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Feightner

[11] **3,924,921**

[45] **Dec. 9, 1975**

[54] **ELECTRICAL-PIN-AND-SOCKET CONNECTOR**

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[21] Appl. No.: **514,605**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 211,586, Dec. 23, 1971, abandoned, which is a continuation-in-part of Ser. No. 65,452, Aug. 20, 1970, abandoned.

[52] **U.S. Cl.** ..... **339/252 P;** 29/630 A; 29/630 D; 140/104; 339/210 R; 339/220 R

[51] **Int. Cl.²** **H01R 13/06**

[58] **Field of Search** ..... 339/17 C, 64, 192, 195, 339/196, 210, 217, 220, 221, 228, 252, 278; 29/622, 630; 113/119; 140/104

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[57] **ABSTRACT**

An electrical connector assembly designed to be produced in miniaturized form, and having a tubular socket member, a pin member comprising a main arm extending outwardly from a base, a U-shaped bend forming a nose that is laterally offset from the axis of the connector, and a secondary arm extending back from the nose to a free end. The arms are shaped to form longitudinally offset contact areas and to distribute flexure along the full length of the arms, and the bend has two legs that are pressed together to prevent flexing in the bend as the arms are pressed together during coupling. In one embodiment, the two connecting members are sheet metal stampings including integral crimping channels and pigtails on two alternative embodiments, the pin connectors are shaped from lengths of wire, one of partially altered circular cross-section and one of flatsided rectangular cross-section. A socket member formed by flat-sided wire is provided in the last embodiment.

36 Claims, 18 Drawing Figures

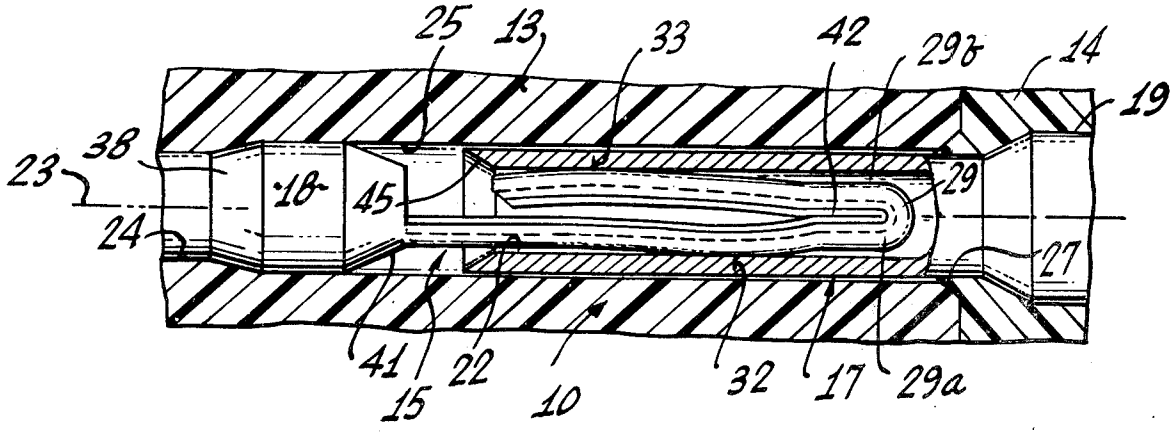


Fig. 1

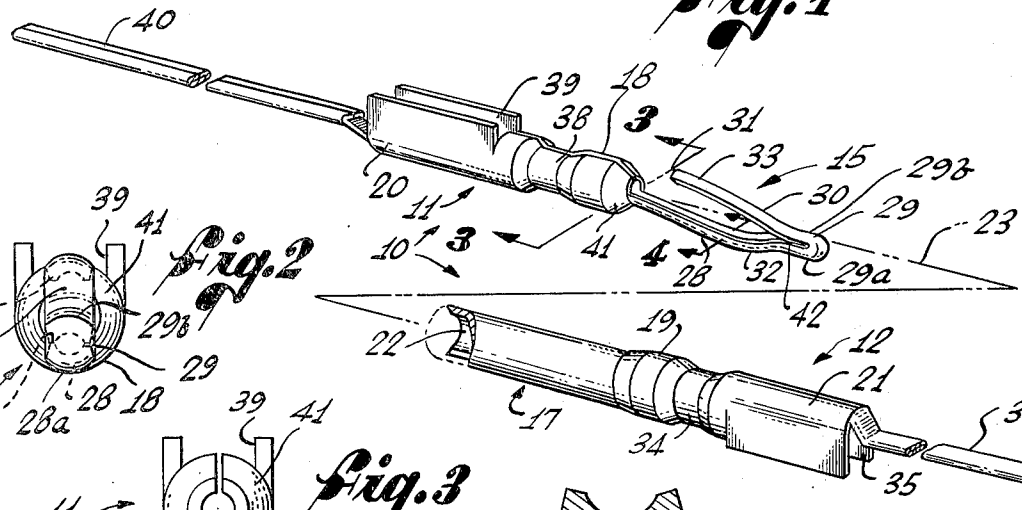


Fig. 2

Fig. 3

Fig. 4

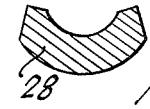


Fig. 5

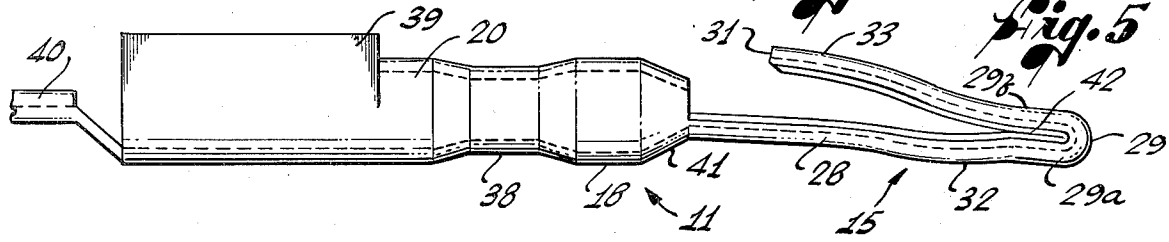


Fig. 6

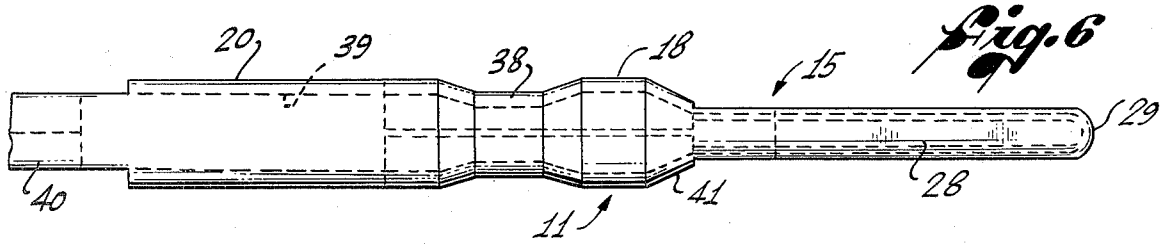


Fig. 7

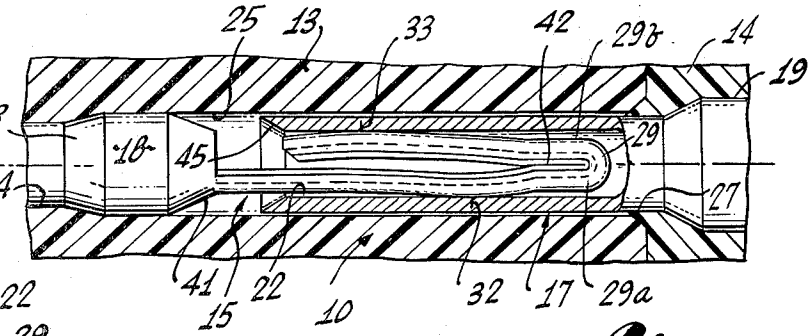


Fig. 8

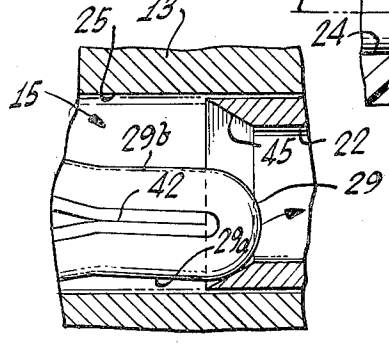


Fig. 9
Fig. 11
Fig. 12
Fig. 13
Fig. 14
Fig. 15
Fig. 10

Fig. 16

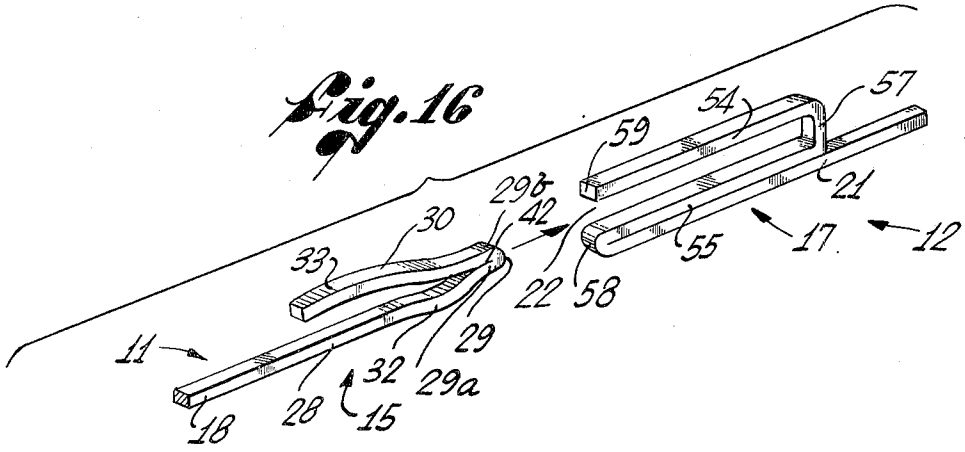
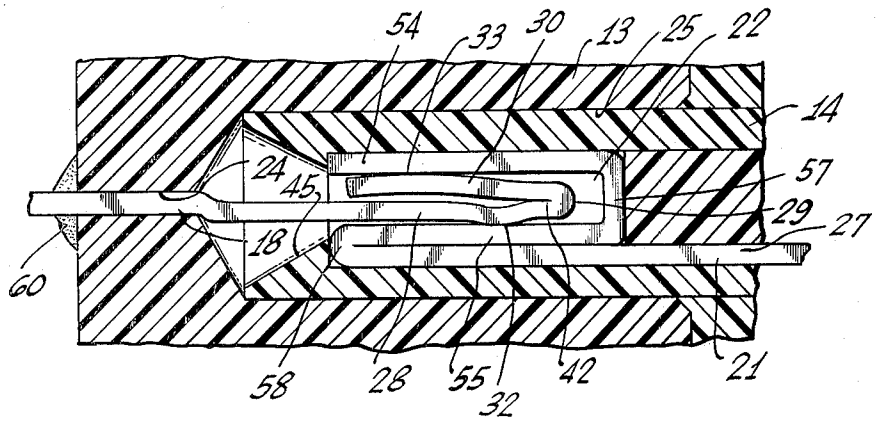


Fig. 17



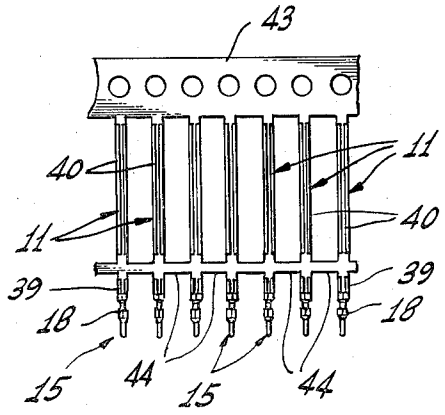


Fig. 18

ELECTRICAL-PIN-AND-SOCKET CONNECTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application Ser. No. 211,586, filed Dec. 23, 1971, now abandoned, which was a continuation-in-part of co-pending application Ser. No. 65,452, filed Aug. 20, 1970, now abandoned; both of these applications being entitled "Electrical Pin Fitting Assembly."

BACKGROUND OF THE INVENTION

This invention relates to electrical connectors of the pin-and-socket type, and has particular reference to electrical connectors that are designed to be produced in miniature form for incorporation in electrical connector assemblies. In such assemblies, one or more (typically more) pin connectors are mounted on a base to form a plug which is engageable with a receptacle having socket connectors for receiving pin-type contacts of the pin connectors as the plug and the receptacle are fitted together.

The uses for such connectors are many and varied, but areas of particular importance are the computer and aerospace industries, where miniaturization of solid-state components is in a highly developed state. There is an existing and growing need for corresponding miniaturized connectors, to keep pace with the development of electronics technology, and this need has not been fully satisfied.

Examples of presently known connectors that are designed for manufacture in small sizes are shown in U.S. Pat. Nos. 3,277,422 and 3,418,623. Both of these connectors are of the general type in which the present invention is an improvement, having metal pin contacts made from fine wire and mounted in insulated bodies to form the plugs, tubular metal socket contacts that are similarly mounted in insulated bodies to form the receptacles. There are connectors of other types for the same general purpose which use different approaches to the problems involved in providing improved miniaturized connectors.

The principal problem in this respect in the production of extremely small connectors which are reliable in operation and, at the same time, capable of being massproduced at low cost. Considering the very large numbers of connectors required for a single computer, the cost of fabricating and assembling the connectors is a significant factor in the cost of the computer. The importance of a high degree of reliability, of course, is self-evident.

As the size of the connector is reduced and the pin contact becomes smaller, finer, and more fragile, it becomes increasingly difficult to provide an economical configuration that will make, and maintain, a reliable conducting connection in a mating socket in a receptacle. This is particularly true of connectors that are subjected to vibration, in use, such as the vibration encountered in aircraft. Also, the reduced size of the pin contact makes it important to optimize the conducting cross-sectional area, and the area of surface contact between the pin contact and the socket member.

Accordingly, the primary objective of the present invention is to provide an improved electrical connector of the pin-and-socket type that may be made in smaller sizes than have been practical with conventional configurations, and which may be mass-produced at significantly lower cost in a form that remains effective for the intended purposes despite the fineness of the materials used for the pin contacts. It will be seen that a corollary aspect of the achievement of this primary objective is the provision of a connector design which will have corresponding advantages in cost and reliability when used for electrical connectors of larger sizes.

SUMMARY OF THE INVENTION

The present invention resides in an improved pin-and-socket connector that can be mass-produced economically in highly miniaturized form, using fine and delicate materials in a manner that takes optimum advantage of the resilience of the material of the pin contact to produce an effective and reliable connection.

For these purposes, the pin contact has a resiliently flexible main contact arm extending from a base portion at one end to a nose at the other end, and a second resiliently flexible arm extending from the nose back toward the base portion and terminating in a free end that is spaced from the main arm, the two arms being joined together by a tight and relatively inflexible bend forming the nose. The main arm is positioned to be deflected and stressed as an incident to insertion of the pin contact in a socket, and to be pressed tightly against one side of the socket in an area close to the nose, thereby distributing the flexure of the arm along substantially its full length. Similarly, the second arm is positioned to be deflected and stressed as an incident to such insertion, and to be pressed tightly against the opposite side of the socket, in an area that is adjacent the free end of the second arm, thereby distributing the flexure of the second arm along substantially its full length, and offsetting the two areas of engagement from each other, longitudinally of the connector.

With this arrangement, the two arms act as relatively long and opposed spring beams, each enhancing the contact pressure produced by the other. Optimum advantage is taken of the available length of each arm for flexing during insertion of the pin contact in the socket, and the longitudinal offset of the contact areas cancels resonant vibration and overcomes any tendency to bounce. The arms preferably are of different effective lengths so as to make it highly unlikely, even under adverse circumstances, that both could vibrate out of contact with the socket at the same time.

To insure that the arms flex along their lengths rather than hinging in the bend forming the nose, the legs of the bend are disposed in closely spaced, side-by-side relation, and preferably are pressed tightly against each other. The main arm is inclined away from the longitudinal axis of the pin contact to offset the contact area of the arm laterally in one direction from the axis, out of alignment with the socket. The nose is rounded for engagement with a beveled mouth of the socket, to be cammed toward the axis and to stress the main arm during insertion of the pin contact in the socket. At the same time, this camming of the nose toward the axis shifts the second arm away from the axis and presses it against the opposite side of the socket.

The first illustrative embodiment of the invention comprises pin-and-socket contacts that are sheet metal stampings, regarded as the most economical manner of manufacturing the connector. Both the pin contact and the socket contact may be provided with channel-shaped extensions for crimped connection to stranded wire conductors, and also may have integral so-called

"pigtails," usable as conducting connections. The pigtails of a series of connectors of each type can be left joined together by an integral band, as an incident to their manufacture, to facilitate handling prior to assembly in plugs and receptacles.

A second illustrative embodiment has a pin contact having a base portion composed of round wire, that is, wire of circular cross-section. The arms and the connecting bend are integrally joined to the base portion continuations of the round wire, but are modified in cross-sectional shape. The socket contact of this embodiment is a tubular sleeve.

The round wire preferably has an initial diameter of more than one-half the socket diameter, and both the arms of the pin contact, and the connecting bend, are partially flattened to be received in the socket. This increases the conducting cross-sectional area that is provided in the pin contact. In addition, the socket-engaging surfaces of the arms preferably are given the same curvature as the interior of the socket contact, for optimum area of contact.

A third embodiment illustrates the contact elements of the invention as fabricated from flat wire, that is, wire of rectangular cross-section. While flat wire is more expensive than round wire, it has manufacturing advantages for connectors in the smallest sizes. The pin contact has basically the same configuration when made from flat wire, except, of course, in its cross-sectional shape. A bend in the wire forms the rounded nose, as before.

The preferred socket contact for the flat-wire embodiment also is formed of flat wire, which is shaped to form an open U-shaped bend for receiving the pin contact. For this purpose, the wire is doubled back upon itself, to form one side of the socket, the bend forming a rounded end surface for camming engagement with the nose of the pin contact. The wire is bent to extend across the closed end of the socket, and then back, parallel to the first side, to form a second side of the socket. The remaining sides remain open until the contacts are mounted in insulating bodies.

Other aspects and advantages of the invention will become apparent from the detailed description, taken in conjunction with the accompanying drawings.

FIG. **1** is an exploded perspective view of a first embodiment of an electrical connector in accordance with the present invention, with parts broken away and shown in cross-section;

FIG. **2** is an enlarged end view of the pin connector of FIG. **1**;

FIG. **3** is an enlarged cross-sectional view taken along line **3—3** of FIG. **1**;

FIG. **4** is an enlarged cross-sectional view taken along line **4—4** of FIG. **1**;

FIG. **5** is an enlarged, fragmentary side elevation of the pin connector of FIG. **1**;

FIG. **6** is a bottom view of the pin connector in FIG. **5**;

FIG. **7** is a fragmentary cross-sectional view showing the contact portions of the connector of FIG. **1** in coupled relation, mounted in insulating bodies;

FIG. **8** is an enlarged partial view of parts shown in FIG. **7**, and showing these parts in positions that occur during coupling;

FIG. **9** is a view similar to FIG. **5** but showing a pin connector of a second embodiment of the invention;

FIG. **10** is a cross-sectional view taken along line **10—10** of FIG. **9**;

FIG. **11** is a bottom view of the pin connector of FIG. **9**;

FIG. **12** is a cross-sectional view, on a reduced scale, showing the pin connector of FIG. **9**, coupled with a socket connector of the second embodiment, both in insulating bodies;

FIG. **13** is an enlarged view of parts of FIG. **12**;

FIG. **14** is a cross-sectional view taken along line **14—14** of FIG. **13**, and showing parts of the pin connector alone;

FIG. **15** is a cross-sectional view taken along line **15—15** of FIG. **13**;

FIG. **16** is an exploded perspective view showing the pin-and-socket contacts of a third embodiment of the invention in uncoupled relation;

FIG. **17** is a cross-sectional view of the contacts of FIG. **16**, shown in coupled relation and mounted in illustrative insulating bodies; and

FIG. **18** is a side elevational view of a plurality of integrally connected pin contacts of the first embodiment, substantially enlarged from typical size.

DETAILED DESCRIPTION OF THE FIRST EMBODIMENT

As shown in the drawings (FIGS. **1** through **8** and **18**) for purposes of illustration, the invention is embodied in an electrical connector, indicated generally by the reference number **10** in FIGS. **1** and **7**, comprising a male connecting member **11** that is insertible in a female connecting member **12** to make an electrical circuit through the connector. Such connectors typically are mounted in insulating bodies **13** and **14** (see FIG. **7**) which form mating plugs and receptacles, typically having a plurality of parallel connectors **10** for a plurality of circuits, for example, between two printed circuit boards (not shown).

In general, each connecting member **11, 12** is an elongated, one-piece part comprising a contact portion **15, 17** at one end, an intermediate, body or base portion **18, 19** on which the contact portion is mounted, and a remote end portion **20, 21** for joining the connecting member to an associated conductor (not shown). The conductor typically leads to an electrical component that is served by the connector.

The contact portion **17** of the female member **12** defines a socket **22** open at one end, and the contact portion **15** of the male member **11** is a pin contact that is insertible into the socket **22** to engage the walls thereof. When the two members are coupled, as shown in FIG. **7**, they lie on common longitudinal axis **23**, which extends through the center of the socket. This axis is represented in offset relation in FIG. **1**, in which the members are shown uncoupled.

During the coupling operation, the connecting members **11** and **12** are generally aligned on this axis, in end-to-end relation with the pin contact **11** adjacent the socket contact **12**, and then are moved axially toward each other to insert the pin contact in the socket contact. The insulating bodies **13** and **14**, of which only parts are shown in FIG. **7**, guide the members together and limit the amount of insertion, generally as illustrated in FIG. **7**. The body **13** for the male member **11** has a passage **24** in which the base portion **18** is anchored, and a cavity **25** in which the pin contact **15** is disposed, and the body **14** has a similar passage **27** in which the intermediate portion **19** of the female member is anchored and through which the socket contact **17** extends. The socket contact typically

projects out of its body to telescope over the pin contact in the cavity **25.**

The present invention is concerned primarily with the configuration of the pin contact **15** of the improved connector **10,** this being the finest and most delicate portion of the connector which presents the greatest problems of manufacture in highly miniaturized sizes, and also being of critical importance in making and maintaining the electrical connection. The pin contact has a configuration that can be massed-produced in materials as fine as 0.003 of an inch thick, and perhaps even thinner, and still will provide an effective and reliable electrical connection.

In accordance with the invention, the pin contact **15** is a strip of resiliently flexible conducting material which is shaped to form an elongated main contact arm **28** extending from the base portion **18** toward the free end of the pin contact, a tight and relatively inflexible bend (indicated generally at **29**) forming a rounded nose at the free end of the pin contact, and a secondary arm **30** extending back from the bend **29** toward the base portion in spaced relation with the main arm and having a free end **31** spaced laterally from the main arm near the base portion. The main arm is inclined to diverge laterally away from the axis **23** as it extends toward the nose, and has a socket-engaging area at **32** near the nose. The nose is offset laterally from the axis on the same side as the main arm, and the secondary arm **30** diverges from the main arm as it extends back toward the base portion, and has a socket-engaging contact area at **33,** near its free end **31.** This contact area is spaced laterally from the contact area **32** of the main arm **28,** on the opposite side of the axis **23,** a distance substantially greater than the width of the socket, when the arms are free.

With the foregoing arrangement, the main arm **28** is flexed and stressed along substantially its full length as an incident to the insertion of the pin contact **15** into the socket contact **17,** by the accompanying movement of the nose **29** into generally coaxial relation with the socket **22,** and, at the same time, the secondary arm **30** also is flexed and stressed along substantially its full length. Thus, the two arms act as elongated spring beams, each tending to press the other tightly against the socket wall, to maintain conducting contact in longitudinally offset areas of the socket.

In the presently preferred embodiment of the invention, shown in FIGS. **1** through **8** and **18,** the two connecting members **11** and **12** are sheet-metal stampings, each formed as a single, integral piece of sheet metal, of substantially uniform thickness, for economical mass-production. The female member has a tubular contact portion **17** of circular cross-section, a tubular intermediate portion **19** which may include a section **34** (FIG. **1**) of reduced diameter, and a remote end portion comprising a channel **35** of U-shaped cross-section and an elongated strap-like extension **37** forming a so-called "pigtail." The channel **35** is open on one side to receive a multiple-stranded wire and be crimped around the wire, if this type of conductor is used. The pigtail **37** facilitates handling of the member, and can serve as a conducting lead for connection to other parts of the circuit.

Similarly, the preferred male member **11** has a tubular intermediate portion **18** optionally formed with a section **38** of reduced diameter, beyond which are a channel **39** and an extension **40** forming a pigtail, both of these being for the same purposes as the corresponding parts of the female member. It is to be understood, however, that the channels **35** and **39,** and the pigtails **37** and **40,** provide alternatively usable connections to other circuit elements, and neither of these, although advantageously provided as parts of the sheet-metal stampings, is essential to the invention.

For optimum engagement between the arms **28** and **30** and the curved wall of the socket **22,** the outer, socketengaging sides of the arms (that is, the sides that are remote from each other) are convexly curved in transverse cross-section to conform to the curvature of the socket wall, at least in the contact areas **32** and **33.** As a matter of manufacturing convenience, and for greater stiffness, the entire pin contact **15** has this transverse curvature, which is shown most clearly in FIGS. **2, 3** and **4.** When the pin contact is stamped from sheet stock which is shaped to provide the outer convex curvature, the inner, adjacent sides of the arms are concavely curved in transverse cross-section.

It will be seen in FIG. **5** that the main arm **28** is integrally connected to a tapered end portion **41** of the intermediate section **18,** where the inner side of the arm is close to the axis **23,** and then diverges from the axis, preferably at a slightly increasing rate, as it extends away from the base portion and toward the free end of the pin contact **15.** In the free end portion of the arm **28,** approaching the bend **29,** the outer side of the arm has a convexly curved portion which forms the contact area **32** also forms a slight shoulder leading to the bend **29.** Thus, the arm is bowed along its length.

The bend **29** has two short, side-by-side legs 29^a and 29^b that are integrally joined to the arms **28** and **30,** these legs preferably being pressed tightly against each other at **42** to prevent flexing of the legs toward each other as the arms are pressed together and stressed. This insures that the stress is distributed along the arms, and protects against fatigue failure in the nose.

From the leg 29^b, the secondary arm **30** is inclined across the axis **23** (upwardly in FIG. **5**) as it extends back toward the base portion **18.** The free end portion of this arm preferably has a slight convex curvature on its outer side to form the contact area **33.**

In the manufacturing process, the male member **11** can be stamped out as an elongated strip, and shaped to provide the desired transverse cross-section and also to give the arms **28** and **30** the desired longitudinal configuration. Then the stamping can be bent back upon itself at the appropriate place to form the nose. Preferably, the legs 29^a and 29^b of the bend **29** are pressed together after this bending operation to provide the desired tight contact and final nose thickness. Work-hardening of the metal by this fabricating process, particularly in the nose, advantageously increases its strength.

The female member **12** is formed in a similar manner, by stamping processes, using basically conventional manufacturing techniques. Nothing more than the foregoing general description will be required by those skilled in the art to understand the manufacturing techniques that may be used.

Shown in FIG. **18** is a fragmentary view of a series of male members **11,** which are integrally joined together at their pigtails **40** by a band or strap **43** of metal that is left in place during the fabricating process. These members also are joined together, adjacent their intermediate portions, by narrow integral strips **44,** also left in place during the fabricating process. Joined in this manner, a plurality of the members can be more easily handled, and are braced against accidental bending

during such handling. When they are to be used, however, they can be easily separated from the band and the strips, and from each other.

It will be seen in FIGS. **1, 5** and **8** that the nose **29** of the pin contact **15** is offset from the axis **23,** downwardly as viewed in the drawings, to a position substantially inline with the outer periphery of the intermediate portion **18.** This positions the nose and the contact area **32** adjacent the sidewall of the cavity **25** in the insulating body **13** when the parts are uncoupled. In fact, the offset preferably is sufficient so that the pin contact is pressed against the sidewall of the cavity, in lightly pre-stressed condition, before coupling.

Similarly, the contact area **33** of the secondary arm **30** is spaced laterally from the contact area **32** of the main arm **28** a distance greater than the width of the socket **22,** and preferably is pressed against the opposite sidewall of the cavity **25,** in lightly pre-stressed condition, before coupling. As can be seen in FIG. **7,** the intermediate portion **18** has the same outside diameter as the inside diameter of the cavity **25.** The secondary arm **30,** when free (FIGS. **1** and **5**), preferably extends laterally slightly beyond the outside diameter of the enlargement.

As shown in FIGS. **7** and **8,** the open, entry end of the socket contact **17** is defined by an internal bevel **45** which cooperates with the rounded nose **29** of the pin contact **15** to cam the nose toward alignment with the axis **23** as the two members are telescoped into coupled relation. The beveled circular end of the socket contact slides along the sidewall of the cavity **25** and lifts the nose away from the sidewall (see FIG. **8**) for entry into the socket **22.** At the same time, the opposite side of the beveled end cams the free end portion of the secondary arm **30** away from the sidewall of the cavity, so that the two arms are squeezed together and stressed during coupling.

In the assembled condition of the connector **10,** shown in FIG. **7,** the pin contact **15** is substantially coaxial with the socket contact **17,** with the main arm extending out through the open end of the socket to the tapered end **41,** which is spaced from the socket member. The nose **29** is substantially centered in the socket, and the arms **28** and **30** have been squeezed together and stressed to maintain good contact pressure.

It will be noted that the configuration of the pin contact **15** is such that the initial engagement with the socket contact **17** is made by a part other than the operating contact areas **32** and **33.** Thus, if a burn accidentally occurs, the burned area is not the operating contact area. Also, the offset of the pin contact, when free, insures that conducting contact is made, and maintained, with a minimum amount of insertion, thereby assuring conducting contact with a maximum amount of accidental separation.

DETAILED DESCRIPTION OF THE SECOND EMBODIMENT

Shown in FIGS. **9** through **15** is a second embodiment of the invention in which parts corresponding to those of the first embodiment are indicated by corresponding reference numbers. In this embodiment, the male member **11** comprises a length of round metal wire that is bent and shaped in accordance with the present invention, and the female member **12** (FIG. **12**) is a metal sleeve that is similar in functional shape to the tubular portion of the stamped female member of the first embodiment.

More specifically, the male member **11** of this embodiment has a base portion **18** that is a length of round wire, a main arm **28** that is an integral continuation of the base portion, a U-shaped bend **29** forming a nose and two short legs **29^a** and **29^b** at the end of the connector, and a secondary arm **30** extending back toward the base portion and terminating at a free end **31.** All of these parts are formed integrally, in one piece, using initially round wire, but the arms and the bend are of altered cross-sectional shape.

As shown most clearly in FIGS. **10** and **11,** the initially circular cross-section of the wire is partially flattened along the arms **28** and **30,** so that the outer side **47** (see FIG. **10**) has a transverse curvature with a larger radius than that of the base portion **18,** thereby increasing the width, as best seen in FIG. **11.** The curvature of the outer side is made the same as that of the sidewall of the socket **22,** for optimum surface engagement in the contact area **32.** The inner side **48** of the arm may be straight in transverse cross-section, as shown in FIG. **10.**

In the nose area, the two legs **29^a** and **29^b** of the bend **29** are pressed together, as shown at **42** in FIG. **14.** In all other significant respects, the pin contact of this embodiment may be the same as the pin contact of the first embodiment, including the work-hardening of the bend **29** for increased strength.

The female member **12** (FIG. **12**) is a sleeve defining the socket **22** and has a beveled open end **45,** as before. The opposite end is closed, and has a coaxial extension **21** that is formed with a bore **50** for receiving the end of a connecting wire **51.**

The initial diameter of the round wire used for the pin contact **11** probably has a diameter that is more than one-half the diameter of the socket **22.** Accordingly, the double-thickness of wire adjacent the U-shaped bend **29** not fit into the socket without the modification of the cross-sectional shape described above. By using wire larger than one-half the socket diameter, the invention increases the amount of conducting metal in the pin contact **11,** and thereby optimizes the conducting capabilities of the connector.

Portions of the insulating bodies **13** and **14** are shown in FIGS. **12** and **13,** and are similar to those in the first embodiment. The base portion **18** of the male member **11,** however, extends out of the body **13** through a passage **24** and a suitable anchor **52,** such as a mass of epoxy. The connecting wire **51** of the female member **12** extends through a similar anchor **53** and out of the body **14.** The members may be anchored in the bodies in various ways, the epoxy anchors **52** and **53** being illustrative only.

The initially offset relationship of the nose **29** and the socket **22** is the same as in the first embodiment, to provide the same coaction between the nose and the bevel **45** during coupling. Thus, the primary difference in this embodiment is the use of round wire as the starting material, rather than sheet material, and the shaping of this wire in accordance with the invention. The techniques used in such shaping are matters that are well within the skill of the art, and need not be detailed herein.

DETAILED DESCRIPTION OF THE THIRD EMBODIMENT

Shown in FIGS. **18** and **19** is a third embodiment in which flat wire is used as the starting material, and is bent to form the contacts of the connector. Although

flat wire presently is less readily available than round wire, and more expensive, fabrication with such wire has advantages, particularly in smaller sizes of connectors.

As shown in FIGS. 18 and 19, in which parts corresponding to parts in the first embodiment are identified by the same reference numbers, the pin contact 15 has a base portion 18 which is a length of flat wire, main and secondary arms 28 and 30 of the same cross-sectional shape but longitudinally curved in substantially the same manner as in the other embodiments. The arms are connected by a U-shaped bend 29, also of the same cross-sectional shape, having legs 29^a and 29^b that are pressed together at 42. At the free end of the pin contact, the bend 29 forms a rounded nose.

While this flat-wire pin contact may be used with different types of sockets, the preferred socket contact 17 of this embodiment also is formed by a length of flat wire. This wire has an elongated straight section 21 which constitutes a connecting section, and an open U-shaped bend defining a socket 22. This bend has two elongated, straight and parallel legs 54 and 55 forming two sides of the socket, and a short crosspiece 57 integrally joined to the two legs and forming a closed end of the socket.

The leg 55 lies against the connecting section 21 and is joined thereto by a tight bend 58 which lies opposite the free end 59 of the leg 54 to cooperate with the latter in defining the open end of the socket 22. Thus, the socket contact 17 has an open end and two open sides, as it initially is formed. The space between the legs 54 and 55 preferably is about two and one-half times the thickness of the wire of the pin contact 11.

The pin contact 11 is mounted in an insulating body 13 having a cavity 25 in which the contact is positioned, with the base portion 18 extending out through a passage 24 in the body and suitably anchored in place at 60. The socket contact 12 is mounted in an insulating body 14 which closes the open sides of the socket 22 and fits into the cavity 25, the body 14 having a beveled open end 45 for camming the nose 29 into alignment with the socket. The connecting section 21 of the socket wire extends out through a passage 27 and is suitably anchored in place at 51. During insertion of the pin contact in the socket contact, the bend 58 serves as an extension of the bevel 45 to complete the camming of the nose 29 into alignment with the socket.

SUMMARY AND CONCLUSION

From the foregoing, it should be apparent that the present invention provides electrical connectors which may be mass-produced economicaly in highly miniaturized form, and which, at the same time, have special design features which provide optimum functional effectiveness in such miniaturized form. It has been found that connectors in accordance with the invention can be made from relatively inexpensive soft copper, instead of the more expensive Beryllium copper commonly used for miniature connectors. Soft copper has much lower resistance and higher conductivity, for better performance, and its use is made practical by the special design features of the present invention.

It also will be apparent that, while three specific embodiments have been illustrated and described, various modifications and changes may be made without departing from the spirit and scope of the invention.

I claim:

1. For use in an electrical connector assembly, a pin connector composed of electrically conductive sheet metal of substantially uniform thickness, and extending generally along a preselected longitudinal axis, comprising:

an elongated, tubular sheet metal body forming a base portion of said connector and extending along said axis, said body having means adjacent one end thereof for connection to an electrical conductor;

and an elongated sheet metal pin contact integrally connected to the other end of said body, and including:

a first resiliently flexible contact arm joined to said one end of said body and extending away from the latter toward the opposite end of said pin contact, said first arm having a laterally facing outer side of convex curvature in transverse cross-section, and extending along one side of said axis to a first contact area closer to said opposite end than to said body, said first arm being inclined away from said axis toward said first contact area, and then extending back toward the axis,

a generally U-shaped, reverse bend joined to the end of said first arm beyond said first contact area, and having two legs disposed in side-by-side relation and joined together by a rounded nose, said nose being offset from said axis on the same side thereof as said first arm, one of said legs being integrally joined to said first arm,

and a second resiliently flexible contact arm integrally connected to the other of said legs and extending from the latter back toward said body, in laterally spaced relation with said first leg, and terminating in a free end adjacent said body but spaced therefrom,

said second contact arm having an outer side facing laterally away from said first arm and of convex curvature in transverse cross-section, and being inclined from said second leg away from said first arm and across said axis to a second contact area that is closer to said free end than to said opposite end, whereby said contact areas are longitudinally offset along said pin contact, and both of said arms flex along substantial lengths thereof.

2. A pin connector as defined in claim 1 in which said legs of said U-shaped bend are pressed tightly together.

3. A pin connector as defined in claim 1 in which said first arm is inclined away from said axis at an increasing rate toward said first contact area, and then curves back toward said axis to form a shoulder between said first contact area and said first leg.

4. A pin connector as defined in claim 1 in which said second leg has a longitudinal convex curvature in said second contact area.

5. A pin connector as defined in claim 1 in which said means on said body for connection to a conductor includes an elongated, open-sided crimping channel for receiving a multiple-stranded conductor, said channel being integrally formed of said sheet metal as an extension of said body.

6. A pin connector as defined in claim 5 further including an elongated pigtail integral with said channel and projecting therefrom away from said body.

7. A pin connector as defined in claim 1 in combination with a socket connector composed of electrically conductive sheet metal and extending generally along said axis, and comprising:

a tubular sheet metal sleeve open at one end to receive said pin contact and defining an elongated socket that is smaller in diameter than the lateral spacing of said contact areas,

said open end having means thereon for camming said nose toward said axis as said connectors are coupled together, thereby to stress said first arm,

and means on said socket connector for connection to an electrical conductor.

8. The combination defined in claim **7** in which said means on said open end comprises an internal bevel.

9. The combination defined in claim **7** in which said means on said socket connector includes a second elongated, open-sided crimping channel for receiving a multiple-stranded conductor, said second channel being integrally formed of said sheet metal as an extension of said sleeve.

10. The combination defined in claim **9** further including an elongated pigtail integral with said second channel and projecting therefrom away from said sleeve.

11. For use in an electrical connector assembly, a pin connector formed by a length of resiliently flexible, electrically conductive material and extending generally along a preselected longitudinal axis, and comprising:

a base end portion lying on said axis and constituting one end portion of the pin connector;

a first resiliently flexible contact arm joined to said base end portion and extending from the latter toward the opposite end of the pin connector, said first contact arm extending along one side of said axis and being inclined away from the axis to a first contact area closer to said opposite end then to said base portion, and then extending back toward the axis;

a generally U-shaped, reverse bend joined to the end of said first arm opposite said base portion, said bend comprising first and second legs in contacting side-by-side relation that are inclined toward said one side relative to said axis, and are joined together by a rounded nose that is offset to said one side relative to said axis;

said first leg being a longitudinal and relatively straight continuation of said first contact arm, and said second leg extending back along said first leg from said nose toward said base end portion;

and a second resiliently flexible contact arm joined to said second leg as a continuation thereof, and extending from said second leg back toward said base end portion, in spaced relation with said first contact arm, and terminating in a free end adjacent said base end portion but spaced therefrom;

said second contact arm being inclined from said second leg away from said axis and from said first contact arm to a second contact area closer to said free end than to said opposite end, whereby said contact areas are longitudinally offset along said pin connector, and both of said contact arms flex along substantial lengths thereof.

12. A pin connector as defined in claim **11** in which said first contact arm is bowed away from said axis and back, to form a longitudinally convex outer side.

13. A pin connector as defined in claim **12** in which said second contact arm is bowed, at least in the free end portion thereof, to form a longitudinally convex outer side.

14. A pin connector as defined in claim **11** in which said pin connector is a length of metal wire of initially circular corss-section having a preselected diameter, said base end portion having the selected initial cross-sectional shape, and said U-shaped bend having partially flattened opposite sides and a combined thickness substantially less than twice said preselected diameter.

15. A pin connector as defined in claim **14** in which said contact arms have adjacent sides that are flattened, and have outer sides with a curvature on a larger diameter than the diameter of said base end portion.

16. A pin connector as defined in claim **11** in which said contact arms and said reverse bend comprise sections of metal wire of substantially square cross-section.

17. For use in an electrical connector assembly, a pin connector formed by a length of resiliently flexible, electrically conductive material and extending generally along a preselected longitudinal axis, said pin connector comprising:

a base end portion lying on said axis;

a first contact arm joined to said base end portion and extending from the latter toward the opposite end of the connector, said first contact arm having an outer longitudinal side that diverges laterally from said axis toward said opposite end, to a first contact area of maximum lateral spacing from the axis adjacent, but spaced from, said opposite end;

a generally U-shaped, tight reverse bend at the end of said first contact arm opposite said base portion forming a nose on said pin connector at said opposite end, said first contact arm being joined to one side of said bend;

and a second contact arm joined to the other side of said bend, and extending back toward said base portion, said second contact arm having a free end adjacent said base portion and an outer longitudinal side that diverges laterally relative to said axis toward said free end, on the side of said axis opposite said first contact arm, to a second contact area of maximum lateral spacing from the axis adjacent said free end;

said U-shaped bend having two legs that are substantially straight and disposed in side-by-side contacting relation, and being offset relative to said axis to the same side thereof as said first contact arm.

18. A pin connector as defined in claim **17** in which said pin connector is composed of wire of initially circular cross-section and having a preselected diameter, said base portion being of said circular cross-section and said preselected diameter, and the legs of said bend being flattened against each other to a combined thickness substantially less than twice said diameter, each of said contact arms at said areas of maximum lateral spacing being spaced from said axis distances that are substantially greater than twice said preselected diameter.

19. A pin connector as defined in claim **18** in which said contact arms, in at least said areas of maximum lateral spacing, have outer sides with curvatures on a larger diameter than said preselected diameter.

20. In an electrical connector assembly, the combination of:

a socket member defining a socket having an open end and laterally spaced sidewalls of electrically conductive material extending from said open end along said socket, said socket having a first longitu-

dinal axis extending through said open end and disposed midway between said sidewalls;

and a pin connector insertible in said socket in conducting engagement with said sidewalls and having a second longitudinal axis that is aligned with said first axis when said pin connector is inserted in said socket member, said pin connector comprising a length of resiliently flexible, electrically conductive material and having:

a base portion lying generally on said second axis and forming one end portion of the pin connector,

a first contact arm joined to said base portion and extending from the latter along said second axis toward the opposite end of said pin connector, said first contact arm having an outer longitudinal side that diverges laterally from said second axis to a contact area of maximum lateral spacing adjacent, but spaced from, said opposite end, for engagement with a sidewall of said socket,

a generally U-shaped, tight reverse bend joined to the end of said first contact arm remote from said base portion and forming a nose on said pin connector at said opposite end, narrower than the spacing of said sidewalls for entry into said socket, said first contact arm being joined to one side of said bend,

and a second contact arm joined to the other side of said bend and extending back toward said base portion, said second contact arm having a free end adjacent said base portion, an outer longitudinal side that diverges laterally from said second axis toward said free end on the side of said axis opposite said first contact arm, to a contact area of maximum lateral spacing from the second axis adjacent said free end for engagement with the opposite sidewall of said socket;

said contact area on said second contact arm being spaced longitudinally of said pin connector farther from said nose than is the contact area of said first contact arm, and the lateral spacing between said contact areas being substantially greater than the spacing of said sidewalls, whereby both of said contact arms are stressed, and flexed longitudinally upon entering said socket;

said U-shaped bend having two legs that are disposed in closely spaced relation to prevent any substantial flexing in said bend as said pin connector is inserted in said socket member.

21. An electrical connector assembly as defined in claim **20** in which said nose is offset laterally relative to said second axis, toward the same side as said first contact arm and out of alignment with said socket when said axes are aligned, and said socket has means thereon for camming said nose toward said second axis as the nose is inserted in the socket, whereby the first arm is initially stressed upon movement of said nose into the socket.

22. An electrical connector assembly as defined in claim **21** in which said pin connector is mounted in a non-conducting connector body having a cavity in which said contact arms are disposed, and said socket member is shaped for coaxial insertion into said cavity around the pin connector, said pin connector being offset laterally within said cavity to dispose said nose adjacent one side thereof.

23. An electrical connector assembly as defined in claim **22** in which said socket is circular in cross-section and has a first preselected diameter, and said pin connector is composed of metal wire of circular cross-section in said base section, said circular cross-section having a second diameter larger than one-half said first diameter, said U-shaped bend having substantially straight legs joined by a rounded section forming said nose, and said legs being composed of the same wire and flattened against each other to a non-circular cross-section having a combined thickness substantially less than said first diameter.

24. An electrical connector assembly as defined in claim **20** in which said contact arms and said bend are composed of flat-sided metal wire, and said socket has flat sidewalls engageable with said wire.

25. An electrical connector assembly as defined in claim **24** in which said socket member comprises an insulating socket body with a cavity therein, and a second length of flat-sided wire defining an open, generally U-shaped bend with two spaced legs forming said flat sidewalls.

26. An electrical connector assembly as defined in claim **25** in which said second length of wire is bent back along one of said legs of said open U-shaped bend, and extends out of said socket body.

27. In an electrical connector assembly, the combination of:

a socket member defining a socket having an open end, and laterally spaced sidewalls of electrically conductive material along opposite sides of a central longitudinal axis of the socket;

and a pin connector coupled to said socket member, and comprising:

a base end portion adjacent said open end,

a first resiliently flexible contact arm within the socket and engaging the sidewall on one side of said axis in an area adjacent the inner end of said pin connector,

a tight U-shaped bend forming a nose on the inner end of said pin connector,

and a second resiliently flexible contact arm extending back outwardly from said bend toward said open end, and having a free outer end within said socket, said second contact arm engaging the sidewall of the socket on the other side of said axis at an area adjacent said free outer end, said areas of engagement being offset from each other longitudinally of said socket, and said contact arms being flexed and stressed over substantial portions of their full lengths, said first contact arm from said base end portion inwardly to its contact area, and said second contact arm from said bend back to its contact area;

said nose being offset laterally toward the same side of said axis as said first arm and out of alignment with said socket when said pin connector is outside the socket, said contact areas being spaced apart laterally of said socket a distance greater than the latter spacing of said sidewalls when said pin connector is outside said socket, and said socket member having means at said open end for camming said nose into alignment with said socket and flexing said first contact arm during insertion of said pin connector in said socket member.

28. The combination defined in claim **27** in which said pin connector is composed of sheet metal of substantially uniform thickness, and said arms have oppositely facing outside surfaces that are convexly curved in transverse cross-section, and adjacent inside surfaces that are concave in transverse cross-section.

29. The combination defined in claim **28** in which said base portion is a tubular sheet metal body to which said first arm is integrally joined, and in which said body has an integral, open-sided sheet metal crimping channel on the end thereof opposite said first arm.

30. The combination defined in claim **29** further including an elongated pigtail integrally joined to said channel and extending therefrom away from said body.

31. The combination defined in claim **29** in which said body has a tapered end to which said first arm is joined, adjacent said axis.

32. The combination defined in claim **29** in which said socket member is composed of sheet metal of substantially uniform thickness, and comprises an elongated tubular sleeve defining the socket, and a second integral opensided, sheet metal crimping channel on the end of said sleeve opposite said open end.

33. The combination defined in claim **32** further including a second elongated pigtail integrally joined to said second channel and extending therefrom away from said sleeve.

34. The combination defined in claim **27** in which said socket is of a first preselected diameter,

said pin connector is composed of wire of initially circular cross-section and having a second preselected diameter more than twice said first diameter,

said base end portion is a length of said wire of circular cross-section having said second diameter,

said arms are of altered cross-section with curvatures in said contact areas matching the curvature of said socket;

and said wire is flattened adjacent said nose to a thickness less than said first diameter.

35. The combination defined in claim **27** in which said pin connector is composed of flat wire that is bent longitudinally to form the elements of said pin connector.

36. The combination defined in claim **35** in which said socket member is a length of flat wire that is shaped to form an open U-shaped bend with spaced parallel legs joined by a crosspiece, said parallel legs forming the sidewalls of said socket, and one of said legs being joined integrally to a section of the wire constituting a connecting section.

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