Jan. 6, 1970 R. P. COLLIN 3,488,625

ELECTRICAL CONNECTOR

Filed March 27, 1967 2 Sheets-Sheet 1

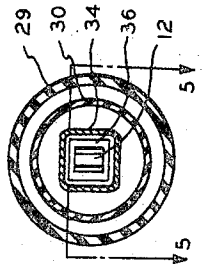


FIG. 2

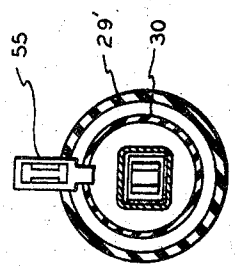


FIG. 4

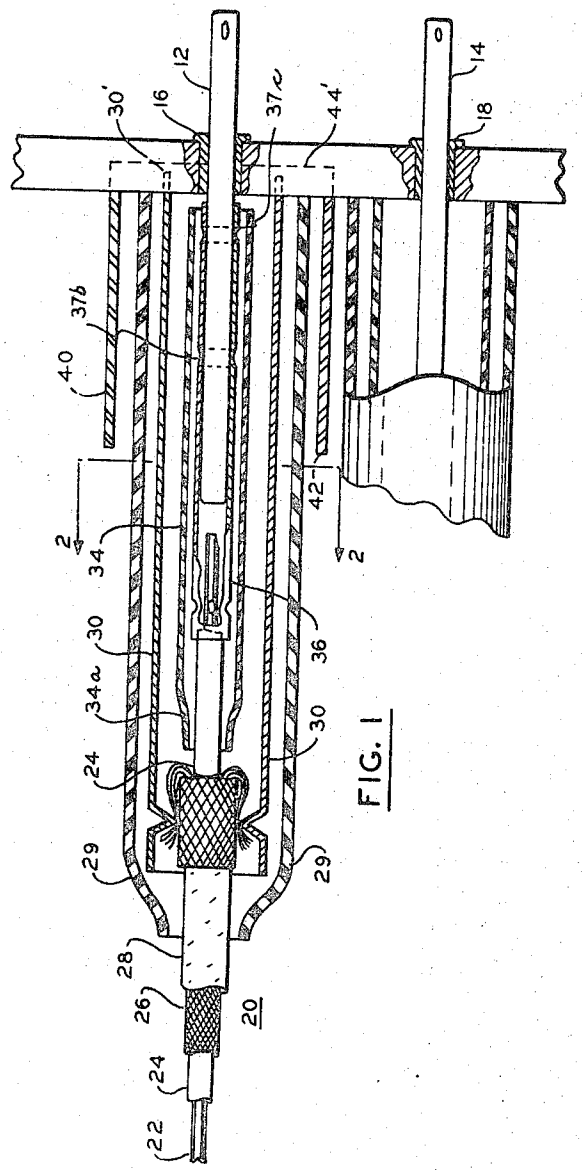


FIG. 1

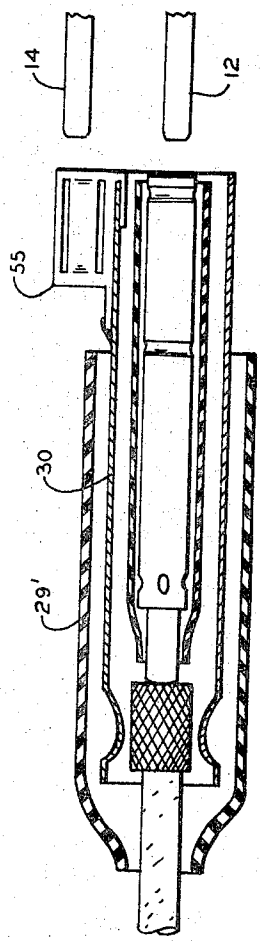


FIG. 3

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ELECTRICAL CONNECTOR

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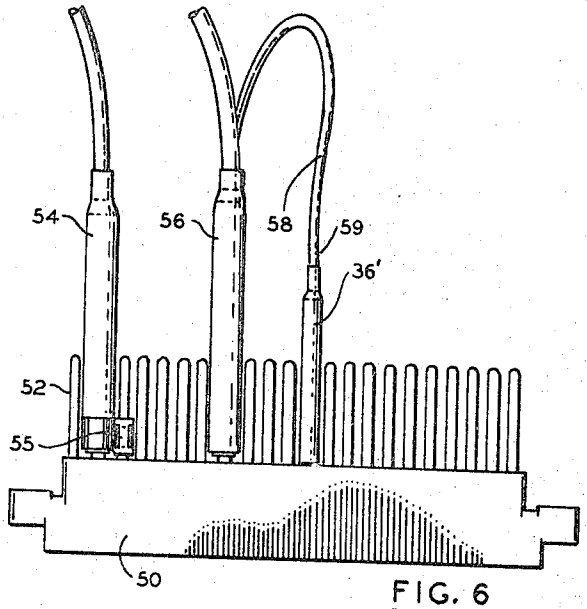


FIG. 6

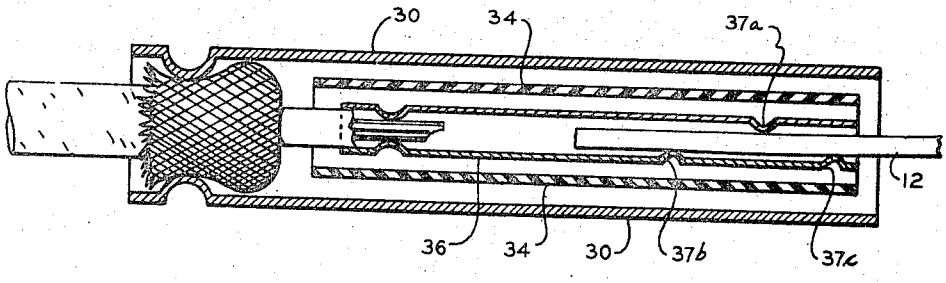


FIG. 5b

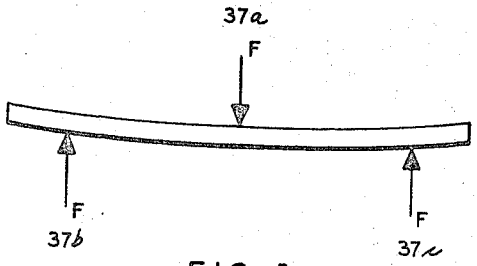


FIG. 5a

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3,488,625

Patented Jan. 6, 1970

3,488,625

ELECTRICAL CONNECTOR

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Filed Mar. 27, 1967, Ser. No. 626,253

Int. Cl. H01r 13/24, 17/18

U.S. Cl. 339—177 7 Claims

ABSTRACT OF THE DISCLOSURE

A device for connecting coaxial cable to closely-spaced rectangular terminal bars comprising a first hollow tube having one end crimped to the central conductor of the coaxial cable and having a plurality of inward projections adapted to hold the tube on the terminal bar by applying bending forces thereto, a second hollow tube of larger diameter concentrically surrounding the first tube, with one end of the second tube crimped around the braided outer conductor of the coaxial cable, and insulation surrounding the first tube to insulate it from the second tube.

This invention relates to method and apparatus, and more particularly, to improved method, apparatus and devices for connecting coaxial cable to terminal posts or bars having a non-circular cross section, such as "Wire-Wrap" terminal bars. A wide variety of applications in the computer, communication, and instrumentation arts, and electronic arts generally require the connection of coaxial cables carrying high frequency signals to such terminal posts.

Because signal conductors may be connected or wired to automatically, under control of a computer program, for example, and because they require no soldering or complex connector, the automatic connection of complex electronic devices with so-called "Wire-Wrap" connections has become extremely common. Briefly, "Wire-Wrap" connections are those in which a conductor is tightly wrapped throughout a plurality of turns about a terminal post having corners or edges, so that the corners or edges of the post tend to bite into the conductive conductor which is wrapped around the post and make contact between the two. Because of the reliability and economy surrounding programmed provision of such connections, Wire-Wrap connections have achieved widespread use. Wire-Wrap connections have been particularly suitable for those applications (typified by digital computers) in which a very large number of connections of exactly the same type must be made in accordance with a predetermined machine program.

While "Wire-Wrap" connections have achieved widespread use in the digital computer arts, for example, their use has been much less common, if noticeable at all, in those arts in which high-frequency wide-band signals and similar signals must be connected. Such signals commonly are routed between various circuit elements by means of coaxial cables, which include a central signal conductor, a concentrically-disposed outer (ground) conductor, frequently in the form of a metal braid, which is separated from the signal conductor by means of insulation, and a thin, outer insulation covering, such as polyvinyl chloride (or "PVC").

A large majority of prior connectors for coaxial cables merely comprise reduced-scale fittings from the plumbing industry, and many prior art coaxial cable connectors occupy far too much space to allow their use in machines where most connections are made by "Wire-Wrap" connections or in other applications where adjacent terminal posts must be close together. The increasing bandwidth

requirements in many devices, such as hybrid analog/digital computers, dictates the use of coaxial cable connections in an increasing number of circuits. Most prior art Wire-Wrap terminations have involved either low frequency signals or digital computer signals of which limited bandwidth treatment was satisfactory, or have involved signal circuits in which shielding from noise and cross-talk was much less important than frequently is now the case. An increasing number of applications require the connection of coaxial cables to closely-spaced rectangular terminal posts, with the signal conductors of such cables appreciable shielded to minimize pickup of noise and cross-talk. A variety of electronic connection devices presently available on the market which have closely-spaced rectangular connection bars and which have been intended for and useful in the past solely for ordinary single-conductor wire-wrap terminations become useful in many additional applications if coaxial cables may be connected to their connection posts in a reliable and economical manner. Thus it is a primary object of the invention to provide an economical and reliable connection technique for connecting coaxial cables to closely-spaced non-circular bars or posts of the type to which Wire-Wrap connections usually are made.

It is another important object of the invention to provide connections of the type described which do not require machining, or soldering and little, if any, application of heat, and which may be made rapidly and reliably by unskilled personnel using simple hand tools, either in the factory or in the field.

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

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts, which will be exemplified in the constructions hereinafter set forth.

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 cross-section view, not to scale, through a coaxial cable termination made in accordance with the invention, in which various of the parts are shown with expanded diameters for sake of clarity.

FIG. 2 is a cross-section view taken at 2—2 in FIG. 1.

FIG. 3 is a side view, also not to scale, of an alternate form of the invention.

FIG. 4 is an end view of the connector of FIG. 3.

FIG. 5*a* is a force diagram illustrating, in exaggerated form, the forces applied to a rectangular connector bar by the connectors of the invention, and FIG. 5B is a view taken at lines 5—5 in FIG. 2.

FIG. 6 is an elevation view illustrating several further modifications of the invention.

Referring now to FIGS. 1 and 2, numeral **10** indicates the wall of an electrical device through which a plurality of non-circular mutually-parallel bars or posts protrude, only two such posts **12** and **14** being shown in FIG. 1. Wall **10** might comprise, for example, the rear wall of a computer patchbay, in which case many rows and columns of such bars equally spaced from each other may protrude through wall **10**. Such matrices of connection bars are typically utilized when connections are intended to be made to them automatically by means of a Wire-Wrap machine. In some applications wall **10** is formed of an insulating material and no insulation is necessary to insulate the bars from each other. In other applications to which the present invention is principally directed, wall **10** either comprises a conductive metal plate or an insulating plate coated with conductive material to facilitate shielding of the individual conductors from each other to prevent cross-talk. In FIG. 1 wall **10** is assumed

to be such a conductive plate, and insulating bushings **16**, **18** surround each post where it passes through wall **10** in order to insulate it from wall **10**.

A typical flexible coaxial cable **20** coming from an external circuit (not shown) is shown in cross-section as including a central signal conductor **22** surrounded by a cylindrical insulation layer **24**, a braided metallic sheath outer or ground conductor **26** and an outer insulation covering **28**. To install the connector of FIG. 1, the outer insulation layer **28** is stripped off a short length of cable **20** and a length of braid **26** folded back over the outer covering as shown in FIG. 1. One end of a piece of brass, copper or other conductive hollow tubing **30**, preferably circular in cross section, is then crimped to surround the folded-back braid, using a conventional plier-like crimping tool which crimps to a controlled depth. Tube **30** extends forwardly from the folded back braid far enough to seat against and electrically contact conductive wall **10**, thereby providing shielding of the signal conductor along its entire length. The inner insulation **24** of the coaxial cable extends forwardly from where braid **26** is folded back to within a rubber, plastic or other insulating tube **34** and terminates adjacent the outer end of a rectangular tube **36**, also preferably formed of brass or copper. Insulating tube **34** preferably is elastically expandable and surrounds tube **36** with a shrink fit, more tightly than is shown in FIG. 1. Alternatively, for ease of assembly, the inner diameter of a permanently-deformable tube **34** and the outer diameter of tube **36** may be chosen so that tube **34** is readily slidable over tube **36**, and then the end of tube **34** may be necked down by crimping as shown at **34***a* in order to prevent tube **34** thereafter from sliding off tube **36**. Also, rather than providing a shrink fit or necked-down portion in tubing **34**, the inner diameter of outer tube **30** may be selected so as to compress or confine insulating tubing **34** to maintain it in place. A portion of the signal conductor **22** is permanently attached to tube **36** by crimping the latter near its outer end as shown. Rectangular tube **36** slides on and attaches to rectangular post **12** with a friction fit provided by plural crimps in tube **36**, as will be further mentioned in connection with FIGS. *5a* and *5b*. To prevent ground tube **30** of the connector assembly from contacting any adjacent equipment when the connectors are pressed on or pulled off of the connector posts, an outer insulating covering **29** also preferably having a shrink fit, surrounds the entire connector.

By careful attention to mechanical tolerances it is possible to insure that the forward end of ground shield tube seats against conductive wall **10** when rectangular tube **36** has been slid all the way onto post **12**, but even then vibration and like influences may sometimes prevent good electrical contact between tube **30** and wall **10**, and the presence of a small space between tube **30** and wall **10** can allow a detectable amount of cross-talk. In extremely high-performance applications, such cross-talk may be eliminated substantially entirely by having the end of tube **30** protrude within the wall **10** structure. For example, wall **10** may be provided with a conductive egg-crate structure on its rear side to surround each connector bar, as indicated by plates **40** and **42** in FIG. 1. Alternatively, recesses may be provided in wall **10**, as indicated by dashed lines at **44'**, and tube **30** may be provided with a greater length, as indicated at **30'** in dashed lines.

The manner in which rectangular tube **36** is made to engage post **12** reliably though removably, will be better understood by reference to FIGS. *5a* and *5b*, wherein tube **36** is shown as having three inwardly-extending projections spaced along tube **36** to apply bending forces to the straight connection post **12** when the connector is pressed onto the post. The nature of the bending forces is illustrated in exaggerated form in FIG. *5a*, where it will be seen that the inward-projections, which may comprise simple controlled-depth crimps in tube **36**, attempt to bend connector post **12**, and press tightly against the post at three points when the connector is installed. It also may be noted that the projections wipe the sides of the connector bar as the connector is pressed on the post, insuring good metal-to-metal contact. It will be apparent that more than three such spaced crimps may be provided, though three are usually regarded to be ample. The use of only two crimps on opposite sides of tube **36** should be avoided. If spaced from each other along the tube they undesirably cause the connector to cant with respect to the connector post, and if spaced directly across the tube from each other the stiffness of the connector post does not contribute to maintaining good contact.

The connector devices of the invention may be made in a variety of sizes to fit different sizes of connector posts and to receive different sizes of coaxial cable. An exemplary embodiment which has found wide utility for connecting .125 inch O.D. coaxial cable utilizes 1.75 inch long pieces of circular brass tubing (having inside and outside diameters of .155 in. and .187 in., respectively) as ground tube **30**, 1.0 inch long pieces of rectangular (square) brass tubing (having an inside dimension of .07 in. and an outside dimension of .10 in., respectively) as tube **36**, with the three crimps spaced approximately one-eighth inch apart along the tube. Shrink tube polyolefin insulation of Alpha Wire Type No. FIT–221 surrounds rectangular tube **36**, and shrink tube insulation of the same type surrounds outer ground tube **30**. Shrink-tube insulation of the type mentioned may be slid easily over the part to be insulated, and then be shrunk to tightly engage the part by the application of hot air. The outside diameter of a complete connector then is only .20 inch. It will be apparent that various other types of insulation may be substituted for shrink-fit insulation, to be wrapped on or painted on.

FIGS. 3 and 4 show a slightly modified female connector having a foreshortened outer insulating covering **29'** to allow a known form of box contact **55** (Amp, Inc. Catalog No. 85487–2LP) to be fixedly attached to the forward end of ground tube **30**, with one finger of box contact **55** extending a short distance inside ground tube **30** and another finger lying against the outer surface of tube **30**, to which it is preferably soldered. Contact **55** may be soldered to tube **30** before the tube is crimped to the coaxial cable braid, so that no heat need be applied to the coaxial cable. When assembled, the device of FIGS. 3 and 4 contacts two adjacent posts **12** and **14**, connecting the ground tube **30** of the connector to adjacent post **14**, as is shown in FIG. 6. As is apparent from FIG. 4, box contact **55** is circumferentially located on tube **30** so that the sides of its post-receiving recess are substantially parallel to a pair of sides of rectangular tube **36**.

FIG. 6 illustrates the use of connections made in accordance with the invention with several different modifications. A plug-type connector **50** (Amp, Inc. Catalog No. 582766–2) of a type frequently used to engage the edges of an etched circuit card is shown having a plurality of upwardly-extending rectangular connection bars **52**, **52** usually intended to be connected to by wire-wrap processes. Female connector **54** shown attached at the left end of connector **50** comprises the connector shown in FIG. 3. The box contact **55** is shown mounted on and engaging the adjacent post of connector device **50**.

Connector **56** in FIG. 6 corresponds to the connector of FIG. 1 except that an insulated "dangle wire" **58** has been connected to the upper end of the connector, the bare end (not shown) of dangle wire **58** being crimped together with the folded-back metal braid at the upper end of tube **30**. The remote end **59** of dangle wire **58** carries a rectangular tube **36'** identical to tube **36** of FIG. 1 and a surrounding shrink-fit insulating covering like covering **36** of FIG. 1. The insulated rectangular tube **36'** is pressed on another connector bar. Because dangle wire **58** is connected to ground at connector **56**, no surrounding ground tube is necessary.

While the rectangular connector post **12** shown in FIG. 2 is shown with a square cross-section, it will be apparent at this point how the dimensions may be altered to con-

nect to posts having other rectangular cross-sectioned shapes, and indeed to posts having other non-circular and even circular cross-sectional shapes.

The steps involved in connecting a cable terminator of the type shown are preferably as follows (with the dimensions herein stated merely being exemplary). The braid and insulation coverings at the end of the coaxial cable are stripped to allow approximately ¼ inch of bare central conductor to protrude. Approximately ¼ inch of the outer conductor is then folded back over the outer insulation, the end of rectangular tube **36** is crimped on the protruding portion of central conductor, and then the shrink tubing is fitted over tube **36**. Next, the outer tubing **30** is slid over the free end of tube **36** until the ends of the two pieces of tubing register, and then outer tube **30** is crimped about the folded-back portion of metal braid. Lastly, the outer shrink tubing is fitted over tube **30**. It will be seen that all of the above operations are extremely simple and may be performed by unskilled personnel using simple tools.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained, and since certain changes may be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A cable terminator for connecting to an elongated bar a coaxial cable having a central conductor, insulation concentrically surrounding said central conductor and a concentric outer conductor, said terminator comprising, in combination: a first metallic tube surrounding a portion of said concentric outer conductor at one end thereof and being crimped to grip and electrically contact said outer conductor; a second metallic tube substantially concentrically disposed within said first tube, said second tube being crimped at one end to grip said central conductor and having a plurality of inwardly-extending projections spaced along its length to provide bending forces to said elongated bar; and an insulation covering surrounding said second metallic tube.

2. A cable terminator according to claim **1** in which said second metallic tube has a non-circular cross-section.

3. A cable terminator according to claim **1** having a metallic spring box contact affixed to the open end of said first tube and adapted to engage a second elongated bar which extends parallel to the previously-mentioned elongated bar.

4. A cable terminator according to claim **1** having a further wire having an end extending within said first metallic tube, said end of said further wire being crimped together with said outer conductor within said first metallic tube.

5. A cable terminator according to claim **2** in which the bore of said second metallic tube is rectangular in cross-section.

6. A cable terminator according to claim **4** having a third metallic tube crimped at one end to grip said further wire.

7. A cable terminator according to claim **1** in which both ends of said second metallic tube are situated within said first tube.

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U.S. Cl. X.R.

339—256