June 2, 1970 W. SCHEINGOLD ET AL 3,516,048

WIRE-FORMED CONTACT

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FIG. 1

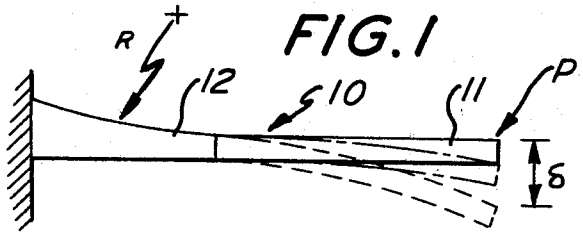


FIG. 2

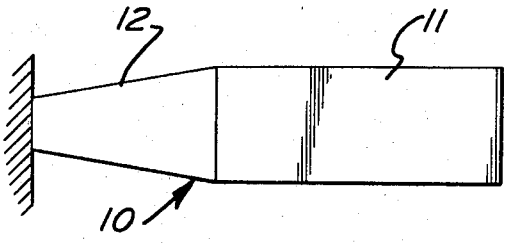


FIG. 3

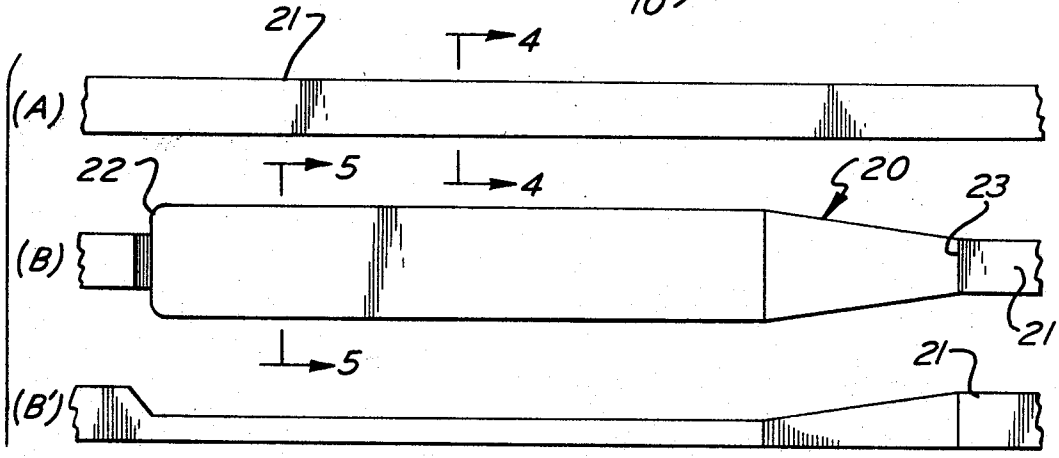


FIG. 4

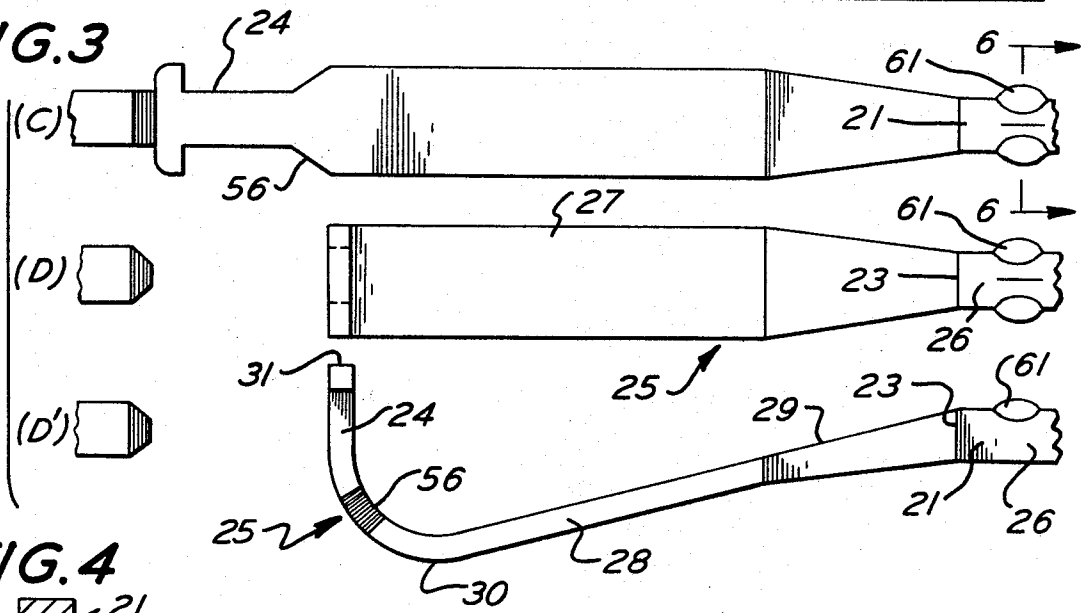
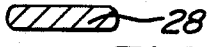




FIG. 5



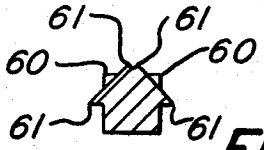


FIG. 6

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WIRE-FORMED CONTACT

Filed March 24, 1967 2 Sheets-Sheet 2

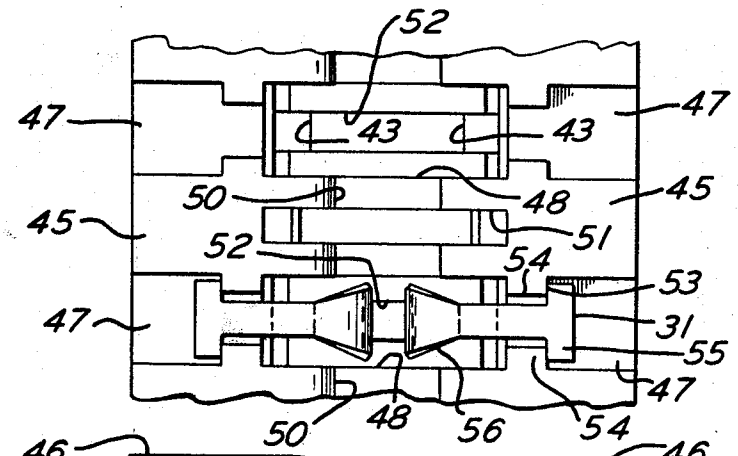


FIG. 7

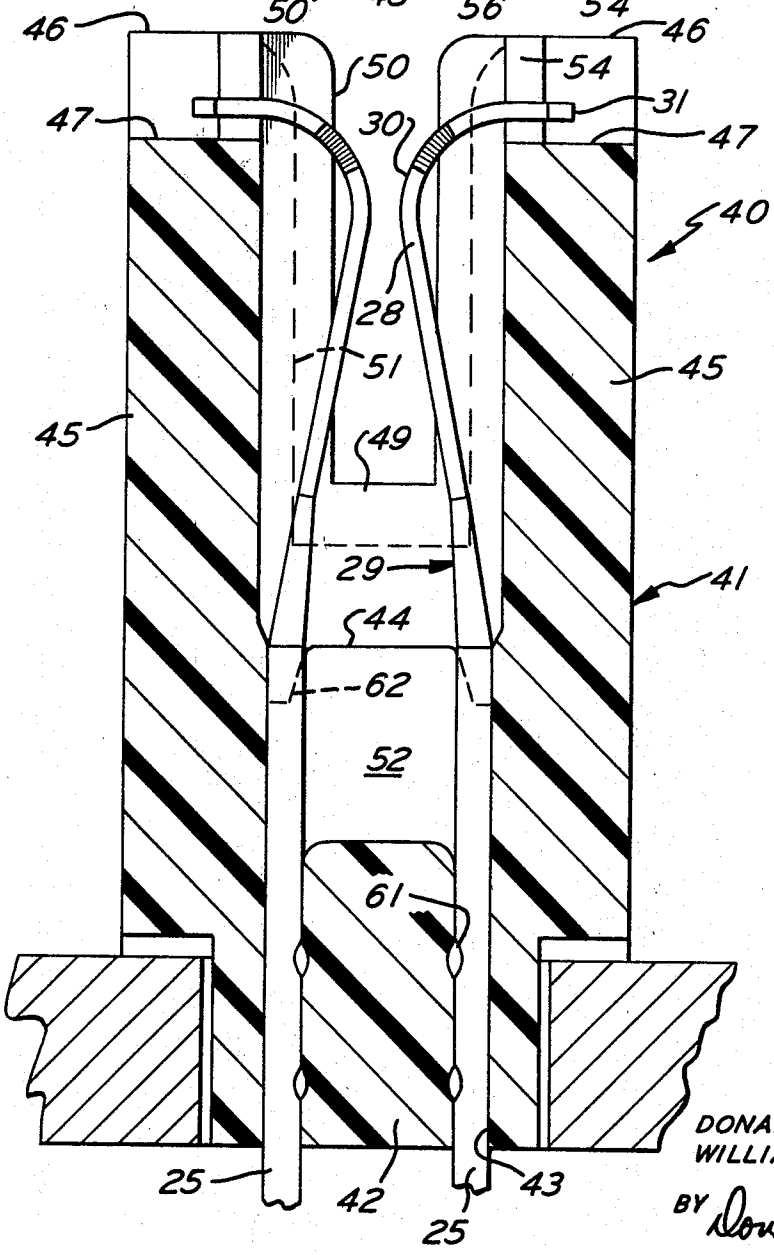


FIG. 8

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WIRE-FORMED CONTACT

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Int. Cl. H01r 9/16
U.S. Cl. 339—221 3 Claims

ABSTRACT OF THE DISCLOSURE

A contact for a card-edge connector has a hook-shaped nose-section that is work-hardened by swaging a section of a non-round wire. The nose section is in the form of a wiping finger whose free end has a uniform section-modulus smaller than the section-modulus of the tail. A transition portion integrally connects the wiping finger to the tail section and has a section modulus that uniformly increases in a direction toward the tail. The cross-section areas of both the wiping finger and the transition portion are substantially the same as the cross-sectional area of the wire. At the free end of the wiping finger, a dynamic stop is provided in the form of a pair of width-wise notches that engage a projection on an insulated housing.

This invention relates to a contact for a card-edge connector.

A card-edge connector is used to terminate circuitry contained on printed circuit boards and includes an insulated casing having a groove to receive an edge of a printed circuit board to which a plurality of spaced conductive tracks lead from the circuitry on the printed circuit board. Mounted in the casing are a plurality of spaced contacts each of which has a nose section that resiliently engages the respective tracks for the purpose of establishing electrical engagement therewith and providing a force on the printed circuit board that resists its withdrawal. Each contact also has a tail section adapted to be connected to a conductor by a conventional procedure, the most popular today being the so-called solderless-wrapped connection. Such connection requires a relatively sharp cornered tail section of considerable length relative to the transverse dimensions of the tail so that a contact of the type described has a non-round tail section, and a nose section that includes a curved wiping finger. The tail and nose sections are integrally connected by a body portion whose function is to permit the contact to be securely attached to the insulated casing.

Given the available spatial parameters of the connector, the thickness and tolerance of the printed circuit board, withdrawal and insertion forces for the printed circuit board, etc., it is possible to arrive at a spring rate for the contact nose section that will give the desired performance results. With this spring rate in mind, the designer is required to produce a cantilever beam that achieves this rate and yet will not have internal stresses that exceed the yield strength of the material being used.

A conventional approach to producing a contact of the type described is to stamp the contact from sheet material providing a blank that is folded and bent into a so-called "double cantilevered" contact, as evidenced, for example, by U.S. Pat. No. 3,231,848, and No. 3,233,208. There are a number of basic problems with using a "strip" contact. One problem arises because the nose-section must generally be of a thickness considerably less than that of the tail section when solderless-wrapped terminations are to be made, in order for the nose-section to provide the spring characteristics necessary to meet specifications. This requires two-stage strip material, the tail section being blanked from the thicker section and the nose section being blanked from the thinner section. To obtain two-stage material, a milling operation is involved and this adds to the expense of the finished product.

Another problem is the lack of different physical properties between the nose and tail section. Thus, while it may be desirable in many instances to have a "soft" tail section to facilitate making solderless-wrapped terminations, it is usually desirable to have a much "harder" nose section to increase the yield strength of the section and so prevent the nose section from taking a permanent set under high load conditions.

While the last described problem can be accommodated by proper design, selection of material, heat treating, etc., there is an inherent deficiency in forming contacts from strip material, and such deficiency is the amount of scrap produced. For many complex contacts, the scrap amounts to about 75% of the material, and it is to the alleviation of this specific problem that the present invention is directed, although the invention also solves the other problems.

Briefly, the invention involves forming the nose section of a contact from a square or rectangular wire by a process of swaging a section of the wire in a particular manner. The cross-sectional area of the wire thus becomes a constraint on the design of the nose section since such area represents the maximum area that any section of the nose section can have. Carried to its ultimate, the nose section should require no significant blanking with the result that there is no scrap.

The swaging contemplated in this invention involves reducing the thickness of the wire along a section thereof so that at the forward end of the section (e.g., the end thereof that will eventually be the free end of the nose section) the thickness is substantially less than the thickness of the wire and such thickness increases in a direction toward the rearward end of the swaged section. In addition, the width of the swaged section at the forward end is substantially greater than the width of the wire and such width decreases in a direction toward the rearward end of the swaged section. As a consequence of this, the section-modulus of the nose section increases in a rearward direction matching the direction in which the bending stresses increase to maintain the internal stresses at a level below the yield point of the material. Actually, the work hardening of the nose section resulting from the swaging operation increases the physical properties of the nose portion over those of the base material, and this also assists in increasing the efficiency of the material being used. Theoretically, it is possible to achieve a parabolic change in both thickness and width, but for practical reasons it is far simpler, from a tool design and maintenance standpoint, to swage the section of wire to produce at the forward end of the swaged section, a portion of uniform section-modulus that operates as a wiping finger to engage a conductive pad on a printed circuit board, and at the rearward end of the swaged section, a transition portion that connects the wiping finger to the remainder of the wire and has a section modulus that increases in a rearward direction.

Such wiping finger is conveniently designed to have a substantially uniform thickness less than the thickness of the wire, and a substantially uniform width greater than the width of the wire. On the other hand, the transition portion is conveniently designed to have a thickness that uniformly increases in the rearward direction. Where the cross-sectional area of the wiping finger and the transition portion is substantially the same as the cross-sectional area of the wire, there is no waste of material and a very efficient and inexpensive contact is achieved.

The invention is described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a side view of a cantilever beam used as a model to design the nose-section of a card-edge connector contact;

FIG. 2 is a top view of the beam shown in FIG. 1;

FIG. 3 is a composite showing the steps by which the nose-section of a card-edge connector is swaged from a wire;

FIG. 4 is a section view taken along the line **4—4** of FIG. 3(A);

FIG. 5 is a section view taken along the line **5—5** of FIG. 3(B);

FIG. 6 is a section view taken along the line **6—6** of FIG. 3(C);

FIG. 7 is a top view of a card-edge connector using a wire-formed connector of the present invention; and

FIG. 8 is a side view, in section, of the card edge connector shown in FIG. 7.

If a material of a system follows Hooke's law and the conditions are such that small deformation due to displacements can be neglected in considering the action of the forces involved, the displacements are linear functions of the forces and the strain energy of such a system can be expressed as a homogeneous function of the second degree in the acting forces. In such case, the theorem of Castigliano states that the partial derivative of strain energy with respect to any such force gives the displacement corresponding to this force. Assuming cantilever beam **10** which is shown in elevation in FIG. 1 and which has a non-uniform section-modulus, is a model for the nose section of a card-edge connector contact, the application of the theorem of Castigliano provides an analytical spring rate at follows:

$$k=\frac{(E)(b_o)(h_o)^3}{12G}=\frac{P}{\delta}$$

where k=spring rate (ratio of load P to deflection δ), E is Young's modulus, b_o is the width of the beam at the support, h_o is the thickness of the beam at the support, and G is a "geometry factor" dependent upon the lengthwise variation of width and thickness in each of the two portions **11** and **12** of the beam. Portion **11** at the free end of the beam is representative of the wiping finger of a contact and portion **12** that connects the free end to the support is a transition portion wherein the maximum stress is usually developed at a point about 90% of the length of the transition portion from the beam support. Because portion **11** is representative of the contact wiping finger, and because it is usually desirable to space contacts in a connector as closely together as possible, the width and thickness of portion **11** are usually made uniform. This simplifies somewhat the terms in the "geometry factor," but does not, however, affect the general nature of the analytical approach since any lengthwise variation in width and thickness can be used if desired. A constraint, however, is placed on the design if the beam is to be swaged from a wire of thickness h_o and of width b_o, since the area of any section of the beam cannot exceed the product $(b_o)(h_o)$.

The optimum design, therefore, is one in which the cross-sectional area of portion **11** is the same as the area of the wire from which the portion is to be swaged. For example, if 0.025 inch square wire is to be used, the optimum design is achieved if portion **11** is 0.010 inch thick by 0.0625 inch wide. Another combination is 0.0125 inch thick by 0.050 inch wide, etc. With this constraint in mind, and perhaps with the beam length fixed by outside considerations, there are usually sufficient variables in the length of the transition portion **12**, its lengthwise variation, etc., to permit the geometry factor to yield a desired spring rate.

With the contact configuration designed on this basis, the next problem is to determine whether the stress due to maximum deflection will exceed the yield point of the material. The stress is highest in the transition portion, and is very responsive to the lengthwise variation in the beam thickness. A reduction in stress is achieved if the lengthwise variation is made non-linear and good results are achieved by making the top surface of the transition portion arcuate rather than flat. This change causes only a second-order effect in the spring rate and so does not affect the validity of the design. As indicated previously, the maximum stress usually occurs at about 90% of the length of the transition section measured from the support. This maximum stress is checked against the yield point of the material to be used in the contact, taking into account the increase in the yield point that is achieved by cold-working the material during the swaging operation. The work-hardening of the material also provides a better base for gold-plating, and resists damage during use due to test probes and the like.

Having followed the above design procedures, there is a very good likelihood that contact with the dimensions so generated will perform to specifications. One such contact designed in this manner uses beryllium copper (quarter-hard) and has an 0.025 inch square tail, a transition portion length of 0.090 inch, total beam length of 0.290 inch, and is 0.0125 x 0.050 inch in width and thickness at the free end.

The method for forming a contact of this type, where the free end cross-sectional area is to be substantially the same as the cross-sectional area of the wire, is illustrated in FIG. 3. In one operation, a section **20** of wire **21** is swaged to reduce its thickness as shown at (B) in FIG. 3. At one end **22** of section **20**, the thickness is substantially less than the thickness of wire **21**, and the thickness increases in a direction toward the other end **23** of the section. The width of section **20** at end **22** is substantially greater than the width of wire **21**, and the width decreases in a direction toward end **22**. After blanking operation shown at (C) in FIG. 3 to notch the free end of the contact as shown at **24**, the forming operation shown at (D) and (C) in FIG. 3 is carried out. The swaging, blanking and forming operations, in and of themselves, are entirely conventional and form no part of the present invention except as they are related specifically to operating on a wire to manufacture a card-edge connector contact.

The completed contact **25** shown at (D) in FIG. 3 thus has a square tail section **26**, and a work-hardened hook-shaped nose section **27** on the forward end **23** of the tail section and integral therewith. At the free end of nose section **27** is curved wiping finger **28** that is adapted to engage a conductive track on a printed-circuit board (not shown) in a conventional manner. Transition portion **29** integrally connects wiping finger **28** to the tail section **26** and has a section-modulus that uniformly increases in a rearward direction. On the other hand, the wiping finger has a uniform section-modulus smaller than the section-modulus of the tail section of the contact. The cross-sectional area of the nose section at any location relative to end **23** of the tail is substantially the same as the cross-sectional area of the tail itself, and in the contact shown, the transition section changes thickness linearly but the sharp corners at the junction between the transition portion and the tail between the transition portion and the wiping finger are blended to reduce stress concentration. This facilitates production and maintenance of the die used in the swaging operation, so that the thickness width variation with length of the transition portion is non-linear and takes a shape dependent upon the flow of metal during the swaging operation.

As seen best at (D') in FIG. 3, transition portion **29** of contact **25** is bent out of alignment with the axis of tail **26**, and wiping finger **28** continues inclined relative to the axis and then curves around at **30** toward the axis, finally terminating in a free end **31** that is substantially perpendicular to the axis. The purpose of this nose section configuration is apparent from a consideration of FIG. 8 which shows an elevation section through card-

edge connector **40**, and indicates how free end **31** of a contact cooperates with the insulated casing **41**. Specifically, casing **41** includes elongated base **42** having two rows of spaced holes **43** therein at each location that is to receive a contact, each hole having the same cross-section as the tail section of the contact. For example, if the tail is 0.025 inch square wire, the hole may be 0.026 to permit the tail to be inserted into the hole in the base from the upper side **44**. Casing **41** also includes a pair of spaced vertical walls **45** on the upper side **44** of the base adjacent the rows of spaced holes, such walls terminating in a free edge **46** that is notched at **47** in alignment with the holes **43**.

As seen in FIG. 7, holes **43** are arranged in lateral pairs in slots **48** molded into the casing, the slots being defined by lateral walls **49** provided with card-edge receiving slots **50** adapted to receive the edge of a printed-circuit board. Lateral walls **49** are vertically slotted as at **51** to reduce the mass of molded material, and a smaller central vertical slot **52** is provided at the bottom of each slot **48** for the same purpose.

In assemblying the contacts into the insulated casing, the tail section of a contact is inserted into the base **42** from the upper side **44**. The casing preferably is a thermo-setting plastic material such as diallyl phthalate, although thermoplastic material can also be used if desired. The 0.001 inch nominal clearance between the contact tail and the hole effects entry of the tail into the hole permitting the contact to be pulled downwardly by the tail until the free end **31** of the contact is contained in notch **47**. In this position, the curved part **30** of the wiping finger is spaced from the wall **45** and is laterally located in slot **48** at a position where it will be engaged by a conductive pad on the edge of a printed circuit board when the latter is inserted into slot **50** of the connector.

To function properly, contact **25** must be maintained at the proper depth of insertion, and the curved part **30** of the wiping finger on one contact must be prevented from touching the opposite contact. The latter condition may arise when a printed circuit board is rapidly withdrawn freeing the opposite wiping fingers from load and permitting them to vibrate until they reach their normal position. To prevent this, a dynamic stop for the contact must be provided and it is conventional to achieve this with a lateral projecting tab on the free end of the contact that engages a projecting ridge on the insulator casing. With a contact blanked from strip material, the provision of a lateral projecting tab on the free end of the wiping finger is no problem since there is adequate material available. When, however, a contact is swaged from wire and the wiping finger has a cross-sectional area substantially the same as the cross-sectional area of the wire from which it is swaged, there will be no material for the tab.

The present invention solves this problem because the free end of the wiping finger on opposite width-wise edges **55** is provided with notches **24**. These notches each have shoulders **53** that can be seated behind stops **54** molded into the walls that form notches **47** in the mold casing (see FIG. 7). Stops **54** will also serve to pre-load the contact if this condition is desired and the wiping finger is designed for pre-load. That is to say, the normal lateral position of the free end **31** of the wiping finger under no-load conditions could be closer to the center of the insulated casing, and it would be necessary to load the contact and thus deflect it to seat the shoulders **53** behind strips **54**. This is most easily accomplished during assembly by deflecting the wiping finger as the contact is drawn to its final junction.

Each notch **24**, as seen in FIG. 7, is long enough to provide clearance for stop **54** as the contact is deflected by the insertion of a printed-circuit board (not shown) into slot **50**. Because of this, the rearward edge **56** of notch **24** is inclined at about 45° relative to the width-wise edges of the wiping finger. This arrangement will prevent the edge of the printed-circuit board from snagging on the rearward edge of the notch during insertion of the board into slot **50**. Without this arrangement, the relatively thin wiping finger is susceptible to damage by the board.

The lack of material from which lateral projections can be blanked from the tail of the contact when it is swaged from wire also complicates the formation of stops to vertically locate the contact.

The present invention solves this problem by coining or swaging a portion on the tail section to establish an up-set that extends beyond the cross-sectional projection of the tail. This is shown in FIGS. 3 and 6, and is achieved by a pair of tools located to one side of the tail section with faces inclined at a 45° angle. These tools are driven into opposite corner edges **60** of the wire in the tail section during the blanking operation that forms notches **24** in the wiping fingers. The resulting coining of the wire causes a pair of up-set bumps **61** to appear as the material of the wire is rearranged as shown in FIG. 6. The resultant up-set bumps **61** will bite into the molded material as the contact is drawn into its final vertical position. Sufficient resistance to movement will result, and the contact will be securely attached to the casing. The latter, as seen in FIG. 8, is provided with lateral stops **62** on opposite sides of slot **48** to permit a contact with locating stops to be used with the casing if desired.

When the contact is drawn to its proper vertical position, the junction **63** between the tail section and the transition portion of the nose section of the contact is even with bevel edge **64** on the inner surface of wall **45** thus establishing the built-in base of the cantilever beam. The length of such beam extends approximately to curved part **30** of the wiping finger. It has been found from actual experience that the lack of locating stops on the contact to provide vertical positioning is advantageous because the contact performance is not seriously degraded when the contact location is moved vertically downward a distance comparable to the wire size. This lowers the point of engagement of the wiping finger with a printed circuit board with respect to the bottom of slot **50** to accommodate designs of the conductive tracks on different printed-circuit boards.

While this disclosure is primarily concerned with wire that is 0.025 square inch, it is obvious that the design principles and swaging operations can be employed when rectangular contact tails are required or when 0.045 inch square tails are required. In the latter case, of course, the cross-sectional area of the crimping finger required for proper spring-rate performance is often smaller than the cross-sectional area of the wire, and in such case, the wiping finger must be blanked. There is a distinct advantage in not having to blank the wiping finger, and that has to do with edge preparation. Referring to FIG. 5, the cross-section of a swaged and unblanked wiping finger is shown. The swaging operation produces curved edges as shown in FIG. 5. This is highly desirable because there are no sharp corners to scratch the conductive pad on the printed-circuit board. When the wiping finger is blanked, however, the edges will be sharp and must be coined to achieve a rounded effect. Thus, swaging the wiping finger from wire directly eliminates the need to coin the edges.

While the transition portion **29** of the contact is shown in FIGS. 3(D') and 8 as being trapezoidal in shape with the forwardly top and bottom surfaces as straight lines, this invention contemplates curved surfaces as indicated in FIG. 1. That is to say, the top surface of portion **29**, for example, could be arcuate with a value that provides an acceptable stress distribution as indicated previously. In such case, the top surface of the contact at the junction between portion **28** and finger **29** would be faired so that the junction is not particularly noticeable by inspection. However, the significant feature of the transition portion remains, namely the relatively rapid rate of increase in

the section-modulus in the transition portion adjacent the tail section as compared to the rate at which the section-modulus increases in the transition portion adjacent the wiping finger. In addition, the transition portion always involves a cross-sectional configuration in which the width uniformly increases and the thickness uniformly decreases in a direction toward the wiping finger. While this configuration is particularly applicable to swaged wire contacts, the entire design approach previously indicated is applicable to contacts swaged from strip.

What is claimed is:

1. A contact for a card edge connector comprising:
(a) a non-round tail section; and
(b) a nose section on the forward end of the tail section including a curved wiping finger at one end of said nose section adapted to engage a conductive pad on a printed circuit board, and a transition portion between the tail section and the wiping finger;
(c) said nose section being thinner than the tail section of the contact;
(d) said transition portion having a section-modulus that uniformly increases in a rearward direction;
(e) the cross-sectional area of the wiping finger, except adjacent its free end, being substantially the same as the cross-sectional area of the tail section;
(f) said wiping finger having at least one notch on a widthwise side edge of the wiping finger adjacent the free end thereof.

2. A card edge connector having a contact mounted in an insulating casing comprising:
(a) said contact having a non-round tail section;
(b) said contact having a nose section on the forward end of the tail section including a curved wiping finger at the free end of said nose section adapted to engage a conductive pad on a printed circuit board, and a transition portion between the tail section and the wiping finger;
(c) said nose section being thinner than the tail section of the contact;
(d) said transition portion having a section-modulus that uniformly increases in a rearward direction;
(e) said transition portion being bent out of alignment with the axis of the tail section, and the wiping finger continuing from the transition portion inclined to said axis and then curving around toward said axis until the free end of the wiping finger is substantially perpendicular to said axis;
(f) said insulating casing having a base with a hole therein and a vertical wall on the upper side of the base adjacent the hole;
(g) the tail of said contact being inserted into the hole in the base from the upper side thereof to a predetermined depth so that the nose section overlies the vertical wall with the curved portion of the wiping finger being spaced from said wall and the free end of the wiping finger overlying the free edge of the wall;
(h) means on the tail section of said contact for gripping the walls of the base defining the hole to vertically locate the contact in the casing; and
(i) co-operable stop means on the free end of said wiping finger and the free edge of the wall for limiting the spacing between the curved portion of the wiping finger and the wall;
(j) the stop means on the free end of said wiping finger being constituted by a notch in a widthwise edge of said wiping finger adjacent the free end thereof, and the stop means on the free end of said wall being constituted by a projection that extends into said notch.

3. A printed circuit board contact made from a length of non-round wire comprising:
(a) a tail section of given cross-sectional area defined by the rearward portion of said non-round wire;
(b) a nose section on the forward end of the tail section, including a curved wiping finger at the free end of said nose section adapted to slideably engage a conductive pad on a printed circuit board; and
(c) a transition portion between the tail section and the wiping finger;
(d) said nose section being thinner than said tail section and work hardened in comparison to the rearward portion of said wire which forms the tail section of the contact;
(e) said transition portion having a section modulus that uniformly increases in a rearward direction;
(f) the cross-sectional area of the transition portion at any location between the tail section and the wiping finger being substantially the same as the cross-sectional area of the tail section;
(g) the cross-sectional area of the wiping finger, except adjacent its free end, being substantially the same as the cross-sectional area of the tail section;
(h) the wiping finger being of uniform width except adjacent its free end;
(i) the wiping finger having a pair of notches on opposite widthwise edges of the wiping finger adjacent the free end thereof.

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RICHARD E. MOORE, Primary Examiner

U.S. Cl. X.R.

339—252, 276; 29—629