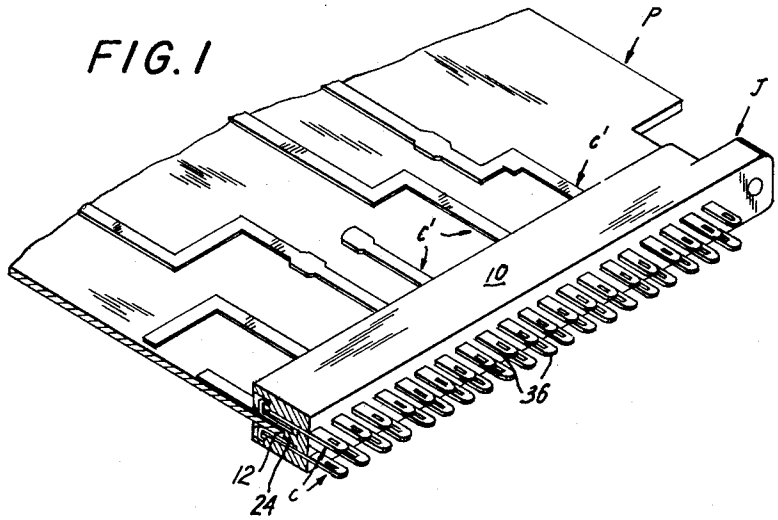
Feb. 11, 1964 L. GILBERT 3,120,988

BELLOWS-TYPE CONTACT CONSTRUCTION

Filed May 25, 1962 3 Sheets-Sheet 1

FIG. 1



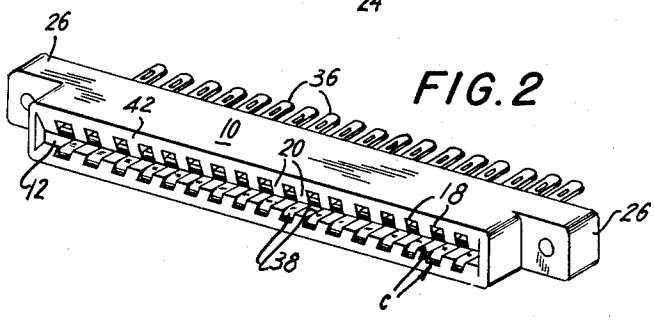


FIG. 2

FIG. 3

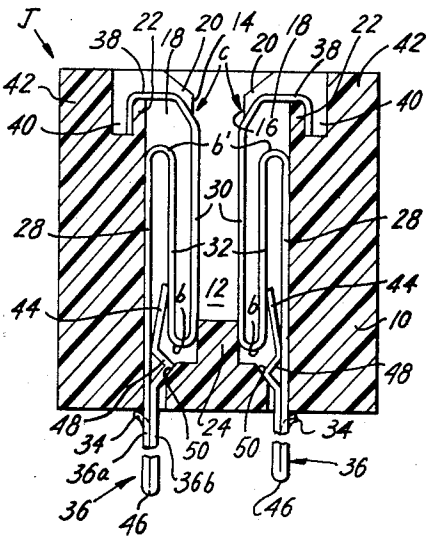
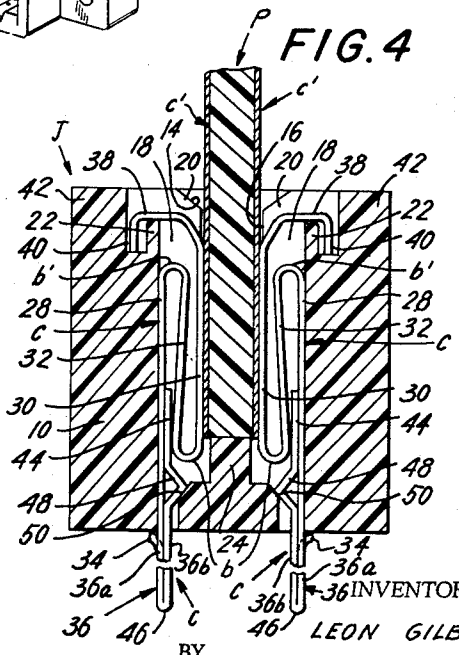


FIG. 4



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BELLOWS-TYPE CONTACT CONSTRUCTION

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FIG. 5

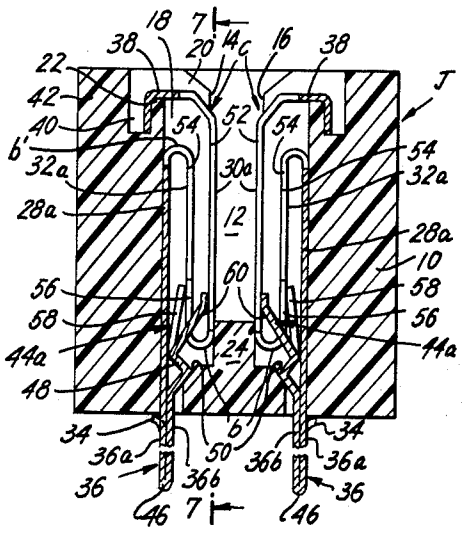
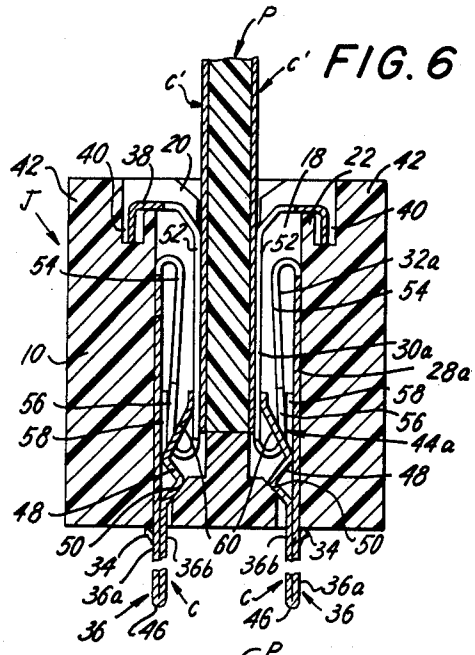


FIG. 6



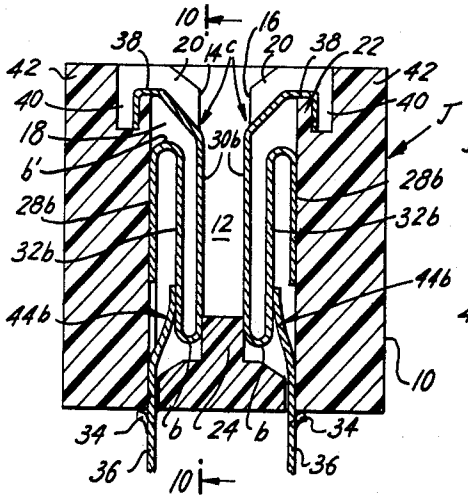


FIG. 8

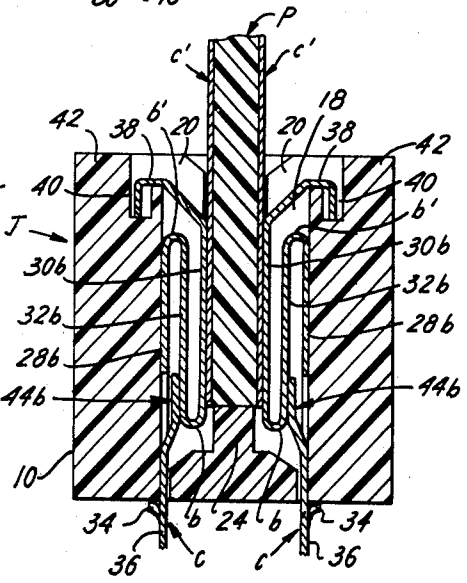


FIG. 9

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BELLOWS-TYPE CONTACT CONSTRUCTION

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FIG. 7

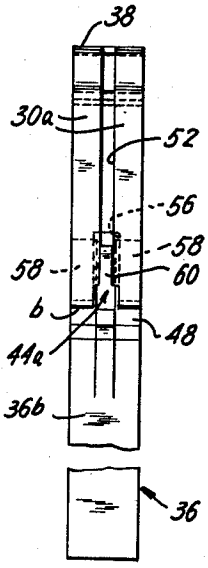


FIG. 10

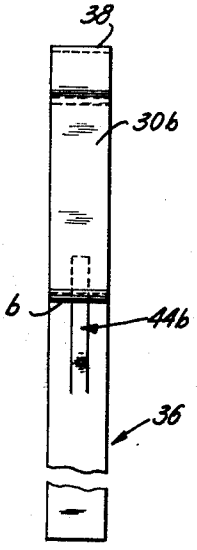
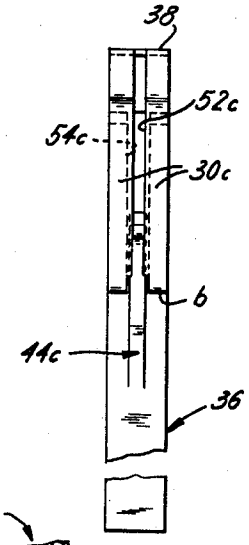


FIG. 13



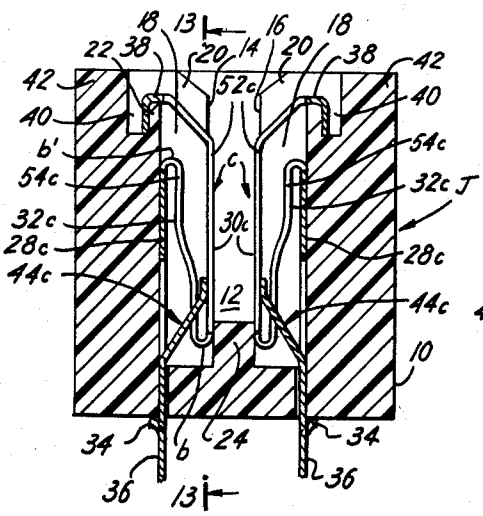


FIG. 11

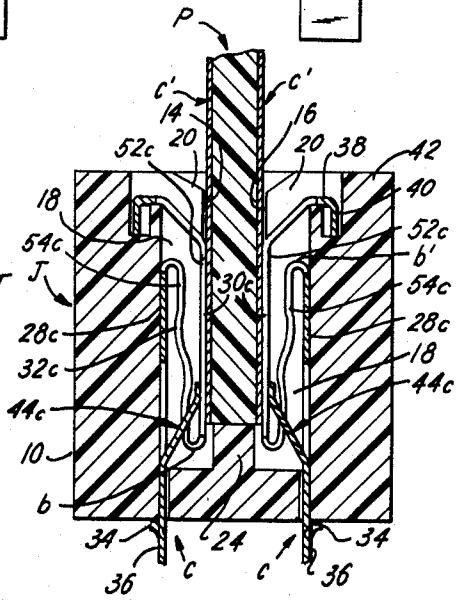


FIG. 12

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United States Patent Office 3,120,988 Patented Feb. 11, 1964

3,120,988

BELLOWS-TYPE CONTACT CONSTRUCTION

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Filed May 25, 1962, Ser. No. 197,743
6 Claims. (Cl. 339—176)

The present invention relates to a bellows-type contact construction, and more particularly one which minimizes resistance and inductance effects arising within the contact structure.

My Patent 2,875,425 of February 24, 1959, entitled "Multiple Electrical Connector," is assigned to the assignee of the instant patent. It discloses a multiple electrical connector, particularly of the miniature type, which comprises a jack or receptacle designed to receive printed circuit cards or plugs. The receptacle is provided with multiple miniature contact elements which engage with mating terminal portions on the printed circuit card or plug when the latter is inserted into the receptacle. The aforementioned Patent 2,875,425 featured miniature contact elements in the receptacle which were made of strip spring stock, and were constructed to act as compression springs, and more particularly bellows-type compression springs. The bellows-shaped part of those contact elements was formed of a plurality of branches or sections, the outermost of which was adapted to make contact with the circuit element or contact of the printed circuit card or plug, that outermost section or branch being electrically connected to the terminal portion of the contact by means of an intermediate branch or section and an inner branch or section, those two sections being serially electrically connected between the outermost or contact section and the terminal portion.

This bellows-type construction has proved to be highly satisfactory, and has been adopted quite widely. One of the fields in which it has proved to be most advantageous is in connection with electronic computers, where different printed circuit cards are adapted to be used depending upon the particular type of computation desired. In applications of this type the signals are often very weak, or function at a high frequency, or both. With weak signals voltage drop is to be avoided, since any such voltage drop results in undesired attenuation of the signal. This voltage drop can arise either by virtue of the contact resistance at the interface between the bellows contact and the terminal portion on the printed circuit card, or by virtue of ohmic losses as the signal passes along the contact unit itself from the outermost branch or section to the terminal portion thereof. The current path in the contact also gives rise to undesirable inductive effects, particularly when, as is the case in the bellows-type contact, that current path is tortuous. These inductive effects become more and more troublesome as the effective frequency of the signal increases.

It is the prime object of the present invention to devise a bellows-type contact arrangement which has all of the advantages of the devices disclosed in my Patent 2,875,-425, and which has the further advantages that voltage drop and inductance effects are greatly minimized when compared with the construction shown in that patent.

This objective is achieved by retaining the basic bellows-shape and bellows-action of the contact units, while at the same time reducing the length and tortuosity of the electrical path which the signal must travel through the contact. The structure employed to accomplish this result has the added advantage of increasing the firmness and reliability of the engagement between the outermost branch or section of the contact unit and the mating conductive portion of the printed circuit card or plug inserted into the receptacle in which the contact units are mounted.

More specifically, the terminal portion of the contact is provided with a conductive element which resiliently engages either the outermost branch of the contact unit or the intermediate branch thereof, preferably adjacent the lower end of the engaged branch, thereby defining a direct conductive path between the terminal portion of the contact and the outer branch thereof, through which path the signal can flow. This in effect electrically short circuits the innermost and intermediate branches or sections of the contact assembly, those sections still functioning, however, to provide the desired bellows-action. The resilient force exerted by the newly added conductive element acts on the outermost branch or section of the contact to urge it to firm and reliable connection, both physical and electrical, with the mating terminal portions on the printed circuit card or plug.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to the construction of the bellows-type contact and the multiple electrical connector in which it is employed, as defined in the appended claims and as described in this specification, taken together with the accompanying drawings, in which:

FIG. 1 is a three-quarter perspective view of a multiple electrical connector made according to the present invention and shown in combination with a printed circuit plug assembly, with parts shown in cross-section;

FIG. 2 is a front perspective view of the multiple electrical connector with the contact units in place;

FIG. 3 is a view shown to an enlarged scale corresponding to the cross sectional part of FIG. 1 of the drawings, but with the printed circuit plug assembly removed, and illustrating one embodiment of the contact construction of the present invention;

FIG. 4 is a view similar to FIG. 3, but showing a typical printed circuit plug assembly in position;

FIG. 5 is a view similar to FIG. 3, but illustrating a second contact construction;

FIG. 6 is a view similar to FIG. 5, but with the printed circuit plug assembly in place;

FIG. 7 is a front elevational view of the contact unit of FIG. 5, taken in the direction of the line 7—7 of FIG. 5;

FIG. 8 is a view similar to FIG. 5 but showing a third embodiment of the contact construction;

FIG. 9 is a view similar to FIG. 8, but with the printed circuit plug assembly in place;

FIG. 10 is a front elevational view of the contact unit of FIG. 8, taken in the direction of the line 10—10 in FIG. 8;

FIG. 11 is a view similar to FIG. 5 but showing a fourth embodiment of the spring unit;

FIG. 12 is a view similar to FIG. 11, but with the printed circuit plug assembly in place; and

FIG. 13 is a front elevational view of the contact unit of FIG. 11, taken in the direction of the line 13—13 of FIG. 11.

Referring now more in detail to the drawings, and having reference first to FIGS. 1–4 thereof, the multiple electrical connector comprises a jack assembly generally designated J and adapted to receive a printed circuit plug assembly P or any like plug assembly, the said jack assembly J being provided with a plurality or series of miniature contact elements *c*, the printed circuit plug assembly P being provided with a plurality of circuit elements or strips *c'* the terminii of which define terminal elements for mating cooperation with the contact elements *c* of the jack assembly J.

The jack assembly J comprises a receptacle 10 made of a single molded piece of insulation formed with a central longitudinal trough 12 for receiving the plug assembly P, the said trough being defined by two oppositely facing walls 14 and 16, at least one and preferably both of which

walls are formed with a plurality of pockets 18, 18 spaced along the trough 12 and corresponding in number to the number of contact elements *c*, each contact element *c* being located and partially housed by a pocket 18. The walls 14 and 16 form the inside walls of said pockets 18, the side walls of said pockets being defined by ribs 20 directed inwardly of said walls. The receptacle 10 is also formed at its top with shoulders 22 extending the length of the trough 12, and with a boss or protuberance 24 at its bottom also extending the length of the trough 12, for purposes that will appear hereinafter. The receptacle 10 may also be formed with terminal lug portions 26 for the reception of attaching elements.

Each of the contact elements *c* comprises a bellows-shaped spring unit made from strip spring stock such as spring tempered Phosphor bronze (which may be gold plated over silver for obtaining low contact resistance), and having three branches or sections, an innermost section 28 being lodged against the inside wall such as the wall 14 or 16 of a pocket 18, an outermost branch 30 defining the contact which is engageable by the mating terminal strip *c'* of the plug assembly P, and an intermediate branch or section 32 forming a spring connection between the other two branches 28 and 30. The lower end of the innermost branch 28 of each bellows-shaped contact *c* is anchored in some appropriate manner to the body of the receptacle 10, as by means of the struck out portion 34 located exteriorly of the receptacle 10, and the ends 36 protruding from the receptacle 10 and extending up into the pockets 18 define terminal ends to which conductors may be connected, as by soldering. The outermost branch or section 30 of the contact *c* terminates at its upper end in a hook portion 38 which is engaged by and over the shoulder wall 22, the end of the hook portion 38 having a limited freedom of movement in a recess 40 formed between said shoulder wall 22 and the outer walls 42 of the receptacle. The wall shoulder 22 forms a stop for limiting the outward movement (into the trough 12) of the top of the contact elements *c*, and the boss 24 forms a stop for limiting the outward movement of the bottom of the contact elements *c*.

When a printed circuit card P having a thickness no greater than the distance between the facing ribs 20 is inserted into the trough 12 of the receptacle 10, engagement is made at once between a terminal element *c'* and the top of the outermost branch or section 30 of the contact element *c*, this branch pivoting about the lower bend *b* of the contact element. As the plug P is moved further into the trough 12 this action continues, together with a pivoting of the intermediate branch or section 32 about the upper bend *b'* of the contact element. As the plug P is forced into its "home" position the contact *c*, in its action as a bellows, is compressed, the contact *c* also acting as a whole as a compression spring. The result is that the electrical engagement section 30 of the contact element *c*, which is preferably linear in configuration, makes contact over substantially its full face or area with the mating terminal element *c'* of the printed circuit plug P. With the compression spring bellows contacts *c*, *c* arranged as pairs on oppositely facing sides of the connector, the further result is achieved that the circuit card or plug assembly P is accurately held resiliently in the receptacle 10 by the oppositely acting compression action of the contact element pairs *c*, *c*. The bellows sections, moreover, makes the face of the contact section 30 follow the printed circuit, preventing circuit discontinuity under severe vibration and printed circuit board misalignment.

The description thus far relates to the basic bellows-type contact construction and mounting as disclosed in Patent 2,875,425. In the construction as thus far described the signal, in passing through the contacts *c*, flows along the following elements in series: terminal portion 36, inner section 28, intermediate section 32 and outer section 30. This path is comparatively long and tortuous. It is satisfactory for many applications, but presents voltage drop and inductance complications for weak and very high frequency signals respectively.

In order to eliminate this disadvantage, and as disclosed in FIGS. 3 and 4, the terminal portion 36 is provided at its upper end with a conductive element 44 the lower end of which is engaged with what may be considered as the upper end of the terminal portion 36. The upper and free end of the conductive element 44 engages and bears against the intermediate contact section 32, preferably adjacent the lower end thereof. The conductive element 44 is physically interposed between the contact sections 28 and 32. More specifically, in this particular embodiment, the terminal portion 36 is formed of two parallel parts 36*a* and 36*b*, connected by integral reverse bend 46, the terminal part 36*a* being connected to the inner contact section 28 and the terminal part 36*b* carrying the conductive element 44 at its upper end. If desired, in order to assist in the vertical location of the contact *c* within the receptacle 10, an offset portion 48 may be interposed between the conductive element 44 and the upper end of the terminal part 36*b*, that offset portion cooperating with a correspondingly oriented wall 50 formed at the bottom of the pocket 18.

When the printed circuit P is removed from the jack J, as illustrated in FIG. 3, the conductive element 44, by virtue of its resilient action on the contact section 32, will urge the bellows contact *c* to expanded position. When a printed circuit plug P is inserted into the trough 12, as illustrated in FIG. 4, the bellows contact *c* will be compressed in bellows fashion. The conductive element 44 will constitute a direct conductive path between the lower end of the intermediate contact section 32 and the terminal portion 36, so that the signal will not have to traverse the contact sections 32 and 28 or the reverse bend *b'* connecting those sections. This shorter and more direct path for the signal reduces voltage drop within the contact *c* and minimizes inductive problems. Moreover, the resilient action of the conductive element 44 tends to urge the lower ends of the contact sections 32 and 30 toward the printed circuit plug P, thus aiding in the attainment of firm electrical connection between the contact *c* and the mating terminal strip *c'*. This reduces voltage drop at the contact interface and improves the reliability of the contact thus made in the presence of shock or vibration.

The embodiment of FIGS. 5, 6 and 7 is in many respects similar to that of FIGS. 3 and 4, and similar parts have similar reference numerals applied thereto. The contacts in FIGS. 6 and 7 differ from those in FIGS. 3 and 4 in that the outer contact sections 30*a* are bifurcated by slot 52, and the intermediate contact sections 32*a* are bifurcated by slot 54. The lower portion of the slot 54 in the intermediate contact section 32*a* is widened at 56. The conductive element 44*a* is composed of laterally outer portions 58 and a central tongue 60, the width of the tongue 60 being less than that of the widened slot portion 56 and greater than that of the slot 52 in the outer contact section 30*a*. The laterally outer portions 58 of the conductive element 44*a* engage those portions of the intermediate contact section 32*a* on either side of the slot 56, while the tongue 60 passes through the slot 56 and engages the lower portions of the outer contact section 30*a*, spanning the slot 52. This construction provides parallel paths for the signal through the tongue 60 and the laterally outer portions 58 of the conductive element 44*a* respectively, with the tongue 60 providing an even more direct conductive path for the signal than the laterally outer portions 58. The laterally outer portions 58 of the conductive element 44*a* exert a resilient force upon the lower end of the intermediate contact section 32*a* in a manner similar to that shown in FIGS. 3 and 4, and in addition, the tongue 60 exerts a resilient force in the same direction directly upon the outermost contact section 30*a*.

The embodiment of FIGS. 11–13 is similar to that of FIGS. 3 and 4, except that the terminal portion 36 is formed of but a single strip of material, with the resilient conductive element 44*b* being struck out from the body of the conductive strip, instead of being formed at the free end of a reversely bent portion thereof, as in the embodiment of FIGS. 3 and 4.

The embodiment of FIGS. 11–13 is similar to that of FIGS. 5–7, except that the terminal portion 36 is formed from but a single length of material and the resilient conductive element 44*c* is struck from the body of the spring strip. As specifically disclosed the slot 54*c* which bifurcates the intermediate contact section 32*c* is, throughout its length, wider than the conductive element 44*c*, the slot 52*c* which bifurcates the outer conductive section 30*c* being smaller in width than the conductive element 44*c*, the latter freely passing through the slot 54*c* and physically and electrically engaging the contact section 30*c*. In the embodiment of FIGS. 11–13, as specifically illustrated, there is no counterpart to the conductive element parts 58 in the embodiment of FIGS. 5 and 6, but these could be provided if desired.

From the above it will be seen that the contact constructions here disclosed provide all of the advantages of the bellows-type contacts used in multiple electrical connectors and, in addition provide a more direct conductive path through the contact units, thereby to minimize voltage drop and undesirable inductive effects. The very structure which produces these additional advantages also serves to make more secure and reliable the electrical connection between the contacts and the terminal portions of the printed circuit plug P adapted to mate therewith. The constructions are such that they can be made simply and economically on a mass production basis through suitable punching, stamping and bending operations performed on spring strip material.

While a limited number of embodiments of the present invention have been here specifically disclosed, it will be apparent that many variations may be made therein, all within the scope of the instant invention as defined in the following claims.

I claim:

1. In a contact comprising a terminal portion, a first section connected to said terminal portion, a second section overlying and spaced from said first section and defining a contact adapted to be engaged by a conductive portion of an external assembly, and a third section spatially located between and spaced from said first and second sections, said contact sections being formed from a strip of conductive resilient material, with said third section being physically and electrically connected between said first and second sections respectively by means including reverse bends of said strip, thereby to define a bellows-shaped spring unit; the improvement which comprises a conductive element electrically connected to said terminal portion and physically resiliently engaging at least one of said second and third contact sections, thereby to function as a comparatively direct electrical path between said second contact section and said terminal portion, said third contact section having an opening therethrough, said conductive element passing through said opening and engaging said second contact section.

2. The contact of claim 1, in which said conductive element is struck out from the body of said strip.

3. The contact of claim 1, in which said terminal portion comprises first and second parallel parts electrically connected to one another, said first part being connected at its upper end to said first contact section, said second part having a free upper member defining said conductive element.

4. In a contact comprising a terminal portion, a first section connected to said terminal portion, a second section overlying and spaced from said first section and defining a contact adapted to be engaged by a conductive portion of an external assembly, and a third section spatially located between and spaced from said first and second sections, said contact sections being formed from a strip of conductive resilient material, with said third section being physically and electrically connected between said first and second sections respectively by means including reverse bends of said strips, thereby to define a bellows-shaped spring unit; the improvement which comprises a conductive element electrically connected to said terminal portion and physically resiliently engaging at least one of said second and third contact sections adjacent the lower end of the engaged section, thereby to function as a comparatively direct electrical path between said second contact section and said terminal portion.

5. The contact of claim 4, in which said third contact section has an opening therethrough, said conductive element passing through said opening and engaging said second contact section.

6. The contact of claim 4, in which said third contact section has an opening therethrough, said conductive element passing through said opening and engaging said second contact section, said conductive element being resilient relative to said terminal portion, thereby to act as a biasing means active on said contact sections in a direction to tend to expand said bellows unit.

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