

AN ELECTRICAL CONNECTOR AND AN ASSOCIATED
METHOD FOR COMPENSATING FOR CROSSTALK
BETWEEN A PLURALITY OF CONDUCTORS

5 The present invention relates to an
electrical connector having a plurality of conductors
arranged to compensate for crosstalk between the
conductors.

10 A number of electrical connectors include a
plurality of elongate conductors which electrically
interconnect respective inputs and outputs of the
connector. As known to those skilled in the art, an
elongate conductor which is adjacent to or relatively
15 near another elongate conductor will typically
experience crosstalk. Crosstalk is generally defined
as the unwanted coupling or transmission of an
electrical signal from one pair of wires to another
nearby pair of wires. Crosstalk occurs by inductive
20 (magnetic field) coupling and by capacitive (electric
field) coupling. In addition, increased levels of
crosstalk are established between conductors which
extend in a parallel or near-parallel relationship,
such as the elongate conductors of many electrical
connectors.

25 Crosstalk is generally undesirable as the
integrity and definition of the signals transmitted via
the conductor is impaired by the interfering coupled
signals. In addition, the strength of the signals
transmitted via the respective conductor is also
30 typically reduced by the energy expended or wasted in
crosstalk, particularly at relatively high frequencies.
Therefore, various methods have been employed to reduce
or compensate for crosstalk, particularly within
electrical connectors which include a plurality of
35 elongate conductors.

A high frequency electrical connector which
has been developed to reduce crosstalk is described in

U.S. Patent No. 5,186,647 which includes a number of conductors mounted on a dielectric surface and extending in a generally parallel relationship for at least a portion of their length. At least one of the
5 elongate conductors crosses the path of another conductor without making electrical contact therebetween to reduce the crosstalk between the conductors.

As technology advances communications systems
10 are being forced to operate at higher frequencies which lead to increases in crosstalk. Although connectors which have their conductors crossing paths are effective at reducing crosstalk, the higher operating frequencies necessitate still greater reductions in
15 crosstalk in order to meet performance standards. The present invention provides a connector having a novel arrangement of conductors in order to achieve a further reduction in crosstalk.

The problem to be solved by the present
20 invention is to provide an electrical connector which compensates for crosstalk between a number of conductor pairs.

It would be most advantageous if this problem could be solved by a connector which is easily
25 manufactured, assembled, cost effective, and easily used; including the characteristic that the connector can be efficiently wired and rewired.

This problem has been solved by providing an electrical connector which includes a housing defining
30 an internal cavity, and a plurality of elongate conductors positioned at least partially within the cavity and including a pair of conductors positioned in an overlapping, vertically spaced relationship to compensate for crosstalk between the conductors.
35 According to one embodiment, the conductors also include first and second elongate conductors which



extend in a substantially parallel, laterally spaced relationship from their respective first ends to a predetermined crossover location. At the crossover location, the first and second conductors laterally cross without establishing electrical contact therebetween. The crossover location is spaced apart from the predetermined location at which the pair of the conductors are positioned in the overlapping, vertically spaced relationship. By laterally crossing the first and second elongate conductors and by positioning at least a pair of the conductors in an overlapping, vertically spaced relationship, the electrical connector of the present invention compensates for crosstalk between the plurality of conductors.

The invention will now be described by way of reference to the drawings, wherein:

Figure 1 is a greatly enlarged exploded perspective view of an electrical connector according to the present invention;

Figure 2 is a greatly enlarged perspective view of an electrical connector of the present invention illustrating the assembled housing;

Figure 3 is a greatly enlarged cross-sectional view of an electrical connector according to the present invention illustrating an elongate conductor and the rearwardly extending silos taken along line 3-3 of Figure 2;

Figure 4 is a greatly enlarged exploded view of an electrical connector according to the present invention illustrating the relationship of the first and second supporting members and the elongate conductors sandwiched therebetween;

Figure 5 is a top plan view of a lead frame assembly according to the present invention illustrating a plurality of aligned lead frames;



Figure 6 is a side view of the lead frame assembly of Figure 5 illustrating the upper, middle and lower lead frames;

Figure 7 is a greatly enlarged cross-sectional view of the lead frame assembly of Figure 5 taken along line 7-7;

Figure 8 is a greatly enlarged fragmentary top plan view of the lead frame assembly of Figure 5 illustrating the overlapping relationship of the compensating segments;

Figure 9 is a greatly enlarged, fragmentary cross-sectional view of an electrical connector according to the present invention illustrating the insertion of a conductor into an insulation displacement slot with an impact tool;

Figure 10 is a plan view of the upper lead frame of the lead frame assembly illustrated in Figure 5;

Figure 11 is a cross-sectional side view of the upper lead frame of Figure 10;

Figure 12 is a plan view of the middle lead frame of the lead frame assembly illustrated in Figure 5;

Figure 13 is a cross-sectional side view of the middle lead frame of Figure 10;

Figure 14 is a plan view of the lower lead frame of the lead frame assembly illustrated in Figure 5; and

Figure 15 is a cross-sectional side view of the lower lead frame of Figure 10.

Referring now to Figures 1-3, one embodiment of an electrical connector 10 according to the present invention is illustrated. In particular, the illustrated embodiment of the electrical connector is a modular jack, such as a modular telephone jack, which is adapted to provide electrical connection between the

individual conductors of a multi-conductor cable, such as a telecommunications cable and a variety of telecommunications devices, such as telephones, computers and facsimile machines. More specifically, the multi-conductor cable is typically a distribution cable which extends from a telecommunications junction box, or a cross-connect, to an outlet. While a modular telephone jack is illustrated and described herein, the electrical connector of the present invention can be embodied in other types of connectors without departing from the spirit and scope of the present invention.

As illustrated in Figures 2 and 3, the electrical connector 10 generally includes a housing 12 defining an internal cavity 14 in which a plurality of elongate conductors 16 are at least partially positioned. Each of the conductors has a resilient contact portion 18 at a first end and an insulation displacement contact portion 20 at a second end, opposite the first end. As shown in further detail in Figure 1, each insulation displacement contact portion preferably includes a pair of opposed blade portions defining an insulation displacement slot 22 therebetween.

The housing 12 is typically comprised of a plastic material, such as polyester resin, to provide a relatively strong and durable structure which is also relatively inexpensive. However, the housing can be comprised of other materials without departing from the spirit and scope of the present invention.

As best illustrated in Figure 1, the housing 12 is generally comprised of multiple components which can be secured together to form the assembled housing.

In particular, the housing of this embodiment includes a housing body 24 defining the internal cavity 14 which opens through a front surface 26 of the housing. As illustrated, the size and shape of the internal cavity

and the opening through the front surface of the housing are preferably designed to received a standard telephone plug. The housing also preferably includes first and second supporting members 28 which are
5 inserted into the housing body and are adapted to support and laterally space the elongate conductors 16 as explained in detail below. Finally, the housing preferably includes a strain relief cap 30 which forms the rear surface 34 of the housing. As illustrated,
10 the strain relief cap defines a plurality of apertures 32 extending therethrough.

The plurality of elongate conductors 16 are generally positioned between the first and second supporting members 28 such that the respective first
15 ends of the elongate conductors extend from a first side 36 of the first and second supporting members and the respective second ends of the elongate conductors extend from a second side 38 of the first and second supporting members, opposite their respective first
20 sides, as shown in Figure 4. At least one of the supporting members preferably includes a plurality of ribs 40 extending inwardly between the opposed first and second supporting members. As illustrated in Figure 1, the first supporting member includes the
25 plurality of inwardly extending ribs, however, the second supporting member can include ribs without departing from the spirit and scope of the present invention. The inwardly extending ribs define a plurality of channels 42 in which the elongate
30 conductors are disposed. Thus, the ribs laterally space the elongate conductors and provide an insulating layer between the conductors to prevent electrical contact therebetween.

As shown in Figure 4, the first ends of the
35 elongate conductors 16 are generally folded about the first side 36 of the first supporting member 28 to form

respective resilient contact portions 18, such as the illustrated spring contacts, for example. As illustrated in Figure 1, the first supporting member can include a forwardly tapered portion 29 to
5 facilitate the folding of the elongate conductors thereabout.

In addition, the second ends of the plurality of elongate conductors are bent, according to a predetermined pattern, at the second side 38 of the
10 first and second supporting members. As shown in Figures 1 and 3, a number of the elongate conductors are bent so as to extend in a generally upward direction while the remainder of the conductors are bent so as to extend in a generally downward direction.

15 According to the illustrated embodiment, one half of the conductors are bent generally upward and one half of the conductors are bent generally downward. The opposed blade portions of the insulation displacement contact portions 20 of the plurality of elongate
20 conductors are also preferably bent so as to extend longitudinally rearward. As illustrated, the first and second supporting members each include an upstanding wall portion 44 which provides a surface to support the bent portions of the elongate conductors.

25 Once the elongate conductors 16 have been shaped or bent, the plurality of elongate conductors and the first and second supporting members 28 can be inserted into the housing body 24 such that the first ends of the plurality of elongate conductors extend, at
30 least partially, into the internal cavity 14 defined by the housing body. The first and second supporting members and the plurality of conductors sandwiched therebetween, are preferably interlocked with the housing body. For example, in the illustrated
35 embodiment, the first and second supporting members include tapered shoulders which deflect and lock behind

complementary tabs extending from the housing body. However, other means of interlocking the first and second supporting members in the housing body can be employed without departing from the spirit and scope of
5 the present invention.

Thereafter, the plurality of rearwardly extending insulation displacement contact portions 20 can be inserted into respective apertures 32 defined in the strain relief cap 30. The strain relief cap is
10 also preferably interlocked with the housing body 24 to form an integral housing 12. As described above, the opposed side surfaces of the strain relief cap can include respective tapered shoulders which deflect and lock behind a pair of complementary tabs extending from
15 the housing body.

Due to the folded configuration of the elongate conductors 16 and the size and shape of the housing 12, the electrical connector 10 of the present invention is relatively compact. Thus, the electrical
20 connector can be mounted within wall plates or other fixtures which provide only limited clearance for the connector.

The plurality of elongate conductors 16 of the electrical connector 10 of the present invention
25 are positioned in an adjacent, laterally spaced relationship. Typically, the plurality of elongate conductors also extend substantially parallel as shown in Figures 1 and 5. As known to those skilled in the art, adjacent conductors and, in particular, conductors
30 which extend in a substantially parallel relationship suffer from crosstalk between the adjacent conductors.

As best illustrated in Figures 5-8 which depict a lead frame assembly 46 including a plurality of elongate conductors 16, the plurality of elongate
35 conductors preferably include a pair of conductors positioned in an overlapping, vertically spaced

relationship to compensate for crosstalk between the conductors. Preferably, the first end 18 and, in particular, the resilient contact portion of each elongate conductor has a predetermined width. The
5 overlapping portions of the conductors are advantageously wider than the predetermined width of the end portions of the conductor to thereby define relatively wide compensating segments 48.

Preferably, the pair of elongate conductors
10 16 are positioned in the overlapping, vertically spaced relationship for a predetermined distance. In addition, only a predetermined portion of their respective compensating segments 48 are preferably overlapped in a vertically spaced relationship so as to
15 establish capacitive coupling therebetween. For example, the overlapping portions of the compensating segments are illustratively shown cross-hatched for clarity in Figure 8. In particular, the length of the compensating segments as well as the width of the
20 portions of the compensating segments which overlap in a vertically spaced relationship can be selected to optimize the capacitive coupling therebetween and, consequently, to compensate for crosstalk between the conductors. For example, increasing the width of the
25 portions of the compensating segments which overlap in a vertically spaced relationship or increasing the length of the compensating segments increase the capacitive coupling between the compensating segments and provide increased compensation for crosstalk
30 between the conductors.

As known to those skilled in the art, the innermost conductors of a plurality of laterally spaced elongate conductors 16 generally experience increased levels of crosstalk in comparison with the outermost
35 elongate conductors. Accordingly, the pair of conductors which include the compensating segments 48

positioned in an overlapping, vertically spaced relationship are preferably an inner pair of conductors. In one embodiment, first and second pairs of elongate conductors are positioned in respective
5 overlapping, vertically spaced relationships. As shown in Figures 5, 7 and 8, the first and second pairs of elongate conductors are preferably the laterally innermost conductors which, accordingly, experience increased levels of crosstalk and require additional
10 compensation.

As illustrated in Figures 5-8, the plurality of elongate connectors can also include first and second elongate conductors which extend in a substantially parallel, laterally spaced relationship
15 from their respective first ends to a predetermined crossover location 49. At the crossover location, the first and second conductors laterally cross without establishing electrical contact therebetween. Accordingly, by laterally crossing the first and second
20 conductors, additional compensation for crosstalk between the conductors is provided. In particular, the lateral crossing of the conductors is believed to reverse the polarity of the crosstalk between the conductors such that the cumulative effect of the
25 crosstalk is reduced, if not eliminated.

In one embodiment, each elongate conductor 16 laterally crosses another of the elongate conductors at a crossover location 49. In this embodiment, the electrical connector 10 preferably includes a plurality
30 of pairs of elongate conductors which extend in a substantially parallel, laterally spaced relationship from their respective first ends to predetermined crossover locations where one conductor of each conductor pair laterally crosses the other conductor of
35 the conductor pair without establishing electrical contact therebetween. Preferably, the crossover

locations of the plurality of pairs of elongate conductors are laterally aligned, such as in a side-by-side relationship.

The position of the crossover location 49 relative to the length of the elongate conductors 16 is preferably selected such that sufficient compensation is provided between the crossover location and the second ends of the respective conductors for crosstalk which occurred, for example, between the respective first ends of the elongate conductors and the crossover location. In one preferred embodiment, the distances 15 defined by each of the conductors between the crossover location and their respective first and second ends, 50 and 52 respectively, are equal.

As described above, the inwardly extending ribs 40 of the first supporting member 28 of the illustrated embodiment laterally spaces and aligns the elongate conductors 16 and prevents electrical contact between adjacent conductors. In addition, in one embodiment, the portions of the first and second conductors which laterally cross at the predetermined crossover location 49 are coated with an insulating coating. Thus, the conductors can be relatively close without establishing electrical contact therebetween. The insulating coating can be polyvinyl formal or polyamide/polyimide, for example. In addition, the compensating segments 48 of the pair of conductors which overlap in a vertically spaced relationship can also be coated with an insulating coating, such as polyvinyl formal or polyamide/polyimide. Therefore, the vertical spacing between the compensating segments can be relatively small without establishing electrical contact between the conductors. Alternatively, in the embodiments of the electrical connector 10 of the present invention in which the compensating segments and the portions of the first and second conductors

which laterally cross are not coated with an insulating coating, the conductors, including the compensating segments, are preferably spaced a sufficient distance to prevent voltage breakdown between the conductors.

5 As illustrated in Figure 9, the electrical connector 10, such as the modular telephone jack of the illustrated embodiment, is adapted to be mounted in a wall plate or face plate 54 which can thereafter be mounted in a wall or other supporting structure to
10 complete the insulation. Although not illustrated, a modular plug can be inserted into the opening 14 defined in the front surface 26 of the housing 12 of the electrical connector to establish electrical connection between a telecommunications device (not
15 shown) and the multi-conductor cable, via the electrical connector.

 As known to those skilled in the art, the modular plug generally includes a plurality of conductive elements arranged in a predetermined order
20 and adapted for electrical connection with predetermined conductors of the multi-conductor cable.

 Accordingly, the respective first ends of the plurality of elongate conductors 16 of the electrical connector 10 of the present invention are preferably
25 arranged in a first predetermined order such that each conductive element of the modular plug deflects and thereby electrically contacts the resilient contact portion 18 of a predetermined conductor.

 In addition, the second ends of the plurality
30 of elongate conductors 16 of the electrical connector 10 are preferably arranged in a second predetermined order. As known to those skilled in the art, the conductors of the multi-conductor cable, such as a telecommunications cable, are generally arranged in
35 pairs which are twisted to reduce crosstalk between the conductors. Therefore, the second predetermined order

of the respective second ends of the elongate conductors is preferably arranged such that each conductor of a conductor pair of the multi-conductor cable is inserted in an adjacent insulation displacement slot 22. Accordingly, the twisted conductor pairs of the multi-conductor cable can remain twisted to a location very near the insulation displacement contact portions 20 so as to further decrease crosstalk between the conductors of the multi-conductor cable. In addition, by terminating each conductor of a twisted conductor pair in an adjacent insulation displacement slot, a technician installing the electrical connector and inserting the conductors of the multi-conductor cable into the respective insulation displacement slots can readily insert the conductor therein. Further, both the conductors and the portions of the housing 12 surrounding the respective apertures 32 are preferably color-coded to further facilitate wiring of the electrical connector 10.

As illustrated in Figure 5, at least one of the plurality of elongate conductors 16 laterally crosses another of the plurality conductors at a location between the crossover location 49 and the second end of the at least one connector. The conductors laterally cross between the crossover location and their respective second ends so that the respective second ends of the plurality connectors are arranged in the second predetermined order.

As illustrated in Figures 5-7, the plurality of elongate conductors 16 are preferably fabricated from a plurality of lead frames 56 of a lead frame assembly 46. Each lead frame preferably includes at least one elongate conductor extending from a first end connected to a first side 58 of the lead frame to a second end connected to a second side of the lead frame

60, opposite the first side. In addition, the lead frame assembly preferably includes alignment means, such as a plurality of aligned apertures 62 defined by each lead frame, for aligning the plurality of lead frames. The lead frames are preferably aligned such that the conductors of the plurality of lead frames include at least one pair of conductors which laterally cross at the predetermined crossover location 49 and at least one pair of conductors which includes compensating segments 48 arranged in an overlapping, vertically spaced relationship as described hereinabove.

As illustrated in Figures 10-15, the lead frame assembly 46 of the illustrated embodiment includes three lead frames 56 which each include a plurality of elongate conductors 16. As shown in Figures 6 and 7, the three lead frames are stacked so as to include upper, middle and lower lead frames. The upper, middle and lower lead frames are illustrated in more detail in top plan views in Figures 10, 12 and 14, respectively, and in cross-sectional side views in Figures 11, 13 and 15, respectively. It will be apparent, however, that the lead frame assembly can include any number of lead frames without departing from the spirit and scope of the present invention.

According to one embodiment of the present invention, the elongate conductors 16 of the electrical connector 10 are comprised of a phosphorous bronze copper alloy material. More particularly, the plurality of lead frames 56, including the plurality of elongate conductors, can be stamped from a sheet of bronze material which is coated with a layer of phosphorous. The plurality of lead frames can also be coated with an insulating coating, such as polyvinyl formal or polyamide/polyimide, to further prevent electrical contact between the plurality of elongate

conductors. The lead frames can then be aligned, such as by aligning the apertures 62 defined by each lead frame, and the first and second supporting members 28 can be positioned on opposite sides of the plurality
5 lead frames. The frame portion of the plurality of lead frames can then be removed and the remaining elongate conductors folded about the first and second supporting members as described hereinabove and as illustrated in Figure 4.

10 As illustrated in Figures 1-4, the strain relief cap 30 of the housing 12 preferably includes a plurality of outwardly projected silos 64. The silos extend laterally rearwardly from the rear surface 34 of the housing and are positioned to project outwardly
15 from portions of the rear surface between the plurality of apertures 32 defined therein. Due to the rearward projection of the silos, the insulation displacement contact portion 20 of each of the plurality of conductors 16 which extend through a respective
20 aperture 32 defined in the rear surface of the housing extends between a pair of adjacent silos. Accordingly, a conductor of the multi-conductor cable can be inserted into the insulation displacement slot 22 by application of a forwardly directed force to the wire,
25 that is, a force directed generally in a direction from the rear surface of the housing toward the front surface of the housing as shown in Figure 9. Each silo can be color-coded to match the color-coding of the conductor of the multi-conductor cable further
30 simplifying installation and wiring of the electrical connector.

The requisite insertion force is typically provided by an impact tool 66, such as those manufactured and sold by AT&T and Krone which bear
35 Product Nos. Harris-Dracon D-814 and LSA-PLUS #6417 2 055-01, respectively. As known to those skilled in the

art, impact tools not only apply the force necessary to insert a conductor 16 into an insulation displacement slot 22 defined by an insulation displacement contact portion 22, but also simultaneously terminate the
5 inserted conductor. The silos 64 are preferably sized and shaped to receive either the impact tool manufactured by either AT&T or Krone. In addition, each silo preferably extends rearwardly beyond the insulation displacement contact portions to separate
10 and protect the insulation displacement contact portions. The portions of the silos which extends rearwardly beyond the insulation displacement contact portions provide a surface against which the impact tool can seat to thereby further protect the insulation
15 displacement contact portions.

By inserting the conductors 16 into the respective insulation displacement slots 22 with a forwardly directed force, the conductors 13 can be inserted after the electrical connector 10 has been
20 mounted in a wall plate 54 as shown in Figure 9. Thus, the installation of the electrical connector is simplified since the electrical connector need no longer be handled after the conductors have been inserted into the insulation displacement slots. In
25 addition, in many instances it is desirable to re-wire or change the wiring pattern of a particular outlet so as to provide different or additional telecommunications features. According to the present invention, the wall plate can be removed and, with the
30 electrical connector installed therein, withdrawn from the wall. Thereafter, the connection of the individual conductors to the insulation displacement slots of the electrical connector can be revised as desired without removing the electrical connector from the wall plate.
35 Accordingly, wiring and re-wiring of the electrical

connector is simplified by the method and apparatus of the present invention.

As illustrated in Figures 2 and 3, each silo 64 preferably includes at least one rib 68 projecting laterally outwardly from each side of the silo. The ribs serve to guide the conductors 16 into the insulation displacement slots 22 defined by the opposed blade portions of the insulation displacement contact portions 20. In one embodiment, first and second ribs project laterally outward from portions of the side surfaces of the silo which are separated by the insulation displacement contact portions. For example, in the illustrated embodiment, a first rib projects laterally outward from a portion of the side surface of the silo which is above the insulation displacement contact portion while a second rib projects laterally outward from a portion of the side surface of the silo which is below the insulation displacement contact portion. The outwardly projecting ribs can also be sized to frictionally engage the conductor. Accordingly, the friction engagement of the conductor restricts movement in the connector and reduces, if not eliminates, strain on the conductor, thereby improving the performance and service lifetime of the conductors.

In the drawings and specifications, there has been set forth a preferred embodiment of the invention, and although specific terms are employed, they are used in generic and descriptive sense only and not for purpose of limitation.



CLAIMS

1. An electrical connector comprising a housing (24,30) and a plurality of elongate conductors (16) positioned at least partially within a cavity (14) defined within said housing, each of said conductors having a contact portion (18) at a first end and a conductor terminating portion (22) at a second end, said plurality of conductors including first and second elongate conductors which extend in a substantially parallel, laterally spaced relationship, characterized in that:

at least a portion of a pair of said conductors are positioned in an overlapping, vertically spaced relationship at a predetermined location (48) spaced apart from the crossover location to compensate for crosstalk between said plurality of conductors.

2. An electrical connector according to Claim 1 wherein the portions of said plurality of conductors which extend between their respective first ends and the crossover location have a predetermined width, and wherein the portions of the pair of conductors which are positioned in an overlapping, vertically spaced relationship are wider than the predetermined width of said plurality of conductors to thereby define respective compensating segments.

3. An electrical connector according to Claim 2 wherein only a predetermined portion of their respective compensating segments of the pair of conductors overlap for a predetermined distance in a vertically spaced relationship so as to establish capacitive coupling therebetween.

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4. An electrical connector according to any preceding Claim, wherein said first and second conductors have a predetermined crossover position (49) where the first and second conductors laterally cross without establishing electrical contact therebetween, and the distances defined by each of said conductors between the crossover location and their respective first and second ends, respectively, are equal.
5. An electrical connector according to Claim 4 wherein said plurality of elongate conductors extend in a substantially parallel, laterally spaced relationship from their respective first ends to their respective crossover locations where each conductor crosses an adjacent conductor without establishing electrical contact therebetween.
6. An electrical connector according to Claim 5 wherein first and second pairs of said conductors are positioned in respective overlapping, vertically spaced relationships at predetermined locations between the crossover location and the second ends of their respective conductors, and wherein said first and second pairs of said conductors are the laterally innermost conductors.
7. An electrical connector according to any of Claims 4-6 wherein portions of said first and second conductors are coated with an insulating coating at the predetermined crossover location.
8. An electrical connector according to any preceding Claim wherein the portions of the pair of conductors positioned in an overlapping, vertically spaced relationship are coated with an insulating



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coating to thereby minimize the vertical spacing therebetween.

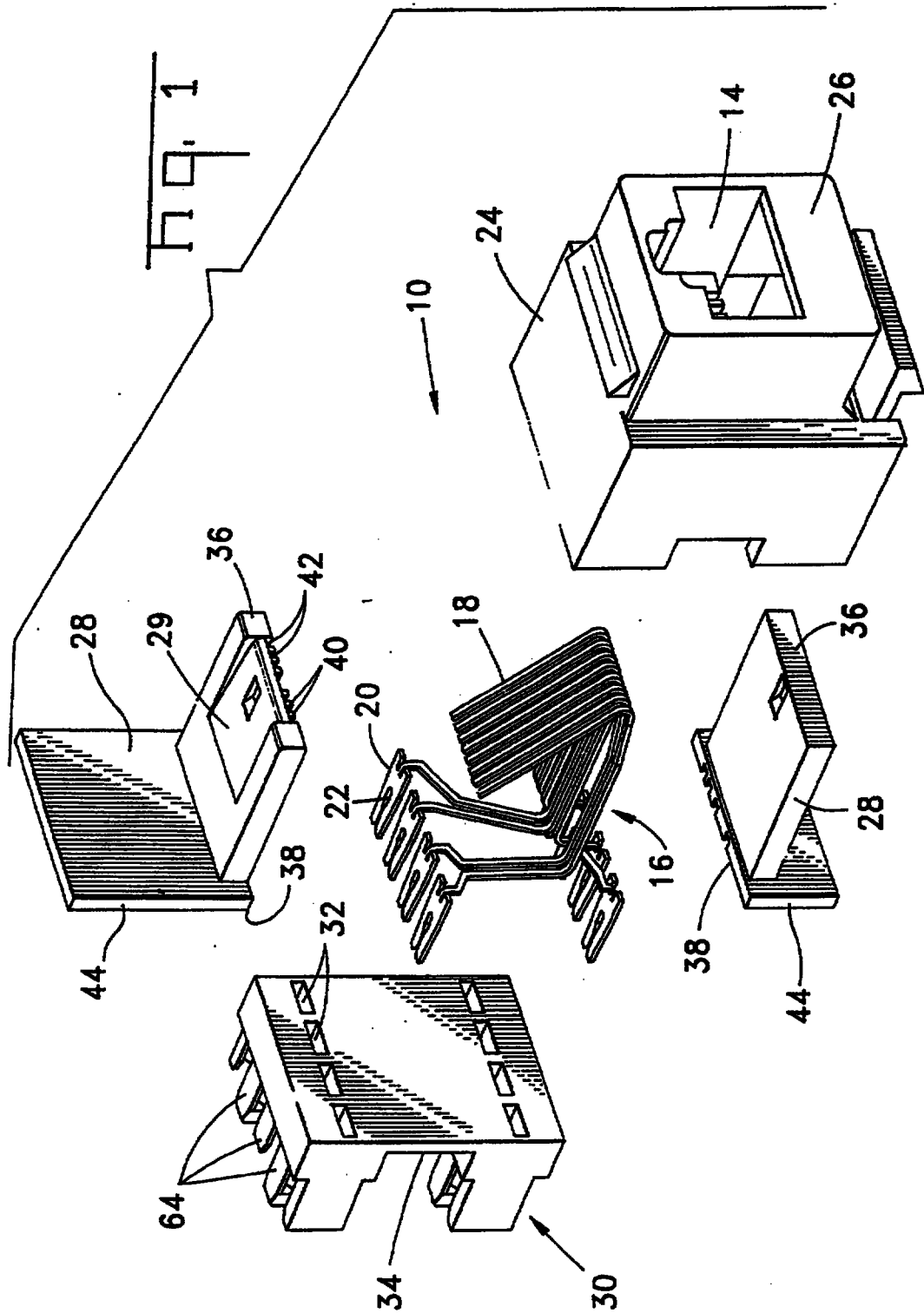
9. An electrical connector according to any
5 of Claims 4-8 wherein the respective first ends of said plurality of conductors are arranged in a first predetermined order, and wherein at least one of said plurality of conductors laterally crosses another of
10 said plurality of conductors at a location between the crossover location and the second end of said at least one conductor such that the respective second ends of said plurality of conductors are arranged in a second predetermined order.

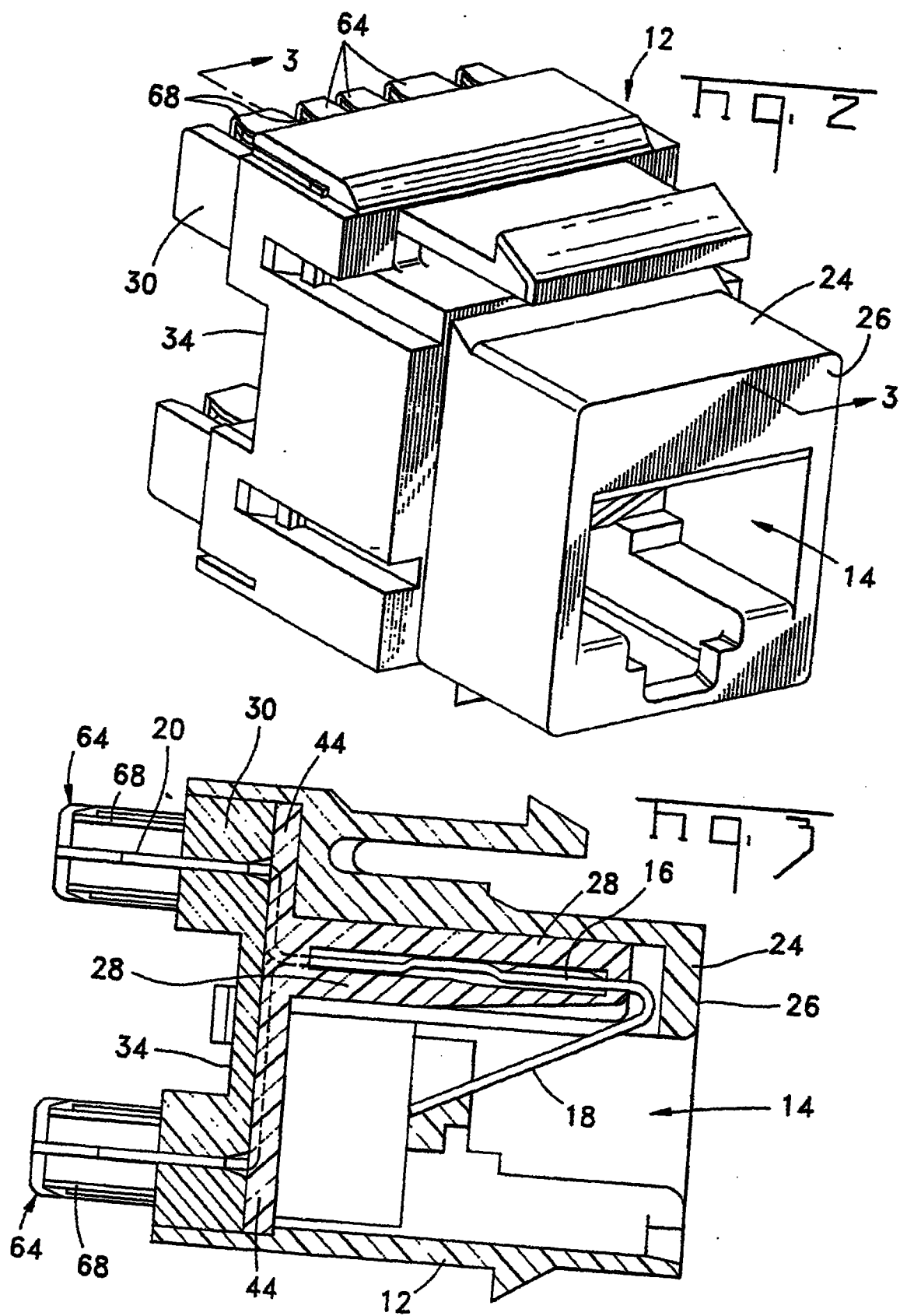
15 10. An electrical connector according to any preceding Claim wherein said housing further comprises a plurality of outwardly projecting silos (64) extending rearwardly from the rear surface (34) wherein
20 said plurality of silos are positioned to project outwardly from portions of the rear surface between the plurality of apertures (32) defined therein, and wherein said insulation displacement contact portion (22) of each of said plurality of conductors, which
25 extends through a respective aperture defined in the rear surface of said housing and between a pair of adjacent silos, includes a pair of opposed blade portions defining an insulation displacement slot therebetween such that a wire can be inserted into the
30 insulation displacement slot by application of a forwardly directed force to the wire.

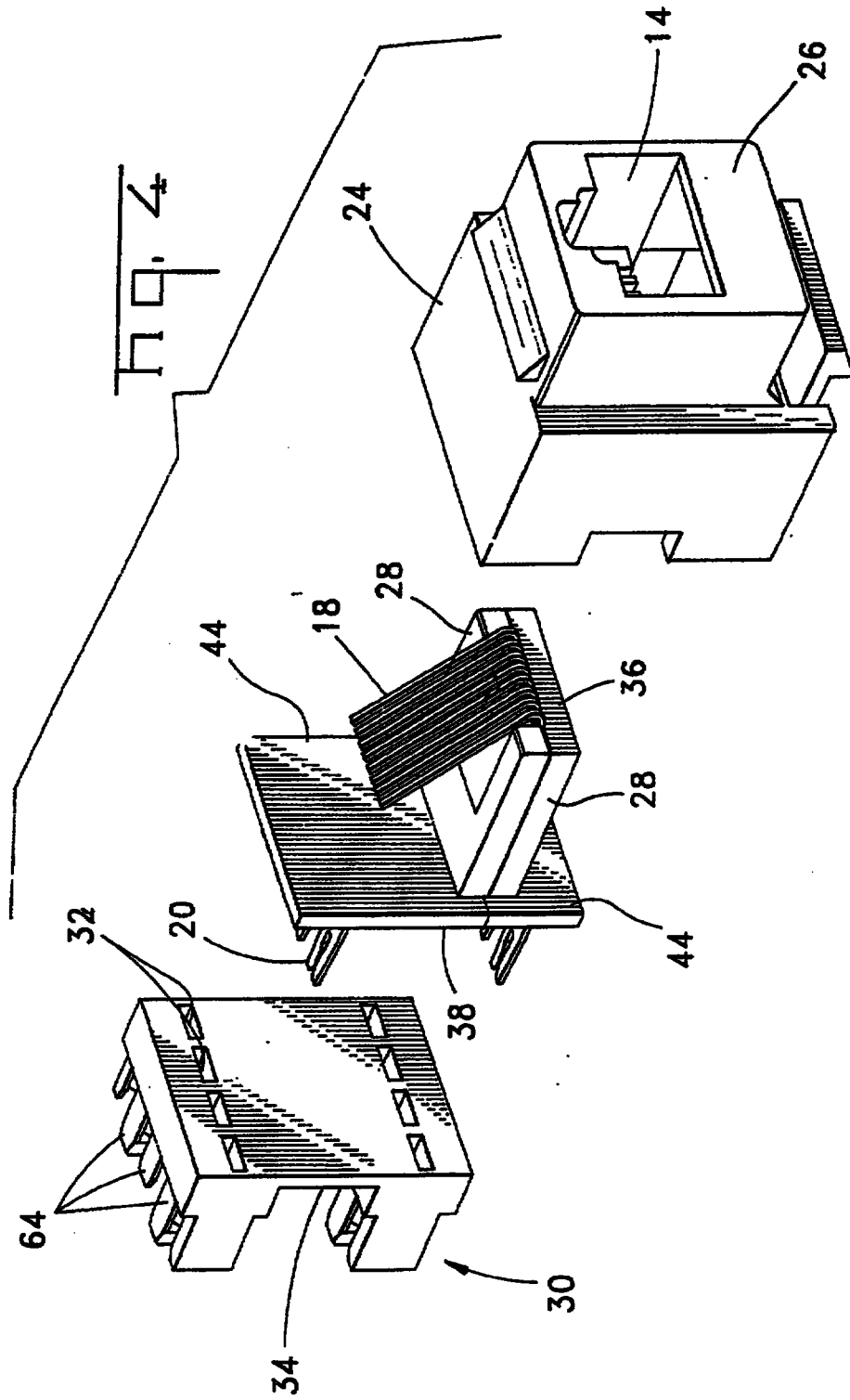
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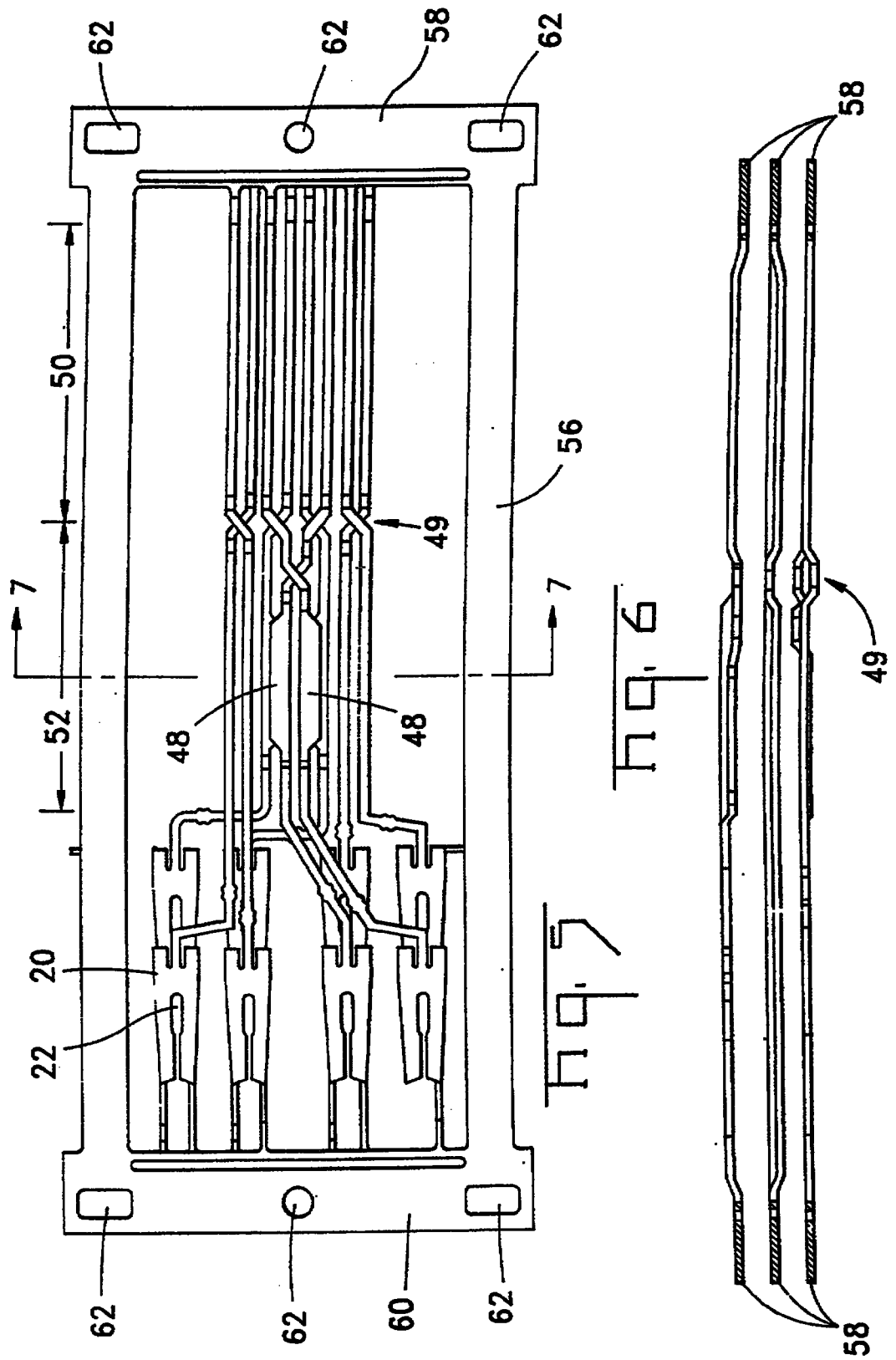
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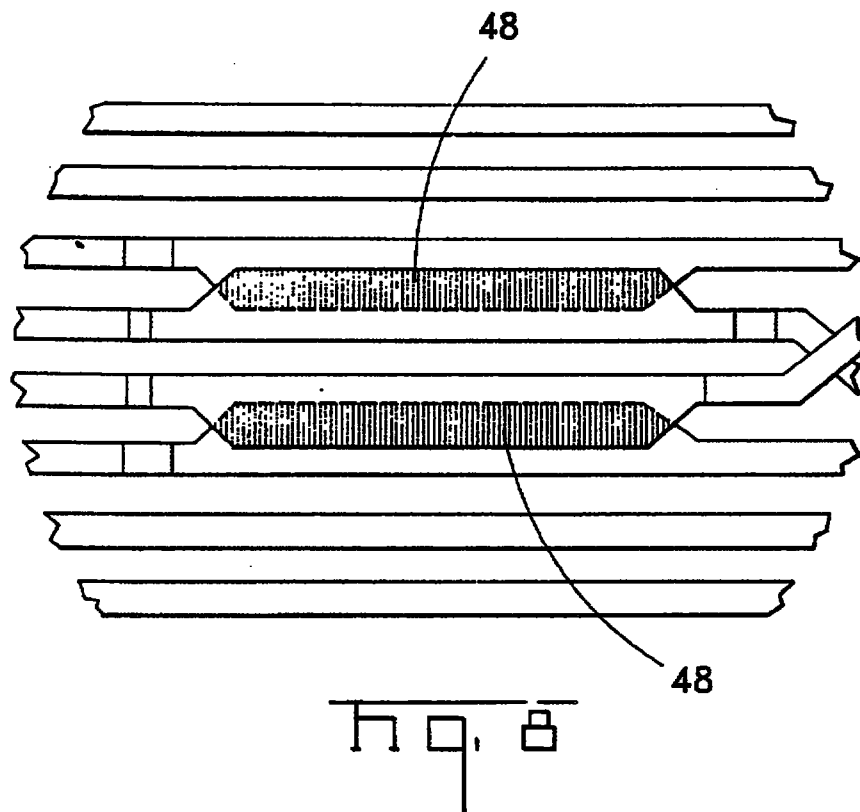
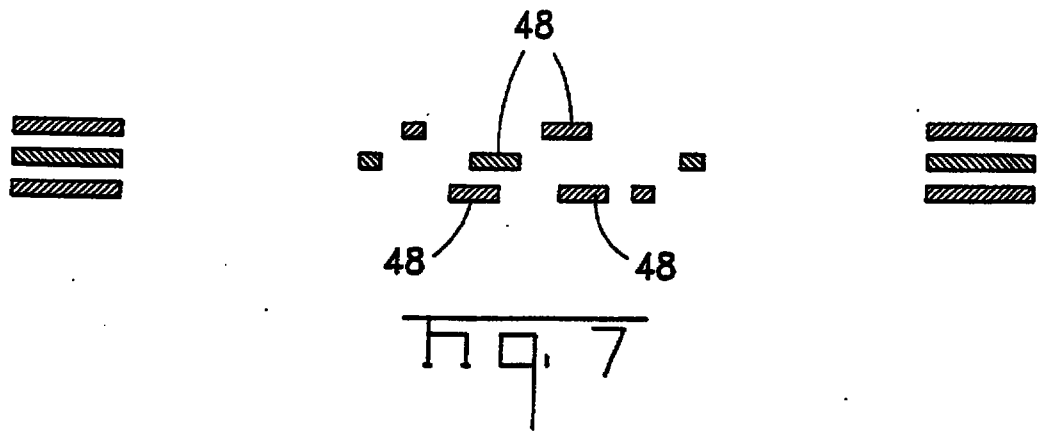












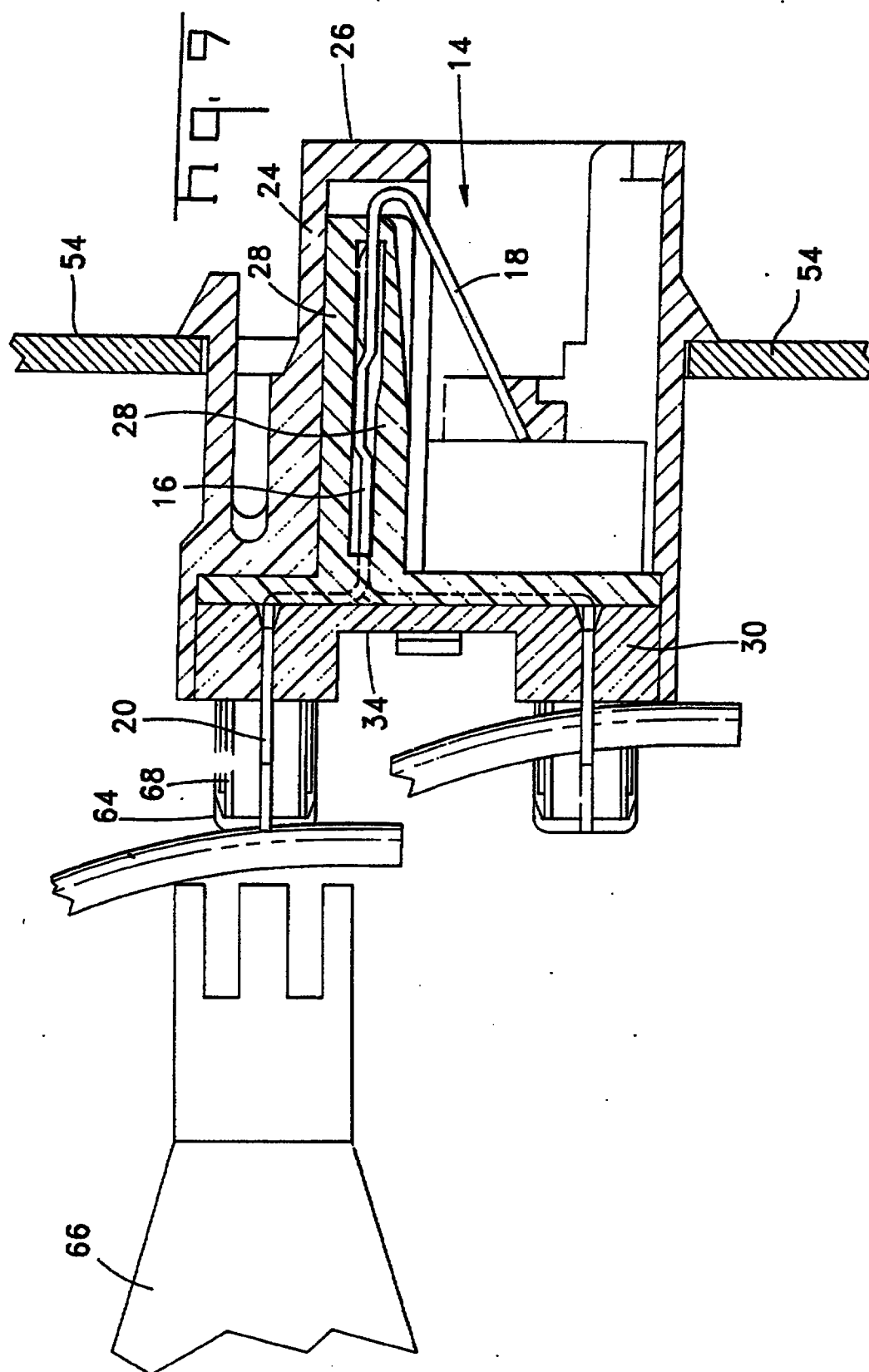


Fig. 10

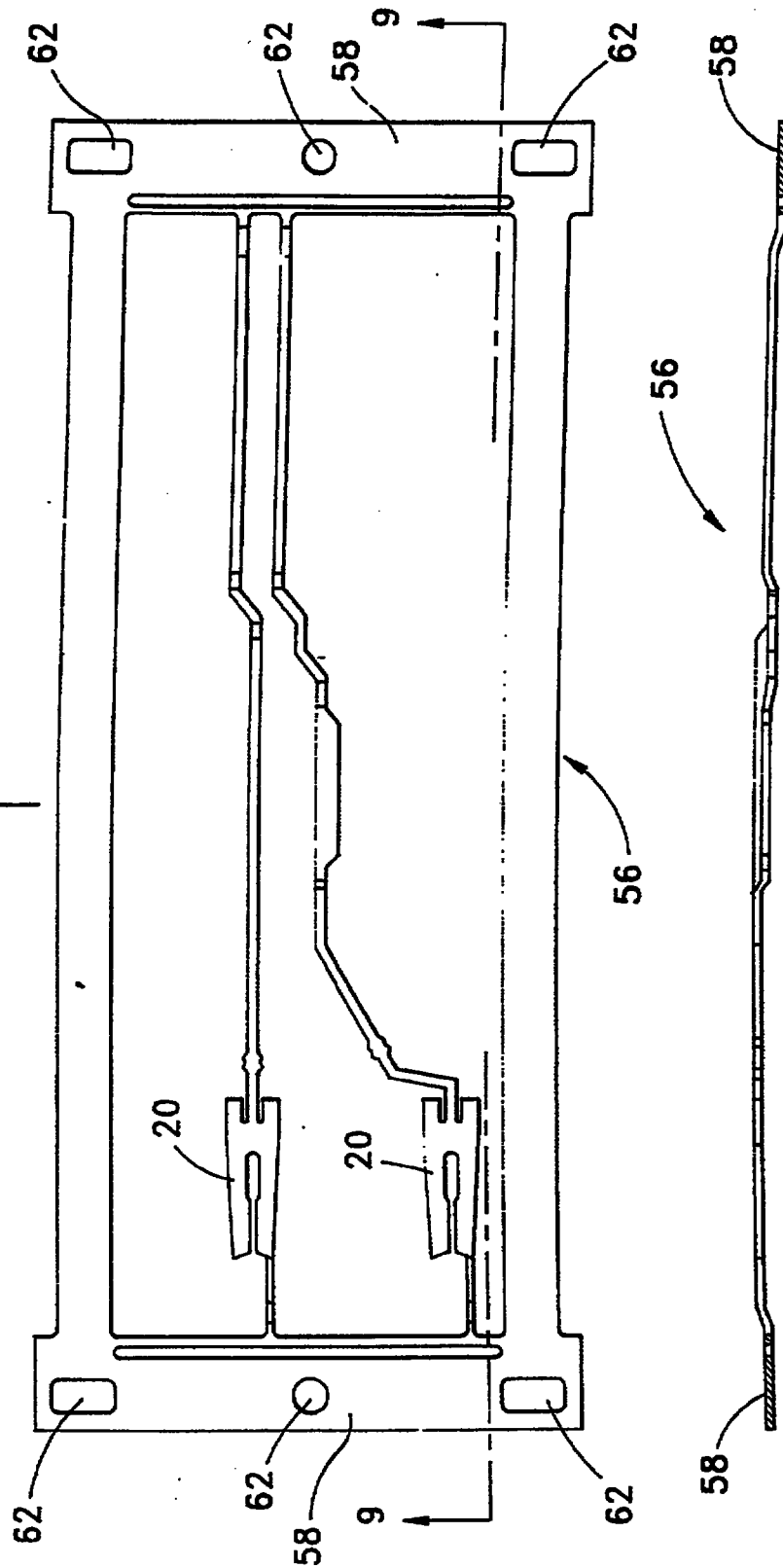
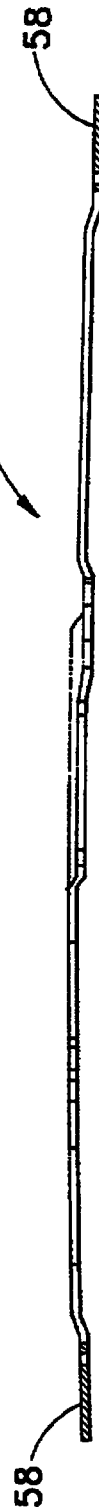


Fig. 11



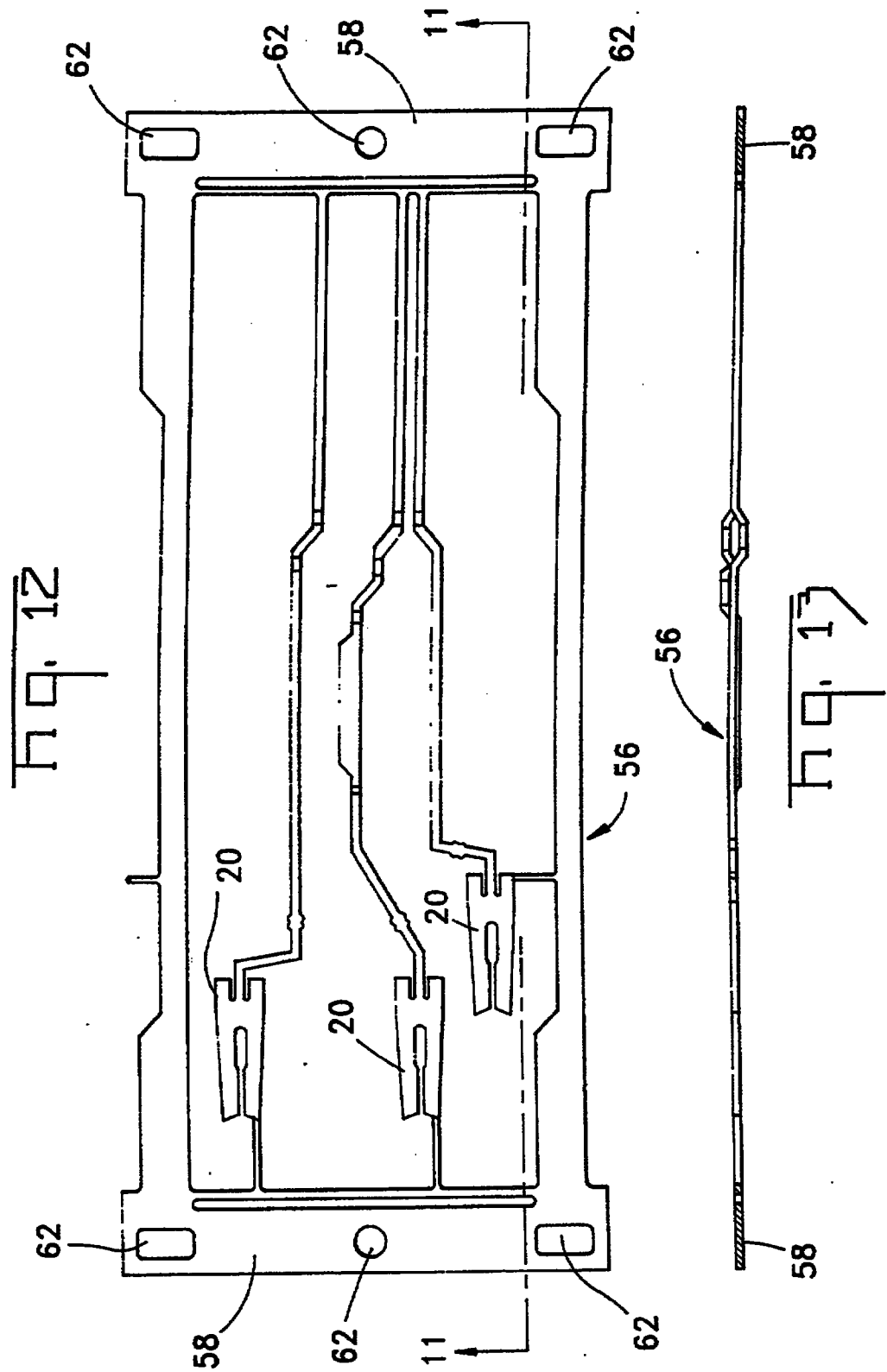


Fig. 12

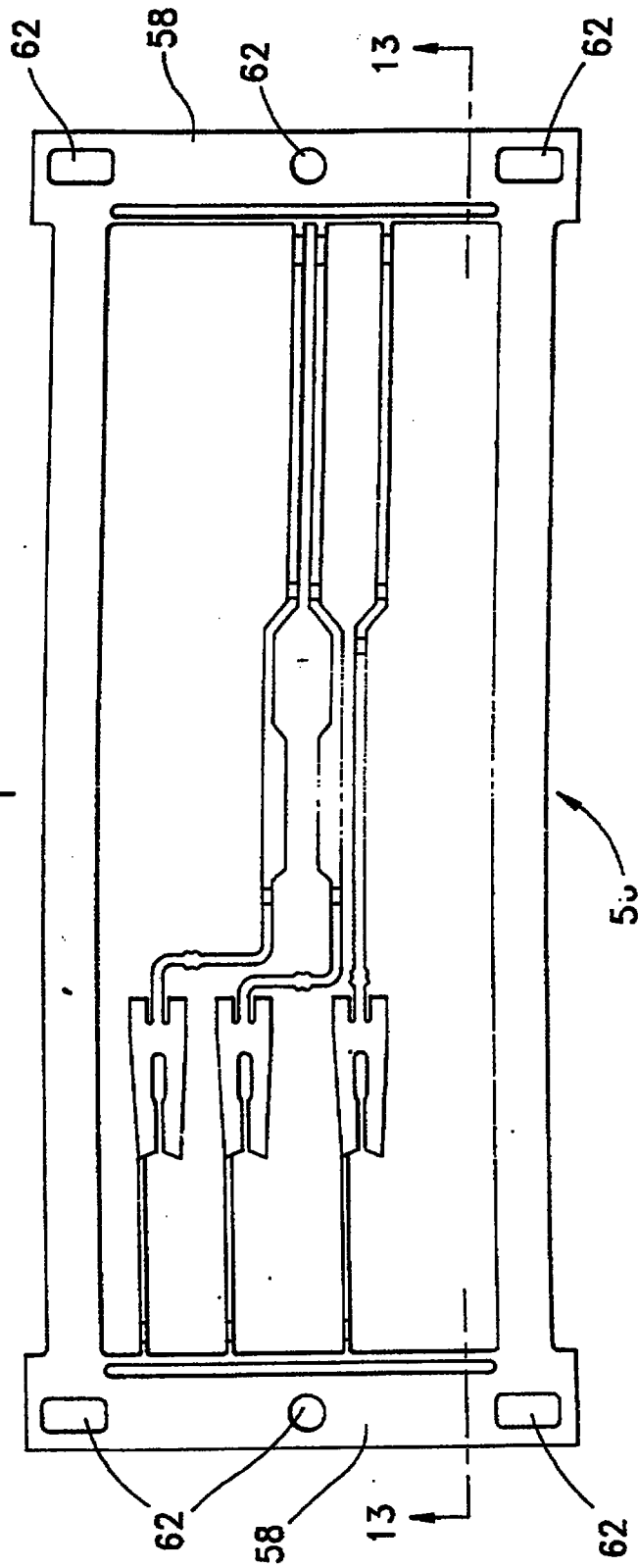


Fig. 13



U.S. Patent No. 5,186,647 which includes a number of conductors mounted on a dielectric surface and extending in a generally parallel relationship for at least a portion of their length. At least one of
5 the elongate conductors crosses the path of another conductor without making electrical contact therebetween to reduce the crosstalk between the conductors.

Another electrical connector which has been
10 developed to reduce crosstalk is disclosed in International Publication Number WO 94/21007. This connector also has a plurality of generally parallel conductors including at least one conductor which crosses the path of another conductor without making
15 electrical contact therebetween. Further, in this connector some of the conductors are laterally spaced-apart and some of the conductors are vertically spaced-apart such that one conductor is located vertically above another conductor.

20 As technology advances communications systems are being forced to operate at higher frequencies which lead to increases in crosstalk. Although connectors which have their conductors crossing paths and located one above the other are effective at reducing
25 crosstalk, the higher operating frequencies necessitate still greater reductions in crosstalk in order to meet performance standards. The present invention provides a connector having a novel arrangement of conductors in order to achieve a further reduction in crosstalk.

30 The problem to be solved by the present invention is to provide an electrical connector which compensates for crosstalk between a number of conductor pairs.

It would be most advantageous if this problem
35 could be solved by a connector which is easily manufactured, assembled, cost effective, and easily

used; including the characteristic that the connector can be efficiently wired and rewired.

This problem has been solved by an electrical connector comprising a housing and a plurality of
5 elongate conductors positioned at least partially within a cavity defined within said housing, each of said conductors having a contact portion at a first end and a conductor terminating portion at a second end, each of said conductors having a respective
10 substantially constant width, said plurality of elongate conductors including first and second conductors which extend in a substantially parallel relationship from their respective first ends to a predetermined crossover location where the first and
15 second conductors laterally cross without establishing electrical contact therebetween, characterized in that:
said first and second conductors are laterally spaced-apart, each of said first and second conductors has a respective compensating segment which
20 is wider than its respective said substantially constant width, and said compensating segments are positioned in an overlapping, vertically spaced relationship at a predetermined location spaced-apart from the crossover location to compensate for crosstalk
25 between said plurality of conductors.

The invention will now be described by way of example with reference to the drawings wherein:

Figure 1 is a greatly enlarged exploded perspective view of an electrical connector according to the present invention;

Figure 2 is a greatly enlarged perspective view of an electrical connector of the present invention illustrating the assembled housing;

Figure 3 is a greatly enlarged cross-sectional view of an electrical connector according to the present invention illustrating an elongate conductor and the rearwardly extending silos taken along line 3-3 of Figure 2;

Figure 4 is a greatly enlarged exploded view of an electrical connector according to the present invention illustrating the relationship of the first and second supporting members and the elongate conductors sandwiched therebetween;

Figure 5 is a top plan view of a lead frame assembly according to the present invention illustrating a plurality of aligned lead frames;



CLAIMS

1. An electrical connector comprising a housing (24,30) and a plurality of elongate conductors (16) positioned at least partially within a cavity (14) defined within said housing, each of said conductors having a contact portion (18) at a first end and a conductor terminating portion (20) at a second end, each of said conductors having a respective substantially constant width, said plurality of elongate conductors including first and second conductors which extend in a substantially parallel relationship from their respective first ends to a predetermined crossover location (49) where the first and second conductors laterally cross without establishing electrical contact therebetween, characterized in that:

said first and second conductors are laterally spaced-apart, each of said first and second conductors has a respective compensating segment (48) which is wider than its respective said substantially constant width, and said compensating segments are positioned in an overlapping, vertically spaced relationship at a predetermined location spaced-apart from the crossover location to compensate for crosstalk between said plurality of conductors.

2. An electrical connector according to Claim 1 wherein only predetermined portions of the respective compensating segments are positioned in the overlapping, vertically spaced relationship.

3. An electrical connector according to any preceding Claim, wherein distances defined by said first and second conductors between the crossover location and their respective first and second ends, respectively, are equal.



4. An electrical connector according to any preceding Claim, wherein said plurality of elongate conductors extend in a substantially parallel, laterally spaced relationship from their respective first ends to respective crossover locations where each conductor crosses an adjacent conductor without establishing electrical contact therebetween.

5. An electrical connector according to Claim 4 wherein first and second pairs of said conductors have respective compensating segments that are positioned in respective overlapping, vertically spaced relationships at predetermined locations between the crossover location and the second ends of their respective conductors, and wherein said first and second pairs of said conductors are the laterally innermost conductors.

6. An electrical connector according to any preceding Claim wherein portions of said first and second conductors are coated with an insulating coating at the predetermined crossover location.

7. An electrical connector according to any preceding Claim wherein the compensating segments of the first and second conductors are coated with an insulating coating to thereby minimize the vertical spacing therebetween.

8. An electrical connector according to any of Claims 4-7 wherein the respective first ends of said plurality of conductors are arranged in a first predetermined order, and wherein at least one of said plurality of conductors laterally crosses another of said plurality of conductors at a location between the crossover location and the second end of said at least



one conductor such that the respective second ends of said plurality of conductors are arranged in a second predetermined order.

- 5 9. An electrical connector according to any preceding Claim wherein said housing further comprises a plurality of outwardly projecting silos (64) extending rearwardly from the rear surface (34) wherein said plurality of silos are positioned to project
- 10 outwardly from portions of the rear surface between the plurality of apertures (32) defined therein, and wherein said conductor terminating portion (20) of each of said plurality of conductors, which extends through
- 15 a respective aperture defined in the rear surface of said housing and between a pair of adjacent silos, includes a pair of opposed blade portions defining an insulation displacement slot (22) therebetween such that a wire can be inserted into the insulation
- 20 displacement slot by application of a forwardly directed force to the wire.

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(71) Applicant: THE WHITAKER CORPORATION [US/US]; Suite 450, 4550 New Linden Hill Road, Wilmington, DE 19808 (US).			
(72) Inventors: FOSTER, George, H.; 600 Wellington Road, Winston-Salem, NC 27106 (US); METZGER, Donald, Lynn; 7832 Dewey Drive, Harrisburg, PA 17112 (US).			
(74) Agents: KAPALKA, Robert, J. et al.; The Whitaker Corporation, Suite 450, 4550 New Linden Hill Road, Wilmington, DE 19808 (US).			

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(54) Title: AN ELECTRICAL CONNECTOR AND AN ASSOCIATED METHOD FOR COMPENSATING FOR CROSSTALK BETWEEN A PLURALITY OF CONDUCTORS

(57) Abstract

An electrical connector which provides compensation for crosstalk includes a number of conductors positioned at least partially within an internal cavity defined by a housing. The elongate conductors are generally substantially parallel and laterally spaced and include a resilient contact portion at a first end and an insulation displacement contact portion at a second end. The elongate conductors include a pair of conductors, at least a portion of which are positioned in an overlapping, vertically spaced relationship. The portions of the pair of conductors which overlap are generally wider than the substantially parallel, laterally spaced portions of the conductors so as to thereby define respective compensating segments. The length of the compensating segments as well as the width of the portion of the compensating segments which overlap can be selected to establish capacitive coupling between the compensating segments so as to thereby compensate for crosstalk between the conductors. The elongate conductors can also include first and second conductors which extend in a substantially parallel, laterally spaced relationship from the respective first and to a predetermined crossover location. At the crossover location, the first and second conductors laterally cross without establishing electrical contact therebetween.

