ABSTRACT: An electrical connector formed by a die blanking operation having an improved smooth edge contact surface formed by a fine scraping of said edge to remove the rough fractured surface remaining after the blanking operation; also, the method and apparatus for forming said improved smooth contact surface.
The present invention relates to electrical connectors having edge contact surfaces and method and apparatus for making the same.

In the manufacture of electrical connectors, particularly of the crimp-type, most are blanked or stamped out on a progressive die from a thin strip of flat metal stock. In some of these connectors the contact surface (i.e. that surface of the connector which makes actual electrical contact) is formed from the cross section of the flat metal stock. A problem has long existed in such edge contact surfaces where only a small portion of the cut edge forming the contact surface has a smooth shear. The remainder of this surface is formed by a break or fracture of the metal portion of the cut face. This is apparently due to the methods required for accomplishing these stamping operations. In a punch die it is typical that a spacing between the punch and its corresponding die should be approximately 6 percent of the width of the material being stamped out. Therefore, the piece stamped out on one side will take the shape of the punch and then will fracture outwardly (and downwardly) an amount approximately equal to the spacing between the punch and its die and then will shear the last 20 to 30 percent of the cross section in a shape identical to the die. Typically, a piece thus blanked out will have an edge surface which is a smooth shear cut of about 20 percent and then is a rough fractured undercut angled therebelow. It is possible to increase the percentage of smooth shear surface somewhat by a reduction in the clearance below the 6 percent figure but only at severe penalties with relatively little gain. Thus, by reducing this clearance and with liberal use of specialized lubricants one might be able to achieve 40 percent and occasionally approach a 50 percent smooth shear surface but with greatly increased power requirements, tool wear, and tool breakage and many other detrimental trade offs well known to those skilled in the art. Since in the manufacture of more modern miniaturized connectors this fractured portion of these edge contact surfaces can amount to more than 80 percent, the resulting design limitations and contact inefficiencies can be sufficient to render such connectors fatally faulty. In such connector design requirements the edge surface must have a minimum smooth shear surface of 50 percent consistently to be effectively reliable. This problem becomes particularly acute where either the edge contact surface or the mating surface with which it is designed to make electrical contact has a cylindrical shape (circular or otherwise). Because the contact area of such a connector becomes more dependent on the height of the contact surface and independently of its length. The more brittle the material, the larger the break caused by this fracturing.

Attempts to solve this foregoing problem by decreasing the punch clearance or by very fine "shaving" steps (i.e. subsequent fine stamping or blanking steps) did not meet with material success, since the degree of break was not materially reduced. A second problem is encountered with the use of edge contact surfaces formed by stamping operations in a sliding contact which is to be made substantially perpendicular to the direction in which the surface was formed by stamping. This problem concerns the very small tool marks which the stamping die leaves in the "smooth" shear edge contact surface but which are sufficiently large to act as a rasplike surface which can wear away the ultrathin gold surface commonly used on mating contact surfaces.

It is an object of the present invention to provide methods and apparatus for overcoming the problems discussed herein. It is a further object of the present invention to improve the effectiveness of edge contact surfaces of standard electrical connectors.

It is yet another object of the present invention to provide electrical connectors having edge contact surfaces which are substantially miniaturized and yet maintain superior contact qualities over similar prior connectors.
FIG. 12 is a vertical cross section taken along lines 12-12 in FIG. 11 showing the two dies in engagement and particularly showing the adjustable backstop; and FIG. 13 is similar to FIG. 12 but showing the two dies in spaced relation.

For convenience in discussing and illustrating preferred embodiments of the present invention, the figures have been identified to a crimp-type electrical connector 10 having a conventional F-clip terminating portion 12 with a dual time contact engaging portion 14 extending therefrom. These wires 20 are designed to cooperate to electrically engage and mechanically grip a contact post 15 inserted in the slot formed between the opposed contact surfaces 18. This connector 10 as illustrated in FIGS. 2 to 10 is shown in strip form (i.e. still attached to the locating strip 16). This is the form in which such connectors are typically supplied to the customer for later application by automatic application machines. As can be most clearly seen from FIGS. 8 to 10, this particular connector 10 has an arcuate edge contact surface 18 on the inside of each time 20 and has a retaining notch 22 for holding the connector 10 in a molded connector block (not shown) when in service. In contrast, the connector 10b shown in FIGS. 11 to 13 is somewhat simplified having no retaining notch 22.

FIG. 2 shows a portion of the stationary lower die 24 of the progressive die with the locating strip 16 carrying newly formed connectors 10 attached thereto at spaced intervals. These connectors 10 move in a step-by-step progression from one station to the next in an intermittent advance from left to right as viewed in FIG. 2.

FIG. 7A shows the rough-cut contact edge surface 18 of the connector time 20 as it appears after having been blanked out in the previous forming operations. As can be seen from FIG. 7A in materials typically used for this type of connector, having a medium hardness and of relatively small cross section, the break or fracture surface 26 is very rough and nonlinear over as much as 80 percent of the edge surface of the time 20. Such a fracture surface is typically undercut so that the entire extent of this surface 26 is made to make electrical contact with the contact post 15 (shown in dash-dot outline). Even if the fracture surface 26 were in line with the contact edge surface 18, its roughness would provide only very poor contact because only the highest points of the roughness would be in engagement with the post 15. Furthermore, this roughness would also score the post 15 as it slides across it, destroying any plating (which typically is gold). The destruction of the plated surface can be very serious in affecting the quality and longevity of the contact assembly, particularly in installations where repeated disconnections are made (as in changing from one programmed plug-in control to another).

FIGS. 8 and 9 show in detail the scraping method of the present invention being performed by apparatus according to the present invention (which latter is more generally shown in FIGS. 2 and 3). FIG. 7B shows the contact edge surface 18 after the scraping process according to the present invention has been performed. It can be seen that this process has scraped off a layer of material 28 (see FIG. 9) leaving a straight, effectively smooth, superior contact surface throughout the entire area of the edge 18. Any minor tool marks left by such scraping are parallel to the direction of sliding contact and, therefore, relatively inconsequential.

As viewed in FIGS. 2 and 3, the connectors 10 shown at the far left are newly formed and have yet to be processed according to the present invention, while those at the far right have been both scraped and sized. After a connector 10 has been advanced to a position just opposite the first scraping tool 30 it is precisely positioned by strip pilots 32 passing through strip pilot holes 34 in the strip 16 and onto pilot holes 36 in the stationary die 24. Spring loaded strip holing plungers 38 clamp the strip 16 in position. At the first scraping station, the right-hand time 20 of the connector 10 therein is supported from beneath by support 40. Hold-down tool 42, carried on the upper moving die 44, firmly positions the time 20 on the support 40 preventing any twisting of the time 20 but permitting a limited horizontal motion therebetween. Positioned between the two hold-down tools 42 are two flexible stops 46. These stops 46 move down with the upper die 44 and pass into slots 48 made in the time supports 50. These stops 46 engage the outer portions of the times 20 when the latter are held in position between the hold-down tools 42 and their respective supports 40 during the scraping operation. These stops 46 serve both to prevent the time 20 from being overstressed and also to maintain a proper pressure of the time 20 against the scraping tools 30 and 50, see FIGS. 3, 5 and 8, and especially FIG. 9 (which latter shows the flexibility of the stops 46).

It will be noted that the first six connectors 10 from the left in FIGS. 2 and 3 have their times oriented in a slightly open V-orientation rather than substantially parallel as illustrated at the right in these same figures. This was done in order to leave sufficient room between the times 20 on a given connector 10, to permit passage of the scraping tools 30 or 50 therebetween to gain access to the blanked out contact edge surface 18.

In order to shape the connector to its final design configuration, they must pass through a sizing operation. In the connectors illustrated in FIGS. 1 to 3 this sizing operation is complicated by the shape of the times 20 having a retaining notch 22. As during the scraping operation, the times 20 of the connector 10 are firmly held to prevent twisting but to permit horizontal displacement during the sizing operation. The times are supported from below by support 52 (see FIG. 4) and are held thereagainst by a hold-down tool 54. As can be seen from FIGS. 2, 3 and 4, and FIGS. 6A and 6B, as the movable sizing unit advances horizontally perpendicular to the strip 16 to engage the times 20 in the sizing station, the sizing fingers 56 pass on either side of the times 20 (while the latter are gripped between the hold-down 54 and its corresponding support 52). As the fingers 56 advance, their outer edges (beveled at 45°) engage the sizing cams 58 (similarly angled). Further advancement of the fingers 56 causes them to be squeezed together against the pressure of the spring 60 and about pivot 62 thereby engaging the spread times 20 and forcing them inwardly into a parallel orientation.

As illustrated in this preferred embodiment, the transverse carriage 64 used for advancing both the scraping tools 30 and 50 and the sizing fingers 56 are shaped to track in a horizontal transverse direction relative to the progression of the strip 16 through the progressive die. This carriage 64 tracks in guide slots 66 and 68. It is actuated by a slide cam 70 which depends from the upper movable die 24. As the cam 70 moves downwardly, it bears upon the cam follower pin 72 (which latter is fixed in the carriage 64) forcing the carriage 64 forward towards the locating strip 16 and the connectors 10 carried thereon. The scraping tools 30 and 50 are carried in front of the leading end of the carriage 64 by a slide block 74 having a locating screw adjustment 76. The sizing fingers have a similar slide block 78 and screw adjustment 80.

FIG. 10 shows an alternative embodiment of the present invention wherein a single scraping tool 30a has two scraping edges. For convenience of reference, features similar to those illustrated in the preceding figures have been given identical reference numerals followed by the suffix a.

As indicated above, FIGS. 11 to 13 indicate still another preferred embodiment of the present invention. Where the parts are equivalent to those illustrated in FIGS. 1 to 9, identical reference numerals have been employed, and where they are substantially equivalent but of different structure, the same reference numerals have been employed but not numbered by the suffix b. The connectors 10b have times 20b which do not have retaining notches 22. Because of this, the sizing mechanism is greatly simplified, being only a sizing cam 82 having a gradually tapered cam slot (as illustrated in FIG. 11) which has a height only slightly greater than the thickness of the times 20b and has a taper shaped to force the ends of the times 20b together into the designed configuration.

Also illustrated in FIGS. 11 to 13 is an improved version of the time stops 46b (best shown in FIG. 13). The main-
vant of the stop illustrated in FIGS. 11 to 13 over that illustrated in FIGS. 1 to 9 is its adjustability. This adjustability not only enables quick and convenient compensation for tool wear and for differing pressure requirements responsive to design variations, but also initially in achieving the proper design pressure. If the pressure which the tine stop 46b exerts against the tine 20b is too great, then the scraping tool 50 will tend to goe and chatter thus destroying rather than improving the contact surface.

The actual backstop portion of the adjustable tine stop 46b is a finger 84 positioned to operate in the slots 48 made in the tine supports 40. This finger 84 is carried by a rigid arm 86 which is pivoted on pin 88 carried in housing 90. In the illustrated embodiment the pin 88 serves as a pivot pin for both arms 86. The adjacent faces of the arms 86 at the point of engagement of the pin 88 are cylindrically recessed to receive the pin 88 therein and capture it therebetween with the respective adjacent faces spaced one from the other. The outer face of the free end 92 of the arm 86 is engaged by a spring loaded probe 94 which is forced into engagement therewith by spring 96. The pressure of the spring 96 is adjustably varied by thumb screw 98. Once the desired spring loading has been achieved, this adjustment can be maintained by the set screw 100. As can best be seen in FIG. 13, the housing 90 is carried vertically by springs 102 which serve to raise the finger 84 out of engagement with the tines 20b thereby permitting advancement of the connectors 10b on the locating strip 16b to the next station. The housing 90 is pressed down into operative position against springs 102 by the spring loaded probe 104 which seats in socket 106. Thus, after the connector 10b has been positioned for scraping, the upper moving die 44b moves downwardly carrying the probe 104 with it and forcing the housing 90 and the finger 84 of its arm 86 into operative position as illustrated in FIG. 12.

With the tine stop 46b positioned as illustrated in FIG. 12, the pressure of the finger 84 against the tine 20b can be increased by screwing the thumbscrew 98 inwardly. The adjustable spring tension serves not only to increase the pressure exerted by the finger 84, but also gives the finger 84 the flexible pressure required where the contour of the tine edge contact surface 18b is curved.

Although it is mechanically possible and within the scope of the broader aspects of this invention to make these backstops 64 rigid rather than flexible and have the scraping tool move in a cammed path following the contour of the tine edge contact, nevertheless this would be considerably less desirable because of the extremely precise positioning of the tine that would be required and the very close tolerances which would have to be maintained.

It has been found that for a particular material and contour of the tine the scraping angles of the cutting tool can be surprisingly critical. For example, in the embodiment illustrated in FIGS. 1 to 9 when the leading face of the cutting edge of the scraping tools 30 was angled at 30° to the perpendicular through the point of the tool and the trailing face was angled at 40°, the tool tended to gouge the surface and did not function properly. Similarly, a 45° angle did not function properly. However, when these angles were modified to 43° (and used on a tine made of number six hardness phos bronze with a thickness of 0.016 inches), this scraper advancing in a linear direction scraped off a curl 28 from the curved contact surface 18b which had a thickness of 0.0002 inches. This was enough to improve the smooth surface of the edge contact surface from about 20 percent to over 60 percent. Anything over 50 percent which can be achieved with any regularity is a significant improvement greatly increasing the utility of the contact. Furthermore, other trial scrapings with this same arrangement resulted in consistent improvement of the edge contact surface to a consistent removal of 90 to 100 percent.

This scraping method is applicable to surfaces formed from metals having a thickness up to at least 0.030 inches. It is an advantage of the scraping method disclosed herein that this processing can be accomplished within very minute and confined spaces and at a very high production rate (300 inspections per minute being typical). In contrast, a rotary cutter or grinder would be comparatively bulky, slow and leave circular rather than linear tool marks. The grinding material would tend to become imbedded in the kind of metals typically encountered in electrical contacts. In a typical application of the embodiment illustrated in FIGS. 1 to 9, the shank of the scraping tool had a thickness of 0.020 inches and a height of 0.160 inches with the scraping point extending out from the shank at essentially right angles by about 0.01 inches. For improved wear characteristics, the point of the tool could be formed on a diamond insert.

1. Apparatus for forming electrical connectors having a flat edge contact surface stamped from flat metal stock comprising a strip-feed metal die stamping machine, a progressive die for said machine shaped to form electrical connectors in successive stamping operations at spaced intervals, blanking station on said die for roughly forming said contact surface in a shearing cut down across the flat metal stock, and a scraping tool having a straight edge being movably mounted on said die at a successive station and actuated to advance in a straight line and at a substantial angle to the direction of shearing during the blanking portion of the stamping cycle to engage said edge contact surface and cut away a thin layer from said edge sufficient to effectively flatten the entire edge at said edge contact surface.

2. Apparatus as claimed in claim 1 further comprising restraining means at the scraping station for holding said blanked connector in position for scraping.

3. Apparatus as claimed in claim 2 for scraping flat an arcuate edge contact surface stamped from flat metal stock wherein said restraining means comprises a hold-down tool for the die which prevents twisting of the connector during scraping and also a pressure backstop for engaging the connector on an edge opposite from that being scraped to yieldably keep said edge contact surface in engagement with said scraping tool at the scraping pressure.

4. Apparatus as claimed in claim 3 wherein said backstop is adjustable to compensate for wear and different scraping pressures.

5. Apparatus as claimed in claim 1 further comprising sizing means on said die at a station successive to said scraping station for positioning said edge contact surface opposite another portion of its connector at a clearance less than that required for said scraping operation.

6. Apparatus as claimed in claim 5 wherein said sizing means comprises a tool on said die having a flat slot with a height sufficient to just accommodate the flat metal from which the edge contact surface is made and the adjacent portion of the connector to which said surface is to be sized and having a width tapered in a direction so oriented to cam said connector portions into the desired size upon insertion into said slot.

7. Apparatus as claimed in claim 5 wherein said sizing means comprises a hold-down tool for engaging the flat surfaces of the portion of the connector forming said edge contact surface and the portion of the connector to which it is to be sized, scissors clamps shaped to the outer edges of said connector portions for engaging said portions and squeezing them together the desired amount to achieve the desired sizing while said holddown tool prevents their twisting, a tapered cam for receiving and closing the jaws of said scissors clamp, means for advancing said clamps into engagement with cam and for closing them on said portions.