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[54] GAS-SEPARABLE ELECTRICAL CONNECTOR AND METHOD

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[51] **Int. Cl.**.....**H01r 13/54**

[58] **Field of Search**.....339/45, 46, 59, 60, 89, 94, 339/111, 112, 117

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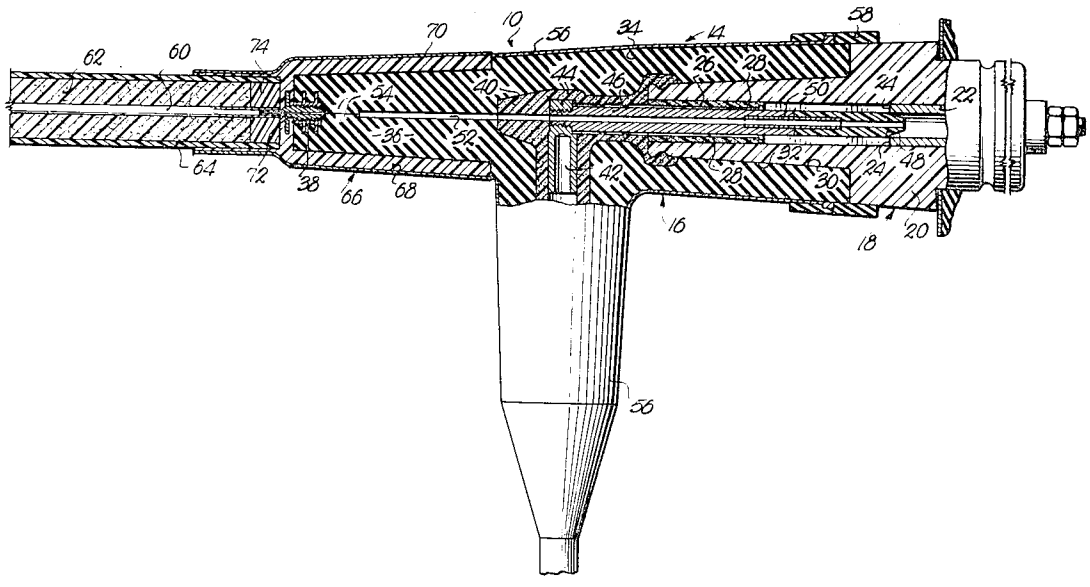
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[57] **ABSTRACT**

An electrical connector has a pair of complementally configured connector components which are adapted to be separated by a pressurized gas. Each of the connector components comprises a contact element and an insulating housing which are normally disposed in interengagement with a complemental contact element and a complemental insulating housing of the other connector component. One of the connector components includes passage-defining means which extends through the insulating housing and the corresponding contact element, and communicates with the other connector component. A passage-defining member is adapted to be coupled in sealing relationship with the passage-defining means, and the member in turn is adapted to be coupled with a source of pressurized gas. By introducing a quantity of the pressurized gas into the connector and directing the same through the one component and against the other component, the two components are caused to shift relatively away from each other.

23 Claims, 5 Drawing Figures



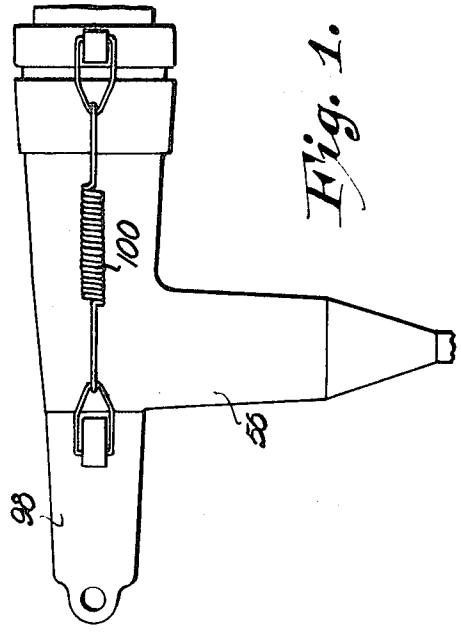


Fig. 1.

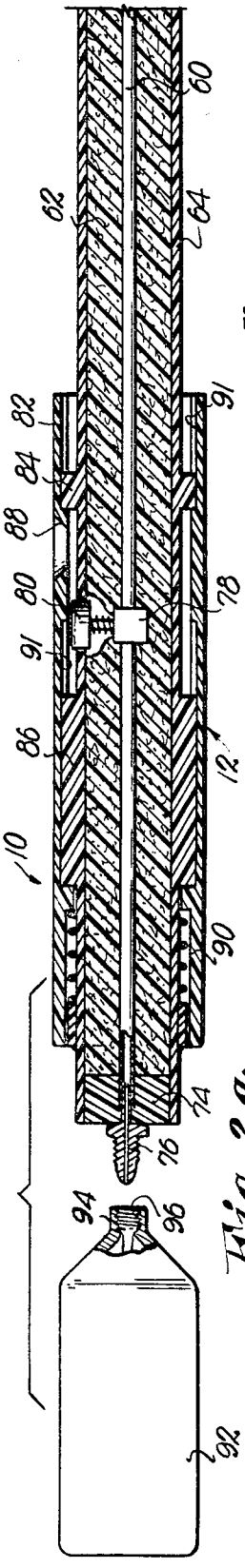


Fig. 2a.

Fig. 2b.

Fig. 3.

Fig. 4.

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GAS-SEPARABLE ELECTRICAL CONNECTOR AND METHOD

This invention relates to electrical distribution equipment and, more particularly, to a novel electrical connector and a method of separating a pair of complemental connector components.

In any electrical connector, and particularly connectors for use in underground installations, it is necessary to provide connector components having complementally configured insulating housings which can be disposed in tight interengagement to preclude the entrance of moisture or other contaminants into the interior of the housings where the electrical connection is effected. It is not unusual for such a connector to be left undisturbed for a period of several months or even years before it is necessary to separate the connector components and break the electrical connection. When this does become necessary however, great difficulty is frequently encountered in the separation of two connector components because of the tendency of the interengaged surfaces of the two insulating housings to bond together during the period of interengagement. Separation is particularly difficult when the connector is located in an underground vault where only limited access is available and a good working leverage is difficult to obtain.

The present invention eliminates the above described problems heretofore encountered in separating a pair of electrical connector components by providing complemental components adapted to be separated by a pressurized gas.

It is, therefore, an object of the present invention to provide an electrical connector having complementally configured connector components one of which is provided with passage-defining means for conveying a pressurized gas to the interior of the connector to cause the two components to shift relatively away from each other.

Another object of the invention is an electrical connector as described in the foregoing object wherein complementally configured contact elements are employed to effect the electrical connection and the pressurized gas is selected for its arc-suppressing characteristics and is directed to the interior of the connector to surround the electrical contacts and prevent arcing thereof during shifting of the two components.

Another important aim of the invention is to provide an electrical connector wherein the complementally configured connector components are readily separable by a pressurized gas but are normally disposed in sufficiently tight interengagement to preclude the entrance of moisture or other contaminants into the interior of the connector.

A still further object of the invention is an electrical connector unit which includes an elongated passage-defining tool for coupling with an electrical connector as described in the foregoing objects to convey a pressurized gas to the connector from a remote location.

As a corollary to the above object an aim of the invention is to provide a passage-defining tool which can be coupled with a source of pressurized gas and is selectively operable to introduce gas into the connector at the discretion of an operator.

An important object of the invention is also to provide a method of separating complementally configured connector components by utilizing the force of a pressurized gas.

In the drawing:

FIG. 1 is a side elevational view of an electrical connector as it would normally appear when effecting an electrical connection;

FIGS. 2*a* and 2*b* illustrate an electrical connector unit including the connector of FIG. 1 which is shown in enlarged partial cross section in FIGS. 2*b* and the apparatus for operating the connector which is shown in cross section and is partially visible in each of FIGS. 2*a* and 2*b*;

FIG. 3 is a fragmentary, cross-sectional view illustrating an alternative means for coupling the operating tool with the electrical connector and also an alternative form of passage-defining means within the insulating housing; and

FIG. 4 is a fragmentary, partial cross-sectional view similar to FIG. 3 and illustrating another alternative form of the means for coupling the operating tool with the connector.

An electrical connector unit is designated by the numeral 10 in FIGS. 2*a* and 2*b* and includes an operating tool 12 which is coupled with an electrical connector 14. The electrical connector 14, which is illustrated in FIGS. 1 and 2*b*, will first be described.

The separable connector 14 includes a first connector component 16 in the form of an elbow connector, and a second connector component 18 which extends from an electrical apparatus housing. The connector component 18 includes an insulating housing 20 having a centrally disposed, longitudinally extending opening therein and a generally cylindrical female contact body 22 disposed within the opening and spaced longitudinally from the exposed end of the latter. The female contact element 22 has a plurality of slots 24 in one end thereof for purposes to be made clear hereinafter. The housing 20 also includes an arc-suppressing, annular insert 26 which is received within the longitudinally extending opening and abuts the slotted end of the female contact element 22. The insert 26 has a plurality of longitudinally extending flutes 28 circumscribing its inner surface and communicating with the slots 24. The insulating housing 20 has a lateral projection which presents an extended surface area 30 for engagement with a complementally configured surface area 32 of a second insulating housing 34 of the connector component 14.

The insulating housing 34 is provided with a projection 36 of frustoconical cross section, the latter having a threaded insert 38 disposed at the terminal end thereof. Embedded within the housing 34 as an integral part thereof is an L-shaped semiconductor 40 which receives one end of a cable conductor 42 having a compression ferrule 44 secured to the end thereof. The ferrule 44 has a threaded opening which receives a complementally threaded end portion of a male contact element in the nature of an annular body 46 which is provided with an arc-suppressing extension 48 secured to the body 46 by an annular connec,ing link 50.

A portion of the insulating housing 34 which presents the projection 36 also defines a passage 52 which extends through the projection 36, the semiconductor 40, and communicates with the passage-defining portion of the annular contact body 46. The passage-defining portion of the insulating housing 34 includes a normally closed section 54 proximal to the threaded insert 38. The outer surface of the housing 34 is provided with a conductive layer 56, and an annular insulating flashback shroud 58 extends from the layer 56 in overlying relationship to a portion of the insulating housing 20.

Referring now to the operating tool 12 which is continuous from the right-hand edge of FIG. 2*a* to the frustoconical projection 36 of the connector 14 in FIG. 2*b*, the tool 12 comprises an elongated passage-defining member which is adapted to be coupled with the passage-defining portion of the insulating housing 34. The passage-defining member is constructed from a tube 60 of insulating material which is surrounded by a rigid body 62 of a foam resin, the latter being enclosed within a casing 64 of resinous insulating material. One end of the elongated passage-defining member is provided with a receptacle 66 of frustoconical cross section which is composed of an inner layer 68 of resilient insulating material, and an outer conductive covering 70. A nipple 72 is embedded within the insulating layer 68 and is provided with external threads for complemental engagement with the insert 38. The receptacle 66 is secured to the casing 64 by a suitable adhesive.

The elongated passage-defining member is preferably constructed according to the teachings of U.S. Pat. No. 2,997,529, which issued to M. H. Fink on Aug. 22, 1961. As described in this patent, a unicellular foam resin, such as polystyrene, may be utilized for the body 62 and a reinforced resinous material such as an epoxy resin may be utilized for the casing 64. The ends of the elongated passage-defining member are closed with blocks 74 which are preferably made from an epoxy resin to preclude the entrance of moisture into

the member. The end of the tool **12** opposite the receptacle **66** is provided with a threaded nipple **76** for purposes to be made clear hereinafter.

A conventional flow control valve **78** is represented schematically in FIG. **2***a* for controlling the flow of gas through the tube **60**, this valve being operated by a spring-biased actuator **80**. To preclude the accidental operation of the actuator **80**, a spring-biased covering plate **82** is supported externally of the casing **64** by an annular rib **84** and an annular shoulder **86**. Access to the actuator **80** is possible only through an opening **88** in the plate **82**, and this opening is normally biased out of alignment with the actuator **80** by a coil spring **90**. A plurality of torsional guides **91** on the inner surface of the plate **82** prevent the opening **88** from being rotated out of alignment with the actuator **80**. A convenient source of pressurized gas is a refillable cylinder **92** provided with a threaded neck **94** and an internal seal **96** which can be penetrated by the end of the nipple **76** when the latter is inserted within the neck **94**.

The insulating housing **34** is preferably a resilient rubber having superior insulating qualities which is cast or molded around the L-shaped semiconductor **40**. The elbow connector component **16** is assembled by first preparing an electrical cable to expose one end of the cable conductor **42** after which the compression ferrule **44** is secured thereto. The ferrule **44** and the electrical cable are then inserted within the vertical arm of the housing **34** until the ferrule abuts the L-shaped semiconductor **40**. The male contact element **46** is then threaded into the opening in the ferrule **44**. The electrical connection is effected by inserting the male contact element **46** within the female contact element **22** of the connector component **18** as the complementally configured insulating housings **20** and **34** are forced into interengagement. The slotted end of the female contact element **22** exerts a springlike gripping force on the male contact element **46** which assures a tight interengagement of the two elements. When the connector **14** is being utilized in an underground vault, it is to be understood that the projection **36** will be disposed in an approximately vertical position, rotated 90° from the horizontal position of FIG. **2***b*.

When it is desired to break the electrical connection, the operating tool **12** is positioned so that the receptacle **66** can receive the projection **36**, and the nipple **72** is threaded within the insert **38** to bring the passage-defining member into tight sealing engagement with the passage-defining portion of the insulating housing. The cylinder **92** is then threaded onto the nipple **76** which breaks the seal **96** and places the tool **12** in a standby condition. Next, the cover plate **82** is moved against the action of coil spring **90** to bring the opening **88** into alignment with the actuator button **80**. The spring-biased covering plate **82**, in addition to preventing the accidental operation of the actuator **80**, also forces the operator to pull rearwardly on the tool **12** prior to introducing the gas into the connector **14**. This, in turn, assures that once the gas effects a partial separation of the components **16** and **18**, the operator will immediately thereafter complete the separation since he is already exerting a rearward force on the tool **12**. When the button **80** is depressed to open the passage through the tube **60**, the pressurized gas from the cylinder **92** will flow through the tube and cause the normally closed section **54** to expand, thereby opening the passage **52**. The gas emanating from the end of the arc-suppressing extension **48** is free to travel through the slots **24** and along the flutes **28** to completely surround the contact region of the respective male and female contact elements **46** and **22**.

Although any one of a number of gases which are characterized by arc-suppressing properties can be employed, it is preferable to use an electronegative gas such as SF_6. When SF_6 is introduced into the cylinder **92** as a liquid, it will develop a pressure of approximately 300 to 350 p.s.i. at 20° to 25° C. The contact elements **46** and **22** are surrounded by the arc-suppressing gas only instantaneously before the pressure of the gas acting against the female contact element **22** forces the two contact elements to separate by moving relatively away from each other. This breaks the bond between the two contact elements and the interengaged surfaces **30** and **32** of their respective insulating housings. It is to be understood that the term "separate," as used in this application, includes a partial separation through relative shifting of the contact elements sufficient to break the aforedescribed seal or "bond" between the two connector components **16** and **18**. Complete separation of the two connector components is immediately effected since, as discussed above, the operator is already exerting a rearward force on the tool **12**. As soon as separation is achieved, the actuator button **80** will be released to allow it to return to its normally closed position and the cover plate **82** likewise will be released to allow it to return to its normally closed position and the cover plate **82** likewise will be released to allow it to return to its spring-biased closed position. By completely surrounding the contact region of the complemental elements **22** and **46** with an arc-suppressing gas, arcing of the two relatively moving contacts is substantially precluded.

When the operating tool **12** is uncoupled from the connector **14** and the latter is in its normal disposition with the connector components **16** and **18** interengaged to effect an electrical connection, a covering member **98**, visible in FIG. **1**, and having the same general configuration as the receptacle **66**, is disposed in sealing relationship to the projection **36**. A holding spring **100** (and a similar holding spring 180° removed from the spring **100** and therefore not visible in FIG. **1**) assures that the covering member **98** remains in tight sealing engagement to the projection **36**. The holding springs also preclude separation of the interengaged connector components **14** and **16**. In the modified form of the invention illustrated in FIG. **3**, the insulating housing **34** includes a projection **136** of frustoconical cross section having a series of external threads **106** along its outer surface. The passage-defining portion of the insulating housing **34** includes a normally closed section **154** coextensive in length with the projection **136**. A receptacle **166** of frustoconical cross section includes an insulating layer **168** of a resilient material which is provided with a plurality of internal threads **104** for complemental engagement with the threads **102**. The outer surface of the receptacle **166** is surrounded by a conductive covering **170**. A nipple **172** is embedded within the resilient insulating layer **168** and projects from the latter to penetrate the projection **136** and couple the passage presented by tube **60** with the passage-defining means of the insulating housing **34**.

When the tool **12** is provided with a receptacle such as **166** and the insulating housing **34** presents a projection such as **136**, the tool is coupled with the connector **14** by applying a torsional force to the tool to bring the threads **102** and **104** into interengagement. As the pressurized gas from the cylinder **92** flows through the passage presented by the tube **60**, it will cause the normally closed section **154** to expand and open the passage within the insulating housing. It will be appreciated that the construction of the normally closed section **154** illustrated in FIG. **3**, is not limited to the embodiment shown in this figure, and is the preferred form of constructing the passage within the insulating housing in any of the embodiments herein described. The extended length of the normally closed section **154** (as compared with the section **54** illustrated in FIG. **2***b*) provides greater protection against the entrance of moisture or other contaminants into the interior of the insulating housing **34**.

In the modified form of the invention illustrated in FIG. **4**, the connector component **16** is provided with a plurality of circumferentially spaced fingers **106**, and a modified receptacle **266** at the end of the tool **12** is provided with an equal plurality of circumferentially spaced fingers **108** for complemental engagement with the fingers **106** upon a twisting movement of the tool **12**.

It will be appreciated that in the modified forms of the invention illustrated in FIGS. **3** and **4**, modified forms (not shown) of the covering member **98** will normally be provided for use when the connector components are interengaged to effect an electrical connection.

From the foregoing description it will be apparent that the present invention also contemplates a novel method of separating an electrical connector comprised of a pair of connector components having complementally contact elements normally disposed in interengagement which includes the steps of introducing a quantity of an arc-suppressing pressurized gas such as SF_6 into the connector, and directing the gas through one of the components and against the other of the components while surrounding the area of contact between the contact elements with the arc-suppressing gas, to shift the two components relatively away from each other.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A separable electrical connector having a pair of connector components adapted to be separated by a pressurized gas, said unit comprising:
- a first connector component comprising a first contact element and a first insulating housing in surrounding relationship thereto; and
- a second connector component comprising a second contact element configured for complemental engagement with the first contact element, and a second insulating housing in surrounding relationship to the second contact element,
- said first and second insulating housings being configured for tight complemental interengagement when said first and second contact elements are in interengagement, one of said components having passage-defining means extending therethrough and communicating with the other of said components for conveying the pressurized gas,
- said passage-defining means including a portion of one of said contact elements and a portion of the corresponding insulating housing, the passage presented by said portions communicating with the other of said contact elements whereby the introduction of said gas into the passage causes said components to shift relatively away from each other.

2. A connector as set forth in claim 1, wherein said insulating housing comprises a resiliently expansible material and said passage-defining portion thereof includes a normally closed section which is expandable by the pressurized gas to present an open passage whereby contaminants are precluded from entering the passage when the latter is not occupied by the pressurized gas.

3. A connector as set forth in claim 1, wherein said one contact element comprises an elongated annular body, and the other of said contacts comprises a cylindrical body which telescopically receives said elongated annular body in tight frictional engagement.

4. A connector as set forth in claim 3, wherein the other of said housings has a longitudinally extending opening therein, said cylindrical body being slotted at one end and received within said opening with the slotted end spaced longitudinally from the exposed end of the opening, the inner surface of said insulating housing presenting a plurality of flutes in communication with the slots in said cylindrical body and extending longitudinally away from the latter, whereby the gas emanating from said one contact element travels through said slots and along said flutes to surround said one contact element as the latter shifts relative to the other contact element.

5. An elbow connector adapted to be coupled with a complementally configured connector component and separable from the latter by a pressurized gas, the elbow connector comprising:
- contact means adapted to be coupled with the complementally configured connector component for effecting an electrical connection,
- said contact means including passage-defining means extending therethrough and communicating with said complementally configured connector component when said contact means is coupled therewith; and
- an insulating housing in surrounding relationship to said contact means,
- said housing including passage-defining means extending therethrough and communicating with the passage in said contact means for conveying the pressurized gas whereby the introduction of said gas into the passages causes said contact means to shift relatively away from said connector component.

6. An elbow connector as set forth in claim 5, wherein said insulating housing is configured for complemental engagement with said connector component.

7. An elbow connector as set forth in claim 6; and means for coupling said contact means with an electrical cable conductor within the interior of said insulating housing.

8. An elbow connector as set forth in claim 6; and means for coupling the passage-defining means of the housing with a source of pressurized gas.

9. Apparatus for introducing a gas under pressure to the interior of an electrical connector housing having a gas-conveying passage therein to facilitate breaking of the electrical connection, said apparatus comprising:
- an elongated passage-defining member,
- said member having an outer portion of insulating material;
- first means on the member for coupling one end thereof with the connector housing in sealing relationship to the gas-conveying passage;
- second means on the member for coupling the other end thereof with a source of pressurized gas; and
- valve means on the member for controlling the flow of gas through the passage in the member and into said connector housing,
- said passage-defining member comprising a tube of insulating material surrounded by a rigid body of a foam resin, said resin being enclosed within a casing of insulating material.

10. Apparatus as set forth in claim 9, wherein said first means comprises a receptacle of resilient insulating material configured to surround a portion of the connector housing in tight complemental engagement, and a nipple disposed within the receptacle for penetrating said connector housing.

11. Apparatus as set forth in claim 9, wherein said second means comprise a threaded nipple.

12. A gas-operated electrical connector unit having a pair of connector components adapted to be separated by a pressurized gas, said unit comprising:
- a first connector component comprising a first contact element and a first insulating housing in surrounding relationship thereto;
- a second connector component comprising a second contact element configured to complemental engagement with the first contact element, and a second insulating housing in surrounding relationship to the second contact element,
- one of said components having passage-defining means extending therethrough and communicating with the other of said components;
- an elongated passage-defining member coupled with the passage of said one component in sealing relationship thereto; and
- means on the member for coupling the latter with a source of pressurized gas to cause the latter to flow through the passages in said member and said one component to cause said components to shift relatively away from each other.

13. A gas-operated elbow connector unit adapted to be coupled with a complementally configured connector component and separated from the latter by a pressurized gas, said unit comprising:
- contact means adapted to be coupled with the complementally configured connector component for effecting an electrical connection,
- said contact means including passage-defining means extending therethrough and communicating with said complementally configured connector component when said contact means is coupled therewith;

an insulating housing in surrounding relationship to said contact means,

said housing including passage-defining means extending therethrough and communicating with the passage in said contact means;

an elongated passage-defining member coupled with the passage of said insulating housing in sealing relationship thereto; and

means on the member for coupling the latter with a source of pressurized gas to cause the latter to flow through the passages in said member, said housing, and said contact element to cause the contact means and the complementally configured connector component to move relatively away from each other.

14. A connector unit as set forth in claim **13**, wherein said complementally configured connector component includes a protective insulative body having a passage-defining projection of frustoconical cross section extending therefrom, said member including an open-ended receptacle of frustoconical cross section for tight complemental engagement with the frustoconical projection and a nipple disposed within the receptacle for penetrating said projection.

15. A connector unit as set forth in claim **14**, wherein said projection and said receptacle each comprises a resilient material.

16. A connector unit as set forth in claim **15**, and means for holding said receptacle and said projection in tight interengagement.

17. A connector unit as set forth in claim **16**, wherein said holding means comprises complementally threaded portions on said projection and said receptacle respectively.

18. A connector unit as set forth in claim **16**, wherein said holding means comprises a threaded insert disposed within said projection and a complementally threaded surface of said nipple.

19. A connector unit as set forth in claim **16**, wherein said holding means comprises a plurality of fingers disposed for complemental engagement on the outer surfaces of said receptacle and said connector component respectively.

20. A method of separating an electrical connector comprised of a pair of connector components having complementally configured contact elements normally disposed in interengagement, said method comprising the steps of:

introducing a quantity of a pressurized arc-suppressing gas into said connector;

directing said gas through one of said components and against the other of said components in a direction to shift said components relatively away from each other; and

surrounding the area of contact between said contact elements with said arc-suppressing gas.

21. A method as set forth in claim **20**, wherein said step of introducing a pressurized gas includes introducing an arc-suppressing gas into said connector.

22. A method as set forth in claim **21**, wherein said step of introducing an arc-suppressing gas includes introducing SF_6 into said connector.

23. A separable electrical connector having a pair of connector components adapted to be separated by an arc-suppressing pressurized gas, said unit comprising:

a first connector component comprising a first contact element and a first insulating housing in surrounding relationship thereto; and

a second connector component comprising a second contact element configured for complemental engagement with the first contact element, and a second insulating housing in surrounding relationship to the second contact element,

one of said components having passage-defining means extending therethrough, communicating with the other of said components and located to convey the pressurized gas to the region of interengagement of said contacts in a direction to cause the introduction of said gas into the passage to shift said components relatively away from each other.

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