April 13, 1965 L. E. ROBERTS 3,178,669

ELECTRICAL CONNECTING DEVICE

Filed June 12, 1964 3 Sheets-Sheet 1

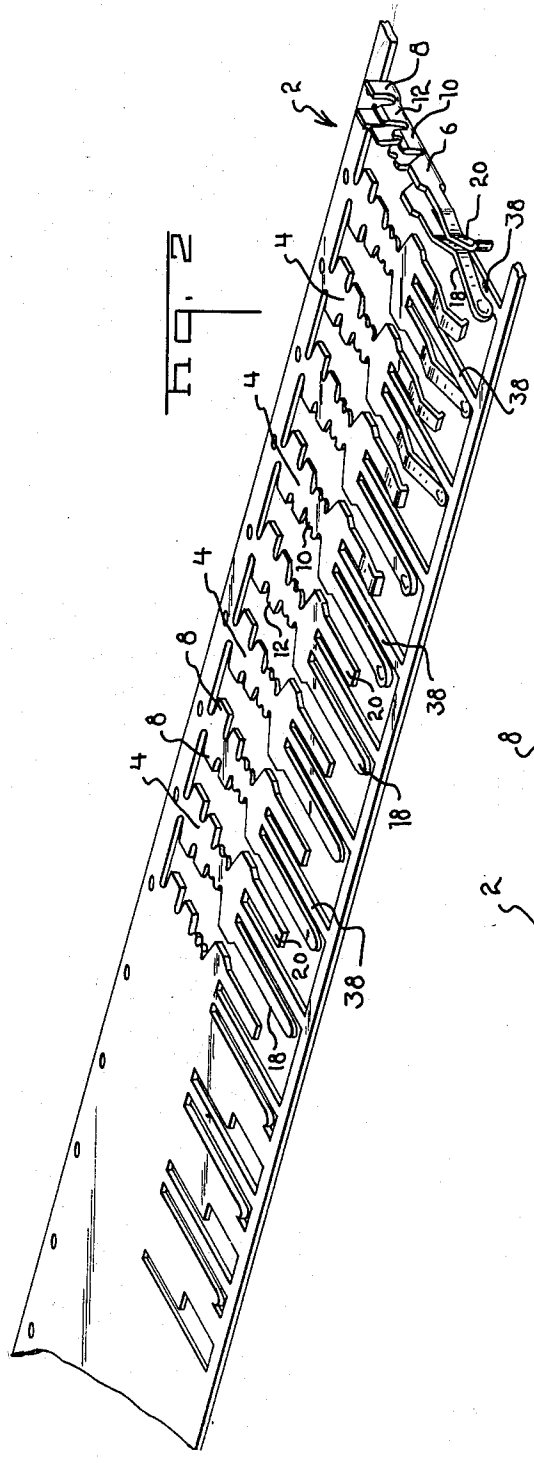

Fig. 2

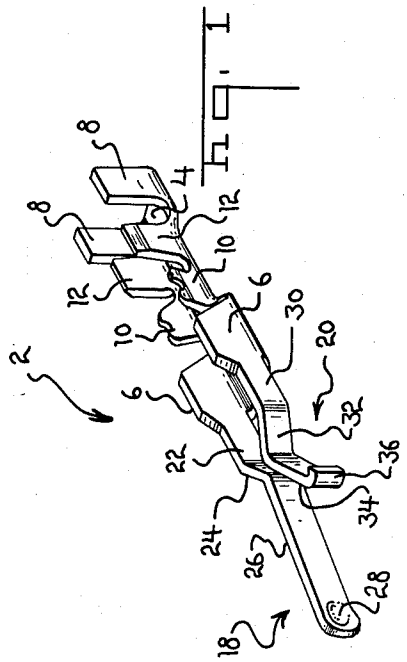

Fig. 1

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ELECTRICAL CONNECTING DEVICE

Filed June 12, 1964 3 Sheets-Sheet 2

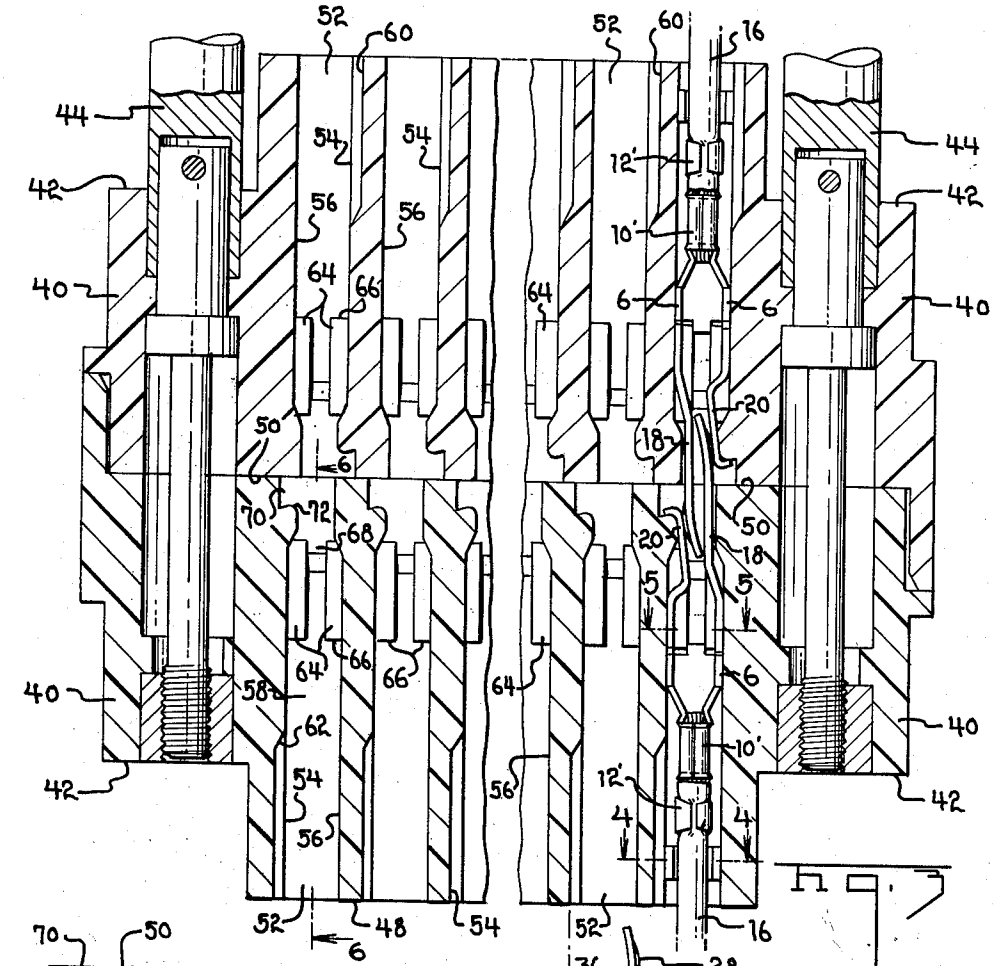


Fig. 3

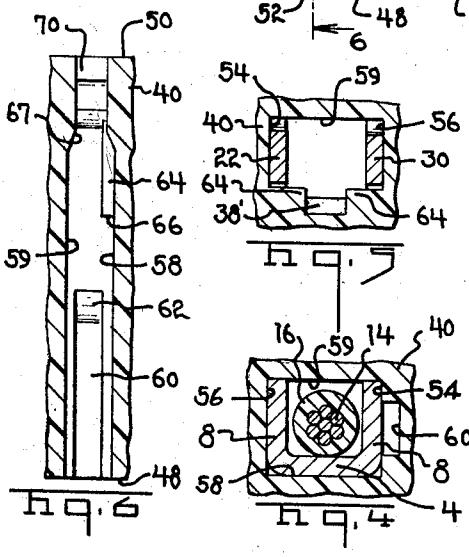
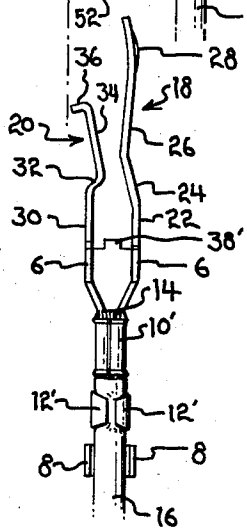


Fig. 6

Fig. 5

Fig. 4



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ELECTRICAL CONNECTING DEVICE

Filed June 12, 1964 3 Sheets-Sheet 3

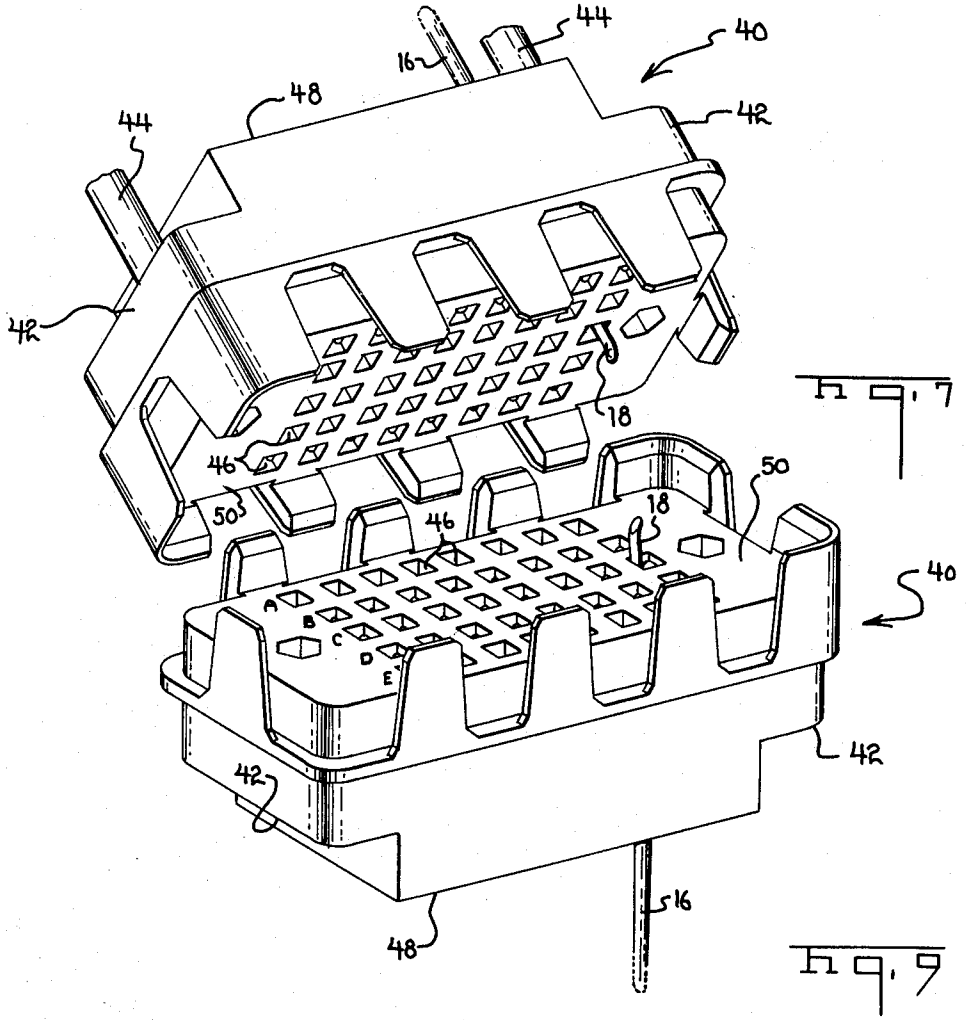

Fig. 7

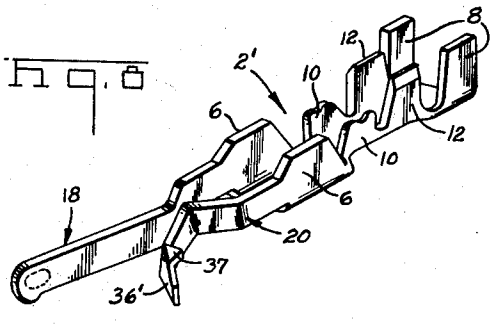

Fig. 8

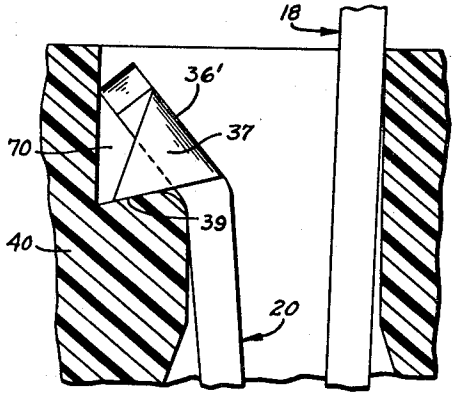

Fig. 9

United States Patent Office 3,178,669
Patented Apr. 13, 1965

3,178,669

ELECTRICAL CONNECTING DEVICE

Lincoln E. Roberts, Harrisburg, Pa., assignor to AMP Incorporated, Harrisburg, Pa.

Filed June 12, 1964, Ser. No. 374,801
5 Claims. (Cl. 339—49)

This application is a continuation-in-part of my co-pending application, Serial No. 183,542, filed March 29, 1962.

This invention relates to multi-contact electrical connectors and to contact terminals for such connectors. The phrase "multi-contact connector" is employed herein with reference to the type of disengageable electrical connecting device comprising a pair of insulating blocks which are engageable with each other and which have a plurality of terminal contacts therein. The terminal contacts are secured to the ends of wires so that upon bringing the blocks into engagement with each other, the wires are electrically connected. Multi-contact connecting devices of this type are widely used where disengageable electrical connections are required among large numbers of conductors.

An object of the invention is to provide an improved hermaphroditic type multi-contact electrical connector. A further object is to provide an improved hermaphroditic terminal contact for electrical connectors. A still further object is to provide a multi-contact electrical connector in which the individual contacts are closely spaced with respect to each other thereby permitting a high density of electrical connections in the connector block. A still further object is to provide a multi-contact electrical connector in which the force required to engage and disengage the blocks with each other is relatively low and which achieves a low resistance electrical contact between the mated terminal contacts in the insulating blocks. A still further object is to provide a durable and foolproof multi-contact electrical connecting device which is not easily damaged in the course of ordinary usage and which is substantially incapable of improper coupling and decoupling.

These and other objects of the invention are achieved in a preferred embodiment in which the terminal contact comprieses a relatively elongated web having upstanding sidewalls extending from the opposite sides thereof at each end. Means are provided on the web intermediate its ends for crimping the contact onto the end of an electrical conductor extending between one of the pairs of sidewalls. A pair of arms extend from the other pair of sidewalls beyond the web and generally along the axis of the contact, one of these arms being relatively longer than the other and having a cusp-like intermediate portion which is directed inwardly towards the axis of the terminal contact. The end portion of this first arm diverges slightly with respect to the contact axis and terminates with an outwardly convex contact surface. The shorter arm has an intermediate inwardly directed section and a divergent (with respect to the contact axis) contact ramp extending from this intermediate portion. An outwardly directed hook is provided on the end of this shorter arm to facilitate its mounting in an insulating block. The terminal contact in accordance with the invention is matable with an identical contacts upon alignment of the two contacts in opposed axial relationship with respect to each other so that as they are moved towards each other, the outwardly directed contact surface of the long arm of each contact engages the contact ramp of the other arm of the other contact.

The insulating blocks in accordance with the invention which contain the terminal contacts have cavities extending therethrough which conform to the shape of the terminal contacts in a manner such that the contacts can only be

inserted into the cavities in the proper and intended manner and will be securely held in the cavities after insertion. The cavities have a rectangular cross section throughout a substantial portion of their lengths which conforms to the cross section of the sidewalls of the web so that the contacts are firmly held by the walls of these cavities bearing against the sidewalls of the web and against the web itself. At its forward end, each cavity has a recess defining a forwardly facing shoulder over which the hooked end of the shorter arm extends. This hooked end thus prevents rearward movement of the terminal contact with respect to the block while forward movement thereof is prevented by means of a shoulder in the cavity which engages the leading edge of the web of the contact. The salient advantage of the invention is that a complete connector assembly comprising two insulating blocks each having a plurality of electrical contacts therein can be achieved with two identical insulating blocks and a number of identical terminal contacts corresponding to the cavities in the blocks. Moreover, this hermaphroditic effect, with its advantages of simplicity and standardization, is achieved without sacrifice of electrical reliability, mechanical durability, or contact density.

In the drawing:

FIGURE 1 is a perspective view of a contact terminal in accordance with a preferred embodiment of the invention;

FIGURE 2 is a perspective view illustrating the progressive stages of the forming of the contact terminal of FIGURE 1 by conventional die-stamping and forming operations;

FIGURE 3 is a cross sectional view showing a pair of insulating blocks in accordance with the invention in engagement with each other and showing contact terminals in only some of the cavities in the block;

FIGURES 4, 5 and 6 are sectional views taken along the lines 4—4, 5—5 and 6—6 of FIGURE 3;

FIGURE 7 is a perspective view showing a pair of blocks in accordance with the invention in face-to-face relationship and illustrating the orientation of the cavities of the blocks;

FIGURE 8 is a perspective view showing an alternative form of a contact terminal in acordance with the invention; and

FIGURE 9 is a fragmentary plan view, on an enlarged scale, showing the hooked end portion of the short arm 20 of the contact terminal of FIGURE 8.

Referring first to FIGURE 1, a preferred form of terminal contact 2 in accordance with the invention comprises an elongated substantially flat web 4 having a first pair of parallel sidewalls 6 extending from opposite sides of its forward end and a second pair of sidewalls 8 extending from opposite sides of its rearward end. Intermediate the ends of the web there are provided ferrule-forming ears 10 and 12 on opposite sides of the web to permit crimping of the contact onto the conducting core 14 of a wire and the insulation 16 of the wire as shown in FIGURE 3. The wire extends between the sidewalls 8 and along the web and may be crimped to the terminal contact by means of an automatic or semi-automatic crimping device as is commonly known to the art.

Arms 18, 20 extend from the forward sidewalls 6 and beyond the forward end of the web. The arm 18 has a portion 22 which is immediately adjacent to the sidewall and constitutes a planar extention thereof and an intermediate cusp-like portion 24, 26 which is directed inwardly towards the terminal contact axis. The end portion 26, of the arm 18 is slightly divergent with respect to the contact axis and terminates in an outwardly facing contact surface. Advantageously, an outwardly convex dimple or boss 28 may be provided at this contact

surface to facilitate smooth even engagement of the terminal contact with a mating contact. The extreme end portion of the arm **18** is slightly inwardly curved, again to facilitate mating of the contact with an identical contact as described below.

A relatively short arm **20** extends from the opposite one of the sidewalls **6**, this arm comprising an initial planar extension **30** of the sidewall, an intermediate abruptly inwardly directed section **32**, and a contact ramp **34** which extends divergently from this intermediate section and which faces towards the contact axis. The extreme end portion **36** of this arm is reversely outwardly bent to form a hook by means of which the contact is retained in the block cavity. The inclination of the contact ramp **34** is not critical, however, for best results its slope should be relatively gentle for reasons explained below. It will be noted that the hooked end **36** of the arm **30** is disposed laterally with respect to the contact axis of the plane defined by the sidewalls **8**, **6** so that if the end of this arm is flexed inwardly it has a tendency to return to its normal position.

Contact terminals in accordance with the invention are advantageously manufactured from strip metal by means of progressive die stamping and forming methods. FIGURE 2 shows the various stages of forming this type of contact in parallel side-by-side form so that the finished strip can be fed to an automatic or semi-automatic crimping machine which simultaneously crimps the leading contact of the strip onto a wire end and severs this leading contact from the side carrier strips. At the time of crimping the connecting slug **38** is sheared from the contact at a location adjacent to the forward end of the web. After shearing, a vestige **38'** of this connecting slug may remain on the end of the web.

Contacts in accordance with the invention can be mated with an identical contact by merely axially aligning the two contacts in face-to-face relationship and moving them relatively towards each other until the contact surfaces **28** of each contact engage the contact ramp **34** of the other contact. A preferred form of insulating block is shown in FIGURE 7 at **40** which can be engaged with an identical block to form a complete electrical connector assembly. The blocks **40** each have flanges **42** on their ends with openings extending therethrough in which are mounted suitable jack screw means **44** for holding the blocks in engagement with each other as is commonly known. The cavities **46** in the blocks which receive the contacts extend from the rearward sides **48** to the forward or mating faces **50**. Each cavity has a substantially rectangular entrance section **52** extending inwardly from the rearward side **48**. This rectangular cavity section has opposed sides **54**, **56** which are spaced-apart by a distance substantially equal to the spacing between the external surfaces of the sidewalls **6** and **8**. The remaining sides **58**, **59** of the cavity are spaced-apart by a distance substantially equal to the height of the contact as measured along the side walls **6**, **8** so that upon insertion, the sidewalls and the web bear against the surfaces of the cavity as shown in FIGURE 4. The side **56** of the cavity has a groove **60** extending partially inwardly of the rectangular section and terminating in an inwardly inclined surface **62** for reception of the hooked end **36** of the arm **20**. The forward end of the rectangular section has ledges **64** on the surface **58** which define rearwardly facing shoulders **66** adapted to act as stops for the frontal edge of the contact web.

The cavity cross section is constricted at a location **67** close to the mating face **50** and the reduced cross section of the cavity extends to and opens into this mating face. A recess **70** extends inwardly from the mating face on the side of the cavity which is adapted to receive the shorter arm **20** of the contact and a curved shoulder **72** is provided at the end of this recess to function as a bearing surface for the curved end of the arm. The cross section of the cavity in the constricted area **68** is such that the arm **20** is resiliently stressed and has a tendency to spring outwardly when its end is hooked over this shoulder.

Insertion of the contacts into the cavities of the blocks **40** is accomplished by merely aligning each contact with its respective cavity as shown in FIGURE 3 with the arm **20** in alignment with the groove **60** and moving the contacts axially through the cavity. Improper insertion is virtually impossible for the reason that the end **36** of the arm **20** will not enter the cavity unless this arm is in alignment with the groove. The contacts are moved inwardly of the cavities until the arms snap over the shoulders as described above and the forward end of the web moves against the stops **66**. After insertion, the longer arm **18** will project beyond the mating face of the cavity by a distance sufficient to permit its being brought into engagement with the contact ramp of a terminal contact in a mating connector.

It will be apparent from FIGURE 3 that the force exerted by the long arm of each contact on the contact ramp of its mating counterpart is in a direction such that it tends to move the blocks **40** laterally with respect to each other. Thus, referring to the contacts shown at the right in FIGURE 3, the long arm **18** of the lower contact exerts a force on the contact ramp of the upper contact which has a component tending to move the upper block **40** to the right in the drawing. The long arm **18** of the upper contact on the other hand exerts a force on the contact ramp of the lower contact which would tend to move the lower block **40** to the left in this Figure. These same force components would be present in all of the contacts in the row of cavities shown in FIGURE 7. It follows that when the blocks are engaged with each other, these lateral force componets must be overcome as the mating faces **50** of the block move towards each other. In order to reduce these lateral force components to a minimum and thereby reduce the force required to move the blocks together to a minimum, it is desirable to orient about half of the cavities in the block in a first attitude and the other half of the cavities in an opposite attitude. Referring to FIGURE 7, the several rows of cavities extending along the long dimension of the block are identified by the leters A, B, C, D and E. The cavities in the rows B, C and D are oriented such that the recesses **70** thereof are on the right in this figure while the cavities in the end rows A and E are oriented such that the recesses **70** are on the left. By virtue of this arrangement, the lateral force components of the contacts in the blocks are at least partially balanced out when the blocks are brought into enagagement with each other. In the particular embodiment shown, three of the rows are oriented with the cavities in one attitude while two rows are oriented with their cavities in the opposite attitude. Ideally, an equal number of cavities should be oriented in the one attitude and the same number oriented in the opposite attitude. However, this is inconvenient where an odd number of rows are provided as in the disclosed embodiment. If six rows of cavities were provided in this block, the most logical arrangement would be to have three rows in one attitude and three rows of cavities on the opposite attitude.

The particular form of block shown is provided with peripheral flanges which extend beyond the projecting long arms of the contacts as is more fully described in the copending application of Charles R. Curtis and Lincoln E. Roberts, Serial No. 183,554, filed March 29, 1962, for Multi-contact Electrical Connector, now Patent No. 3,112,974. These flanges function as polarizing and keying means for the block and additionally form a protecting shroud in surrounding relationship to the projecting arms of the contacts.

In order that the dielectric insulating blocks **40** may be hermaphorditic, that is in order that they shall be capable of being brought into engagement with an identical block, the cavities should be symmetrically arranged with

respect to at least one of the axes of the block. Thus, in the disclosed embodiment of the invention, which contains 40 cavities, the cavity row identified by the letter C is symmetrically arranged with respect to an axis extending transversely of the long dimension of the block and centrally through the openings for the jack screws. The flanges which surround the block must also be preferentially arranged as is fully described in the above-mentioned Curtis et al. application.

A principal advantage of the instant invention is that close spacing of the contacts in the dielectric blocks is achieved in spite of the fact that the contacts themselves are a hermaphroditic and nonsymmetrical (as compared with pin and socket contacts) type of contact. The features of the invention which permit such close spacing without sacrifice of electrical or mechanical integrity in the connector are briefly described below.

It will be noted that the arms **18**, **20** are disposed within the planes defined by the sidewalls **6** and **8** excepting the hooked end **36** of the shorter arm **20**. The cavities are necked down at **67** so that the openings in the mating faces of the blocks are relatively small as compared to the openings in the rearward face **48**. The divergent end **36** of the short arm **20** of each contact is received within the recess **70** of each cavity and does not extend to the mating face of the block. The arrangement of the cavities in the block is such that the recesses **70** of the lower block in FIGURE 3 are adjacent to the recesses of the next adjacent cavity of the upper block, however, since the arms are recessed with respect to the mating faces of the block, a relatively long path is provided between adjacent contacts which must be electrically separate from each other so that a high breakdown voltage between adjacent contacts is achieved. It should be added that while the openings in the rearward ends of the cavities are relatively large, this fact does not adversely affect the breakdown voltage of the connector between adjacent contacts since the contacts are themselves all contained within their respective cavities and a relatively long path is provided between adjacent contacts.

Contacts of the instant type are often plated with gold or other highly conductive metal to improve their electrical performance. Ordinarily, when contacts are moved into and out of engagement with each other, the plating is worn by the sliding contact surfaces as they move over each other and may be removed after a relatively low number of coupling and decoupling cycles. This wear problem is particularly important where the contacts are gold plated since gold plating must be kept to a minimum thickness for economic reasons. The instant type of contact reduces the plating wear to an extremely low minimum by virtue of the contact ramp **34** and the contact dimple **36** if these parts are matched to each other as regards inclination of the ramp and radius of the dimple. Particularly, the radius of the dimple and the inclination of the ramp should be such that as the dimple of one of the long arms moves over the ramp the zone of tangency of both parts, the contact zone continually changes in the same manner as the contact zone of a ball or sphere rolling over a surface continually changes as the ball moves along the surface. Since the zones of contact of the parts continually change during movement of the contacts into engagement with each other, the amount of wear on any given point is reduced to an absolute minimum.

The disclosed arrangement provides an extremely durable contact which will not be damaged easily in the ordinary course of usage. The long contact arms **18** of the contact terminals can be flexed towards the short contact arms without impairing the electrical function of the contact since this arm will snap back into its normal position after such flexure. In case of slight misalignment of a given contact with respect to its mating counterpart, the parts are brought into proper alignment as the insulating blocks are moved against each other by virtue of the inclined ramp surface of the one contact and the curved contact surface of the long arm of the mating contact. Furthermore, the actual contact force acting between each individual contact ramp and contact surface **28** is maintained within relatively close limits by reason of the relatively long stem of the long contact arm about its bending axis which is at the inwardly directed cusp portion of the arm.

Contacts in accordance with the invention are amenable to straightforward and simplified die-forming processes as is apparent from the progression of FIGURE 1. After stamping of the form of the contact from the strip, it is merely necessary to form the inwardly displaced intermediate sections of the contact arms **18**, **20** and thereafter to bend up the sides of the contact with respect to the web. Operations of this type can be formed with relative ease by conventional die-stamping and forming methods.

FIGURE 8 shows a contact terminal **21** having a modified hooked end portion **36'**. In accordance with this embodiment, the hooked end **36'** extends obliquely of the ramp portion **34** but diverges from the plane of the ramp at a smaller angle than the angle of the embodiment of FIGURE 1. A laterally extending ear **37** is provided on the upper side of the hooked end **36'** to provide a rearwardly facing edge **39**. The contact terminal of FIGURE 8 is useable with a block having cavities of the type previously described and shown in FIGURES 3–6. The hooked end portion **36'** of the arm **20** is dimensioned such that the ear **37** occupies a substantial portion of the recess **70** and the tip of the end portion **36'** normally bears against the left-hand wall of this recess as viewed in FIGURE 9. A comparative advantage of this embodiment is that the surface of the hooked end **36'** provides a somewhat wider lead-in for the long arm **18** of the mating terminal than the lead-in of the previous embodiment. In other words, when two contact terminals in accordance with the embodiment of FIGURE 8 are mated with each other, the long arms of the terminals will be guided into engagement with the ramp portions even if these long arms are initially somewhat out of alignment. It will be apparent that with the exception of this provision of a relatively wider lead-in surface, the terminal of FIGURE 8 is similar to the terminal of FIGURE 1.

Changes in construction will occur to those skilled in the art and various apparently different modifications and embodiments may be made without departing from the scope of the invention. The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only. The actual scope of the invention is intended to be defined in the following claims when viewed in their proper perspective against the prior art.

I claim:

1. A contact terminal for an electrical connector comprising, an elongated web, a first pair of parallel sidewalls extending from opposite sides of said web at one end thereof and a second pair of parallel sidewalls extending from opposite sides of said web at the opposite end thereof, means on said web intermediate the ends thereof and between said sidewalls for securing said contact to an electrical conductor extending between said second pair of sidewalls, an arm extending from and constituting a planar extension of each of said first pair of sidewalls, a first one of said arms having an intermediate cusp portion directed inwardly towards the axis of said contact and having a diverging end portion terminating in an outwardly facing contact surface, the second one of said arms being substantially shorter than said first arm and having an inwardly directed intermediate section, a contact ramp extending divergently of the axis of said contact from said intermediate section and terminating in an outwardly hooked end portion, said contact terminal being mateable with an identical contact terminal upon axial movement of said contacts towards each other until the contact surface of the first arm of each contact terminal engages

the contact ramp of the second arm of the other contact terminal.

2. Electrical connecting means comprising an insulating block having a contact terminal receiving cavity extending therethrough and a contact terminal in said cavity, said cavity having a rearward end, a first section of said cavity having a rectangular cross section extending from said rearward end to a location adjacent the forward end of said cavity, one pair of opposed walls of said cavity tapering towards each other in a zone adjacent to said forward end, one of said opposed walls extending axially from said adjacent zone to said forward end and the other of said opposed walls having a reentrant surface defining a forwardly facing shoulder recessed from said forward end, said contact terminal having a web portion disposed in said rectangular first section, upstanding parallel sidewalls on said web, said web and sidewalls bearing against the opposed walls of said first section whereby said contact is firmly wedged in said cavity, a first arm extending from one of said sidewalls as a planar extension thereof, said first arm having an intermediate cusp portion directed inwardly towards the axis of said contact terminal and said first arm projecting substantially beyond said forward end, a second arm extending from a second one of said sidewalls, said second arm having an inwardly directed intermediate section and a diverging contact ramp, said second arm terminating in an outwardly hooked end portion extending into said recess and over said forwardly facing shoulder, said connecting means being mateable with an identical connecting means disposed in axial alignment and opposed relationship thereto upon movement of said connecting means together until the end of the first arm of each contact terminal engages the contact ramp of the other contact terminal.

3. Apparatus as set forth in claim 2 wherein said block has a plurality of cavities extending therethrough, a first group of said cavities having said reentrant surface on one sidewall and a second group of said cavities having said reentrant surface on an opposite sidewall from said first group whereby, when said block is brought into engagement with a mating block, the lateral force produced

by the contact terminals in said first group of cavities is counteracted by the lateral force component of the contact terminals in said second group of cavities.

4. Apparatus as set forth in claim 3 wherein said first group of cavities is arranged in a first row in said block and said second group is arranged in a second row.

5. An insertable contact terminal for an electrical connector comprising, an elongated web, a pair of sidewalls extending from opposite sides of said web at one end thereof, stablizing means extending from said web at the opposite end thereof, said stabilizing means and said sidewalls being cooperable with the sidewalls of a connector block cavity to stabilize said contact terminal within said cavity, means on said web intermediate the ends thereof for securing said contact to an electrical conductor, a pair of arms extending from and constituting planar extensions of each of said sidewalls, a first one of said arms having an intermediate cusp portion directed inwardly towards the axis of said contact and having a diverging end portion terminating in an outwardly facing contact surface, the second one of said arms being substantially shorter than said first arm and having an inwardly directed intermediate section, a contact ramp extending divergently of the axis of said contact from said intermediate section and terminating in an outwardly hooked end portion, said contact terminal being mateable with an identical contact terminal upon axial movement of said contacts towards each other until the contact surface of the first arm of each contact terminal engages the contact ramp of the second arm of the other contact terminal.

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