April 18, 1967 R. WEEKS, JR 3,315,211

ELECTRIC MALE PLUG HAVING REINFORCED BLADES

Filed Feb. 15, 1965

FIG. 1

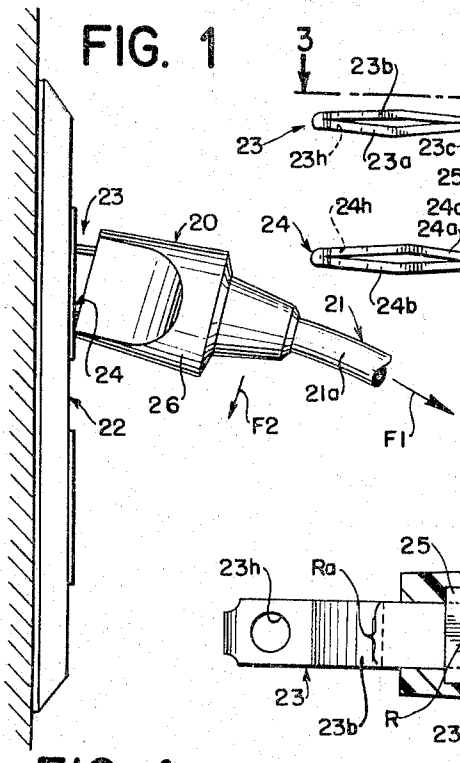



FIG. 2

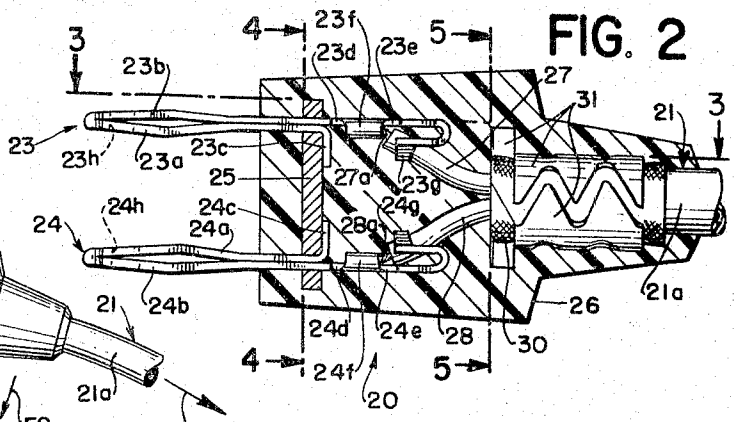



FIG. 3

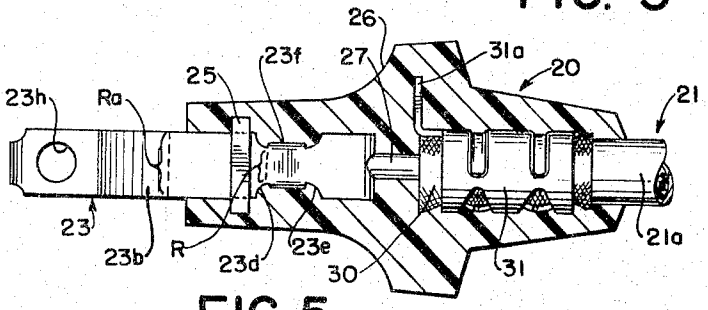



FIG. 4

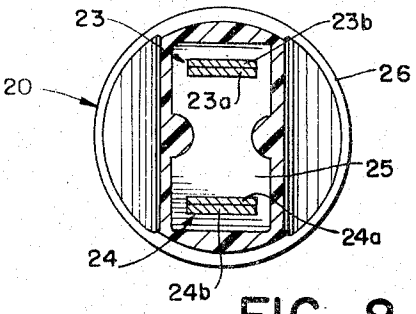



FIG. 5

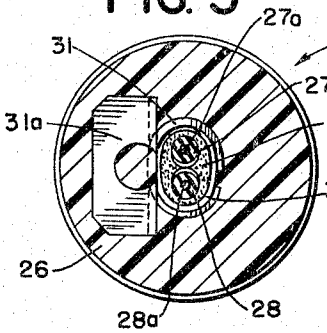



FIG. 6

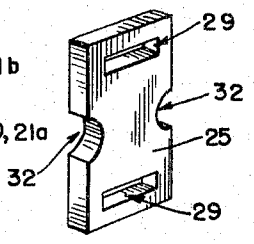
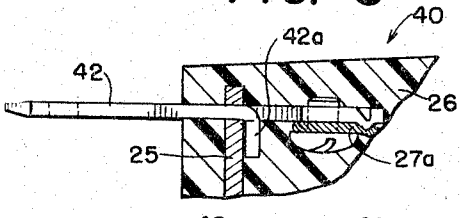



FIG. 8



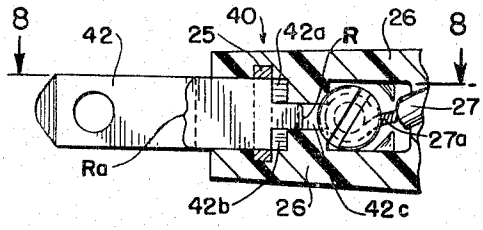
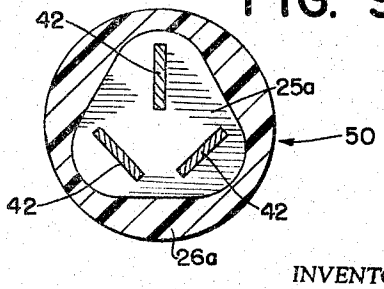




FIG. 7

FIG. 9




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# 3,315,211 ELECTRIC MALE PLUG HAVING REINFORCED BLADES

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Filed Feb. 15, 1965, Ser. No. 432,485
5 Claims. (Cl. 339—63)

My invention pertains, in general, to electric male plugs of the kind wherein each of one or more blades embedded in a nonrigid body, or cap (e.g., a body of dielectric elastic material), has a portion which is structurally weaker in flexure than the rest of the blade. More particularly, however, my invention pertains to reinforcing each blade of such plugs to prevent rupture of the blade at its structurally weaker portion, and my principal objective is to substantially increase the useful life of the aforementioned male plugs in applications in which the blades are subjected to repeated, or periodic, flexure or bending.

There are many instances where the male plug at the end of an electric cord is subjected to forces which cause bending or flexure of its blades while the blades are within, or partly within, a female receptacle; e.g., a wall mounted receptacle. Such blade flexure occurs frequently in connection with the use of portable electrical appliances such as vacuum cleaners, electrically powered hand tools and the like. Sometimes, also, the pins or prongs of male electrical connectors incorporated in stationary apparatus are subjected to the same kind of flexural forces due to the vibratory nature of the apparatus.

Many factors cause or contribute to blade flexure. Among such factors are: the carefulness of the person using the apparatus; the degree of dexterity which this person possesses; the nature of the apparatus being used; the effort involved in manipulating the apparatus and the parts thereof; the length of electric cord extending from the apparatus to a fixed receptacle; and, the direction, or disposition, of the cord length extending to the receptacle.

While many specific examples illustrating one or more of the aforementioned factors are matters of common knowledge it will suffice to set forth one of the more common place examples. Many people using a vacuum cleaner while being at what seems, to them, to be a relatively long distance from the wall receptacle have a tendency to jerk or yank the electric cord in order to pull the plug out of the distant receptacle. Hardly ever is the length of cord exactly perpendicular to the face of the receptacle and the sudden jerk transmitted through the cord to the plug body and the blades causes, among other things, a sudden flexural force to be imparted to the blades. This force, being of a dynamic or impact nature rather than a static nature, stresses and strains the blades in flexure rather severely. This dynamic flexural force is all the more severe as the angle of the cord length in relation to the planar face of the receptacle departs from a straight line perpendicular to the receptacle face. By their very nature, people having the aforesaid tendency repeat such a practice and, as a consequence, it is usual that one (sometimes both) of the blades ruptures at its flexurally weak portion. Hence, repetition of such a practice substantially reduces the life of the plug.

In addition to my principal objective, hereinbefore set forth, it is another of my objectives to provide additional strain relief for blades of plugs of the kind described.

In accordance with one illustrative embodiment of my invention I achieve my principal objective as well as others in a two-blade plug by securely attaching a rigid



dielectric member between the two parallely disposed blades and embedding this rigid member together with end sections of the blades, each of which includes a structurally weak portion, in a body of an elastic dielectric material; e.g., vinyl plastic, rubber, or the like. The rigid member is securely attached to the embedded sections of the blades within the body at a location between the structurally weak blade portion and a surface of the body from which the protruding sections of the blades extend in cantilever fashion.

Without the aforesaid rigid member, repeated flexure of the blades causes bending moments and vertical shearing forces to occur at the structurally weak blade portions and, eventually, one of the blades will rupture at this structurally weak portion. However, by incorporating my rigid member, in the way hereinbefore described, the aforesaid bending moments and vertical shearing forces (which in the absence of my rigid member would cause rupture at the weaker blade portions) are relocated so that these bending moments and shearing forces occur at structurally stronger parts of the blades. In other words, the shear and moment diagrams of the blades without the rigid reinforcing member are different from the shear and moment diagrams where the rigid reinforcing member is used. Thus, by using the rigid member the blades are able to withstand many more flexures than blades which are not reinforced by the rigid member. Moreover, if the rigid member is not used, each of the blades act as independent flexure members. However, when the blades are interconnected by the reinforcing member they act in concert as though they were a unitary flexure member and, as a result, such a unitary member is stronger.

In addition to substantially increasing the life of the blades against flexural rupture, the rigid reinforcing member provides additional strain relief for the plug. To achieve this additional advantage I employ a rigid reinforcing member which is of a planar beam-like or slab-like form. Such a reinforcing member is secured to all of the blades in such a way that the longitudinal axes of the blades are substantially perpendicular to the large area planar surface of the rigid member. When the electric cord is jerked or yanked, the force is transmitted through the nonrigid body, or cap, and to the blades. However, since the blades are usually held in the sockets of the female receptacle by suitable detention means and/or by friction, a longitudinal component of resisting force, or reaction force, occurs in each of the blades. If, the initial yanking force is substantial, and in the absence of my rigid member, there exists the danger that one, or more, of the blades will, due to detention and/or friction, remain within its socket in the receptacle with the result that the nonrigid body will seriously deform relative to the detented blade or even become completely severed from the blade or blades, sometimes leaving the blade within its socket. Moreover, even if the initial yank or jerk on the cord is not substantial, repeated impact forces would eventually tend, in the absence of my rigid member, to cause the aforesaid deformation or severance of the non-rigid body, or cap, from the blade or blades. However, by incorporating my form of rigid member in the way hereinbefore described, the longitudinal resisting or reaction forces imparted to the blades are, by virtue of the wide area of my rigid member, distributed over a large cross-sectional area of the nonrigid body, or cap, thereby substantially reducing the intensity of the force imposed on the body. As a consequence the body can withstand many more such forces imparted to it and, thus the useful life of the plug is substantially increased as

compared with a like plug not incorporating my rigid reinforcing member.

Further objects and advantages of my invention will be apparent from the following description when considered in conjunction with the accompanying drawing on which:

FIG. 1 shows a two-blade male plug according to a first embodiment of my invention inserted in a wall mounted receptacle and being bent;

FIG. 2 is a longitudinal cross-section of the two-blade male plug according to the first embodiment of my invention;

FIG. 3 is a cross-sectional view of the two-blade male plug as viewed along the section line 3—3 in FIG. 2;

FIG. 4 is a cross-sectional view of the two-blade male plug as viewed along the section line 4—4 in FIG. 2;

FIG. 5 is a cross-sectional view of the two-blade male plug as viewed along the section line 5—5 in FIG. 2;

FIG. 6 is a perspective view of the rigid reinforcing member employed in the first and second embodiments of my invention;

FIG. 7 is a partial longitudinal cross-section, similar in part to FIG. 3, of a second embodiment of my invention showing a different blade construction from that used in the aforesaid first embodiment of FIGS. 2 through 5;

FIG. 8 is a partial longitudial cross-section as viewed along the section line 8—8 in FIG. 7; and

FIG. 9 is a cross-sectional view, similar to the view shown in FIG. 4, showing a three-blade male plug in accordance with a third embodiment of my invention.

A two-blade male plug **20**, in accordance with a first embodiment of my invention (FIGS. 1–5), is attached to the end of a two-wire electric cord **21**. This cord **21** is comprised of an outer jacket **21***a* of dielectric material situated within which are the two conductors **27***a* and **28***a*. Each of the conductors **27***a* and **28***a* has its own separate dielectric jacket **27** and **28**, respectively. Also, the outer jacket **21***a* includes a filler material **21***b* which may be jute cord.

In FIG. 1 the arrow **F1** represents a longitudinal force suddenly applied to the electric cord **21** by a person distant from the fixed wall receptacle **22** for the purpose of pulling the plug **20** out of the receptacle **22**. The arrow **F2** represents the flexure or bending component of the force **F1** and the bending force **F2** causes flexure of the two blades **23** and **24** which are situated within suitable sockets provided in the receptacle **22**.

FIGS. 2–5 show the details of the structure and arrangement of the various elements comprising the plug **20**. FIG. 6 is a perspective view of one form of a rigid reinforcing member **25** which I incorporate in the plug **20** to substantially increase its useful life.

The reference number **26** designates the body, or cap, of the plug **20** and this body **26** is comprised of a non-rigid material, such as an elastic dielectric material; e.g., vinyl plastic, rubber or the like. In the illustrative example shown in FIGS. 1–5, the body **26** is a vinyl plastic which may be injection molded in the form illustrated and having embedded therein the various elements shown in the drawing and described in more detail hereinafter. When cured, the molded vinyl plastic has a hardness in the range 78–83 (Durometer, Shore A).

Two parallelly disposed blades **23** and **24** (like the solderless blade illustrated and described in U.S. Patent No. 2,476,738 granted on July 19, 1949 to F. Klumpp, Jr.) are employed in the plug **20**. Each of the blades is formed from an elongated strip of electrically conductive material. For example, in the embodiment illustrated in FIGS. 1–5 the blades **23** and **24** are formed from brass (70% copper–30% zinc) having a hardness in the range **52–62** (Rockwell). The conductive strip is folded back on itself to form a two-layer, or double thickness, protruding blade section. For example, the blade **23** is comprised of the two superposed layers **23***a* and **23***b* and the blade **24** is, likewise, comprised of the two superposed layers **24***a* and **24***b*. As shown in FIG. 2, in the protruding blade section each of the layers may be permanently arched relative to each other to provide spring action so that as the blade enters its socket in the receptacle **22**, the arched sections will be compressed by the walls of the socket urging the two layers of the protruding blade section toward each other against the restraint of the aforesaid spring action. This spring action tends to provide a high pressure, low resistance electrical contact between the blades and suitable contact elements provided in the sockets.

Each layer **23***a* and **24***a* includes an inturned ledge **23***c* and **24***c*, respectively, at one end thereof. Both of these ledges are essentially perpendicular to the longitudinal center line of the blades. Formed in the layer **23***b* are two pairs of cut-outs **23***d*, **23***d* and **23***e*, **23***e*. Similarly, there are formed in the layer **24***b*, the two pairs of cut-outs **24***d*, **24***d* and **24***e*, **24***e*. These pairs of cut-outs in the layers **23***b* and **24***b* are for the purpose of providing the pairs of lugs **23***f*, **23***f* and **24***f*, **24***f*. As noted in the aforementioned Klumpp patent the lug pairs **23***f* and **24***f* formed by the cut-outs are of sufficient length so that they can encompass the bare conductors **27***a* and **28***a*, respectively, when crimped thereabout. Also, formed at the end of each layer **23***b* and **24***b* are the pairs of lugs **23***g*, **23***g* and **24***g*, **24***g*, respectively. Lug pairs comparable to lug pairs **23***g* and **24***g* are shown in the Klumpp patent and these lug pairs **23***g* and **24***g* are intended to be crimped about the insulating jackets **27** and **28** as shown in FIG. 2. At the lead end of each of the blades **23** and **24** (the ends which first enter the sockets of the receptacle **22**) there are provided the holes **23***h* and **24***h*, respectively. These holes, which may be formed by punching through both layers of each blade, serve the well known purpose of engaging detents in the receptacle **22** for holding the blades therein.

Due to the formation of the cut-out pairs **23***d* and **23***e* in the blade layer **23***b*, the blade **23** is structurally weakened in flexure. Similarly, the blade **24** is made structurally weak in flexure due to the formation of the cut-out pairs **24***d* and **24***e* therein. In the blade **23**, the distance between the two cut-outs **23***d* and **23***d* at the region R (FIG. 3) is small, as is the distance between the two-cut-outs **23***e* and **23***e*. Moreover, the thickness of the blade **23** at these locations is only the thickness of the single blade layer **23***b*. Therefore, being of small cross-section between the two cut-outs **23***d* and **23***d*, the blade **23** is weak in flexure or bending at this location R. The blade **23** is likewise weak in flexure along the line between its other cut-outs **23***e* and **23***e*. The same is true of the blade **24**.

Accelerated bending tests have shown that a plug like plug **20**, but without the reinforcing member **25**, usually fails because one of its blades ruptures along a straight line at the region R. Moreover, it is usual that such rupture at region R will occur in the blade which is more acutely affected by the bending force component **F2**. For example, in FIG. 1, the lower blade **24** which is stressed to a greater extent than the upper blade **23** will almost always rupture first at region R before the blade **23** ruptures.

However, by employing the rigid reinforcing member **25** (FIG. 6) in combination with the blades **23** and **24** and the plug body **26**, in the way hereinafter described, I have found that a bending force **F2** repeatedly applied will eventually cause rupture of one of the blades (usually the more acutely stressed blade, such as the blade **24** in FIG. 1) not at the region R, but at a double layer portion of the blade, outside of the body **26** of the plug. The use of the rigid member **25** seems to isolate the region R from stresses due to bending or at least the member **25** substantially reduces the stresses due to bending at this region R. In other words, the use of a rigid member **25** seems to transfer the bending

moments and shearing forces which tend to cause blade rupture to the region R*a* (FIG. 3). For example, assuming in FIG. 3 that the blade **23** is the more acutely stressed blade (as if the blade **23** were the lowermost blade in FIG. 1) rupture almost always occurs along a straight line in approximately the region designated R*a*. Since the region R*a* is doubly thick because of its two superposed blade layers **23***a* and **23***b* and since these superposed layers are of maximum width the region R*a* is much stronger than the region R in flexure. As a consequence many more flexures are required to cause a rupture at the region R*a*. Accelerated blade rupture test results comparing the plug **20** as herein disclosed with a like plug having no reinforcing member are set forth hereinafter.

As shown in FIG. 6, the reinforcing member **25** is a relatively flat beam-like or slab-like body formed from a dielectric material, such as a body made from commercial grade vulcanized fibre in accordance with NEMA Standard VU1 (See NEMA Standards Publication, Pub. No. VU 1–1963 entitled Vulcanized Fibre, authored by National Electrical Manufacturers Association). The vulcanized fibre reinforcing member **25** is much more rigid than the material from which the plug body **26** is made.

Two rectangular slots **29, 29** are formed in the member **25** so that the two blades **23** and **24** can be inserted therethrough until, as indicated in FIGS. 2 and 3, one face of the reinforcing member **25** bears against the faces of the ledges **23***c* and **24***c*. The area of the rectangular slots **29, 29** is just a little larger than the cross-sectional area of the double layer portion of the blades so that the blades are fitted rather tightly within these slots. Since the elastic material of the body **26** is to be molded about the blades, the reinforcing member, the cord and a strain relief element **31**, the cut-outs **32, 32** are preferably formed on opposite sides of the member **25** to permit injected material to flow easily to all parts of a mold cavity, which cavity is of the same form as the body **26**. It is to be understood however, that the provision of cut-outs **32** is optional and are not required for the proper functioning of the completed plug.

A metallic strain relief element **31** having a large area **31***a* is securely crimped over an end section of the jacket **21***a* of the electric cord **21** after first taping the jacket's end section with an adhesive dielectric tape **30** which prevents the element **31** from puncturing the jacket **21***a* when it is crimped thereabout. As is discussed in more detail hereinafter, the projection **31***a* serves to transmit a pulling force such as F1 in FIG. 1 applied to the cord jacket **21***a* directly to the body **26**.

After mechanically and electrically assembling the taped electric cord, the strain relief element **31**, the blades **23, 24** and the reinforcing member **25** in the way suggested in FIG. 1, the entire assembly is placed in a suitable mold with the blades **23** and **24** protruding therefrom. Then the mold is filled, as by pressure injection, with a substance which when cured has the aforesaid suitable dielectric and elastic properties; e.g., vinyl plastic, rubber or the like.

In order to determine what contribution the reinforcing member **25** makes toward increasing the life of the blades against rupture due to flexure, a number of plugs like the plug **20**, but without the reinforcing member **25** incorporated therein, had their blades subjected to repeated applications of a flexural force F2 until blade rupture occurred. Also, the same number of plugs **20** having the reinforcing member **25** therein, as shown in FIGS. 1–4, had their blades **23** and **24** subjected to repeated applications of the same flexural force F2 until blade rupture occured. A test fixture simulating the bending the plug's blades in a female receptacle, like receptacle **22**, was employed to bend the blades through an angle of 30° at the rate of 44 bends per minute. The structure and materials used in both sets of plugs were the same, except for the inclusion of the reinforcing member **25** in one set of plug samples. The test results followed in tabulated form.

| Plug I (With reinforcing member 25) | | Plug II (Without reinforcing member) | | (5) | (6) |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | | |
| Plug Sample | Bends until blades rupture [1] | Plug Sample | Bends until blades rupture [2] | Extended life of Plug I over II | Ratio: Life of Plug I to life of Plug II |
| 1 | 923 | 1 | 361 | 562 | 2.56 |
| 2 | 929 | 2 | 427 | 502 | 2.17 |
| 3 | 931 | 3 | 435 | 496 | 2.14 |
| 4 | 938 | 4 | 567 | 371 | 1.65 |
| 5 | 1,073 | 5 | 640 | 433 | 1.67 |
| 6 | 1,110 | 6 | 733 | 377 | 1.51 |
| 7 | 1,111 | 7 | 785 | 326 | 1.42 |
| 8 | 1,238 | 8 | 787 | 451 | 1.57 |

[1] One blade (the more acutely stressed blade, like blade 24 in Fig. 1) ruptured at region R*a*.
[2] One blade (the more actuely stressed blade, like blade 24 in Fig. 1) ruptured at region R.

In the above table the two sets of plug samples are arranged in ascending order of life. That is, the lowest life plug sample of one set (columns 1 and 2) is compared with the lowest life plug sample of the other set (columns 3 and 4), the next lowest life plug sample of one set is compared with the next lowest life plug of the other set, and so forth. Columns **5** and **6** clearly show that the plugs which have the reinforcing member **25** incorporated therein have a substantially greater life than those plugs not employing such a reinforcing member.

The reinforcing member **25** also provides additional strain relief between the blades **23, 24** and the body material **26**. Assuming that the blades **23, 24** are within their respective sockets in the receptacle **22**, if a force F1 is suddenly applied to the cord jacket **21***a* such force is distributed and transmitted through the projection **31***a* of the strain element **31** to the material of the body **26**. From the body **26** this force is transmitted through the large area of reinforcing member **25** to the two blade ledges **23***c* and **24***c* into and along the blades **23** and **24**, respectively. However, since the blades are held to some extent within their respective receptacle sockets reaction forces are set up in and along the blades **23** and **24**. These reaction forces in the blades **23** and **24** are transmitted back to the body **26** through the large area of reinforcing member **25** via the relatively small area blade ledges **23***c* and **24***c*. Therefore, the intensity of the force on the body **26** is much less, by virtue of the interposed wide area of the reinforcing member **25**, than the intensity of the force which would be directly transmitted to the body **26** by the ledges **23***c*, **24***c* if no reinforcing member were used. Thus, the reinforcing member **25** enables the plug **20** to withstand many more applications of such force F1 applied thereto before the body **26** seriously deforms or becomes severed from the blades, than a like plug not having such a reinforcing member.

In FIGS. 7 and 8 there is illustrated a second embodiment of my invention wherein the reinforcing member **25** (FIG. 6) is employed in combination with blades of different construction. In the fragmentary views of FIGS. 7 and 8 the reference number **40** designates the plug generally and the body **26** of this plug is of the same non-rigid material as hereinbefore described in connection with plug **20**. Except for the blade construction the plugs **40** and **20** are alike in arrangement, construction and the elements employed. The plug **40** uses solid blades, such as the blade **42** shown. This blade **42** has two inturned ledges **42***a* and **42***b* formed therein and these two ledges serve the same purpose as the ledge **23***c* on blade **23** of plug **20**. Adjacent the ledges **42***a* and **42***b* the blade section **42***c* at region R is relatively narrow

nd is much weaker in flexure than the rest of the blade. f the rigid reinforcing member **25** (FIG. 6) were not sed repeated blade flexure would eventually cause the lade **42** to rupture at the region R. However, by inluding the reinforcing member **25** as shown in FIGS. 7 nd 8 repeated flexure causes the blade **42** to rupture at he region R*a*. The reasons for relocation of the rupture egion have been set forth hereinbefore with reference to he discussion relating to the plug **20**. Since blade **42** at he region R*a* is of maximum thickness and width it is tronger in flexure than at the region R. Hence, many nore flexures are required to rupture the plug at R*a* than it R.

The rigid reinforcing member **25** also serves as additional strain relief between the blades **42** and the material of the body **26**. The reasons for this additional idvantage have been set forth hereinbefore with reference o the discussion relating to the plug **20**.

In FIG. 9 there is shown a third embodiment of my invention, a plug **50** employing three blades **42** and a slab-like reinforcing member **25***a*. The blades **42** are of the same construction as shown in FIGS. 7 and 8 in the second plug embodiment, plug **40**. The reinforcing member **25***a* is suitably shaped and provided with slots, like the slots **29** in reinforcing member **25**, for receiving the blades **42**. The reinforcing member **25***a* is shaped in a somewhat triangular form to accommodate the three blades **42**. The blades **42** together with rigid reinforcing member **25***a* are embedded in a body **26***a* of nonrigid material; for example a dielectric elastic material, such as one of those hereinbefore described.

While I have shown and described more than one specific embodiment of my invention, it is to be understood that this has been done for purposes of illustration only and that the scope of my invention is not to be limited thereby, but is to be determined from the appended claims.

What I claim is:

**1.** An electrical connector comprising a nonrigid body, an elongated contact element having one end embedded in said body and the other end protruding therefrom for engagement with an electrical receptacle, whereby said contact element may be subjected to a bending stress, the embedded end of said element having portion which is structurally weaker than the rest of the contact element, and rigid means secured to said contact element within said body between said weakened section and the projecting end of said contact element for transmitting bending stress from the projecting end of said element to said body thereby diverting said stress away from said weakened section.



**2.** An electrical connector comprising: a body member of elastic material; a plurality of contact elements, each said contact element having an end section including a portion thereof which is structurally weaker than the rest of the contact element, each said end section including said structurally weaker portion being embedded in said body and the remainder of each said contact element protruding from a surface of said body; and rigid means embedded in said body rigidly connected with all the contact elements at their respective end sections, said rigid connection means being located in the body between said structurally weaker portions of the contact elements and said surface of the body from which the contact elements protrude.

**3.** The plug defined in claim **2** wherein said rigid connection means comprises a plate-like member having a relatively wide surface area which serves the additional purpose of diminishing the intensity of any force transmitted to the body by a force which may be applied to the protruding end of one or more of the blades.

**4.** A male electrical plug comprising: a body of elastic dielectric material; a plurality of blades, each said blade having an end section including a ledge formed therein, said ledge being disposed substantially perpendicular to the longitudinal center line of the blade, each said blade having a portion which is weaker in flexure than the rest of the blade, said end section including the ledge and the flexurally weaker portion being embedded in the material of the body, the remainder of each blade protruding from a surface of the body, said ledge being located in said end section between said flexurally weaker portion and the protruding remainder of the blade; and a rigid member embedded in the material of the body and rigidly secured to all of the blades at their respective end sections at a location between said ledge and said surface of the body.

**5.** The plug defined in claim **4** wherein the rigid member has a wide surface area against which said ledges bear.


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J. H. McGLYNN, *Assistant Examiner.*