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(54) **ELECTRICAL CONNECTOR**

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H01R 13/207 (2006.01)
H01R 13/639 (2006.01)

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CPC ***H01R 13/20*** (2013.01); *H01R 13/207* (2013.01); *H01R 13/639* (2013.01)

(58) **Field of Classification Search**
CPC H01R 13/20; H01R 13/207; H01R 13/639
See application file for complete search history.

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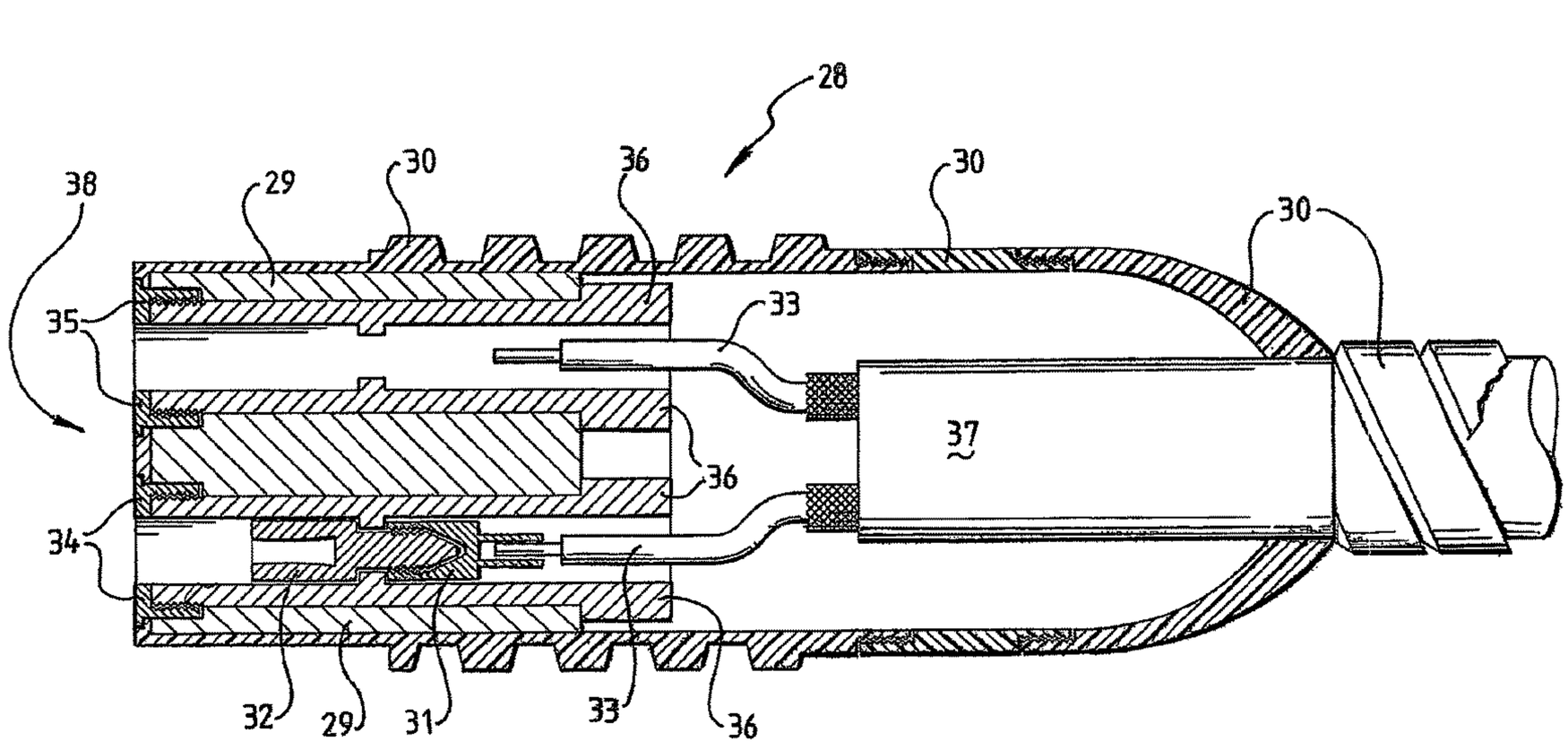
(57) **ABSTRACT**

The present invention provides an electrical connector for connecting a core of a machine cable (**37**) to a pin (**28**) or a socket (**32**) of an electrical connection device. The connector has a first part and a second part. The first and second parts have first and second locking surfaces respectively and first and second separate contact surfaces (**50**, **52**). The second part further includes a projection for securing the core of the machine cable and which is electrically connected to the second contact surface. The contact surfaces are so arranged that when the locking surfaces are interlocked, the contact surfaces are in electrical contact with each other so that an electrical contact is established between the core of the machine cable and the pin or socket.

15 Claims, 4 Drawing Sheets



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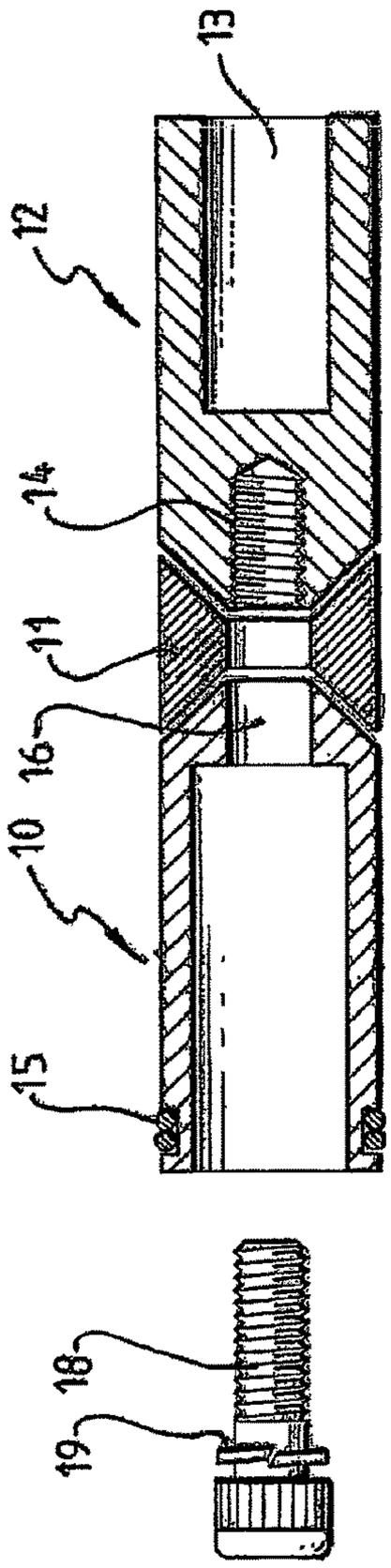

Fig. 1 Prior Art

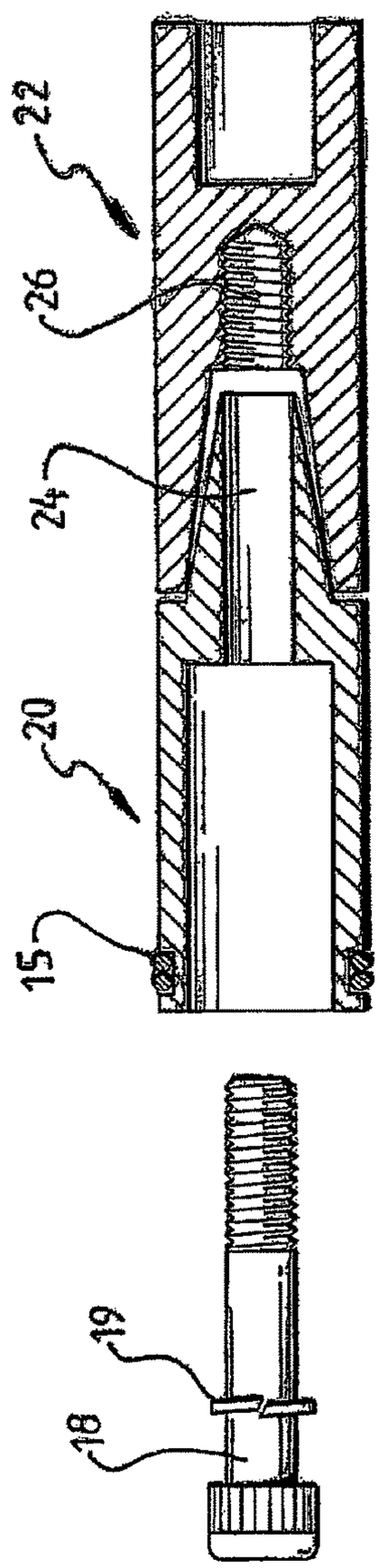

Fig. 2 Prior Art

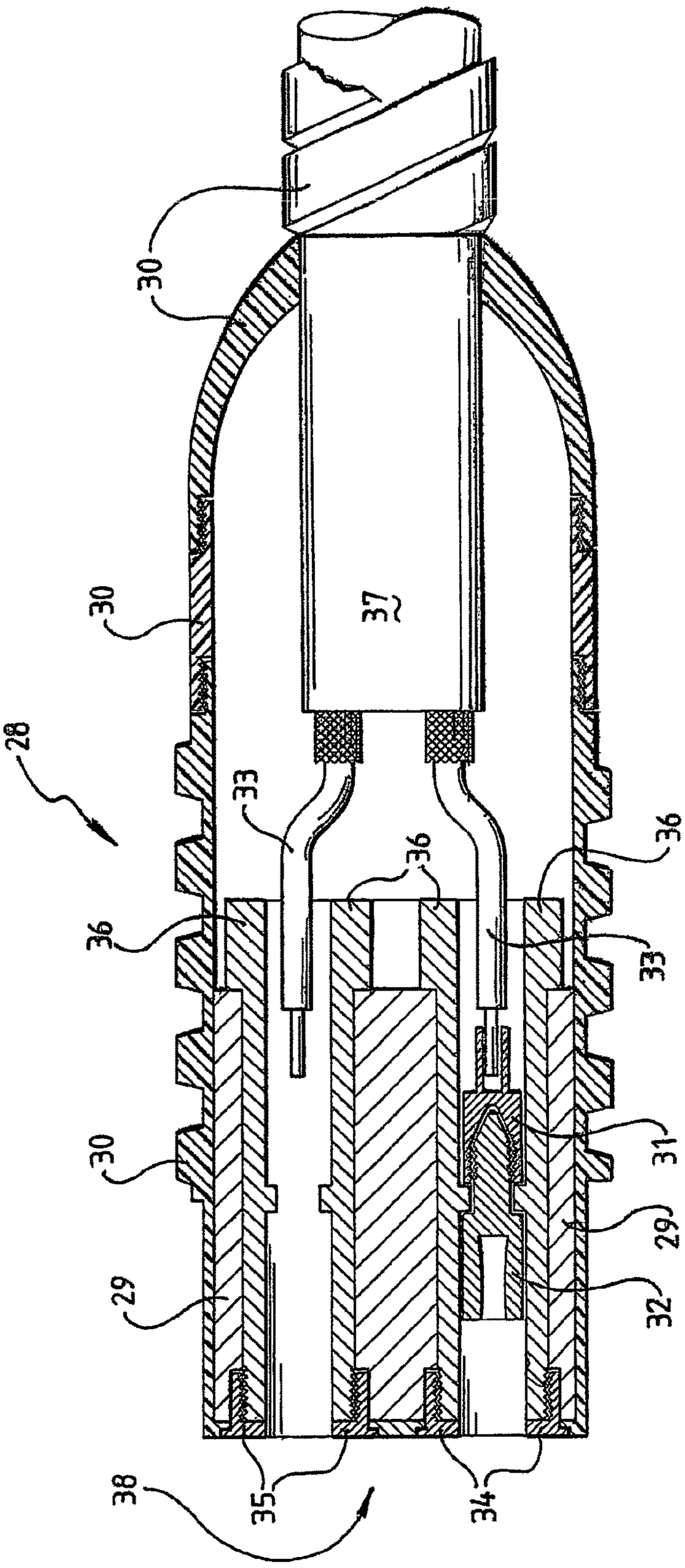

Fig. 3

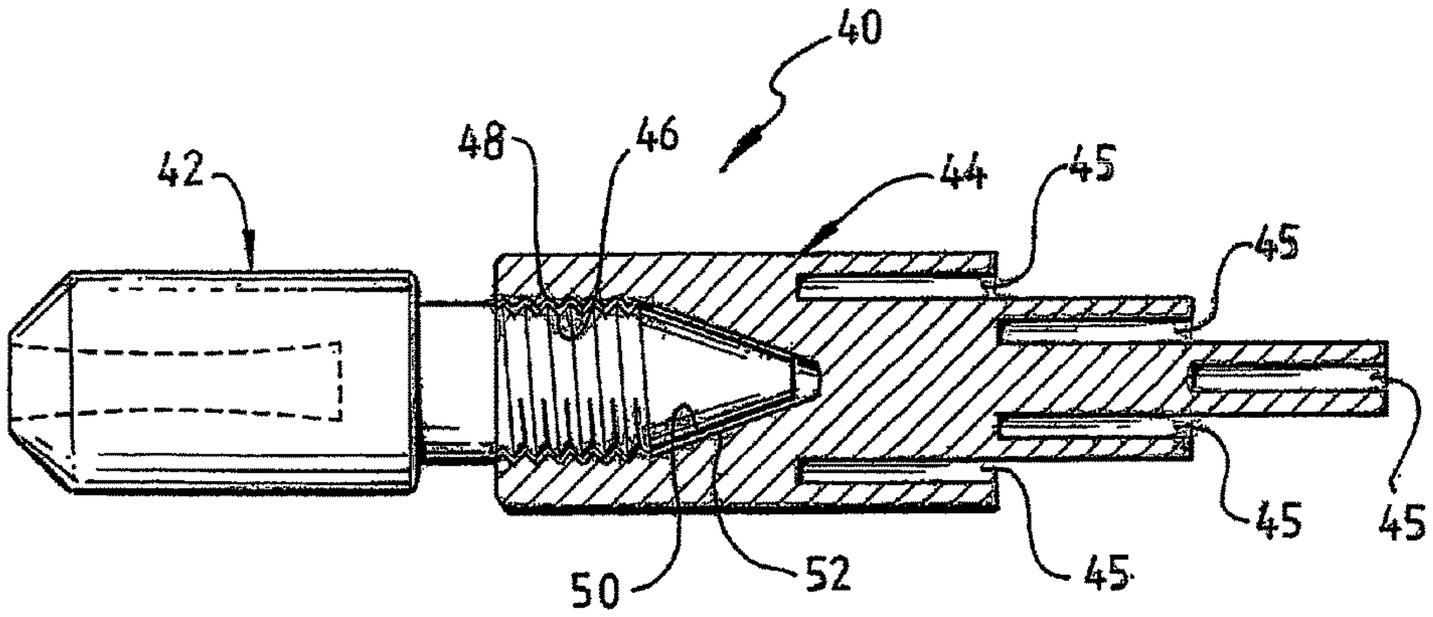

Fig. 4

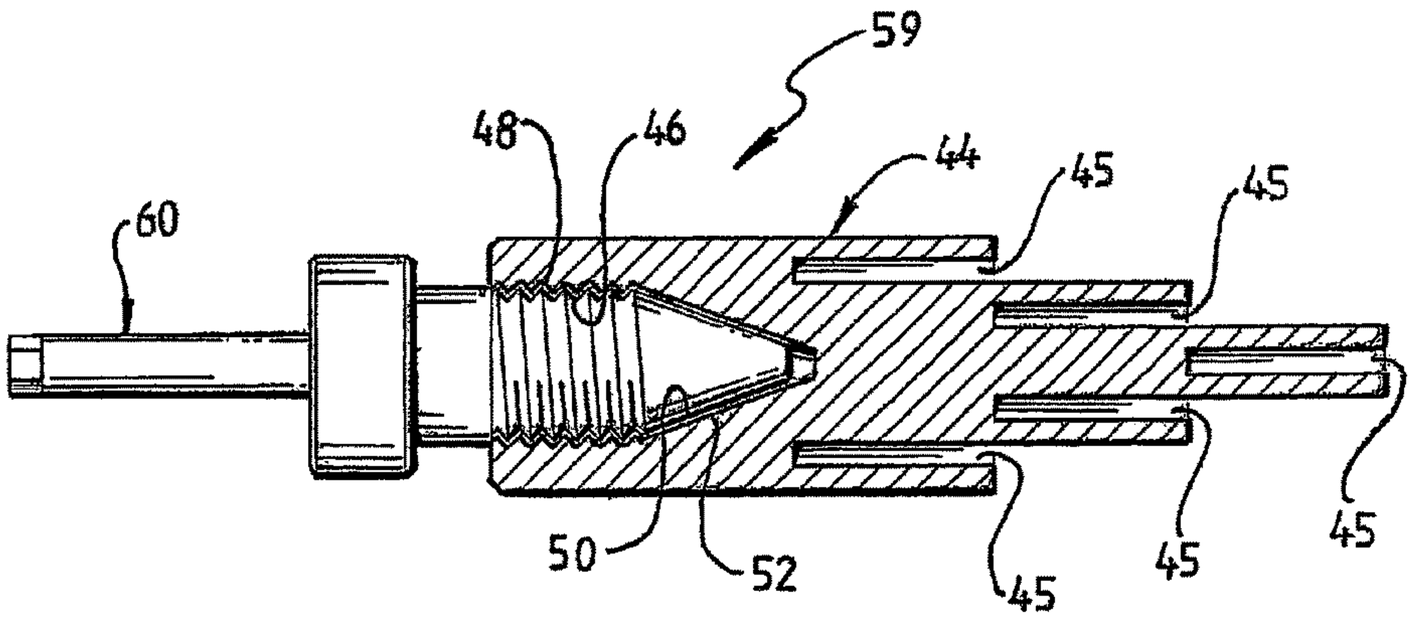

Fig. 5

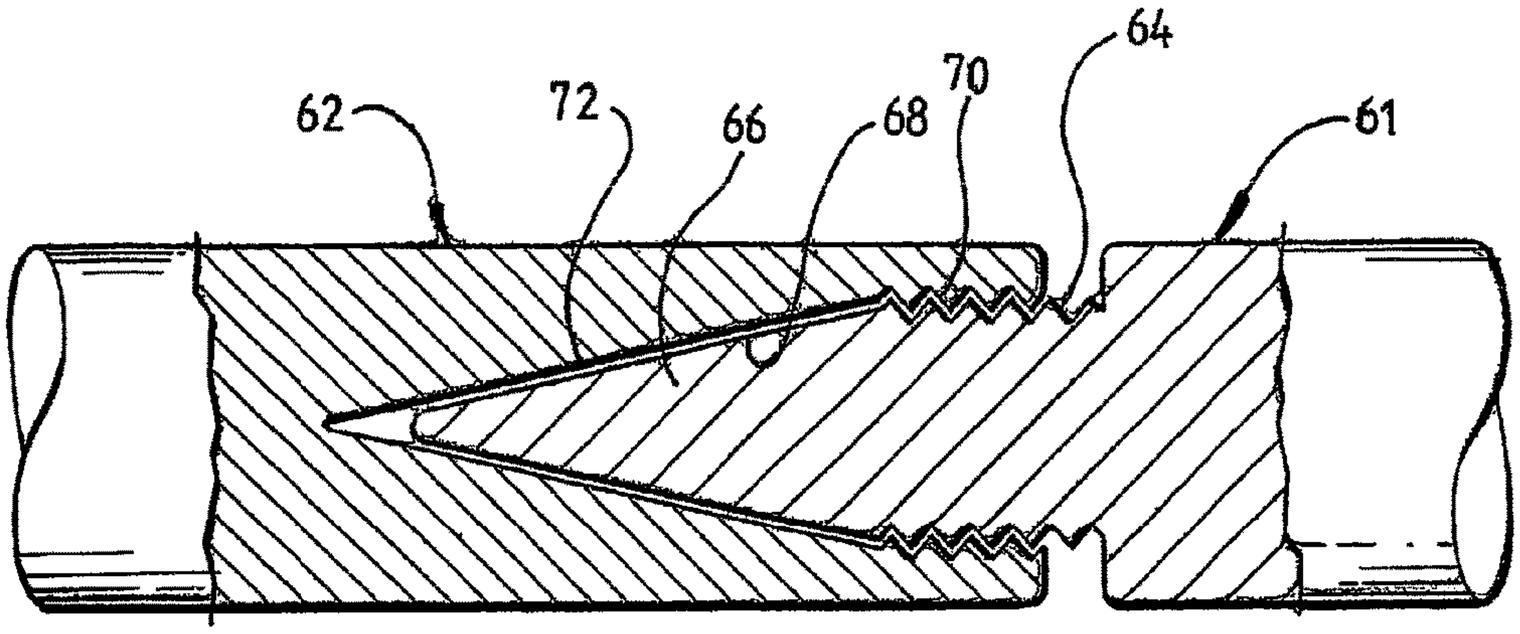

Fig. 6a

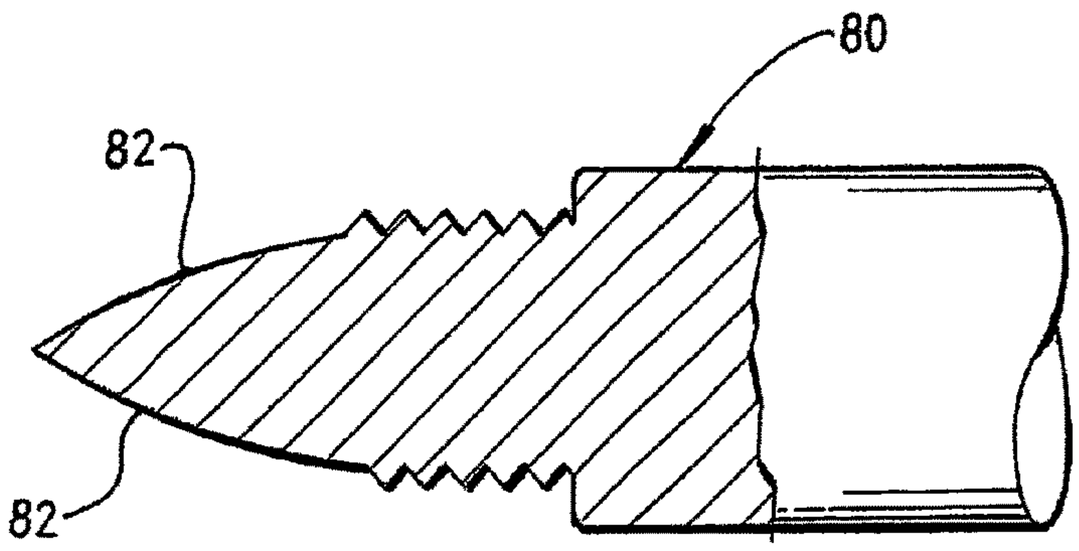

Fig. 6b

ELECTRICAL CONNECTOR

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of International Application No. PCT/AU2004/000065, filed 20 Jan. 2004 which claims the benefit of Australian Application No. 2003900291, filed 20 Jan. 2003 and Australian Application No. 2003902257, filed 9 May 2003, the disclosures of which are hereby incorporated herein in their entireties by reference.

FIELD OF THE INVENTION

The present invention broadly relates to an electrical connector for connecting a core of a machine cable to a pin or a socket of an electrical connection device. Throughout this specification the term "machine cable" is used for any machine, reeling or trailing cable that is arranged for delivery of power to mobile machinery such as large machinery in petroleum or mining industry. The term "connector" is used for any connector including a plug, lug, electrical adaptor, coupler or receptacle.

BACKGROUND OF THE INVENTION

Machine cables are typically used to provide an electrical connection for mobile electrical machines. For example, in the mining or petroleum industry often large electrical machinery is used and each machine cable may have to provide power in the order of a few hundred kilowatts. Typically such power is delivered with a voltage of one or more kilovolts. The cables usually comprise a plurality of cores and are connected using connectors having sockets and pins.

FIG. **1** shows a cross-sectional representation of an electrical connector for connecting a socket with a core of such a machine cable. The Figure shows the socket **10** arranged to receive a pin (not shown). The Figure also shows a thimble **12** which has an open end-portion **13** arranged to receive the core of the machine cable. Fingers of the socket **10** are biased by spring **15** so that an electrical connection with the pin may be achieved. However, the biasing force of the spring **15** may decay over time and it may be necessary to replace the spring **15** and/or the socket **10** from time to time. For this purpose the socket is realisable connected to the thimble **12**. The thimble **12** has a threaded portion **14** and the socket **10** has a bore **16**. The threaded portion **14** and the bore **16** are arranged to receive stainless steel screw **18** which engages socket **10** and thimble **12** via intermediate part **11**. To reduce the likelihood that the stainless steel screw **18** may loosen over time, the stainless steel screw **18** is inserted with a spring washer **19**. Socket **10** and thimble **12** have matching conical contact surfaces that match those of intermediate part **11**.

FIG. **2** shows a variation of the connector shown in FIG. **1**. In this case contact surfaces of socket **20** and thimble **22** do not match when the device is dissembled. However, when

the stainless screw **18** is inserted into the bore **24** of the socket **20** and received by the threaded portion **26** of the thimble **22**, the contact surface of the socket **20** bents the contact surface of the thimble **22** outwards.

Both prior art devices have the disadvantage that the screw has to be relatively small as the screw head is positioned within the socket. However, the relatively small screw often does not provide sufficient strength for the connection of the socket with the thimble. Further, the contact surfaces are relatively small and the additional pathway that is provided for the current through the screw itself is often not satisfactory. The current has to pass through up to three interfaces (between socket, intermediate part and thimble or, alternatively, between socket and spring washer, between spring washer and screw head and between the thread of the screw and the thread of the bore) and contact potentials, corrosion and contamination may result in contact resistivity at every interface. Further, the screw and the spring washer themselves may not have satisfying electrical properties.

SUMMARY OF THE INVENTION

The present invention provides an electrical connector arranged for connecting a core of a machine cable to a pin or a socket of an electrical connection device, the connector comprising:

a first part having a first locking surface and having a further surface that forms a first contact surface, the first part further including a pin or a socket which is electrically connected to the first contact surface,

a second part having a second locking surface arranged to interlock with the first locking surface and having a further surface that forms a second contact surface which is arranged to contact the first contact surface, the second part further including a projection for securing the core of the machine cable to the second part, the projection being electrically connected to the second contact surface,

wherein the contact surfaces are arranged so that, when the locking surfaces are interlocked, the contact surfaces are in electrical contact with each other so that an electrical contact is established between the core of the machine cable and the pin or socket.

An advantage of the present invention is that the first part and the second part can be held together without any additional part which makes the assemblement of the device relatively easy. Further, the assembled device may only have one interface which is of advantage for electrical properties of the device. Prior art devices typically use a stainless steel screw which is inserted through bores of the socket and the thimble to hold together the thimble and the socket (see FIG. **1**). Such screws are of relatively low electrically conductivity and their usage therefore increases the electrical resistivity for current conducted through the conductor. The above-defined connector does not require such a screw and consequently the cross-sectional area through which electricity can be conducted with a relatively low specific resistance may be increased compared with prior art devices.

The electrical connection device typically is arranged for delivery of a power of a few hundred kilowatts. Further, the electrical connection device typically is arranged for delivery of power having an associated voltage of one or more kilovolts.

The first locking surface typically is positioned between the first contact surface and the pin or socket.

The second contact surface typically is positioned between the second locking surface and the projection.

The first part may have opposing first and second end-portions, the first end-portion may include a socket and the second end-portions may include the first contact surface.

Alternatively, the first end-portion may include a pin. The second end-portion of the second part may include the second locking surface and the second end-portion of the first part may include the first locking surface.

At least one of the first part and the second part may be integrally formed and typically both the first part and the second part are each integrally formed.

In one embodiment the first locking surface comprises a first threaded portion and the second locking surface comprises a second threaded portion arranged to receive the first threaded portion.

For example, the first threaded portion may be a cylindrical portion having an outer thread and the second threaded portion may be a complimentary threaded bore arranged to receive the cylindrical portion.

Alternatively, the second threaded portion may be a cylindrical portion having an outer thread and the first threaded portion is a complimentary threaded bore arranged to receive the cylindrical portion.

An advantage of this arrangement is that the threaded cylindrical portion and the respective threaded bore may be larger in diameter and consequently mechanically and electrically stronger than those of prior art devices as there is no need to locate a screw and screw head within another part which is a requirement in the prior art (prior art devices are shown in FIGS. **1** and **2**). As the threaded cylindrical portion and the respective threaded bore may be larger than in that of the screw and the respective receiving thread of the prior art devices, the mechanical connection and consequently electrical connection between the threaded portions and the contact surfaces may also be of improved.

Electrical contact is established when the contact surfaces are in electrical contact, but may additionally also be established when the locking surfaces are in contact. For example, as the threaded cylindrical portion and the threaded bore can be relatively large, the mechanical connection can be relatively strong and, as a consequence of the stronger mechanical connection and the larger area at which the threaded portions contact, the electrical connection may be improved compared with prior art devices. In a specific embodiment the contact area that is established when the locking surfaces are interlocked is at least as large as the contact area that is established when the contact surfaces are in contact.

Alternatively or additionally, a portion of one of the locking surfaces may be arranged to scrape over a portion of the other locking surface when the locking surfaces interlock.

The first contact surface may have a conical tip and the second contact surface may have a respective conical bore arranged to receive the conical tip of the first contact surface. Alternatively, the first contact surface may have a conical bore and the second contact surface may have a respective conical tip arranged to be received by the conical bore of the first contact surface.

The first and the second contact surfaces may have matching profiles.

The conical tip may have a surface that is not curved or that is outwardly curved and arranged for contact with the conical bore within a ring-like zone near the apex of the curvature. In this case the conical bore may have a surface that is not curved or that has a suitable inwardly or outwardly curved profile. Alternatively, the conical tip may have a surface that is inwardly curved and that is arranged for contact with a suitable inwardly or outwardly curved conical bore. For example, the inwardly or outwardly curved surfaces may have a curvature that has a profile corresponding to a section of a sphere. Each curved surface may also comprise more than one curvatures.

For example, a portion of one of the contact surfaces may be arranged to scrape over a portion of the other contact surface when the locking surfaces interlock whereby the contact surfaces may be cleaned and seated onto each other and therefore a better electrical contact may be established.

The invention will be more fully understood from the following description of specific embodiments. The description is provided with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a cross-sectional representation of an electrical connector for connecting a core of a machine cable to a socket of an electrical connection device (prior art),

FIG. **2** shows a cross-sectional representation of another electrical connector for connecting a core of a machine cable to a socket of an electrical connection device (prior art),

FIG. **3** shows an electrical connector for connecting a core of a machine cable to a socket of an electrical connection device according to a specific embodiment,

FIG. **4** shows an electrical connector for connecting a core of a machine cable to a socket of an electrical connection device according to another specific embodiment,

FIG. **5** shows an electrical connector for connecting a core of a machine cable to a pin of an electrical connection device according to a further specific embodiment, and

FIGS. **6** (a) and (b) show details of the electrical connector according to yet another specific embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **3**, a plug incorporating an electrical connector according to a specific embodiment is now described. The plug **28** comprises a socket **32** and a thimble **31**. In this embodiment, socket **32** and thimble **31** are each integrally formed. The thimble **31** is connected to a core **33** of a machine cable **37**. The socket **32** is arranged to receive a pin (not shown) and has a threaded cylindrical portion that is inter-locked with a threaded bore of the thimble **31**.

The plug **28** comprises a body **29** that is of substantially cylindrical shape and an outer shell **30** composed of metallic and/or insulating material(s). The plug **28** has an end-face **38** that has three apertures that are defined by nuts such as nuts **34** and **35**. From each aperture an insulating sleeve **36** projects inwardly. Thimble **31** has a key (not shown) and sleeve **36** has a corresponding key way (not shown) arranged so that rotation of the thimble **31** in the sleeve **36** can be avoided whereby screwing of the socket **32** into the thimble **31** is simplified. Alternatively, the sleeve **36** may have a key and the thimble **31** may have a corresponding key way arranged so that rotation of the thimble **31** is avoided when the socket **32** is screwed into the thimble **31**.

Referring now to FIG. **4**, the electrical connection device **40** comprising a socket **42** and a thimble **44** is described in more detail. The socket **42** is arranged to receive a pin (not shown) and the thimble **44** comprises a plurality of recesses **45** arranged to be connected to individual branches of a core of a machine cable (not shown). The socket **42** has a first locking surface which has the form of cylindrical portion **46** having an outer thread. The thimble **44** comprises a com-

plimentary threaded bore **48** arranged to receive the cylindrical threaded portion **46**. The outer diameter of the cylindrical threaded portion **46** is relatively large compared with the outer diameter of the socket and it therefore is possible to achieve a relative strong inter-locking of the threaded cylindrical portion with the threaded bore.

The socket **42** has a contact surface **50** and the thimble **44** has a matching contact surface **52**. In this example the contact surface **50** is provided in form of a conical tip of the threaded cylindrical portion **46**. The thimble **44** has a respective conical extension which provides the contact surface **52** arranged to be in electrical contact with the conical contact surface **50**. The contact surface **50** and the contact surface **52** have matching profiles.

FIG. **5** shows a variation **59** of the device shown in FIG. **4** comprising a pin **60** instead of the socket in the device shown in FIG. **4**. The pin **60** is arranged to receive a socket (not shown) and is interlocked with the thimble **44** in the same way as the socket **42** shown in FIG. **4**.

It will be appreciated that the socket **42** of the device **40** shown in FIG. **4** and the pin **60** of the device **59** shown in FIG. **5** can be exchanged. Therefore, a connector such as a plug or receptacle incorporating device **40** and/or **59** shown has the advantage of greater flexibility compared with prior art devices where pins and sockets are not exchangeable (see FIGS. **1** and **2**).

Referring now to FIG. **6** (a), the electrical connection device is now described in further detail. FIG. **6** (a) shows a portion of a socket **61** and a portion of a thimble **62** interlocked with the socket **61**. In this embodiment, the socket **61** has a cylindrical portion **64** with outer thread. The cylindrical portion **64** has a conical tip **66** which provides a contact surface **68**. The thimble **62** has a threaded bore **70** that has a contact surface **72** in form of a conical bore shaped complimentary to the conical tip **66** of the cylindrical portion **64**. If the threaded cylindrical portion **64** is screwed into the threaded bore **70**, the conical tip **66** scrapes over the conical contact surface **72** when the socket **61** is interlocked with the thimble **62** whereby the contact surfaces are cleaned and therefore a better electrical contact may be established.

Referring now to FIG. **6** (b), a variation of the electrical connection device is now described. In this case the socket **80** has a conical contact surface **82** that is curved. The area in which electrical contact between the contact surface **82** and the contact surface **72** of the thimble **62** is near within a ring-like zone near the apex of the curvature and may be smaller than that of the device shown in FIG. **6** (a). However, the curved conical contact surface profile **82** may have other advantages such as a progressive cleaning action when the contact surfaces scrape ever each other when the thimble **62** and the socket **80** are being engaged together. Such scraping action may result in one contact surface being seated on the other contact surface which would improve the electrical connection as interfacial resistance can be reduced.

Although the invention has been described with reference to particular examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms. For example, the connector may comprise a pin instead of the socket as described in the above embodiments. Also, the thimble may have a threaded cylindrical portion and the socket may have a threaded bore arranged to receive the threaded cylindrical portion. Further, the socket and the thimble may not be integrally formed but may be composed of different parts that are joined.

The invention claimed is:

1. An electrical connector arranged for connecting a core of a machine cable to a pin or a socket of an electrical connection device, the connector comprising:

a first part having a first locking surface and having a further surface that forms a first contact surface, the first part further including a pin or a socket which is electrically connected to the first contact surface,

a second part having a second locking surface arranged to interlock with the first locking surface and having a further surface that forms a second contact surface which is arranged to contact the first contact surface, the second part further including a projection for securing the core of the machine cable to the second part, the projection being electrically connected to the second contact surface,

wherein the first locking surface comprises a first threaded portion and the second locking surface comprises a second threaded portion arranged to receive the first threaded portion,

[and**]** wherein the contact surfaces are arranged so that, when the locking surfaces are interlocked, the contact surfaces are in electrical contact with each other so that an electrical contact is established between the core of the machine cable and the pin or socket,

wherein one of the first or the second contact surfaces has a conical tip and the other one of the first and second contact surface has a conical bore arranged to receive the conical tip, and

wherein the conical tip comprises an outwardly curved surface which is arranged for contact with the conical bore within a ring-like zone near the apex of the curvature, or the conical bore comprises an inwardly curved surface which is arranged for contact with the conical tip within a ring-like zone near the apex of the curvature.

2. The electrical connector as claimed in claim **1** wherein the electrical connection device is arranged for delivery of a power of a few hundred kilowatts.

3. The electrical connector as claimed in claim **1** wherein the electrical connection device is arranged for delivery of power having an associated voltage of one or more kilovolts.

4. The electrical connector as claimed in claim **1** wherein the first locking surface is positioned between the first contact surface and the pin or socket.

5. The electrical connection device as claimed in claim **1** wherein the second contact surface is positioned between the second locking surface and the projection.

6. The electrical connector as claimed in claim **1** wherein the first part has opposing first and second end-portions, the first end-portion including a socket and the second **[**end-portions**]** *end portion* including the first contact surface.

7. The electrical connector as claimed in claim **6** wherein **[**the**]** *a* second end-portion of the second part includes the second locking surface and the second end-portion of the first part includes the first locking surface.

8. The electrical connector as claimed in claim **1** wherein the first part has opposing first and second end-portions, the first end-portion including a pin and the second **[**end-portions**]** *end-portion* including the first contact surface.

9. The electrical connector as claimed in claim **8** wherein **[**the**]** *a* second end-portion of the second part includes the second locking surface and the second end-portion of the first part includes the first locking surface.

10. The electrical connector as claimed in claim **1** wherein at least one of the first part and the second part is integrally formed.

11. The electrical connector as claimed claim **1** wherein a portion of one of the contact surfaces is arranged to scrape over a portion of the other contact surface when the locking surfaces interlock.

12. The electrical connector as claimed in claim **1** wherein a portion of one of the locking surfaces is arranged to scrape over a portion of the other locking surface when the locking surfaces interlock.

13. The electrical connector as claimed in claim **1** wherein the first threaded portion is a cylindrical portion having an outer thread and the second threaded portion is a complimentary threaded bore arranged to receive the cylindrical portion.

14. The electrical connector as claimed in claim **1** wherein the second threaded portion is a cylindrical portion having an outer thread and the first threaded portion is a complimentary threaded bore arranged to receive the cylindrical portion.

[15. The electrical connector as claimed in claim **1** wherein the second contact surface has a conical tip and the first contact surface has a respective conical bore arranged to receive the conical tip of the second contact surface.**]**

[16. The electrical connector as claimed in claim **15** wherein the conical bore comprises an inwardly curved surface which is arranged for contact with the conical tip within a ring-like zone near the apex of the curvature.**]**

[17. The electrical connector as claimed in claim **1** wherein the first contact surface has a conical tip and the second contact surface has a respective conical bore arranged to receive the conical tip of the first contact surface.**]**

[18. The electrical connector as claimed in claim **17** wherein the conical tip comprises an outwardly curved surface which is arranged for contact with the conical bore within a ring-like zone near the apex of the curvature.**]**

[19. The electrical connector as claimed in claim **17** wherein the conical bore comprises an inwardly curved surface which is arranged for contact with the conical tip within a ring-like zone near the apex of the curvature.**]**

20. The electrical connector as claimed in claim **1** wherein the first and the second contact surfaces have matching profiles.

[21. The electrical connector as claimed in claim **20** wherein the conical tip comprises an outwardly curved surface which is arranged for contact with the conical bore within a ring-like zone near the apex of the curvature.**]**

* * * * *