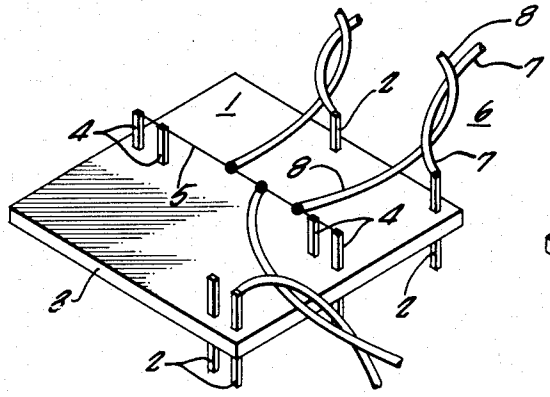
Sept. 7, 1965 J. C. DAVIDSON 3,205,295

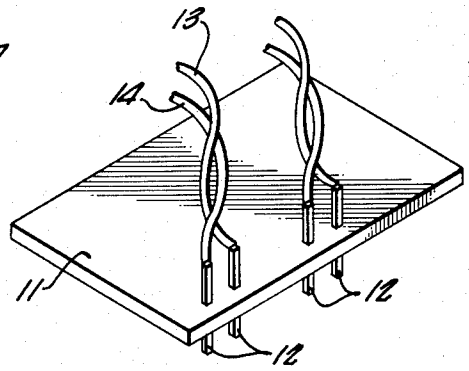
ELECTRICAL CONNECTOR

Filed March 18, 1963 2 Sheets-Sheet 1



PRIOR ART

FIG. 1



PRIOR ART

FIG. 2

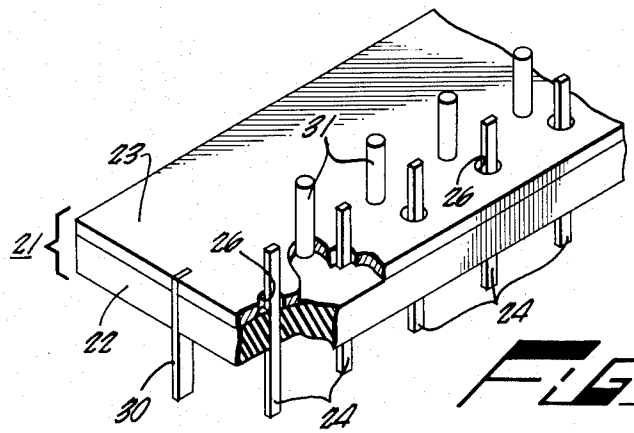
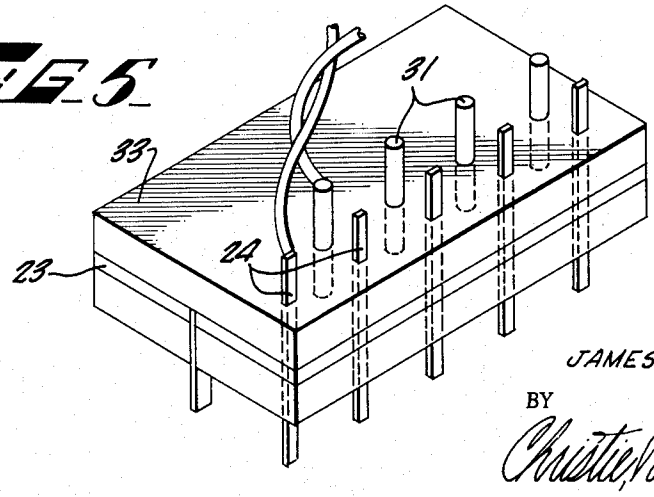


FIG. 4

FIG. 5



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ELECTRICAL CONNECTOR

Filed March 18, 1963 2 Sheets-Sheet 2

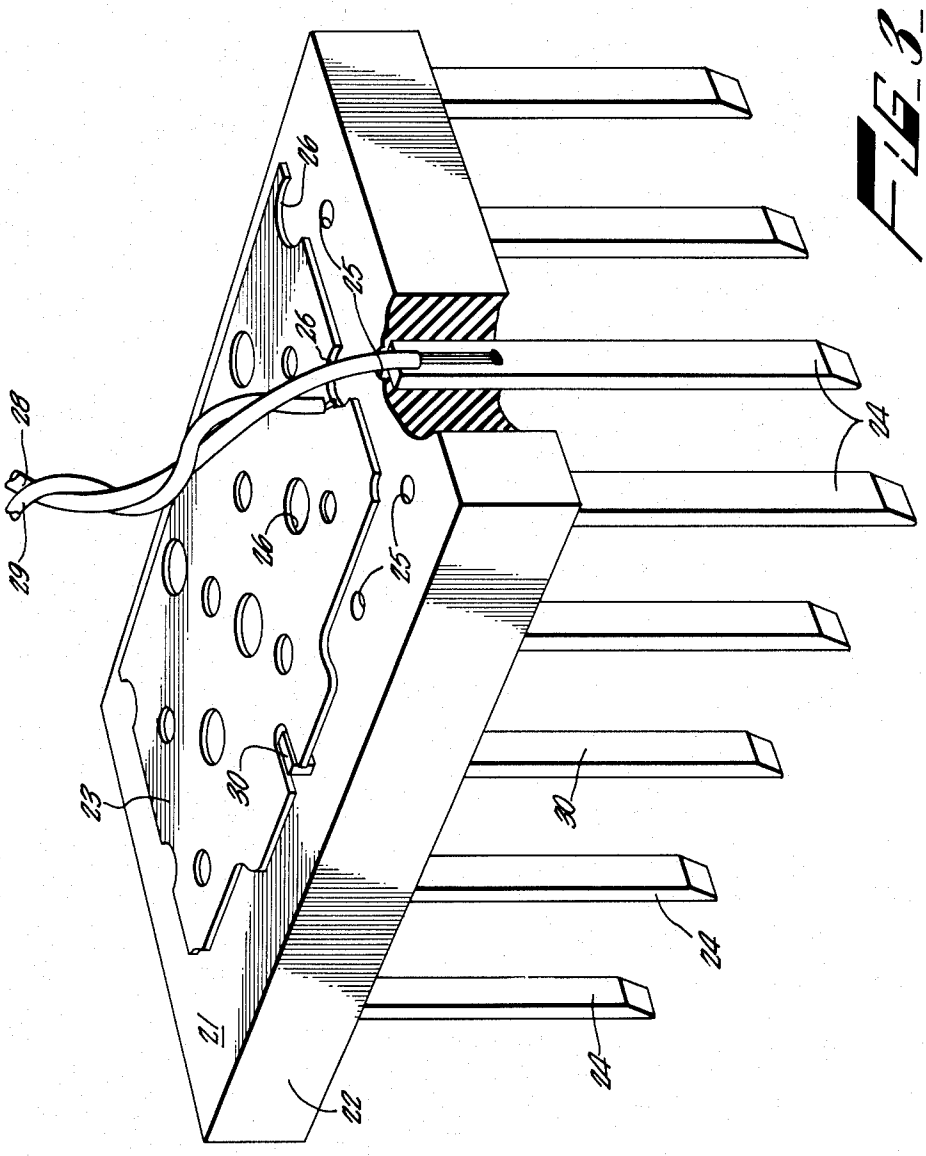

FIG. 3

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United States Patent Office

3,205,295
Patented Sept. 7, 1965

3,205,295

ELECTRICAL CONNECTOR

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Filed Mar. 18, 1963, Ser. No. 265,782
5 Claims. (Cl. 174—32)

This invention relates to electrical connectors and more particularly to electrical connectors for the interconnection of twisted pair transmission lines.

When a plurality of conductors are placed in close proximity, there is a tendency for the signals travelling on one conductor to interfere with signals travelling on adjacent conductors. This interference is commonly called "cross-talk" and is especially noticeable and detrimental in high frequency circuits. One way to reduce the cross-talk is to entwine or twist the pair of conductors which constitute a transmission line. Thereafter, the twisted pair of conductors may be placed adjacent to each other without significant interference.

The twisted pair of transmission lines will usually terminate in a connector to form a cable for the interconnection between circuits. It is desirable to continue the twist or entwining of each pair of conductors down to its connection with the connector in order to avoid the cross-talk problem. In the past, the connectors have taken the form of a plurality of pins embedded in a layer of insulating material. Thereafter, two or more of the pins are interconnected by a conductor to form a terminal point for the ground conductors of the transmission line pairs. The signal conductors of each pair terminate at an individual pin. In such a construction, the ground conductors are all connected to a common point so that the twisting of a particular pair of conductors must be discontinued prior to the connection to the signal pin to provide sufficient length in the ground conductor to reach its terminal point. Thus, the problem of cross-talk is apparent.

However, another prior art connector overcame this problem of cross-talk by connecting the two conductors of each pair to adjacent pins on the connector. Thus, the twisting or entwining of the pairs could be continued down to the point of connection of each conductor. There is a big disadvantage in such a connector in that every other pin has a ground conductor connected thereto. This results in a highly inefficient use of the pins that extend through the connector and of the available area in which the pins can be located.

Therefore, in accordance with the present invention, there is provided a connector which substantially overcomes the problem of cross-talk and provides a highly efficient use of the pins or prongs of the connector. The connector includes a plurality of pins embedded in a layer of insulating material. In addition to the layer of insulating material there is provided a layer of conducting material on top of the insulating material. The pins are perpendicular to the surface of the layer of insulating material and extend away from the layer of conducting material. There is provided a plurality of holes or apertures in the layer of conducting material, with each hole being positioned directly above a pin in the layer of insulating material. Thereafter, a twisted pair of conductors advantageously have the twist extending down to the layer of conducting material, where the ground conductor is attached. Thereafter, the signal conductor is passed through an adjacent hole and connected to the pin located below the hole. Thus, the layer of conducting material effectively forms a finite ground plane or ground plate in the connector and substantially eliminates any

cross-talk. Rather than having a plurality of pins of the connector associated with the ground conductors of the transmission lines, there may be as few as one pin associated with the ground conductors. This pin is electrically connected to the ground plate.

A particularly advantageous modification of the connector involves the extension of the pins associated with the signal conductors through the holes in the layer of conducting material so that the signal conductors may be more easily attached to the pins.

Thereafter, a further modification is particularly advantageous. Rigid conductors are attached to the layer of conducting material and extend above the surface thereof adjacent to one of the pins so that the ground conductor may also be more easily connected. Thus, the entwining or twisting of each pair may be continued down to the point of connection.

The above and other features and advantages of the present invention will be understood more clearly and fully upon consideration of the following specification and drawing in which:

FIG. 1 is a pictorial diagram of a prior art connector;

FIG. 2 is a pictorial diagram of another prior art connector;

FIG. 3 is a pictorial diagram of the connector in accordance with the invention;

FIG. 4 is a pictorial diagram of a preferred embodiment of the connector in accordance with the invention; and

FIG. 5 is a pictorial diagram showing a modification of the preferred embodiment of FIG. 4.

Prior art connectors are shown in FIGS. 1 and 2 to further the understanding of the problems that existed in connectors for twisted pair transmission lines. The prior art connector of FIG. 1 is representative of one of the types previously employed to terminate twisted pairs of conductors. This particular type resulted in excessive cross-talk in that the twisting of the pairs had to be discontinued at some distance from the connection to permit sufficient length for the ground conductor of each pair to be connected.

The connector **1** of FIG. 1 includes a plurality of pins, of which only a few are shown, embedded in a layer of insulating material **3**. Of the pins embedded in the insulating material and extending therethrough, four are shown connected in common by a conductor **5**. These four pins are separately numbered for identification purposes. For example, the pins that are connected together and are associated with the ground conductor of each pair through ground conductor **5** are pins **4**. On the other hand, the pins that are associated with the signal conductor are pins **2**.

A typical pair of transmission lines **6** includes a signal conductor **7** and a ground conductor **8**. The signal conductor **7** is connected to a pin **2** and the ground conductor **8** is connected to the ground conductor **5**, which is connected to the pins **4**. It is seen that the twisting or entwining of the conductors must be discontinued a substantial distance from the connection to provide a sufficient length of ground conductor **8** for connection to pins **4**. Therefore, cross-talk becomes a problem in this prior art connector.

Another prior art connector, which overcomes this problem of cross-talk, permits the twisting of the conductors to continue down to the connection and is shown in FIG. 2. The connector comprises a layer of insulating material **11** and a plurality of pins **12**. A typical twisted pair of conductors includes a signal conductor **13** and a ground conductor **14**. The two conductors of the pair are connected to adjacent pins so that every other pin **12**

which extends through the layer of insulating material **11** will have a ground conductor attached thereto. This results in a very inefficient use of the pins, that extend through the insulating material.

Now referring to FIG. 3, the improved electrical connector of the present invention will be described. The connector of FIG. 3 includes a laminated frame **21** which comprises a layer of insulating material **22** and a layer of conducting material **23**. A plurality of pins **24** are embedded in the layer of insulating material **22**. These pins **24** are positioned perpendicular to the flat surface of the laminated frame **21** and extend away from the layer of insulating material **22** on the side opposite the layer of conducting material **23**. An aperture or hole **25** is located in the layer of insulating material **22** above each pin **24**. Above each hole **25** is a coaxial hole **26** in the layer of conducting material **23**.

A transmission line comprising a signal conductor **28** and a ground or signal return conductor **29** is shown attached to the connector of FIG. 3. The signal lead **28** passes through a hole **26** in the layer of conducting material and a hole **25** in the layer of insulating material and makes contact with and is connected to one of the pins **24**. This connection may be by a solder connection or any one of the other well-known ways of connecting electrical conductors to pins. The ground conductor **29** is connected to the layer of conducting material **23** adjacent to the hole **26** through which its associated signal conductor passed. Every other twited pair of transmission lines will be similarly connected to the connector, i.e., the signal conductor will pass through the holes **26** and **25** to make contact with a pin and the ground conductor will be connected to the layer of conducting material adjacent to the hole through which its associated signal conductor passed. Thus, the twisting is continued down to the point of connection and the ground conductors are connected to a layer of conducting material, which effectively forms a finite ground plane or ground plate. Therefore, cross-talk is substantially eliminated and substantially all of the pins have signal conductors attached thereto.

To complete the connector, the layer of conducting material **23** is electrically connected to one or more pins **30**, so that the ground conductors of the transmission lines will be effectively connected to the circuit to which the connector is attached. Thus, as few as one pin may be associated with the ground or signal return conductors rather than having one-half of the pins required for ground conductors.

A preferred embodiment of the connector, in accordance with the invention, is shown in FIG. 4. This connector is similar to the connector of FIG. 3 and includes a laminated frame **21** which comprises a lamina of insulating material **22** and a lamina of conducting material **23**. The pins **24**, which are embedded in the lamina of insulating material, extend through holes **26** in the layer of conducting material **23**. Thereafter, the signal conductor of the transmission lines may be more easily connected to the pins above the finite ground plane or ground plate formed by the layer of conducting material **23**. Additionally, rigid conductors **31** are embedded in or connected to the layer of conducting material **23** and extend above it so that the ground conductors of the transmission lines may also be more easily connected. The layer of conducting material **23** is electrically connected to at least one pin **30** to carry all of the ground conductors or signal return conductors of the paired conductors into the next circuit.

A modification to the connector shown in FIG 4 is shown in FIG. 5. To the connector of FIG. 4 there is added a layer of insulating material **33** on top of the layer of conducting material **23**. This is provided to more effectively isolate the pins **24** and the rigid conductors **31**. Additionally, the layer of insulating material **33** will make the connector more rigid and durable.

After all of the conductors are connected to the connectors of FIGS. 3, 4 and 5, the unit may be advantageously encased in a solid material, e.g., a plastic, to protect the electrical connections and the wires.

What is claimed is:

1. An electrical connector comprising a first layer of insulating material, a second layer of insulating material, a layer of conducting material sandwiched between the first and second layers of insulating material, a plurality of apertures located in the layer of conducting material and positioned in a spaced-apart relationship, a plurality of pins, each one of the pins extending through one of the apertures and embedded in the first layer of insulating material and the second layer of insulating material, the pins extending beyond the second layer of insulating material to form the prongs of the connector and extending in the opposite direction above the first layer of insulating material to form terminals for electrical conductors, rigid conductors embedded in the layer of conducting material and extending through the first layer of insulating material to form terminals for electrical conductors, and at least one pin embedded in the layer of conducting material and extending through the second layer of insulating material to form one of the prongs of the connector.

2. In combination, a layer of insulating material, a plurality of pins embedded in the layer of insulating material, a layer of conducting material positioned on top of the layer of insulating material, at least one of the pins being in electrical contact with the layer of conducting material, a plurality of paired transmission lines, each pair including a signal conductor and a signal return conductor, the signal conductor and the signal return conductor of each pair being intertwined, means for connecting each signal conductor to one of the pins, and means for physically connecting each signal return conductor to the layer of conducting material adjacent the pin of its associated signal conductor.

3. An electrical connector for twisted pair transmission lines comprising a layer of insulating material, a plurality of pins embedded in the insulating layer, a ground plate of conducting material attached to the layer of insulating material, a plurality of apertures located in the ground plate, the apertures being positioned in a spaced-apart relationship and each aperture being immediately above an individual pin, a plurality of paired transmission lines, each pair including a signal conductor and a signal return conductor, the signal conductor of each pair passing through an aperture and connected to the pin therebelow, the signal return conductor of each pair being connected to the ground plate adjacent to the aperture associated with the signal conductor of the pair, and at least one pin passing through the layer of insulating material and making electrical contact with the ground plate.

4. In combination, a layer of insulating material, a layer of conducting material attached to the layer of insulating material, a plurality of pins embedded in the layer of insulating material and positioned perpendicular to the plane of the layers, the pins extending away from the layer of insulating material to form the prongs of the connector and extending in the opposite direction above the layer of conducting material to form electrical terminals, a plurality of rigid conductors attached to the layer of conducting material and extending in a direction parallel to the plurality of pins above the layer of conducting material, a twisted pair of conductors connected to adjacent pins and rigid conductors so that the signal conductor will be coupled through the layers by the pins and the ground conductor will be coupled to the layer of conducting material by the rigid conductors, and at least one pin extending through the layer of insulating material from the layer of conducting material and in contact with the layer of conducting material.

5. In combination, a laminated frame including a layer of insulating material and a layer of conducting material, a plurality of conductive pins embedded in the layer of

insulating material, the pins positioned perpendicular to the laminated frame and extending away from the layer of insulating material on the side opposite the layer of conducting material, apertures in the conducting material above each pin, and a plurality of twisted pairs of conductors, the twist extending down to the layer of conducting material, one of the conductors of each pair extending through an aperture and connected to a pin, and the other conductor of each pair connected to the layer of conducting material adjacent to the aperture of its associated signal conductor, at least one pin being in electrical contact with the layer of conducting material.

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