United States Patent

Rosenbaum

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[54] APPARATUS FOR SPLICING WIRES

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[21] Appl. No.: **810,759**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 554,129, May 31, 1966, abandoned.

[52] **U.S. Cl.** .....**29/203 D,** 29/33, 53/138

[51] **Int. Cl.**.....**H01t 5/10**

[58] **Field of Search**.....29/203 D, 203, 203 DT, 243.57, 29/243.56, 33.5; 53/138 A; 83/468, 694

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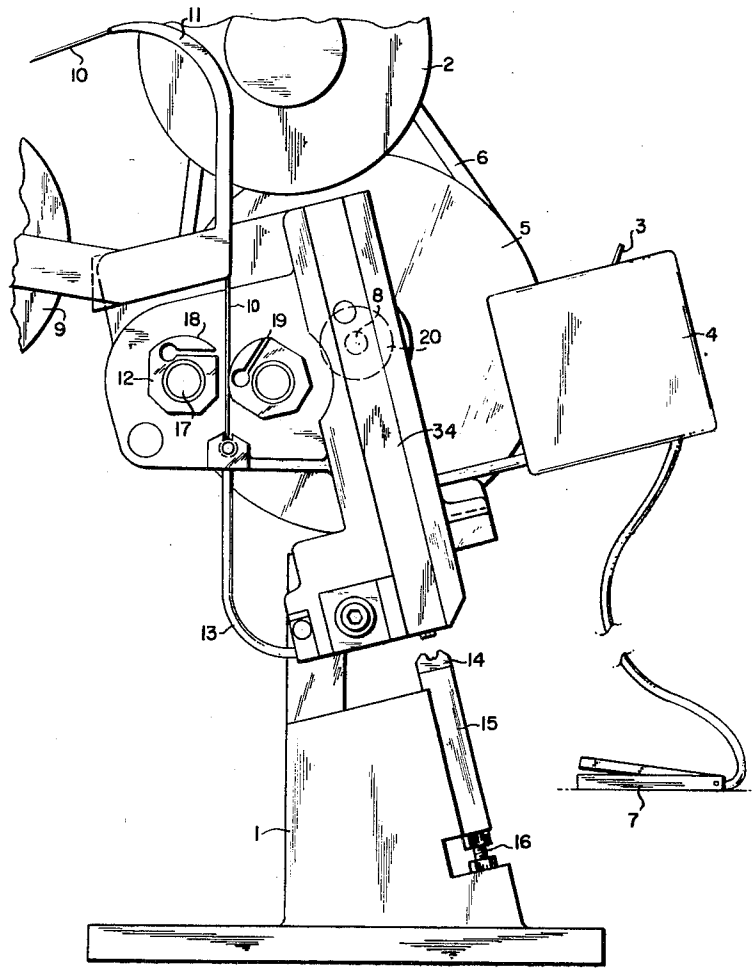
[57] **ABSTRACT**

A semiautomatic machine which cuts flat metal strip or wire transversely into blanks, bends the blanks into C-shaped connectors, and clinches the connectors about wires inserted in a die for conductively connecting the wires. Wires as small as 0.001 inch can be spliced effectively. The operator's intervention is limited to insertion of the wires into the die, and the closing of a switch for each splice to be made.

16 Claims, 9 Drawing Figures



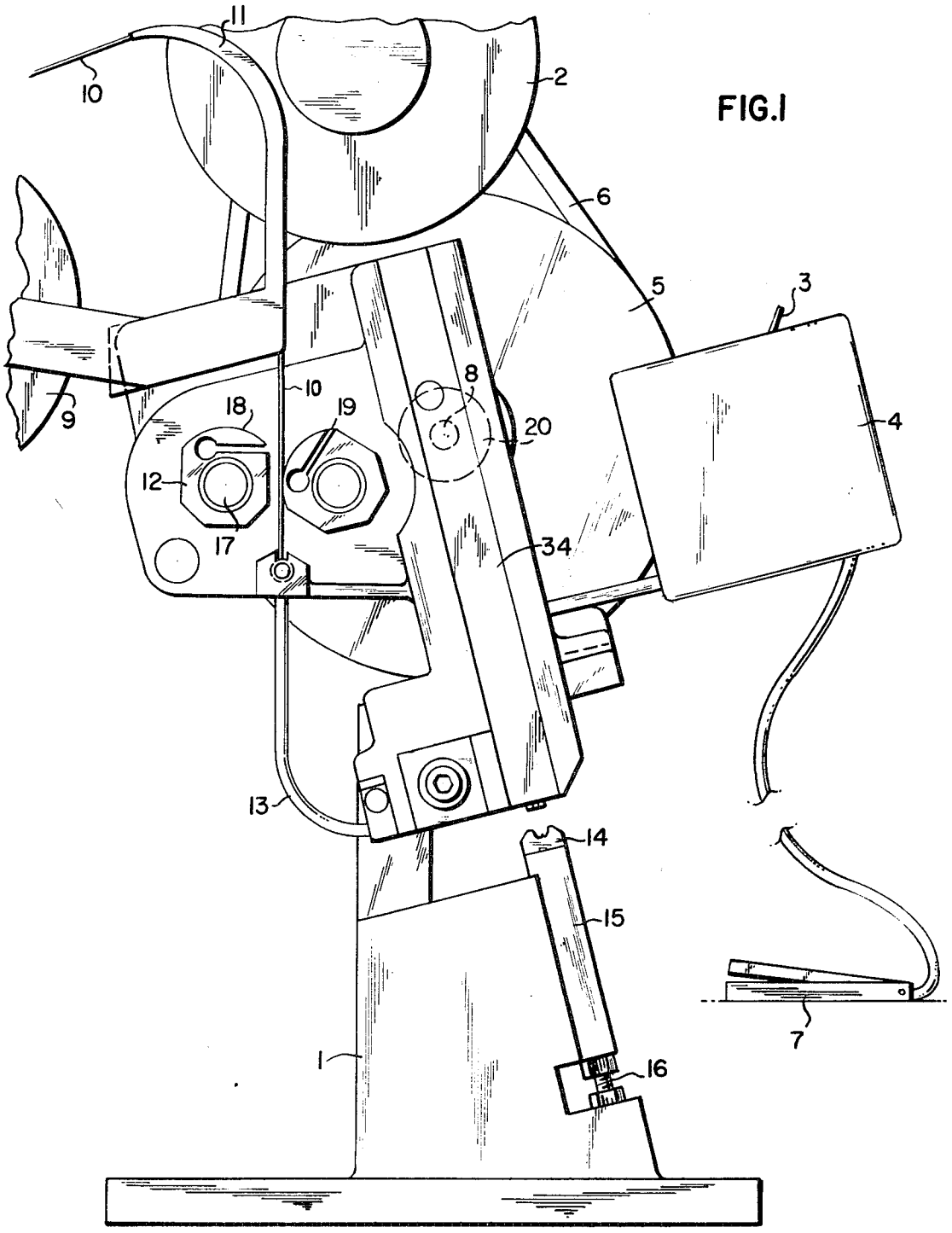


FIG.1

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FIG.3

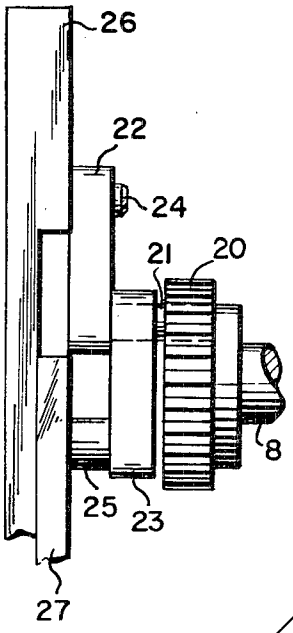

FIG.2

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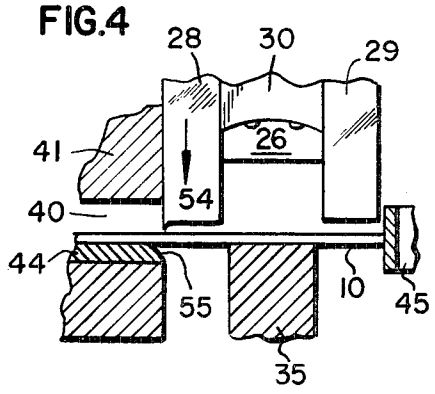
FIG.4



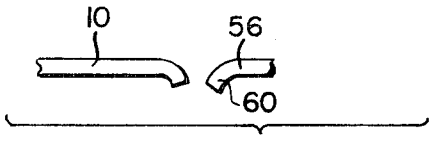


FIG.5

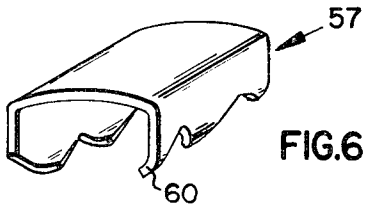


FIG.6

FIG.7

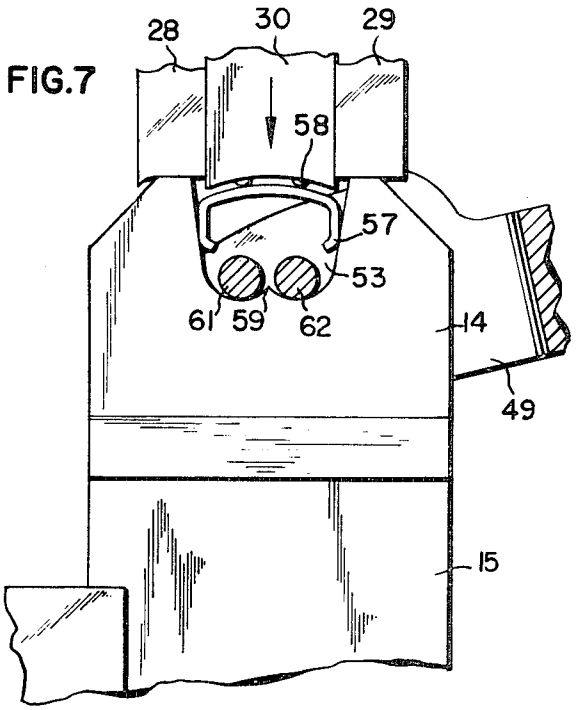
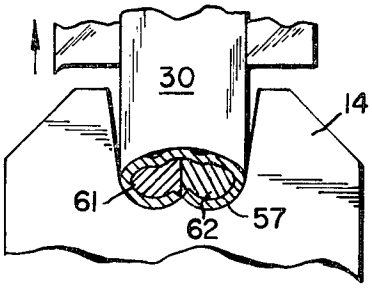


FIG.8



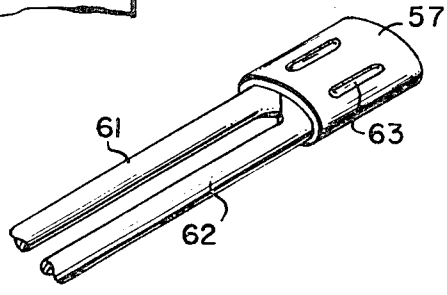


FIG.9

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APPARATUS FOR SPLICING WIRES

This application is a continuation-in-part of my copending application Ser. No. 554,129, filed on May 31, 1966, and now abandoned.

This invention relates to the making and use of electrical connectors, and particularly to apparatus for making conductive connectors and for applying the connectors to wires which are to be conductively connected.

Wire staples and similar devices have been employed heretofore for conductively connecting two parallel wires by clinching or crimping the staples or the like about the wires, and it has been common practice to provide terminal lugs with crimping ends which may be used for connecting the lugs to one or more wires in an analogous manner.

Connectors of the aforedescribed type which were used prior to this invention were made from flat strip on a power press and left the press as a string of integrally connected staplelike elements. The elements were individually severed from the string and crimped about the wires to be spliced in an attaching apparatus separate and remote from the power press. The string of elements had to be coiled for storage prior to use on the attaching apparatus, and great care had to be taken to avoid distortion of the string or of individual elements in coiling in order to avoid jamming of the attaching apparatus.

The object of the invention is the provision of apparatus which accepts a feed of readily coiled wire or strip of uniform cross section, forms the fed material into individual connectors, and attaches each connector, as soon as it is formed, to one or more wires whose diameters may be extremely small, such as wires having a diameter of 0.001 inch which are used as leads in miniturized electronic circuits.

With these and other objects in view, as will hereinafter become apparent, the invention provides an apparatus for conductively connecting two wires whose operating elements are mounted on a common, normally stationary support or stand. These elements include a fixedly mounted, freely accessible die whose cavity is generally U-shaped so as to have a concavely arcuate bottom wall and one side open in a direction transverse to that wall. A ram moves into and out of the cavity through the open side of the same in the aforementioned direction. A face of the ram opposite the bottom wall of the die cavity preferably is also concavely arcuate, and the axes of curvature of the concave ram face and of the cavity wall extend in a common direction.

An anvil moves in the direction of the axes into and out of an operating position in which it is spaced in the path of the ram from the die and has an abutment face directed away from the die. Two bending tools mounted on opposite sides of the ram path move jointly in a plane transverse to the aforementioned axes toward and away from respective positions continuously adjacent the die.

Sequential end portions of a flat wire or metal strip are fed in the aforementioned transverse plane across the abutment face of the anvil in the operative position of the latter by an indexing feed mechanism, and are sheared from the remainder of the strip by cooperating shearing devices on one of the bending tools and on the stationary support when the tools move toward the die, the tools being spaced sufficiently from each other to receive the anvil and the ram therebetween.

The ram, anvil, bending tools, and feed mechanism are actuated in timed sequence by a common motor to form a connector and to crimp the connector about wires in the die cavity, the cavity being open in the direction of the axis of curvature of its bottom wall for access by the wires to be connected.

Other features, additional objects, and many of the attendant advantages of this invention will readily become apparent from the following detailed description of a preferred embodiment when considered in connection with the attached drawing. In the drawing:

FIG. 1 is a front elevational view of an apparatus of the invention;

FIG. 2 shows the shaping tools and associated elements of the apparatus of FIG. 1 in an exploded, perspective view generally taken from the rear of the apparatus;

FIG. 3 shows a detail of the device of FIG. 2 in side elevation;

FIG. 4 shows some of the shaping tools of FIG. 2 and a metal strip or flat wire engaged by the tools, the view being in partly sectional front elevation and on a larger scale than FIG. 2;

FIG. 5 is a fragmentary and further enlarged view of the strip of FIG. 4 after an initial stage of the shaping operation;

FIG. 6 shows a connector made from the strip by the tools of FIG. 2 in a perspective view approximately on the scale of FIG. 5;

FIG. 7 shows a group of the shaping tools of FIG. 2 ready to crimp the connector of FIG. 6 about two wires to be connected, the view being in front elevation and on a larger scale than FIG. 4;

FIG. 8 partly illustrates the device of FIG. 7 after completion of the crimping step; and

FIG. 9 shows the wires conductively connected by a connector of the invention in a perspective view.

Referring now to the drawing in detail, and initially to FIG. 1, there is seen a cast iron stand 1 which supports the operating elements of the illustrated apparatus and whose horizontal bottom face normally rests on a work bench or table, not itself shown. An electric motor 2 mounted atop the stand or frame 1 is controlled by a toggle switch 3 on a control box 4 mounted on the stand 1. A belt 6 connects the motor 2 with the input pulley of a single revolution clutch 5, not otherwise shown in detail, since it is a staple article of commerce (The Hilliard Corp., Elmyra, N.Y.). A pedal switch 7 is connected to the nonillustrated triggering solenoid of the clutch 5 through the control box 4 in a conventional manner to connect the output shaft 8 of the clutch to the pulley 5 for one revolution when the switch 7 is closed.

A reel 9 rotatable on the frame 1 carries a coiled strip or flat wire 10 whose free end is trained over an arcuate guide plate 11 and between two identical feed cams 12 into a metal tube 13 leading to the shaping and attaching station of the apparatus. A fixed die plate 14 is the only tool of the apparatus fully visible in FIG. 1. It is releasably mounted on a carrier 15 which may be adjusted on the frame 1 by means of a spindle 16 and associated nuts. The die plate 14 is exposed in all directions, and access to the die cavity may be had at right angles to the plane of FIG. 1 by wires to be connected, there being ample space to accommodate even voluminous circuit elements which may be attached to the wires.

Each feed cam 12 is mounted on a shaft 17 and has a circularly arcuate cam face 18 centered in the axis of the shaft 17 and having a length of about 90°. A slot 19 extending from one end of the cam face 18 approximately along the chord of the face into the body of each cam 12 gives some resiliency to the circularly arcuate cam portion whose radius is approximately equal to one-half of the spacing of the axes of the shafts 17.

The shafts 17 are connected with each other and with the clutch output shaft 8 by a gear train of which only a spur gear 20 on the shaft 8 is indicated in FIG. 1, and which turns the shafts 17 for one revolution in opposite directions when the switch 7 is closed. Setscrews, not themselves visible in the drawing, permit the cams 12 to be angularly adjusted on the shafts 17. The cams feed the strip 10 into the tube 13 as long as the cam faces 18 cooperate to grip the strip. The length of the cooperating portions, and the corresponding length of the strip 10 which is fed into the tube 12 during each revolution of the shaft 8 may thus be adjusted by setting the cams on the shafts 17.

FIG. 2 shows the shaping tools which convert the wire or strip 10 into a sequence of connectors, and attach each connector to wires inserted into the cavity of the die 14. An axial crankpin 21 projects eccentrically from the gear 20 illustrated in FIG. 2 in phantom view, and better seen in FIG. 3. Two heavy links 22, 23 are freely pivoted on the pin 21 and on

respective pins 24, 25 on end portions of two elongated superposed slides 26, 27. The slides are guided longitudinally in a groove of the machine stand 1 normally closed by a cover 34 (FIG. 1). When the gear 20 makes one revolution, the slides reciprocate longitudinally once.

The longer slide 26 carries two spacedly juxtaposed elongated bars 28, 29 on its end remote from the pin 24 which projects beyond the slide 27 in all operative positions of the apparatus. A narrow elongated ram 30 longitudinally projects from the slide 27 into the conforming guide channel between the bars 28, 29 which function as bending tools, as will presently become apparent. The exposed terminal face 31 of the ram 30 is cylindrically arcuate and concave. The ram 30 moves into and out of the cavity in the die plate 14 during its longitudinal reciprocating movement.

The die plate 14 is approximately U-shaped about its cavity which has a concavely arcuate bottom wall opposite the ram face 31, as will be described in more detail hereinafter. The die plate is releasably, but fixedly fastened in a slot 32 of the carrier 15 by screws 33 in all operative conditions of the apparatus.

An anvil 35 is mounted on the stand 1 by means of a pivot pin 36 and biased by a strong helical compression spring 37 toward an operative position in which a flat transverse abutment face 38 on a relatively narrow blade portion of the anvil, largely obscured in FIG. 2, is directed away from the die plate 14 and opposite the terminal face 31 in the path of the ram. The blade portion of the anvil 35 also has an obliquely inclined cam face 39 contiguous to the abutment face 38. It is dimensioned to fit the guide channel between the bending tools 28, 29 with respective clearances not significantly greater than the thickness of the strip 10. Movement of the anvil 35 beyond the operative position under the urging of the spring 37 is prevented by engagement of respective vertical faces of the anvil and of the tools 28, 29.

The strip 10 is fed to the shaping tools through a slot 40 in a guide block 41 normally mounted on the frame 1 in a fixed, but adjustable position by means of a screw (not shown) passing through an elongated aperture 42 of the block 41. An edge face of the block 41 which intersects the end of the slot 40 has alternating ribs and grooves 43 which engage mating grooves and ribs on the bending tool 28 in the assembled condition of the apparatus for precisely guiding longitudinal movement of the slide 26 and of the tools 28, 29. The slot 40 is downwardly bounded by an insert 44 in the block 41 which will presently be described in more detail.

A stop 45 is spaced from the bending tools 28, 29 in a direction away from the guide block 41 and is adjustable in the direction of strip movement on a forked bracket 46 fixedly mounted on the stand 1 in a nonillustrated manner. The stop 45 may be secured in its adjusted position by means of a screw 47 passing through the two branches of the bracket 46 and a slot 48 in the stop.

A trimmer 49, omitted from FIG. 1 for the sake of clarity, is pivotally mounted on a bracket 50 releasably attached to the stand 1. A strong leaf spring 51 biases the trimmer counterclockwise toward the position seen in FIG. 2. In the assembled condition of the apparatus, an edge portion of the die plate 14 is movably received in a guide groove 52 of the trimmer 49, and a hook-shaped cutter 53 on the free end of the trimmer 49 is positioned behind the cavity of the die plate 14 and above the bottom wall of the latter so that a wire inserted horizontally into the die cavity from the front of the machine, and projecting rearwardly from the cavity, is received in the bight of the cutter 53.

The operation of the aforedescribed apparatus, and additional structural details will now be described with reference to FIGS. 4 to 8.

The distance over which the strip 10 is fed by the cams 12 is not determined by the angular setting of the cams with sufficient precision for making connectors of extremely small dimensions. The strip 10 itself and the tube 13 are slightly resilient so that the effective distance between the cams 12 and the operating station of the machine cannot be known precisely. The strip 10, as is shown in FIG. 4, is therefore fed through the slot or channel 40 in the guide block 41 against the fixed stop or abutment 45. The cams 12 are set to provide a slight excess of strip length. The strip 10 buckles slightly after hitting the stop 45 and resumes its initial shape after it is released by the cams 12.

The abutment face 38 of the anvil 35 is normally aligned in a common plane with the exposed face of the insert 44 in the slot 40, and the bending tool 28 is moved into engagement with the leading strip portion immediately after the latter strikes the stop 45 so that buckling is limited to that portion of the strip which is outside the operating station proper.

The bending tool 28 has a projecting shearing edge 54 bounded by a longitudinal face of the tool perpendicular to the plane of FIG. 4 and by the bottom face or bending face of the tool which is otherwise flat and recessed relative to the edge 54. The front end 55 of the insert 44 is rounded or beveled. Ribs and grooves aligned with the ribs and grooves 43 extend through the shearing edge 54 and the rounded front end 55 of the insert as is shown in FIG. 2, but not visible in FIG. 4.

When the slide 26 moves toward the die plate 14 in the direction of the arrow in FIG. 4, the shearing edge 54 first deflects the strip 10, which is unsupported between the anvil 35 and the insert 44, bending it over the front end 55 of the insert 44, and ultimately severs a blank 56 from the remainder of the strip 10, as partly shown in FIG. 5. The leading transverse edge of the strip 10 and the trailing edge of the blank 56 are bent arcuately out of the plane defined by the abutment face 38. The second and each subsequent blank 56 have partly rolled or arcuately bent leading and trailing transverse edges 60. Because of the configuration of the shearing tools 54, 56, the transverse edges 60 of the blank are toothed or scalloped.

Immediately after blanking, the bottom faces of the bending tools, 28, 29 abuttingly engage the blank 56 and drape it over the anvil 35. The spring 37 is strong enough to prevent movement of the anvil under the stresses transmitted by the relatively soft material of the blank 56. However, work-hardening of the strip material as it is being bent along the edges of the anvil face 38 causes the central portion of the blank to assume a convexly arcuate shape about an axis of curvature perpendicular to the plane of FIG. 4. The connector 57 formed by the bending step is seen in FIG. 5. It is moved outward of the guide channel between the bending tools 28, 29 by the now descending ram 30, and the anvil 35 is thereby pivoted out of its operative position and out of the path of the ram as the connector 57 slides over the cam face 39 of the anvil.

The bending faces of the tools 28, 29 ultimately abut against the die plate 14 and the connector 57 is shifted by the ram 30 into the die cavity as is seen in FIG. 7. The arcuate terminal face 31 of the ram 30 carries two symmetrically arranged ribs 58 which are elongated at right angles to the plane of FIG. 7, but do not extend over the full axial length of the face 31. Initial contact of the face 31 with the connector 57 is limited to the ribs 58 whereby the force of the descending ram is concentrated initially on a small surface portion of the blank 56.

The cavity of the die plate 14, which is of uniform cross section, flares slightly toward the open side jointly covered by the tools 28, 29 and the ram 30 in the position of FIG 7. The bottom wall of the cavity has two concavely arcuate face portions which meet in an elongated, angular ridge 59, and whose axes of curvature are approximately aligned with the ribs 58 on the ram face 31 in the direction of ram movement. As the connector 57 is driven by the ram 30 toward the bottom of the die cavity, its edges 60 follow the contour of the arcuate die face portions and are crimped about two wires 61, 62 previously introduced into the die cavity from the front of the apparatus and trimmed flush with the rear wall of the die plate 14 by the cutter 53 as the slide 26 forces the cutter downward, as viewed in FIG. 7, against the restraint of the spring 51 when the bending tools 28, 29 approach the die plate.

When the ram approaches the lowermost position of its stroke, as shown in FIG. 8, the connector 57 backed by the wires 61, 62 resist deformation by the ram with sufficient force to cause elongated depressions to be formed in the metal of the connector by the ribs 58, and further overall deformation of the connector to be resumed only after the same makes area contact with the terminal ram face 31. The wires 61, 62 are deformed in the contracting space within the connector 57, and voids between the wires and the inner connector surface are eliminated practically completely, in the position shown in FIG. 8 in which the connector is confined in all directions transverse to the ridge 59 by the die plate 14 and the ram face 31.

As is evident from FIG. 8, upward withdrawal of the bending tools 28, 29 starts toward their starting position begins while the ram 30 still moves inward of the die plate 14, and ultimately the ram 30 is withdrawn, permitting the finished connection or splice shown in FIG. 9 to be withdrawn from the apparatus. Elongated depressions 63 in the outer surface of the connector duplicate the shape of the ribs 58 by means of which they were formed. The depressions elongated in the direction of the axes of the connected wires have been found to be as effective as transverse depressions in gripping the fastened wires 61, 62 in the connector 57 if the wires adequately fill the space within the connector, and to avoid the formation of voids between the wires and the connector surface which have been found along otherwise similar and similarly applied transversely elongated projections on the inner face of the connector provided with transverse depressions in its outer face.

The longitudinal depressions 63, and the corresponding internal projections on the connector 57 are less likely to cut very thin and overly ductile wires than transverse projections. They are more effective than transverse projections in distributing stranded wires over the full available cross section of the connector member, and thereby to eliminate voids.

Contact over an adequate area is particularly important in connecting wires of very small diameter, and was difficult to achieve heretofore by means of purely mechanical connectors without soldering. The contact resistance between very thin conductors is low in splices or conductive connections produced on the aforedescribed apparatus of the invention because of the close packing of the wires within a connector of suitably selected size having depressions aligned with the two halves of the split opposite connector wall. Aside from the longitudinal depressions 63, the specific illustrated shape of the edges 60 contributes most to low contact resistance.

The scallops or saw teeth of the edges 60 are beneficial in facilitating engagement of the edges between the strands of stranded cable. The saw teeth also interdigitate in the ultimate crimping operation and thus permit interlocking of the edges 60 in the crimped connector. The bending of the edges achieved during shearing, as shown in FIG. 5, slightly, but significantly stiffens the edges, and increases their resistance to deformation during crimping. It has also been found that the slightly bent or rolled edges travel along the walls of the die cavity more smoothly, and that connectors of very small size, such as those dimensioned for connecting one wire 0.001 in. in diameter to another conductor of 0.002 inch diameter, produced on the illustrated apparatus under normal manufacturing conditions are never deformed in an objectional manner.

As is evident from FIG. 2, the shaping tools in the illustrated apparatus are readily replaced by tools of different dimensions when it is desired to make different connectors, and the length of strip fed to the operating station can be quickly and precisely adjusted by angularly setting one of the cams 12 and by shifting the abutment or stop 45 on the supporting bracket 46. The guide block 41 may be used for a wide variety of strip and connector sizes, and is merely adjusted along the aperture 42 to match the thickness of the bending tool 28.

While it is necessary to provide the ram 30 with a concavely arcuate end face 31 for effectively crimping the smallest connectors for which the splicing apparatus is intended, and better splices are made with connectors of all sizes if the ram face is concavely arcuate, at least some of the advantages of this invention may be achieved with a ram having a flat face perpendicular to the direction of ram movement.

If the wires to be spliced are introduced manually into the cavity of the die plate 14, it is most convenient to have the die plate 14 fixedly mounted on the stand or frame 1. If the wires are presented automatically to the die plate 14 by an indexing turntable, as is known in itself, it is necessary to retract the die plate 14 downward and out of the path of wires carried by the turntable during the indexing movement of the latter. The movement of the die plate may be derived from the rotation of the shaft 8 in a manner obvious from FIG. 2 and not directly relevant to this invention.

What I claim is:

1. An apparatus for conductively connecting two wires comprising, in combination:
   a. a support;
   b. a die member mounted on said support,
      1. said die member defining a cavity of generally U-shaped cross section and having a concavely arcuate wall in the bottom of said cavity,
      2. the cavity being open in a direction transverse to said wall;
   c. a ram mounted on said support for movement in a path extending into and out of said cavity through the open side of the same,
      1. said ram having a face opposite said wall,
      2. said wall having an axis of curvature transverse to said path;
   d. an anvil mounted on said support for movement in the direction of said axis into and out of an operative position in which the anvil is spaced from said die member in said path and has an abutment face directed away from said die member;
   e. two bending tools mounted on said support for joint movement in a place transverse to said axis toward and away from respective positions contiguously adjacent said die member,
      1. said tools being spaced in said transverse plane and receiving said anvil in the operative position and said ram therebetween;
   f. indexing feed means movable for feeding sequential end portions of flat wire or strip in said transverse plane across said face of the anvil in the operative position of said anvil;
   g. cooperating shearing means on said support and on one of said tools for shearing said wire or strip therebetween when said one tool moves toward said die member, and for thereby severing the end portion of said wire or strip from the remainder of the same; and
   h. actuating means for causing said movements of said ram, said anvil, said tools, and said feed means in timed sequence,
      1. said actuating means including means for first feeding an end portion of said wire or strip across said face of the anvil by means of said indexing feed means, means for secondly moving said bending tools toward said die member until said end portion is severed from the remainder of said wire or strip by said shearing means, and the severed portion is wrapped about said anvil between said tools and thereby shaped into a connector, means for thirdly moving said anvil out of said operating position thereof, and mans for ultimately moving said ram into said cavity until the shaped connector is shifted into the cavity and into conforming engagement with said wall and said concave face and confined in all directions perpendicular to said axis by said ram and by said die member.

2. An apparatus as set forth in claim 1, further comprising a projection on said face of the ram, said projection being elongated in the direction of said axis.

3. An apparatus as set forth in claim 1, further comprising a ridge elongated in the direction of said axis and centered on said wall in said cavity, respective face portions of said wall on either side of said ridge being concavely arcuate and angularly meeting said ridge.

4. An apparatus for conductively connecting two wires comprising, in combination:

a. a support;

b. a die member mounted on said support,

1. said die member defining a cavity of generally U-shaped cross section and having a concavely arcuate wall in the bottom of said cavity,

2. the cavity being open in a direction transverse to said wall;

c. a ram mounted on said support for movement in a path extending into and out of said cavity through the open side of the same,

1. said ram having a face opposite said wall,

2. said wall having an axis of curvature transverse of said path;

d. an anvil mounted on said support for movement in the direction of said axis into and out of an operative position in which the anvil is spaced from said die member in said path and has an abutment face directed away from said die member;

e. two bending tools mounted on said support for joint movement in a plane transverse to said axis toward and away from respective positions contiguously adjacent said die member,

1. said tools being spaced in said transverse plane and receiving said anvil in the operative position and said ram therebetween;

f. indexing feed means for feeding sequential end portions of flat wire or strip in said transverse plane across said face of the anvil in the operative position of said anvil and including

1. a guide member fixedly amounted on said support and defining a guide channel for said wire or strip extending in a common plane with said abutment face of said anvil in the operative position of the latter and spaced from said anvil in said common plane for discharging the wire or strip across said face,

2. stopping means for stopping said end portion while said end portion is being fed by said feed means, said stopping means having a stop face transverse to said common plane and spaced from said abutment face in a direction away from said guide member, and

3. adjusting means for adjusting the spacing of said stop face from said abutment face;

g. cooperating shearing means on said support and on one of said tools for shearing said wire or strip therebetween when said one tool moves toward said die member, and for thereby severing the end portion of said wire or strip from the remainder of the same; and

h. actuating means for causing said movements of said ram, said anvil, said tools, and said feed means in timed sequence,

1. said cavity being also open in the direction of said axis for access by the wires to be connected.

5. An apparatus as set forth in claim 4, wherein said shearing means include a shearing edge on said guide member, said shearing edge being of arcuate cross section in said transverse plane and obliquely sloping from said common plane toward said die and said anvil, and another shearing edge on one of said bending tools.

6. An apparatus as set forth in claim 5, wherein said bending tools have respective bending faces substantially parallel to said common plane and equidistant from the same in all operative positions of said tools, said other shearing edge projecting from the bending face of the associated bending tool toward said die member, and being elongated in the direction of said axis.

7. An apparatus as set forth in claim 6, wherein said shearing edges are scalloped.

8. An apparatus as set forth in claim 1, further comprising trimming means responsive to movement of said bending tools toward said positions thereof for trimming a wire projecting from said cavity in the direction of said axis.

9. An apparatus as set forth in claim 1, wherein said face of the ram is concavely arcuate about an axis substantially parallel to the axis of curvature of said wall.

10. An apparatus as set forth in claim 1, further comprising a ridge centered on said wall in said cavity, respective concavely arcuate face portions of said wall angularly meeting in said ridge, said axis being the axis of curvature of one of said face portions, and the other face portion being curved about an axis of curvature extending in a common direction with said first-named axis; and two projections on said face of the ram elongated in said common direction and approximately aligned with the axes of curvature of said two-face portions in the direction of ram movement.

11. An apparatus as set forth in claim 1, wherein said shearing means include two shearing members having respective toothed shearing edges, said actuating means including means for moving one of said shearing edges relative to the other edge while said wire or strip is received between said shearing edges.

12. An apparatus as set forth in claim 1, wherein said actuating means include drive means comprising a motor, an output shaft drivingly connected to said motor for rotation thereby, and a plurality of motion-transmitting means, said motion transmitting means respectively connecting said output shaft to said ram, to said bending tools, and to said feed means for joint movement of said ram, of said tools, and of said feed means with the rotating shaft.

13. An apparatus as set forth in claim 12, wherein said actuating means include a single revolution clutch operatively interposed between said motor and said output shaft, and triggering means connected to said clutch for engaging said clutch while said output shaft makes a single revolution, and for thereafter disengaging said clutch, said motion-transmitting means moving said ram, said bending tools, and said feed means away from and toward a starting position during said single revolution of the output shaft.

14. An apparatus as set forth in claim 12, further comprising mounting means for fixedly mounting said die member on said support in each of a plurality of positions spaced in the direction of ram movement.

15. An apparatus for conductively connecting two wires comprising, in combination:

a. a support;

b. a die member mounted on said support,

1. said die member defining a cavity having a bottom wall,

2. an elongated ridge centered in said wall, respective portions of said wall on either side of said ridge being concavely arcuate about respective axes of curvature extending in the direction of elongation of said ridge and meeting said ridge,

3. said cavity being open in a direction transverse to said wall and in the direction of said axes;

c. a ram mounted on said support for movement in a path extending in said transverse direction into and out of said cavity, said ram having a face opposite said wall;

d. an anvil mounted on said support for movement in the direction of said axis into and out of an operative position in which the anvil is spaced from said die member in said path and has an abutment face directed away from said die member;

e. two bending tools mounted on said support for joint movement in a plane transverse to said axis toward and away from respective positions contiguously adjacent said die member,

1. said tools being spaced in said transverse plane and receiving said anvil in the operative position and said ram therebetween;

f. indexing feed means movable for feeding sequential end portions of flat wire or strip in said transverse plane across said face of the anvil in the operative position of said anvil;

g. cooperating shearing means on said support and on one of said tools for shearing said wire or strip therebetween when said one tool moves toward said die member, and for thereby severing the end portion of said wire or strip from the remainder of the same;

h. pressure concentrating means on said face of the ram for initially concentrating pressure exerted by the ram on a severed end portion of said flat wire or strip on a small portion of the surface of said severed end portion during movement of the ram into said cavity and for exerting said pressure on a greater portion of said surface after deformation of said small surface portion under the initially exerted pressure; and

i. actuating means for causing said movements of said ram, said anvil, said tools, and said feed means in timed sequence.

16. An apparatus as set forth in claim **15**, wherein said face of the ram is concavely arcuate about an axis substantially parallel to said axes of curvature, said pressure-concentrating means including a projection on said concavely arcuate face.

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