United States Patent [19]

Iversen

[11] **3,764,957**

[45] **Oct. 9, 1973**

[54] **ELECTRICAL CONNECTOR**

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[22] Filed: **Dec. 17, 1971**

[21] Appl. No.: **209,323**

[52] **U.S. Cl.** ..... **339/92 R,** 85/36, 339/184 M, 339/217 S

[51] **Int. Cl.** **H01r 13/54,** H01r 13/64

[58] **Field of Search** ..... 339/92 M, 176 R, 339/176 M, 217 S, 184, 186; 85/36

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Attorney—Samuel Lindenberg et al.

[57] **ABSTRACT**

Apparatus for enabling the rapid and reliable connection and disconnection of plug type connectors and their low cost manufacture, including a nut member that indicates when a screw is fully tightened, frames that facilitate unplugging in a commonly practiced though officially unrecognized manner, and contact elements shaped for accurate location in the frames. The nut member has a thread-engaging lip initially angled to extend away from the other connector frame, so that as a screw from the other frame becomes fully tightened the lip deforms and thereby suddenly increases screw-tightening resistance that signals the repairman to stop turning the screw. The female frame of a connector set has end walls that are tapered to permit disconnection of the frames by tilting them away from one another without binding. The recesses in each frame that receive tiny contact elements, have inwardly extending flanges near the tops of the recesses, and each resilient contact element has a wide lower portion biased upwardly against the flanges and a narrower upper portion passing between and beyond the flanges.

7 Claims, 11 Drawing Figures

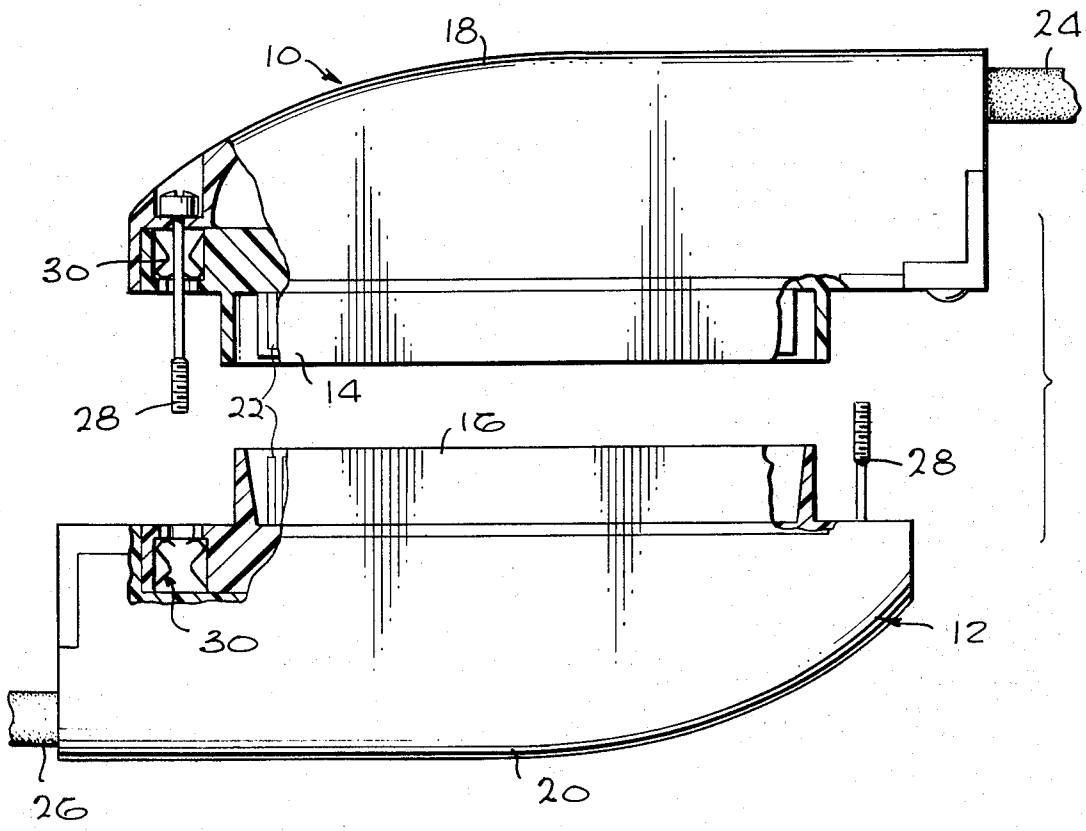

Fig. 1

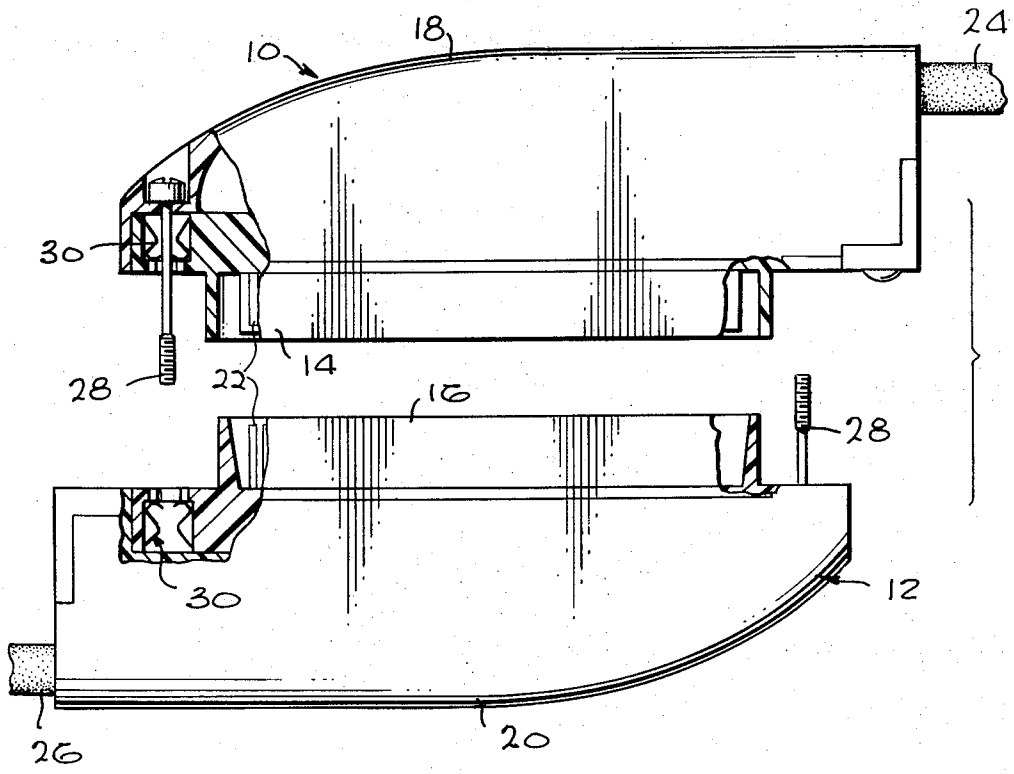

Fig. 5

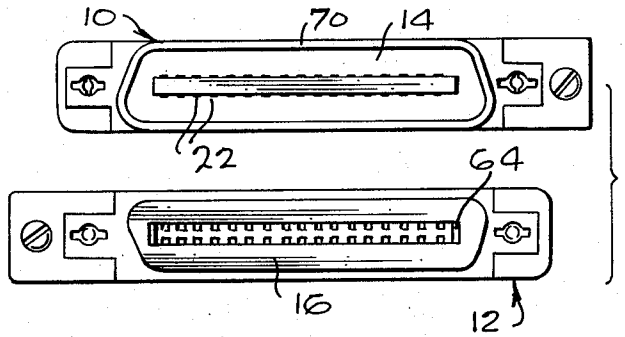

Fig. 6A

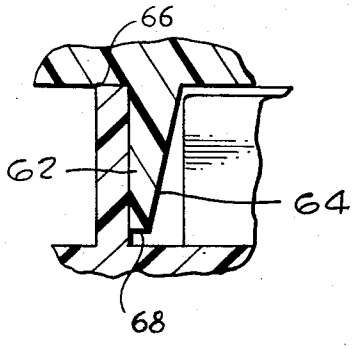

Fig. 6

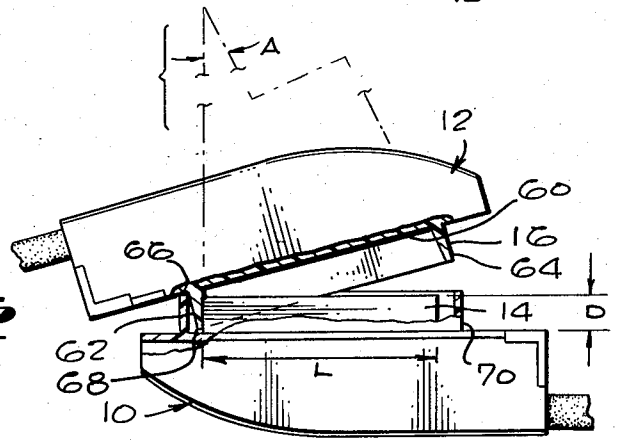

Fig. 3

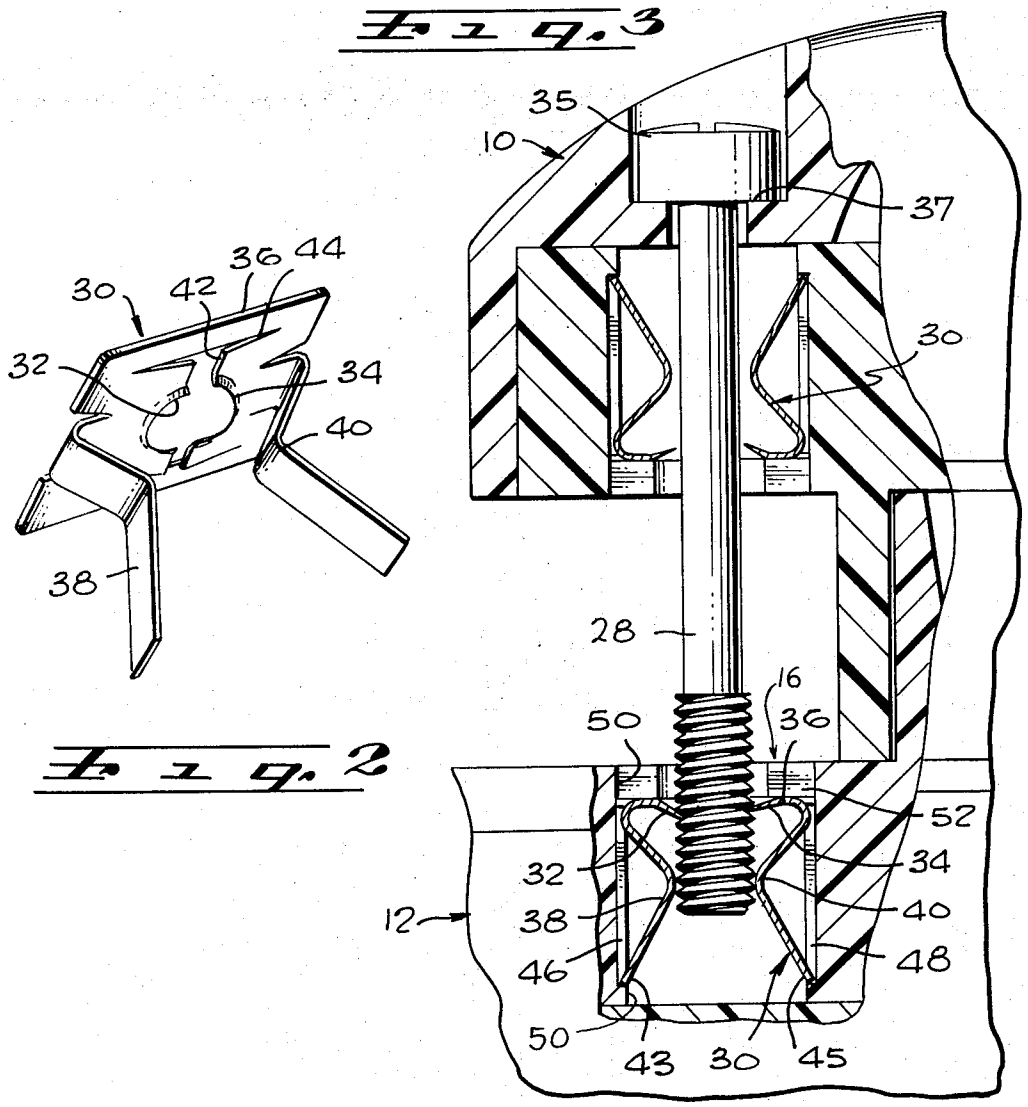

Fig. 2

Fig. 4

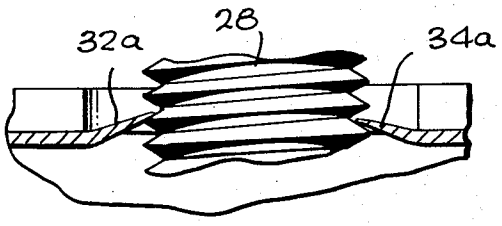

Fig. 7

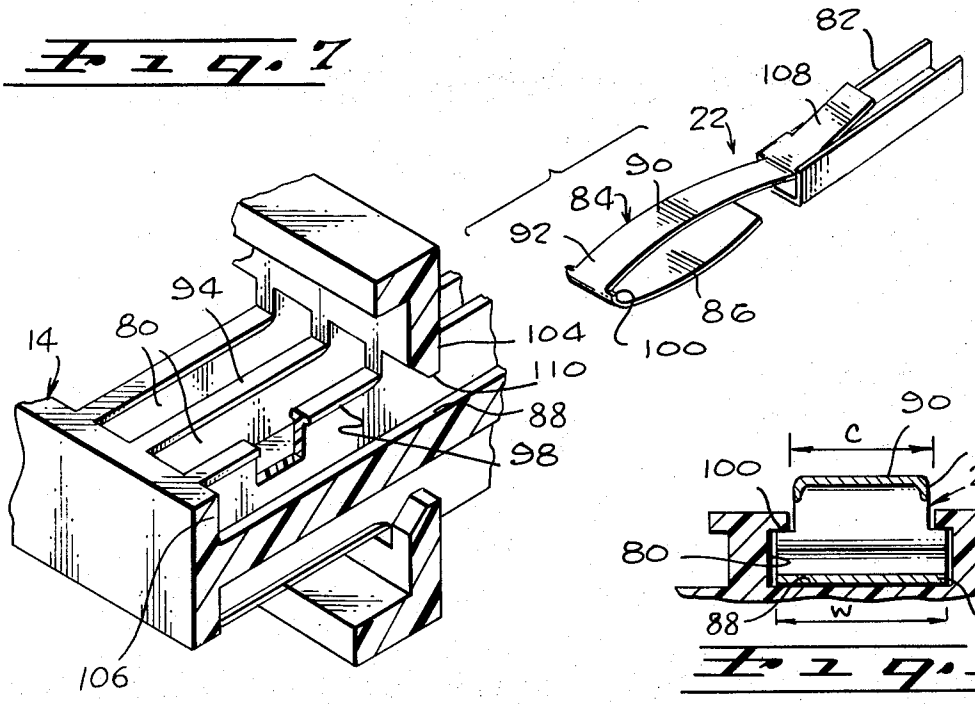

Fig. 10

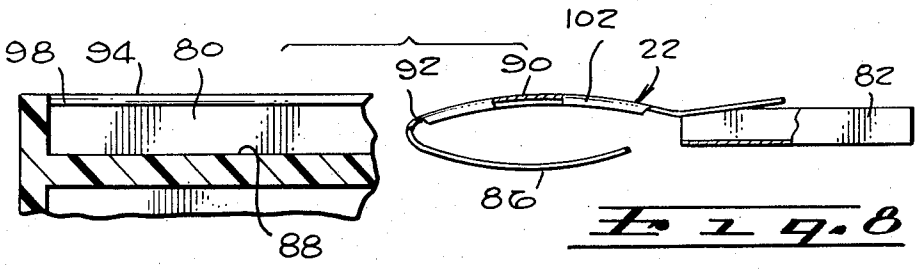

Fig. 8

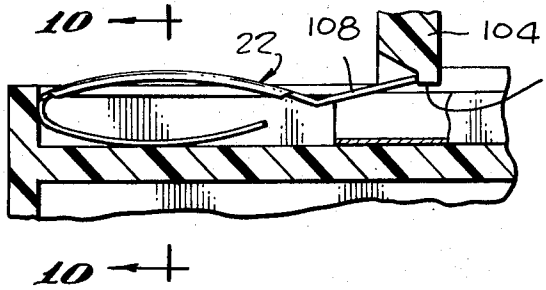

Fig. 9

ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

This invention relates to electrical connector apparatus.

One type of plug connector commonly used in telephone installations and other applications includes a male frame or plug that can be inserted into a female frame or receptacle, so that contact elements of the two frames touch one another. Screw and nut type fasteners are often utilized to securely hold the frames together. One problem that often arises in field installations is over-tightening of the screws, which damages the nut. This occurs largely because small screws are utilized which require only a small torque for tightening.

Another problem that often arises in field installations of connectors is binding during unplugging of the connectors. It is often assumed that the connectors will be unplugged by pulling one of them straight out from the other. However, in practice field repairmen often separate the connectors by tilting them apart, inasmuch as tilting provides greater leverage for initially loosening the connectors from one another. The ends of the connectors generally bind during such tilting, so that repairmen often have to tilt them back and forth while pulling them apart, which leads to increased effort and annoyance particularly in awkward installation areas.

Each electrical connector of a set generally includes a row of recesses and a row of electrically conductive contact elements of spring material that lie in the recesses and have portions extending a slight distance therefrom. The contact elements must be bent to accurately follow a predetermined curve so that when one side bears against the bottom of the recess the other side extends a small but definite distance out of the recess. However, it is difficult to bend such spring elements to close tolerances, so that close control of their shape involves substantial expense.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, an electrical connector assembly is provided which is easy to assemble and disassemble in the field and which can be manufactured at low cost. The assembly includes a plug and receptacle that can be connected and then securely joined by screws extending from one connector and engaged with a nut on the other connector. A sheet metal nut member is utilized which has a thread-engaging lip extending with a directional component away from the other connector. As the screw becomes fully tightened, the lip begins to be deformed, or coned over, and begins to extend with a directional component towards the other connector. The repairman can sense a sudden increase in resistance to screw turning as such coning over begins, so that he can cease further tightening. Even if further tightening occurs and the lip is fully coned over, it thereafter merely clicks on the threads when the screw is turned so the repairman can sense that no further tightening is required.

The connectors are constructed to allow disassembly of the plug from the receptacle by tilting them apart. To permit this, the ends of the receptacle walls are tapered so that they diverge, to provide clearance that allows tilting of the plug without binding on the receptacle. However, when the plug is fully installed, there is only a small clearance between its end walls and the nearest regions of the receptacle end walls, to assure accurate location of the plug.

Each of the connectors has a row of recesses that hold resilient contact elements, the elements being formed to extend a small distance out of the recesses so they contact corresponding elements on the other connector. In order to more accurately locate the protruding contact element portions, a pair of sidewardly extending flanges is formed in the recesses. Each of the contact elements is provided with a wide lower portion that lies in the recess below the flanges and that resiliently bears against the flanges, and is also provided with a narrow upper portion that extends between the flanges and a small distance out of the recess. The fact that the wide lower portion of the contact element is held at a predetermined depth within the recess means that the protruding portion of the element is more accurately located in depth, and therefore larger dimensional tolerances can be utilized in forming the contact element.

The novel features of the invention are set forth with particularity in the appended claims. The invention will be best understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially sectional side elevation view of connector apparatus constructed in accordance with the invention, the connectors thereof being shown separated and ready for interconnection;

FIG. 2 is a perspective view of a nut member of the apparatus of FIG. 1;

FIG. 3 is an enlarged sectional side view of a portion of the apparatus of FIG. 1, showing a screw and nut member engaged;

FIG. 4 illustrates a portion of the apparatus of FIG. 3, but showing the configuration of the nut member after overtightening of the screw;

FIG. 5 is a plan view of the connector apparatus of FIG. 1, showing the faces of both connectors thereof;

FIG. 6 is a sectional side view of the connector apparatus of FIG. 1, showing the manner in which the two connectors can be tilted apart;

FIG. 6*a* shows the particular taper of the invention which allows tilting apart of the connectors;

FIG. 7 is a perspective view of a portion of a connector frame of the apparatus of FIG. 1;

FIG. 8 is a side view of the apparatus of FIG. 7;

FIG. 9 is a view of the apparatus of FIG. 8 in an assembled configuration; and

FIG. 10 is a view taken on the line 10—10 of FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a pair of electrical connector assemblies **10, 12,** each including a frame **14, 16** and a hood **18, 20.** One of the frames **14,** is a male frame of plug, while the other frame **16** is a female frame or receptacle that can receive plug **14.** When the plug **14** is inserted into the receptacle **16,** rows of contact elements **22,** on the two frames engage one another to establish electrical contact between a group of wires **24** leading to the connector assembly **10** with another group of wires **26** leading to the other assembly **12.**

After the two assemblies **10, 12** have been connected by inserting the plug into the receptacle, they are generally fastened together by the use of machine screws **28,** that threadably engage nut members **30.** It often requires many turns of the screw **28** before it becomes fully tightened on the nut **30.** In prior art installations, field repairmen often could not determine when to stop tightening of the screws. Such over tightening could damage the typical sheet metal nut so that it would not hold the screw. In accordance with the present invention, the nut member **30** is formed so that it readily indicates to the repairman when full tightening has been achieved, and so that it functions to hold the screw even after over tightening.

As shown in FIG. **3,** the nut member **30** that is installed on the connector assembly **12,** has a pair of tread-engaging lip portions **32, 34** that extend with directional components away from the other connector assembly **10.** When the screw **28** is being tightened, the lip portions **32, 34** threadably engage the screw to advance it. As the screw **28** becomes fully tightened, so that its head **35** firmly engages a ledge **37** and cannot advance any further towards the nut member, it begins to pull out the lip portion **32, 34.** If such turning of the screw **28** continues for a few turns, then the lip portions **32, 34** will be coned over, or in other words, bent in a reverse direction until they have the configuration shown at **32***a*, **34***a* in FIG. **4** wherein they extend with directional components towards the other connector assembly. However, as such coning over begins, the resistance to further turning of the screw **28** sharply rises. This signals the repairman that he has fully tightened the screw and should stop any further tightening. Accordingly, the repairman normally will not over tighten the screw so as to cone over the lips of the nut member.

The nut member can be formed from sheet metal, and has a sheet-like base portion **36** and two curved arms **38, 40** extending from the base portion. The base portion has a slot **42** of substantially constant width except at the center which forms the two lips **32, 34.** The regions on opposite sides of the slot **42** are bent out of the plane of the rest of the sheet-like base portion, to allow the lip portions to extend at the required incline. Slits **44** are formed at opposite ends of the slot **42** to facilitate such bending of the regions on opposite sides of the slot. The two arms **38, 40** extend from opposite sides of the base, converging to locations aligned with the hole formed between the lip portions **32, 34** and then diverging. As shown in FIG. **3,** the arms **38, 40** can engage the threaded shank portion of the screw to keep it oriented so that it threadably engages the lips **32, 34.** The arms **38, 40** have free end portions **43, 45** that are received in slots **46, 48** of the frame **16** to retain the nut member **30** in a recess of the frame.

The nut member **30** is readily installed in the frame **16** by inserting it through an opening **50** therein until the free ends **43, 45** of the arms snap into the slots **46, 48.** The base portion **36** of the nut member is held by an inner ledge formed by a wall **52** of the frame. The nut member **30** is useful during many tightenings and loosenings of the screw. If a repairman should accidently over tighten the screw and thereby cone over the lips to the positions of FIG. **4,** the lips will still threadably engage the screw to prevent its free withdrawal. As the repairman continues to rotate the screw **28,** the lips **32***a*, **34***a* will repeatedly rise and fall on the threads of the screw, creating clicking sounds that the repairman can sense. Thus, even if the nut is over tightened, it can still function, and can still inform the repairman when the screw is fully tightened so that he does not have to continue turning it.

It is often assumed that the plug **14** is removed from the receptacle **16** by pulling the plug straight out without tilting it. However, in practice the plugs are often tilted in the manner shown in FIG. **6** relative to the receptacle during removal. Repairmen often utilize this method because they can obtain greater leverage in loosening the plug from the receptacle by tilting it. However, the length of the plug-receiving region in the receptacle is often made only slightly greater than the length of the plug, in order to accurately locate the contact elements. As a result, repairmen using prior art connectors often had to tilt the plug or receptacle first one way then the other, since the connectors would bind on one another after a more than a few degrees of relative tilting.

In accordance with the present invention, the receptacle **16** is formed so that the length of the recess or receiving portion **60** gradually decreases with depth, from a minimum length only slightly greater than the length L of the plug at the innermost part of the region **60,** and increasing to a substantially greater length. This is accomplished by tapering the end walls **62, 64** of the receptacle so that its inner surfaces diverge from one another at an angle A of more than several degrees. For a connector assembly where the length L of the plug is a plurality of times greater than the depth D, which is the typical situation, an angle A of divergence of the end walls of more than about 15° can allow complete disassembly by a single tilting without binding at the end walls. Of course the angle that is required depends upon the tolerances and the length-to-depth ratio of the plug. However, a draft greater than the draft of less than a few degrees, that is, less than about three degrees, that may be utilized in injection molding merely to permit ejection from the mold, is generally required.

When the connectors are separated in the manner shown in FIG. **6,** the receptacle **16** can pivot about the point **66** while the opposite end wall **62** moves completely away from the plug **14,** without binding. The fact that both ends of the receptacle are tapered means that pivoting can occur at the deepest position **66** rather than at a location such as a point **68** near the outer face of the receptacle. This means that the end wall **64** is not shifted outwardly so as to abut a shroud **70** that is typically provided to surround the plug **14.** It would be possible to taper the ends of the plug **14** instead of the walls of the recess, but this could result in a requirement for greater tapering to prevent binding of the receptacle **16** with the shroud **70** on the plug.

FIGS. **7–10** illustrate the manner in which the contact elements **22** are received and held in one of the frames such as the plug frame **14.** The frame **14** has numerous recesses **80** arranged in two rows on either side of the frame, each recess holding one contact element **22.** The contact elements **22** are formed with trough-shaped rearward portions **82** for receiving and connecting to the bared ends of wires, and have loop-shaped forward portions **84** which are designed to contact similar elements of the other connector frame. The loop-shaped forward portion may be considered as having an inner arm **86** that lies near the bottom wall **88** of a re-

cess, and an outer arm **90** that protrudes past the walls of the recess.

The two arms **86, 90** of the contact element **22,** amy be considered to be joined together at a forward location **92** where the loop has its sharpest curve. The contact element **22** is constructed of a conductive material which is highly resilient, so that the outer arm **90** can deflect inwardly as it encounters another contact element on the other frame, to firmly press against it. When the outer arm **90** is deflected inwardly, the element is bent primarily at the sharpest curved region **92.** In prior art connector assemblies, relatively close tolerances had to be maintained over the form of the loop portion **84** and its orientation with respect to the rearward portion **82** to assure that the inner arm **86** was initially bearing against the bottom wall **88** of the recess and so that the outer arm **90** extended a small but definite distance above the side face **94** of the frame. The accurate bending of such spring elements is difficult to achieve, and therefore considerable effort and expense was required in the forming of the contact elements.

In accordance with the present invention, the recesses **80** are formed with side walls **96** that have flanges **98** that extend towards one another to form a constriction near the outer end of the recess. Furthermore, the loop portion **84** of each contact element **22** is formed so that the inner arm **86** lies beneath the flanges **98** and is biased against them, while the outer arm **90** extends in a curve between and out past the flanges **98** and the side **94** of the frame. This is accomplished by forming the lower arm **86** with a width W (FIG. **10**) slightly smaller than the distance between the side walls **96** of the recess but greater than the width C of the constriction. The outer arm **90,** however, has a width which is less than the width C of the constriction, so that the arm **90** can pass between the flanges **98.** The loop portion **84** of the contact element is formed so that the inner arm **86** must be bent in order to fit between the bottom wall **88** of the recess and the flanges **98.** This assures that the steps **100** formed at the intersection of the inner and outer arms bear against the bottom of the flanges **98.** The outer arm **90** is formed with sufficient curvature so that part of it lies above the side face **94** of the frame. The fact that the steps **100** fix the location of the center of the loop portion, means that the contact elements can be formed with smaller dimensional tolerances, and still there is assurance that the outer arm **90** will protrude a small but definite distance past the side face **94** of the frame.

The loop portion **84** of the contact element is constructed of a strip of resilient conductive material which is initially of uniform width. However, notches are formed at the steps or ledges **100,** and portions **102** at the sides of the strip are bent over to reduce the width of the outer arm **90** so that it can pass through the constriction between the flanges of the recesses. Each contact element **22** can be installed in a recess **80** by moving the element forwardly through the recess beneath a retainer wall **104** that bridges the recesses. The element is moved forward until the front end of the element abuts the front wall **106** of the recess. In order to prevent retraction of the contact element, it is provided with a tab **108,** as shown in FIG. **9,** which normally lies above the bottom of the retainer wall **104.** As the element is slid forward during installation, the tab **108** deflects downwardly under a ledge **110** on the retainer and the tab then springs up to lie in line with the ledge **110.** The contact element **22** thereafter cannot be moved rearwardly out of the recess because the tab **108** will abut the ledge **110** to prevent this.

Thus, the present invention provides connector apparatus that can be reliably installed, easily disconnected, and manufactured at low cost. Reliable fastening is facilitated by the use of a nut member with reverse-deformable lips that initially extend away from the opposite connector but which can be bent to reverse their direction or inclination. The deformable lips provide a sudden increase in tightening torque that signals the repairman to stop tightening the screw, and even when the lips have been deformed because of over tightening, they provide clicks after full tightening that signal the repairman that the screw has been fully tightened. Disconnection of the connector assembly in a tilting manner is facilitated by angling at least one end wall of the connector, and preferably by angling both end walls of the receptacle. This allows accurate location of the plug in the receptacle when it is fully installed, and yet allows disconnection by tilting one end of the plug away from the receptacle. Manufacture of the connectors is facilitated by utilizing flanges in the element-receiving recesses of each connector frame, and by utilizing contact elements with inner arms too wide to pass by the flanges and outer arms that pass between the flanges and a small distance past the side walls on the frame.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and, consequently, it is intended that the claims be interpreted to cover such modifications and equivalents. What is claimed is:

1. Electrical connector apparatus comprising:

a pair of connector assemblies, each having electrical contact elements that engage contact elements of the other when the two assemblies are connected, and each having screw-engaging means for enabling fastening by a screw to the other assembly;

at least one of said screw-engaging means which is on a first of said assemblies including a nut member having a thread-engaging lip portion extending with a directional component away from the other assembly and being deformable, by rotation of said screw when it cannot advance any further into said nut member, to a reverse orientation extending with a directional component toward the other assembly;

said nut member including a sheet-like base portion with a slot therein and with slits extending perpendicular to said slot and intersecting opposite ends of said slot, said slot being widened at a center portion thereof so it can closely surround a cylindrical screw shank,

the portion of said base on at least one side of said slot being bent out of the plane of the rest of the sheet portions to extend with a directional component away from said second connector to form said thread-engaging lip portion;

said first connector assembly having a wall with a screw-passing hole therein and said base portion of the nut member resting against the wall but with the lip portion being unsupported by the edge of the hole, the hole being large enough so that a length of the lip portion at least twice the thickness of the lip portion extends into the hole to permit

reverse lip deformation into the hole, whereby to permit permanent lip deformation so that a workman can notice a sudden decrease in resistance to tightening of the screw.

2. An electrical connector comprising:

a male frame having an elongated plug portion with a plurality of contact elements thereon; and

a female frame having an elongated receiving portion with a recess only slightly longer than said plug portion for closely receiving said plug portion, said female frame having a plurality of contact elements along said recess for contacting said elements of said plug portion when it is received in said recess;

said plug portion and said recess of said receiving portion being constructed so that at least one of them is tapered to have a progressively greater length at progressively greater distances from the portion that first engages the other frame when the frames are mated, said tapering being sufficient to allow one end of said plug portion to completely withdraw from said recess while the other end of said plug portion remains at substantially the deepest position to which it can be received in said recess.

3. The electrical connector described in claim **2** wherein:

said receiving portion has end walls whose inner surfaces each have a draft or more than 15°.

4. The electrical connector described in claim **2** wherein:

said plug portion is substantially a block with a length at least a plurality of times greater than its depth, and having a substantially constant length between its ends, and

said receiving portion has end walls defining said recess, that diverge from each other at an included angle of at least 15°.

5. An electrical connector comprising:

a frame with a plurality of recesses that have opposite side walls and flanges extending from the side walls to leave a constriction of a predetermined width; and

a plurality of resilient and electrically conductive contact elements, each element having a region formed into a loop, an inner portion of said region being wider than said constriction and lying deeper within said recess than said constriction, and said inner portion having an end where it merges with an end of an outer portion of said region which is narrower than said constriction, at least part of said outer portion lying within said constriction, said end of said inner portion being biased against said flange and said end of the outer portion lying in the constriction whereby to more accurately locate said outer portion in depth.

6. An electrical connector comprising:

a frame with a plurality of recesses that have opposite side walls and flanges extending from the side walls towards each other to leave an opening of a predetermined width between them; and

a plurality of resilient, electrically conductive contact elements, each having first and second arms joined at one end to form a loop, said first arm being wider than said predetermined opening between said flanges and lying deeper within said recess than said flanges and biased against said flanges at a location beyond the beginning of the loop, and said second arm being narrower than said predetermined opening between said flanges and protruding from it, whereby said second arm is more accurately located in depth.

7. The electrical connector described in claim **6** wherein:

said first arm is resiliently deformed between a bottom wall of the recess and the flange, and the depth of the flanges is less than the depth of the recess between the bottom surfaces of the flanges and said bottom wall.

* * * * *