United States Patent

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[54] METHOD OF FORMING SWAGED CONTACTS USING PROGRESSIVE DIE
3 Claims, 11 Drawing Figs.

[52] U.S. Cl. 113/119, 29/630
[51] Int. Cl. B21d 53/26
[50] Field of Search 113/119; 29/630C; 339/17, 176NP, 252, 258

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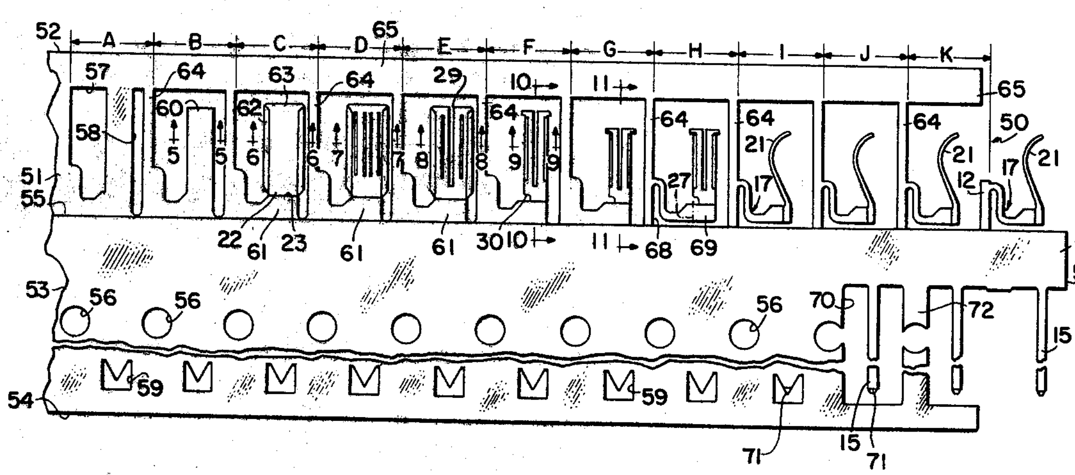
ABSTRACT: The nose section of a printed circuit board connector stamped from a strip of metal has two different thicknesses achieved by progressively piercing a U-shaped hole in the strip to form a cantilevered lug oriented normal to the grain direction, and then swaging the lug to increase its width and reduce its thickness. The U-shaped hole provides clearance for the two dimensional growth of the lug resulting from the swaging operation without affecting the remainder of the strip which is then progressively pierced to form a cantilevered car oriented in a direction parallel to the grain with the swaged lug supported on the free end of the car. The cantilevered car is then progressively bent along the line perpendicular to the grain to turn the lug so that it defines a surface perpendicular to the car thus establishing the wiping finger of the contact.



PATENTED FEB 2 1971

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SHEET 1 OF 2

FIG. 3

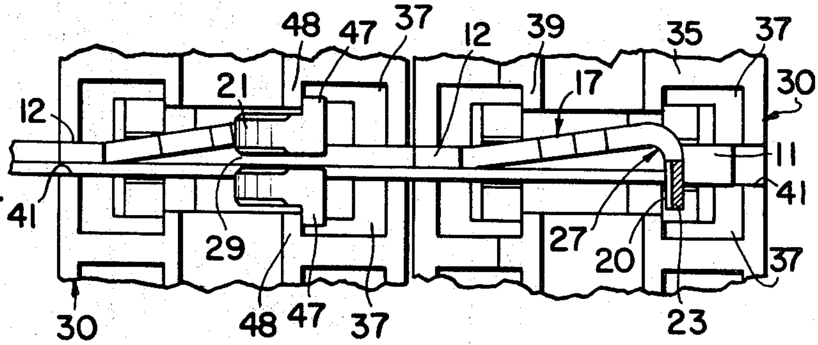


FIG. 2

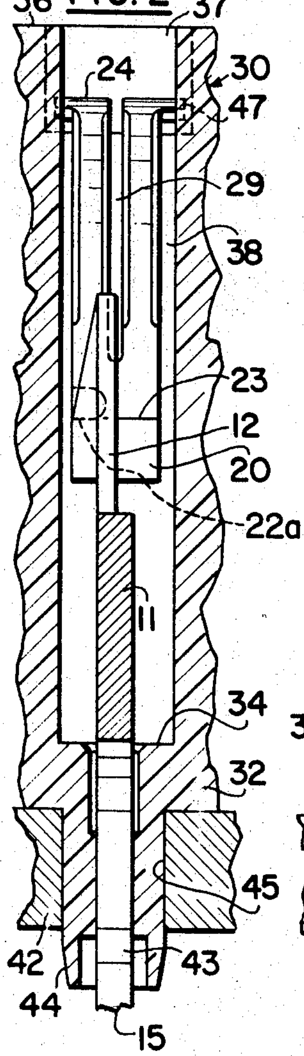
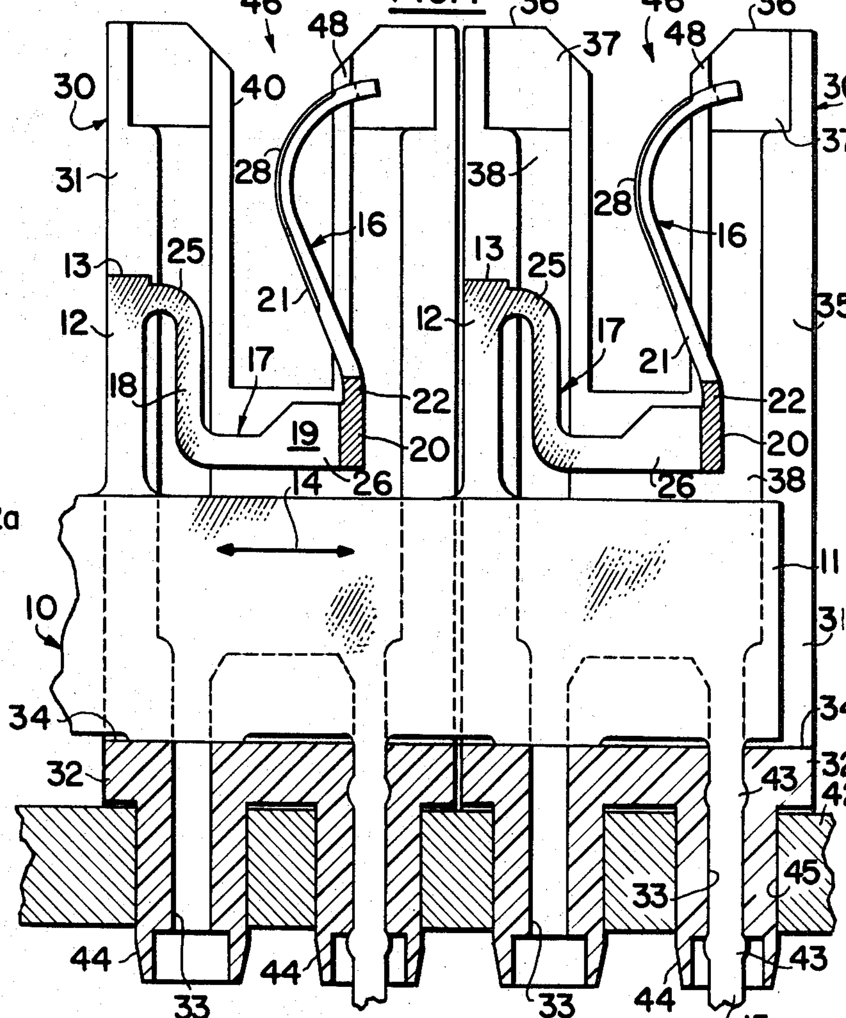


FIG. 1



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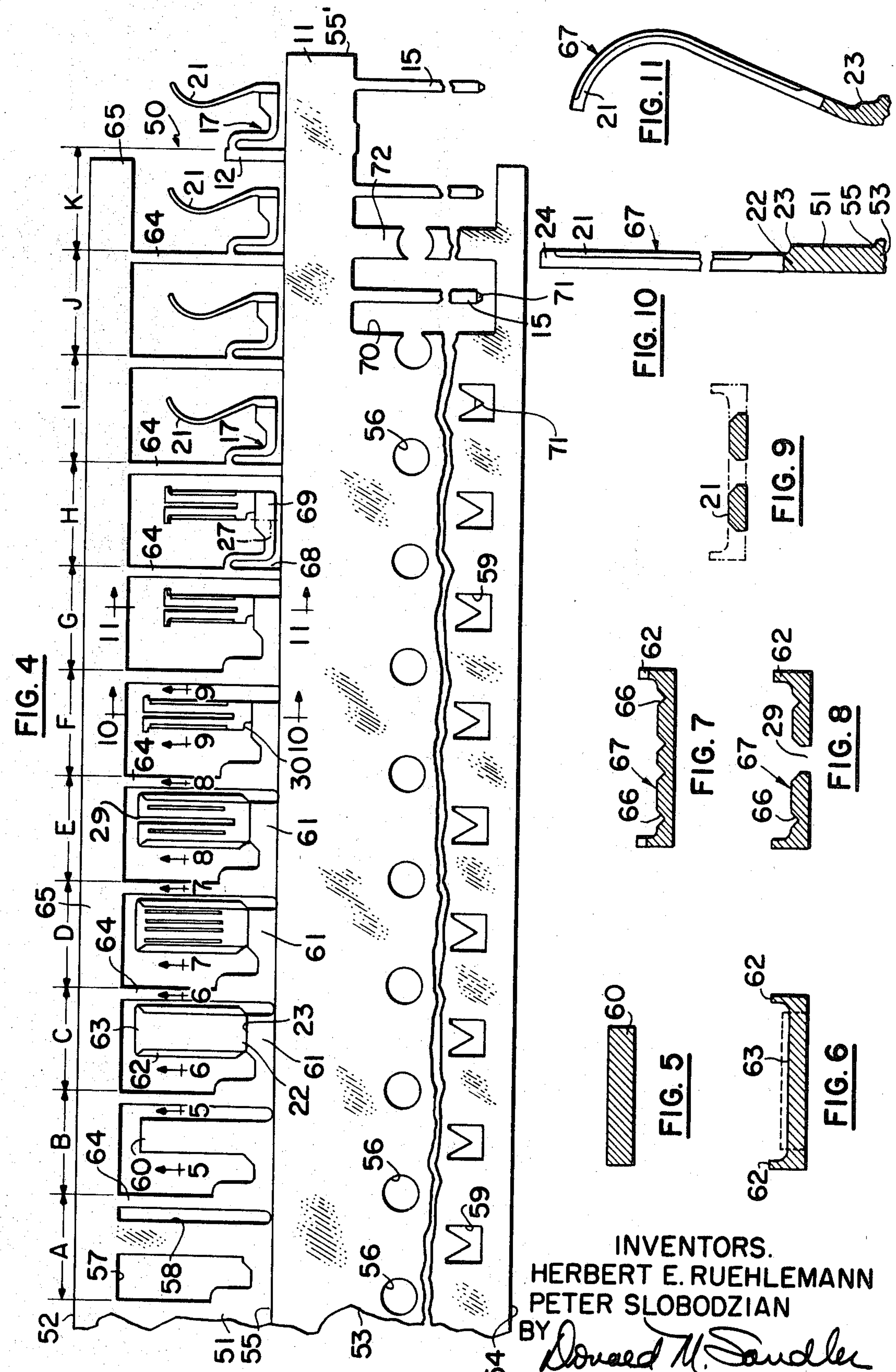

FIG. 4

FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 10

FIG. 11

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METHOD OF FORMING SWAGED CONTACTS USING PROGRESSIVE DIE

This is a division of application Ser. No. 630,612 filed Apr. 13, 1967, now abandoned.

This invention relates to a contact for a card-edge connector, and to a method for making such contact from strip material using a progressive die.

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 resisting withdrawal. Each contact also has a tail section to which conductors can be attached for effecting internal and external connections with the circuitry on the printed circuit board, and a body section interconnecting the nose and tail sections.

Ideal contacts of the type described are distinguished by a difference in thickness and hardness between the nose section on the one hand, and the body and tail sections on the other hand. The size and hardness of the tail section is dictated by the type of termination to be made, the currently popular one being the so-called solderless-wrapped connection which has been standardized, in the main, to 0.025 inch and 0.045 inch square tails. Grade A phosphorous bronze provides the ideal degree of hardness for connections of this type although this material is often too soft to give the nose section the required yield stress.

When contacts of the type described are stamped from a strip of material using a progressive die, the thickness of strip is determined by the tail size of the contact, but such thickness is generally considerably greater than the thickness that provides the proper deflection characteristics for the nose section of the contact, For this reason, it is conventional to use two-stage strip material fed into the die so that the nose section is stamped from the thinner portion of the strip adjacent one edge, and the tail section is stamped from the thicker portion adjacent the other edge. While this arrangement provides the desired thickness differential between the nose and tail sections, the hardness differential frequently must be sacrificed at the expense of the tail section in order to obtain the requisite degree of hardness for the nose section to accommodate the stresses induced therein by deflection resulting from engagement with the printed circuit board. Accordingly, it is often necessary to use two-stage beryllium copper strip rather than the less expensive phosphorus bronze in order to obtain a nose section that will not fail when deflected by the printed circuit board, even though the tail section will be harder than optimum.

The use of two-stage beryllium copper strip results in contacts which are considerably more expensive than contacts made from single-stage phosphorus bronze strip, and which lack the optimum tail softness for making solderless-wrapped terminations. Therefore, the primary object of the present invention is to provide a method for utilizing single-stage relatively inexpensive strip material to produce a contact whose nose section is thinner and harder than the tail section. It is a further object of the invention to produce from a single-stage strip, a contact with thickness variations within the nose section itself.

A nose section having a thickness and hardness differential in comparison to the tail section is achieved from metal strip using a progressive die by progressively piercing a U-shaped hole in the strip along one edge thereof to form a cantilevered lug, and then swaging the lug to reduce its thickness from a point short of the support for the lug to the free end thereof. The pierced hole in the strip provides clearance for the increase in width of the lug which can occur without lengthwise distortion of the strip. Such distortion, if it were to occur, would buckle the strip or interfere with the alignment of the strip at the various stations of the progressive die. After the swaged lug is trimmed and formed, the strip is blanked to produce a contact which has a work-hardened nose section thinner than the tail.

The more important features of this invention have thus been outlined rather broadly in order that the detailed description thereof that follows may be better understood, and in order that the contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will also form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for designing other structures for carrying out the several purposes of this invention. It is important, therefore, that the claims to be granted herein shall be of sufficient breadth to prevent the appropriation of this invention by those skilled in the art.

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

FIG. 1 is a sectional view of two card-edge connectors mounting a special bus-contact made in accordance with the present invention;

FIG. 2 is a end sectional view taken along the lines 2–2 of FIG. 1;

FIG. 3 is a top view of the connectors shown in FIG. 1 with only a portion of each casing shown;

FIG. 4 is a strip formed in a progressive die in accordance with the present invention and showing completed nose sections as well as all of the intermediate steps by which such sections are formed; and

FIGS. 5 to 11 are sectional views taken along lines 5–5 and 11–11, respectively, of FIG. 4.

Referring now to FIG. 1, a special bus-strip contact produced from strip using a progressive die in accordance with the present invention is designated by reference numeral **10**. Strip **10** comprises elongated flat bar **11** constituting the body section of the contact and a plurality of spaced support arms **12** integral with bar **11** an and projecting upwardly therefrom and terminating in free ends **13** spaced from the bar. Strip **10** is stamped from a strip of material such as grade A, phosphorus bronze with the grain of the material running lengthwise as indicated by arrow **14**. Thus, support arms **12** are normal to the grain and lie in the same plane as the bar. Depending downwardly from bar **11** are a plurality of tail sections **15** of square cross section with thickness and width equal to the thickness of bar **11**. The tail sections **15**, which are staggered relative to support arms **12** for a reason to be indicated, have considerable length relative to their transverse dimensions and are ideally suited for making solderless-wrapped terminations.

In addition to support arm **12**, each nose section **16** includes a generally flat connecting arm **17** of uniform thickness equal to that of support arm **12**, and a curved wiping finger **21** of lesser thickness. Arm **17** has a first portion **18** spaced from and parallel to support arm **12** and a second portion **19** angularly disposed at 90° to the first portion **18** and extending away therefrom in a direction generally parallel to the grain direction **14** of the metal bar. One end **25** of portion **18** of arm **17** is integral and coplanar with the free end **13** of arm **12**, and the other end **26** of portion **19** of arm **17** lies adjacent to but spaced from bar **11**. Tab **20**, which is integral with and of the same thickness as end **26** of arm **17**, is bent out of the plane of the latter along a bend line **27** (FIG. 3) perpendicular to the grain of the metal. As will be explained below, the nose section of the contact in the region of bend **27** is not work-hardened, and since the bend is oriented at a right angle to the grain, an approximately 90° bend can be achieved with a radius of the same order of magnitude as the thickness of the tab and connecting arm, all without fracturing the metal.

Wiping finger **21** is integral with connecting arm **17** with transition portion **22** of the wiping finger extending upwardly from the upper edge **23**(FIG. 2) of tab **20**; the free end **24** of the wiping finger terminates away from bar **11** and has a curved surface **28** that is substantially normal to the plane of the support arm. Surface 28 is oriented so that the projection thereof substantially bisects bar 11 as shown in FIGS. 2 and 3. The wiping finger has a thickness gradient that is normal to the grain direction. and in particular. the thickness of the transition portion 22 of the wiping finger decreases from the junction between upper edge 23 of tab 20 toward the free end 24 of the wiping finger. Actually. over most of its length the wiping finger has a uniform thickness which is less than that of the connecting arm; thickness and the length of the transition portion are parameters determining the spring rate of the nose section of the contact. In one form of the invention, the thickness of bar 11 is 0.025 inch. the thickness of support arm 12 is 0.017 inch, and the thickness of the uniform portion of wiping finger 21 is 0.010 inch. The wiping finger 21 may also be bifurcated by slot 29 for reasons concerned with vibration characteristics of the wiping finger. A notch 22*a* (FIG. 2) may be provided in the transition portion 22 of the wiping finger adjacent bend 27 facilitates making the bend.

Contact 10 is designed to furnish a supply voltage to a plurality of printed circuit boards plugged into a plurality of sidewise-aligned connectors 30 mounted, for example, on a metal plate as shown in FIG. 1. Specifically, each connector includes an insulated casing 31 carrying a plurality of contacts individually engageable with the respective conductive pads on a printed circuit board (not shown) when the latter is plugged into the connector. Casing 31 includes an elongated base 32 having two rows of spaced holes 33 at each location that is to receive a contact, each hole having essentially the same cross section as the tail sections 15 of contact 10. For example, if the tail is 0.025 inch square. the holes may be 0.026 inch square to permit the tail to be inserted into a hole from the upper side 34 of the base. Casing 31 also includes a pair of spaced vertical walls 35 on the upper side 34 of the base adjacent the two rows of spaced holes, such walls terminating in a free edge 36 that is notched at 37 in alignment with holes 33.

As seen in FIG. 1, holes 33 are arranged in lateral pairs in vertical slots 38 in opposite faces of walls 35, the slots being defined by lateral walls 39 provided with card-edge receiving slots 40 adapted to receive an edge of a printed circuit board (not shown). Vertical walls 35 are also provided with aligned transverse slots 41 that permit bar 11 to pass completely through the casing 31 in a direction normal to the length of the casing. When a plurality of connectors are mounted on metal plate 42 in sidewise alignment, slots 41 in the connectors are aligned thus permitting bar 11 of the contact to pass from one connector to another. In actual use, there are many such connectors and it should be apparent that the number of connectors is not an important factor in the present invention. Also, one or more contacts like that shown at 10 can be used with the connectors, depending upon the circuitry requirements of the printed circuit boards. Individual contacts (not shown) are provided at other locations in the connectors.

In fabricating the connector shown in FIG. 1, it is preferred to preassemble individual contacts in the insulated casings at each location that does not require a bus-contact. Such individual contacts (not shown) have a nose section similar to that shown for contact 10, but the connecting arm does not extend across the width of slot 40. Moreover, the support arm is immediately above the body and tail section of the contact, and the tail section extends into a hole in base 32 of the casing adjacent the vertical wall containing the slot 38 within which the wiping finger is contained, Since these contacts are entirely conventional, there is no need to show their details. The tail section of these contacts has a pair of vertically spaced enlarged rounded ears 43 that are larger than the hole size and serve to grip the plastic material of the casing and so secure the contact to the casing. As seen in FIG. 1, base 32 of the casing is provided with a plurality of hubs 44 aligned with the two rows of holes 33 in the base, such hubs being pressed into aligned holes 45 in plate 42 to establish a friction fit that retains the casing to the plate.

After the individual contacts are preassembled into the casings, the various casings are attached to metal plate 42 as indicated above. At this time, contact 10 can be inserted into the aligned casings by aligning the tail sections 15 with proper holes 33 in the base. In such position, support arms 12 will be contained within slots 41 in the casings and portion 19 of each connecting arms 17 will bridge slot 40 within which an edge of a printed circuit board is inserted. This is the reason arms 12 and sections 15 are staggered on bar 11.

As indicated previously, the free ends of tail sections 15 are inserted into holes 33 in upper side 34 of the base of the casing, the 0.001 inch nominal clearance between the contact tails and the holes in the casing effecting entry of the tails into the holes. A tool may be seated against flattened free ends 13 of the support arms 12 for the purpose of pushing the contact into the aligned casings until the free ends 24 of the contact are contained in notches 37 of the casings. In this position, the curved part 28 of each wiping finger 21 is spaced from a wall 35 of a casing, and is laterally located in the recess 46 formed between the walls of the casing. Such curved part of the wiping finger will be engaged by a conductive pad on an edge of a printed circuit board (not shown) when the latter is inserted into slot 46 of a casing.

It is conventional to preload the wiping fingers to achieve the desired performance characteristics. This is achieved by providing laterally extending preload tabs 47 on free end 24 of each wiping finger, each such tab engaging a projecting ridge 48 in notch 37 on the insulator casing when the contact is fully seated for the purpose of initially deflecting the wiping finger from its no-load position. In such case, curved part 28 of the contact will lie closer to adjacent vertical wall 35 than would be the case where tabs 47 and projections 48 not present.

Because contact 10 is a bus-strip contact, wherein the body section 11 is common to each contact nose tail section, it lends itself to being produced in a progressive die from two-stage material. Referring now to FIG. 4, a flat strip of metal is designated by reference numeral 50, such strip having a width slightly greater than the entire height of the contact to be produced therefrom, and a thickness in a region 51 adjacent upper edge 52 of the strip less than the thickness in a region 53 adjacent the lower edge 54, Stop 55 in the top surface of strip 50 is the demarcation line between regions 51 and 53. Preferably, strip 50 is formed by milling region 51 from a coil of uniformly thick strip.

A progressive die is the term given to a metal forming machine in which a plurality of metal-forming operations are carried out in a predetermined sequence on a continuous strip of metal intermittently fed into the die. Such operations are achieved at spaced stations in the die requiring an arrangement to intermittently index the strip through the die in a precise manner. Pilot holes punched in the strip in a region that will not interfere with the finished product are usually used for indexing the strip properly.

Accordingly, when the strip is fed into the die, pilot holes 56 are punched at a pilot punch station (not shown). The strip (containing only pilot holes 56) is then indexed to the right (as seen in FIG. 4) until its right end 55′ is located at the right edge of station A where a punch pierces closed holes 57, 58 in region 51 adjacent edge 52, and closed hole 59 in region 53 adjacent edge 54. Hole 58 is rectangular and oriented in a direction perpendicular to the grain direction of the strip and to demarcation step 55, at which one end of the hold hole preferably terminates. Hole 57, spaced from hole 58 also is elongated in a direction perpendicular to step 55 but terminates short thereof in a narrow reduced portion. Hole 59 establishes the free end or tip of tail section 15.

After holes 57, 58 and 59 are punched, the strip is again indexed until end 55′ is located at the right edge of station B where the strip is pierced to interconnect holes 57 and 58 adjacent edge 52 and define a closed U-shaped hole that forms a cantilevered lug 60 directed toward edge 52. At the same time additional holes 57, 58 and 59 are formed in the portion of the strip now located at station A. As seen in FIG. 5, lug 60 is uniformly thick.

After indexing, end 55′ is located at the right edge of station C where the cantilevered lug is swaged to reduce its thickness and increase its width as shown in FIG. 6. Simultaneously the portion of the strip located at station B to is punched to form another cantilevered lug, and holes 57, 58 and 59 are punched in the portion of the strip located at station A. The swaging of cantilevered lug 60 is at station C is done from a point short of step 55, leaving support portion 61 for the lug. Also the swaging is done to only a central strip of the lug to produce lengthwise running ridges 62 as seen in FIG. 6. The thin section 63 of the swaged lug is now of a width slightly wider than the width of the wiping finger which is trimmed from the swaged lug at a succeeding station. The lug will have a transition portion 22 which has a thickness gradient normal to the grain direction 14. For most of the length of the swaged lug, however, the thickness is uniform and of a value less than that of region 51 with the result that the thickness of the lug decreases from the junction between the lug and the support 61 therefore to the uniform thickness according to a design that provides the desired spring rate and stress distribution.

The rigidity of the blanked strip is maintained to permit it to be fed further into the die by vertical webs 64, which define holes 57 and 58 in respective portions of the strip, and which are integral with horizontal web 65 that interconnects webs 64 along edge 52 of the strip and bar 11. The width of holes 57 and 58 are such as to permit the widthwise growth of lug 60 to occur during the swaging operation at station C without distorting the remainder of the strip. So that the swaging does buckle or distort the strip or interfere with the pilot holes. In other words, growth of the lug due to swaging is confined precisely to the region of the strip associated with an individual nose section and does not affect the overall length and width of the strip as it is fed into the die.

After lug 60 is swaged, the strip is indexed so that end 55′ is at the right edge of station D where four lengthwise grooves 66 are coined into the upper surface 67 of the swaged lug as shown in FIG. 7. These grooves will later define the edges of the bifurcated surface 28 of the completed wiping finger, and are provided for the purpose of preventing the edge of a printed circuit board from snagging on the wiping finger during an angular insertion of the printed circuit board into the connector. It should be understood, of course, that simultaneously with the coining operation at station D, the operations associated with stations A, B, and C, as well as the pilot station, also occur.

After these operations, the strip is indexed until end 55′ is located at the right edge of station E where the swaged and coined lug is slotted at 29 to form the bifurcated nose of the contact. As shown in FIG. 8, the die that slots the swaged and coined lug is precisely located so that the inwardly facing edges of the slot are beveled. As before, the operations already described at the previous stations occur simultaneously with the slotting, after which the strip is again indexed until end 55′ is located at the right edge of station F. Here, the remainder of the wiping finger 21 is trimmed from the slotted lug as shown in FIG. 9, At this location, the wiping finger is still flat but is completely established except as to forming which occurs at station G.

The trimmed lug is formed at station G, where the required concave curvature is imparted to the wiping finger.

At station 11 support 61 is pierced or slotted to produce an L-shaped hole 68 that defines a cantilevered ear 69 oriented parallel to grain direction 14. One leg of hole 68 is even with demarcation step 55 and the other leg of the hole is parallel to web 64. Ear 69 is thus supported from vertical web 64 at a point remote from step 55 and defines the development of connecting arm 17 and tab 20.

After this operation, the strip is indexed until end 55′ is located at the right edge of station 1 where the tab 20 is bent along line 27 until surface 67 of the blanked wiping finger faces to the left as seen in FIG. 4. Surface 67 (corresponding to surface 28 previously described) is curved and is oriented at a right angle to web 64. At this station, the top and bottom surfaces of the strip at the apex of the triangular form defining hole 59 may be coined as at 71 to finish the free end of tail section 15 after the latter is formed at a subsequent station.

After further indexing, the end 55′ of the strip is located at the right edge of station J where closed hole 70 is pierced to establish the tail section 15 of the contact.

The vertical web 72 is removed at station K after indexing end 55′ to the right edge of that location. In addition, web 64 is severed to establish support arm 12.

While the strip shown in FIG. 4 indicates grooves 66 are coined prior to blanking the wiping finger from a swaged lug, this is optional with the tool designer since the lengthwise edges of the wiping finger can be coined after such blanking. It should also be understood that the steps illustrated in sections A through 11, where the nose section is swaged, pierced, and then formed, can be applied to forming individual contacts from single-stage strip using a progressive die, after which the contacts can be blanked from the strip.

It should be noted that at station D less than the entire width of lug 60 is swaged because the lug need be swaged to a width only slightly greater than the width of the trimmed wiping finger. This feature reduces the swaging force requirement at station D. Still another observation is in order with regard to the bending step that occurs at station I. The bend occurs in a region of the car 69 that is not cold-worked, and is oriented so that bending occurs along a line normal to the grain of the metal. Under these conditions a rather sharp bend can be made without fracturing the metal.

Strip 50 shown in FIG. 4 actually has three thicknesses; the tail and body section being of one thickness, namely 0.025 inch; and the nose section having a differential thickness ranging from 0.017 inch for arms 12 and 17 and tab 20 to 0.010 inch for the free end of the wiping finger, Two-stage strip is actually used, but the principles involved in providing a U-shaped hole to define a lug that can be swaged without disturbing the indexing of the strip are applicable to individual contact blanking as indicated previously.

We claim:

1. The method for progressively forming, from a strip of metal having a grain oriented in parallel to the longitudinal edges of said strip, the nose sections of contacts for a printed circuit board connector, comprising the following steps:

a. feeding said strip until a first portion thereof is at a first piercing station;

b. at said piercing section forming a U-shaped hole in said strip near a longitudinal edge thereof to form a first cantilevered lug which points towards said longitudinal edge and is perpendicular to said grain orientation;

c. feeding said strip until said first portion is at a swaging station; and

d. simultaneously (1) piercing a second portion of said strip at said piercing station to form a second cantilevered lug similar to said first cantilevered lug, and (2) swaging said first cantilevered lug at said swaging station to reduce its thickness and increase its width from the free end thereof to a location spaced from the support region for said first lug, said swaging producing a thickness gradient in said lug which is perpendicular to said grain orientation, said U-shaped hole in said strip providing clearance for the increase in width of the lug due to swaging, whereby said swaging will not produce lengthwise distortion of said strip.

2. The method of claim 1, further including the step of feeding said strip until said first portion is at a second piercing station and simultaneously (1) piercing a third portion of said strip at said first piercing station to form a third cantilevered lug similar to said first cantilevered lug, (2) swaging said second cantilevered lug at said swaging station to reduce its thickness and increase its width in a manner similar to the swaging of said first cantilevered lug, and (3) piercing said strip at said second piercing station in the region of support for said first lug to produce a cantilevered ear which points in a direction parallel to said grain orientation so that said first

swaged lug will be supported on the free end of said cantilevered ear.

3. The method of claim 2, further including the step of feeding said strip until said first portion thereof is at a bending station and simultaneously (1) piercing said strip at said piercing station to form a fourth cantilevered lug similar to said first cantilevered lug, (2) swaging said third cantilevered lug at said swaging station to reduce its thickness and increase its width in a manner similar to the swaging of said first cantilevered lug, (3) piercing said strip at said second piercing station in the region of support for said second lug to produce a cantilevered ear which supports said second lug in a manner similar to that by which said first lug is supported, and (4) at bending station, bending said cantilevered ear supporting said first lug along a line which is perpendicular to said grain orientation and which is located between the support region of said cantilevered ear and said support region for said first lug.