United States Patent [19]

Kinnear

[11] **3,813,638**

[45] **May 28, 1974**

[54] **CABLE CONNECTOR**

[76] Inventor: **Joseph D. Kinnear,** 3019 E. Miles Rd., Warren, Mich.

[22] Filed: **Apr. 18, 1972**

[21] Appl. No.: **245,138**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 57,568, July 23, 1970, abandoned.

[52] **U.S. Cl.** ..... **339/64 R,** 339/186 R, 339/255 R

[51] **Int. Cl.** **H01r 13/62**

[58] **Field of Search** 339/59–61, 339/64–66, 186, 187, 255

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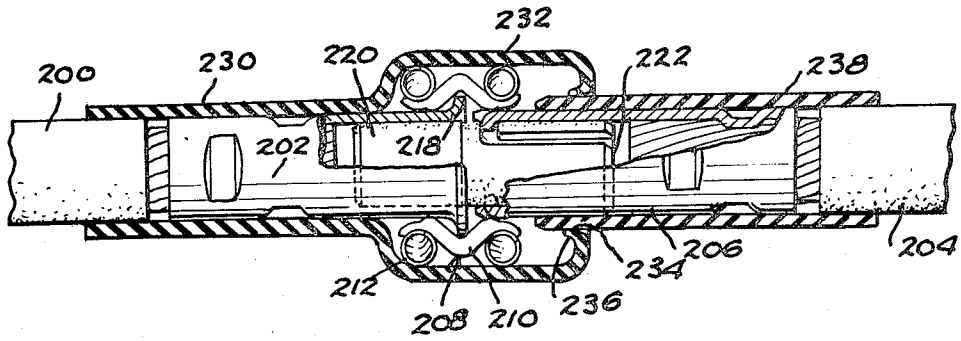
[57] **ABSTRACT**

An electrical connector having a pair of telescopically engageable housings in which the ends of single or double pole conductors to be connected are enclosed. A tulip-type connector is mounted on the enclosed end of one of the conductors for engagement with the end of the other conductor when the housings are telescopically engaged. The operative end face of the housing enclosing the tulip connector is constructed to present a dead front to prevent accidental contact with the live conductor with one's finger or a tool, such as a screwdriver. The housings and the ends of the conductors are constructed to minimize arcing between the conductors to a maximum extent when the connector is coupled and uncoupled under load.

32 Claims, 25 Drawing Figures



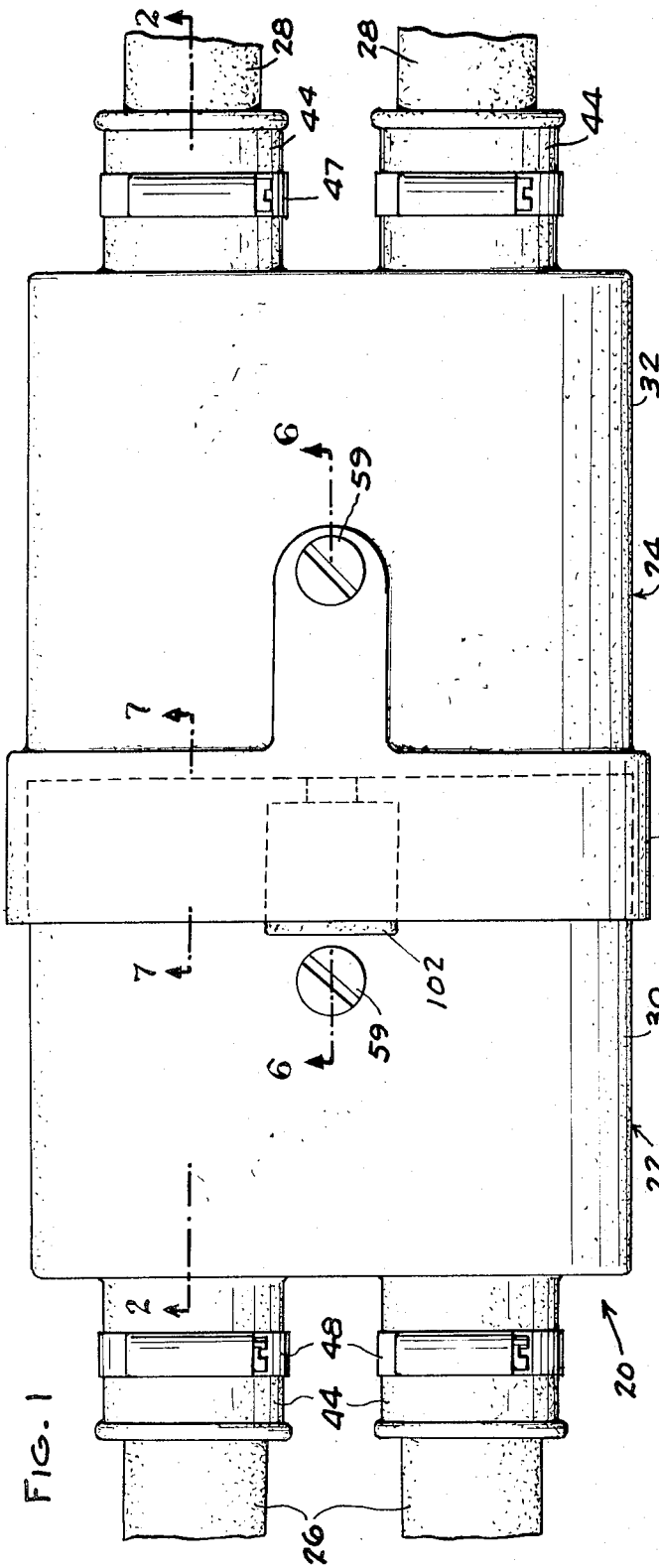


FIG. 1

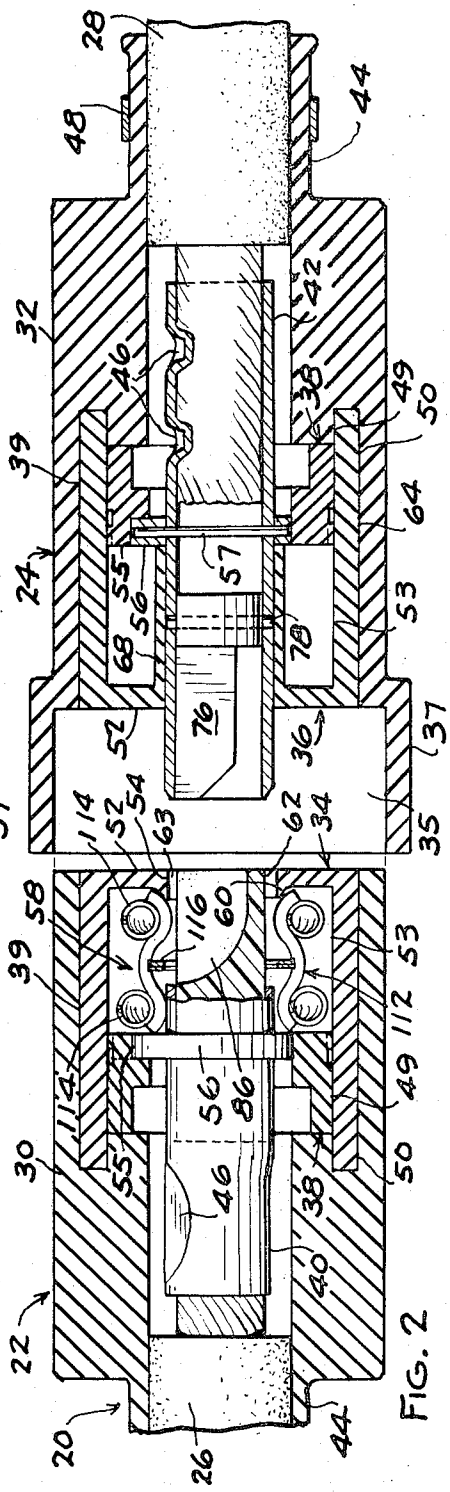


FIG. 2

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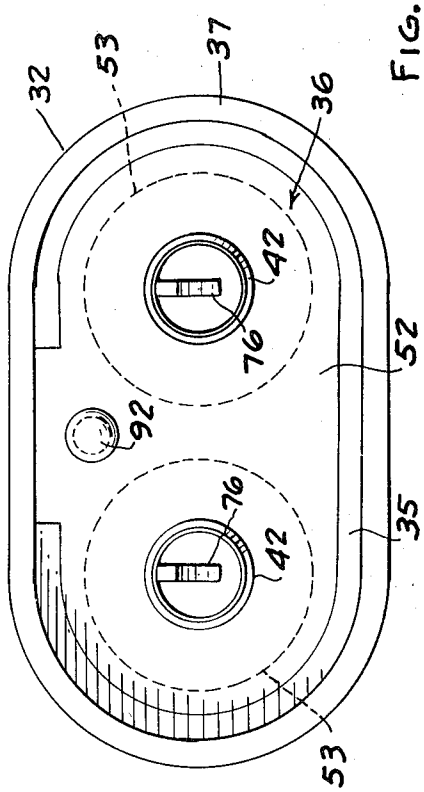

FIG. 4

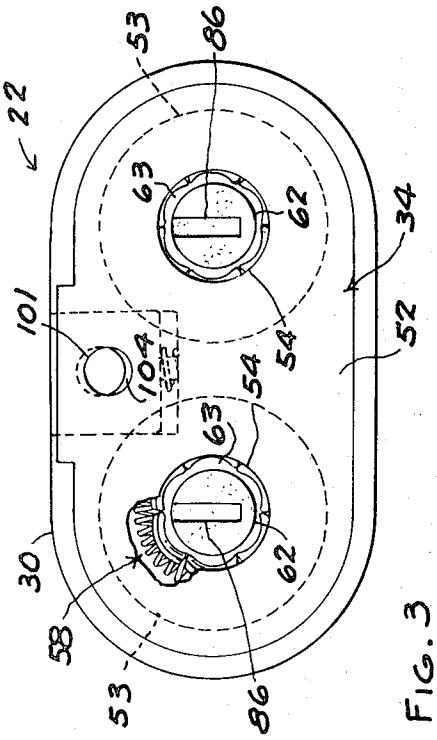

FIG. 3

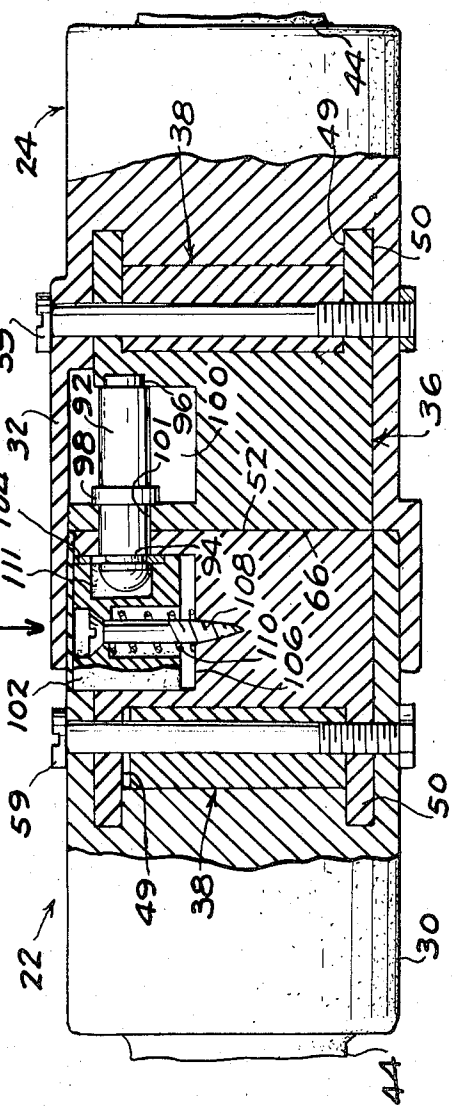

FIG. 6

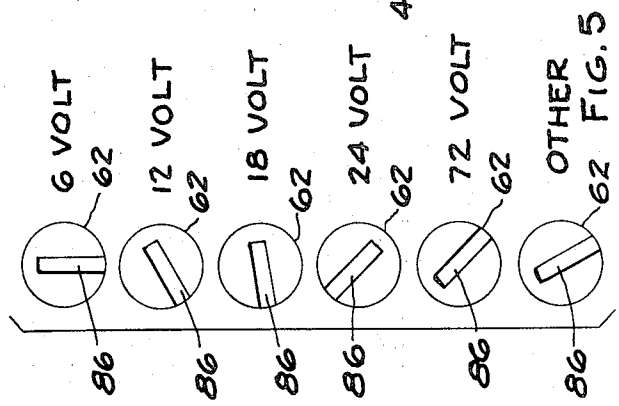

FIG. 5

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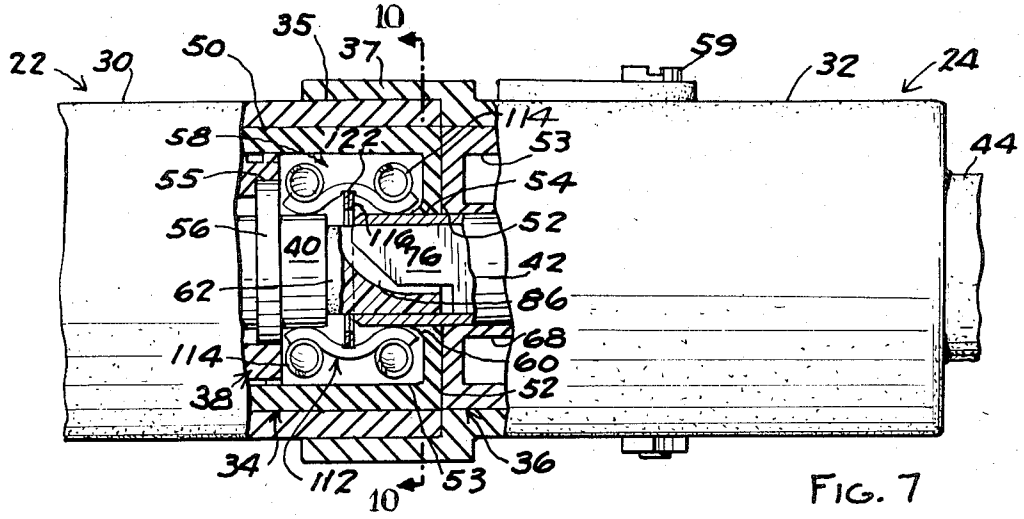

FIG. 7

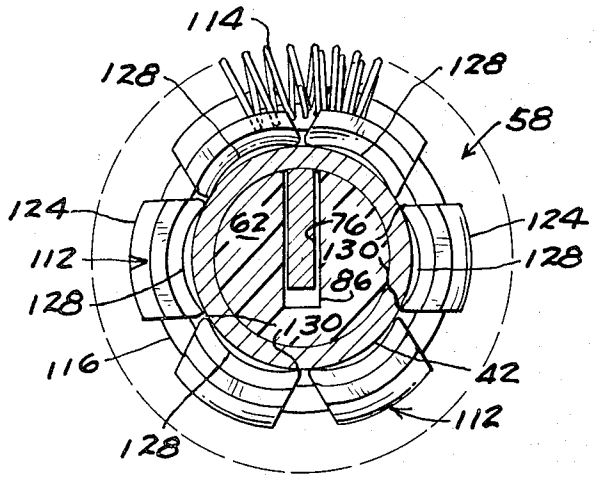

FIG. 10

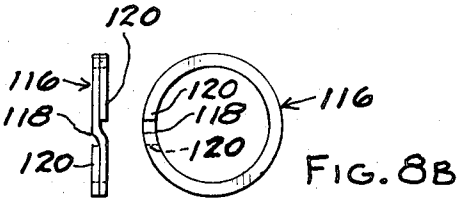

FIG. 8B

FIG. 8A

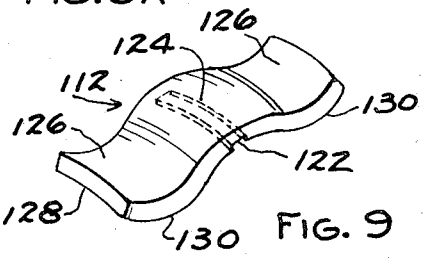

FIG. 9

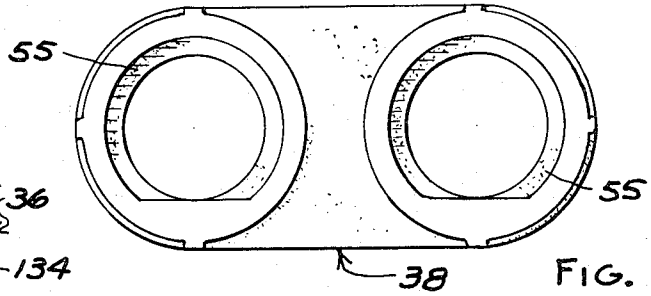

FIG. 12

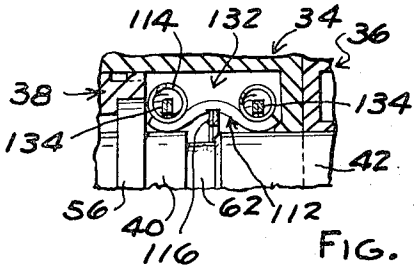

FIG. 11

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FIG. 13

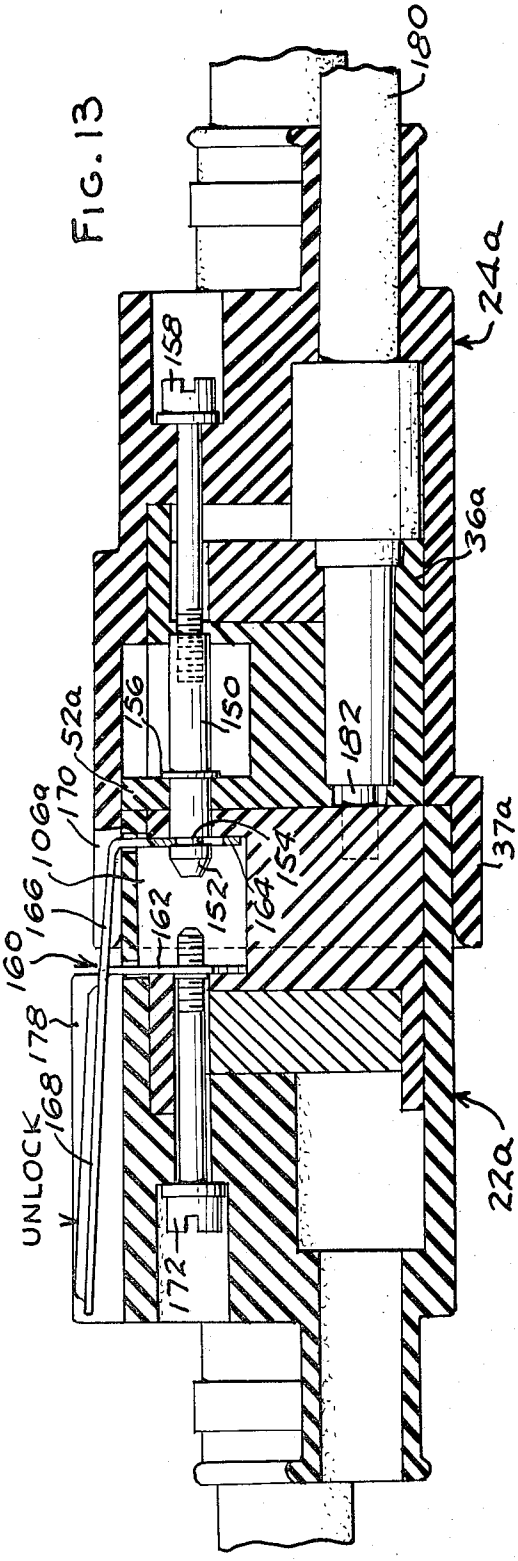


FIG. 14

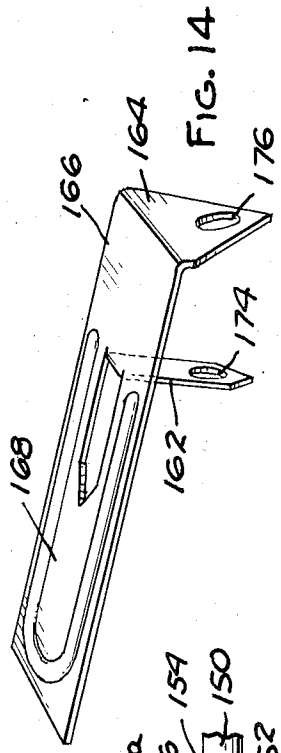


FIG. 16

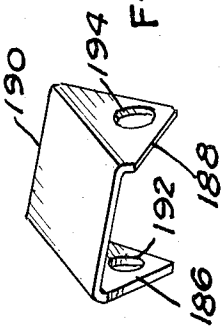


FIG. 15

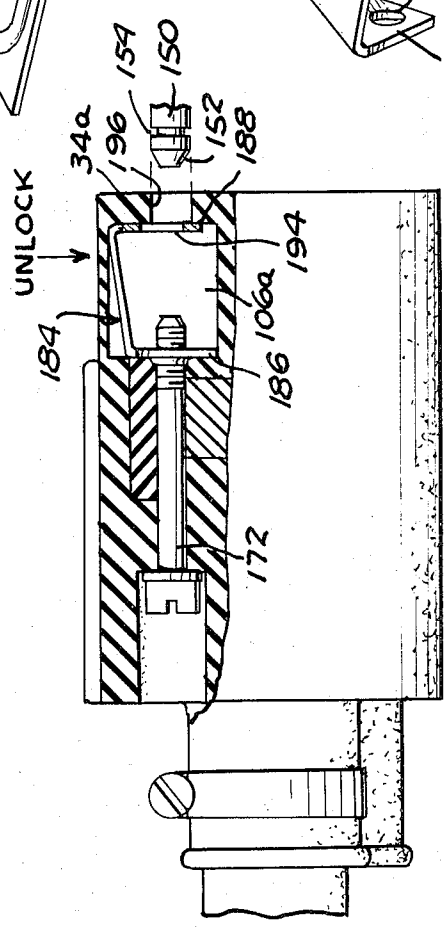
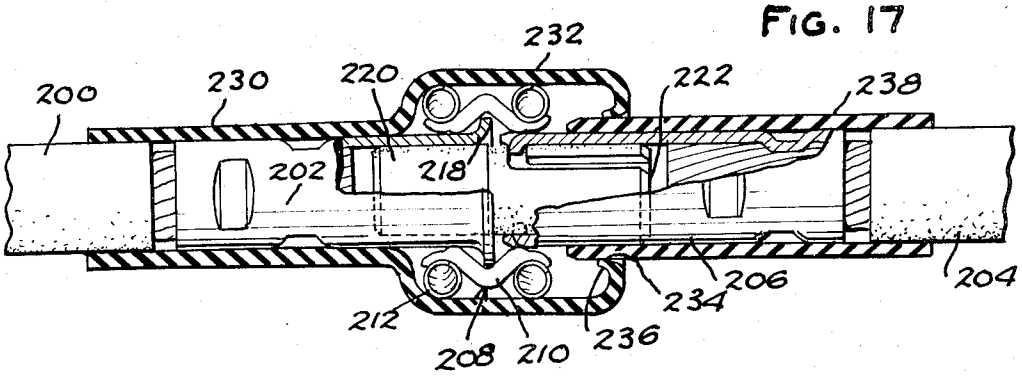


FIG. 17



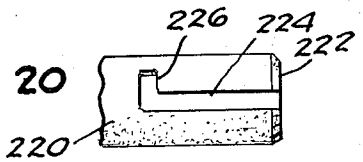


FIG. 20

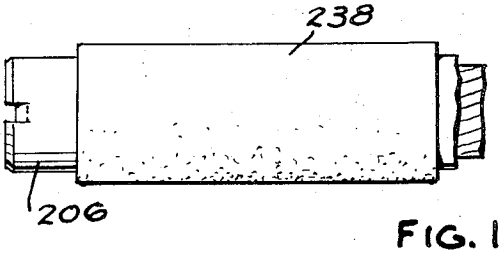


FIG. 18

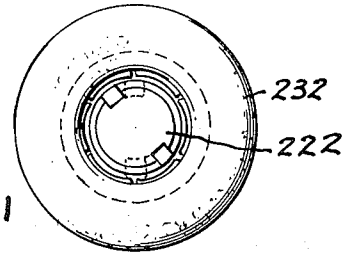


FIG. 21

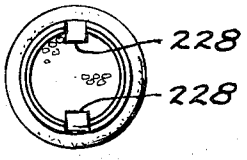


FIG. 19

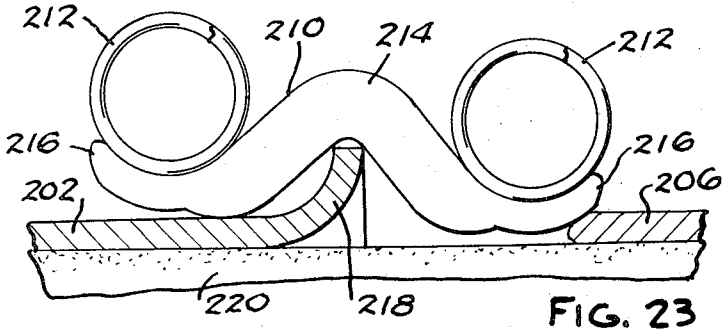


FIG. 23

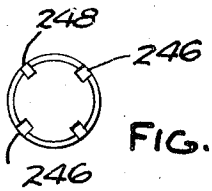


FIG. 22

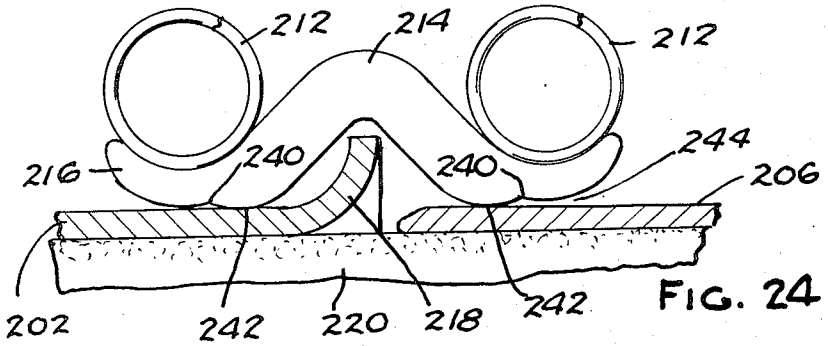


FIG. 24

CABLE CONNECTOR

This application is a continuation-in-part of my prior co-pending application Ser. No. 57,568, filed July 23, 1970, now abandoned.

This invention relates to electrical connectors and more particularly to a device for releasably coupling or connecting electric power cables and the like.

The connector of this invention is usable for releasably connecting electric cables to each other and to control or other electric panels, and is particularly suitable for releasably connecting cables adapted to carry rather low voltage, high current loads in the range of 200 to several thousand amperes. Such cables are usually used to carry a direct current although the coupler of this invention is suitable for use with both alternating and direct current sources. This coupler is particularly useful on battery-operated electric industrial lift trucks, heavy duty welders and other electrical devices with high current loads requiring a disconnect from their electrical power source.

Objects of this invention are to provide a coupling device for heavy current loads which can be readily connected and disconnected, which has a dead front providing improved safety characteristics such that the electrical conductors cannot be accidentally touched, in which a male or female conductor cannot be coupled with a conductor carrying a current at another or opposite potential (thereby preventing accidental coupling of cables to improper power sources), which inhibits the tendency to arc and burn the conductors when connected and disconnected under load without diminishing the load carrying capacity (thereby decreasing the safety hazard to persons manipulating the connector and substantially increasing its useful life), and to provide a compact connector of economical construction and assembly which can be easily serviced and maintained.

These and other objects, features and advantages of this invention will be apparent from the following description and accompanying drawings, in which:

FIG. 1 is a plan view of a double pole connector embodying this invention shown in the coupled condition.

FIG. 2 is a sectional view on line 2—2 of FIG. 1 illustrating the connector in the uncoupled or disconnected condition.

FIGS. 3 and 4 are end views of the confronting faces of the two housings of the connector.

FIG. 5 is a fragmentary semi-schematic view of the means employed for assuring connection to the proper power source.

FIG. 6 is a fragmentary side elevational view with a cut away section on line 6—6 of FIG. 1 illustrating a latch mechanism for releasably securing the two housings of the connector in coupled condition.

FIG. 7 is a fragmentary side elevational view with a cut away section on line 7—7 of FIG. 1 illustrating the component parts of the conductor receptacles and plugs and the housings in coupled condition.

FIGS. 8A and 8B are end and side elevational views respectively of a spacer ring in the tulip connector assembly.

FIG. 9 is an isometric view of a petal of the tulip connector assembly.

FIG. 10 is a sectional view on line 10—10 of FIG. 7.

FIG. 11 is a fragmentary sectional view similar to the sectional portion of FIG. 7 illustrating a modified form of tulip assembly.

FIG. 12 is an end view of a carrier for the conductors of the connector device.

FIG. 13 is a sectional view somewhat similar to FIG. 6 but showing a modified form of latch assembly for retaining the two housings in locked conductor-connecting condition.

FIG. 14 is a perspective view of the spring latch shown in FIG. 13.

FIG. 15 is a side view, partly in section, of a cable connector housing showing a further modified form of latch.

FIG. 16 is a perspective view of the spring latch shown in FIG. 15.

FIG. 17 is a longitudinal sectional view, with parts broken away, showing a single pole connector according to the present invention of modified construction.

FIG. 18 is a fragmentary view of one of the tubular connectors shown in FIG. 17.

FIG. 19 is an end view of the conductor shown in FIG. 18.

FIG. 20 is a fragmentary side elevational view of the pilot pin on the other conductor illustrated in FIG. 17.

FIG. 21 is an end view of the component shown at the left of the assembly illustrated in FIG. 17.

FIG. 22 shows a modified form of tubular conductor somewhat similar to that illustrated in FIG. 19.

FIGS. 23 and 24 show a modified form of tulip connector and the manner in which it is engaged with one of the tubular conductors.

As shown in FIGS. 1 and 2, a connector device 20 embodying the invention includes housings 22 and 24, each attached to a pair of cables 26 and 28 respectively. Both housings include hollow outer boots 30 and 32 of a resilient supple nonconductive material, such as rubber, in which rigid bodies or shells 34 and 36 of a nonconductive material are slidably received. The front end portion of housing 22 is slidably received in an opposed front end pocket or socket 35 of housing 24. Socket 35 is defined in part by a continuous integral peripheral wall 37 providing a generally airtight seal between the coupled housings. Identical rigid carriers 38 (specifically shown in FIG. 12) of a nonconductive material mount two pair of axially aligned tubular conductors or contacts 40 and 42 in boots 30 and 32. Insulated cables 26 and 28 are received in tubular necks 44 of boots 30 and 32 and are mechanically and electrically connected to contacts 40 and 42 by crimps or indentations 46. Cables 26,28 are mechanically secured and sealed airtightly to boots 30 and 32 by hose-type clamps 48 encircling necks 44.

As shown in FIGS. 2, 3, 4, 6 and 7, the rear or inner end portions 49 of shells 34 and 36 are generally hollow with an outer sidewall 50. The front of outer ends of shells 34,36 are defined by an end wall 52. A pair of laterally spaced cylindrical recesses 53 extend between end wall 52 and the hollow portion 49 at the rear of each shell. Carriers 38 are slidably received in the hollow portions 49 of shells 34,36. Conductor contacts 40,42 are mounted in the shells by D-rings 56. As shown in FIG. 12, each carrier 38 has two D-shaped recesses 55 to receive and retain D-rings 56 which are fixed to conductors 40 and 42 by pins 57 (FIG. 2).

Shells **34,36** and their carriers **38** are fixed with respect to each other and secured in boots **30,32** by bolt and nut assemblies **59** (FIG. **6**). Thus, the tubular conductors **40,42** are prevented from rotating relative to boots **30,32.**

As shown in FIGS. **2** and **3,** a radially resilient conductive connector sleeve in the form of a tulip connector assembly, designated generally as **58,** engages the outer cylindrical surface at the free end of each conductor contact **40** and each is received in one of the cylindrical recesses **53** of shell **34.** Access holes **54** in end wall **52** of shell **34** are concentric with each tubular contact **40,** and the free end of tulip connector **58** engages a ridge or rim **60** on the inside of wall **52** around each hole **54** to retain the tulip connectors **58** concentric with holes **54.** A guide pin **62** of an electrically nonconductive material such as nylon is received within each tubular contact **40.** Each guide pin is fixed against axial and rotative movement within its tubular conductor. Each guide pin **62** extends coaxially into a hole **54** in wall **52** of shell **34** and terminates at its forward end essentially flush with the front face of shell **34.** The extension of pins **62** into holes **54** totally encloses contacts **40** and tulip connectors **58** in housing **22** except for two very narrow ring-like openings **63** (FIG. **2**) formed between the pins and the edges of the holes which provide a dead front for housing **22.** This dead front eliminates the risk of a person accidentally contacting contacts **40,** thereby reducing the hazard of electrical shock and injury to persons using connector **20.** For example, if cables **26,28** are of 4/0 size, contacts **40** would have a diameter of about ¾ inches. However, the wall thickness of conductor **42** would be on the order of 1/16 inches and the width of annular openings **63** would be on the order of 3/32 inches. This relatively narrow opening coupled with its circular contour precludes accidental or otherwise insertion of a person's finger or a tool (such as a screwdriver) into openings **63** into contact with petals **112** of the tulip connector. Each tulip **58** is prevented from shifting axially in its pocket **53** beyond a very slight extent by abutment with end wall **52** and D-ring **56.**

As shown in FIGS. **2** and **4,** the two tubular contacts **42** associated with housing **24** are axially received in recesses **53** by tubular guides **68** which are formed as integral rearward extensions on wall **52** of shell **36.** Contacts **40** are prevented from shifting axially by abutment of D-rings **56** with guides **68** and carrier **38.** The free end of each contact **42** extends forwardly beyond shell **36** and into pocket **35** to provide a tubular male plug engageable in the female receptacle formed by each tulip **58,** guide pin **62,** and contact **40.** A key **76** extends axially in each contact **42** and is fixed therein by a pin **78.** When the housings are coupled (as shown in FIG. **7**) each tubular plug portion of conductor **42** is received on guide pin **62** and extends through opening **54** and engages the free end of tulip assembly **58.** Key **76** is received in a properly radially oriented axially extending slot **86** in guide pin **62.** As shown in FIG. **5,** contacts **40,42** can be rotatably oriented relative to D-rings **56** so that their slots **86** and keys **76** assume different angular positions which are related to the particular voltage of the cables with which the connector device is used. The different angular orientation of slots **86** and keys **76** for each voltage prevents a housing of one cable from being coupled with a mating housing of another cable at a different voltage which avoids connecting a load with a source of power at an incorrect voltage. The angular position of keys **76** and slots **86** is fixed by the angular position in which D-rings **56** are secured to contacts **40** and **42** since the D-rings are restrained from rotation by the correspondingly shaped recesses **55** in carriers **38.** By using D-rings **56** to retain slot **86** and key **76** in any predetermined angular position, the assemblies of contact **40** and pin **62** and assemblies of contact **42** and key **76** can be identical regardless of the eventually desired position of angular orientation.

As shown in FIG. **6,** housings **22,24** can be releasably retained in the coupled position by a latch pin assembly. A latch pin **92** with a groove **94** adjacent its leading end, a reduced shank portion **96** adjacent the other end, and an intermediate shoulder **98** is retained in a pocket **100** in shell **36** with its free leading end projecting forwardly through an opening **101** in wall **52** of shell **36.** A plunger **102** is slidably retained in a pocket **106** in shell **34** by a screw **108** and is biased upwardly by a spring **110.** Plunger **102** is formed with cavity **111** axially aligned with the forward end of pin **92.** When housings **22,24** are telescopically engaged pin **92** is adapted to project into pocket **106** and groove **94** is engaged by a ring **104** on plugner **102** which is depressed by the tapered end of pin **92** to releasably latch the housings together.

Tulip connector **58,** as shown in FIGS. **2, 7** and **10,** has a plurality of conductive metal petals **112** of identical shape and size arranged in a generally parallel edge abutting spatial circular or tube-like shape. Petals **112** are urged radially inward into edge abutting relationship by a pair of garter springs **114** bearing on their outer periphery adjacent their free ends. One end of each garter spring is threaded within its other end (as shown in FIG. **10**) so that the spring will exert a substantially equal radially inward force on each petal **112.** A spacer ring **116** is centrally received within petals **112** in a plane generally perpendicular to the longitudinal axis of the tulip connector to stabilize the assembly of petals **112** so that it will not be readily collapsed by a radially inward force applied locally on the outer periphery of the petals **112.** As shown in FIG. **8** spacer ring **116** is wound from a generally flat strip of metal with a rectangular cross section and has as shown in FIGS. **8A** and **8B** an offset central portion **118** with the free ends **120** of the metal strip terminating adjacent the offset on opposite sides thereof so that the ring has a substantially uniform thickness throughout its periphery. Each petal **112** has in the central portion on the interior side a generally transverse groove **122** adapted to engage in assembly with the sidewalls of spacer ring **116.** Engagement of spacer ring **116** in grooves **122** aligns petals **112** so that they extend longitudinally generally parallel to each other and restrains the petals from being longitudinally displaced with respect to each other so that their opposite ends will remain circumferentially aligned and terminate in substantially a single plane perpendicular to the longitudinal axis of the tulip connector.

Petals **112** are formed with a generally sinuous longitudinal cross section defined by a central outwardly curved portion **124** and reverse curved portions **126** adjacent their free ends adapted to provide annular seats for springs **114.** As shown in FIG. **10,** the radially inner surface of end portions **126** has a radius of curvature as at **128** in a plane perpendicular to the longitudi-

nal axis of petal **112** smaller than the outer radius of tubular contacts **40,42.** The smaller radius of curved surface **128** provides each petal with two points or surfaces of contact **130** adjacent each end thereof for engagement with contacts **40,42.** Providing each petal with two distinct points of contact **130** with each contact **40,42** reduces the tendency and severity of arcing when connector **20** is coupled and uncoupled under load because it provides a plurality of electrically conductive paths on each petal **112.** The smaller radius of the petals also enables the number of petals used in the tulip to be increased to accomodate larger size conductors. The tendency and severity of arcing is also decreased by the use of guide pin **62** and opening **54** in shell **34** to axially align the male tubular plug of contact **42** so that it engages and disengages all of the petals **112** of tulip assembly **58** at substantially the same time. The use of rim or ridge **60** adjacent the inner side of opening **54** to align the free end of all of petals **112** of tulip assembly **58** so that they are coaxial with opening **54** and pin **62** also decreases the tendency and severity of arcing when connector **22** is coupled under load. The tendency for arcing is also reduced by the fact that when the connector is coupled or uncoupled the opposite ends of the tulip petals abut and are aligned in the same vertical plane perpendicular to the longitudinal axis of the tulip connector by the inner face of wall **52** and D-ring **56.**

When housings **22,24** are coupled, flexible wall **37** provides a substantially airtight seal enclosing the conductors in boots **30,32** so that a partial vacuum is created within the enclosure by separation of the male and female housings. This partial vacuum also decreases the tendency and severity of arcing when connector **20** is uncoupled under load.

A slightly modified form of a tulip connector designated generally as **132** is shown in FIG. **11.** Tulip assembly **132** has petals **112,** a spacer ring **116** and garter springs **114** identical to tulip connector **58.** To further stabilize petals **112** so that they cannot be easily collapsed by an application of radially inward force on one end of the petals, retainer rings **134** are inserted in garter springs **114.** Retainer rings **134** have substantially the same form as spacer ring **116** with an offset center portion and free ends terminating adjacent the offset portion on opposite sides thereof. When a radially inward force is applied to one end of a petal **112,** the retainer ring **134** adjacent the opposite end of the petal prevents the petal from excessive pivoting about spacer ring **116** and disengaging from edge abutting relationship with its adjacent petals. If a petal is disengaged from edge abutting relationship with its adjacent petals, the tulip connector will usually collapse. Thus, retainer rings **134** tend to stabilize tulip connector **132** when one or both ends are disengaged from contacts **40,42.**

In using the connector device **20** to couple or electrically connect two pair of cables **26,28,** housing **22** is slidably inserted fully into pocket **82** of housing **24.** As housing **22** is inserted into housing **24** pilot and guide pins **62** engage in the free ends of tubular contacts **42** and coaxially align the contacts with the free ends of tulip connectors **58.** As pointed out, this decreases the tendency and severity of arcing if conductors **40,42** are electrically connected and disconnected under load. Further engagement of housing **22** in housing **24** causes the free end of the petals **112** of tulip connectors **58** to engage the outer cylindrical surface of contacts **42,** thereby electrically connecting each contact **42** with its corresponding contact **40.** Preferably, the petals **112** of each tulip connector have two points of engagement or contact at each end with contacts **40,42** which tends to increase the current carrying capacity of connector device **20** and to decrease the tendency of arcing and the severity of arcing if contacts **40,42** are electrically connected and disconnected under load. As housing **22** becomes fully engaged in housing **24** the free end of latch pin **92** engages ring **104** moving plunger **102** initially downward (FIG. **6**) and then allowing plunger **102** to snap upward as the bottom portion of ring **104** engages in groove **94** to lock housings **22,24** together in the fully coupled position.

To disengage housings **22** and **24** and electrically disconnect conductors **40** and **42,** plunger **102** is manually pushed downward against the bias of its spring **110** by applying pressure in the direction of the arrow in FIG. **6** on the portion of flexible wall **84** above plunger **102** to disengage ring **104** from latch pin **92** so that the housings can be manually separated. As the housings are separated the free end of each contact **42** slidably disengages from all of the petals **112** of its corresponding tulip connector **58** simultaneously, thereby electrically disconnecting contacts **40,42.** Withdrawal of each contact **42** from its associated tulip assembly **58** allows the free end of the tulip to engage with ridge **60** so that it will be coaxially aligned with its associated guide pin **62** and hole **54,** thereby decreasing the tendency and severity of arcing if contacts **40,42** are subsequently coupled under load. Separation of housings **22** and **24** also creates a partial vacuum reducing the tendency and severity of arcing if contacts **40,42** are electrically disconnected under load.

It will be understood that in the arrangement illustrated cables **26** would be electrically connected to a power source and cables **28** would be connected to the load to be supplied with power.

The embodiment illustrated in FIG. **13** is in general similar to the overall arrangement illustrated in FIG. **6.** The general design of housing **22*a*** and the internal components thereof follow closely the general design of housing **22** and the components thereof. Likewise, the general design and the internal components of housing **24*a*** follow closely the general design of housing **24** and the internal components thereof. However, in the modified construction shown in FIG. **13** the latch assembly for retaining the two housings in the locked condition comprises a stud **150** which extends through the front wall **52*a*** of shell **36*a*** and is provided with a tapered free end **152** and an annular groove **154** which is flush with the inner face of the front wall of pocket **106*a*.** Stud **150** is retained in housing **24*a*** by a snap ring **156** and a screw **158.**

Within pocket **106*a*** there is arranged a spring latch **160** having resilient ears **162,164** projecting downwardly into pocket **106*a*** and connected by a resilient bight portion **166** formed with a handle extension **168.** As shown in FIG. **14,** resilient ears **162,164** depend from bight portion **166** in a somewhat divergent manner so that the lower pointed ends of these spring ears must be squeezed together in order to insert them in pocket **106*a*.** The peripheral wall **37*a*** of housing **24*a*** is cut away as at **170** and the top wall of pocket **106*a*** is correspondingly slotted to accommodate latch **160.** When spring ears **162,164** are inserted in pocket **106*a***

latch **160** is locked in place by a screw **172** which threads through an opening **174** in spring ear **162.** In this free relaxed position of the spring latch the opening **176** in spring ear **164** is offset downwardly from the end **152** of pin **150** and handle **168** simply overlies the outer portion of housing **22***a* in somewhat spaced relation thereto. However, it is prevented from being accidentally depressed by a pair of upstanding ribs **178** on housing **22***a* which straddle the opposite side edges of handle **168.** When it is desired to release the two housings, handle **168** is depressed to resiliently urge spring ear **164** upwardly to a position wherein the upper edge of opening **176** in ear **164** is retracted from annular groove **154** and opening **176** is shifted upwardly to a position where it is concentric with and capable of enabling pin **150** to be retracted therefrom. When the two housings are in the separated condition the tapered end **152** engages the offset upper edge of opening **176** to resiliently displace ear **164** upwardly and when the housings are fully telescoped together the upper edge of opening **176** snaps into engagement with annular groove **154** to retain the housings in the locked condition.

In the arrangement illustrated in FIG. **13** an additional conductor **180** is assembled within and projects from housing **24***a*. Adjacent the front face **52***a* of shell **36***a* conductor **180** has a spring-biased plunger **182** which is depressed to a circuit closing position when the two housings are locked together.

The modification shown in FIG. **15** differs from that shown in FIG. **13** primarily in that the spring latch **184** is merely U-shaped having a pair of resilient ears **186** and **188** which are connected by a bight portion **190** and which in the free position depend from bight portion **190** in a slightly divergent direction. When ears **186,188** are slightly compressed latch **184** is adapted to be inserted in pocket **106***a* and retained therein by screw **172** which threads into an opening **192** in spring ear **186.** It will be observed that in the normal free position of latch **184** bight portion **190** is biased so that it extends upwardly from ear **186** to ear **188** and that the opening **194** in spring ear **188** is offset axially upwardly from opening **196** in the front wall of shell **34***a* which is adapted to accommodate pin **150.** Thus, to interlock the two housings they are telescoped together to a position wherein the tapered end **152** of pin **150** urges the lower edge of opening **194** downwardly to displace ear **188** downwardly so that the opening therein registers with pin **150.** As soon as ear **188** registers axially with slot **154** in pin **150** the spring bias of latch **184** displaces ear **188** upwardly to interengage the lower edge of opening **194** with annular groove **154** and thus lock the two housings together. Obviously once locked the two housings can be separated by merely depressing on the forward portion of the bight portion **190** of latch **184** to shift ear **188** downwardly to a position wherein opening **194** is coaxially aligned with pin **150.**

In the previous embodiments illustrated the cale connectors were of the dual pole type; namely, connectors for electrically connecting two conductors of opposite polarity in one housing with two other conductors of opposite polarity in the other housing. In FIG. **17** there is illustrated a single pole conductor; namely, a conductor for simply electrically connecting two conductors of the same polarity. Thus, there is illustrated a cable **200** having a tubular conductor **202** crimped or otherwise secured to the bared end thereof and a second cable **204** having a tubular conductor **206** crimped or otherwise connected to the bared end thereof. As in the previous embodiment the connector illustrated in FIG. **17** includes a radially resilient conductive connector sleeve in the form of a tulip connector generally designated **208.** Tulip connector **208** is similar in most respects to the tulip connector previously described in that it includes a plurality of conductive metal petals **210** of identical shape and size arranged in generally parallel edge abutting spatial circular or tubular shape. Petals **210** are urged radially inwardly into edge abutting relationship by a pair of garter springs **212.** Each petal **210** has a centrally outwardly bowed portion **214** (FIG. **23**) with reversely bent end portions **216** in which the garter springs **212** are seated. Tulip connector **203** is mounted on the leading end of tubular conductor **202** by flaring the leading open end of conductor **202** outwardly as indicated at **218** in FIGS. **23** and **24.** The flared end **218** of conductor **202** generally serves the same function as spacer ring **116** shown, for example, in FIG. **2.** In addition, it automatically provides yieldable connection between the tulip connector and conductor **202.**

A nonconductive pilot pin **220** is press fitted or otherwise fixed into the open leading end of conductor **202.** As shown in FIG. **17,** pin **220** extends axially beyond the flared end **218** of conductor **202** and terminates at its slightly tapered leading end designated **222.** In the arrangement illustrated in FIGS. **17** through **21,** pilot pin **220** has a pair of diametrically opposite axially extending grooves **224** on the outer surface thereof. Grooves **224** extend axially inwardly from the leading end **222** of pilot pin **220** and at the axially inner end these grooves have circumferential extensions **226.**

The other conductor **206** has a pair of diametrically opposite inwardly extending lugs **228** which are dimensioned to be snugly received in grooves **224** in pilot pin **220.** When conductor **206** is telescoped into engagement with tulip connector **208** to a position wherein lugs **228** advance to the inner ends of grooves **224,** the leading end of conductor **206** is firmly engaged with the petals of tulip connector **208** and the two conductors can be relatively rotated in opposite directions to interengage lugs **228** with the circumferential extension **226** of grooves **224.** This effectively couples cables **200** and **204** together and prevents accidental disconnection thereof. It also prevents interconnection of two cables of different polarities where the lugs **228** and slots **224** would be so designed as to prevent their interengagement.

The arrangement illustrated in FIG. **17** incorporates several features which tend to minimize arcing when the conductors are connected and disconnected. One of these features has to do with the provision of an insulating sheath **230** formed of rubber or other suitable material which is molded or otherwise applied to cable **200** so as to enclose conductor **202** and tulip connector **208.** It will be noted that the enlarged portion **232** of sheath **230** extends well beyond tulip connector **208** and terminates just short of the leading end **222** of pilot pin **220.** The forward end of sheath **230** is formed with a circular opening **234** provided with a thin tapered and deflectable lip **236.** The other cable **204** is enclosed with a cylindrical sheath **238** which terminates short of the leading end of conductor **206** as illustrated in FIG. **17.** The outer diameter of sheath **238** and the diameter of opening **234** as defined by lip **236** is such that when

the two cables are connected as shown in FIG. 17 the chamber formed by the enlarged portion 232 of sheath 230 is substantially airtight. Thus, when the cables are disconnected, separation of the two conductors 202,206 creates a partial vacuum in the chamber formed by the enlargement 232 on sheath 230 which tends to minimize arcing between the conductor 206 and the petals 210 of tulip connector 208. In addition, as more specifically shown in FIGS. 23 and 24, the outwardly bowed portion 214 of each petal 210 is substantially thicker than the reversely bent portions 216 of these petals. Furthermore, the outer surface of these petals forms a smooth continuous curve whereas the radially inner surfaces of these petals define curves which have a rather abrupt intersection as at 240. Thus, the opposite end portions of each petal between intersections 240 and the free ends of the petal are not only thinner than the remaining central portion but also define a circle of slightly greater inner diameter than the curved portions 242 of minimum inner diameter of the tulip connectors. The advantage of this construction is shown in FIG. 23 where it can be seen that as soon as the leading end of conductor 206 comes into engagement with the corresponding end of tulip connector 208 it engages the thinner reversely bent portions 216 of each petal. If any arcing occurs it occurs at this instant where initial contact is made between conductor 206 and the petals of the tulip connector. However, if the conductor is advanced into the tulip connector after initial contact is made, it engages with the thickened curved portions 242 of the petals and there is a slight clearance indicated at 244 in FIG. 24 between the conductor and the thinner end portions 216. Thus, the current is conducted from conductor 206 to conductor 202 through the thicker, and therefore greater, current carrying capacity central portions of the petals. Likewise, when the two housings are separated the two conductors retract from one another from the position shown in FIG. 24 to that shown in FIGS. 23. Conductor 206 remains in contact with each petal 210 until contact is broken with the thinned end portion 216 of each petal. Accordingly, if arcing occurs it occurs between the conductor and the thinned end portion. Thus, while a certain amount of arcing may be inevitable when the conductors are connected and disconnected under heavy loads, nevertheless the portions of the petals and of the conductors which are subject to arcing are not operative for conducting current when the two conductors are fully connected.

In the event that an arrangement such as shown in FIG. 17 is utilized for interconnecting two sets of cables of different polarity it is important that the two negative cables be properly connected and the two positive cables be properly connected. Under such circumstances one set of conductors would have the lug and groove arrangement shown in FIGS. 18 thru 21 and the other two cables would have the lug and groove arrangement shown in FIG. 22. In the latter arrangement two diametrically opposed lugs 246 would be wider than the other two diametrically opposed lugs 248. Likewise, the four grooves in the pilot pin of the other conductor would be similarly arranged and dimensioned so that lugs 246 could only interfit with the two wider grooves (similar to grooves 224 in FIG. 20). This would prevent interconnection of a cable of positive polarity with another cable of negative polarity.

I claim:

1. An electrical connector comprising first and second conductors each having an axially extending cylindrical exterior surface, a resilient connector sleeve electrically connected on one end of the first conductor, said connector sleeve comprising a plurality of axially extending conductive petals arranged in generally circular spatial relation and biased radially inward, each of said petals adjacent one end thereof being adapted to be telescoped over a frictionally engaged with said cylindrical surface of the second conductor, a pilot pin of nonconductive material extending axially from and beyond the leading end of one of said conductors and a co-axial socket at the leading end of the other conductor, said socket being adapted to slideably receive said pin for coaxially aligning said cylindrical surface of the second conductor with said petals of said connector sleeve prior to and during axial movement of said cylindrical surface of said second conductor into telescopic engagement with said petals of said connector sleeve.

2. The electrical connector of claim 1 in which each of said petals has two points of contact adjacent each end thereof with said cylindrical surface of said conductors.

3. The electrical connector of claim 1 which also comprises a key mounted in a radially extending predetermined angular orientation in said socket and a slot in a corresponding angular orientation in said pin to slidably receive said key.

4. The electrical connector of claim 1 wherein the petals of said connector sleeve resiliently engage the outer cylindrical surface of said end of said first conductor, said petals being biased radially inwardly by springs which encircle the petals and cause the axially extending edges thereof to abut.

5. The electrical connector of claim 4 in which said springs comprise garter springs circumscribing said petals and bearing on the outer side thereof adjacent opposite ends of said petals, and including a rigid retainer ring mounted within each of said garter springs adjacent opposite ends of said petals to limit the extent to which the ends of said petals can be moved radially to prevent disengagement of the side edges of a petal with the side edges of its adjacent petals.

6. The electrical connector of claim 1 wherein said pin extends axially beyond the leading end of the conductor on which it is mounted and said socket is located at the leading end of the other conductor, said pin telescopingly engaging said socket prior to telescopic interengagement of said sleeve and said second conductor.

7. The electrical connector of claim 6 wherein said conductors comprise two pairs, one conductor in each pair being of opposite polarity from the other conductor in said pair, said pin extending axially from each conductor of one pair, said pins having axially extending grooves on the surface thereof and each conductor of the other pair having radially inwardly extending lugs at the leading ends thereof, the grooves and lugs of one set being of different arrangement than the grooves and lugs of the other set such that in each pair of conductors a conductor of one polarity can be telescopically engaged only with the sleeve on the conductor of similar polarity of the other pair.

8. The electrical connector of claim 6 wherein said pin has an axially extending groove thereon and said other conductor has a radially inwardly prjecting lug at

the leading end thereof which must register axially with said groove to enable telescopic engagement of said second conductor and said sleeve.

9. The electrical connector of claim **8** wherein the axially inner end of said groove has a circumferential extension adapted to receive said lug when the lug registers axially with said extension and one of said conductors is rotated about its axis relative to the other conductor.

10. The electrical connector of claim **9** wherein said circumferential extension is located to register with said lug after said sleeve and the second conductor have telescopically interengaged.

11. The electrical connector of claim **1** which also comprises first and second housings of nonconductive material which define chambers for said conductors which are generally closed, except at the confronting end faces of said housings, said first housing having a socket opening to the exterior thereof and adapted to telescopically receive a portion of said second housing, said housing socket being dimensioned to have a close fit with said portion of the second housing, one of said housings surrounding said first conductor and the other housing surrounding the second conductor such that when the second housing is fully received in the socket of the first housing the second conductor telescopically engages said petals of said connector sleeve, said housing socket being dimensioned to have a close fit with said portion of said second housing such that when the housings are telescopically disengaged a partial vacuum is created within the housings at the portions thereof enclosing the connected portions of said conductors, the axial extent of said housing socket being dimensioned such that when the housings are telescopically disengaged the petals of said connector sleeve disengage said second other conductor prior to disengagement of said housing socket and said second housing.

12. The electrical connector of claim **11** which also comprises a wall of a nonconductive material on said housing enclosing said one conductor, said wall being adjacent said end of said petals of said connector sleeve and having a hole therein substantially coaxial with said end of said petals, said pilot pin being carried by said first conductor and extending axially beyond the end thereof and beyond said end of said petals of said connector sleeve, said pilot pin extending coaxially with said hole in said wall, and in which said second conductor has a tubular leading end portion having an outer diameter only slightly smaller than said hole and an inner diameter only slightly greater than said pilot pin, said leading end portion of said second conductor being adapted to extend through said hole, telescope over said pilot pin and engage said end of said petals when said housings are fully telescopically engaged.

13. The electrical connector of claim **12** wherein said pin extends concentrically into said hole to define an annular opening in said wall for guiding the tubular leading end portion of said second conductor into concentric engagement with the petals of the connector sleeve.

14. The electrical connector of claim **12** including means on the inner side of said wall surrounding said hole and supporting said ends of said petals concentrically with said hole.

15. The electrical connector of claim **1** which includes first and second housings of a nonconductive material surrounding said conductors, a single conductor in each of said housings, one of said housings snugly embracing said first conductor and being circumferentially enlarged to accommodate said sleeve and extending axially beyond said sleeve, said enlarged portion of said one housing having an opening at the free end thereof concentric with the axis of the sleeve therein, the other housing snugly embracing said second conductor, the opening in the end of the first housing being dimensioned to snugly receive the portion of the second conductor surrounded by said second housing so that when said second conductor is engaged with said sleeve the opening in the first housing forms a generally air-tight fit with the outer surface portion of the second housing.

16. The electrical connector of claim **15** wherein the opening in the first housing has a peripheral, generally radially inwardly extending flexible lip thereon dimensioned to facilitate formation of said generally air-tight fitting with the surface of the first housing.

17. The electrical connector of claim **12** which also comprises a key mounted in a radially extending predetermined angular orientation in said tubular portion of said second conductor and in which said pin has a slot in a corresponding angular orientation to slidably receive said key.

18. The electrical connector of claim **17** wherein said nonconductive pin extends coaxially beyond the free end of the first housing to at least the open end thereof, said second conductor being tubular at the free end thereof so that said pin telescopes within said second conductor with a smooth guiding fit as the two housings are interengaged before the free end of the second conductor is engaged by the leading ends of the petals of said sleeve.

19. The electrical connector of claim **18** wherein said pin has an axially extending groove therein and said second conductor has a radially inwardly extending lug at the free end thereof which must axially align and register with said groove to enable telescopic engagement of said pin and second conductor, the groove and lug arrangement being different for conductors of different voltages and polarities so that only conductors of similar voltages and polarities can be telescopically engaged.

20. The electrical connector of claim **1** wherein said sleeve connector comprises a tulip connector, each of said petals having a radially outwardly bowed central portion with reversely bent end portions of smaller outer diameter, said end portions having radially outwardly curved ends, the centrally bowed portion of each petal having a greater radial thickness than the reversely bent end portions, the minimum inner diameter of the centrally bowed portion being smaller than the minimum inner diameter of the reversely bent end portions so that, when said second conductor is telescopically engaged with said tulip connector, the outer surface of said second conductor first encounters the inner periphery of the reversely bent end portions and, as the second conductor is further telescoped into said sleeve, the end portion of the second conductor then contacts the inner periphery of the centrally bowed portion.

21. The electrical connector of claim **20** wherein said inner diameters of said centrally bowed portions are dimensioned such that, when said second conductor is fully telecoped within said sleeve, the reversely bent

end portions are radially spaced outwardly from the outer peripheral surface of said second conductor.

22. An electrical connector comprising a pair of housings each surrounding an end of a conductor, said conductor ends being of tubular shape, one of said conductors having a nonconductive pilot pin extending coaxially beyond the end thereof, a resilient connector sleeve on the end of said one conductor and having one end thereof extending circumferentially around said pilot pin, the housing enclosing said one conductor having an end wall provided with an opening aligned axially with said pin and slightly larger in diameter than said pin, said pin extending into said opening and terminating substantially flush with the outer face of said end wall to define a narrow annular opening in said end wall, said connector sleeve being disposed behind said wall so that said wall and said pin define a dead front on said housing, the end of the other conductor being tubular and adapted to be inserted through said annular opening between the outer end of said pin and opening in said end wall to engage with said end of the resilient connector sleeve.

23. The electrical connector of claim **22** including means on the inner side of said wall surrounding said opening and supporting said end of the resilient connector sleeve concentric with the opening.

24. The electrical connector of claim **22** wherein said connector sleeve comprises a series of petals of arcuate shape in transverse section, said petals being arranged in circumferential fashion with their longitudinal edges in abutting relation, yielding means circumferentially circumscribing said end of said connector sleeve, the opening defined by said end of the connector sleeve being smaller than the outer diameter of the end of said other conductor.

25. The electrical connector of claim **22** wherein said connector sleeve comprises a series of petals of arcuate shape in transverse section, said petals being arranged in circumferential fashion with their longitudinal edges in abutting relation, yielding means circumferentially circumsribing said end of said connector sleeve, said end wall being perpendicular to the longitudinal axis of the connector sleeve at the portion of its inner face surrounding said opening, means in said one housing adjacent the other end of said connector sleeve forming an abutment perpendicular to the longitudinal axis of said connector sleeve, said petals all being the same length and slightly shorter than the distance between said abutment and said portion of said end wall.

26. The electrical connector of claim **22** wherein the width of said annular space is not more than about 3/32 inches.

27. The electrical connector of claim **26** wherein said other conductor has a diameter of at least about ¾ inches.

28. A tulip connector for electrically coupling a pair of conductors comprising, a plurality of axially extending conductive petals arranged in generally circular spatial relation and biased radially inwardly to define a generally circular passageway in the connector, one end of said connector being adapted to be telescoped over and frictionally engage the outer cylindrical surface of a conductor having a diameter at least slightly greater than the minimum diameter of the passageway in the connector, each of said petals having a radially outwardly bowed central portion with a reversely bent, radially outwardly extending portion at said one end of the connector, spring means seated within and extending circumferentially around the annular seat formed by the junction of said outwardly bowed portion and said reversely bent end portions of said petals, said reversely bent end portions being thinner than the portion of the outwardly bowed portion of the petal spaced axially inwardly of said junction, the radially inner surfaces of the outwardly bowed portions being curved radially outwardly to intersect with the radially inner surfaces of said reversely bent end portions at said junction so that the minimum inner diameter of the outwardly bowed portions is smaller than the inner diameter of said junction, the diameter of the portion of the passageway defined by the radially inner surfaces of the reversely bent end portions being substantially greater at the free ends of said end portions than at said junction so that, when said conductor with said cylindrical outer surface is telescopically engaged with said one end of the connector, the outer surface of the conductor first encounters the inner periphery of the reversely bent end portions and, as the conductor is further telescoped into said connector, the leading end of the conductor thereafter contacts the inner periphery of the connector at said portion of the passageway of minimum diameter which is spaced axially inwardly of said junction and causes the connector to circumferentially enlarge to thereby displace the radially inner surfaces of said petals at said junction radially outwardly from the outer surface of the conductor.

29. A tulip connector as called for in claim **28** wherein the configuration of the other end of each petal is substantially the same as said one end.

30. A tulip connector as called for in claim **28** wherein the inner surfaces of the outwardly bowed portion and the reversely bent end portion of each petal are shaped to form a sharp line of intersection at said junction.

31. A tulip connector as called for in claim **28** wherein the inner surface of each petal at said junction is defined by the line of intersection between oppositely inclined surfaces.

32. A tulip connector as called for in claim **28** wherein the inner surface of each petal at said junction is defined by the intersection between surfaces which are inclined relative to one another in a direction axially of said passageway.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,813,638 Dated May 28, 1974

Inventor(s) KINNEAR, Joseph D.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 10, Line 23 Cancel "surface" and insert in place thereof -- surfaces --

Column 11, Line 36 Cancel "other"

Correct Patentee's Address on Title Page to read:

-- 3019 E. Eight Mile Road,
Warren, Michigan --

Signed and sealed this 15th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents