May 21, 1968 J. A. NAVA 3,384,866

CONTACT PRESSURING MEANS FOR AN ELECTRICAL CONNECTOR

Filed Sept. 3, 1965 2 Sheets-Sheet 1

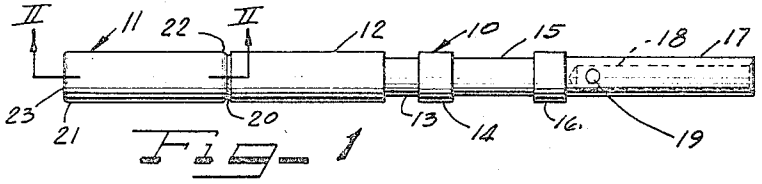


Fig. 1

Fig. 3

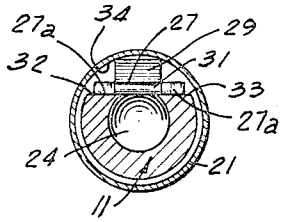
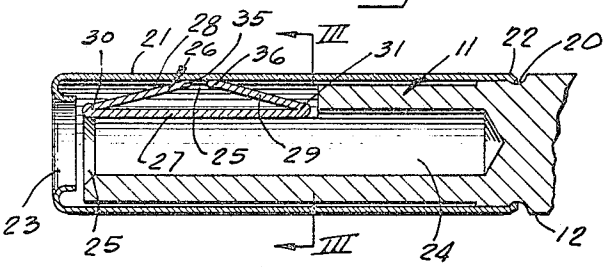


Fig. 2



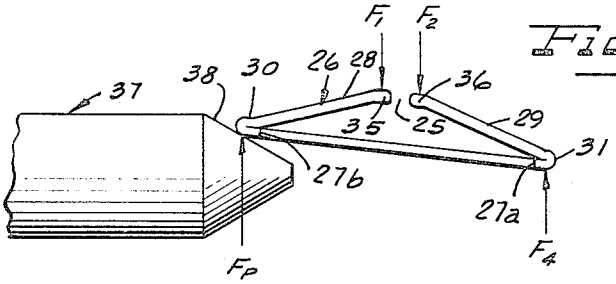
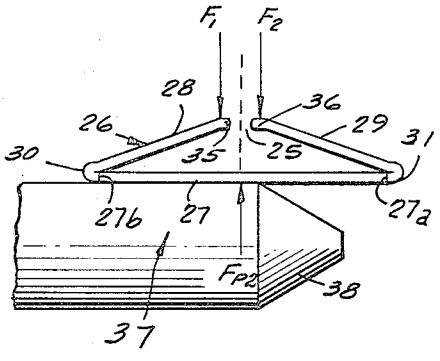


Fig. 4

Fig. 5



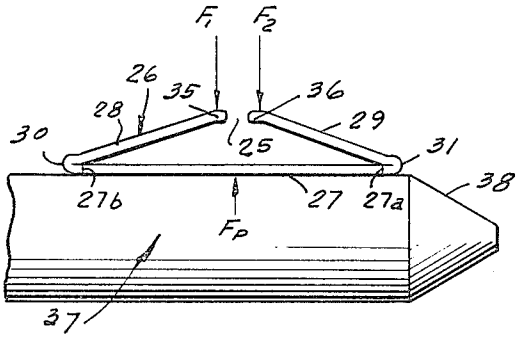


Fig. 6

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CONTACT PRESSURING MEANS FOR AN ELECTRICAL CONNECTOR

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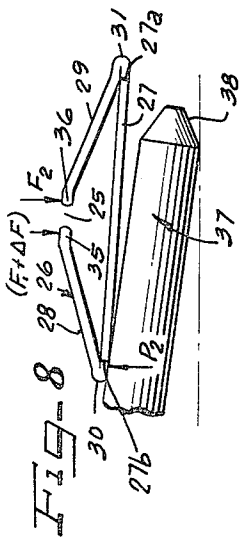


Fig. 8

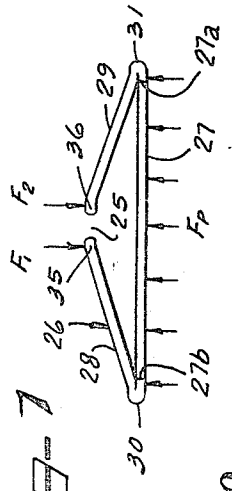


Fig. 7

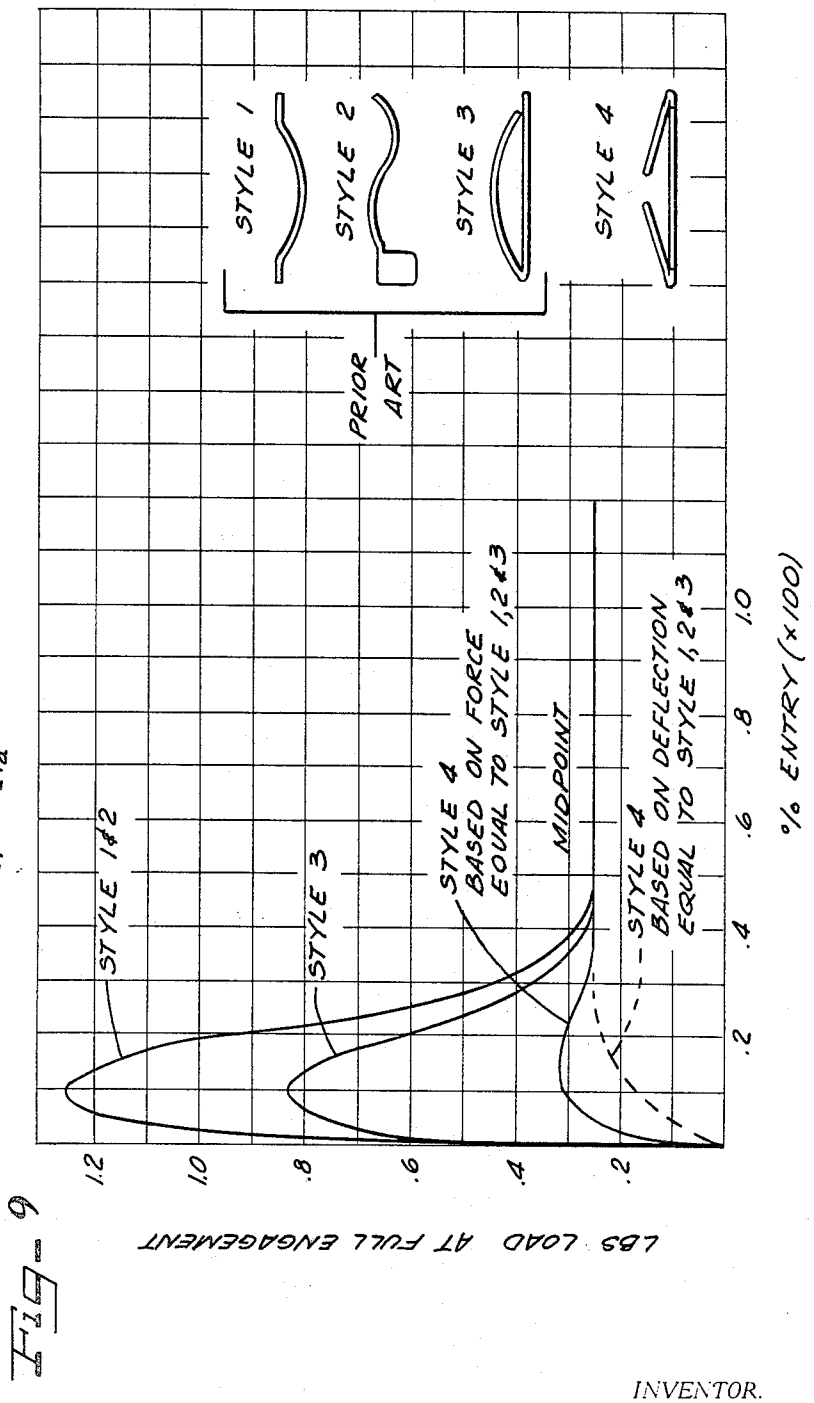


Fig. 9

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CONTACT PRESSURING MEANS FOR AN ELECTRICAL CONNECTOR

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8 Claims. (Cl. 339—256)

ABSTRACT OF THE DISCLOSURE

An electrical connector having female socket portions and an opening formed in the wall of the socket portions for positioning a contact spring therein. The opening has flat surfaces on opposite sides thereof, and the contact spring has a beam section and reversely turned integral spring arms. The beam section contacts the flat surfaces of the opening and the reversely turned integral spring arms engage a shroud which is fitted over the socket portion.

This invention relates to electrical connectors and particularly to a pressurized electrical contact plate having inwardly directed cantilever spring arms and providing a contact force with a mating contact member which is reduced at start of entry and increased at full engagement.

Electrical contacts are an essential component of many electrical devices. Their purpose is to provide the means for disconnecting an electrical circuit mechanically. The contact must perform its conductivity function with a minimum of electrical resistance and with no detectable discontinuity within a time period of micro or nano seconds when the contact is under mechanical stress such as vibration or shock.

To accomplish the conductivity function, the contact must be designed with mechanical means for maintaining intimacy between two contacts in a given circuit and with the ability to separate and reengage when desired. Such separation and engagement must be accomplished reproducibly. The electrical characteristics such as electrical resistance, mechanical forces, and plating integrity must be maintained from one engagement to another for hundreds and possibly thousands of cycles. Only narrow limits of variations are permitted from the normal operation specifications.

Furthermore, recent developments in circuit electrical requirement have made reproducibility of the mating contact elements increasingly mandatory. For instance, the magnitudes of electrical circuit characteristics have been decreasing to the lower ranges of millivolts potential and micro ampere currents. As these characteristics have decreased, the precision with which the contacts must control the resistance through the contacting surfaces has greatly increased. Under such circumstances the associated contacts must maintain not only a low resistance but a consistency of resistance which is the essence of reproducibility.

While the need for reproducibility of contacts in certain electrical circuits has become increasingly mandatory, the physical environments associated with those circuits have become increasingly obstructive to obtaining that objective. For instance electrical connectors are now being required to operate under temperatures up to 200° C. and under vibration and shock up to hundreds of G's. The resulting strain on the mating electrical members tends to develop a loss of continuity between the contact surfaces which is the antithesis of contact reproducibility.

In addition to the need for reproducibility under conditions of high physical strain, certain connector designs have required a decrease in the engagement force of the individual contacts. The number of contacts associated with a given connector have increased steadily from 28 to 55 and recently to 80. As a consequence, the force required to couple and uncouple the connector has increased in direct proportion resulting in an increased wear on the connector coupling mechanism. On the contrary a reduction in the individual engagement force would correspondingly reduce the coupling force and the wear on the associated coupling mechanism.

Accordingly, it is an object of this invention to provide a pressurizing means for improving the reproducibility of a pair of mated electrical contacts.

It is also an object of this invention to provide a pressurizing means having an improved contact continuity under conditions of high physical strain.

It is another object of this invention to provide mating electrical contact members having a significantly reduced contact force at start of engagement and an improved contact force at full engagement.

It is a further object of this invention to provide a pressurizing means for use with a shrouded contact socket having a substantially flat contact plate and inwardly directed cantilever supported spring arms.

It is also an object of this invention to provide a pressurizing means for an electrical contact socket having a uniformly distributed engagement force with a mating contact member.

It is an additional object of this invention to provide a pressurizing means for an electrical contact socket which is responsive for correcting misalignment of a cooperable contact member.

Other objects and advantages of the present invention will become manifest to those versed in the art upon reference to the following detailed description and accompanying drawings wherein a preferred embodiment of an electrical contact having the characteristics of the present invention is illustrated.

On the drawings:

FIGURE 1 is an elevated view of an electrical contact socket and its associated circuit connection;

FIGURE 2 is a sectional view of a portion of the contact socket of this invention as taken along the lines II—II of FIGURE 1;

FIGURE 3 is a cross-sectional view of the socket assembly of this invention as taken along the lines III—III of FIGURE 2 for illustrating the mounting of a pressurizing means on the socket contact body;

FIGURE 4 is a diagrammatical representation of the mating relationship of a contact pin and the pressurizing means of this invention for illustrating the force relationships existing at start of entry of the contact pin into the socket of FIGURE 2;

FIGURE 5 is a diagrammatic representation similar to that shown in FIGURE 4 and illustrating the described force relationships during partial engagement of the contact pin and cooperable contact socket;

FIGURE 6 is a further diagrammatic view in the sequence characterized in FIGURES 4 and 5 and illustrating the force relationship between the pressurizing means and the contact pin during full engagement therewith;

FIGURE 7 is a force diagram illustrating the uniform force distribution associated with the contact plate of this invention;

FIGURE 8 is also a diagrammatic representation of the responsive force relationship existing between the pressurizing means of this invention and a contacting pin during misalignment of the cooperable contact members, and

FIGURE 9 is a graphical representation illustrating prior art pressurizing structures and the associated force relationship exerted on a contacting pin at various stages of engagement with a cooperable contact socket.

As shown on the drawings:

Electrical contacts in an electrical connector are, generally, of a pin and socket configuration due to the density of contacts in the connector. This requires that the contact mechanical features be disposed axially along the length of the contact. Therefore, most pin and socket contacts consist of a pin which is generally a solid cylinder terminated to a circuit wire and a socket which is a hollow cylinder terminated to another wire representing the continuation of the circuit. Depending upon the design of the contacts, the pin or the socket may provide the mechanical means for providing intimacy between them. Experience shows, however, that the most reliable method is to provide the pressurizing means on the socket contact. This implies a spring member mounted on the socket, which will react mechanically with the pin when that pin is mated coaxially with the socket.

As shown on FIGURE 1, the socket contact of the present invention is indicated generally at **10** and comprises a tubular socket portion **11** and a plurality of stepped or recessed body portions **12, 13, 14, 15** and **16** to accommodate assembled relationships with related connector components. However, any suitable structural configuration could be employed without affecting the principles of the present invention.

The socket contact is also provided with a rear barrel portion **17** having a recess or groove **18** for receiving a bared conductor wire. An inspection hole **19** is provided to facilitate checking or inspection of the wire conductor within the recess **18**.

The tubular socket portion **11** has an annular groove or recess **20** formed circumferentially thereabout for providing a retaining function with a cooperable shroud **21**. The shroud **21** is crimped as at **22** about the reduced diameter provided by the recess **20** and extends coaxially about the socket portion **11** to terminate a bell opening **23**.

The tubular socket body **11** has a cylindrical bore **24** formed axially thereof which is provided with a countersunk or tapered end opening **25** disposed adjacent to the bell opening **23** of the associated shroud **21**. The substantial alignment of the bell opening **23** and the tapered end opening **25** is provided to allow the insertion of a contact pin into the cylindrical bore **24**.

To assure reproducible mating of a contact pin with the tubular socket portion **11**, a pressurizing spring **26** is disposed within the socket **24** for maintaining a continuous load at the external surface of a complementary fitted pin.

The pressurizing spring **26** comprises a substantially flat contact plate **27** and a pair of cantilever spring arms **28** and **29** extending inwardly from opposite ends of the plate **27**. The spring arms **28** and **29** are formed integrally with the contact plate **27** and are folded therewith to assume the configuration shown in FIGURE 2. In folding the spring arms **28** and **29** about the plate **27** rounded faces **30** and **31** are formed at the outer surface of the resulting crease. It is apparent from FIGURE 2 that the rounded face **30** aids in the insertion of a contact pin within the bore **24** by reducing the contact friction and hence the wear of the mating parts.

The pressurizing spring **26** is mounted within the cylindrical bore **24** at a set of plane surfaces **32** and **33** milled substantially parallel to the axis of the bore **24**. The spring arms **28** and **29** are provided to have sufficient tension to secure the pressurizing spring **26** between the milled surfaces **32** and **33** and the inner surface **34** of the shroud **21**. A feature of this mounting and of the configuration of the pressurizing spring **26** is that the contact plate **27** has a substantial width for overlying the plane surfaces **32** and **33**, while the spring arms **28** and **29** have a substantially reduced width for extending against the inner surface **34** at a point significantly removed from the surfaces **32** and **33**. This increased distance allows for a correspondingly increased spring motion between the contact plate **27** and the external surface of a mating contact **10**.

A further feature of the pressurizing spring **26** is found in rounded spring tips **35** and **36** formed at the outer extremities of the cantilever arms **28** and **29**. The insertion of a contact pin within the cylindrical bore **24** will cause a gradual compression of the contact plate **27** relative to the cantilever arms **28** and **29**, and the rounded tips **35** and **36** allow the cantilever arms **28** and **29** to pivot or roll about their contact point with the inner surface **34** of the shroud **21**. Therefore, the contact of the tips **35** and **36** with the shroud **21** will not interfere with the intended deflection of the cantilever arms **28** and **29**.

One of the drawbacks of previous pressurizing devices has been that the engagement force, when a pin contact enters a socket contact is several times higher than the extraction force. This is because the pin contact experiences only a frictional force during extraction, whereas, the insertion force is the sum of the frictional force plus the force required to physically overcome the pressurizing means and displace it into an axial position tangent to the pin contact.

This additional engagement force is totally unnecessary to the mechanical and electrical function of the mated contacts. Its existence increases the coupling force of a connector assembly. In addition, and more important, it increases the wear on the contacts because of its higher value and also because of the shearing attitude between the end of the pressurizing means and the nose of the pin contact.

The force diagrams of FIGURES 4 through 6 illustrate the manner in which the present invention overcomes the drawback of previous pressurizing devices. However, because of the variable nature of the spring, the calculations illustrated conditions at the extreme positions. This makes it possible to describe the functional conditions without resorting to mathematical equations which define any and every state. In this way, it is possible to reduce discrete variables by elimination at specific conditions, although it is understood that such elimination is possible only at the stated extremes.

The extreme position illustrated in FIGURE 4 is the start of entry of a pin **37** having a nose portion **38** into the cylindrical bore **24**. The nose **38** of the pin **37** contacts the pressurizing spring **26** at the rounded surface **30** provided by the fold between the contact plate **27** and the cantilever spring arm **26**. At this extreme, rotation of the spring occurs at the reaction pont F_4, and F_2 remains less than F_1 due to the rotation. The transverse force seen by the pin **37** is derived by

$$\Sigma M_4 = F_1 \frac{L}{2} - F_p L = 0$$

therefore $F_p = \frac{1}{2} F_1$. For purposes of the foregoing equation, F_2 is considered negligible. It is apparent, therefore, that the transverse force which the pin **37** experiences is one-half the force which one cantilever section of the spring exerts. On the other hand, the force F_p as shown in FIGURE 4 related to the force F_{p2} as shown in FIGURE 5 at full assembly is:

$$F_p 2 = F_1 + F_2$$
$$F_p 2 = 2F_1$$
$$F_p = \tfrac{1}{2} F_1$$
$$F_1 = 2F_p$$
$$F_p 2 = 2(2F_p) = 4F_p$$
$$F_p = \tfrac{1}{4} F_p 2$$

This means that the present invention provides a spring which exerts a force at entry which is ¼ times the force at full engagement.

The spring attitude slightly past midpoint is shown in FIGURE 5 and the static force equation is as follows:

$$\Sigma F_y = F_1 + F_2 - F_p = 0$$
$$F_p = F_1 + F_2$$

No moments exist and the force system achieves stability. At this point F_p has increased from $\frac{1}{4}(F_1+F_2)$ to the sum of F_1+F_2 and is at a maximum.

To provide a comparison to other types of springs, it is necessary to perform similar analysis. Three typical spring designs are displayed in FIGURE 9 both graphically and analytically. All, except the present design, show forces at entry substantially higher than at any other point in the engagement sequence.

It is apparent from FIGURE 9 that the present design displays a uniformly increasing force during entry to the full engaged force, without the obvious disadvantages of excessive initial forces.

The full engagement position shown in FIGURE 6 illustrates a balanced system with a concentrated load at F_p at the center of the flat beam section. In practice, however, this is impossible since the flat beam will deflect upon application of a load. The forces seen by the pin contact, therefore, become distributed across the full length of the flat beam from the center to the end thereof following orthodox stress patterns.

Therefore, the present design provides a spring member wihch distributes its force generally uniformly over the length of its engagement portion with the pin contact.

The distribution of the engagement force over the extended contact plate **27** is a decisive improvement over previous pressurizing means which have characteristically exerted their force on a concentrated area. Such forces increase the unit pressure on the surface of the pin contact, thereby increasing the rate of wear of the associated parts. The pressurizing spring of this invention reduces wear accordingly by redistributing concentrated forces over an extensive contact area.

In addition to the problems of high entry forces and increased wear due to concentrated pressures on the contact surfaces, many pressurizing means are incapable of reacting to misalignment of the pin to the socket and producing forces which will bring the two into axial alignment. The existence of such misalignment has attendant with it, the condition wherein the fulcrum between the pin and socket exists, allowing movement of the two relative to each other. This movement causes changes in the electrical resistance of the contacts which is most undesirable.

This invention, however, provides a force system which creates a reactive force responsive to the misalignment in excess of the normal engagement force.

If normal engagement forces are illustrated by FIGURE 7 and a misaligned condition is further shown in FIGURE 8 it is apparent that a new force system has been created by the indicated misalignment. In particular, an additional force ΔF is developed at the rounded tip **35** and the pin is reacted at p_2 such that

$$F_{p2} = \tfrac{1}{2}(F_1 + \Delta F + F_2)$$

The uniqueness of this concept is that not only does ΔF additional force occur, but it occurs in the location and direction most necessary to correct the misalignment, and simultaneously, p_2 has moved from the center of the contact plate **27** to the misaligned end. An equal, but opposite condition will prevail if misalignment occurs in the opposite direction in the same plane.

To further illustrate and identify the structural characteristcs of the spring, it may be noted that the beam section **27** terminates at axially spaced shoulder portions **27***a* and **27***b*. The spring arms **28** and **29** are of a considerably narrower width (FIGURE 3). Thus, the folded portions extend axially outwardly from the respective shoulders **27***a* and **27***b* to form the rounded faces **30** and **31**, which, in functional effect, operates as camming faces for engagement with an adjoining pilot portion of a pin contact such as the nose **38**. The arms **28** and **29** are reservsely turned from the folded rounded free portions **30** and **31** and extend towards one another at an inclination relative to the beam section **27**, terminating short of engagement to leave a space **25**.

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

I claim as my invention:

1. A connector comprising:
- a socket having a circumferentially extending wall for receiving a male contact member,
  - said wall having an opening formed therein, the edges of said opening in said wall being formed by flat surfaces on opposite sides thereof,
- a contact spring in said opening including a flat beam section engaging said flat surfaces,
- and a shroud sleeve on said socket for retaining said contact spring,
  - said contact spring including a reversely turned integral spring arm disposed angularly with respect to said beam section for engagement with said shroud sleeve and spring loading said beam section towards said shoulders, and means on said contact spring engaging said socket to cause said contact spring to pivot towards said shroud sleeve at first contact of the male contact member with said contact spring when the male contact member is inserted into said socket to reduce the force on the male contact member at entry relative to the force on the male contact member at full engagement.

2. A connector as defined in claim **1** and further characterized by
- said spring arm being formed of a narrower width than said beam section.

3. A connector as defined in claim **1** and further characterized by
- said spring arm being formed of a narrower width than said beam section,
- said spring arm being reversely turned at a folded portion extending axially from said beam section and then extending angularly to form a rounded camming face for sliding engagement with a male contact member inserted into the socket.

4. A connector as defined in claim **1** and further characterized by
- said spring arm being formed of a narrower width than said beam section,
- said spring arm being reversely turned at a folded portion extending axially from said beam section and then extending angularly to form a rounded camming face for sliding engagement with a male contact member inserted into the socket,
  - there being a spring arm at each end of said beam section and the respective spring arms terminating short of engagement with each other.

5. A female contact having an opening formed in the peripheral walls thereof extending inwardly of its end,
- said opening being flat shoulders at opposite sides formed in said walls,
- a shroud sleeve surrounding said contact,
- and a contact spring between said sleeve and said opening comprising
  - a flat beam section of a length and width to engage the flat walls and extend chordally across said opening,
  - integral spring loading means to bias said beam section towards said shoulders, and
- said spring loading means consisting of a pair of reversibly turned arms disposed angularly with re-

spect to said beam section and terminating short of engagement with each other, and means on said contact spring engaging said female contact to cause said contact spring to pivot towards said shroud sleeve at first contact of a male contact member with said contact spring when the male contact member is inserted into said female contact to reduce the force on the male contact member at entry relative to the force on the male contact member at full engagement.

6. A female contact as defined in claim **5** and further characterized by said arms being narrower in width than said beam section.

7. A female contact as defined in claim **6** and further characterized by said spring having a curved folded face portion between said beam section and each said arm forming a camming surface to slidably engage an adjoining male connector surface.

8. A generally cylindrical hollow contact having an axial opening in one end for receiving a male pin,

said contact having an axially extending opening in the walls thereof forming a pair of flat shoulders in co-planar relationship,

means for applying spring pressure against the male pin comprising a spring member having

a flat beam section engaging said flat shoulders and spanning the space therebetween,

and a pair of reversely turned spring arms disposed at an angle relative to said beam section,

and a sleeve fitted over the slotted portion of said contact and covering said spring member and clamping said spring arms to bias said beam section towards said flat shoulders and into engagement with the male pin, and

means on said spring member engaging said contact to cause said spring member to pivot towards said sleeve at first contact of the male pin with said spring member when the male pin is inserted into said contact to reduce the force on the male pin at entry relative to the force on the male pin at full engagement.

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