June 13, 1961 L. A. ARCHER 2,988,723

HIGH CURRENT ELECTRICAL CONNECTOR

Filed May 31, 1957

Fig. 1

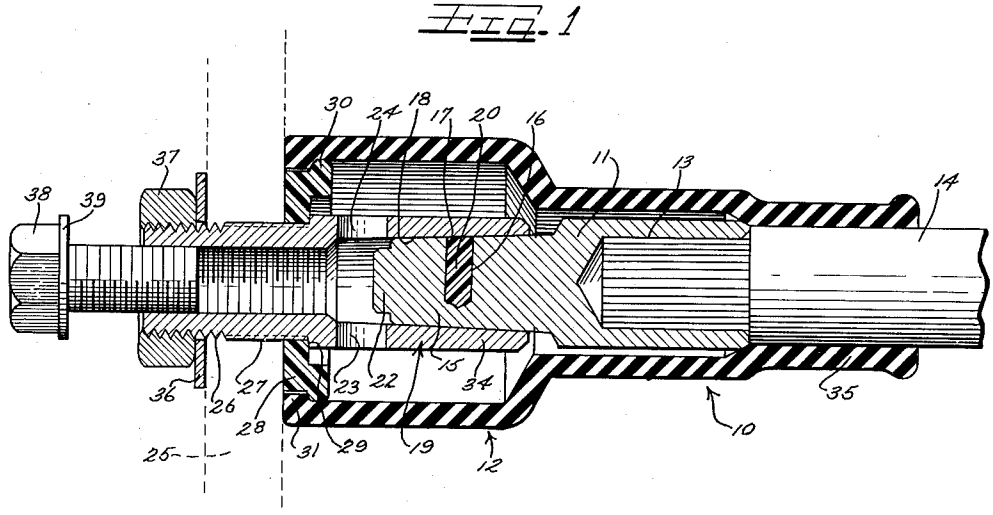


Fig. 2

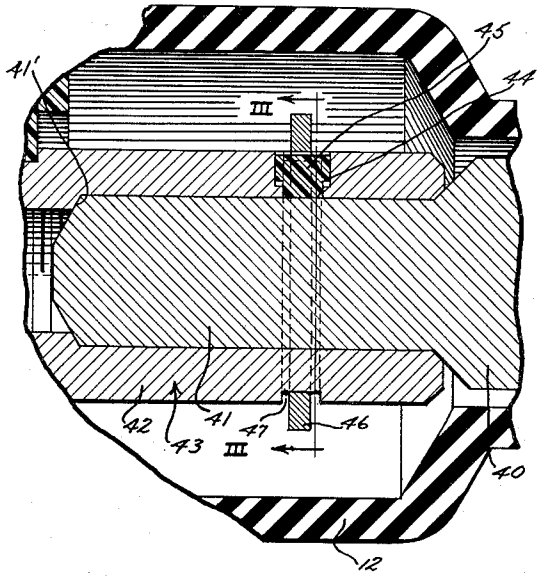
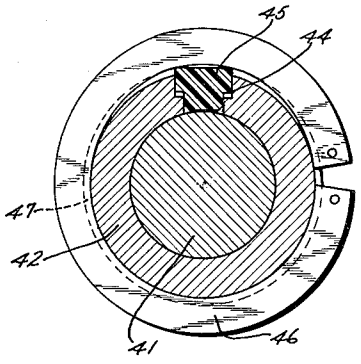


Fig. 3



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HIGH CURRENT ELECTRICAL CONNECTOR

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This invention relates generally to separable electrical connectors, and more specifically to an improved contact having a high current-carrying capacity.

Although the principles of the present invention may be included in various connector assemblies or plugs, a particularly useful application is made in connector assemblies of the larger types that require both ease of assembly and disassembly, and an extremely high current-carrying capacity. In an electrical connector assembly, the portions which engage each other have a surface-to-surface electrical resistance or contact resistance which normally is higher than the electrical resistance of any incremental portion of the length of the contacts. It is therefore desirable to keep this value as low as possible, so as to avoid excessive heating due to conduction of current at such point. The contact material itself also has an electrical resistance which decreases as the size of the contact is increased. When the connector size is increased, it may be expected that the force required for engaging and disengaging or separating the contacts will also increase. Therefore, for a particular installation, where a given current must be handled, a connector assembly must be selected which has the ability to carry the current without an undue temperature rise of the contacts.

The present invention contemplates the utilization of a male contact pin having a solid distal end or entrant end, which is received within a correspondingly configured female contact or socket. Either of the pin or the socket may be provided with a relatively high expansion plug which bears against the other contact. When current is caused to flow through the assembly, the inherent resistance of the contacts, and the surface-contact resistance, cause heating of the contact assembly and the expansion plug. The plug, being directed transversely to the direction of withdrawal of the pin, expands transversely and positively drives the one contact against the other contact to produce a substantial increase in contact pressure, which remains present as long as current is passing . When the current is not passing, so that the contacts are comparatively cool, the contact pressure is somewhat lower so as to facilitate separation of the contacts. Further, since elevated temperatures are expected of the contacts, this invention contemplates the use of an insulating boot spaced from the contacts so that its properties will not be adversely affected by the presence of the heat, such boot nevertheless affording adequate physical protection to the contacts.

Accordingly, it is an object of the present invention to provide a contact assembly which requires a minimum of force to insert and withdraw the one contact from the other.

A still further object of this invention is the provision of a connector assembly which will have an unusually high current-carrying capacity with a minimum temperature rise.

Yet another object is the provision of a connector assembly which will utilize an initial temperature rise to retard or limit a further temperature rise.

Yet another object of this invention is the provision of an electrical connector wherein contact pressure will increase in response to temperature rise.

A still further object of this invention is the provision of a high-current-carrying contact assembly having heat-resistive means for insulatingly protecting such assembly.

Many other advantages, features and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description and the accompanying sheet of drawings, in which a preferred structural embodiment and a variation thereof incorporating the principles of the present invention are shown by way of illustrative example.

On the drawings:

FIGURE 1 is a cross-sectional view of an electrical connector assembly equipped with contacts provided in accordance with the principles of the present invention;

FIGURE 2 is an enlarged fragmentary cross-sectional view of a variation which may be applied to the embodiment shown in FIGURE 1; and

FIGURE 3 is a view taken along line III—III of FIGURE 2.

As shown on the drawings:

The principles of this invention are particularly useful when embodied in an electrical connector assembly such as illustrated in FIGURE 1, generally indicated by the numeral **10**. The connector assembly **10** includes a contact **11**, here shown to be a male contact or pin, a second contact **19**, here shown to be a socket or female contact assembly, and a protective means generally indicated at **12**. The male contact pin **11** includes a portion **13** adapted for receiving a cable **14** therein. The cable **14** may be secured to the contact **11** by any convenient means. The pin **11** further includes an entrant portion **15** received within the socket **19**. The portion **15** is provided with a pocket **16** which has an opening indicated at **17** which is directed transversely to the direction in which the contact **11** is separated from the contact **19**. Thus, the pocket **16** is directed toward an inner surface or portion **18** of the contact **19**. Within the pocket **16**, there is a plug **20** which substantially fills the pocket **16** and abuts the inner surface **18** at the opening **17** of the pocket **16**. The plug **20** comprises a material which has a somewhat higher coefficient of thermal expansion than does the material from which either contact **11** or **19** is made, Thus, when the plug **20** is heated, as by current flowing through and across the contacts, the plug **20** expands more than do the contacts, thereby reacting with the contact **11** and against the contact **19** to force the portion **15** of the contact **11** against the inner surface **18** of the contact **19** with a substantial force. It has been found that nylon has the required physical and thermal properties required of the plug **20**. Of course, it is to be understood that any other rigid material having a greater relative expansion than do the contacts **11** and **19** may also be utilized. It is to be further understood that the pocket **16** may be located in either the pin **11** or in the socket **19**. However, for ease of manufacture, the pin is the preferable location. The contact **11** may further include an abutment **22** which registers with a pair of holes **23**, **24** disposed adjacent to the contacting portion of the socket **19**. Either or both of the pair of holes **23**, **24** may receive a hand tool (not shown) which may act intermediate the contact **19** and the abutment **22** on the contact **11** for loosening the one from the other should it be desired to do so while the nylon plug **20** is at an elevated temperature and thereby tending to prevent free loosening.

The assembly may be secured to a mounting means **25** which has an aperture **26** for receiving the contact **19** therethrough. The contact **19** may have means such as a knurling **27** to provide a locking engagement between

the contact 19 and the mounting means 25 whereby relative rotation between them is precluded. A bushing 28 of material having poor heat transfer qualities, for example plastic, is disposed between the mounting means 25 and a shoulder 29 on the contact 19. The bushing 28 extends radially from the contact 19, and at its periphery, has a means such as an annular bead 30 for engaging with an appropriately shaped locking means or portion 31, annularly disposed on the inside of and at one end of the generally tubular shaped boot 12.

The boot 12 extends in spaced relation along each of the contacts 19 and 11 so as to preclude the conduction of heat from the heated contacts 11 and 19 directly to the boot 12. The boot 12 may comprise resilient insulated material, but in particular, its ends should be resilient. Thus, the means 31 may be forced axially past and over the bead 30 to provide a lock against relative axial movement. The boot 12 converges at its other end to define a supporting portion for resiliently engaging the insulation of the cable 14. Since relatively little heat is developed at the cable connecting portion 13 of the contact 11, the boot 12 need not be spaced to the same extent adjacent to such cable connecting portion 13 and therefore the boot, being resilient, may be grasped by the hand at such portion, the boot thereby deflecting resiliently against the adjacent portion of the contact pin 11, whereby the pin contact 11 may be engaged or disengaged by pushing or pulling action respectively. The socket contact 19 may be externally threaded at the end opposite to the engaging portion 34, which threads may project through the mounting means 25. In this embodiment, a washer 36 and a nut 37 have been provided to draw the contact 19 firmly against the bushing 28, which in turn is thereby drawn firmly against the mounting means 25. In this embodiment, the externally threaded end of the contact 19 has been provided with an axial opening, which may be internally threaded, such as for receiving a cap screw 38 and a washer 39, which together with the threaded end of the contact 19 serve as a mounting terminal for receiving a terminal on a cable or bus bar (not shown).

If it be desired to limit the increase of axially transverse contact force, a shorter nylon plug than illustrated may be utilized. Such a plug, carried by the socket, is illustrated in FIGURES 2 and 3. A further way in which the increase in force may be limited is also illustrated in FIGURES 2 and 3 wherein resilient means are provided intermediate the plug and the contact in which the plug is received. It will be appreciated that the structure in FIGURE 2 may be applied to an assembly having a tapered contacting portion such as shown in FIGURE 1 or an assembly having a non-tapered portion such as shown in FIGURE 2. Further, under certain circumstances, it may be desirable to use both forms in the same assembly. Referring to FIGURE 2, a pin 40 has a contacting portion 41 which is received within a contacting portion 42 of a socket 43. The entrant end of the contact 40 may be provided with a radius or camming surface 41'. The boot 12 and the bushing 28 together with the other details shown in FIGURE 1 may be used with the structure of FIGURE 2. The contacting portion 42 of the contact 43 is provided with a pocket 44 in one side thereof which pocket has an opening which is directed toward the contacting portion 41 of the contact 40. An expansion plug 45 is received within the pocket 44 of the contact 43 so as to engage the contacting portion 41. A resilient means 46 is provided for urging the plug 45 against the portion 41, which means 46 is here illustrated as being a snap ring. An annular groove 47 registering with the opening 44 may also be included to hold the snap ring 46 in axial position. Referring to FIGURE 3, the snap ring or retaining ring should be positioned so that its opening does not register with the nylon plug 45. In this form, the nylon plug 45 extends outwardly of the pocket 44 so that the retaining ring 46 bears directly thereagainst forcing the plug 45 against the portion 41.

The plug 45, having a higher coefficient of thermal expansion than do the conductive contacts, will expand upon a temperature rise by an amount greater than the contacting portions in the same manner as has already been described, thereby forcing the one contact against the other so as to increase the initial contact force therebetween. However, since in this form the plug is not firmly held, but is resiliently reacted against by the retaining ring 46, the rate of increase of contact force as a function of temperature rise is lower than it is for the structure of FIGURE 1. At room temperature and with the contact 40 withdrawn, the plug 45 preferably projects slightly into the socket portion of the contact portion 43. In order to prevent the plug from dropping into this socket portion, a pair of mating shoulders are provided on each of the plug 45 and the contact 43 as shown. When the male contact is inserted, the camming end 41' outwardly displaces the plug 45 slightly against the force of the retaining ring and thereby provides the initial tension between the contacts. Thereafter, a temperature rise of the contacts increases the relative length of the expansion plug 45, thereby slightly displacing the resilient retaining ring 46 and causing an increase in the contact pressure between the contacting portions 41 and 42.

Although various minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. In an electrical connector assembly including a pair of contacts each having an engaging portion, said portions being separably-telescopically electrically-conductively engageable with each other with an initial contact force, the improvement comprising: a rigid plug firmly carried within and reacting directly with one of said portions and abutting the other portion in a direction transverse to the direction in which the contacts separate; said plug comprising material having a greater thermal expansion than said contacts; whereby upon relative expansion of said plug due to a temperature increase, said plug forces one contact radially as a unit against the other thereby increasing the contact force between the contacts.

2. In an electrical connector assembly including a pair of contacts each having an engaging portion, said portions being in separably-telescoping electrically-conducting engagement with each other, the improvement comprising: a thermally responsive rigid plug carried by and reactive with respect to one of said portions and abutting the other portion in a direction transverse to the direction in which the contacts separate; resilient means supporting said plug and biasing said plug in said transverse direction toward the other of said contacts; said plug comprising material having a greater thermal expansion than said contacts; whereby upon relative expansion of said plug due to a temperature increase, said plug forces one contact radially as a unit against the other thereby increasing the contact force between the contacts.

3. In an electrical contact having an engaging portion for telescopically and conductively mating with another contact with an initial contact force to carry a high current, said contact being responsive to normal current to be heated a substantial amount thereby, the improvement comprising: a pocket in said portion, said pocket having an opening whose axis is directed transversely to the direction in which the contact telescopically mates; a rigid plug received in said pocket in thermally conductive relation to said contact portion, said plug having a greater thermal expansion than the contacts, said plug extending along the axis of said opening and having an end for abutting the other contact; and means for reacting on said plug opposite to said end, said plug being responsive to a temperature increase of said portion to expand a relatively greater amount to force the contact radially as a unit against the other contact, for thereby increasing

the engaging force between said contact and the other contact, and to reduce the electrical resistance therebetween to minimize further contact heating.

4. An electrical cable connector assembly for carrying a high current comprising in combination: a pair of separably telescoping contacts each having a portion in conductive engagement with the other for carrying the high current and being heatable thereby, said contacts having an initial contact force therebetween; a rigid thermally responsive expansion plug received by and reactive with respect to one of said portions and abutting the other portion in a direction transverse to the direction in which the contacts separate, said plug having a greater thermal expansion than said contacts; a rigid heat resistive bushing carried by only one of said heatable contacts and having an axially directed shoulder in engagement with an oppositely axially directed shoulder on said one contact, said bushing having a single rigid locking bead extending around said one heatable contact in spaced relation therefrom; and a generally tubular protective and insulating boot extending along said heatable contacts in spaced relation thereto and entirely separated by an annular air space therefrom, said boot having a resilient annular bead directed inwardly thereof adjacent to one end thereof and of a diameter smaller than said rigid bead for surrounding said rigid bead in axial locking engagement, the other end of said boot extending beyond the other of said heatable contacts and converging for resiliently encircling the cable, said plug being responsive to a temperature increase of said one portion to expand a relatively greater amount of force one of said portions radially as a unit against the other portion for thereby increasing said initial contact force between said portions, and to reduce the electrical resistance therebetween to minimize further contact heating.

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