April 27, 1965 F. R. BONHOMME 3,181,112

MINIATURE CONTACT ELEMENTS OF TUBULAR PROFILE FOR ELECTRIC COUPLINGS OF THE PLUG AND SOCKET TYPE

Filed Nov. 23, 1962 3 Sheets-Sheet 1

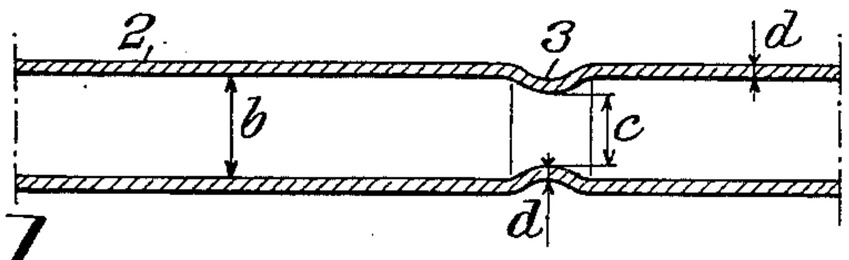


Fig. 1.

Fig. 5.

Fig. 2.

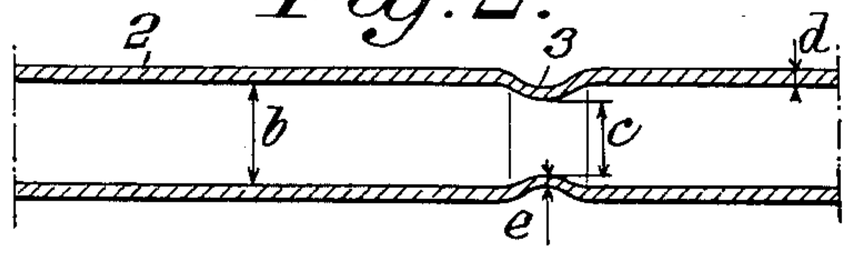


Fig. 6.

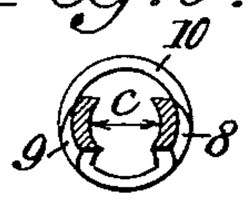


Fig. 3.

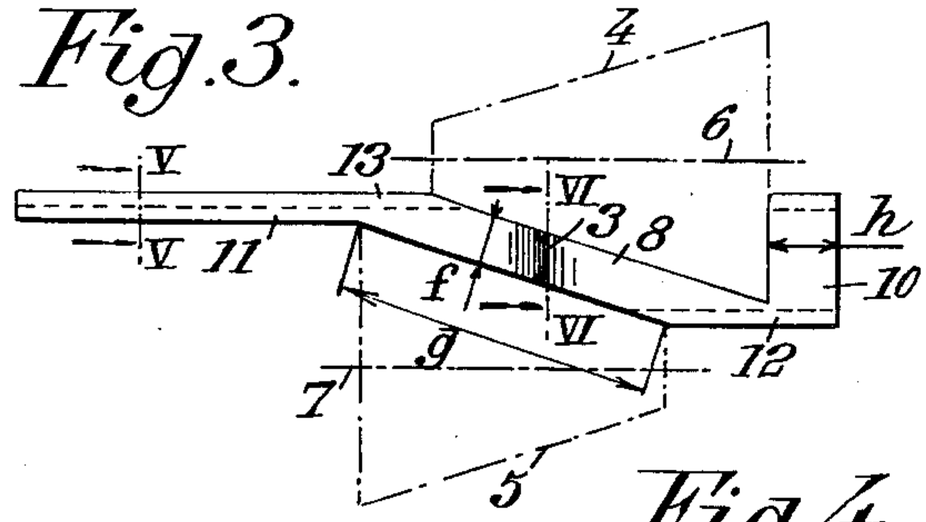


Fig. 7.

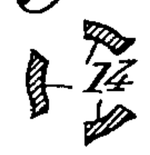


Fig. 4.

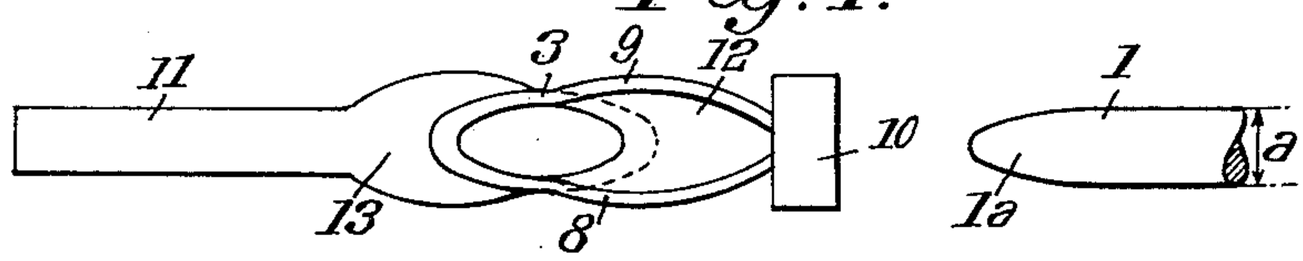


Fig. 8.

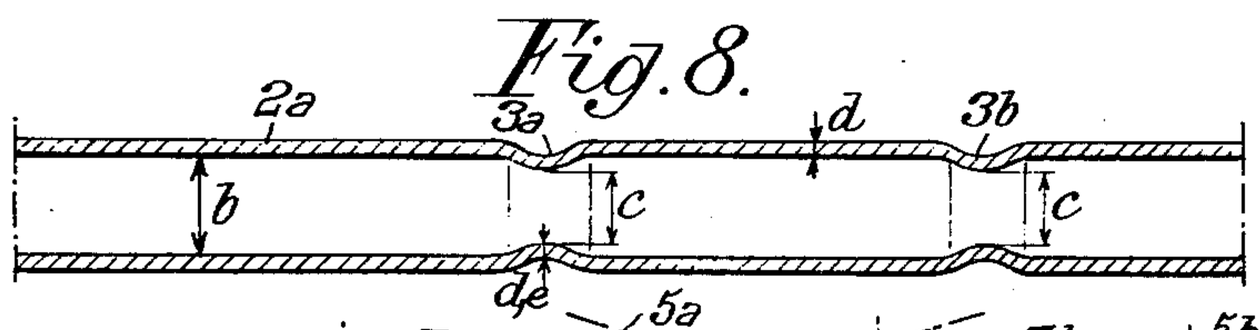


Fig. 9.

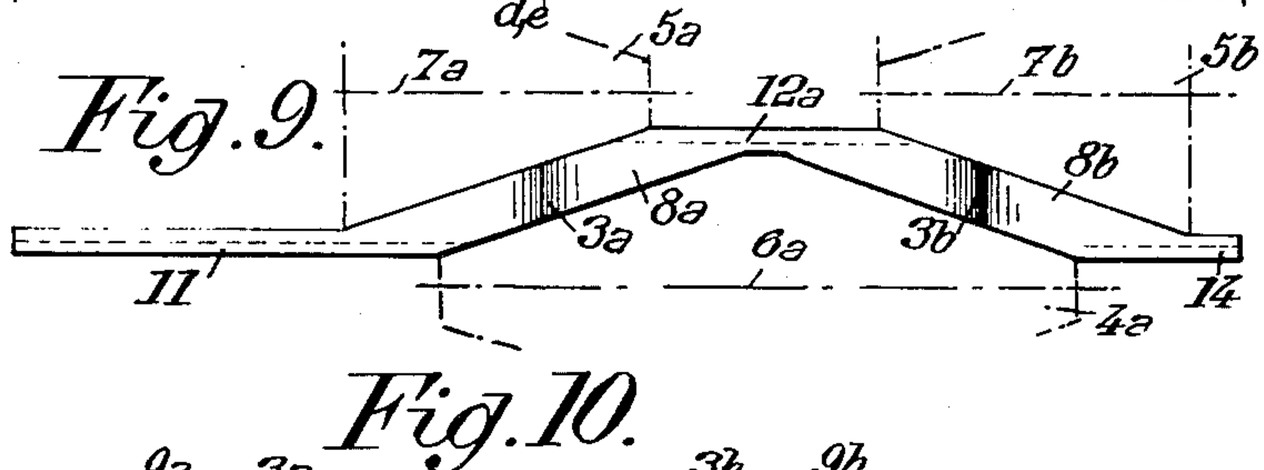
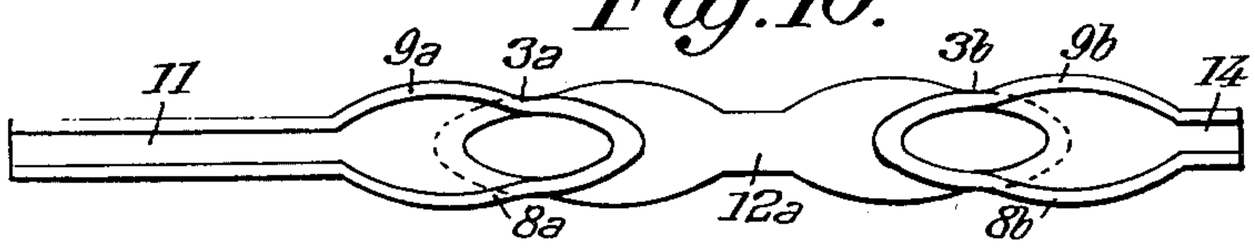


Fig. 10.



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MINIATURE CONTACT ELEMENTS OF TUBULAR PROFILE FOR ELECTRIC COUPLINGS OF THE PLUG AND SOCKET TYPE

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Fig. 11.

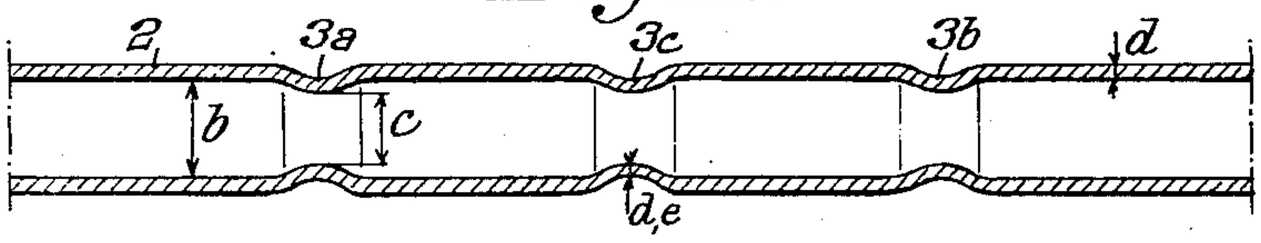

Fig. 12.

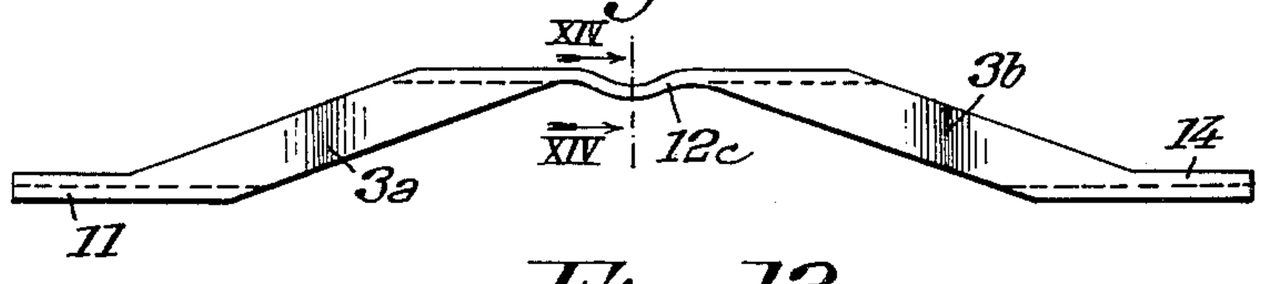

Fig. 13.

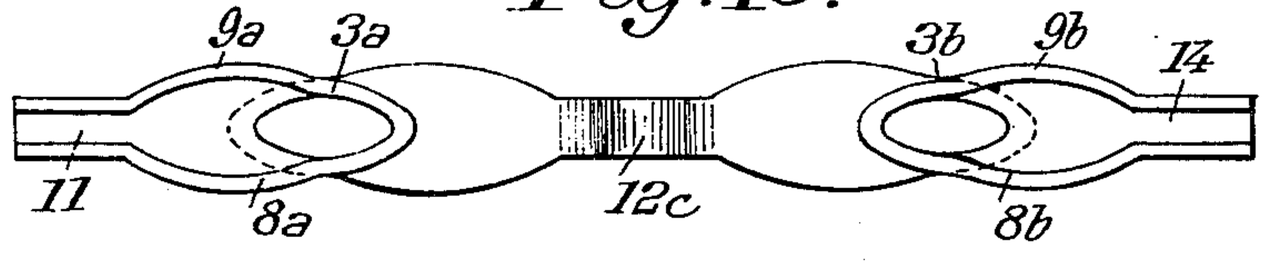

Fig. 14.

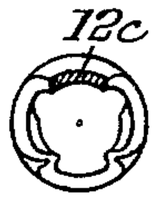

Fig. 15.

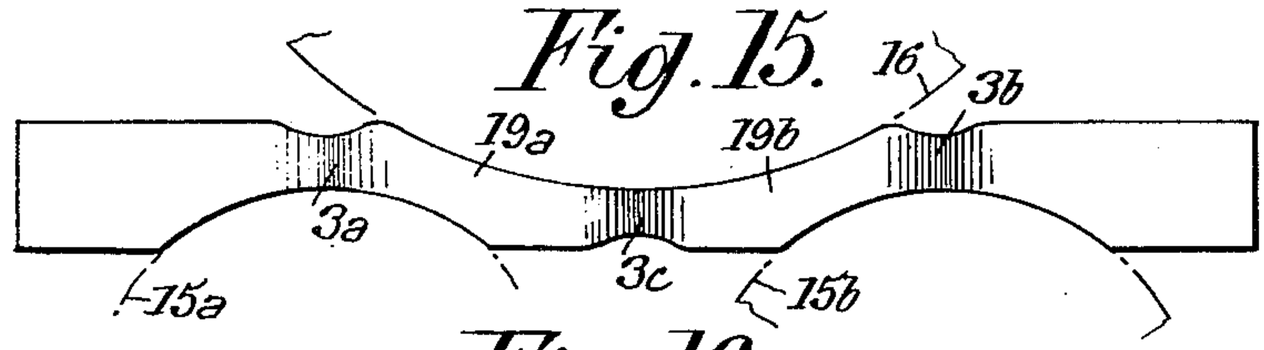

Fig. 16.

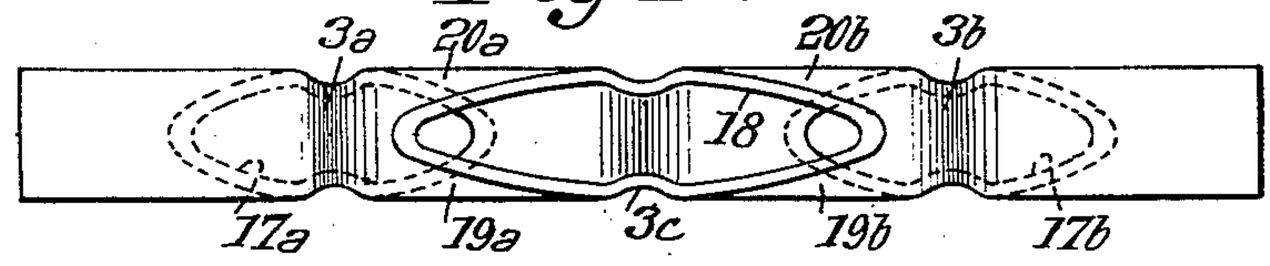

Fig. 17.

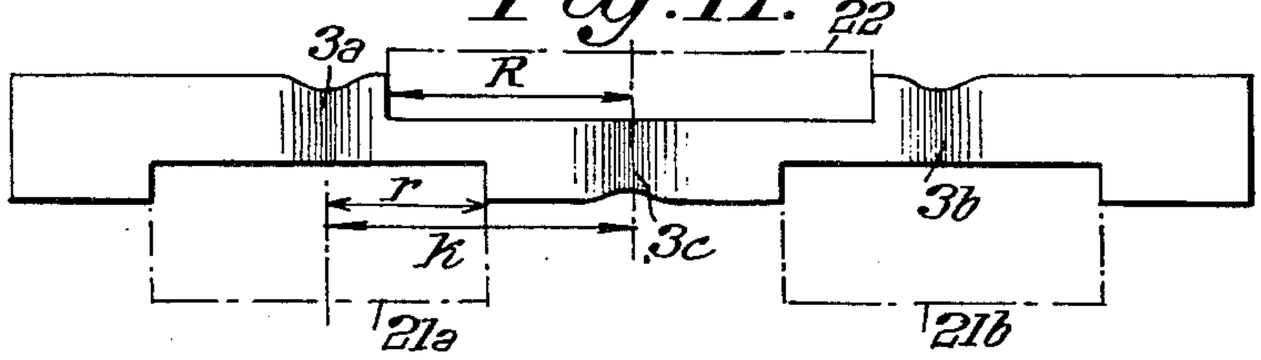

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Fig. 18.

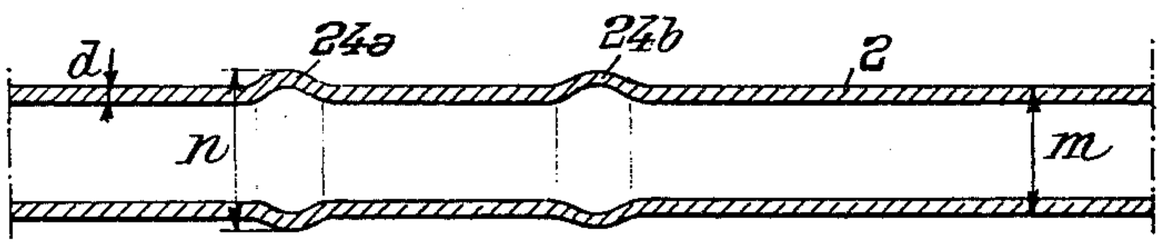


Fig. 19.

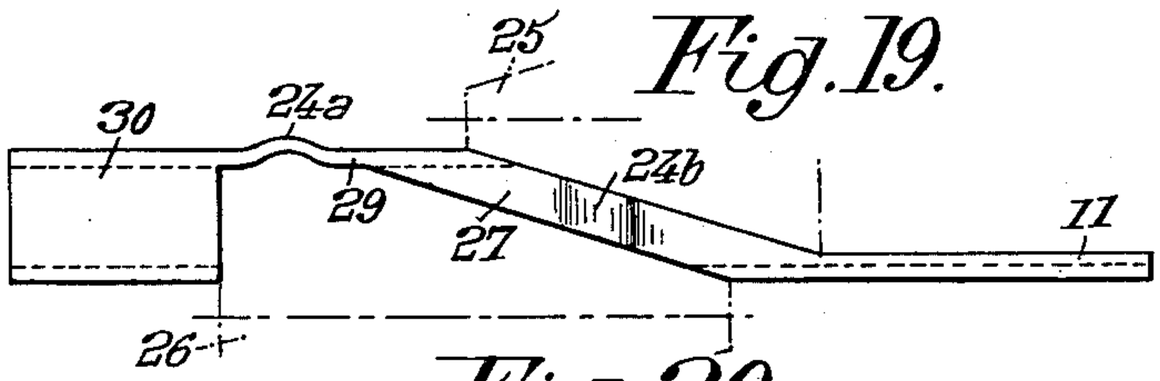


Fig. 20.

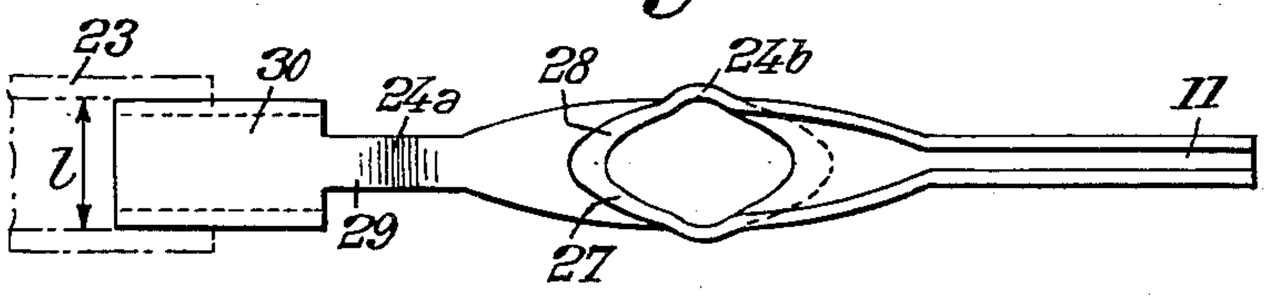
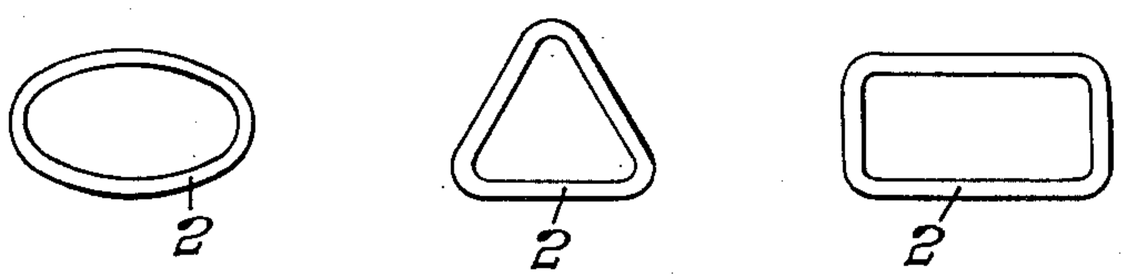


Fig. 21. Fig. 22. Fig. 23.



United States Patent Office

3,181,112

Patented Apr. 27, 1965

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3,181,112
MINIATURE CONTACT ELEMENTS OF TUBULAR PROFILE FOR ELECTRIC COUPLINGS OF THE PLUG AND SOCKET TYPE

Francois Robert Bonhomme, Courbevoie, France, assignor to Curtiss-Wright Corporation, a corporation of Delaware

Filed Nov. 23, 1962, Ser. No. 239,845
Claims priority, application France, Nov. 24, 1961, 879,989
4 Claims. (Cl. 339—252)

The present invention relates to miniature contact elements of tubular profile for electric couplings of the plug and socket type (said contact elements generally consisting of sockets but being possibly plugs).

In the following description and claims the term "miniature contact element" means an element the transverse dimensions of which do not exceed 0.6 mm., and may be as small as 0.2 mm. and even less. The use of such elements in certain types of electric and electronic apparatus has been steadily increasing.

Such small dimensions involve problems which are extremely difficult to solve for practical purposes. As a matter of fact, in order to have good qualities, such contact elements must have at least two, and preferably three, reliable points or areas of contact between the plug and the socket. Furthermore, they must be as resilient as possible so as to take into account the tolerances of machining and they must permit a very great number of connecting and disconnecting operations without deterioration of the device. Finally they must provide surface protection such as by an electric coating of silver, gold, rhodium or an analogous substance adapted to the application that is being considered. This protection is particularly difficult to obtain in the case of contact elements having a tubular profile of closed outline, the inner diameter of which is of course very small, because in this case the electrolyte or any other treatment bath cannot penetrate thereinto from one end to the other due to surface tension phenomena.

A principal object of my invention is to provide an electric element of this type which is better adapted to meet the requirements of practice than those known up to this time, especially from the point of view of safety of operation and of surface protection by an electrolytic coating.

For this purpose, according to an essential feature of my invention the contact element is characterized in that, seen in end view, it has a closed tubular profile but that, over its length for cooperating with the other element of the electric coupling, the solid portions located in any transverse plane have a peripheral development smaller than 180° and have angular configurations variable from one section to the other. This contact element has, in at least one transverse area thereof, a projection with respect to said closed tubular profile intended to ensure a tight contact with the other element of the electric coupling.

This projection is turned inwardly when the element under consideration is a socket (intended to cooperate with a cylindrical plug), the transverse dimensions of which range between the inner transverse dimensions of the general cylindrical profile of the socket and those of the inner cross section thereof at the level of said projection. This projection is, on the contrary, turned outwardly when the element under consideration is a plug (intended to cooperate with a cylindrical socket), the inner transverse dimensions of which range between the external transverse dimensions of the general cylindrical outline of the plug and those of the external cross section thereof at the level of said projection.

In order to obtain such a contact element, I start from

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a cylindrical tube which is made of a resilient material which is a good conductor of electricity, having a continuous solid wall. I locally deform this tube so as to form said projection and then cut off said wall over the whole length thereof intended to cooperate with the other element of the electric coupling over at least 180° of peripheral development, after which I generally proceed to a surface protection of the element by an electrolytic method.

Preferred embodiments of my invention will be hereinafter described with reference to the appended drawings, given merely by way of example, and in which:

FIG. 1 is an axial section of a tube adapted for the manufacture of a contact socket according to a first embodiment of the invention;

FIG. 2 is a similar view of a modification;

FIG. 3 is a side elevational view of the contact socket obtained from either of the tubes of FIGS. 1 and 2;

FIG. 4 is a plan view seen from under FIG. 3 and corresponding thereto;

FIGS. 5 and 6 are sectional views of the socket element of FIGS. 3 and 4, respectively on the lines V—V and VI—VI of FIG. 3;

FIG. 7 is a transverse sectional view of a socket according to a modification of the construction of FIGS. 3 and 4;

FIG. 8 is a view similar to FIG. 1 but corresponding to another embodiment of the invention;

FIGS. 9 and 10 show, similarly to FIGS. 3 and 4 respectively, a contact socket obtained from the tube of FIG. 8;

FIG. 11 is a view, similar to FIGS. 1 and 8, of a tube for making the contact socket according to a third embodiment of the invention;

FIGS. 12 and 13 are views similar to FIGS. 3 and 4, respectively, of a contact socket made from the tube of FIG. 11;

FIG. 14 is a transverse sectional view on the line XIV—XIV of FIG. 12;

FIGS. 15 and 16 show, similarly to FIGS. 3 and 4 respectively, a socket element made according to a fourth embodiment of the invention from a tube such as shown by FIG. 11;

FIG. 17 shows, similarly to FIGS. 12 and 15, a socket element made, according to a fourth embodiment of the invention, also from the tube of FIG. 11;

FIG. 18 is an axial sectional view of a tube serving to manufacture a contact plug element according to the invention;

FIGS. 19 and 20 are an elevational view and a plane view, respectively, of a plug element made from the blank of FIG. 18;

Finally FIGS. 21 to 23 show various profiles, different from circular ones, of the tubes shown by FIGS. 1, 2, 8, 11 and 18.

I will first consider the manufacture of a contact socket intended to cooperate with a plug 1 of diameter *a* (FIG. 4).

I start from a cylindrical tube 2 of a resilient metal such as an alloy of copper and beryllium, a bronze, or the like, the inner diameter *b* of which is slightly greater than the diameter *a* of plug element 1, said tube preferably being of circular cross section (FIGS. 1, 2, 8 and 11) and I cut off a portion of this tube of a length equal to the desired length of the socket element.

According to the embodiment of FIGS. 1 to 4, I form an inward annular projection 3 such that the inner diameter of the tube at this level has a value *c* smaller than *a*.

By way of example, for a plug 1 having a diameter *a* equal to 0.25 mm., I take a tube 2 of an inner diameter

b equal to about 0.3 mm. and of a thickness *d* averaging 0.05 mm. and I reduce the diameter of this tube at **3** in a uniform manner so that the minimum diameter *c* averages 0.2 mm. According to FIG. 1 this deformation is carried out without reducing the thickness of the tube wall. However in order to increase the flexibility of the socket element I may, as shown by FIG. 2, give it, at the level of said reduced diameter **3**, a thickness *e* smaller than the thickness *d* of the wall of the remainder of the tube.

The wall of tube **2** is then cut off over its whole length intended to cooperate with plug element **1**, over at least 180° of its peripheral development, preferably by means of a cutting tool of suitable shape.

As shown by FIG. 3, I may use two frustoconical cutting tools (or milling tools) **4** and **5** the axes **6** and **7** of which are parallel to the axis of the tube and are preferably, as shown, located in the same plane as said axis (this plane being that of FIG. 3), the respective generatrices of these cutting tools that are closest to each other being substantially parallel to each other. I thus obtain two portions or strips **8** and **9**, as shown by FIGS. 3, 4 and 6, located at a distance from each other, in the plane of the inner projection **3**, equal to *c* (see FIG. 6). These two portions are connected on one side to a ring-shaped portion **10**, serving to guide plug element **1**, the end **1***a* of which is tapered and on the other side to a socket portion **11** intended to receive an electric terminal conductor fixed thereto for instance by welding. This socket portion **11** is advantageously reduced to a small portion of the periphery of the initial tube to form a strip as illustrated by the drawings.

Similar arrangements, which will be hereinafter described, are shown in FIGS. 8 to 10, FIGS. 11 to 13, FIGS. 15 to 17 and FIGS. 18 to 20 respectively.

I thus obtain a contact socket which, seen endwise (FIGS. 5 and 6), has a closed tubular outline but the solid portions of which, over the length thereof intended to cooperate with plug element **1**, have a total peripheral development smaller than 180° and angular dispositions which may differ from one portion to another. These solid portions consist of the respective strips **8** and **9**, of the junctions **12** and **13** of these strips, and of longitudinal portion **11**. The socket has, at the level of the portion **3** of reduced diameter, a projection on every portion **8** and **9** intended to come into contact with plug element **1**, which is further guided by ring **10** and by the beginning of portion **11**.

By way of example the width *f* of portions **8** and **9** may be about 15 mm., their length **9** about 2 mm. and the width *h* of ring portion **10** about 0.15.

Of course, instead of making two strips **8** and **9** by means of two cutting tools **4** and **5** I might make three strips **14** (FIG. 7) by means of three cutitng tools, the total development of these strips being at most equal to 180°.

Owing to the shape thus given to the socket element it is posisble to protect by electrolysis the inner faces of strips **8** and **9** or **14** and of the remainder of the contact socket.

Instead of having strips **8** and **9** disposed at the same level in the longitudinal direction of the socket I might offset them in this direction, in which case I might provide initially two portions of reduced diameter, such as **3**, offset in the longitudinal direction so that the corresponding projections are approximately located at the middle point of every strip. This arrangement, not shown by the drawings, would permit increasing the resiliency of the strip.

According to the construction of FIGS. 8 to 10 inclusive, I provide a socket element by making in a single piece two sockets analogous to that above described connected together by a junction **12***a* corresponding to twice junction portion **12** of the preceding example.

In a general manner the elements of FIGS. 8 to 10 that are identical to those of FIGS. 1 to 4, are designated by the same reference numerals, sometimes followed by letters *a* or *b*.

I provide on tube **2** two annular constrictions **3***a* and **3***b*, and this tube is cut by means of two frustoconical cutting tools **5***a* and **5***b*, the respective axes **7***a* and **7***b* of which are in line with each other, and of a bi-conical cutting tool **4***a* having its axis **6***a* parallel to axes **7***a* and **7***b* and located in the same plane as said axes and as the axis of tube **2**. I thus obtain two strips **8***a* and **9***a* at the level of constriction **3***a* and two strips **8***b* and **9***b* at the level of constriction **3***b*, the whole of these four strips being connected together as above stated by junction **12***a*. On the other side strips **8***a* and **9***a* are connected to a portion **11** identical to that of FIGS. 3 and 4 and strips **8***b*, **9***b* to a blade element **14** which, contrary to ring **10**, has not a closed outline. In this case, plug **1** is applied at a point of each of the four strips **8***a*, **9***a*, **8***b* and **9***b*. The access of electrolyte is possible, as in the preceding case, to the inner surface of the socket during the surface protection treatment.

The construction of FIGS. 11 to 13 differs from that of FIGS. 8 to 10 only by the provision of a fifth point of contact with plug element **1**. For this purpose, tube **3** is provided, in addition to constrictions **3***a* and **3***b*, with a third middle constriction **3***c* which, after milling operations analogous to that illustrated by FIG. 9, provides an inward projection on junction **12***c* which is analogous to the junction **12***a* of FIGS. 9 and 10. This increases the flexibility of the socket element between its ends **11** to **14**, and facilitates good electrical contact with the plug at the level of constrictions **3***a* and **3***b* despite the functional wear and tear and metal fatigue.

In the foregoing, it was assumed that tube **2** is cut by means of tools having their axes parallel to the axis of the tube. Of course other cutting arrangements are possible as shown by FIGS. 15 to 17 where the initial tube is identical to that shown by FIG. 11.

According to the construction of FIGS. 15 and 16 I make use for instance of three milling tools **15***a*, **15***b*, and **16**, the respective axes of which are perpendicular to the axis of tube **2**, the middle planes of a cutting tool passing through this last mentioned axis. Cutting tools **15***a* and **15***b* are located on the same side of this axis and cutting tool **16** on the other side, the transverse plane passing through the axis of cutting tool **16** being at equal distances from the transverse planes passing respectively through the axes of the two other cutting tools. As shown by FIG. 16 the oval shaped hole **18** provided by the middle tool **16** has its ends at the same longitudinal level as those of the oval shaped holes **17***a* and **17***b* provided by the end tools **15***a* and **15***b*. Thus, even at the level where these holes are narrowest the solid portion that remains of the tube does not exceed 180° in the peripheral direction, at least over most of the length of the socket member. Preferably, hole **18** is obtained by a tool of greater diameter than those of the two other tools and over a greater length than holes **17***a* and **17***b*. The solid portion consists as in the preceding embodiments of strips **19***a*, **19***b*, **20***a*, **20***b* between which the surface protection electrolyte can pass.

Instead of being cylindrical, milling tools **15***a*, **15***b* and **16** may be spherical. Furthermore instead of parallel disposition of the axes of these tools, they may be offset by 120° for instance with respect to the axis of tube **2**.

Finally, according to the embodiment of FIG. 17, I may use tools **21***a*, **21***b* and **22** having their respective axes perpendicular to the axis of tube **2**, the distance *k* between the axes of the middle tool **22** and that of either of the extreme tools **21***a* and **21***b* being preferably smaller than the sum of the respective radii R and *r* of these tools.

If now it is intended to provide a contact plug intended to cooperate with a socket **23** having an inner diam-

eter equal to *l* (FIG. 20), I proceed as for making the sockets of FIGS. 1 to 17 with the difference that, instead of one or several constrictions such as **3**, **3***a*, **3***b* and **3***c*, I provide tube **2** with one or several portions of enlarged diameter such as the two portions **24***a* and **24***b* in the case of FIG. 18. I determine the whole in such manner that the external diameter *m* of the tube is smaller than said diameter *l* but that the external diameter *n* at the level of portions **24***a* and **24***b* is greater than this diameter *l*.

By means of two frusto-conical milling tools **25** and **26** (disposed approximately in the same manner as the respective tools **4** and **5** of FIG. 3). I cut tube **2** in such manner as to leave only two inclined strips **27** and **28** (analogous to strips **8** and **9** of FIGS. 3 and 4) connected on one side to a portion **11** (analogous to that designated by the same member on FIGS. 3 and 4) and on the other side through a blade portion **29**, with a ring element **30** serving to the centering of socket member **23**. In this manner, I obtain between said socket **23** and the plug member, three points of contact, to wit two on strips **27** and **28** (at the level of flaring portion **24***b*) and one on portion **29** (at the level of flaring portion **24***b*). Anyway, in every cross section, there remains only solid portions extending over less than 180° which permits free access of the electrolyte or other electrolytic or chemical protection bath.

In the preceding description it has been assumed that the initial tube is of circular cross section. Of course this cross section might have a different shape without modifying the principle of the invention, in particular the tube may have an oval shape (FIG. 21), an approximately triangular shape, (FIG. 22) or an approximately rectangular shape (FIG. 23).

The contact elements according to my invention include the following advantages:

(1) Longitudinal flexibility of the active portion of the contact element;

(2) Strength of the contact element;

(3) Safety, owing to the provision of at least two sure contact points (or areas), the number of these points being possibly increased without complicating the construction;

(4) Absence of any inner surfaces which cannot be reached for chemical or electrolytic protection;

(5) Easy construction permitting complete automatic fabrication and a reduction of the cost of manufacture.

In a general manner, while the above description discloses what are deemed to be practical and efficient embodiments of the invention, the present invention is not limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the invention as comprehended within the scope of the appended claims.

What I claim is:

1. In a miniature electrical connector having plug and socket contact elements, one of said elements being formed of integrally united elemental portions of a conducting sleeve and comprising a ring defining the end for cooperating with the other contact element, a pair of spaced strips shaped as opposing side wall portions respectively, of the sleeve and extending at corresponding ends thereof from a common junction with said ring generally along and obliquely with respect to the longitudinal axis of the sleeve, and a terminal strip extending parallel to said axis in alignment with a point on said ring peripherally spaced from the aforesaid junction, at least one of said strips having a projection extending transversely of said axis for wiping contact engagement with the other contact element, and both strips at their other corresponding ends having a common junction with said terminal strip.

2. In a miniature electrical connector of the plug and socket type, a socket element for receiving a pin-like plug contact, said socket element being formed of integrally united elemental portions of a conducting sleeve, comprising a ring defining the socket entrance for guiding the plug contact, a pair of spaced strips shaped as opposing side wall portions respectively, of the sleeve and extending at corresponding ends thereof from a common junction with said ring generally along and obliquely with respect to the longitudinal axis of the cylinder, and a terminal strip extending parallel to said axis in alignment with a point on said ring generally opposite the aforesaid junction, at least one of said strips having a projection extending inwardly toward said axis for wiping contact engagement with said plug contact, and both strips at their other corresponding ends having a common junction with said terminal strip.

3. In a miniature electrical connector of the plug and socket type, a socket element for receiving a pin-like plug contact, said socket element being formed of integrally united elemental portions of a conducting cylinder, comprising a ring defining the socket entrance for guiding the plug contact, a pair of spaced strips shaped as opposing side wall portions respectively, of the cylinder and extending at corresponding ends thereof from a common junction with said ring generally along and obliquely with respect to the longitudinal axis of the cylinder, the combined width of said strips at a transverse section representing less than 180° of the corresponding periphery of said cylinder, and a terminal strip extending parallel to said axis in alignment with a point on said ring generally opposite the aforesaid junction, each strip having a projection extending inwardly toward said axis for wiping contact engagement with said plug contact, and both strips at their other corresponding ends having a common junction with said terminal strip.

4. In a miniature electrical connector of the plug and socket type, a socket element for receiving a pin-like plug contact, said socket element comprising a ring defining the socket entrance for guiding the plug contact, a pair of bowed spaced strips diverging at corresponding ends thereof from a common junction with said ring generally along and obliquely with respect to the longitudinal axis of the ring so as to conform to the corresponding plug surface, and a terminal strip extending parallel to said axis in alignment with a point on said ring generally opposite the aforesaid junction, at least one of said strips being deformed to provide a projection extending inwardly toward said axis for wiping contact engagement with said plug contact, and both strips at their other corresponding ends converging to make a common junction with said terminal strip.

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JOSEPH D. SEERS, *Primary Examiner.*