United States Patent

Brown

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[54] **ELECTRICAL CONTACT DEVICES FOR HIGH VOLTAGE ELECTRICAL SYSTEMS**

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[22] Filed: **Dec. 30, 1969**

[21] Appl. No.: **889,243**

[52] **U.S. Cl.** .... **339/111,** 339/143 R

[51] **Int. Cl.** **H01r 13/52**

[58] **Field of Search** 174/73; 200/144, 151; 339/111, 339/143

[56] **References Cited**

UNITED STATES PATENTS

3,323,097	5/1967	Tordoff	174/73 X
3,513,437	5/1970	McMorris	200/144 X

Primary Examiner—Richard E. Moore

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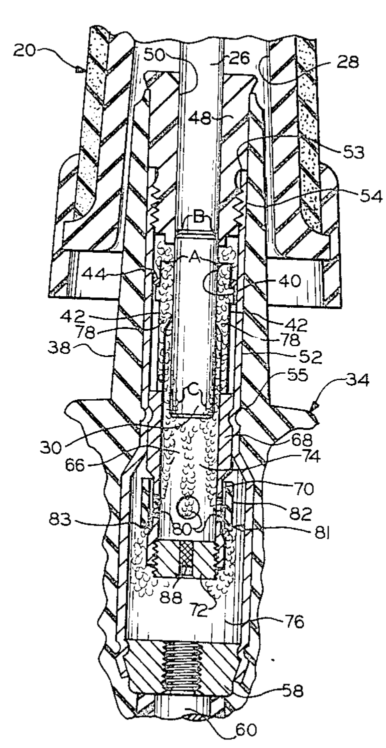
[57] **ABSTRACT**

An electrical device in the form of an electrical connector for making a connection between complementary electrical contacts, shown in the form of a pin and a socket, under high voltage fault conditions, the device including a sleeve of arc-quenching material for guiding the pin into contact with the socket, the sleeve being axially spaced from the socket to provide a gap between the sleeve and the socket, and a metallic tubular member surrounding the gap and contacting the socket, the wall of the tubular member being radially spaced from the pin such that the gap has a longitudinal length no less than the order of magnitude of one-half the distance between the pin and socket at which an arc will be struck between the pin and the socket as the pin approaches the socket under high voltage fault conditions and a lateral width no less than the order of magnitude of one-half the same arc-strike distance.

12 Claims, 3 Drawing Figures



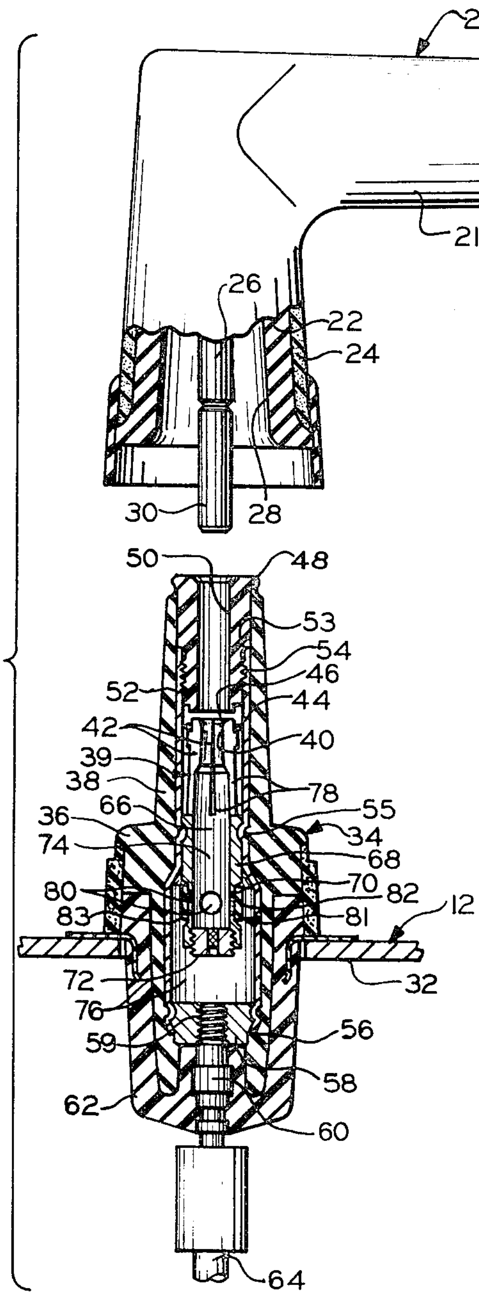


Fig_1

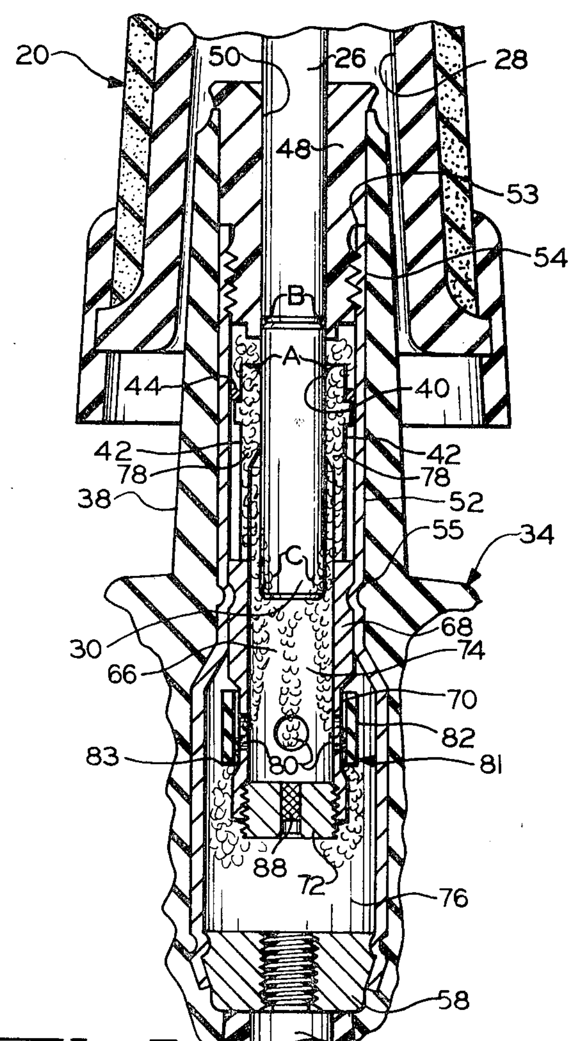


Fig_2

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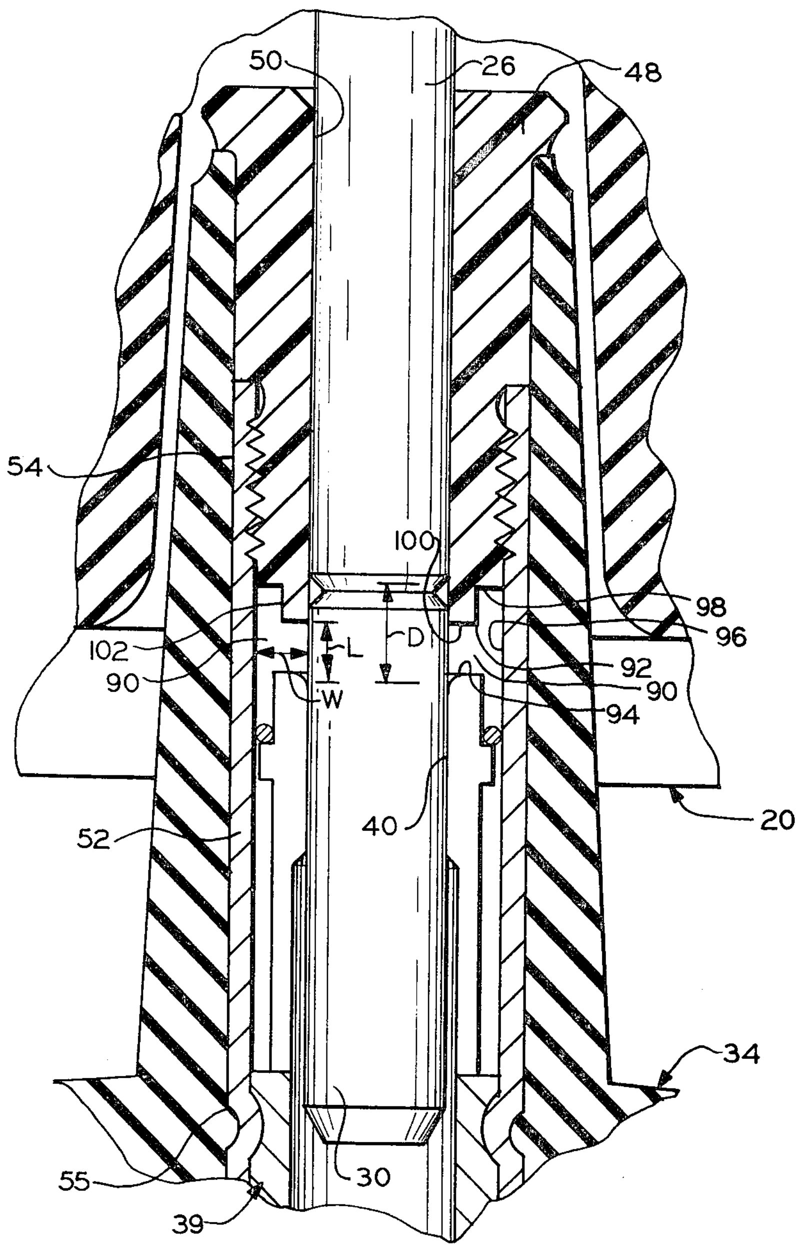

Fig. 3

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ELECTRICAL CONTACT DEVICES FOR HIGH VOLTAGE ELECTRICAL SYSTEMS

The present invention relates generally to electrical devices such as switches and connectors for use in high voltage electrical systems and pertains, more specifically, to electrical switches and connector elements which employ arc-quenching materials for interrupting an electric arc ordinarily struck during connection and disconnection under high voltage load conditions, and embodying means for accommodating gases generated by the arc so that such connection and disconnection may be accomplished without failure of the switch or connector structure and means for accommodating an arc which will be struck when a connection is made under high voltage short circuit, or fault, conditions.

It is now commonplace to find electrical switches and disconnectable electrical connectors employed in a variety of locations in high voltage electrical distribution systems. While it is always best to make or break such disconnectable connections or throw the contacts in such switches under no-load conditions, it is not always easy or expeditious to determine whether or not high voltage is present in a switch or in a connection and then assure that no voltage is present before throwing the switch or disconnecting the connection or reconnecting the connection. Thus, connections and disconnections are constantly being made under high voltage load conditions. Additionally there is present the risk of inadvertently making a connection to a faulted circuit, that is, making a connection under short circuit conditions, and such devices should be capable of withstanding such an occurrence.

The use of arc-quenching materials in switches or other types of electrical connectors is now well known in the art. For example, in electrical connectors which employ complementary pin ad socket contacts, arc-quenching material has been utilized in the form of a tip placed upon the pin and a complementary sleeve placed ahead of the socket such that the tip and the sleeve will accurately guide the pin into contact with the socket while providing arc-quenching material between the pin and the socket as the pin approaches the socket. As the pin and the socket are closed in under high voltage fault conditions in such connectors, a circuit will be established well before the pin engages the socket by the striking of an arc, and since the arc must exist between the surfaces of the arc-quenching material of the tip and the sleeve, large volumes of evaporation products will form and such products, when confined in the relatively small volume of the interior of the connector, can create sufficient pressure to preclude complete closure of the connector with the result that the connector can burn up, perhaps backfire or even explode with varying degrees of violence, depending upon the materials selected. In an effort to prevent such undesirable effects, some electrical connectors have been constructed with vents while others have been constructed with expansion chambers.

Electrical connectors employing vents are illustrated in U.S. Pat. No. 3,413,592. The use of such vents has been found to be undesirable since a vent will allow the carbonaceous materials as well as other electrically conductive and undesirable materials in the gases to be expelled into the atmosphere where restrike of the electrical circuit is possible, or in some instances, the vents expel gases into the interior of an electrical oil-filled device, such as a transformer, thus contaminating the oil and introducing the possibility of an electrical failure within the transformer.

Electrical connectors employing expansion chambers are illustrated in U.S. application Ser. No. 730,807, filed May 21, 1968, now U.S. Pat. No. 3,539,972. The use of such expansion chambers within the electrical connectors themselves eliminates the problems introduced by the use of vents; however, such expansion chambers are rather limited in volume due to the limitations placed upon the maximum practical size of the connector elements themselves and, under aggravated conditions, the limited volume of these expansion chambers has been found to be inadequate in accommodating all of the gases produced by the arc.

It has now been found that the amount of gas generated by the arc can be greatly reduced by the introduction of a gap of minimum prescribed dimensions between the sleeve of arc-quenching material and the socket and by surrounding the gap with a wall of conductive material, preferably in the form of a metallic member.

It is therefore an important object of the invention to improve the performance and reliability of electrical contact devices, such as electrical switches and electrical connectors, which use solid arc-quenching materials to interrupt the electrical arc which appears during the breaking of an electrical connection under high voltage load conditions in order to enable successful connection under fault conditions without a disastrous failure of the device.

Another object of the invention is to reduce to an absolute minimum the volume of gases created during the closing of contacts in a device as described above under high voltage, short circuit conditions thereby enabling the device, when enclosed, to be enclosed within a container of smallest possible volume, the small size being particularly desirable when used in conjunction with underground distribution systems.

A further object of the invention is to provide an electrical contact device of the type described above having a relatively simple construction capable of economical fabrication.

The above objects, as well as still further objects and advantages, are attained by the invention which may be described briefly as providing, in an electrical device, such as an electrical connector element, in which electrical contact is to be made between at least a first contact and a complementary second contact under high voltage fault conditions by movement of the first contact into engagement with the second contact, means for guiding the first contact for movement along a path of travel leading to the second contact and providing a guide of arc-quenching material for receiving the first contact prior to engagement of the first contact with the second contact, the guide being spaced longitudinally from the second contact in the direction of movement of the first contact, and means for surrounding the space between the guide and the second contact and providing a wall of electrically conductive material juxtaposed with the sleeve and the second contact and spaced laterally from the path of travel of the first contact, the wall being electrically connected to the second contact, the longitudinal spacing between the guide and the second contact and the lateral spacing between the wall and the path of travel providing a gap having a longitudinal length no less than the order of magnitude of one-half the distance between the first and second contact at which an arc will be struck between the contacts as the first contact approaches the second contact under high voltage fault conditions and a lateral width no less than the order of magnitude of one-half the same arc-strike distance.

The invention will be more fully understood, while still further objects and advantages thereof will be made apparent, in the following detailed description of an embodiment of the invention illustrated in the accompanying drawing, in which:

FIG. 1 illustrates complementary electrical connectors with a connector element constructed in accordance with the invention shown in a longitudinal cross-sectional view;

FIG. 2 is an enlarged fragmentary cross-sectional view of portions of the connectors of FIG. 1 as the connectors are being connected; and

FIG. 3 is a further enlarged fragmentary cross-sectional view of a portion of FIG. 2.

Referring now the the drawing, and particularly to FIG. 1, an electrical connection is to be made between a high voltage cable **10** and a transformer **12** in a high voltage electrical distribution system. The high voltage cable **10** has a central conductor **14**, which is covered with an insulating jacket **16** which, in turn, is sheathed within a conductive shield **18**. The cable **10** is terminated within an electrical connector element **20** shown in the form of an elbow having a body **21** which includes an inner member **22** of insulating elastomeric material and an outer member **24** of conductive elastomeric material.

A central electrical contact is shown in the form of a pin 26 of conductive metal projecting axially through a receptacle 28 in the body 21 of the connector element 20. A tip 30 of nonconductive plastic arc-quenching material is affixed to the end of the pin 26 for purposes which will be described hereinafter.

Affixed to the transformer 12, and projecting outwardly of the casing 32 thereof, is an electrical connector element constructed in accordance with the invention and shown in the form of a transformer bushing 34. Bushing 34 is provided with a housing 36, preferably fabricated of an elastomeric material and having an axially projecting outer body portion 38 constructed of a dielectric material, preferably an insulating elastomer. Within the housing 36 is an electrical contact 39 shown in the form of a metallic socket 40 having a plurality of segments 42 which are biased radially inwardly by an annular spring member 44 which encircles segments 42 adjacent the mouth 46 of the socket 40. A sleeve 48 constructed of a plastic arc-quenching material is located ahead of the socket 40 within the housing 36 and has an axially directed cylindrical bore 50 having an inside diameter complementary to the outside diameter of the plastic tip 30 and the pin 26 of the corresponding connector element 20 for receiving and guiding the plastic tip and the pin into proper engagement with the socket as the connector elements 20 and 34 are connected.

Both the electrical contact 39 and the plastic sleeve 48 are actually affixed to a first tubular member 52 adjacent one end 53 thereof, the sleeve 48 being affixed to a portion 54 of the tubular member 52 by cooperating screw threads while the contact 39 is affixed to a portion 55 of the tubular member 52 by cooperating bead-like deformations. The first tubular member 52 extends axially to the other end 56 thereof where the tubular member 52 is terminated by a base 58. The base 58 has a threaded aperture 59 so that the bushing 34 may be removably secured to a threaded stud 60 carried by a well member 62 which is permanently secured to the transformer casing 32. The threaded stud 60 is mechanically affixed and electrically connected to a lead 64 of the transformer 12. The first tubular member 52 and the base 58 are electrically conductive and are preferably constructed of metal. The first tubular member 52 and the base 58 thus establish a cavity 66 within the bushing 34.

A second tubular member 68, which is actually an integral portion of the electrical contact 39, extends axially into the cavity 66 and has an annular wall 70 spaced radially from the first tubular member 52 and closed off by an end wall 72 secured thereto, thus establishing dividing means for dividing the cavity 66 into a first chamber 74 and a second chamber 76. The first chamber 74 is in open communication with passages 78, established between the segments 42 of the socket 40, and with the interior of the socket, while the second chamber 76 is sealed off from the housing 36 by the first tubular member 52 and the base 58. A plurality of apertures 80 are spaced circumferentially around and extend radially through the annular wall 70 of the second tubular member, and valve means 81 shown in the form of an annular band 82 of elastomeric material normally closes the apertures 80 by virtue of the resilience of the elastomeric material of the band. The annular band 82 is seated within an annular recess 83 in the annular wall 70 so as to be positively retained against axial movement along the second tubular member 68.

As best seen in FIG. 2, as the complementary connector elements 20 and 34 are brought together, the plastic tip 30 will cooperate with the plastic sleeve 48 to serve as a pilot or guide for aligning the respective electrical contacts prior to the making of any electrical contact between these contacts and prior to actual engagement of the pin with the socket. As the connector element 20 is pushed toward full engagement with the bushing 34, the metallic pin 26 will approach the socket 40 and an electric arc may be struck between portions A and B, immediately causing a rapid generation of gases C which could either preclude a full engagement of the connector elements by establishing a back pressure or could cause an explosive failure of the bushing 34. However, since the socket 40 provides an internal path between the arc and the interior of the socket in the form of passages 78, which path is in open communication with the first chamber 74, the gas C can flow into the first chamber and, as the volume available in the first chamber for the gas decreases by virtue of the penetration of the contact pin 26 and tip 30 and the pressure of the gas builds up in the first chamber 74, the annular band 82 will dilate resiliently to allow such pressure to be relieved and the first chamber will be vented through the valve means 81 into the second chamber 76. Thus, the cavity 66 provides the volume necessary to relieve the internal pressure which could otherwise build up to an intolerable level so as to permit completion of the connection between the metal pin 26 and the socket 40 before the uncontrolled generation of very large volumes of gas can take place with concomitant deleterious effects. Immediately upon the completion of such a connection the electric arc is extinguished and no further gases are generated. Completion of the connection enables the axially projecting body portion 38 of the housing 36 to be seated within the receptacle 28 of the complementary connector element 20 to establish a watertight connection.

It is noted that bushing 34 provides an extra measure of protection against violent explosive failure and flying debris when the housing 36 is constructed of an elastomeric material. Should the volume of gases generated by an electric arc become so great as to cause the bushing to burst, such a failure would merely rupture and tear the elastomeric material and would not tend to throw harmful fragments which could injure persons in the vicinity of the connector.

Upon disconnecting the complementary connector 20 from the bushing 34 under high voltage load conditions, an electric arc may be struck as the metallic pin 26 is withdrawn from the socket 40 and again approaches the position shown in FIG. 2. It is desirable to extinguish this arc as quickly as possible and to restrain any gases which may be generated by the arc so that the arc will cause no damage and ionized gases do not escape and restrike an arc to ground which could injure personnel in the vicinity of the connection. As the contact pin 26 and the plastic tip 30 are withdrawn from the socket 40 and the first chamber 74, a partial vacuum is established in the first chamber 74 by virtue of the withdrawal of the elements formerly occupying the socket 40 and the chamber 74, and the closing of the valve means 81 to maintain the available volume of the chamber 74 relatively small. Since the ambient pressure will now be greater than the pressure within the first chamber, the gases generated by the electric arc will be drawn into the first chamber 74 and held there by the higher ambient pressure outside the bushing 34 until the contact pin 26 is withdrawn far enough for the arc to be extinguished. Hence, the combination of the first and second chamber 74 and 76, respectively, with valve means 81 between the chambers provides adequate volume for accommodating gases generated upon connection of the complementary connector elements to enable complete connection without back pressure under many high voltage fault conditions and provides a more limited volume upon disconnection of the connector elements under high voltage load conditions to restrain gases generated upon disconnection of the elements under such conditions.

Since the second chamber is of limited volume by virtue of cavity 66 being wholly within the bushing 34, it will be seen that dissipation of enough of the gases entrapped within the second chamber should take place prior to making another connection at load so that any further gases generated during such a subsequent connection can be accommodated. Hence, the gases which have been trapped within the second chamber 76 may be allowed to dissipate slowly and preferably back into the first chamber 74 and thence out of the connection by passing through passages 78 between the segments 42 of the socket 40 and the cylindrical bore 50 of the plastic sleeve 48. To this end, a plug 88 of porous material, such as a porous member of sintered metal, is placed in the end wall 72 to allow slow leakage of gas from the second chamber 76 to the first chamber 74 when the valve provided by the annular elastomeric band 82 is closed over apertures 80.

It has been discovered that the volume of gases generated by the arc which is struck as the complementary contacts in the form of pin 26 and socket 40 are closed in under a high voltage, short circuit or fault condition may be reduced considerably by the provision of a gap 90 of prescribed axial length L between the sleeve 48 and the socket 40. By thus reducing the volume of the gases C, the above described construction, which includes an expansion chamber in the form of second chamber 76, has been found to operate successfully under extreme conditions which, in a construction which did not include such a gap, previously caused failure of the bushing 34.

Turning now to FIG. 3, the construction of the connector element in the form of bushing 34 in the vicinity of the gap 90 is illustrated in a greatly enlarged fragmentary view which shows the pin 26 located at a distance D from the socket 40 as the pin is being advanced into engagement with the socket. The distance D is the maximum distance at which an arc will be struck between the pin and the socket under high voltage alternating current conditions when the pin and socket are unused, i.e., are not contaminated with electrically conductive materials from prior use. It has been found that by terminating the sleeve 48 at an end face 92 which is spaced longitudinally from the socket 40 the resulting gap 90 apparently provides some volume which can be occupied by the arc and which can immediately accommodate gases generated at the surfaces of the arc-quenching material of the sleeve 48 and the tip 30 contacted by the arc. At the same time, the provision of a gap 90, rather than arc-quenching material, in the vicinity of the arc reduces the amount of arc-quenching material upon which the arc can act to produce gas, thereby reducing somewhat the volume of gas generated. Additionally, the tubular member 52 which surrounds the gap 90 is exposed to the arc and since the tubular member 52 is electrically connected to the socket 40 at portion 55, the tubular member can act as a contact to help carry current during arcing. Because the tubular member 52 is fabricated of metal, the material of the tubular member will not evaporate as quickly as a plastic arc-quenching material under the influence of an arc. Furthermore, any metal vapor within the gap 90 will tend to condense upon the tubular member 52 since the tubular member is generally cooler than the pin 26, the socket 40, the tip 30 and the sleeve 48. Thus, the tubular member 52 itself, when exposed to the arc through the use of the gap 90, becomes an important component part in the accommodation of the arc.

It has been determined that for optimum performance the longitudinal spacing between the end face 92 of the sleeve 48 and the confronting end 94 of the socket 40 should be in the order of magnitude of at least one-half the arc-strike distance D. Thus, the axial (longitudinal) length L of the gap 90 should be no less than one-half the distance D. Since it is preferable that the arc be struck, at least initially, between the pin 26 and the socket 40, rather than between the pin and the exposed portion 96 of the wall of the tubular member 52, the inside diameter of the tubular member 52 at the exposed portion 96 of the wall thereof is such that the exposed portion 96 of the wall of the tubular member is spaced radially from the path of travel of the pin 26, i.e., the outside diameter of the pin when the pin is engaged in the socket, a distance sufficient to provide the gap 90 with an annular configuration having a radial (lateral) width W no less than, and preferably slightly greater than, the axial length L of the gap 90. In any event, radial width W should be no less than the order of magnitude of one-half the arc-strike distance D.

As the connector element ages (that is, as the connector element is used and gases are generated therein), electrically conductive material can condense upon the end face 92 of the sleeve 48 and provide an electrical path between the pin 26 and the wall of the tubular member 52 enabling an arc to be struck initially between the pin and the tubular member rather than between the pin and the socket 40 as the pin is advanced toward the socket. In order to aid in precluding such an occurrence, a portion 98 of the end face 92 adjacent the tubular member 52 is spaced longitudinally further from the socket 40 than the portion 100 of the end face 92 which is contiguous with the path of travel of the pin 26 by reducing the outside diameter of the sleeve 48 at 102. Thus, any path along the end face 92 between the pin 26 and the tubular member 52 will have a greater length than the lateral distance (equal to distance W) between the bore 50 and the tubular member 52. This reduction of the outside diameter of the sleeve at 102 also serves to eliminate more arc-quenching material from the vicinity of the arc occupying the gap 90 thereby further reducing the volume of gas generated by that arc.

Thus, by providing a gap 90 of prescribed length L and width W between the sleeve 48 and the socket 40 and by surrounding the gap 90 with an electrically conductive wall, preferably in the form of a metallic tubular member 52, a means has been found by which gases generated by an arc which must be struck as the pin 25 approaches the socket 40 can be controlled and advantageously reduced in volume so as to render the connector element in the form of bushing 34 more effective even under extreme conditions of high voltage short circuit or fault connection. Such a reduction in the volume of these gases thus improves the performance and reliability of the connector element. In addition, the use of a gap, as described above, within a connector element employed in lower voltage circuits where a fault, or short circuit, would not present conditions as severe as similar occurrences within high voltage circuits, and the resulting reduction in the volume of gases generated under such conditions permits a concomitant reduction in the volume of the expansion chamber to a degree sufficient to eliminate the necessity for two separate chambers connected by a valve means, a single relatively small chamber being sufficient to accommodate the gases generated upon connection under fault and being limited enough in volume to restrain gases generated upon disconnection under load. Furthermore, the utilization of a gap, as described above, in connection with an electrical connector of the type which employs a vent will improve the performance of such a connector in that the undesirable effects of expelling gas from the connector will be reduced by virtue of the reduction in the volume of expelled gases.

It is to be understood that the above detailed description of an embodiment of the invention is provided by way of example only. Various details of design and construction may be modified without departing from the true spirit and scope of the invention as set forth in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In an electrical device, such as an electrical connector element, in which electrical contact is to be made between at least a first contact and a complementary second contact under high voltage fault conditions by movement of the first contact into engagement with the second contact:

means for guiding the first contact for movement along a path of travel leading to the second contact and providing a guide of arc-quenching material for receiving the first contact prior to engagement of the first contact with the second contact, said guide being spaced longitudinally from the second contact in the direction of said movement; and

means for surrounding the space between the guide and the second contact and providing a wall of electrically conductive material juxtaposed with the guide and the second contact and spaced laterally from said path of travel, said wall being electrically connected to the second contact;

the longitudinal spacing between the guide and the second contact and the lateral spacing between the wall and the path of travel providing a gap having a longitudinal length no less than the order of magnitude of one-half the distance between the first and second contacts at which an arc will be struck between the contacts as the first contact approaches the second contact under said high voltage fault conditions and a lateral width no less than the order of magnitude of one-half said arc-strike distance.

2. The invention of claim 1 wherein the lateral width of the gap is at least as great as the longitudinal length thereof.

3. The invention of claim 1 wherein the first contact includes a metallic pin and the second contact includes a metal socket for receiving the pin:

said guide includes a sleeve of arc-quenching material for receiving the pin, the sleeve being longitudinally spaced from the socket; and

said surrounding means includes a metallic tubular member overlapping the sleeve and the socket and spaced laterally from the path of travel of the pin to surround the longitudinal spacing between the sleeve and the socket with said wall;

the longitudinal spacing between the sleeve and the socket and the lateral spacing between the tubular member and the path of travel providing said gap.

4. The invention of claim 3 wherein the guiding means include a tip of arc-extinguishing material carried by the pin and receivable within the sleeve.

5. The invention of claim 3 wherein the lateral width of the gap is at least as great as the longitudinal length thereof.

6. The invention of claim 3 wherein the sleeve includes an end face confronting the socket and spaced longitudinally from the socket, said end face having at least a portion adjacent the tubular member spaced longitudinally further from the socket than the portion of the end face which is contiguous with the path of travel of the pin such that a path along the end face between the pin and the tubular member will have a greater length than the lateral distance between the pin and the tubular member.

7. The invention of claim 3 wherein the pin is cylindrical and has a prescribed diameter and the socket is cylindrical and has an internal bore of a diameter complementary to the diameter of the pin, and an outside diameter;

the sleeve is cylindrical and has an inside diameter complementary to the diameter of the pin and a prescribed outside diameter, said sleeve being spaced axially from the socket; and

the tubular member is cylindrical and includes first portions having an inside diameter complementary to and overlapping with the outside diameter of the sleeve and the outside diameter of the socket, and a second portion surrounding the axial spacing between the sleeve and the socket and having an inside diameter greater than the diameter of the pin such that the second portion is spaced radially from the outside diameter of the pin when the pin is engaged in the socket;

said axial spacing and said radial spacing providing the gap with an annular configuration such that said longitudinal length is axial and said lateral width is radial.

8. The invention of claim 7 wherein the guiding means include a tip of arc-quenching material carried by the pin and receivable within the sleeve.

9. The invention of claim 7 wherein the radial width of the gap is at least as great as the axial length thereof.

10. The invention of claim 7 wherein the sleeve includes an end having an end face confronting the socket and spaced axially from the socket, and the outside diameter of the sleeve is reduced adjacent said end such that a portion of the end face adjacent the tubular member is spaced axially further from the socket than the portion of the end face contiguous with the pin when the pin is engaged in the socket.

11. The invention of claim 3 wherein the longitudinal length of the gap and the lateral width thereof are each approximately one-half said arc-strike distance.

12. The invention of claim 7 wherein the width of the gap is approximately the same as the length thereof.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,654,590 Dated April 4, 1972

Inventor(s) Robert R. Brown

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

In the name of the assignee, "Ameraca" should read -- Amerace --; Column 1, line 26, a comma (,) should be inserted between "Additionally" and "there"; Column 1, line 33, "ad" should read -- and --.

Signed and sealed this 10th day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents