hence relative to the rows of conductor ends.

With the connector plate 18 thus assembled with the cable 12, one row 24 of conductor ends overlays the contacts 16 on one side of the board 42 and the other row 26 of conductor ends overlays the contacts on the other side of the board 42. Further, each conductor end is disposed substantially above the center of a contact.

The conductor ends are then attached and electrically connected to the contacts as by reflow soldering. A preferred technique is to heat the assemblage with infrared energy to cause a solder pretinned on the contacts 16 to flow and bond to the overlying conductor ends 14*a*, which can also be pretinned. Because the contacts 16 on each side of the plate 14 are on center line spacings twice as large as the conductor-to-conductor centerline spacing in the cable, sufficient space can be provided between adjacent contacts so that solder does not "bridge" between two adjacent contacts causing an undesired short circuit.

The final step in the assembly of the termination 10 is to mold or otherwise form the encapsulation 10 (FIG. 1) bridging the adjacent ends of the cable 12 and the connector plate 18. The forward portion of plate 18 extends beyond the encapsulation 20 (toward the board forward edge 42*a*) so that the contacts thereon can be engaged for connecting the cable 12 to other devices. A thermosetting synthetic resin material is preferred for the encapsulation 20. The encapsulation serves to join the conductor plate and cable insulation mechanically, thereby relieving the conductors that extend between the connector plate and the cable insulation from being stressed by manipulation and use of the terminated cable. The encapsulation also provides mechanical and electrical protection for the termination, and as previously noted, facilitates plugging the end of the connector plate protruding from the encapsulation into a mating conventional connector.

It will thus be seen that the object set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above method, in the described article, and in the construction set forth, without departing from the scope of

the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which is a matter of language, might be said to fall therebetween.

Having described the invention, what is claimed as new and secured by Letters Patent is:

1. Electrical cabling apparatus in which:
   i. a ribbon cable has plural insulated electrical conductors disposed side by side, and
   ii. a connector element is electrically attached to said cable conductors at a first end of said cable,

said apparatus being characterized by the improvement wherein

   A. said cable has, at said first end, uninsulated conductor ends disposed in first and second rows which are spaced apart in the direction of the cable thickness wherein, in one direction, each conductor end is in line with the corresponding cable conductor, and
   B. said connector element
      1. comprises
         a. a dielectric board having first and second opposed surfaces and first and second peripheral edges each of which bounds part of said surfaces, and
         b. conductive contacts secured on both said surfaces, said contacts on each surface being insulatively spaced from each other and extending at least part way between said first and second edges,
      2. is disposed with said first board edge seated between said rows of uninsulated conductor ends, with said conductor ends in said first row thereof overlying and electrically connected to said contacts on said first board surface and with said conductor ends in said second row thereof overlying and electrically connected to said contacts on said second board surface, and wherein said uninsulated conductor ends extend along the entire length of said cable that overlies said conductive contacts.

2. Cabling apparatus defined in claim 1 further characterized in that said cable conductors are substantially cylindrical conductors.

3. Cabling apparatus as defined in claim 1 further characterized in that said cable conductors have insulation that extends at said first cable end to be closely spaced from said first board edge in the direction along said cable away from said connector element, and said conductors extend therefrom free of said insulation.

4. Cabling apparatus as defined in claim 1 further characterized in that
   A. dielectric encapsulation encloses said conductors at said first cable end, and encloses a portion of said board surfaces adjacent said first board edge and the portions of said contacts thereon, and
   B. a further portion of said board surfaces adjacent to and contiguous with said second edge and the contact portions thereon are exposed outside said encapsulation.

5. Cabling apparatus as defined in claim 1 in which said uninsulated ends of adjacent cable conductors are in different ones of said first and second rows thereof.

6. Cabling apparatus as defined in claim 1 in which the spacing between said conductor ends in each row thereof is not substantially greater than the spacing between alternate conductors in said cable.

7. Cabling apparatus as defined in claim 1 wherein said insulation has a melting point temperature greater than that temperature provided by electrical soldering techniques.

8. Cabling apparatus as defined in claim 1 wherein said insulation is a fluorocarbon compound.

9. Cabling apparatus as defined in claim 8 wherein said insulation is polytetrafluoroethylene.

10. Cabling apparatus as defined in claim 1 wherein said uninsulated conductors in said first row are substantially in the same plane as their corresponding insulated conductors which are in a first plane and wherein said uninsulated conductors in said second row are in a second plane substantially parallel to said first plane.

11. Electrical cabling apparatus in which:
   i. a ribbon cable has plural insulated electrical conductors disposed side by side, and
   ii. a connector element is electrically attached to said cable conductors at a first end of said cable,

said apparatus being characterized by the improvement wherein

   A. said cable has, at said first end, uninsulated conductor ends disposed in first and second rows which are spaced apart in the direction of the cable thickness, said uninsulated conductor ends in said first row being substantially in the same plane as their corresponding insulated conductors and said uninsulated conductor ends in said second row being in a second plane substantially parallel to said plane of said first row, and
   B. said connector element
      1. comprises
         a. a dielectric board having first and second opposed surfaces and first and second peripheral edges each of which bounds part of said surfaces, and
         b. conductive contacts secured on both said surfaces, said contacts on each surface being insulatively spaced from each other and extending at least part way between said first and second edges,
      2. is disposed with said first board edge seated between said rows of uninsulated conductor ends, with said conductor ends in said first row thereof overlying and electrically connected to said contacts on said first board surface and with said conductor ends in said second row thereof overlying and electrically connected to said contacts on said second board surface.

12. Cabling apparatus as defined in claim 11 further characterized in that said uninsulated conductor ends extend along the entire length of said cable that overlies said conductive contacts.

13. Cabling apparatus as defined in claim 12 further characterized in that the insulation of said insulated electrical conductors has a melting point temperature greater than that temperature provided by electrical soldering techniques.

14. Cabling apparatus as defined in claim 12 further characterized in that the insulation of said insulated electrical conductor is a fluorocarbon material.