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[54] ELECTRICAL CONNECTORS

11 Claims, 5 Drawing Figs.

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 [51] Int. Cl. H01r 17/04,
 H01r 13/12
 [50] Field of Search 339/59, 61,
 177, 205, 213, 256, 259; 24/213, 216, 217, 230
 SL, 230; 287/126, 58 CT; 308/26; 16/2

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ABSTRACT: This invention relates to improvements in electrical connectors. A two circuit jack and plug are described in which the jack is formed of a series of sleeves inserted one within the other to expose, at one end of the jack, a pair of contacting rings. The contacting rings are noncircular in that their sidewalls are flat at spaced points around their periphery. They are held in encompassing ring retainers having inner dimensions to squeeze the contacting rings such that they are more nearly circular. The jack is associated with a phonograph type plug whose outer contact is arranged to have its outer surface, rather than its inner surface, mate with a respectively associated one of the contacting rings of the jack.

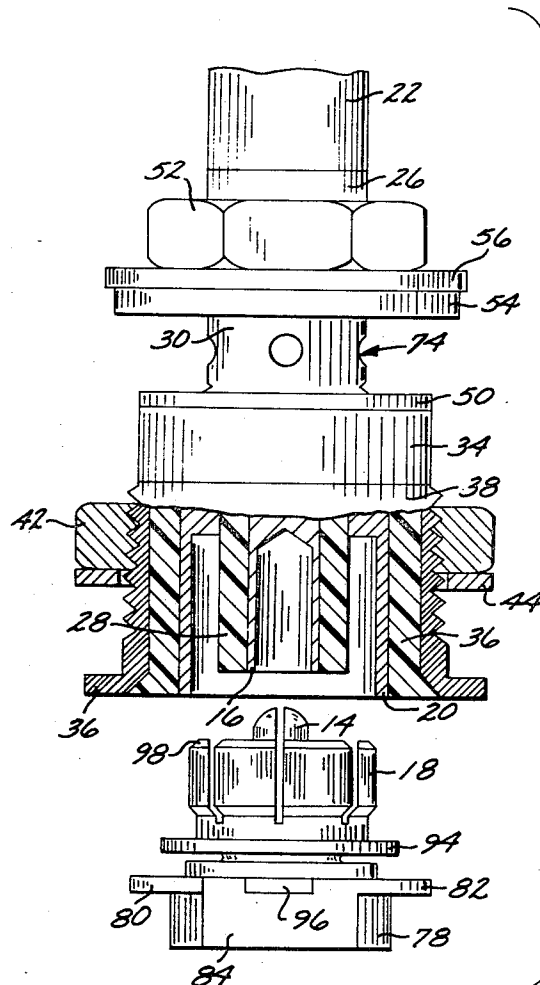


FIG. 1

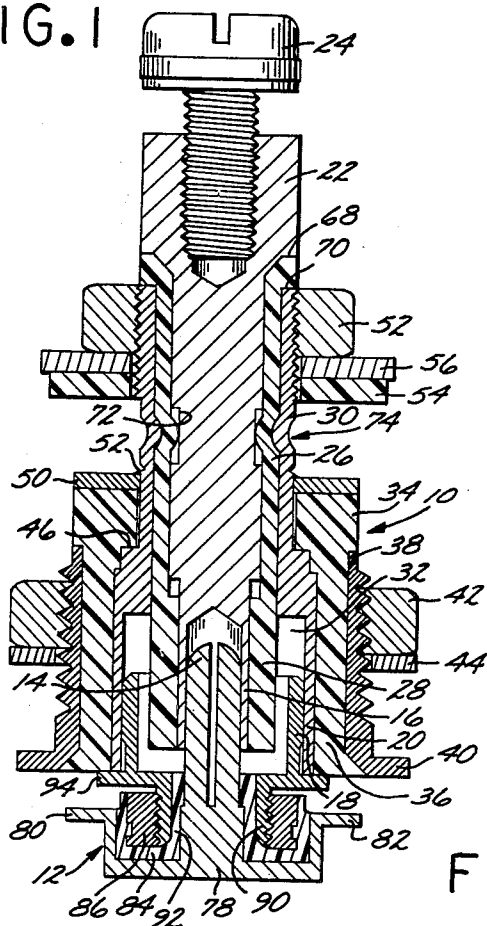


FIG. 2

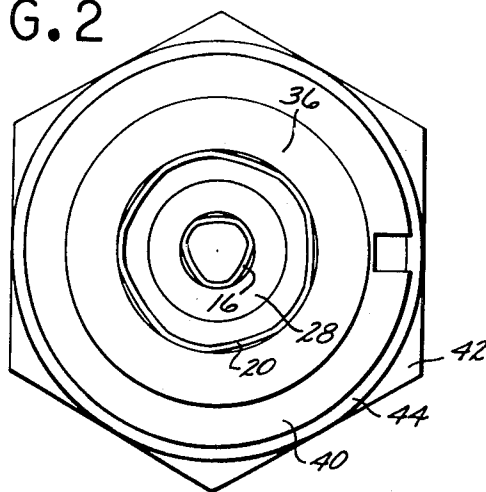


FIG. 3

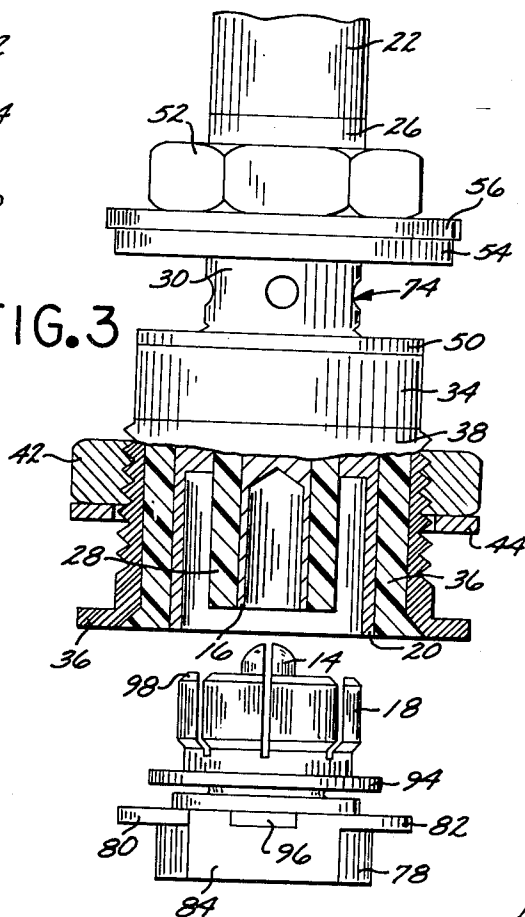


FIG. 4

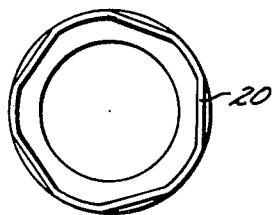
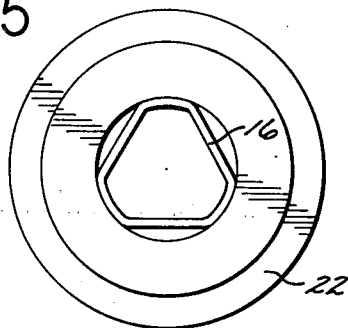


FIG. 5



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ELECTRICAL CONNECTORS

This invention relates to improvements in electrical connectors and in particular it relates to improvements in connectors of the kind in which contact is maintained by friction.

In those instances and applications where it may be necessary to disconnect and reconnect an electric circuit from time to time, it is desirable to employ an electrical connector in which the connecting elements are maintained in electrical contact by utilizing the force of friction between them. Such connectors are usually divided into male and female parts which are mated by sliding the surface of one part along the surface of another until the parts overlap over a sufficient area to assure adequate electrical contact. To produce connectors of this kind in which electrical connection does not fail with time and which will reliably complete an electrical connection after repeated disconnections has proven to be quite difficult. Friction connectors are produced in a wide variety of designs many of which attempt to overcome the difficulty, at least in part, by the use of resilient materials or other biasing means intended to maintain the contact members in electrical contact. Sometimes, as for an example in the case of cable connectors, an attempt is made to maintain contact by screwing or otherwise fastening together the structures in which the two contacting members are housed.

The problem is complicated because the choice of materials sometimes is limited by environmental conditions and by the frequency and by the magnitude of the electrical currents to be passed through the connector. Attempts to solve the problem of reliability and to find an acceptable compromise between cost and reliability have produced a very wide variety of designs which are successful in varying degree. Nonetheless improved connectors are needed. Failure of an electric circuit can have a costly, dangerous and sometimes even catastrophic effect. This possibility coupled with the fact that electrical connectors have proven to be one of the least reliable of all the electrical circuit elements, makes the problem a serious one in which any improvement is important.

It is the object of the invention to provide a novel connector of the friction-type which overcomes some of the difficulties that have gone unsolved in prior devices. It is an object of the invention to provide a friction connector which utilizes the resilience of the connector material in a novel fashion and which avoids excessive stress at any point of the connector whereby to minimize failure resulting from fatigue or from stressing a connector part beyond its yield point. Failure occasioned by stressing connector parts beyond their yield point is a rather common occurrence occasioned in part by variation in manufactured dimension from part to part. This difficulty is multiplied because the mating parts of the connector may have been produced by different manufacturers. Accordingly, among the objects of the invention is to provide a connector one of whose elements is arranged so that it can accommodate a mating connector whose dimensions fall within a wide tolerance range.

Other objects of the invention are to provide a connector structure in which the parts can be mated by relative motion between the mating parts in one direction only and which requires no orientation in other than that one direction. A related object is to provide a connector useful in interconnecting coaxial conductors and in which the advantages of the invention are realized in the connection structure of both of the conductors. Another object is to provide an improved connector to mate with a "phonograph jack" in an arrangement in which both the inner and outer contact of the phonograph jack serve as male connection elements. Thus it is an object of the invention to provide an improved jack and plug connector.

Certain of these and other objects and advantages of the invention are realized by the provision of an electrical connector which includes a contacting ring of electrically conductive resilient material formed, in its relaxed condition, about a central axis such that alternating sections of its inner peripheral

surface lie beyond, and such that alternate intervening sections thereof lie within, an imaginary circle defined by the average distance from the central axis to that inner peripheral surface; and by the provision of a ring retainer structure which encompasses the outer peripheral surface of the ring and has a dimension to force the ring against its resiliency to more nearly circular shape in which the alternate sections of the inner peripheral surface lie less far beyond, and so that the said alternate intervening sections lie less far within, said circle than in the relaxed condition of the ring.

In the drawings:

FIG. 1 is a cross-sectional view taken on the vertical centerline through an electrical connector plug and jack in which the invention is embodied;

FIG. 2 is a bottom plan view of the electrical connector jack shown in FIG. 1;

FIG. 3 is a view in side elevation of the connector plug of FIG. 1 shown disassembled from the plug, which is shown fragmented and partly in side elevation and partly in a cross section;

FIG. 4 is a top plan view of the outer contacting ring employed in the embodiment illustrated in FIGS. 1, 2, and 3;

FIG. 5 is a top plan view of the inner contacting ring employed in the embodiment illustrated in these drawings.

Referring to FIG. 1 of the drawing, the connector assembly there shown comprises a jack designated generally by the reference numeral 10 and a plug which is identified by the reference numeral 12. In this embodiment the plug and jack are arranged so that two circuits leading to the plug are interconnected with two electrical circuits leading to the jack. The female connector for both circuits is housed in jack 10 and the male connector for both circuits is formed by the structure of plug 12. The inner circuit is completed through the electrical contact between the split center pin 14 and inner contacting ring 16. The other circuit is completed by interconnection between split wall, cylindrical contact 18 and the outer contacting ring 20.

The inner contacting ring 16 is formed at one end of an elongated rod or pin 22 which is bored axially for a distance from its opposite end. The bore is threaded to receive the threads of a terminal screw 24. Both the pin rod 22 and the inner contacting ring 16 are formed of an electrically conductive material, such for example as a copper or brass, whereby an electric circuit is completed from the contacting ring 16 to the terminal screw 24 and any conductor that may be clamped in electrical contact with the pin 22 by the screw.

Pin 22 fits within a sleeve 26 formed of electrically insulating material. The portion of sleeve 26 which surrounds the inner contacting ring 16 is called a ring retainer and this portion is designated by the reference numeral 28. The sleeve 26 fits within another sleeve 30 formed of electrically conductive material. At one end, the upper end in FIG. 1, the sleeve 30 fits tightly around the sleeve 26 but at its other end, the lower end in FIG. 1 sleeve 30 has increased inside diameter to clear the ring retainer portion 28 of sleeve 26 and provide an annular space 32. The space 32 separates ring retainer 28 from the lower end of sleeve 30. This lower end of sleeve 30 is designated by the reference numeral 20 and is the outer contacting ring described above.

The sleeve 30 is encompassed by a tightly fitting sleeve 34 the lower end 36 of which functions to restrain and shape the outer contacting ring and is called a ring retainer for the outer contacting ring 20. In this embodiment the sleeve 34 and its ring retainer section 36 are formed of electrically insulating material. Insulation is not required where it is permissible or desirable that the outer contacting ring be connected electrically to the panel or chassis on which the connector assembly is mounted. This embodiment is arranged so that the contacting rings will be insulated from the chassis or panel. The ring 34 is encompassed by a sleeve 38 the lower margin of which is provided with an outwardly extending flange 40. The exterior of the sleeve 38 is threaded to accommodate a nut 42 and a washer 44. This unit is intended for mounting in a panel hole

or a chassis hole having diameter less than the diameter of the flange 40, and at least as great as the diameter of the threaded sleeve 38. The unit is mounted so that the flange 40 abuts the opposite face and is held by the nut 42. Sleeve 34 is made of a plastic material molded around the threaded sleeve 38 to form a high strength insulator of low dielectric constant. The inner diameter of the sleeve 34 is smaller whereby the wall thickness of the sleeve is increased above the point where the sleeve 30 has increased diameter to form the outer or larger contacting ring 20. The increase in diameter of the sleeve 30 occurs at a shoulder 46 which serves as a locating surface to limit the degree of insertion of sleeve 30 within the sleeve 34. In addition, this shoulder 46 serves as a support for a compressive load applied in making electrical connections to sleeve 30 and the outer contacting ring 20. Another supporting shoulder for the sleeve 34 is provided by the upper end by sleeve 38. A washer 50 of electrically collective material overlies the upper end of the sleeve 34 and is staked in that position by upsetting the material of the sleeve 30 immediately above the washer 50 as shown at point 52 in FIG. 1. Electrical connection to sleeve 30, and thereby to the contacting ring 20, is made by clamping a conducting wire or terminal device around the sleeve 30 and against the washer 50. This is accomplished by turning down the nut 52 to compress the external conductor between the washer 50 on one side and the flat washer 54 on the other. A lock washer 56 is interposed between the nut 52 and the flat washer 54 to make the connection more secure. The upper end of the sleeve 30 is threaded to receive the threads of nut 52.

The outermost sleeve 38 is held against axial movement relative to the insulating sleeve 34 because the latter is molded such that portions of it lie above and below the sleeve 38. The sleeve 34 is held against motion relative to the sleeve 30 by being abutted against the sleeve 30 at shoulder 46 and by having the sleeve 30 upset at point 52 against the washer 50. Also, provision is made to assure against relative motion in the axial direction between the sleeves 30 and 26 and the pin 22. At its upper end the pin 22 has increased diameter to form a shoulder 60 against which the upper end of sleeve 26 abuts. Similarly, the upper end of sleeve 26 has increased diameter to form a shoulder 70 against which the upper end of sleeve 30 abuts. Relative motion in the opposite direction is precluded in this embodiment by forming a midregion of the pin 22 with reduced diameter and by upsetting or extruding the sleeves 30 and 26 inwardly into the space formed at that reduced diameter section 72. This construction is generally designated by reference numeral 74 in FIGS. 1 and 3.

The pin 14 of the plug is generally cylindrical and has a rounded end to facilitate its insertion into the inner contacting ring. It is slotted throughout its length and is formed of a resilient material so that the two halves of the pin thus formed may be squeezed together to permit their insertion into the inner contacting ring when the parts are dimensioned on the high side of their manufacturing tolerance.

The pin 14 is integrally formed with, and extends upwardly from, the center of a cup-shaped base structure 78. The sidewall of the cup extends upwardly in the direction of the pin and terminates at its upper lip in an outwardly extending flange. Diametric portions of the cup are cut away on parallel planes equidistant from the center axis of the cup whereby the flange at the upper rim of the cup sidewalls is reduced to a pair of projections extending in opposite directions from the pin, one of which is designated 80 and the other of which is designated 82 in the drawing. An inner lining 84 of insulating material encircles the lower end of the pin 14, the bottom inner wall of the cut 78, and the inner surfaces of the sidewalls of the cup. The insulating lining 84 is cup shaped. It fills the space left by the cutaway portions of the cup 78 and is visible at the exterior of the plug as shown in FIG. 3.

A retaining ring 86 is disposed within the insulating cup 84 with its outer peripheral surface in engagement with the outside sidewalls of the insulating cup 84. Complimentary conformations in the outer peripheral surface of the ring 86 and the

inner peripheral surface of the sidewall of the lining 84 insure retention of the ring within the lining. The inner peripheral surface of the retaining ring 86 is threaded to receive the external threads formed on the hollow shank 90 of the contact structure of which the cylindrical contact 18 is a part. Shank 90 has dimensions to fit within the annular space between the inner peripheral surface of retaining ring 86 and the outer peripheral surface of the portion 92 of the cup 84 which encompasses the lower end of pin 14. The shank 90 extends downwardly from a flange 94 which lies in a plane perpendicular to the axis of the plug. This flange is integrally formed with shank 90 and with the cylindrical contacting member 18.

The plug 12 is arranged for mounting upon a circuit board. Electrical connection from the pin 14 to appropriate conductor runs on the face of the circuit board are made through the cup 18 and the projections 80 and 82. Another pair of projections extend laterally outward from the ring 86 through the insulating liner 84 at the sides where the cup 78 is cut away. These other two projections overlie other circuit runs of the circuit board and are formed in the same plane as are the projections 80 and 82. One of these two projections is visible in FIG. 3 where it is designated by the reference numeral 96.

As best shown in FIG. 3, in the preferred construction the inner contacting ring 16 does not extend to a point flush with the lower face of the connected jack. Instead it ends at a point removed from that face although in the preferred form, as shown, the inner contacting ring 16 lies within the outer contacting ring 20. This arrangement serves to insure that the inner contacting ring 16 will not be short circuited by elements of the plug to the structure which supports the contact sleeve 18. In addition it helps to insure that the smaller and less rugged inner contacting ring and its ring retainer sleeve are protected from damage. The pin 14 of the plug extends beyond the end rim of the sleeve 18 in a degree which depends upon the distance from the lower face of the jack to its inner contacting ring and which depends also upon whether it is the center contact or the outer contact that is to be first broken and first made upon disconnection and reconnection of the plug and jack.

The connector relies upon frictional engagement between pin 14 and the inner contacting ring 16 and between the sleeve 18 and the outer contacting ring 20 to accomplish electrical connection and to maintain mechanical connection. The resilience of the contacting rings and of the pin 14 and sleeve 18 is utilized to maintain the frictional contact. The resilience of the contacting members is utilized by forming them so that they may be deformed, and are deformed, when the connection is made. By their resiliency the several contacting parts exert a force in opposition to that deformation and that force is utilized to maintain frictional contact between the pairs of mating connector parts. In the invention this principle is employed in a special way. One of the connector elements of a pair has the form of a connector ring which is made of resilient material. Further, the contacting ring is formed about a central axis and alternating sections of the ring, or at least of its inner peripheral surface, lie beyond the circle defined by the average distance from that central axis to the inner peripheral surface of the ring. Alternate intervening sections of the inner peripheral surface of the ring lie within that circle. A contacting ring may be formed from a cylindrical sleeve by deforming the sidewalls of the cylinder around the periphery so that flattened sections are created. These flattened sections may be flat but advantageously are bowed in a large diameter arc. The sidewall of this ring is advantageously curved between the flattened sections and sharp corners between successive flattened sections are to be avoided. The contacting ring being thus formed in its relaxed condition, may be treated and advantageously is treated to remove internal stresses. The two contacting rings employed in this embodiment are shown in this condition in FIGS. 4 and 5. FIG. 4 is a top plan view of the contacting ring 20 and sleeve 30 of which it is a part. FIG. 5 is a top plan view of the inner contacting ring 16 and the pin 22 of which it is a part. These elements are shown in FIGS. 4 and

5 to have the relaxed shape they have prior to being assembled within their respective ring retainers and to which they tend to return upon being disassembled from their respective ring retainers. The ring retainers encompass the contacting rings and have dimensions attending to force these portions of the exterior peripheral surface of the rings which extend at greatest distance from the central axis of the rings inwardly toward that axis. In effect, the retaining rings squeezes the contacting ring and makes it more nearly round so that the flattened portions of the ring are caused to bow outwardly forming a smaller diameter arc whose center is on the side of the ring section toward the central axis of the ring. The result is that the contacting ring has a shape which approaches being cylindrical but which is not quite cylindrical in that spaced points around its inner periphery are closer to its central axis than are intervening points. When a plug formed by a cylindrical contacting member having outside diameter greater than the distance from the central axis of the contacting ring to its sections closest to the axis is forced into the ring, it will bear upon those sections of the inner surface of the contacting ring and push them outwardly in a direction tending more nearly to force the contacting ring to circular shape. The greater the outer diameter of the mating plug part, the greater will be the area of contact between the two parts.

To facilitate insertion of the mating plug parts into the contacting rings, the plug is advantageously formed with a smaller outer dimension at points where it first begins to enter the contacting ring. It is for this reason that the forward end of the plug pin 15 is rounded and it is for this reason that the forward end of the sleeve 18 of the plug is tapered inwardly at 98 so that it will have a smaller diameter at its upper margin. The inner diameter of the ring retainers are related to the dimensions of the other respectively associated rings so that the contacting rings can be forced to assume a perfectly circular form. Advantageously, as in the embodiment illustrated, the plug members are formed so that they too can yield whereby both elements of a contact pair are made to deform. This reduces the possibility that one of them will be deformed beyond its yield point.

It is not essential that the contacting rings be formed integrally with the sleeve leading to the external connections structure as shown in this embodiment although that construction is preferred. Similarly it is not essential that the ring be continuous. The contacting ring may be formed as a split ring although a continuous ring is preferred so that the points of maximum stress will be equally spaced around the periphery. In certain applications of the invention it may be advantageous to employ a partly slotted ring to facilitate initial insertion but limiting the degree of slotting so that at least one annular portion of the ring is continuous in a plane normal to the central axis.

The insulating material employed in the inner ring retainer in this embodiment must have considerable hoop strength, must be a good electrical insulator, and have a reasonably low dielectric constant. A number of materials are suitable. One of them is polysulfone. The ring retainer 34 in this embodiment is supported by the encompassing sleeve 38 so that its hoop strength may be considerably less. Consequently, a greater range of materials will perform suitably in the outer ring retainer. In the outer retainer compressive strength becomes more important and hoop strength less important and it is possible to use ceramic materials as well as plastic materials for this element. However, it will be apparent that an encircling sleeve could be placed around the ring retainer 28 of the inner contacting ring without upsetting the electrical circuitry through the connector thereby making it possible to employ other materials.

The contacting ring and ring retainer construction is advantageous because the stress is distributed more uniformly whereby each portion of the structure is stressed less to achieve a total dimensional change as its mating part is inserted in the ring. Because the ring is first formed as a cylinder during manufacture, the difficulty in holding its inner and

outer dimensions to tolerance is no greater than that faced in producing the prior art connector devices which employ circular form. Consequently, dimensional differences of the same magnitude can be expected.

The invention provides a construction in which stresses are divided more evenly over a wider area of material and it follows, since the total stress can be expected to be comparable, that each portion of the connecting structure is stressed in lesser degree in the invention thereby reducing the possibility that any part will be deformed past its yield point. The stress being comparable, the frictional force is comparable and the connectors are held together such as securely in the invention as in the prior art device. It follows also that the connecting elements in the invention can be made to fit more tightly, thus to insure greater security for both the mechanical and electrical connection, without danger of overstressing the connecting parts.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

1. An electrical connector comprising a combination;
 - a contacting ring of electrically conductive, resilient, material formed, in the relaxed condition of the ring, about a central axis such that alternating sections of its inner peripheral surface lie beyond, and alternating intervening sections thereof lie within, the circle defined by the average distance from said axis to inner peripheral surface; and
 - a circular ring retainer encompassing the outer peripheral surface of the ring and having dimensions to force said ring against its renitence to more nearly circular shape in which such alternate sections lie less far beyond, and said alternate intervening sections lie less far within, said circle than in the relaxed condition of said contacting ring.
2. The invention defined in claim 1 in which all portions of the inner peripheral surface of said ring, when assembled with said ring retainer, are bowed on an arc having a center on the side thereof toward said central axis.
3. The invention defined in claim 2 in which said contacting ring comprises at least three sections whose inner peripheral surface lie beyond, and a like number of sections whose inner peripheral surface lie within, said circle.
4. The invention defined in claim 3 in which at least one annular portion of said ring is continuous in a plane normal to said central axis.
5. An electrical connector comprising a combination:
 - a contacting ring of electrically conductive, resilient material formed, in the relaxed condition of the ring, about a central axis such that alternating sections of its inner peripheral surface lie beyond, and alternating intervening sections thereof lie within, the circle defined by the average distance from said axis to inner peripheral surface;
 - a ring retainer encompassing the outer peripheral surface of the ring and having dimensions to force said ring against its renitence to more nearly circular shape in which such alternate sections lie less far beyond, and said alternate intervening sections lie less far within, said circle than in the relaxed condition of said contacting ring;
 - all portions of the inner peripheral surface of said ring, when assembled with said ring retainer, being bowed on an arc having a center on the side thereof towards said central axis;
 - said contacting ring comprising at least three sections whose inner peripheral surface lie beyond, and a like number of sections whose inner peripheral surface lie within, said circle;
 - at least one annular portion of said ring being continuous in a plane normal to said central axis; and
 - a second contacting ring having a structure like that described for the first mentioned contacting ring and

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which further comprises a second ring retainer having a structure like that described for the ring retainer first mentioned; said second ring retainer having a central axis coincident with said central axis of said first mentioned ring and ring retainer.

6. The invention defined in claim 5 in which said second ring and said second ring retainer are smaller in diameter than the first mentioned ring and ring retainer, respectively, and have an annular portion in said plane normal to said axis.

7. The invention defined in claim 6 in which said second ring retainer is formed of electrically nonconductive materials and has outer diameter in said plane sufficiently small to clear said contacting ring first mentioned.

8. The invention defined in claim 7 in which said second ring is formed at one end of a rod, in which said second ring retainer comprises a sleeve surrounding said rod; in which said ring first mentioned comprises a sleeve surrounding said second ring retainer; and in which said ring retainer first mentioned comprises a sleeve formed of electrically nonconductive material surrounding said ring first mentioned.

9. The invention defined in claim 8 which further comprises

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a male connector including a cylindrical sleeve of electrically conductive resilient material having an outer radius greater than the distance from said central axis of the ring and ring retainer first mentioned to the inner peripheral surface of said alternate intervening sections of said ring when encompassed by said ring retainer but less than that of said circle.

10. The invention defined in claim 1 which further comprises a male connector including a cylindrical sleeve of electrically conductive resilient material having outer radius greater than the distance from said central axis to the inner peripheral surface of said alternate intervening sections of said ring when encompassed by said ring retainer but less than that of said circle.

11. The invention defined in claim 10 in which said cylindrical sleeve of electrically conductive material terminates at a marginal edge having outer radius less than the distance from said central axis to the inner peripheral surface of said alternate intervening sections of said ring when encompassed by said ring retainer.

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