Nov. 12, 1968 C. J. ADAMS 3,411,127

SELF-MATING ELECTRIC CONNECTOR ASSEMBLY

Filed July 8, 1963 2 Sheets-Sheet 1

FIG. 1.

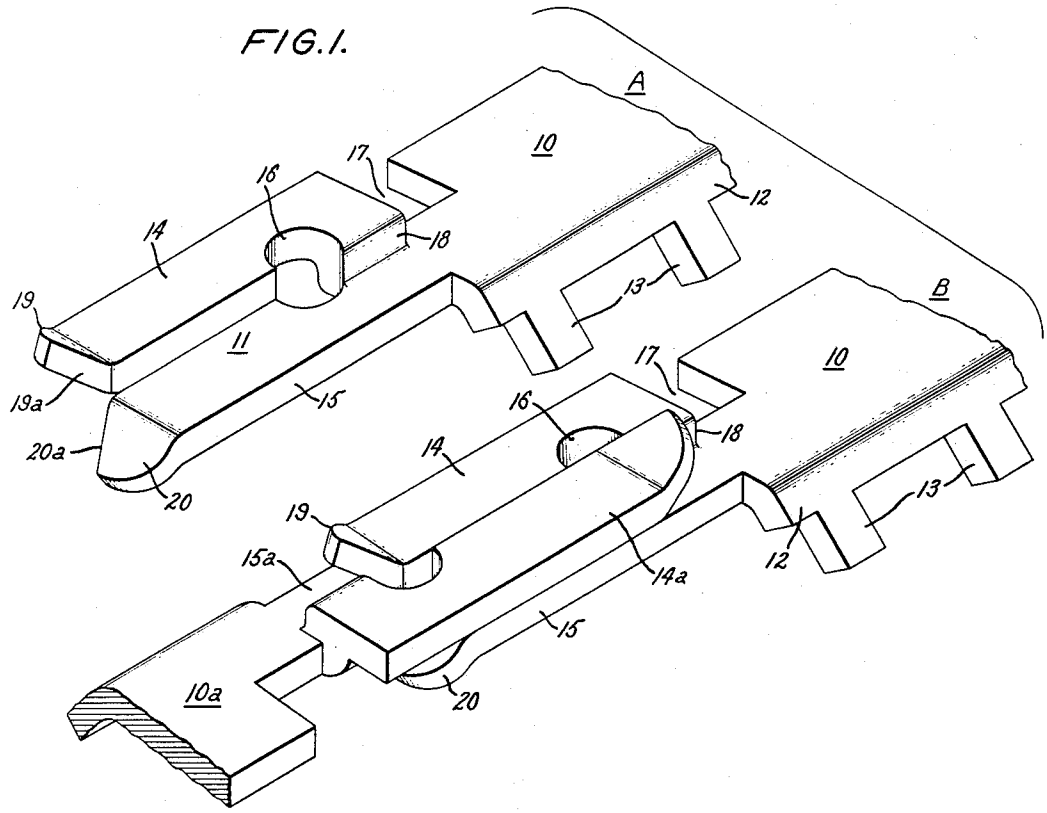


FIG. 2.

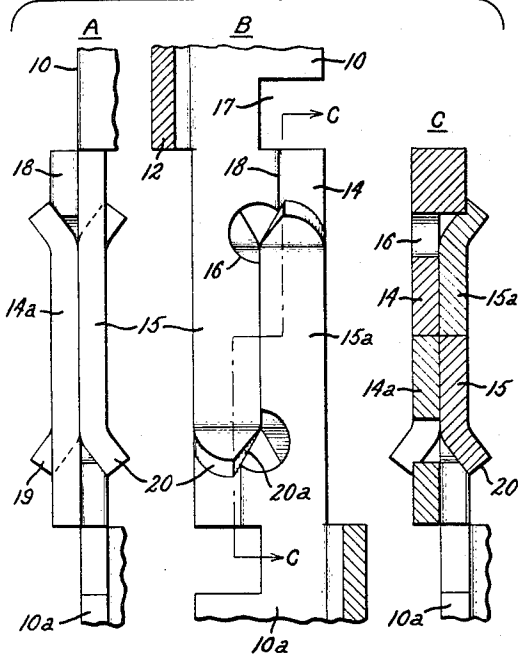
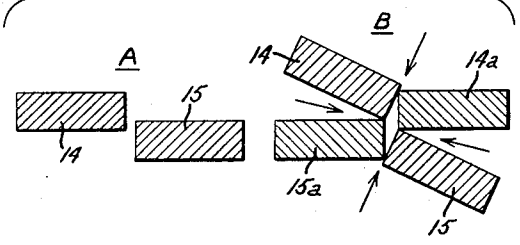


FIG. 3.



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Filed July 8, 1963 2 Sheets-Sheet 2

FIG.4.

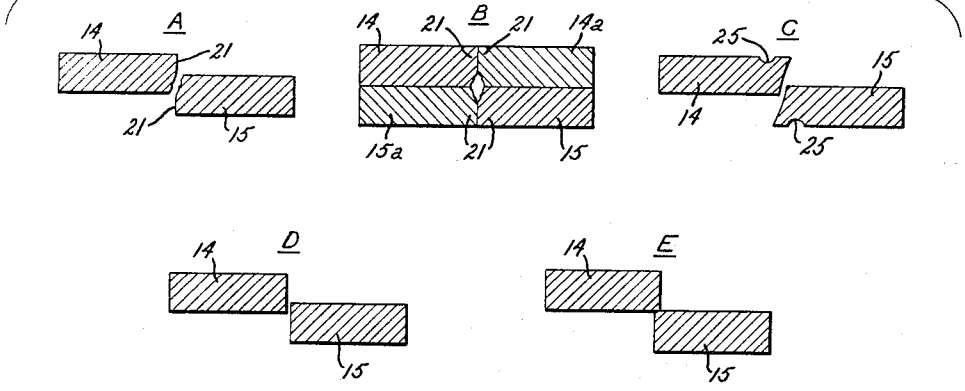


FIG.5.

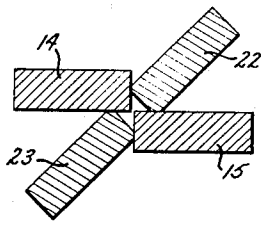


FIG.6.

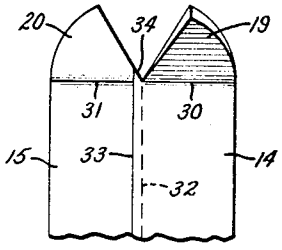
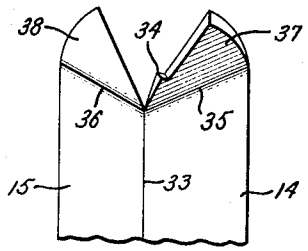


FIG.7.



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3,411,127

SELF-MATING ELECTRIC CONNECTOR ASSEMBLY

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3 Claims. (Cl. 339—47)

My invention relates to detachable electric connector contacts of the self-mating or hermaphrodite type, and particularly to a multiplanar two-finger contact of this type having improved electrical and mechanical engagement. My improved connector contact is especially adapted for multiple mounting in large arrays or banks for quick detachable connection of printed circuit boards or other electrical subassemblies.

With the recent rapid development of complex electric information handling apparatus, for example telephone dialing equipment, electronic computer and detection apparatus, automatic machine tool control apparatus and the like, there has arisen a need for modular circuit assembly to facilitate efficient subassembly and rapid replacement of individual circuit elements and functional units. The accompanying development of printed electrical circuitry and elemental printed circuit board assemblies has facilitated such modular construction. These developments have created a need for improved detachable electric connector contacts of small size especially adapted for multiple assembly in large numbers in closely spaced cooperating arrays.

A variety of electric contacts have been devised and used in modular signal circuit assembles of the types referred to. Conveniently, many of these have been self-mating or hermaphrodite types wherein each contact is designed to mate with another having the same configuration at its mating end. While these devices as previously known have performed satisfactorily to a degree, they have demonstrated certain limitations. For example, many such contacts may be conveniently mated only with one of identical mating end configuration and not with other commercially available types having differently configured mating ends; in some the mechanical forces required for connection and disconnection of large banks of contacts is inordinately large; in some the electric contact area is limited and thus generates excessive heat, and in some the mechanical forces developed during mating create such stress in the contact that deformation and fatigue precludes more than a limited number of mating operations.

Accordingly it is a primary object of my invention to provide a novel and improved electric connector contact of the self-mating type having improved electrical and mechanical engagement characteristics.

It is another object of my invention to provide a novel and improved two-finger electric contact designed primarily for hermaphrodite mating with a contact having a mating end of identical configuration but adapted also to mate with a bifurcated contact having a differently configured mating end.

It is still another object of my invention to provide a novel and improved multiplanar two-finger electric contact which provides a large contacting area when mated with another having the same mating end configuration and which will mate also with a bifurcated contact of uniplanar type.

It is a particular object of my invention to provide a novel and improved two-finger hermaphrodite contact designed for spring-pressed contact engagement in flatwise or broad area planar relation without the development of unbalanced rotational forces on the contact mounting.

It is a still further object of my invention to provide a novel and improved electric contact matable with itself and matable also with conventional contacts, and having unique guide tips to facilitate mating and to limit the degree of mating.

In carrying out my invention in one preferred embodiment, I provide a blade of resilient electric conducting material having one end formed to provide a mounting base and having at its other end a multiplanar, two-fingered mating contact head. The contact head is formed by slitting the blade longitudinally to define a single pair of elongated contact fingers disposed in closely spaced edge-to-edge relation and having opposite planar, broad area contacting faces. The fingers are relatively offset in a direction perpendicular to their planar faces by an amount approximately equal to the blade thickness, so that the fingers reside in parallel planes with the contacting face of one finger substantially coplanar with the contacting face of the other. These two parallel offset fingers are adapted to engage the like fingers of another contact in interleaving relation so that the substantially coplanar contacting faces and the inner edges of the fingers of one contact engage the substantially coplanar contacting faces and inner edges of the fingers of the other contact. Preferably the offset fingers overlap slightly, either edgewise or flatwise, so that the slight deformation required in hermaphroditic engagement provides a positive contacting pressure. Preferably, also, an enlarged aperture is provided at the base of the fingers to relieve stresses at the end of the dividing slit. To facilitate longitudinal sliding engagement of two like contacts, the outer or leading tips of the fingers of each contact are inclined outwardly (i.e. away from the medium plane) in opposite directions.

My invention will be more fully understood and its various objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing in which:

FIG. 1 shows at A a fragmentary perspective representation of a single contact embodying my invention, and at B a fragmentary perspective representation of a pair of such contacts in fully mated contacting engagement;

FIG. 2 presents three fragmentary views of a pair of such contacts in mated engagement, these views showing the mating heads in side elevation (A) in plan view (B) and in longitudinal cross section (C) taken on the line C—C of FIG. 2B;

FIG. 3 presents transverse cross-sectional views of a single contact head (A) and a pair of mated contact heads (B) to illustrate the rotational forces involved;

FIG. 4 presents five transverse cross-sectional views of mating heads to illustrate several embodiments of the invention designed to overcome rotational forces;

FIG. 5 is a transverse cross-sectional view of a multiplanar contact embodying my invention and shown mated with a bifurcated uniplanar contact of the prior art;

FIG. 6 is a fragmentary view in top plan of a contact showing in particular the formation of an undesired part by inaccurate slitting of the contact head; and

FIG. 7 is a view similar to FIG. 6 showing an embodiment of the invention which eliminates the adverse effects of the undesired part in FIG. 6.

Referring now to the drawing and particularly to FIG. 1, I have shown at FIG. 1A a single electric connector contact embodying my invention. The contact is formed from a blade or flat strip of electric conducting material to provide at one end a base or mounting portion **10** and at the opposite end a multiplanar mating head or contacting portion **11**. While it will be understood that the base or mounting portion **10** may be formed in a variety

of ways to provide suitable affixation to a support of any desired nature, I have shown by way of illustration a mounting end designed primarily for connection to a printed circuit board. For this purpose a side portion **12** of the base **10** is turned downwardly at an angle of approximately 45° to the planes of the contact fingers and is provided with a pair of spaced-apart mounting posts **13** adapted for insertion through suitable apertures in a printed circuit board (not shown). The reason for the 45° angle of the side portion **12** will be explained hereinafter.

The mating contact head portion **11** of my improved contact is slit longitudinally to define a single pair of contact fingers **14** and **15** of substantially equal length and disposed in closely spaced parallel edge-to-edge relation, the inner end of the slit terminating in an enlarged stress-relieving aperture **16** at the base of the fingers. The planar faces of the fingers **14** and **15** are of appreciably larger area than the edge surfaces, and by the means described below one flat face of each finger is arranged to provide broad surface contact area with flat faces of identically configured fingers of another contact. The two finger faces of each contact which engage finger faces of another contact are opposite to each other and will be referred to hereinafter as contacting faces.

The contact fingers **14** and **15** are relatively offset in a direction perpendicular to the planes of their faces and by an amount equal approximately to the thickness of the fingers. While it will be evident to those skilled in the art that this offset may be accomplished in a variety of ways, I have shown by way of illustration an upset or deformation of a base portion of the contact finger **14**. In the illustrated embodiment of the invention the base portion of finger **14** is shown divided from the supporting base portion **10** by a lateral notch **17**, and offset of the finger **14** is effected by a longitudinal bend **18** in the strip between the aperture **16** and the notch **17**. It will, of course, be evident to those skilled in the art that the fingers may be offset into parallel planes by bending one or the other or both of the fingers transversely in the region of their base. It will be apparent that offsetting of the fingers **14** and **15** in the amount described results in bringing the lower contacting face of the finger **14** into substantially coplanar relation with the upper contacting face of the finger **15** in the manner generally illustrated in all the cross-sectional views of FIGS. 2, 3, 4 and 5. In order to facilitate mating of the contact head **11** by longitudinal sliding engagement with another contact head of identical configuration, the forward or leading edges of both contact fingers **14** and **15** are inclined or bent outwardly (i.e. away from the median plane of the blade) in opposite directions, as at **19** and **20** respectively. The outturned leading tips **19** and **20** are preferably rounded on their outer sides as shown and formed with flat, outwardly inclined, adjacent inner sides as at **19***a* and **20***a*.

At FIG. 1B I have illustrated in perspective view a pair of electric contacts of the configuration described above disposed with their mating contact fingers in full interleaved engagement. In FIG. 1B a first contact having a base portion **10** and a pair of contact fingers **14** and **15** is shown with the contact head in fully mated engagement with a second contact having a base portion **10***a* and a pair of contact fingers **14***a* and **15***a*. It will be observed that in this engaged position the offset fingers **14** and **15** are interleaved in complemental relation with the offset fingers **14***a* and **15***a* so that the substantially coplanar contacting faces and the inner edges of the fingers of one contact engage the substantially coplanar contacting faces and inner edges of the fingers of the other contact. Specifically, the lower contacting face of finger **14***a*, the upper contacting face of finger **15***a* and the inner edges of these fingers engage respectively the upper contacting face of finger **15**, the lower contacting face of finger **14** and the inner edges of the latter fingers.

In the engaged position of a pair of my improved hermaphrodite contacts as illustrated at FIG. 1B, the position of full mating engagement is defined and limited by engagement of the outturned leading tip of one contact finger on each contact with the rear wall of the base aperture **16** of the other contact. The interleaved relationship of a pair of the contacts as shown at FIG. 1B is further illustrated in plan and elevation at FIGS. 2A and 2B. The cross-sectional view of FIG. 2C is taken along the line C—C of FIG. 2B. In all the views of FIG. 2 the same reference numerals utilized at FIG. 1B are used to identify the like parts. Inspection of my improved contact reveals that it can successfully mate with another contact when in either of two positions spaced angularly about its longitudinal axis by 180°. Thus, rotation of the contact shown in FIG. 1A about its longitudinal axis from its illustrated position to a position spaced angularly therefrom by 180° serves to merely reverse the relative positions of the two contacting faces which are of the two contacting faces which are still effective as such in their new positions.

Having now described the overall configuration of each multiplanar two-finger contact and the interleaving relation of a pair of such contacts, it is desirable to consider more particularly the available means for providing contact pressure at the mating surfaces and counterbalancing rotational forces resulting from such contact pressure. It will be evident that if the substantially coplanar contacting faces of each connected pair of contact fingers were in exact coplanar relationship, the engagement of a pair of such contacts would produce little or no contact pressure. Accordingly, it is desirable that some slight overlap of each connected pair of fingers be provided, as illustrated for example at FIG. 3A. In that figure the fingers **14** and **15** are shown slightly overlapped edgewise so that the lower contacting face of finger **14** is slightly offset, and thus only approximately coplanar, with respect to the upper contacting face of the finger **15**.

To illustrate the rotational forces involved in engaging two such contacts each having its fingers in slightly edgewise overlapped relation, I have illustrated at FIG. 3A a slight lateral separation between the fingers **14** and **15**. If now a similar pair of overlapped fingers **14***a* and **15***a* are interleaved with the fingers **14** and **15**, each connected pair of fingers tends to force the cooperating pair of fingers toward an exactly coplanar relationship of their contacting faces; that is the fingers exert upon each other bending forces in directions perpendicular to their contacting faces. These bending forces tend to rotate the overlying fingers away from each other as shown at FIG. 3B, and such rotation is limited only by edge engagement of the fingers and their relative rigidity against spreading. It is evident of course that in an engagement such as shown at FIG. 3B the contact fingers could be brought back into parallel planar relationship by force exterted upon their mounting ends. This, however, would require very rigid mountings for each contact and would eliminate the slight looseness or "float" which is preferably provided in the mounting of each contact of a large array. Accordingly, therefore, I have provided means for counterbalancing within the contact head itself the rotational forces illustrated at FIG. 3B. Several arrangements for effecting such counterbalance are illustrated at FIG. 4.

At FIG. 4A I have shown in cross section an offset pair of parallel contact fingers **14** and **15** constituting the mating head of a single contact with the fingers slightly overlapped in an edgewise direction to provide contact pressure against the mating fingers of another contact. In order to counterbalance the rotational forces generated by interleaving of two pairs of such overlapped fingers, I form the adjacent inner edges of each connected pair of fingers with a slight inward chamfer toward the median plane of the contact. In the embodiment shown at FIG. 4A this chamfer is produced by breaking away the edge of each finger on the side toward its contacting face as is done almost unavoidably in any common stamping operation. This produces at the outer side of the inner

edge of each finger an inwardly protruding lip **21**, the lips **21** extending in opposite directions. It will now be evident from an examination of FIG. 4B that when two contacts having the cross-sectional configuration of FIG. 4A are interleaved, the lips **21** of the upper fingers are brought into engagement and the lips **21** of the lower fingers are similarly brought into engagement. This edgewise engagement produces in each connected pair of contact fingers a lateral spreading force in a direction parallel to the contacting faces. Since the fingers are relatively rigid in this direction, these spreading forces effectively overcome the rotational forces generated by contact pressure flexure of the fingers perpendicular to their contact faces.

At FIG. 4C I have illustrated in cross-sectional view another method of producing oppositely directed chamfers at the adjacent inner edges of a pair of connected contact fingers. As illustrated at FIG. 4C, the outer planar surface of each finger has coined therein a longitudinal groove **25** parallel to the dividing slit. By this means the outer portion of each inner edge is deformed toward the other finger.

I have found that while it is desirable to ensure firm edge engagement of interleaved contacts by opposite chamfering of the inner edges of the fingers as described in connection with FIGS. 4A, 4B and 4C, adequate edge engagement and force counterbalance may be provided by other means. In FIG. 4D, for example, I have shown a cross-sectional view of the offset fingers of a single contact with the fingers slightly overlapped in an edgewise direction and in such close proximity that the rotational effect illustrated at FIG. 3B is not appreciable or significant. It will be understood of course that since the counterbalancing forces set up by edge engagement depend upon the rigidity of the fingers against lateral spreading, the effectiveness of any arrangement wherein edge engagement is provided to counterbalance flatwise contact pressure is enhanced by utilizing fingers having a large width dimension relative to their thickness.

At FIG. 4E I have illustrated another embodiment of my invention wherein the offset contact fingers **14** and **15** of a single contact (shown in cross section) are slightly overlapped along the common plane of their faces or flatwise. By this arrangement, edgewise contact pressure is provided against a cooperating pair of interleaved fingers by lateral spreading deformation of each pair. While of course rotational forces are generated by such deformation, these forces are counterbalanced by flatwise contact engagement. This counterbalance can be made optimally effective if the opposite contacting faces of the connected fingers are maintained as nearly as possible in precisely coplanar relation as illustrated at FIG. 4E.

To illustrate that my improved two-finger multiplanar contact is adapted not only for hermaphroditic self-mating interconnection with a contact having an identically configured mating head but is adapted also for cooperation with bifurcated uniplanar contact having a differently configured mating head, I have shown such an interconnection in cross section at FIG. 5. In this figure the offset fingers **14** and **15** constitute the mating head of a contact embodying my invention such as shown at FIG. 1. Since the inner parallel edges of the fingers **14** and **15** are in approximately coplanar relation as previously described these fingers provide adjacent these edges two pairs of perpendicularly disposed surfaces, constituted in each case by a contacting face of one finger and an inner edge surface of the other. Thus, in FIG. 5 I have shown in engagement with these two pairs of surfaces the two coplanar contact fingers **22** and **23** of a bifurcated uniplanar contact having rounded or tapered adjacent inner edges. Such a bifurcated uniplanar contact is illustrated in Re. Patent 23,547 issued to Benjamin Fox. As illustrated in the Fox patent, the bifurcated contact having the fingers **22, 23** of FIG. 5 is designed primarily for hermaphroditic interconnection, but it is evident that it will cooperate equally effectively with my improved multiplanar contact. It is observed that when my contact is mated with the uniplanar contact of the Fox patent, the uniplanar contact forms a 45° angle with the planes of the fingers of my contact. It is thus seen that when my contact is mounted by the side portion **12**, the fingers thereof form a 45° angle relative to a horizontal plane and thereby mate with a uniplanar contact of the Fox patent which is located in such a horizontal plane.

It is noted with reference to FIG. 1A that the outturned guide tips **19** and **20** are formed by bending the ends of the fingers along parallel lines perpendicular to the slit between the two fingers. While this arrangement is satisfactory, it can under certain circumstances produce in the mating heads of contacts so formed parts which interfere with proper mating of two contacts. For example, in FIG. 6 is shown a fragmentary view of a contact having the fingers **14** and **15** with the guide tips **19** and **20** formed by bending the ends of the fingers along parallel lines **30** and **31** which are perpendicular to the slit between the fingers. Ideally, the slit is formed so as to intersect the line of jointure of the inner edges of the guide tips. The ideal slit is represented by the dash line **32** in FIG. 6. If for some reason, such as inaccuracies in tooling, the slit is not formed ideally but is formed instead along the line **33** in FIG. 6, a projection **34** is created on one of the fingers depending upon the direction of lateral shift of the slit from the line **32** of ideal slitting. In FIG. 6, it is assumed that the slit is formed along the line **33** to the left of the line of ideal slitting so as to form a projection **34** on the finger **14**. Subsequent bending of the end of finger **14** about the line **30** will not appreciably displace the projection **34** out of the median plane of the finger **14**. It is thus possible that mating of two contacts each containing a projection corresponding to projection **34** can be prevented by engagement of the two projections during an attempt at mating.

In accord with the invention, I form the guide tips at the ends of the fingers in a manner so that any projection formed on a finger by inaccurate formation of the slit between fingers is displaced out of the plane of the associated finger. I accomplish this desirable result by bending the ends of the fingers about oblique lines which causes movement of the undesired projection out of the plane of the associated finger. In FIG. 7, there is shown part of a contact including fingers **14** and **15** formed by the slit **33** which is displaced to the left from the line of ideal slitting to provide the undesired projection **34**. To eliminate the adverse effect resulting from formation of the projection **34**, the ends of the fingers **14** and **15** are bent about oblique lines **35** and **36** to form the guide tips **37** and **38** which perform the same function as the tips **19** and **20** previously described. The lines **35** and **36** extend from the outer edges of the fingers toward the inner end of the slit **33** to the inner edges of the fingers so that bending of the end of finger **14** about the line **35** results in movement of the projection **34** out of the plane of finger **14** where it cannot engage a corresponding projection on another contact during contact mating.

While I have described a preferred embodiment of my invention by way of illustration, many modifications will occur to those skillled in the art. I therefore wish to have it understood I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A detachable electric connector contact comprising a blade of resilient electrically conducting material having a base portion at one end and a longitudinally split multiplanar mating head at the opposite end, the split in said mating head having an enlarged aperture at its inner end and defining a single pair of flat fingers disposed in closely spaced edge-to-edge parallel relation, each of said fingers having a planar contacting face with the

contacting faces parallel and oppositely positioned on the fingers, said fingers being relatively offset perpendicular to their contacting faces with their contacting faces substantially coplanar, the leading tips of said fingers being outturned away from each other and out of the planes of the respective fingers to facilitate complemental mating with a contact having a like mating head by longitudinal sliding engagement, said tips being outturned about oblique lines extending from the outer edges of said fingers towards the end of said split to the inner edges of said fingers.

2. A detachable electric connector contact comprising a blade of resilient electrically conducting material having a base portion at one end and a longitudinally split multiplanar mating head at the opposite end, the split in said mating head having an enlarged aperture at its inner end and defining a single pair of flat fingers disposed in closely spaced edge-to-edge parallel relation, each of said fingers having a planar contacting face with the contacting faces parallel and oppositely positioned on the fingers, said fingers being relatively offset perpendicular to their contacting faces with their contacting faces substantially coplanar, the leading tips of said fingers being outturned away from each other and out of the planes of the respective fingers to facilitate complemental mating with a contact having a like mating head by longitudinal sliding engagement, said tips being outturned about oblique lines extending from the outer edges of said fingers towards the end of said split to the inner edges of said fingers, said fingers being in slightly overlapped relation.

3. A detachable electric connector contact comprising a blade of resilient electrically conducting material having a base portion at one end and a longitudinally split multiplanar mating head at the opposite end, the split in said mating head defining a single pair of flat fingers disposed in closely spaced edge-to-edge parallel relation, each of said fingers having a planar contacting face with the contacting faces parallel and oppositely positioned on the fingers, said fingers being relatively offset perpendicular to their contacting faces with their contacting faces substantially coplanar, the leading tips of said fingers being outturned away from each other and out of the planes of the respective fingers to facilitate complemental mating with a contact having a like mating head by longitudinal sliding engagement, said tips being outturned about oblique lines extending from the outer edges of said fingers towards the end of said split to the inner edges of said fingers, said fingers being in slightly overlapped relation.

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