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DeCenzo

[11] **3,924,922**

[45] **Dec. 9, 1975**

[54] **CONSTRICTOR BIASED ELECTRICAL PIN AND SOCKET TYPE CONNECTOR**

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[52] **U.S. Cl.** .... **339/259 R;** 339/262 R

[51] **Int. Cl.²** **H01R 11/22**

[58] **Field of Search** 339/255, 256, 258, 259, 339/262; 267/156, 157

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[57] **ABSTRACT**

A close tolerance pin and socket type electrical connector wherein the socket is characterized by a constrictive high tensile spring-damper that biases radially retractile inwardly formed end portions of low tensile contact fingers into coextensive vibrationless contact with the pin. Complementary male and female components of right cylinder form are involved, and the latter is reformed so as to comprise a plurality of longitudinally recurved circumferentially adjacent fingers with their terminal end portions embraced by said constrictive spring-damper that is held in working placement thereon by shouldered engagement with the fingers. The said fingers are resonant at varied frequencies and the said spring-damper inhibits vibration of the said fingers. The finger and constrictive spring-damper assembly is protectively encased, and all of which is maintained within conventional diameter limits.

2 Claims, 12 Drawing Figures

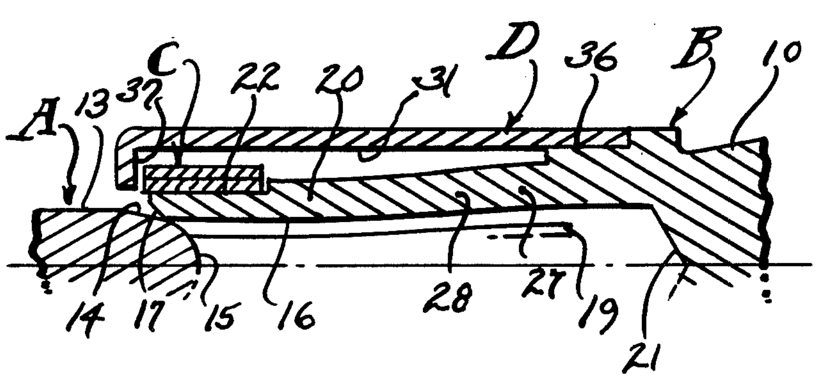

FIG. 1.

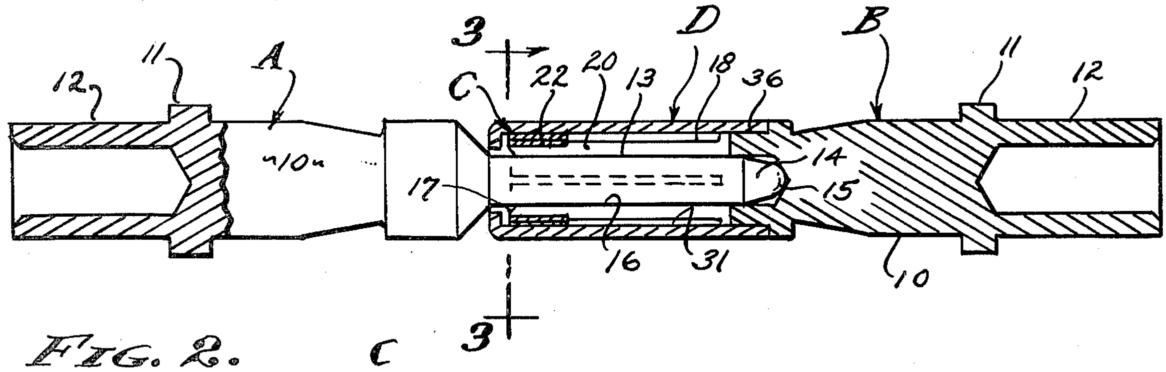

FIG. 2.

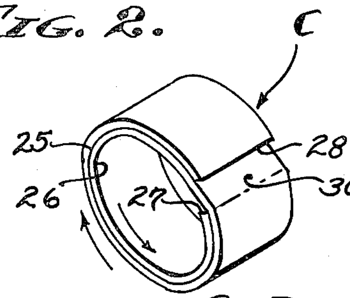

FIG. 5.

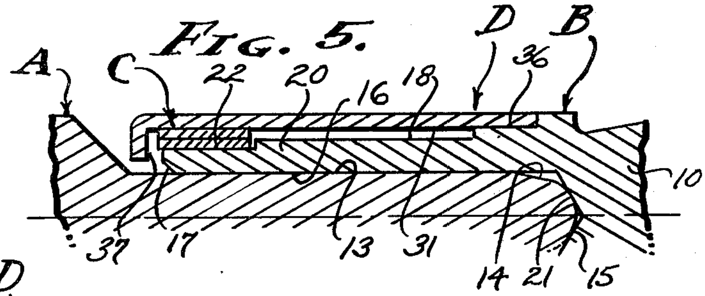

FIG. 3.

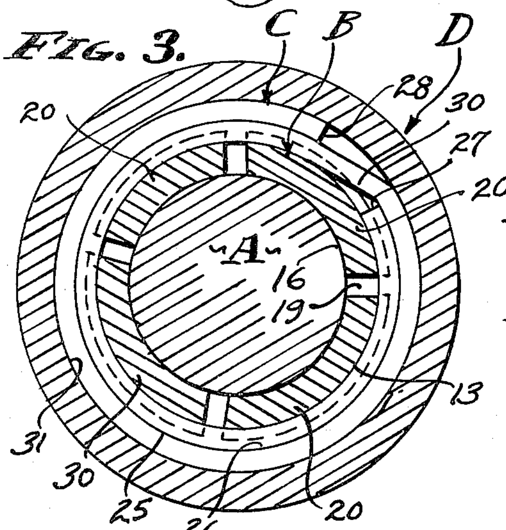

FIG. 6.

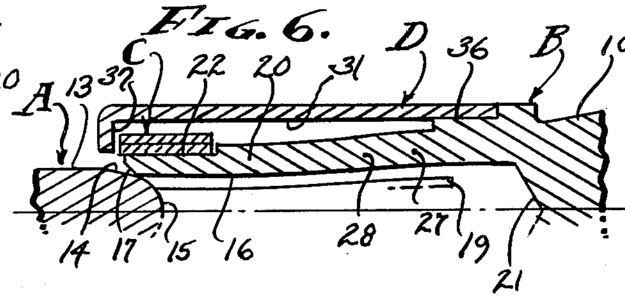

FIG. 7.

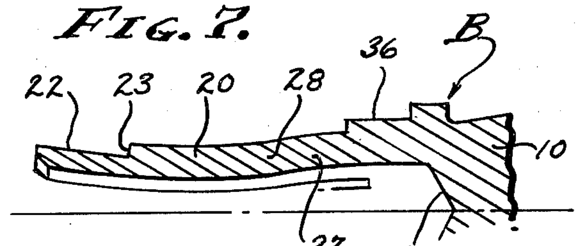

FIG. 4.

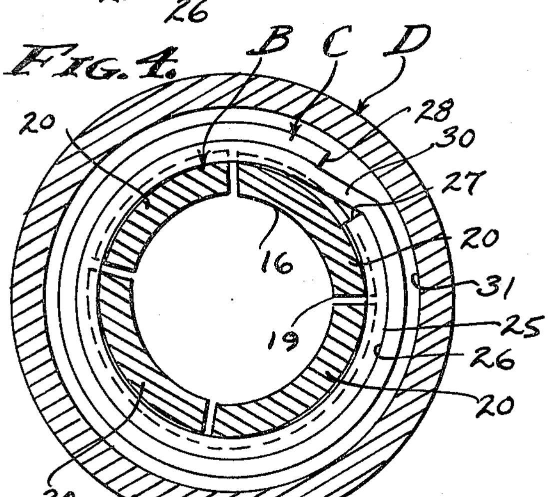

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FIG. 8.

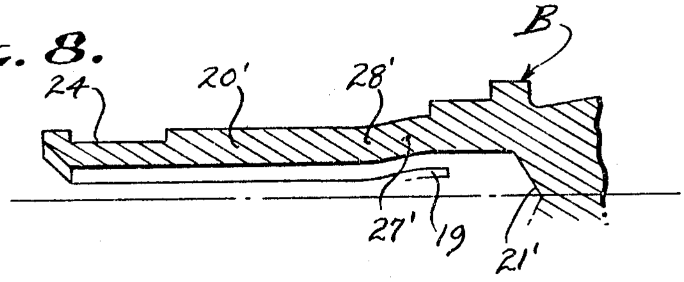


FIG. 9.

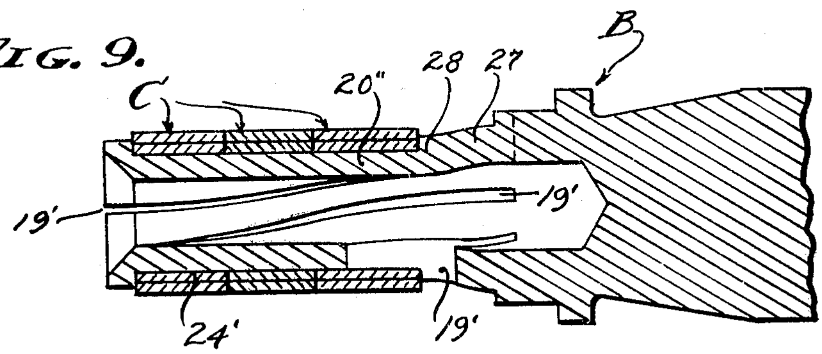


FIG. 10.

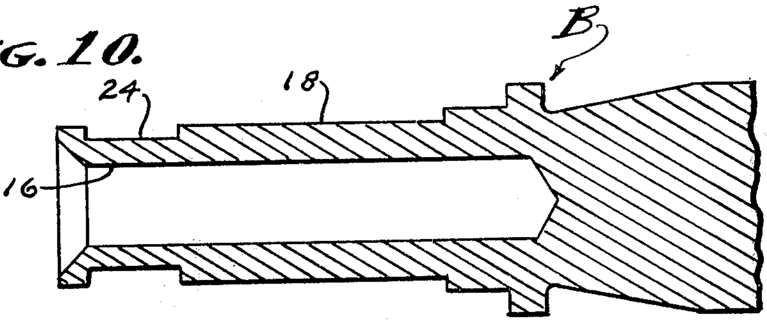


FIG. 11.

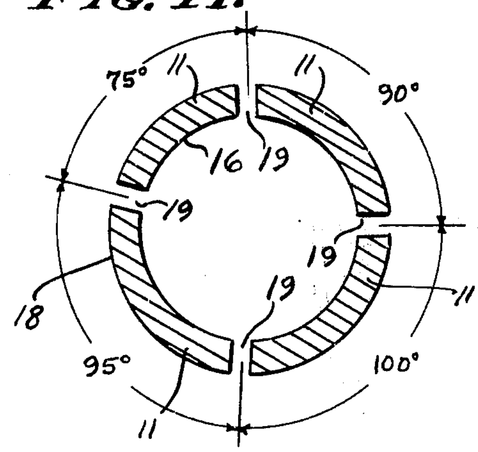
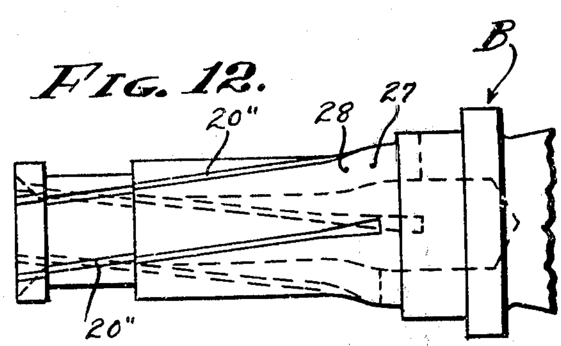


FIG. 12.



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CONSTRICTOR BIASED ELECTRICAL PIN AND SOCKET TYPE CONNECTOR

BACKGROUND

The art of pin type connectors is redundant with various ideas of means designed to effect the constrictive spring pressure of a female sleeve onto a male pin. Particular reference is made to electrical connectors wherein, ideally, sliding contact is to be established between male and female components, either singly or in multiplicity and wherein each mated male and female component conducts a circuit. It is common practice, therefore, to install the male and female components in aligned bodies of insulating material and to secure the bodies together with the male and female components matedly engaged therebetween. A surrounding shell is usually employed for rotational orientation and as the securement means, and to shield the circuits involved. It is these types of electrical couplings with which the present invention is involved, and despite their design for area contact they are most often found to have point and/or line contact of resonant fingers that vibrate to great disadvantage.

FIELD OF INVENTION

It is a general object of this invention to provide a "high reliability-close tolerance" pin and socket type electrical connector wherein the male pin is assured of maintaining coextensive circumferential and longitudinal engagement with the contact fingers of the female receptacle. With the present invention, coextensive sliding contact between male and female electrical components is assured over a maximum interface engagement resulting in minimized electrical resistance to current flow therethrough.

An object of this invention is to provide means in the body of a connector socket and which comprises inwardly curved contact fingers of low tensile highly conductive material biased radially inward by means of a high tensile spring into pressured contact with a removable cylindrical male pin member. Specifically, a restrictive spring-damper encircles the longitudinally disposed circumferentially adjacent female fingers comprising a sleeve-like receptacle that frictionally receives the said male pin member. Heretofore, reliance has been made upon the resilience of the female fingers per se and special attention has been exercised in the heat treatment and zone annealing of the female component, and all of which can be adversely affected by cracking and part failure, and by the application of heat when soldering conductors to the female component.

With the present invention the female component remains in the low tensile condition for various unobvious reasons, as follows: since contact pressure is established primarily by a separate and independent means, the female component is advantageously formed of highly conductive low tensile material such as leaded copper or aluminum which have relatively high electrical conductivity as compared with the usual prior art components fabricated of beryllium copper and the like which have relatively low electrical conductivity at best. Therefore, heat generation will be minimal and consequently there will be reduced danger of the connector overheating.

Another object of this invention is the reduction of resonant frequencies through the formation of the contact fingers of the female component of the connec-

tor. The contact fingers are of unequal circumferential and/or longitudinal extent so that each finger has a distinct resonant frequency. With the contact fingers shaped as hereinafter described damping of vibrations is inherent; and combined with the spring-damper there is a snubbing action which virtually eliminates vibration.

It is still another object of this invention to provide a pin and socket type connector of the character thus far referred to and which offers improved conductivity with reduced susceptibility to vibrational harmonics. Special heat treatment and/or zone annealing is eliminated from manufacture thereof; and full advantage is thereby realized from the inherent physical properties of the materials employed. The cooperative male and female components are so designed that there is no interference fit in the initial formation, while pressured electrical contact is assured by the two-fold means of the finger formation and the cooperative effect of the spring-damper which biases the fingers inwardly and simultaneously damps radial movement through circumferential frictional engagement.

It is also an object of this invention to provide a spring-damper which has both internal and external frictional characteristics and disposed so as to resist vibration as described herein. The contact fingers of the female element are essentially "dead," being made of low tensile material; but nevertheless a degree of resilience exists therein, and due to their longitudinal disposition they do tend to vibrate at resonant frequencies. Therefore, the spring-damper, as it will be described, is formed to have a vibration susceptibility restricted to a plane disposed transverse to the transmission of vibrations axially through the connector structure; and in said plane the spring-damper is frictionally laminated to have lapped braking engagement within itself and as well with the contact fingers which it engages and controls.

DRAWINGS

The various objects and features of this invention will be fully understood from the following detailed description of the typical preferred forms and applications thereof, throughout which description reference is made to the accompanying drawings, in which:

FIG. **1** is a longitudinal sectional view of a typical constrictor biased electrical pin type connector, approximately four times actual size.

FIG. **2** is an enlarged perspective view of the constrictive spring-damper component removed from the example structure of FIG. **1.**

FIGS. **3** and **4** are enlarged detailed sectional views, FIG. **3** being taken as indicated by line **3—3** on FIG. **1.**

FIG. **5** is an enlarged fragmentary view illustrating the engagement of the male and female elements.

FIG. **6** is a view similar to FIG. **5** illustrating the separation of the male and female elements.

FIG. **7** is a view similar to FIGS. **5** and **6** illustrating the reformation of the female element which advantageously characterizes the present invention.

FIG. **8** is a view similar to FIG. **7** and illustrates a most practical modified embodiment in the reformation of the female element.

FIG. **9** is a longitudinal sectional view of the female element illustrating a modified embodiment wherein the female fingers are helical as they extend longitudinally.

FIG. 10 is a view illustrating the initial right cylinder formation of the female element slotted into contact fingers prior to the reformations shown in FIGS. 7 and 8.

FIG. 11 is a sectional view taken as indicated by line 11—11 on FIG. 10. And,

FIG. 12 is a longitudinal elevational view of a most practical embodiment having straight canted slots of varied depth.

PREFERRED EMBODIMENTS

This connector is of the socket and pin type wherein a male pin member A is frictionally engaged in a female receptacle member B. Either a single connection is made or multiples thereof, and it is common practice to install the mated male and female members in insulated bodies that are keyed and coupled together with the male and female members in aligned engagement. There are various ways of mounting the male and female members, and of joining them to conductors; neither of which is controlling in the present invention except that it is feasible with the present invention to use any mounting and any conductor connection means that may be desired. As shown, there is a mounting cylinder **10** and a positioning flange **11** on both the male and female members, and each member also has an open tubular extension **12** for the reception of a conductor end (not shown) and which is crimped or filled with solder to effect a sound electrical connection.

The male pin member A and female receptacle member B are complementary for mating purposes and adapted to be assembled as shown in FIG. **1**, the former being slideably insertable into the latter. Accordingly, the pin member A is an elongated shaft preferably of round cross section and having a straight cylindrical exterior wall **13** with its terminal end portion tapered at **14** and round at **15**. The female receptacle member B is an equally elongated sleeve preferably of round cross section and having a straight cylindrical interior wall **16** with a chamfered entry **17** (see FIGS. **5–7**). In carrying out this invention the diameter of walls **13** and **16** are held to close tolerance and of the same dimension so as to have coextensive engagement when the male pin member A is fully inserted into the female receptacle member B. In practice, manufacturing tolerances are applied whereby the interior diameter of member B is never less than the exterior diameter of the member A, and preferably the said interior and exterior diameters are as nearly identical as is practically possible.

The female socket or receptacle member B is initially formed with straight cylindrical exterior and interior diameters **18** and **16** as shown in FIG. **10** of the drawings, said diameters being concentric and defining a cylinder wall of minimal radial thickness; and the said cylinder wall which characterizes the female member is divided circumferentially by longitudinal slots **19** of minimal width and that sever the member into elongated radially movable fingers **20** as shown in FIG. **11** of the drawings. The female receptacle member is cut into from its open terminal end by means of a multiplicity of slots **19**, preferably unequally spaced slots establishing fingers **20** differing in cross section. It is to be understood that the number of slots will depend upon the size and proportions of the member. As shown, there are four unequally cross sectioned fingers **20** established by cutting four slots **19** spaced circumferentially in rotational sequence 90°, 100°, 95° and 75° apart, for example; thereby establishing fingers susceptible to differing vibrational frequencies. It will be understood that the arcuate cross sections of the fingers **20** will vary according to the arcuate extent thereof, the slots being substantially coextensive with the contact length of the female receptacle member B and terminate at the bottom **21** of interior diameter **16** upon which the male pin member engages to determine the penetration thereof.

In accordance with the invention a constrictive spring-damper C is carried on and embraces the terminal end portions of the fingers **20** immediately adajcent to the open end of the slotted cylinder wall. The female receptacle member B is prepared for the constrictive member C by turning a minimal step **22** therein, having a shoulder **23** (see FIG. **7**) and a bottom extending to the end of the member. The constrictive spring-damper C is a right cylinder laminiform member that encircles the terminal end portions of the fingers **20** when placed within the confines of the step **22**, and which engages upon the bottom thereof to constrict the fingers radially inward a limited distance and cooperating with the hood D to restrict outward radial movement of the fingers. Thus, the spring-damper C is radially constrictive to an exacting limit so that its inner diameter presses the fingers **20** inwardly from their normally operative positions as shown in FIGS. **1** and **5**, and thereby decreasing the opening within the female receptacle member B as shown in FIGS. **4** and **6**. However, this constriction is not to exceed that limit which still permits entry of the male pin member A, as governed by the taper **14** engaging chamfer **17** (see FIG. **6**).

The constrictive collar or spring-damper C is a laminiform ring of high tensile material having physical properties producing a yieldable and resilient spring that permits a circumferential increase and consequent radial expansion; preferably a continuous multi-layer member of resilient metal such as beryllium copper having stop means limiting constriction of the fingers **20** to a prescribed dimension, and that proportionately increases its resistance to expansion so as to establish a restriction to outward movement of the fingers **20**. In practice therefore, the bias of the constrictive spring-damper C is mild when the fingers **20** are collapsed inwardly and is increasingly severe as the fingers are moved radially outward. Accordingly, the spring-damper C is a continuously wrapped multi-layer of flat strip material comprising two convolutions with the outside wall **25** of its inner convolution engaging the inside wall **26** of its outer convolution. The walls **25** and **26** are coextensive with the length of material forming the laminiform member C and terminate at inner and outer ends **27** and **28** that are normal to the parallel sides thereof. Coextensive engagement with the right cylinder form of step **22** is achieved by forming the inner and outer convolutions as right cylinders when in the constricted condition as shown in FIGS. **2, 4, 6** and **9**; this being the limit of constriction as predetermined by stop means **30** comprising a continuing abuttment that extends between and integrally joins the inner and outer convolutions. It will be observed that the said inner and outer convolutions are each confined to their respective concentric diameters with the abuttment of stop means **30** joggled therebetween (see FIG. **2**). Consequently, the member C remains of right cylinder form as initially formed with the ends **27** and **28** apposedly engaging the abuttment of stop means **30**, and as it is expanded by outward radial pressure applied from within; and the transition from the initial form to the expanded form is initially accompanied by sliding contact of the walls **25** and **26**, one with the other and of the wall **26** of the inner convolution with the step **22** on the fingers **20**; also, the wall **25** of the outer convolution with the inner diameter **31** of hood D. This sliding contact restrains relative circumferential movement of the two convolutions and is a brake against and restricts radial expansion and contraction of the member C.

In accordance with the present invention and referring specifically to the form thereof shown in FIG. **7** of the drawings, the fingers **20** are reformed and thereby prestressed so as to preclude the usual point and/or line contact which characterizes the prior art connectors of the type under consideration. The said reformation is made subsequent to the above described establishment of the straight and concentric right cylinder diameters **16** and **18** shown in FIG. **10**; and the result is a preformed spring finger **20** that has substantially uniform pressured engagement throughout the apposed areas of said two members. That is, uniform pressured engagement is made coextensively of both the length and arcuate width of the interface between finger **20** and the apposed exterior wall **13** of pin member A. As shown, the finger **20** is turned radially inward as it projects axially from the bottom **21** on a radius or curve **27** (exaggerated) defined by said turning or bending. Continuing from the curve **27** the finger **20** is reversely turned or bent radially outward from said first mentioned bend, on a radius or curve **28** (exaggerated) defined by said second mentioned turning or bending. As a result of the above described bend reformation of the finger **20**, a semi-elliptical inwardly bowed leaf spring is preformed, having its root in the body member B at the bottom **21** and having its free end turned radially outward. In practice, the degree of inward turning at radius **27** is minimal, being a short bend or curve, and sufficient to effect the desired uniform pressure contact between walls **13** and **16** when the finger **20** assumes one constant diameter position along its entire length (see FIGS. **1** and **5**). The degree of outward turning at radius **28** is more extensive than at radius **27** (see FIG. **7**), being a long bend or curve, and sufficient to effect the desired uniform pressure contact between walls **13** and **16** when the finger **20** reassumes said one constant diameter position along its entire length (again see FIGS. **1** and **5**).

The modified embodiment of contact finger **20'** shown in FIG. **8** of the drawings is reformed from a right cylinder form as shown in FIG. **10**, the same as in the female element B hereinabove described, the finger **20'** being turned radially inward as it projects axially from the bottom **21'** on a radius or curve **27'**. However, the finger **20'** is reversely turned from the first mentioned curve **27'** or bend on a radius or curve **28'** to extend parallel with the central axis of the female element B. In this embodiment, the usual spring retaining channel **24** is shown in place of the single step **22** above described.

The modified embodiment of spring finger **20''** shown in FIG. **9** of the drawings provides axial elongation of the spring-damper or dampers C', either by axial elongation (not shown) of a single member or as is shown by employing a series of next adjacent spring-dampers C', and to the end that the female member B is coextensively biased by resilient means adapted to apply radially inward pressure. In this embodiment the usual spring retaining step or channel **24'** is widened so as to receive the axially elongated member or members C' as the case requires.

The modified embodiment of contact fingers **20''** shown in FIG. **9** is provided for elimination of vibration, by means of a mechanical interlock. Accordingly, the slots **19'** which divide the right cylinder form into fingers are angularly disposed with respect to the longitudinal axis of the female element B. The angular displacement can vary and is substantial and correspondingly effective; being established by either straight canted cuts as is shown in FIG. **12** or by helical cuts as is shown in FIG. **9.** In practice, the cuts establishing the slots **19'** revolve 90° in the length of the fingers **20'**, thereby giving a maximum locking action normal to the root mounting of the fingers; a lesser revolvement being practical such as 60° as illustrated in FIG. **12** providing an arcuate extent of each finger which sufficiently braces the finger against radial movement. Thus, by embracing the pin element A laterally at the outer end portions of female element B, and/or by laterally bracing the fingers within themselves, longitudinal vibrations transmitted through the connector cannot lift the inner end portions of the fingers. Referring to FIG. **12**, the slots **20''** are cut to varied longitudinal depth in order to establish finger **20''** of distinct vibrational frequency; and as shown there are opposite pairs of shallow and deep slots **20**; thereby establishing diametrically opposite short and long fingers **20''** with diametrically opposite intermediate fingers of effective medium length. Further, the encompassing spring-damper C completes the vibration restriction and simultaneously biases the contact fingers for tight electrical engagement upon the male pin element A.

The preformed contact fingers **20** are reformed as hereinabove described, of low tensile material such as aluminum or as leaded copper (annealed) having an electrical conductivity of 98 percent. The degree of curvature in the radii **27** and **28** is minimal and the bending required for the fingers to reach the constricted position shown in FIG. **6** does not exceed the yield of this relatively soft material. However, the initial formation of the walls **13** and **16** to close tolerance interface dimensions, as hereinabove described, makes possible a coextensive interfit therebetween with minimal movement and/or deflection, the constrictive collar C of high tensile material affording the mechanical control and determining the pressured engagement applied to the terminal end portions of fingers **20.** Therefore, when the male pin member A is inserted as shown in FIGS. **1** and **5**, the fingers **20** assume their initial right cylinder formation (or segmental portions thereof) and the straightening from their prestressed condition transfers the constrictive force of collar C throughout the longitudinal extent of the fingers and to the roots thereof.

The hood D is provided to house the spring biased and damped female receptacle member B and to operatively position the constrictive spring-damper C, and it involves a cylindrical shell with an inwardly turned locating flange. The hood shell has an inner diameter wall **31** that normally clears the constrictive member C (see FIG. **4**) and which imposes a positive limit on its expansion (see FIG. **3**). The wall **31** is press fitted onto a raised boss **36** at the base end of the female receptacle member B, and it is the wall **31** that establishes the limit of expansion as it encirlces the member C positioned in the step **22** in which it is held positioned by the inwardly disposed face **37** of the said flange. Thus, the constrictive spring-damper C is entered into operative position without deflection of fingers **20** beyond the limit of movement shown in FIG. **6.**

From the foregoing, the fundamental structure of this pin and socket type connector will be understood and it will now be apparent that close tolerances are feasible and that high reliability is inherent therein. The initial formation of the slideably related male and female diameters **13** and **16** is feasibly established in cylindrically parallel telescopically engageable members that are adapted to be coextensively engaged without interference fit. The constrictive spring-damper C encircles the radially inward movable fingers **20** of the female receptacle member B and is held in working position, either by placement in the channel or by placement on the step and thereby confined in operating position. It is significant that this is the optimum placement for the effect of constrictive spring-damper C which has a positive limit of motion in its constrictive ability; a spring member made of high tensile material having a reliable memory to its initial formation; and in no case during assembly or in use can the constrictive motion be excessive.

With the female receptacle member B constructed of highly conductive material as hereinabove described, the male pin member A is slideably inserted therein by spreading the contact fingers **20** in opposition to the radially inward pressure exerted principally by the constrictive spring-damper C, and as a result of the initial cylindrical parallelism of the diameters **13** and **16,** the male and female members seek coextensive telescoping engagement with a maximum area of electrical contact. In the event that lateral forces are applied and which would cause axial displacement of members A and B, substantial resistance to this effect is present in the application of the ever increasing constrictive pressure applied at optimum locations of the spring-damper C and root attachment of the contact finger **20.** In this event of applied lateral pressure, the terminal end of the male pin member A pivots at a fulcrum within the root attachment of the contact fingers **20** and the spring-damper C applies inward resistance to the axial displacement at the outermost extremity of the member B. In the event that said lateral force is extreme, then the hood D come into play and prevents expansion of the spring-damper C and limits its outer diameter to a dimension which restricts movement of the contact fingers **20** to the above mentioned optimum cylindrical parallelism and which at all times ensures coextensive interface engagement of the male and female members of this pin and socket type electrical connector.

With the spring-damper C constructed as herein disclosed, the inward constrictive force applied thereby is positively limited as shown clearly in FIG. **4,** while expansion and/or contraction between the conditions shown in FIGS. **3** and **4** involve sliding engagement of

the inner and outer convolutions of said spring member. It is this circumferential sliding engagement which is at least twice removed from vibration applied longitudinally of the female element B; in that expansibility of member C is disposed in a plane normal to the axis of member B and in that the expansion of said member C requires opposite movements of the lamination circumferentially around said axis of the female member B. Consequently, the tendency of contact fingers **20** to vibrate is prevented by the retarding effect of friction in the member C which is not in itself susceptible to vibrating.

Having described only typical preferred forms and applications of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any modifications or variations that may appear to those skilled in the art:

Having described my invention, I claim:

1. A hooded pin and socket connector wherein a male pin member is frictionally slidable into a female receptacle member, the male member having an exterior diameter of right cylinder form and the female receptacle member having an interior diameter of right cylinder form, said exterior and interior diameters of the two said members being of substantially the same diameter for coextensive interface engagement, the said female receptacle member having an outer diameter of right cylinder form concentric with said interior diameter forming a wall open at one end to receive the male pin member, there being slots through the said wall from said open end and substantially coextensive with the depth of penetration of said male pin member therein and thereby severing the female receptacle member into a plurality of radially movable longitudinally disposed circumferentially adjacent contact fingers fixedly rooted in said female receptacle member, and a laminiform spring-damper of right cylinder form embracing the said contact fingers and comprising concentrically wrapped inner and outer frictionally engaged convolutions and one convolution integrally continuing from the other by means of an angularly disposed member extending therebetween and the inner convolution engageable with the outer diameter of said female receptacle, and a cylindrical hood carried on and extending from the base and spaced from the outer wall of the female receptacle member and having an inner diameter wall engageable with the outer convolution of the laminiform spring-damper stopping its lateral expansion when the female receptacle member reassumes right cylinder form.

2. The pin and socket connector as set forth in claim **1** wherein the inner and outer convolutions have circumferentially spaced and opposed inner and outer ends engageable to stop against inner and outer sides of said angularly disposed member.

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