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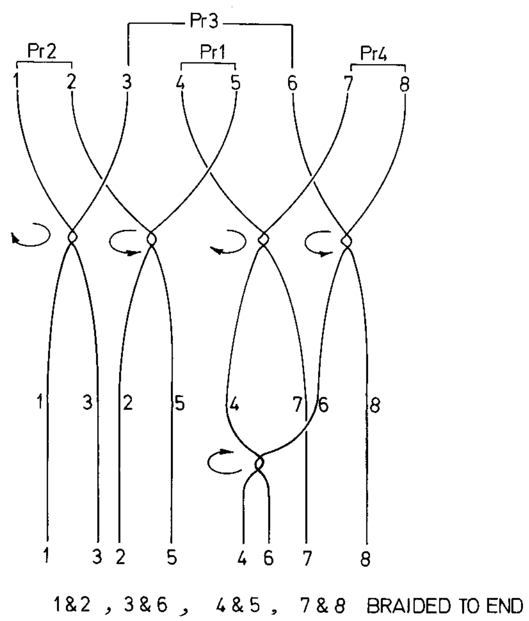
(54) **Electrical connectors.**

(57) Cross-talk in RJ 45 type connectors can be reduced by twisting individual wires of a conductor pair with wires of another conductor pair. Alternate pairs may be twisted clockwise and counter clockwise and at least one further twisted pair may be formed from a wire of each of two twisted pairs. The wires may then be braided in their original conductor pair configurations.

Fig.5.



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(3.10/3.09/3.3.4)

This invention relates to electrical connectors and in particular to the reduction of cross-talk between wires in telecommunications connectors. The term telecommunications connector used throughout includes connectors for both voice and data applications.

High speed data transmission is prone to interference problems which must be controlled. One of the most important forms of interference is cross-talk which may be defined as the voltage generated in one wire due to interference from a signal passing in an adjacent wire. The induced signal will have some inductive and capacitive components and will, therefore, vary with frequency. Cross-talk is a particular problem at higher frequencies and an especially difficult problem to control in data transmission lines as the induced cross-talk signal is a true data signal and is recognised, accepted and processed as such by the associated data processing equipment.

The Standard Connector used in Data Communications Interfaces is the RJ 45 connector. The specification for this connector is defined in International Standard IEC 603-7 of the International Electrotechnical Commission. The RJ 45 connector, available from AT & T corporation of Warren, New Jersey, USA, is a miniature connector having eight parallel contacts formed from spring wire.

It is well known that cross-talk may be reduced in communications cabling systems by twisting pairs of conductors used for a single circuit. As the current flows 'out' through one conductor and 'back' through the other, the nett interference effect of these two current flows is destructive as they are mutually cancelling; the electromagnetic and electrostatic fields induced by the outward flow will exactly cancel those induced by the return flow.

The nature of the RJ 45 interface and the standardised connection practice involved results in a significant portion of the signal transmission path between adjacent conductor circuits being parallel, untwisted and transposed between pairs, resulting in a considerable degradation in the cross-talk performance of the connector. This problem may be appreciated from consideration of Figure 1 which shows the 258A or EIA T560D sequence standard connection arrangement.

The cross-talk between pairs 1 and 3 will be higher than that between other pairs as the contact wires for pair 1 are arranged between the contact wires for pair 3.

The invention aims to reduce the effect of cross-talk between communications contacts.

The invention in its various aspects resides in various arrangements which reduce the problem of cross-talk in the situations discussed.

More specifically the invention is defined by claim 1 to which reference should be made.

Embodiments of the invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

Figure 1, referred to previously, shows the arrangement of contacts in an RJ 45 connector according to the EIA T560D sequence;

Figure 2, illustrates the conventional twisted pair configuration for the contact arrangement of Figure 1;

Figure 3, illustrates a twisted pair arrangement according to a first embodiment of the invention.

Figure 4, illustrates a twist arrangement according to a second embodiment of the invention;

Figure 5, illustrates a twist arrangement according to a third embodiment of the invention; and

Figure 6, illustrates a portion of a modular jack and wire assembly showing how the invention is incorporated in a modular jack.

Referring again to Figure 1, cross-talk arises between pairs 1 and 3 as a long section of wire for each conductor of each pair is laid in the connector in close proximity. A typical length is about 25 mm. Wire 3 induces cross-talk in wire 4 and the opposite sense of flow in wire 6 induces cross-talk in wire 5 in the opposite sense to that induced in wire 4.

As the current flows in wires 4 and 5 which make up pair 1 are of opposite sense, the two induced voltages mutually reinforce each other doubling the cross-talk.

The various embodiments of the invention reduce the cross-talk between pairs 1 and 3 dramatically by deliberately inducing cross-talk but of opposite sense such that the effects cancel out and cross-talk is eliminated or reduced. Thus, in Figure 1 wire No. 3 of pair 3 is arranged to interfere with wire 5 of pair 1 and wire 6 to interfere with wire 4.

Solutions to the problem of cross-talk must take into account the effects of parallel conductor paths in both the plug and the receptacle.

Figure 2 shows the normal twist of the wire pairs illustrated in Figure 1 according to the prior art. Thus, the wires of each pair are twisted one with the other. The first embodiment of the invention, shown in Figure 3 departs from this by twisting wire 3 from pair 3 with wire 5 from pair 1, and wire 6 from pair 3 with wire 4 from pair 1. This arrangement is adopted for a short length which can be determined experimentally or mathematically to cancel the cross-talk in the receptacle.

Instead of twisting the wires in the manner outlined above, they may be simply crossed over and laid parallel in a similar manner to the way in which they are situated in the receptacle.

As an alternative to the twist arrangement shown, the wires may be connected to the rear insulation displacement connector at a fixed wiring interface such that they are transposed relative to their position in the receptacle. Thus, in Figure 1, wire 3 is transposed to be adjacent wire 5 and wire 4 is adjacent to wire 6.

Figure 4 shows a second embodiment of the invention, again, the eight parallel wires are numbered 1 through 8 and their standard wiring pairs are indicated above. Thus, wires 4 and 5 form pair 1 line 4 being the 'out' line and wire 5 the 'return'. Wires 1 and 2 form pair 2, wires 3 and 6 pair 3 and wires 7 and 8 pair 4. This configuration is adopted by convention although the fourth pair is sometimes omitted if not needed.

As discussed earlier cross-talk is greatest between the wires of the first and third pairs. The solution to this problem is illustrated in the figure as a series of twists between pairs of wires in clockwise and counter-clockwise directions. Table 1 below shows the wires in each pair, the chamber of twists per unit length and their sense.

TABLE 1

JACK WIRES (RJ45)	TWISTS PER UNIT LENGTH	SENSE
1 + 3	4	CW (= clockwise)
6 + 8	2	CCW (= counter clockwise)
4 + 7	3	CW
2 + 5	2	CCW
4 + 6	2	CW
4 + 5	3	CCW
1 + 2	2	CCW
3 + 6	2	CW
7 + 8	2	CW

It will be appreciated from table 1 and figure 4 that each wire is twisted with at least two other wires, and three in the case of 4. The net effect is to present the wires for termination at the IDC in the correct pairs with wires of each pair being adjacent. It will be appreciated that the position of the wires of pair 1 at the IDC have been reversed, thus wire 5 is on the left of wire 4.

In figure 4, wires 1 and 3 are twisted four times per unit length (P.U.L.) in a clockwise direction. Wires 6 and 8 are twisted twice (P.U.L.) in a counter-clockwise direction, wires 4 and 7 three times P.U.L. clockwise and wires 2 and 5 twice P.U.L. counter-clockwise. The relative positions of the wires is shown at A in the figure.

Wire 4 is then twisted twice P.U.L. with wire 6 in a clockwise direction and then three times with wire 5 counter-clockwise. Wires 1 and 2 are twisted twice counter-clockwise, wires 3 and 6 twice clockwise and wires 7 and 8 also twice clockwise. The result is the wire configuration at the IDC and is shown at B in the figure.

Figure 5 shows an alternative twist configuration which is set out in table 2 below. Although not shown in the drawings, the wires of each pair, after twisting according to table 2 below are twisted together continuously to the edge of the connector. Thus, wire 1 is first twisted two twists clockwise with wire 3 whilst wire 2 is twisted with wire 5 two twists counter clockwise. Wires 1 and 2 are then braided in their normal configuration. It should be noted that in the table 2 configuration the first recited wire is twisted over the second wire. Thus, wire 1 is twisted over wire 3.

TABLE 2

JACK WIRES	NO. OF TWISTS	SENSE
1 + 3	2	CW
5 + 2	2	CCW
4 + 7	2	CW
6 + 8	2	CCW
4 + 6	2	CW

It will be noted that the number of twists in figure 5 is the same for each twist pair in contrast to the embodiment of figure 4. The twist rate is the figure 5 embodiments should be approximately 4-5 twists per inch and the twist length 9 to 12 mm measured from the jack to the V of the wires in each of the first, or previous twist pairs. This is best appreciated from figure 6 which shows a WE8W carrier 10 which carries eight contact wires A - H. The insulated wires 1 - 8 are each attached to a respective contact wire A - H and the twists occur in the region proximate the end 12 of the carrier 10 into which the insulated wires are inserted. Although not shown the carrier and wires are mounted in a body to form a modular jack or connector.

The net effect of the clockwise and counter-clockwise twisting is to reduce cross-talk greatly. It will be appreciated that as well as twisting each wire with its pair member, each wire is twisted with at least one wire from a different pair. Other configurations which achieve the result may be determined by those skilled in the art.

Claims

1. A telecommunications connector comprising a wire carrier having a plurality of contact wires and a plurality of insulated wires each connected to a respective contact wire and forming at least three conductor pairs, wherein an insulated wire of a conductor pair is twisted or crossed with an insulated wire of another conductor pair to form a twisted or crossed wire pair.

2. A telecommunications connector according to claim 1, wherein an insulated wire of each conductor pair is twisted with an insulated wire of another conductor pair to form a least three twisted wire pairs.

3. A telecommunications connector according to claim 2, wherein each twisted pair comprises two wire twists.

4. A telecommunications connector according to claim 2 or 3, wherein the twisted pairs are twisted alternatively in a clockwise and counter clockwise direction.

5. A telecommunications connector according to claim 2, 3 or 4, wherein an insulated wire of at least one twisted pair is further twisted with an insulated wire of another twisted pair.

6. A telecommunications connector according to any of claims 1 to 5, comprising eight insulated wires divided into four conductor pairs, wherein a first wire of the first conductor pair is twisted in a counter clockwise sense with a first wire of the second pair, to form a first twisted pair, a second wire of the first pair is twisted with a first wire of the fourth pair in a clockwise sense to form a second twisted pair, a second wire of the second conductor pair is twisted with a first wire of the third conductor pair in a clockwise sense to form a third twisted pair, and the second wire of the fourth pair is twisted in a counter clockwise sense with the second wire of the fourth pair to form a further twisted pair.

7. A telecommunications connector according to claim 6, wherein a first wire of the fourth twisted pair is twisted with a first wire of the second twisted pair to form a fourth twisted pair.

8. A telecommunications connector according to claim 6 or 7, wherein each wire of each twisted pair is braided with the wire with which it formed a conductor pair.

9. A telecommunications connector according to claim 6, 7 or 8, wherein the fourth and fifth insulated wires for the first conductor pair, the first and second insulated wires form the second conductor pair, the third and sixth insulated wires form the third conductor pair and the seventh and eighth wires form the fourth conductor pair, and wherein the fifth and second insulated wires form the first twisted pair, the fourth and seventh insulated wires form the second twisted pair, the first and third insulated wires form the third twisted pair, and the sixth and eighth insulated wires form the fourth twisted pair.

10. A telecommunications connector according to claim 9, wherein the fourth and sixth insulated wires form the further twisted pair.

11. A telecommunications connector according to claim 1, 2, 6 or 7, wherein the number of twists in each twisted pair is not equal.

12. A telecommunications connector according to claim 6, wherein a second wire of the second twisted pair is twisted with a second wire of the fourth twisted pair to form a second further twisted pair, a first wire of the first twisted pair is twisted with a first wire of the third twisted pair to form a third further twisted pair, a second wire of the third twisted pair is twisted with a first wire of the further twisted pair to form a fourth further twisted pair and the second wire of the first twisted pair is twisted with the second wire of the further twisted pair to form a fifth further twisted pair.

Fig.1.

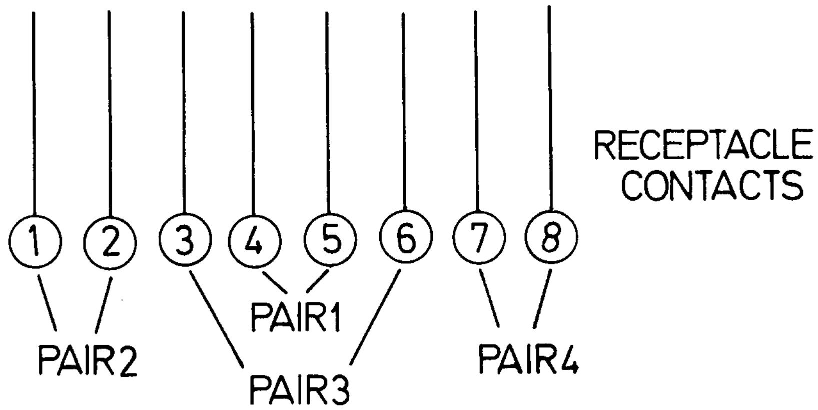


Fig.2.

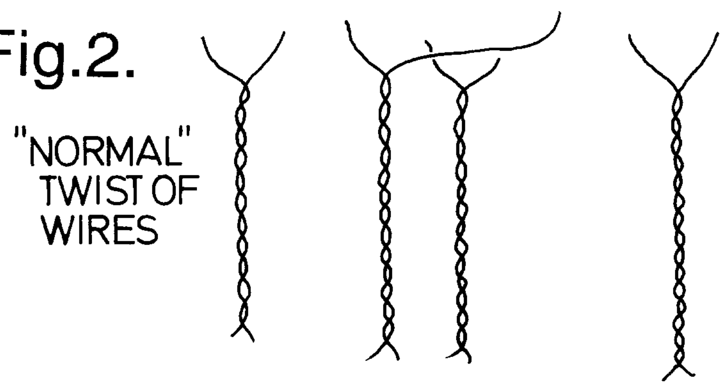


Fig.3.

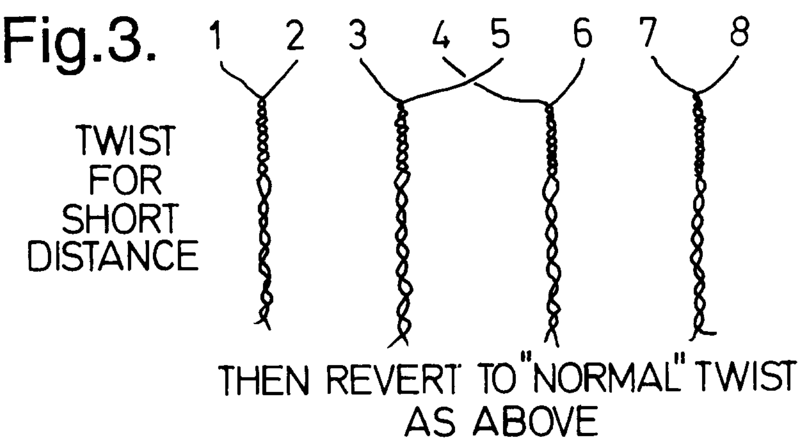


Fig.4.

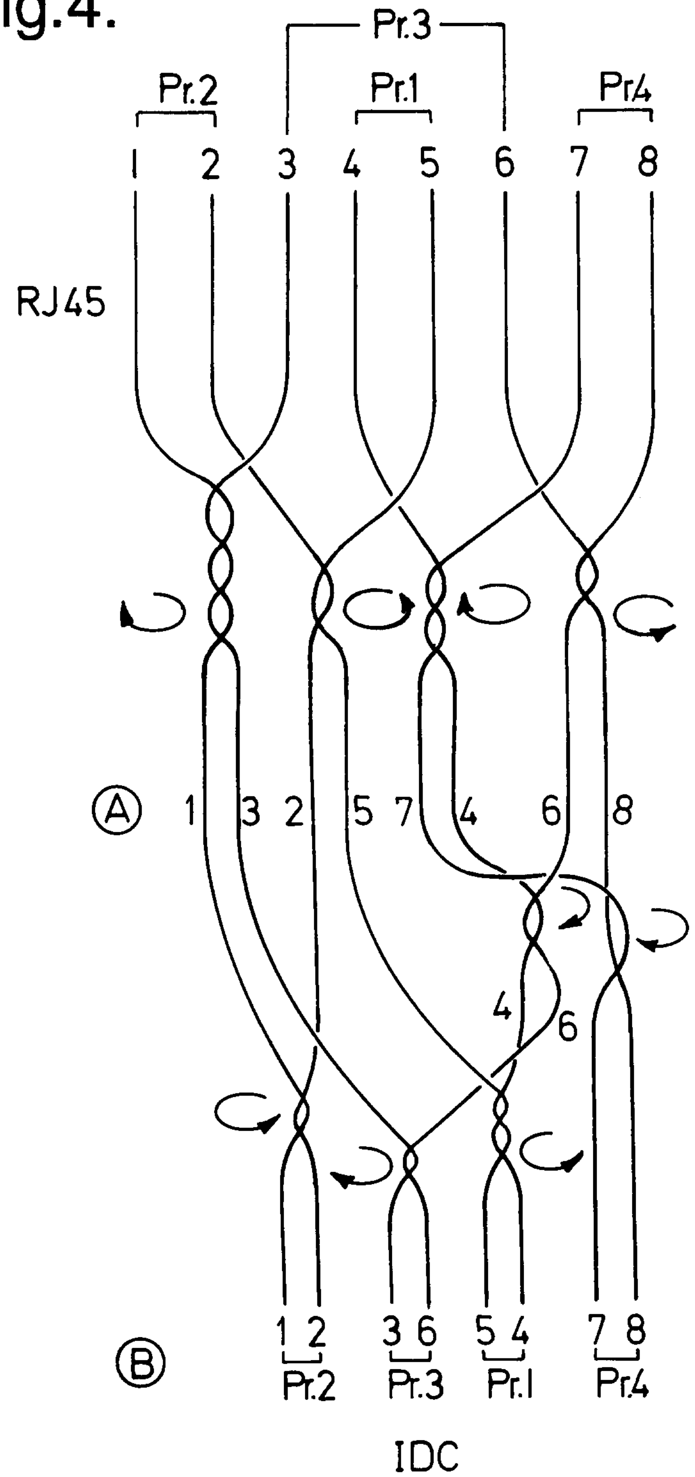
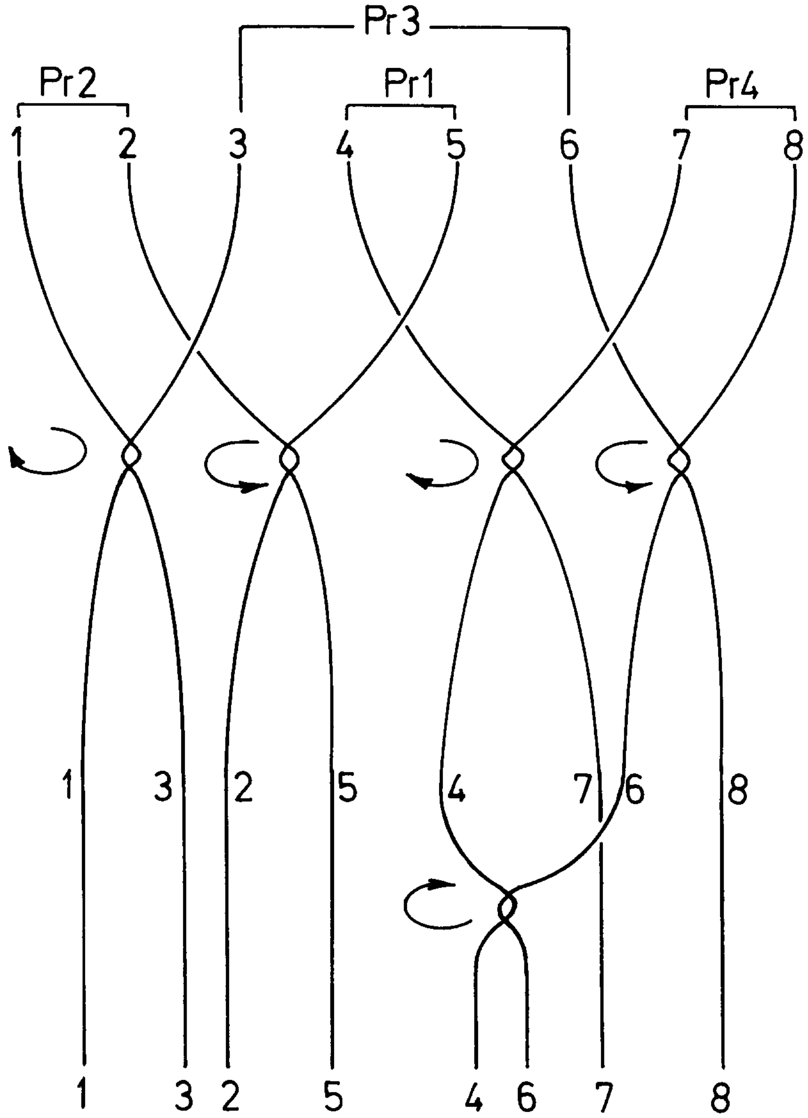
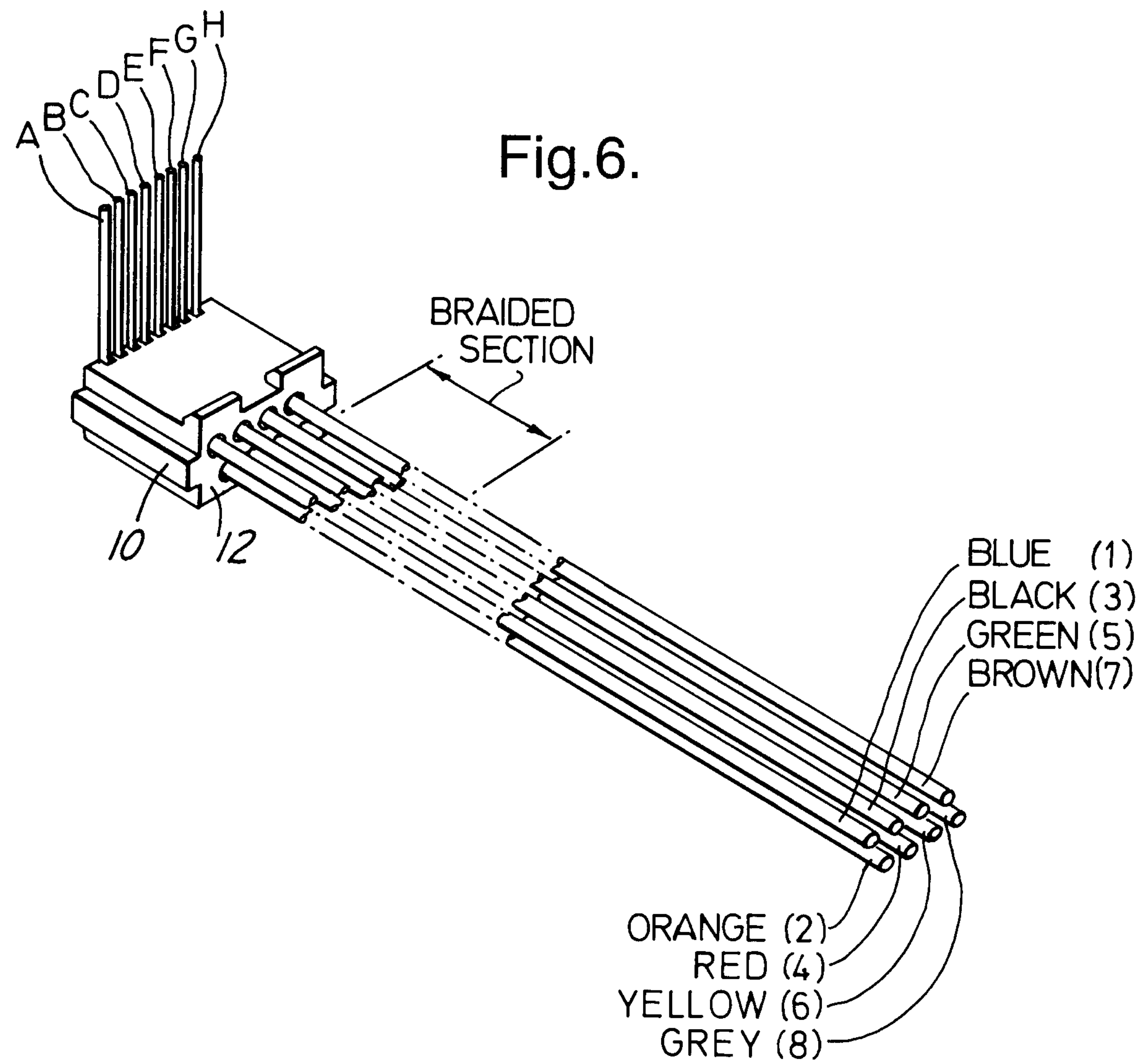

Pr.3
Pr.2
Pr.1
Pr.4
1 2 3 4 5 6 7 8
RJ45
A
1 3 2 5 7 4 6 8
4
6
B
1 2
Pr.2
3 6
Pr.3
5 4
Pr.1
7 8
Pr.4
IDC

Fig.5.



1&2 , 3&6 , 4&5 , 7&8 BRAIDED TO END

Fig.6.


A
B
C
D
E
F
G
H
BRAIDED SECTION
10
12
BLUE (1)
BLACK (3)
GREEN (5)
BROWN(7)
ORANGE (2)
RED (4)
YELLOW (6)
GREY (8)