United States Patent

Wessely

[15] **3,646,500**

[45] **Feb. 29, 1972**

[54] ELECTRICAL CONNECTOR HAVING A CONTACT SPRING MOUNTED IN A HOUSING CAVITY

[72] Inventor: **Hermann Wessely**, Munich, Germany

[73] Assignee: **Siemens Aktiengesellschaft**, Berlin and Munich, Germany

[22] Filed: **Sept. 25, 1969**

[21] Appl. No.: **861,022**

[30] **Foreign Application Priority Data**

Sept. 26, 1968 Germany ..... P 17 90 199.4

[52] **U.S. Cl.** ..... **339/65**, 339/210 R, 339/258 R

[51] **Int. Cl.** **H01r 13/62**

[58] **Field of Search** 339/65, 66, 176, 210, 217, 339/258

[56] **References Cited**

UNITED STATES PATENTS

3,464,054	8/1969	Mansfield	339/176 MP
2,875,425	2/1959	Gilbert	339/176 MP
2,641,746	6/1953	Keller	339/210 R
3,101,231	8/1963	Klostermann	339/176 MP
3,160,459	12/1964	Greco et al.	339/258 P

Primary Examiner—Joseph H. McGlynn

Attorney—Hill, Sherman, Meroni, Gross & Simpson

[57] **ABSTRACT**

An electrical connector, of the type having a contact spring for unilaterally clamping a conductive contact member and being mounted within the cavity formed in a housing having a guide aperture intersecting the cavity and defining an insertion axis along which the contact member may be inserted for engagement with the contact spring, is characterized by the contact spring comprising an elastic contact portion normally biased toward the insertion axis for contacting an inserted conductor member with a predetermined unilateral contact force and a resilient portion attached to the contact portion and having a free end normally held in a deflected position by engagement with abutment means for outwardly biasing the contact to present an initial plugging force approaching zero and being deflectable to a position out of contact with the projection for presenting a sharply increasing plugging force and a gradually increasing contact force.

4 Claims, 11 Drawing Figures

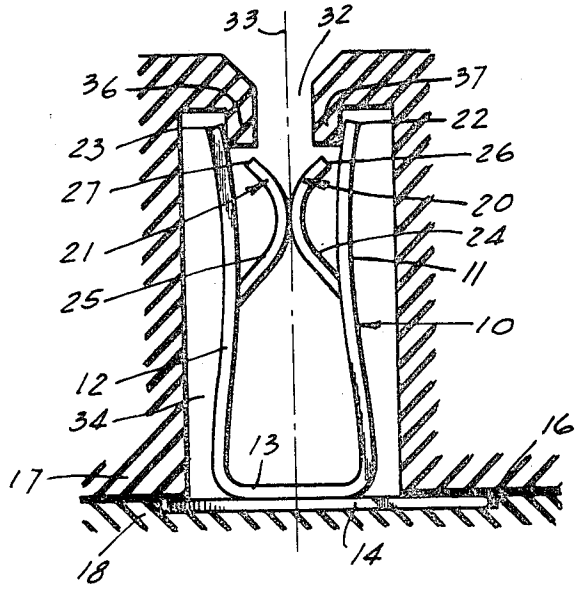


Fig.1a

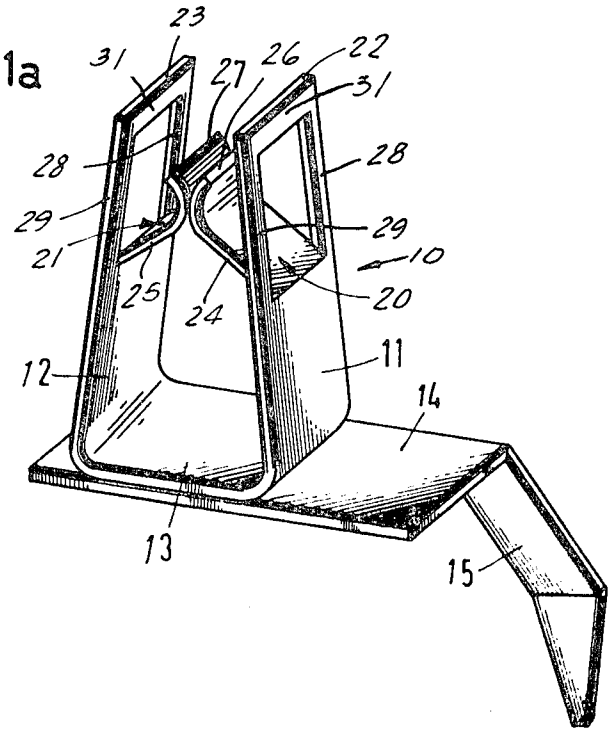
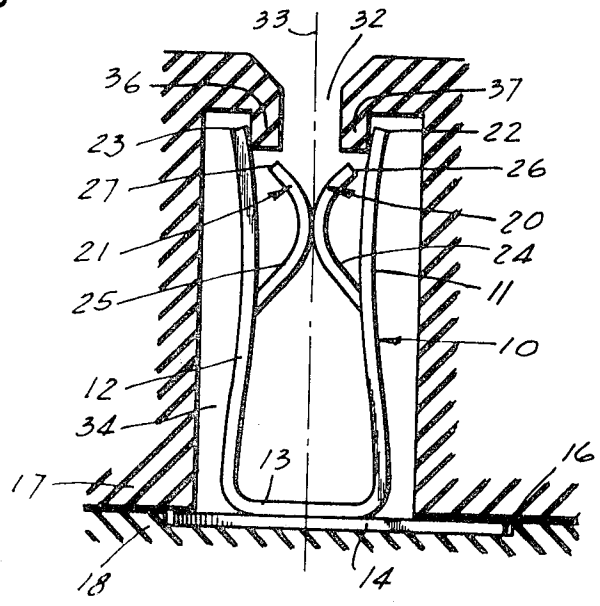


Fig.1b



INVENTOR
HERMANN WESSELY

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Fig. 2

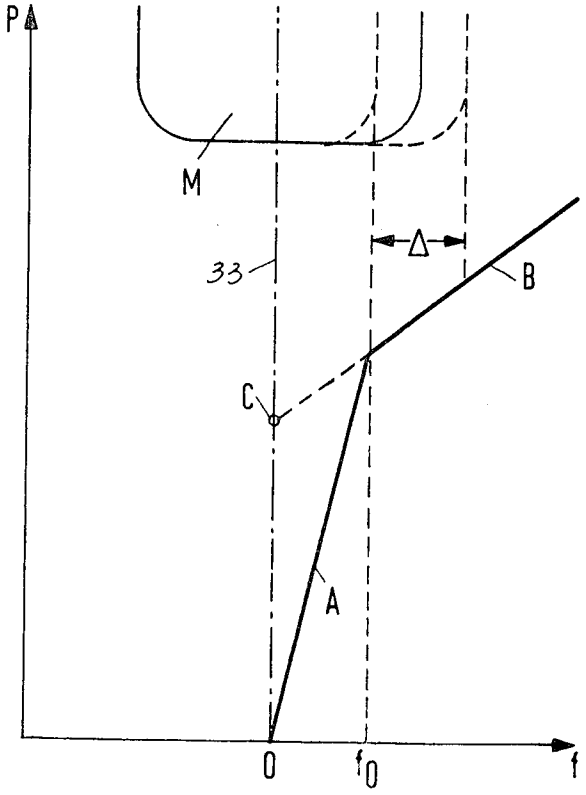
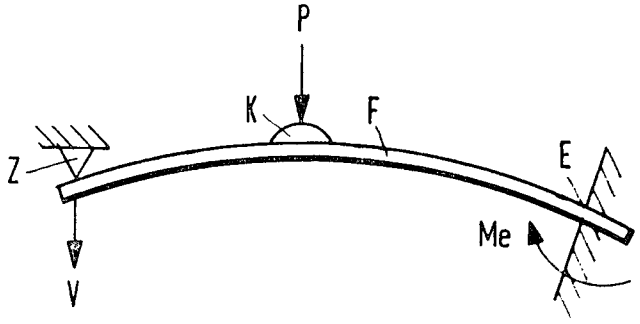


Fig. 3



INVENTOR

HERMANN WESSELY

BY Hill, Sherman, Meroni, Gross & Simpson

ATTORNEYS

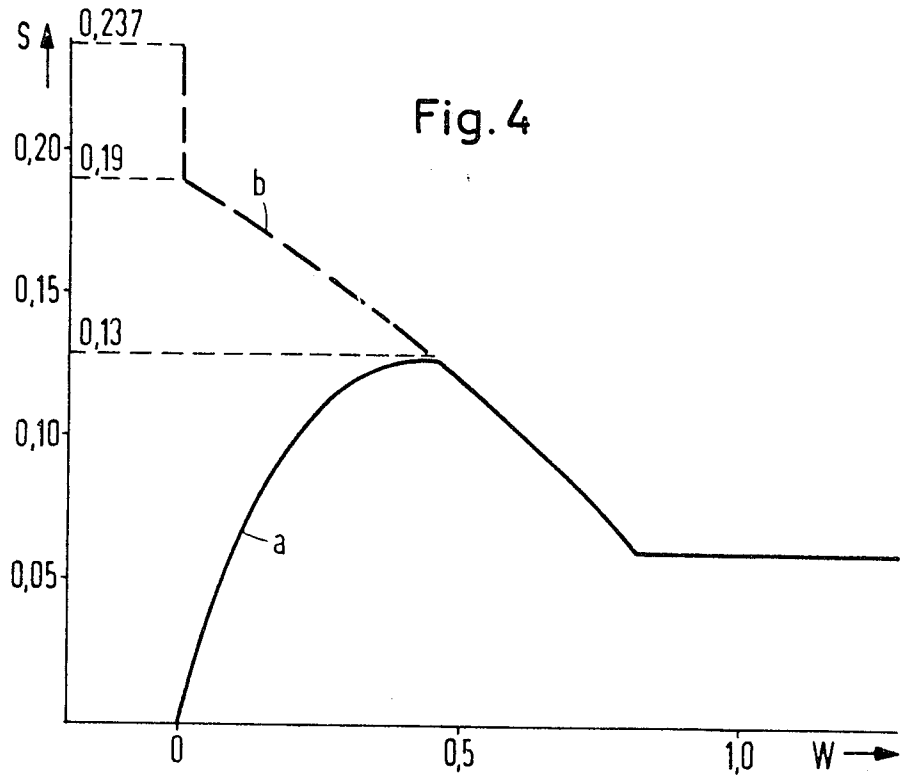


Fig. 4

Fig. 5

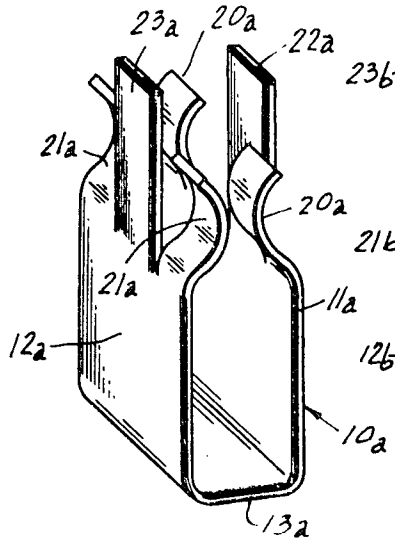


Fig. 6

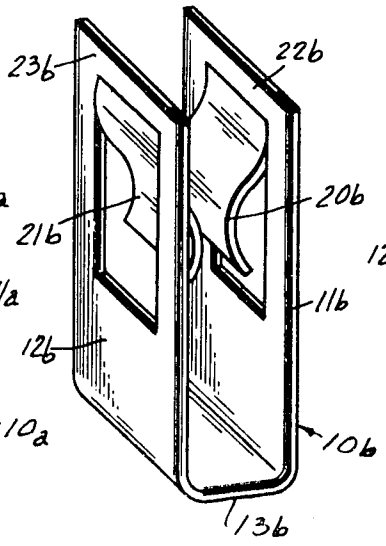
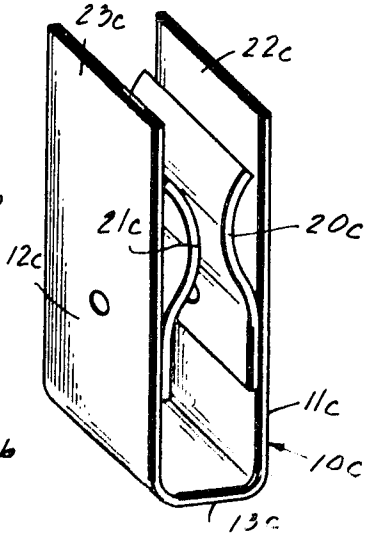


Fig. 7



INVENTOR
HERMANN WESSELY

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Fig.8a

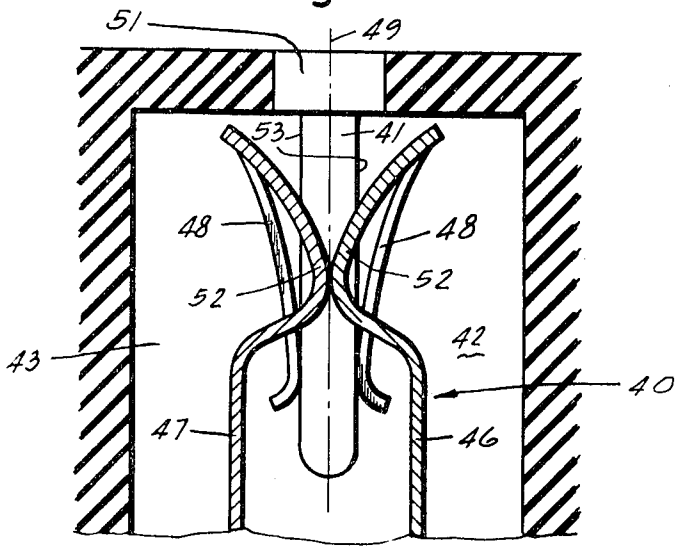


Fig.8b

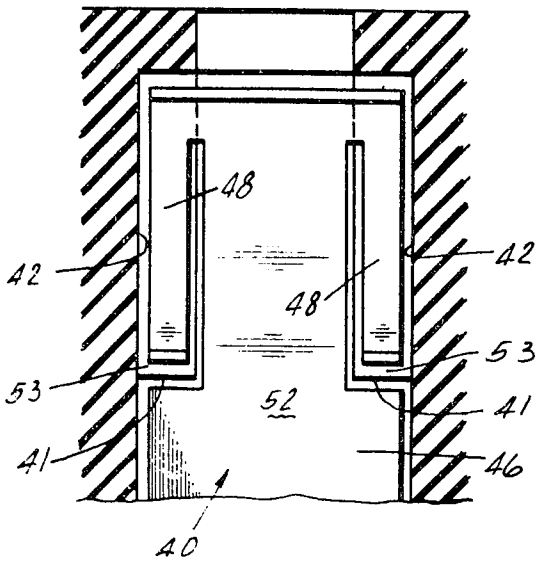
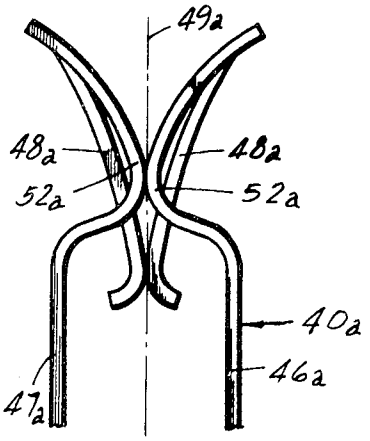


Fig.9



INVENTOR
HERMANN WESSELY

BY Kile, Sherman, Meroni, Gross & Simpson ATTORNEYS

ELECTRICAL CONNECTOR HAVING A CONTACT SPRING MOUNTED IN A HOUSING CAVITY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to electrical connectors and more particularly refers to an electrical connector of the type having a contact spring mounted in a housing cavity for plugging engagement with a conductive contact member to provide an electric connection.

2. Description of the Prior Art

Major electronic equipment and systems, particularly solid state circuit devices such as data processing equipment generally comprise individual pluggable building components or subcircuits to facilitate production and servicing. In order to make a plug connection, a pluggable, conductive contact member, for example a spring bar, is electrically connected to each circuit component or subcircuit, or the conductor panels include integral conductor tracks or circuits extending to a peripheral edge of the circuit panel so that the conductor panel is directly pluggable into a correspondingly designed receptacle to form an appropriate electric connection or circuit.

The ever-increasing miniaturization of almost all electrical and mechanical circuit components, and particularly the ever-increasing use of integrated circuitry, requires corresponding miniaturization of plug contact members and contact springs for receiving the contact members. For example, it is becoming common practice to allocate a cross-sectional area in the order of 5×5 mm. for contact points or contact members, thereby providing only a few millimeters in which to dimension a contact spring and the insulative wall thickness forming a housing for receiving the contact spring.

To assure perfect operation, a contact spring must fit snugly within a housing cavity to prevent the spring from being pushed rearwardly during insertion of the contact member, and the contact spring also must have sufficient clearance in the spring cavity or chamber to prevent the contact member from scrapping, hooking or impacting on the cavity or chamber walls.

In order to form a safe electrical connection, the unilateral contact force between the contact spring and the contact member must not decrease below a minimum value, and on the other hand, the contact force may not exceed a maximum value that will cause abrasion of the contact coating, which may, for example be gold. Further, to assure a substantially consistent contact force, the contact spring should have a minimum elastic force fluctuation due to manufacturing tolerances which may occur in both the contact spring and the contact members.

Miniaturization of circuit components has also resulted in an increase in the number of contact members disposed on a circuit board for simultaneous plugging into a receptacle having a plurality of contact springs. Thus, unless the plugging force, i.e., the resistance to insertion of the contact member into the contact spring, is maintained at a minimum, the accumulated plugging forces of a plurality of contact springs to be simultaneously plugged may exceed the mechanical strength of the circuit plates.

It should be noted that the requirements of a minimum plugging force and a sufficiently high contact force substantially independent of manufacturing tolerances in the production of the contact elements are contradictory. In particular, a minimum plugging force and a sufficiently high contact force requires that the spring force increase rapidly in response to increased opening or deflection of the spring as the contact member is inserted, thereby requiring a spring deflection curve, i.e., a graphical representation describing the force exerted by the contact spring as a function of spring deflection, to be steeply sloped. On the other hand, the requirement of a contact force substantially independent of manufacturing variations in the thickness of the contact member requires a spring deflection curve that is substantially flat.

One prior art contact spring of which I am aware achieves a compromise between the contradictory requirements by providing a spring having a deflection curve with an initial steeply sloped portion changing to a substantially flat portion. That prior art spring has a lug or projection bent outwardly at an angle of approximately 140° and having an end portion bearing down against a wall of the spring housing. As the contact member is inserted, the point of support of the spring end shifts, due to deformation of the spring, toward a base wall of the cavity, thereby to increase the spring lever arm. To shift the point of adhesion of that prior art spring on the chamber wall requires overcoming a frictional force which may increase the plugging force. Further, if the chamber wall is somewhat roughened by frequent plugging or by dust particles, the shifting of the projection along the chamber wall may be severely impeded, thereby increasing the plugging force in an unacceptable manner. That spring also requires substantial space in a direction perpendicular to the longitudinal extension of a multicontact spring bar, thereby limiting its use in a spring bar having a plurality of closely spaced rows of contacts.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, a contact spring for unilaterally clamping a contact member and being mounted in a cavity of a housing having a guide aperture intersecting the cavity and defining an insertion axis along which a contact member may be inserted for engagement with the spring is characterized as comprising an elastic contact portion biased toward the insertion axis and an elastic leg portion attached to the contact portion and having a portion thereof held in a deflected position prior to a contact member being inserted, by engagement with abutment means and being deflectable out of contact with the projection as the contact member approaches a fully inserted position, thereby to elastically support the spring contact portion in a manner to provide a plugging force initially approaching zero and sharply increasing to the desired contact force as the contact member is inserted into the contact spring. The elastic support provides a gradually increasing contact force subsequent to the deflected portion lifting out of contact with the abutment means, thereby to reduce any effect manufacturing tolerances may have on the unilateral contact force.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1*a* is an isometric view of one embodiment of an unmounted contact spring embodying the features of the present invention;

FIG. 1*b* is a side elevational view of the contact spring shown in FIG. 1*a* and illustrating a spring housing in cross section;

FIG. 2 is a graph illustrating a deflection curve of the contact spring shown in FIGS. 1*a* and 1*b* with the abscissa representing deflection of the spring by insertion of a contact member and the ordinate representing the unilateral force between the contact spring and the contact member.

FIG. 8 is a schematic view illustrating basic elements of the contact spring to facilitate understanding of the principles of the present invention;

FIG. 4 is a graph illustrating variations in plugging force as a function of the depth of insertion of the contact member with the abscissa representing the inserted depth and the ordinate representing the plugging force;

FIGS. 5, 6 and 7 are isometric views illustrating alternative embodiments of contact springs constructed in accordance with the principles of the present invention;

FIG. 8*a* is a fragmentary transverse sectional view similar to FIG. 1*b* and illustrating a further alternative embodiment of the present invention;

FIG. 8*b* is a fragmentary end elevational view of the contact spring illustrated in FIG. 8*a* with the housing shown in cross section; and

FIG. 9 is a fragmentary side elevational view of a still further embodiment of the present invention.

DETAILED DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

Referring to the drawings, and first particularly referring to FIGS. 1*a* and 1*b*, a contact spring **10**, constructed in accordance with the principles of the present invention, comprises a U-shaped member composed of an elastic, conductive material, for example sheet copper, and having a pair of generally upstanding elastic leg portions **11** and **12** connected by a base portion **13**.

A sheet-form mounting plate **14** characterized by an offset connecting lug **15** is secured to the spring base **13** by spot-welding or other suitable securement means and is clamped in a recess **16** formed between mating housing parts **17** and **18** composed of insulating material, thereby to securely support the contact spring within the housing. The connecting lug **15** extends beyond the housing parts **17** and **18** to facilitate connecting a lead thereto. With the mounting plate **14** securely clamped between the housing parts **17** and **18** and the spring base **13** securely fastened to the mounting plate, the pair of upstanding elastic leg portions **11** and **12** form mechanically independent leaf springs each having one end portion firmly clamped to the housing.

It is contemplated by one embodiment of the present invention to form elastic contact portions or tabs by shearing rectangular tabs as at **20** and **21** along three sides from an upper portion of the legs **11** and **12** so that the tabs are integrally attached along a fourth side of the rectangle to the leg portions along planes substantially midway between the fixed lower end portions of the legs and free upper end portions as at **22** and **23**. Each of the contact tabs **20** and **21** have first portions as at **23** and **24** bent inwardly of the U-shaped contact spring **10** and converging toward each other and second or upper portions as at **26** and **27** diverging away from each other to form a mouth or entrance for receiving a contact member (not shown).

With the contact tabs **20** and **21** punched from the upstanding spring legs **11** and **12**, upper portions of each leg have a parallel pair of narrow strips as at **28** and **29** interconnected at the upper free ends by a transversely extending bridge portion as at **31**.

The upper housing part **17** has a guide aperture **32** formed therein and defining an insertion axis **33** contained within a juncture plane passing between the contact tabs **20** and **21** and along which the contact member may be inserted for deflection of and engagement with the contact spring for completing an electric connection. The guide aperture **32** intersects a spring cavity **34** receiving the contact spring **10** and defined by the housing parts **17** and **18**.

In accordance with the principles of the present invention, the upper free ends **22** and **23** of the spring legs **11** and **12** are deflected outwardly and held in the deflected position by abutting engagement with abutment means including a pair of projections **36** and **37** extending inwardly of the cavity **34** and oppositely disposed at peripheral edge portions of the insertion aperture **32**, thereby to initially outwardly bias the contact tabs **20** and **21** so that curved portions of the tabs bearly contact each other along the juncture plane containing the insertion axis **33** and thus presenting an initial resistance to insertion of the contact member, or plugging force, approaching zero.

Further, by disposing the projections **36** and **37** on opposite peripheral edge portions of the insertion axis **32**, those projections form centering bridges for guiding the contact member along the insertion axis **33** and for centering the opposed contact tabs **20** and **21**, thereby to prevent loose plugging even when the contact member is initially inserted at an angle eschewed relative to the insertion axis. Thus, the contact spring **10** and housing parts **17** and **18** form a so-called "head-centering" contact spring. It should also be noted that by disposing the centering projections **36** and **37** parallel to the insertion axis, those projections may be sufficiently long to provide a large overlapping of the spring legs **11** and **12**, since the contact is not dimensionally restricted in that direction.

From the foregoing description, it should be noted that the contact spring **10** of the present invention includes elastic contact tabs **20** and **21** separately supported on the elastic spring legs **11** and **12**, which in turn are normally held in a deflected position by abutting engagement with the projections **36** and **37** in a manner to outwardly bias the contact tabs for providing an initial plugging force approaching zero. As the contact member is inserted central portions of the spring legs **11** and **12** intermediate the clamped and free ends thereof are outwardly deflected until the spring legs lift away from the projections **36** and **37** which occurs as the contact member approaches a fully inserted position. As illustrated graphically in FIG. 2, the deflection curve of each of the elastic leg portions **11** or **12** has a sharply increasing portion as at *a* due to a decreasing biasing force counteracting the unilateral contact force between the contact portions **20** and **21** and the contact member.

To facilitate description of the theoretical aspects of the present invention, one of the spring legs **11** or **12** of the contact spring **10** is schematically shown in FIG. 3 and identified by the reference character F. The elastic leg portion of leaf spring F has one end portion E unilaterally clamped to represent the lower end of the spring legs and has a free end portion thereof deflected and held in the deflected position by abutment with the projection or support Z. Due to the deflection of the elastic spring F, the support Z exerts a biasing force on the free end of the spring as represented by the force vector V, thereby to produce a torque Me on the spring F at the clamped end portion E.

If a contact force P due to insertion of a contact member acts on the contact point K intermediate the clamped end E and the free end, the spring F deflects in the direction of the force vector P, and thus the bending or arcuate deflection of the spring F decreases to correspondingly decrease the bias force V. Since the sum of the deflection force P and the biasing force V counteract the torque Me created on the spring at the clamped end portion E, as the biasing force V decreases due to deflection or straightening of the elastic spring F, the deflecting force P must correspondingly increase to further deflect the spring. When the free end of the spring F moves out of contact with the support Z, the biasing force P necessary for further deflection of the contact point K is only dependent upon the properties of the spring portion between the clamped end portion E and the contact point K. Thus, the deflecting force required for deflection after the free end lifts out of contact with the projection increases at a considerably lesser rate than when the free end is in contact with the projection, as represented by the upper portion B of the deflection curve as illustrated in FIG. 2.

A contact M is superimposed on the graphical representation of the deflection curve with dashed lines separated by the distance Δ representing minimum and maximum widths of the contact member due to manufacturing tolerances. The steeply sloped portion A of the deflection curve represents the rapid increase in the deflection force P while the free end of the spring is in contact with the abutment Z, whereas the substantially flatter portion B of the curve represents the increase in the deflection force subsequent to the free end moving out of contact with the projection, which occurs at a deflection of f_0.

The deflection f_0 corresponds to one-half of the minimum thickness of the contact member M taking into consideration manufacturing tolerances of the contact member and the contact spring, thereby positioning any variation in the deflection force P, or in the contact force between the contact member and the contact spring, in the substantially flat portion B of the deflection curve, and thus minimizing variations on the contact force due the manufacturing tolerances. Further, to achieve a minimum plugging force it is desirable to dimension the contact spring and the projections so that the tolerance range begins at the deflection f_0.

Point C on the graph represents the intersection of the flatter portion B of the curve with the insertion axis 33, or a longitudinal axis of the contact member M, and the ordinate of the point C would be the initial force necessary to deflect the spring F, or initial plugging force, which would occur if the free end of the spring was not initially deflected and held in the deflected position by abutting engagement with the projection Z.

Differences in the required plugging force for an elastically centered contact spring, constructed in accordance with the principles of the present invention, and a similarly configured, nonelastically centered spring are graphically represented in FIG. 4. That graph illustrates the calculated course of the plugging force S as a function of the plugging path W or extent of the insertion of the contact member into the contact spring. The solid line curve *a* represents the plugging force for an elastically centered spring, whereas the dashed line *b* represents a noncentered spring. In the calculations, it was assumed that the contact point had an arcuate configuration and that the contact member was squared off perpendicularly to a longitudinal axis thereof. In practice, the contact members generally have a slightly beveled free end portion.

The plugging force for an elastically centered contact spring, as represented by the curve a, steadily increases from zero to a maximum value and then decreases to a constant value necessary for overcoming sliding friction between the contact member and the contact spring. For a nonelastically centered contact spring, the initial plugging force has a value substantially exceeding the maximum value for an elastically centered spring, and the plugging force steeply decreases until overcoming the adhesive friction and then gradually decreases to the constant terminal value necessary for overcoming the sliding friction.

Utilizing contact springs providing a contact force of 145 ± 5 p and mounted in a 24-pole spring bar housing, the following values were measured for the plugging force and the traction force:

Type of Spring	Plugging Force (k_p)	Traction Force (k_p)
elastically center	1.8	1.4
not centered	2.5	1.4

From the table, it should be noted that the plugging force for a nonelastically centered contact spring is approximately 40 percent higher than the plugging force of an elastically centered contact spring, constructed in accordance with the principles of the present invention.

As illustrated in FIGS. 5 through 7, inclusive, contact springs constructed in accordance with the principles of the present invention may have various alternative configurations, and structural elements of the alternative embodiments having a similar configuration to those shown in FIGS. 1*a* and 1*b* are identified with like reference characters to which a small letter *a*, *b* or *c* has been added.

In the embodiment of the contact spring 10*a*, as illustrated in FIG. 5, two pairs of contact tabs as at 20*a*, 20*a* and 21*a*, 21*a* are respectively punched from opposite, lateral side edge portions of the spring legs 11*a* and 12*a*. That embodiment is particularly appropriate for planar contact members as opposed to arcuately shaped contact members. As illustrated in FIG. 6, the contact tabs 20*b* and 21*b* are attached at an upper end portion thereof to the spring legs 11*b* and 12*b*, thereby to further lessen any possibility of damage to the contact tabs by an end portion of the contact member abutting the free end of the tabs.

It is also contemplated by the present invention, as illustrated in FIG. 7, to form the contact tabs 20*c* and 21*c* from sheet material independent of the spring legs 11*c* and 12*c* and attach the contact tabs to the spring legs by welding or other suitable securement means. Although the last-mentioned embodiment requires a somewhat more expensive manufacturing operation, that embodiment permits an optimum selection of materials for the contact tabs and the spring legs.

Referring now to FIGS. 8*a*, 8*b* and 9, it is also contemplated by the present invention to provide a contact spring of the so-called "laterally centered" type, as generally indicated at 40, wherein projections 41 for holding portions of the spring in a deflected position prior to insertion of the contact member are disposed along opposite sidewalls as at 42 of the spring cavity 43 defined by the housing 44 for guiding side edge portions of the contact member disposed laterally of the contact spring.

The contact spring 40 is a generally U-shaped sheet-form member composed of an elastic, conductive material and having a mounting plate including a connecting lug secured to a medial or base portion (not shown) of the U-shaped member. Upstanding spring leg portions 46 and 47 of the contact spring 40 each have a pair of centering tabs as at 48 punched outwardly therefrom at laterally opposite side portions and attached along an upper edge to form integral tabs. Associated pairs of the centering tabs 48 disposed on similar lateral sides of the contact spring 40 converge inwardly of the U-shaped contact spring and toward an insertion axis 49 defined by the guide aperture 51 formed in the housing 44 and intersecting the spring cavity 43. Contact portions or tabs 52 are formed by bending a central portion of the spring legs 46 and 47 intermediate the pair of centering tabs 48 into a tuliplike configuration. With the contact spring 40 properly mounted in the cavity 43 so that lower free end portions of the centering tabs 48 are outwardly deflected by abutting engagement with opposite side edges as at 53 of the projections 41, the contact portions 52 are outwardly biased to provide an initial plugging force approaching zero. The outward bias provided by the centering tabs 48 decreases the deflection force otherwise necessary to spread the contact tabs 52 as the contact member is inserted. Just prior to the contact tabs 52 being spread a sufficient distance to permit full insertion of the contact member, the centering tabs are deflected out of engagement with the projections 41, thereby to render further increases in the deflection force and corresponding contact force dependent solely upon the elastic characteristics of the spring legs 46 and 47. In that manner, a deflection curve similar to that shown in FIG. 2 is provided for an elastically, laterally centered contact spring.

A still further embodiment of the present invention, as illustrated in FIG. 9, contemplates eliminating the necessity for centering projections similar to the projections 41 by initially bending the lateral centering tabs 48*a* past the insertion axis 49*a* so that in the rest position, without the contact member being inserted, opposed ones of the centering tabs 48*a* engage along a juncture plane containing the insertion axis. In that manner, the contact portions or tabs 52*a* are outwardly biased by coaction between the opposed centering tabs 48*a*, thereby to provide a sharply increasing plugging force until the centering tabs are deflected out of contact, at which time the deflection force or contact force gradually increases with further deflection of the contact tabs.

It should also be noted, that contact springs constructed in accordance with the principles of the present invention need not have a substantially U-shaped configuration, but may comprise a single leaf spring anchored at a lower end portion to a spring housing. A contact spring of that configuration has particular utility in plug connectors for direct plugging of printed circuit panels. Also, by disposing a pair of independently mounted leaf spring on opposite sides of an insertion axis and electrically insulating the pair of springs, a bilaterally printed circuit board may be directly plugged in a manner to form separate electric connections on opposite side surfaces of the panel.

Although those versed in the art may suggest various minor modifications, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. An electrical connector for receiving a contact member comprising:

means forming a housing having a cavity formed therein and a guide aperture intersecting the cavity and defining an insertion axis along which a contact member may be inserted;

a generally U-shaped contact spring having a medial base portion clamped to a cavity wall portion disposed opposite said guide aperture and a pair of generally upstanding elastic leg portions disposed on opposite sides of the insertion axis,

elastic contact portions disposed on said pair of elastic leg portions and converging toward the insertion axis for engagement by the contact member to form an electric connection,

said contact portions including substantially rectangular tabs punched along three sides from said elastic leg portions and being inwardly bent along a fourth side;

abutment means attached to said housing means and extending inwardly of said cavity,

said abutment means having a pair of oppositely disposed projections attached at peripheral edge portions of said guide aperture for guiding the contact member,

upper free end portions of said elastic leg portions being outwardly deflected and engaging side surfaces of said projections disposed oppositely of said guide aperture for outwardly biasing said contact portions in a manner to provide a minimum resistance to insertion of the contact member, and

said upper free end portions of said elastic leg portions being deflected out of engagement with said abutment means as the contact member approaches a fully inserted position,

thereby to provide a contact spring presenting a sharply increasing plugging force until the contact member approaches the fully inserted position and presenting a gradually increasing contact force subsequent to said upper free end portions moving out of engagement with said abutment means.

2. In an electric contact device having a contact spring mounted on one of its sides in a spring housing in a manner to form a detachable electric contact engageable with a contact pin which determines an insertion axis, the improvement comprising said contact spring being divided into at least two parts which extend substantially in longitudinal directions of said contact spring, one of said parts being bent toward the insertion axis, and the other of said parts being supported by means forming a support in a manner so that the last-mentioned one of said parts is only lifted from said support means whenever the contact pin is partially inserted into the contact device, said first mentioned part including a substantially rectangular tab punched along three sides from said contact spring and being bent toward the insertion axis along a side of said tab.

3. An electric contact device as defined in claim 2 and further characterized by said rectangular tab being bent toward the insertion axis along a side of said tab furthest from the point of insertion of the contact pin.

4. An electric contact device as defined in claim 2 and further characterized by said rectangular tab being bent toward the insertion axis along a side of said tab nearest the point of insertion of the contact pin.

* * * * *