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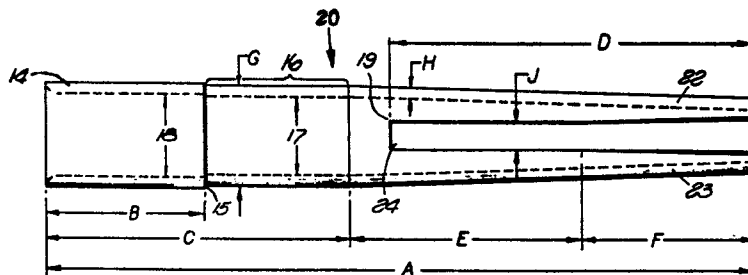
54 **Socket member for electrical connectors and method of manufacturing the same.**

57 In a socket member (20) for electrical connectors, the mutually inclined tines (22, 23) are separated by slots (24) which, from the tine root region (24) toward the socket aperture, are limited by parallel edges of the tines (22, 23) over a first partial length, and by divergent edges of the tines (22, 23) over the remaining length.

In the method of manufacturing the socket member (20), the mutual inclination of the tines (22, 23) is produced by forming a tube to have a conical taper over a length at

least equal to the length (D) of the tines, and then slotting the tube.

The starting material is a tube an end portion of which is formed into the conical shape by drawing prior to the slotting operation. Thus, at the roots (19) of the tines at rest, the socket body is not subjected to any stress (tensile deformation on the outside, compressive deformation on the inside), which otherwise would be caused by the subsequent bending operation.



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Socket Member for Electrical Connectors and Method of Manufacturing the Same

The present invention relates to a socket member for electrical connectors comprising a sleeve portion on the rear side, a mid-body section serving to mount the socket member, and a forward, slotted pin-gripping portion whose tines are inclined  
5 to each other in the direction of their free ends.

In the prior art, the tubular electrical socket contact with split tines is familiar and has been widely employed. Ordinarily, the process of manufacturing the individual socket members, a plurality of which may be included in a multicon-  
10 nection electrical connector, have been manufactured by processes including a step of bending or deforming the tines in a radially inward fashion. This constricts the aperture of the socket to an effective diameter less than that of the pin such that when a mating pin is inserted therein, a substantial  
15 frictional gripping force is exerted against it. Usually, there is some flaring of the tines outwardly at the aperture or, in other cases, a small amount of countersink is put into the insulating body block holding the socket connector members to provide some guidance, compensating for slight pin misalign-  
20 ments as the connectors are mated.

Typical prior art sockets are extensively described in the technical and patent literature, for example, in U.S. Patent 3,286,222 and in the drawings of U.S. Patent 3,043,925. The socket members in those patents are of the crimped or bent-  
25 tine types. Those conventional socket contacts exhibit several sensitive parameters that adversely effect the achievability

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- of repeatable, low insertion force while maintaining satisfactory contact pressure. Those areas of concern are: the modulus of elasticity (or Young's modulus) of the material; length of the beam (considering the tines as cantilevered  
5 beams); the moment of inertia of the beam representing the tines (governed by socket outside diameter, inside diameter and slot width); beam deflection called for by the design; and, finally, frictional characteristics of the pins within the sockets.
- 10 Forces resisting the mating of the pin and socket are essentially frictional forces arising from the socket tines, producing a normal force, i.e., a frictional force, on the pin. These forces, applied by the socket tines, are more thoroughly analyzed hereinafter. Suffice it to say at this  
15 point in the description that a particular minimum amount of normal force is necessary to assure proper electric conduction. Normal forces in excess of this minimum, however, contribute little to electric conduction but still increase the insertion forces.
- 20 In the manufacture of the individual socket members according to prior art methods, the crimping or bending of the tines radially inward produces plastic (inelastic) deformation of the tines at their roots; i.e., adjacent to the inward ex-  
25 tremity of the slots which are cut in to produce the tines themselves from the tubular body of the material. Not only does this operation result in workhardening of the material in the root area, it does so in a relatively unpredictable fashion and nonuniformly with respect to the inside and out-  
30 pressive and tensile deformation, respectively.

The pin-gripping force achievable, according to the aforementioned prior art manufacturing method, is highly variable; therefore, in order to insure the least minimum pin-gripping force for all connections, overdesign in that

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respect is the usual approach. Thus, particularly in the connector assembly involving the substantial number of socket members, the overall insertion force can be quite large.

It is the objective of the invention to provide electrical  
5 connector socket members which exhibit highly controllable  
and repeatable pin-gripping force which may be minimized without the risk of encountering unacceptably low values in one or more socket members where a plurality of these are assembled in a multicontact connector arrangement, and a method of manu-  
10 facturing such a socket member.

The advantages offered by the invention are mainly that at the roots of the tines, the socket body is not subjected to any stress, such as tensile deformation on the outside and compressive deformation on the inside. By the method according  
15 to the invention, the socket members can advantageously be manufactured so that the gripping forces exerted by the tines on the inserted pin are not higher than absolutely necessary. As a consequence, multicontact connectors can be manufactured whose halves can be mated with minimum effort.

20 One way of carrying out the invention is described in detail below with reference to drawings which illustrate only one specific embodiment. In the drawings:

Fig. 1a is a cross-sectional view of a typical prior art  
connector socket member prior to tine crimping or  
25 bending;

Fig. 1b is a pictorial of a socket member such as in Fig.  
1a after the tine bending operation has been  
accomplished;

Fig. 1c depicts a typically shaped mating pin insertable  
30 in the facing (aperture) end of the socket of  
Fig. 1b;

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Figs. 2a and 2b illustrate insertion force and frictional pin-gripping forces, respectively;

5 Figs. 3a and 3b illustrate the need for and form of the typical tine partial flattening from the aperture end of the socket according to the invention before flattening and after flattening, respectively;

Fig. 4a is a side view of a typical socket member according to the invention;

10 Fig. 4b is an aperture end view of Fig. 4a;

Fig. 4c is an enlarged end view of a tine of the socket of Fig. 4a further illustrating the partial flattening operation which produces the oblate tine cross-section evident from Fig. 4b.

15 Referring now to Fig. 1, the cross-sectional view is of a typical prior art socket member before the bending of the tines is effected. The generally tubular walls of the socket are axially slotted to a depth 12, producing tines 10 and 11. The OD (outside diameter) of the aperture end is essentially  
20 that of the stock, the same applying to the ID (inside diameter). The beam length depicted in Fig. 1a is of significance throughout the description, this representing the equivalent cantilevered beam represented by each of the tines. The tine root area around 12 is obviously the area of maximum stress  
25 as the tines are flexed in operation or when they are inwardly bent as part of the prior art manufacturing process, as illustrated in 1b. Insertion of the pin 13 of Fig. 1c flexes the tines 10 and 11 in Fig. 1b radially outward so that they effectively assume a "sprung-out" position gripping  
30 the pin 13 along their internal surfaces.

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As hereinbefore indicated, a manufacturing step involving the radially inward bending of the tines produces the configuration of 1b and involves a plastic (inelastic) deformation in the tine root region. This produces work-hardening  
5 of the copper base material in the said root region, but not at all uniformly throughout the tine roots. As previously indicated, the inside fibers of each tine are compressed, whereas the outside fibers are deformed plastically as a result of tensile overstressing. By overstressing, it is, of  
10 course, meant that the material exceeds its yield point and takes on a "permanent set". As also previously indicated, this prior art manufacturing technique results in large variations in contact and, therefore, also in insertion force, leading to the necessity for acceptance of a high average force in  
15 a production lot of such sockets in order to assure that all will have at least the minimum necessary pin-gripping force. The only practical alternate in using the prior art approach is individual inspection and selection of those providing the minimum acceptable, but not an excessive, amount of insertion  
20 resistance.

Figs. 2a and 2b are helpful in understanding the geometry of insertion forces and pin-contact friction. Upon pin entry into the socket aperture, the mating force is defined by the relationship depicted in Fig.2a and may be expressed as:

25 
$$\text{Mating Force} = R(N \cos \theta + F_r \sin \theta).$$

Once the pin is well within the socket, the mating force may be defined as the product of R and  $F_r$ .

where:  $F_r = \mu N$

$R$  = number of tines

30  $N$  = normal force

$\mu$  = coefficient of friction

Referring now to Fig.4, a typical socket according to the invention will be described. One practical embodiment according

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to Fig. 4a has the following dimensions:

- A = .353/.350 in = 8.97/8.89 mm
- B = .083/.080 in = 2.11/2.03 mm
- C = .153/.150 in = 3.89/3.81 mm
- 5 D = .182/.180 in = 4.62/4.57 mm
- E+F = .200 in = 5.08 mm
- G = .0495/.0485 in = 1.26/1.23 mm
- H = .0060/.0055 in = 0.15/0.14 mm
- J = .014/.013 in = 0.36/0.33 mm

- 10 The socket member of Fig. 4a has a sleeve portion 14 of axial length B. The inside diameter of the bore 18 of this portion 14 may be greater than indicated on a relative visual scale, as might the corresponding outside diameter also be larger than indicated. The purpose of this portion 14 is to provide
- 15 a wire installing sleeve or, alternatively, a sleeve for receiving an intermediate stub or adaptor which is itself attached to a wire. The purpose, in turn, of providing such an intermediate stub is the avoidance of any crimping of the sleeve 14. The entire socket member 20 according to
- 20 Fig.4a is of a material, preferably a copper alloy, having significant spring properties, good machinability, ductility and conductivity. However, such an alloy may not be ideal for crimping at sleeve 14, hence the intermediate stub alternative, the latter being tightly inserted (press-fit, for example)
- 25 into the bore 18 of the sleeve portion 14.

A shoulder 15, which may be chamfered, facilitates mounting against a corresponding internal shoulder in a connector assembly insulating block, a typical expedient in electrical connectors.

- 30 A transition of mid-body section 16 having an inside diameter 17 also has an outside dimension G. Its length is equal to C minus B, and ID 17 is a mating pin clearance dimension, although the pin would not always be inserted to a depth even as great as the full length of dimension D.

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So far, the manufacturing process can be one of straight-forward machining operations.

Over the dimensions E and F, during manufacture, the stock may be advantageously drawn into a die having the conical shape which begins at the transition from the mid-body section 16 to E and F. A drawing process is particularly advantageous from the point of view that the tine root region around 19 may be formed with closely held material thickness (tubular wall thickness), that being an important factor in controlling the characteristics of the tine considered as a cantilevered beam as aforementioned. Typical dimension H will be seen to call for holding this wall thickness within a 0.0055 in = 0.14 mm range.

Of course, drawing does introduce work hardening, but it is relatively uniform over the material cross-section and is predictable and controllable. Thus, the amount of work hardening introduced by drawing can be predicted and, therefore, factored into the design.

The next step in the process of manufacture would normally be the slotting by cutting, or other known process step, to the depth D and width J. At this step, the slot 24 of width J would continue to the aperture of the socket 20. Tines 22 and 23 are thereby formed.

In lieu of drawing, however, full machining operations can be used to complete the process, those machine processes being largely adapted to automatic sequential screw machines.

The process thus far described and the structure which would result would produce the situation depicted in Fig.3a. The tines which would be generated obviously have the smaller circular cross-section produced by the conical shaping hereinbefore described. In Fig. 3a, the tine 22' illustrates this

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fact, and it will be noted the contact with the pin 13 is limited to two edges 27 and 28. Thus, not only would the spring tines tend to score the pin, but the area of contact between socket and pin is unduly limited thereby. By partially  
5 flattening the tines at their aperture ends and for a distance equivalent to the depth of pin insertion into the socket member, the contact area can be shifted more or less to the circumferential inside center surfaces of the tines. The illustrations in Figs. 3a and 3b are obviously exaggerated  
10 for emphasis, however, this situation is more realistically portrayed in the partial end view of Fig.4c. Thus, the tines, 22 for example, in Fig. 4a, have a longer radius, no longer centered on the axial center line of the socket aperture. This is illustrated in Fig. 4c in that the radius  $R'$  of the  
15 unflattened tine 22' changes to  $R$  for the reshaped tine 22.

Fig.3b would indicate that the flattening is such as to produce an effective tine radius greater than the radius of pin 13. This is a possible construction or design choice; however, the radius may be as small as substantially that  
20 of the pin 13 itself.

The partial flattening, as it has been called, referring to the process of modifying 22' to the form of 22 for a predetermined distance inward from the socket aperture, is actually a change of curvature and not actually a flattening  
25 in the ordinary sense of that adjective and, as such, does represent plastic deformation. In that connection, it is pointed out that bending or flattening action which achieves this change of curvature is accomplished by insertion of a mandrel into the socket aperture or through the socket body  
30 from the rear to prevent the application of sufficient bending moment to the tine root region 19 to cause the plastic deformation which is particularly to be avoided.

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The plastic deformation thus produced by time end curvature modification plays no part in the design insofar as insertion and pin frictional forces are concerned, since the new curvature R, once achieved, is a fixed shape.

- 5 Fig. 4b illustrates that the outline of the socket aperture after this so-called flattening operation is an oblate circle; i.e., one in which the dimension 25 is less than the orthogonal dimension of the aperture at the same axial point (same cross-sectional plane). When the pin is inserted into this aperture,  
10 the radii of the surfaces 26 and 26' are at least equal to that of the pin, if not greater.

- Various modifications in the axial proportions and dimensions of a socket member according to the invention are obviously possible without departing from the structural concepts and  
15 manufacturing methods which form the invention. Other dimensional and configuration freedoms will obviously be possible. The socket may obviously be scaled to be consistent with an application.

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Claims:

1. Socket member for electrical connectors comprising a sleeve portion (14) on the rear side, a mid-body section (16) serving to mount the socket member (20), and a forward, slotted pin-gripping portion whose tines (22, 23) are inclined to each other in the direction of their free ends,  
characterized in that, from the tine root region (19) toward the socket aperture, the slots (24) are limited by parallel edges of the tines (22, 23) over a first partial length, and by divergent edges of the tines (22, 23) over the remaining length.
2. A method of manufacturing a socket member for electrical connectors, characterized by the following steps:
  - a) forming the free end of a length of tubular stock to have a conical taper over a predetermined length (E,F);
  - b) slotting the tube wall in the region of the conical portion over a length (D) not exceeding the length (E,F) of the conical portion;
  - c) flattening the tines (22, 23), separated by the slots (24), from the aperture end of the socket member (20) over a length (F) shorter than that of the slots (24) such that the cross-sectional shape of each tine is given a radius (R) greater than the previous radius (R');
  - d) cutting off the finished socket member (20) from the length of tubular stock over an axial length (A) which is held within predetermined limits.
3. A method as claimed in claim 2 in which the conical taper of the socket member (20) is formed by drawing the tube.
4. A method as claimed in claim 2 in which the flattening of a partial length of the tines (22, 23) is done with the aid of a mandrel inserted into the pin-gripping portion.

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5. A method as claimed in claim 2 in which the inside edges of the ends of the tines (22, 23) are rounded in an additional step following the conical shaping.

CS/P-Ka/Sch

October 20, 1978

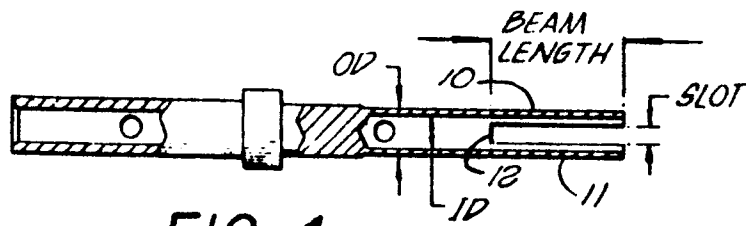


FIG. 1a

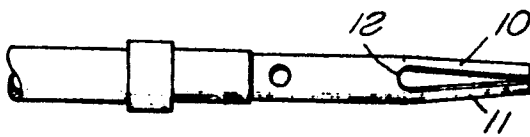


FIG. 1b

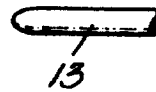


FIG. 1c

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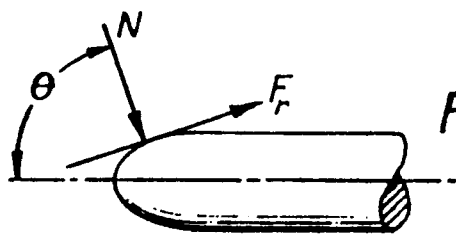


FIG. 2a

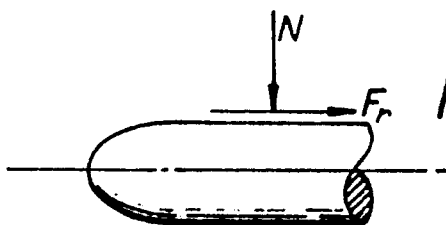


FIG. 2b

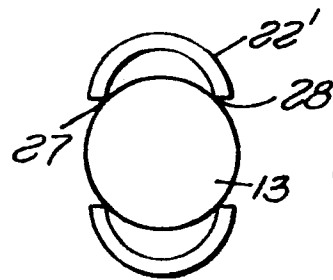


FIG. 3a

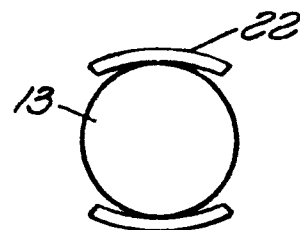


FIG. 3b

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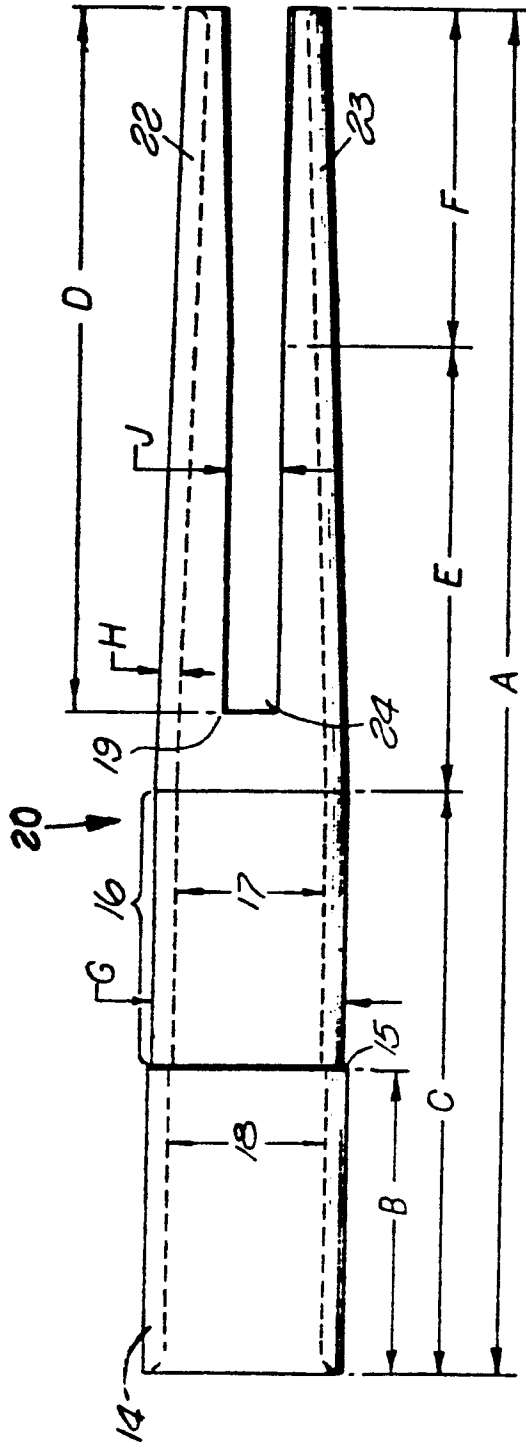


FIG. 4a

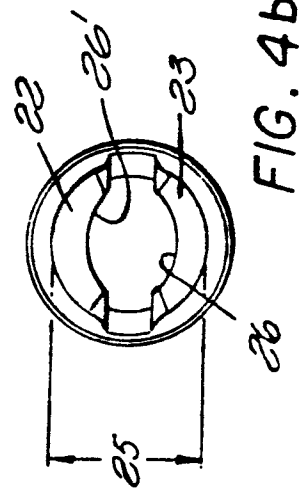


FIG. 4b

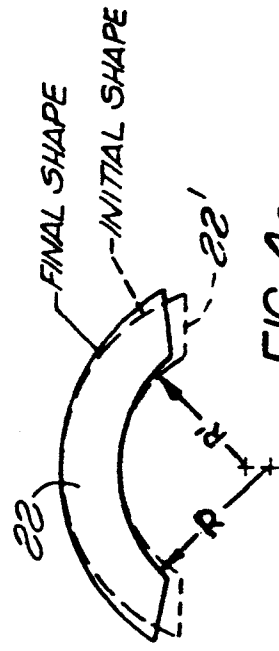


FIG. 4c



DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. <sup>2</sup> )
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>FR - A - 1 237 873</u> (SGE) * Page 2, right-hand column; figures * --	1,5	H 01 R 13/12 43/00
	<u>GB - A - 632 503</u> (BENDIX) * Page 2, lines 26-103; figures * --	2,5	
	TECHNICAL NOTES RCA, nr. 1131, October 28., 1975, Princeton, USA, L.R. HINEY "Socket contact forming tools", pages 1-6 * Page 1 - page 4, paragraph 1; figures 1-5 * --	1,2,4	TECHNICAL FIELDS SEARCHED (Int.Cl. <sup>2</sup> )  H 01 R 13/12 43/00 13/10 43/04
P	<u>US - A - 4 090 772</u> (ITT)(23-05-78) * Figures; abstract * & BE - A - 863 231 (24-07-78) & FR - A - 2 378 379 (18-08-78) & NL - A - 78 00810 (26-07-78) --	1,5	
A	<u>US - A - 3 601 763</u> (IBM) * Figures * --	1,5	CATEGORY OF CITED DOCUMENTS  X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
A	<u>US - A - 3 842 497</u> (BUNKER RAMO) * Column 2, lines 38-43; column 3, lines 40-47; figures * --	1	
A	<u>FR - A - 2 057 512</u> (DEUTSCH) ./.	1,5	
The present search report has been drawn up for all claims			&: member of the same patent family, corresponding document
Place of search	Date of completion of the search	Examiner	
The Hague	14-02-1979	RAMBOER	



European Patent  
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# EUROPEAN SEARCH REPORT

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Application number  
EP 78 20 0289  
-2-

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	* Page 2, lines 9-17; figures *  ---		
	<u>GB - A - 1 152 232 (OXLEY)</u> * Page 1, lines 79-88; figures 3,4 *  -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.)