Oct. 3, 1967 C. A. COWSERT 3,344,499

MACHINE FOR CRIMPING METAL CONNECTORS

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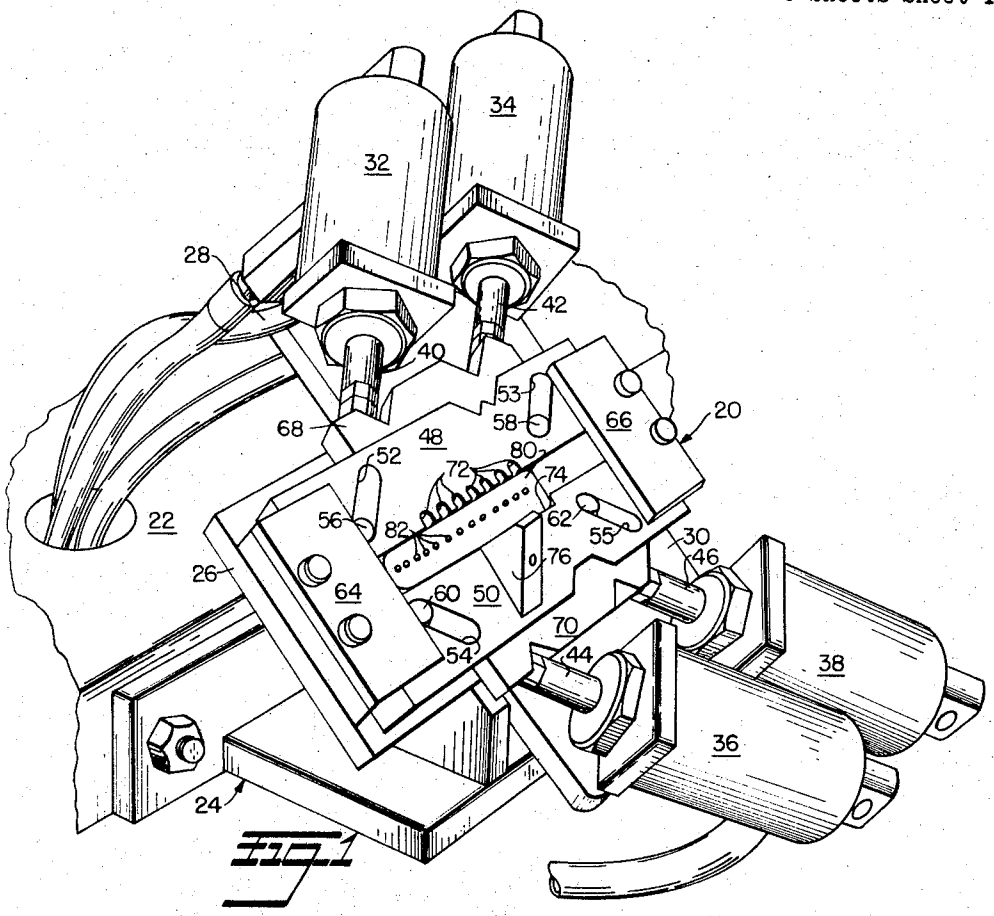


FIG. 1

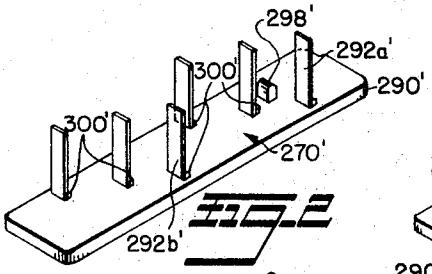


FIG. 2

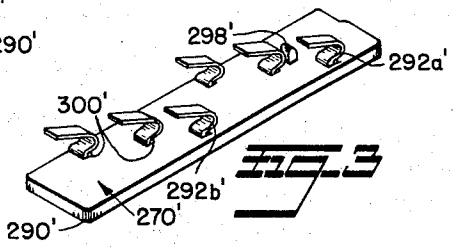


FIG. 3

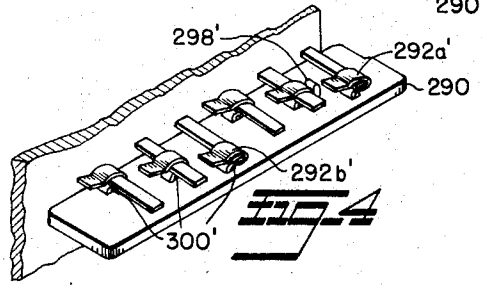


FIG. 4

INVENTOR
CHARLES A. COWSERT

BY Strauch, Nolan, Neale, Nies and Bronaugh
ATTORNEYS

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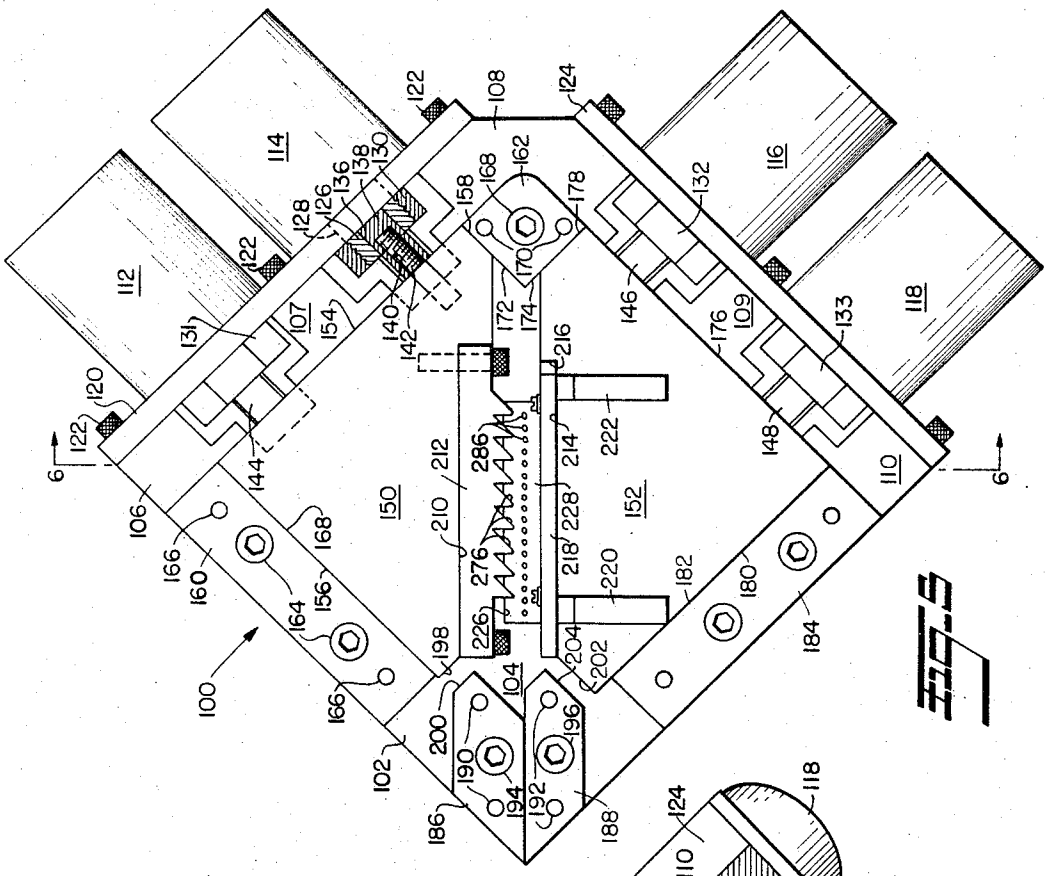


FIG. 5

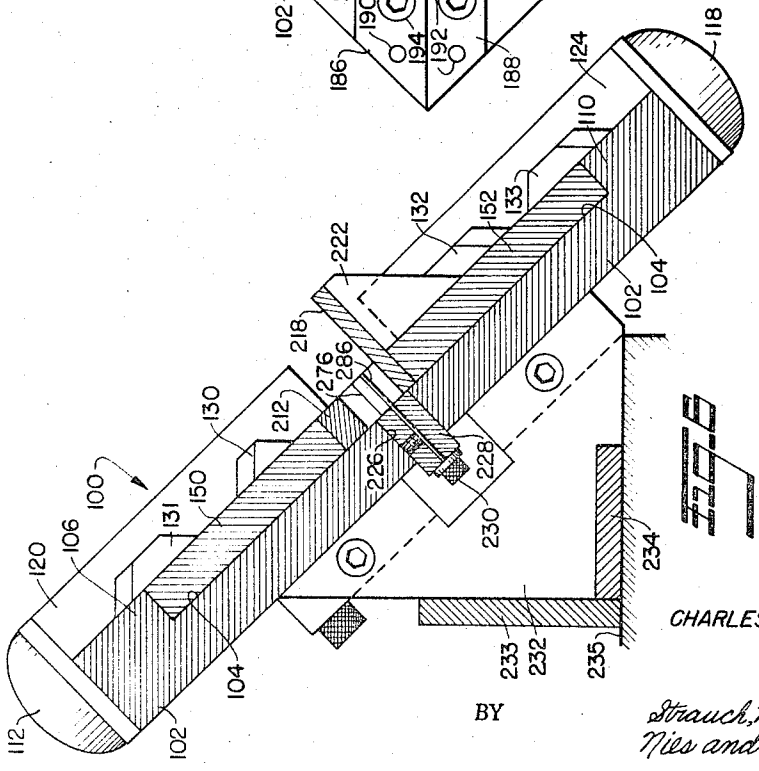


FIG. 6

INVENTOR
CHARLES A. COWSERT

BY Strauch, Nolan, Neale, Nies and Bronaugh
ATTORNEYS

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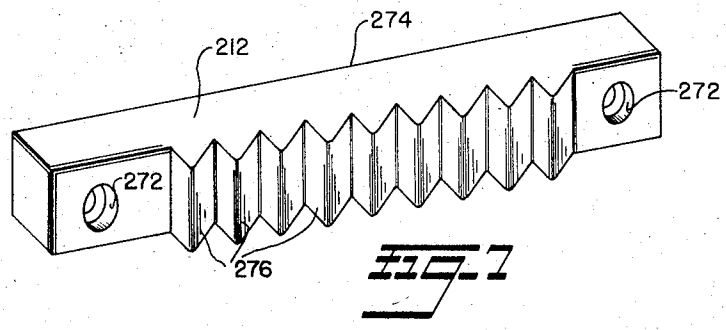


FIG. 7

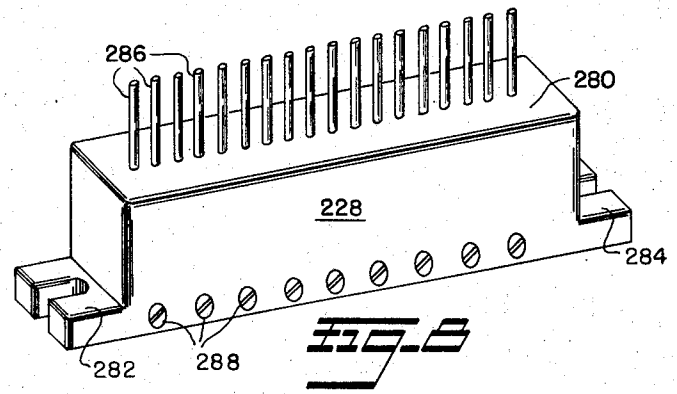


FIG. 8

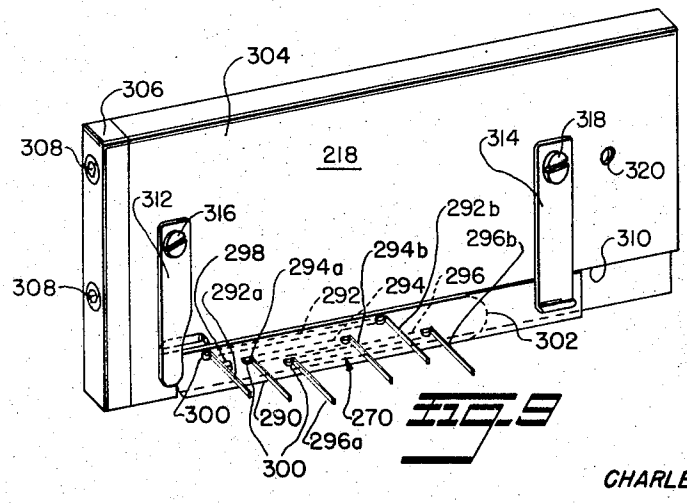


FIG. 9

INVENTOR
CHARLES A. COWSERT

BY Strauch, Nolan, Neale, Nies and Bronaugh
ATTORNEYS

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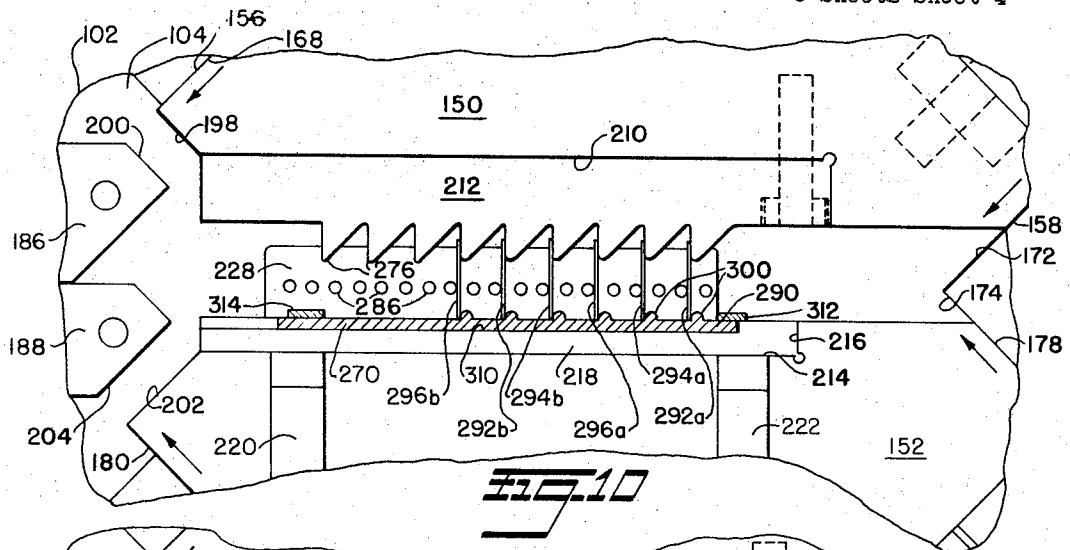


FIG. 10

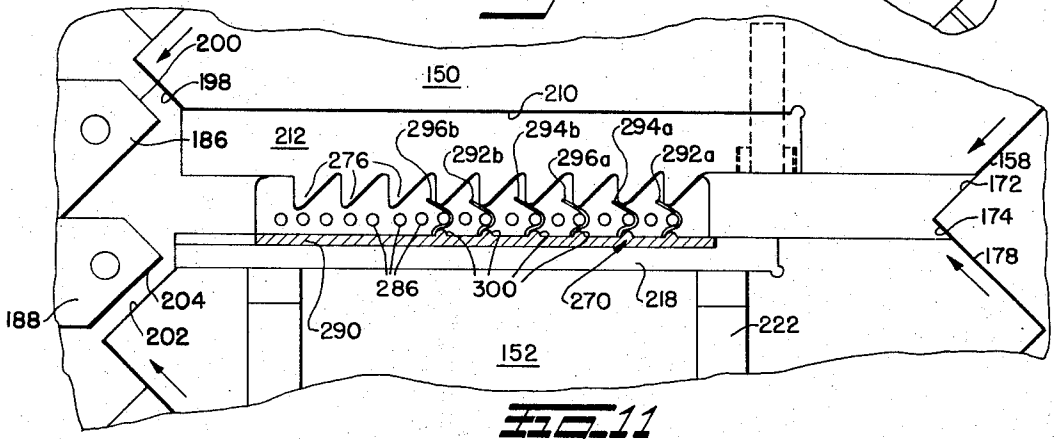


FIG. 11

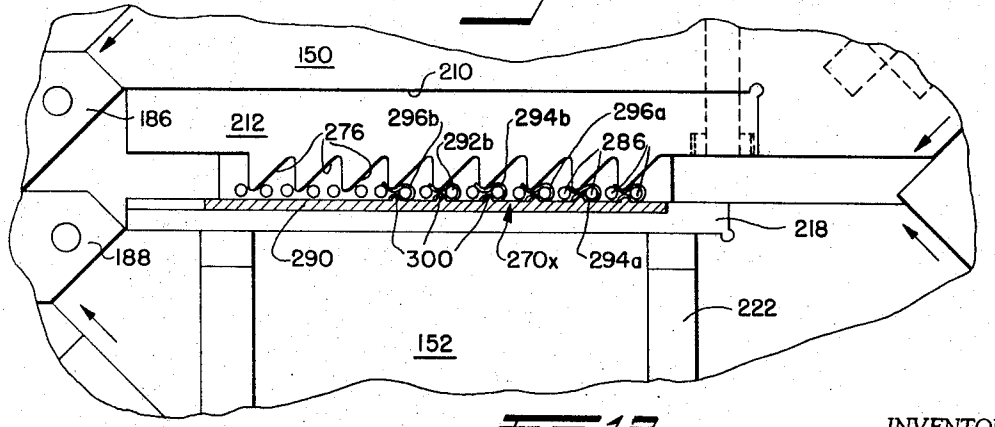


FIG. 12

INVENTOR
CHARLES A. COWSERT

BY Strauch, Nolan, Neale, Nies and Bronaugh
ATTORNEYS

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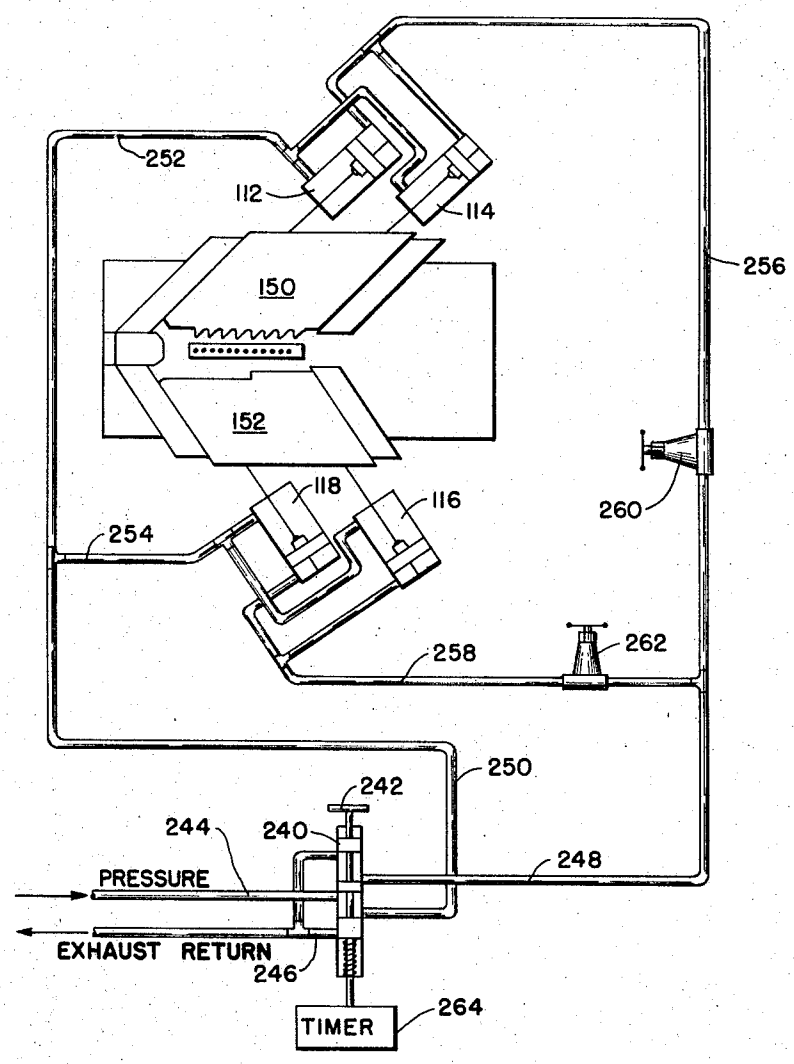


Fig. 13

INVENTOR
CHARLES A. COWSERT

BY Strauch, Nolan, Neale, Nies and Bronaugh
ATTORNEYS

United States Patent Office 3,344,499 Patented Oct. 3, 1967

3,344,499

MACHINE FOR CRIMPING METAL CONNECTORS

Charles A. Cowsert, Council Grove, Kans., assignor to Monarch Molding, Inc., Council Grove, Kans., a corporation of Kansas

Filed Aug. 11, 1965, Ser. No. 478,880
15 Claims. (Cl. 29—203)

This invention relates to the metal crimping art and more particularly to a machine for crimping the terminal end portions of conductors on a base member for use in bridging electrical terminals and the like and the connector article made by the machine. The new machine enables rapid mass production of terminal bridging connector units having integrally formed and accurately spaced and shaped C-shaped clips with reflexed entry portions formed on the ends of bridging conductors which are rigidly mounted in a dielectric base.

The improved shape of the article made by this machine, and resulting from this present invention constitutes an inventive improvement over previously known bridging connectors with conductor clips. Those previously known connectors in the past have been made by hand and it was difficult to form a serpentine bend in the protruding end portions of the bridging connectors to form U-shaped electrical clips all facing in the same direction for enabling placement of the bridging connector on a terminal block. The clips had to be accurately formed to embrace the bridged terminals with pressure and contact surfaces on both sides of the terminal in addition to the fact that the bight of each clip had to be accurately located relative to the other clips to assure placement of the bridging connector in accurate engagement with all desired bridged terminals. The previously known hand made connectors required multiple handling of the workpiece with many rejects resulting in an extremely high cost per unit item.

Accordingly, a primary object of this invention resides in the provision of a novel machine for forming, in one cyclic operation, a serpentine connector clip on one or more terminal ends of conductors mounted in a common dielectric base.

A still further object resides in the provision of a novel machine for simultaneously forming, in one cyclic operation, a serpentine connector clip on each of a plurality of terminal ends of conductors mounted in a common dielectric base member, each conductor having at least two of the terminal ends. In conjunction with this object a further object resides in the universal nature of the machine enabling forming of clips on multiple conductor end portions spaced along the common base member as well as on several conductor end portions spaced side by side in the base member.

In conjunction with the foregoing objects a further object resides in the provision of a machine for making terminal end clips on conductors by crimping, the machine having three relatively shiftable tool devices mounted on a common base, a first and second of the tool devices being shiftable relative to each other and also relative to a third tool device, the third tool device comprising one or more abutments about each of which is formed the bight of a C-shaped crimped end clip and the first and second of the tool devices forcing the terminal end portion of a conductor against and bending it around an associated abutment of the third tool device and, in cooperation with the third tool device, shaping reflex bends in the leg of the clip on both sides of the clip bight.

In conjunction with the preceding object and also as an improved article, a still further object resides in the unique provision in a connector workpiece of an elongate semi-rigid dielectric base from one side of which projects at right angles, at least one terminal end portion of a

conductor which will be made into a C-shaped conductor clip disposed parallel to the side and extending in the long dimension of the base, the opening of the C-shaped clip facing one end of the base, and an semi-cylindrical lug or protuberance integral with the base adjacent to and engaging the terminal end portion of the conductor on the side opposite the clip opening, said base and lug of the workpiece, together with a holding jig piece, comprising one of the first and second tool pieces used to make the completed workpiece.

A further object of the present invention resides in the provision, in the machine referred to in the two previous objects, of multiple tool elements in each of the three tool devices to enable simultaneously making C-shaped conductor end clips in a plurality of terminal end portions of conductors projecting in parallel arrangement from and normal to a side face of a common semi-rigid dielectric base. In connection with this object it is contemplated that a plurality of such conductor end portions can project at predetermined spaced apart positions along the length of the elongate base member and/or at various locations across the width of the base member at the same longitudinal location. In any event, each of the terminal end portions will have associated with it an individual semi-cylindrical back up lug on the side of the terminal end portion opposite the open face of the clip which will be made from the end portion.

Another object of this invention resides in the provision of a connector having a semi-rigid dielectric base member and at least one conductor, part of which is secured and embedded inside the base member and a terminal end portion of which projects from a flat side of the base member and is crimped into a C-shaped conductor end clip closely adjacent the flat side of the base member, the terminal end portion, as it projects from the base member, immediately passing first through an abrupt curved bend toward the base member then, by means of a reverse reflex bend, forming the bight of the clip and thence reversing its shape through a still further reflex bend, together with a small backup protuberance integral with the base member and in engagement with the clip under its initial bend to minimizing flexing of the clip at the initial bend during use of the connector.

Still another object of this invention resides in an improved terminal block bridging connector member having C-shaped conductor end clips accurately and uniformly shaped and spaced in plural arrangements on a semi-rigid dielectric base member, all clips facing in the same direction and each clip having associated therewith a small protuberance integral with and extending from the base member and backing a reflex bend in the conductor clip which occurs at the location where the clip material projects from the base member material.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings showing a preferred structure and embodiment, in which:

FIGURE 1 is a perspective view illustrating one embodiment of a crimping machine in accord with the present invention, the machine being mounted on a work table in the position in which it is most conveniently used;

FIGURES 2, 3 and 4 are enlarged perspective views showing various stages in the shapes of the machine made and improved connector workpiece of this invention, FIGURE 2 illustrating a preconstructed bridging connector, prior to being placed in the machine, having three bridging conductors with their six terminal end portions extending perpendicular from the dielectric base, FIGURE 3 showing an intermediate stage in the shaping of the crimped terminal ends of the conductors which

occurs approximately two-thirds of the way through the crimping machine forming cycle, and FIGURE 4 illustrates the connector end product in place on six terminals of a terminal block after the crimping operation is complete (the connector shapes in these three figures can be correlated approximately with FIGURES 10, 11 and 12);

FIGURE 5 is a top plan view of a second embodiment of the crimping machine of the present invention and shows the two rams, their associated pneumatic motors and the three relatively shiftable tool parts;

FIGURE 6 is a section view taken on line 6—6 of FIGURE 5 and shows the machine inclined in the manner in which it will be mounted on an assembly table;

FIGURE 7 is an enlarged detail perspective view illustrating the multiple tooth tool part which, in the machine assembly, is secured to one of the pneumatically operated rams seen in FIGURE 5;

FIGURE 8 is an enlarged detail perspective to substantially the same scale as FIGURE 7, showing a fixed tool part which includes a plurality of studs and which, in assembly, is removably inserted from the underside into the bed of the machine shown in FIGURE 5;

FIGURE 9 is an enlarged perspective, again to substantially the same scale as FIGURE 7, illustrating a workpiece and a jig which in fact is a third tool assembly inserted and removed from the second ram member seen in FIGURE 5. The jig is adapted to receive a preconstructed connector workpiece, the jig and portions of the retained workpiece constituting, in combination, the third tool assembly;

FIGURES 10, 11 and 12 are enlarged plan views of the central portion of FIGURE 5 to depict, respectively, stages during the crimping cycle. In FIGURE 10, the start position of the rams is shown with a preformed connector workpiece such as in FIGURE 2 disposed in its jig and the jig and workpiece placed in initial position; FIGURE 11 shows the disposition of the two rams after they have progressed thru approximately two-thirds of the crimping stroke and have accomplished an intermediate or partial crimping of the terminal ends of the conductors to a shape such as shown in FIGURE 3; and FIGURE 12 shows the completion of the strokes of both rams to complete the final crimping with reflex bends adjacent the terminal ends of the conductors, this final view showing the shapes of the crimped connectors prior to retraction of the rams which will permit the connectors to expand slightly under inherent springiness to the shape seen in FIGURE 4 and thereby enable removal of the connector from the machine and FIGURE 13 illustrates a simple basic pneumatic actuating and control system for the machine motors.

Both of the illustrated machine embodiments include the same basic components, the embodiment shown in FIGURE 5 constituting a refined arrangement of the machine assembly shown in FIGURE 1. The specific description will be primarily directed to the embodiment of FIGURE 5; however, with respect to FIGURE 1, a general description of the machine follows.

The crimping machine **20** of FIGURE 1 is secured to the front edge of a production bench or table **22**. A mounting bracket assembly **24** is bolted to the edge of the table and the base plate or bed **26** of the machine **20** in turn is rigidly secured to bracket assembly **24** in an inclined disposition, an arrangement enabling convenient insertion and removal of the workpieces. Bed **26** provides a planar upper surface and has two integral shalf-like extensions **28** and **30** at top and bottom edges to which are rigidly secured four pneumatic motors **32, 34, 36** and **38**. All four motors are double acting piston type, commercially available units. The reciprocable piston rods **40, 42, 44** and **46** are clearly shown extending toward and connected to the rams of the machine.

The two slidable rams **48** and **50** are made from flat blocks of steel having lower flat faces in surface sliding engagement with the upper planar surface of bed **26**. Slots **52** and **53** in upper ram **48** and slots **54** and **55** in lower ram **50** constitute tracks for guiding the reciprocating movement of the two rams. Slots **52** and **53** of the upper ram fit with a close sliding fit over two guide pins **56** and **58** secured in and projecting up from the bed **26**. In a similar manner two additional guide pins **68** and **62**, also secured in the bed, have a close sliding fit in guide tracks **54** and **55** of the lower ram **50**. Retaining plates **64** and **66**, secured by screws to support blocks and to the ends of bed **26** overlay and retain the rams on their guide pins and in sliding engagement with the upper surface of bed **26**.

Fastened to the outer edge of upper ram **48** is an adapted **68** which in turn is secured by threaded studs (not shown) to the ends of piston rods **40** and **42** of the two upper motors. A similar adapter **70** is secured in like manner to the lower ram **50** and to the piston rods **44** and **46** of the two lower motors **36** and **38**. Reciprocation of the two upper motors **32** and **34** imparts reciprocating motion to the upper ram **48** and reciprocation of the two lower motors **36** and **38** imparts reciprocating motion to the lower ram **50**.

Upper ram **48** on its working edge face is provided with a plurality of tooth like projections **72** which constitute the actual tool portions operable by the first ram **48**. The teeth can be made integral with the ram or on a separable portion as in the second embodiment. The lower ram **50** retains, supports and shifts a workpiece held in a jig, such as seen in FIGURE 9, although no jig or workpiece is shown in FIGURE 1. During operation, a jig and connector workpiece assembly is placed in a notched recess **74** located on the edge of ram **50** which faces the teeth of the upper ram **48**. Inasmuch as the jig is a small rectangular flat block and is disposed substantially normal to the ram **50**, to assure rigidity a small gusset shaped backing block **76**, secured by means of screws to the upper surface of ram **50**, serves as a backup abutment behind the jig. The lower ram **50**, the jig and a portion of the workpiece, as will be more fully described, are in fact one of the tool means and, in conjunction with the upper ram and its tool teeth **72**, co-operate with a third workpiece located between the two rams.

The third workpiece is a sub-assembly consisting of a mounting block carrying a plurality of upstanding round studs **82** (made from a tough hard metal like drill rod) which project up from the plane of the bed **26** a distance at least equal to the thickness of rams **48** and **50**. The relationships between studs **82** (which are miniature mandrels) and teeth **72** will be described hereinafter in conjunction with the second embodiment.

It is noted that a pre-constructed workpiece, as shown in FIGURE 2, is placed in a jig as shown in FIGURE 9. The jig is then placed into the notch **74** and against the backing gusset **76** of the lower ram **50** with the protruding terminal strips on the workpiece passing between studs **82** and terminating in front of teeth **72** in the manner shown in FIGURE 10. Subsequent energization of all four motors, **32, 34, 36** and **38** will cause the upper ram **48** and the lower ram **50** to be slidably shifted toward each other and at opposed angles across the face of bed **26**. The teeth **72** on the upper ram force one end of all connector terminal strips toward the left and simultaneously the lower ram **50** shifts the jig and workpiece, which contains the anchored body of the strip which forms the terminals, also to the left. The studs 82 remain fixed and stationary in bed **26** and provide a fixed abutment acting against the mid points of the connector strips on the workpiece. Continued sliding movement of the rams toward each other and at an angle will bend the connector terminal strips in a C- or U-shape around the studs **82** and completion of the ram movement shapes reflex bends in the terminal strip clips as will be fully explained hereinafter. All four ram motors with their

two rams are then retracted, leaving the jig and the workpiece loosely hanging on the studs **82**. The jig and workpiece may then be slid up off the studs **82** and the workpiece removed from the jig. If necessary, the end of the connector base can be clipped to make it a finished item, or the length can be a predetermined final size before the connector piece is placed in the machine.

Second embodiment

The second and refined embodiment of a clip crimping machine **100** is shown in plan view in FIGURE 5 and in sectioned elevation in FIGURE 6. Machine **100** is constructed on a bed **102** made from a square plate of cold rolled steel, milled or otherwise shaped so that its upper surface provides a flat sliding bed for the two rams, later described. The plane flat bed surface **104** terminates adjacent two of the edges of the bed in upstanding shoulder portions **106, 107, 108, 109** and **110** which are shaped to accommodate assembly of ram motors **112, 114, 116** and **118**. The four motors, as in the first embodiment, are double acting piston type pneumatic motors and are commercially available. They are shown somewhat schematically and in FIGURE 5 do not have the pneumatic line connections shown.

The two upper motors **112** and **114** are secured in side by side parallel arrangement to a support plate **120** made of cold rolled steel and the support plate in turn is rigidly fastened to the sides of bed shoulders **106, 107** and **108** by screws **122**. The two lower motors **116** and **118** are mounted on a similar support plate **124** which in turn is rigidly fastened to bed plate shoulders **108, 109** and **110** by screws.

All four motors are secured in a similar manner to their support plates respectively **120** and **124**, one such means being illustrated for the motor **114**. Each motor has a threaded spigot portion **126** which fits through a hole **128** in its associated support plate **120**. A hexagonal nut **130** threaded on spigot portion **126** clamps the motor housing to the plate **120**. Similar nuts **131, 132** and **133** secure the other three motors to their respective support plates. The housing spigot portion of motor **114** has a coaxial through bore **136** enabling passage of the reciprocable piston rod **138** disposed in a path parallel to the flat plane surface **104** of bed **102**. The end of piston rod **138** is provided with a threaded blind bore **140** into which is threadedly secured a ram connecting stud **142**. Piston rods **144, 146** and **148** of motors **112, 116** and **118** respectively are identically secured to their respective rams, and all piston rods reciprocate along axes which lie in a same plane parallel to and disposed above the plane flat face of bed **102**.

The two piston rods **142** and **144** of the upper motors reciprocate in paths which are parallel to each other and in a similar manner the two piston rods **146** and **148** of the lower motors also reciprocate in paths which are parallel to each other. However, as seen in FIGURE 5, the axes of piston rods **142** and **144** are disposed in paths which are perpendicular to the paths of piston rods **146** and **148**. It is noted that this angle does not necessarily have to be 90°, the 90° disposition being selected so that the directional components of bending forces at the beginning and the end of a crimping operation are substantially equal. As will be later apparent, the bending force at the start of the machine cycle is in a path which extends horizontally of the machine as shown in FIGURE 5, whereas the bending load at the termination of operation is in a path which extends substantially normal to the initial horizontal bending force. There are several variable components of bending occurring at the termination of the work stroke of the cycle (FIGURE 12).

As clearly shown in FIGURE 5, the mounting nuts and pistons of the four motors, when assembled on mounting plates **120** and **124** and when the mounting plates are secured to the bed **102**, will be disposed in the open spaces between adjacent ones of shoulders **106, 107, 108, 109** and **110** and the piston rods reciprocate in paths located just above the plane flat face **104** of bed **102**.

Studs **142** in the rods of the two upper motors **112** and **114** secure the respective piston rods to a side edge of an upper ram **150** and in a like manner the piston rods of the two lower motors **116** and **118** are secured to a side edge of lower ram **152**. While the two rams **150** and **152** are both somewhat triangular in shape they are two distinctly different components.

Considering the edge face **154** as the rear edge of upper ram **150** to which the piston rods of motors **112** and **114** are connected, the upper ram **150** has an elongated plane face **156** along one of its edges which extends perpendicularly from the rear edge **154** and a short plane face **158** which is parallel to face **156** and also extends perpendicular from the rear edge **154**. The two edges faces **156** and **158** constitute guide surfaces which are parallel to the axes of piston rods **142** and **144** and cooperate with tool steel guide blocks **160** and **162** which provide guide tracks during the work cycle reciprocation of ram **150**. Guide block **160** is rigidly secured along one edge of the plane face **104** of bed **102** by screws **164** and locator pins **166** so that its tracking edge **168** cooperates with the elongate plane face of edge **156** of ram **150**. Guide block **162** is fitted into the corner of the bed plate shoulder **108** and rigidly secured to bed plate **102** by screw **168** and locator pins **170** and provides guide tracks for both the upper and lower rams **150** and **152** by means of its perpendicular edge faces **172** and **174**. The guide block edge **172** is parallel and accurately located relative to the guide track **168** of block **160** and cooperates with the short plane face of edge **158** of the upper ram **150**.
edge **176**, has parallel short guide face **178** and long guide face **180**. Short guide face **178** cooperates with the pre-

The lower ram **152** is similarly secured to the two piston rods **146** and **148** of the lower motors along its base viously described guide track face **174** of block **162** and the long guide face **180** cooperates with the guide track **182** of another guide block **184** secured to bed **102** in a manner identical to that described for guide block **160**. All blocks are made of tool steel in order to resist the wear and forces which occur during the work strokes of the rams.

When the two rams are retracted by their respective motors the limit of travel is defined by abutment of rear edge face **154** of the upper ram **150** against the faces of shoulders **106, 107** and **108** and abutment of the rear edge face of lower ram **152** against shoulders **108, 109** and **110**. The work stroke limit of both rams is determined by abutment of the respective rams **150** and **152** against stop blocks **186** and **188**, respectively, which are secured to the bed **102** by means of the locator pins **190** and **192** and screws **194** and **196**. The edge face **198** of upper ram **150** opposite the rear edge face **154** is disposed perpendicular to the direction of travel of ram **150** and constitutes a limiting abutment on ram **150** which can engage a parallel abutment surface **200** on the stop block **186**. A similar end limit abutment surface **202** on lower ram **152** will engage a stop abutment surface **204** on stop block **188** to determine the work stroke limit of the lower ram **152**.

Both of the edge faces of the rams **150** and **152** which are in facing relationship are recessed and the bottoms of the two recesses provide surfaces which are perpendicular to the plane surface **104** of bed **102** and are also parallel to one another throughout the strokes of their respective rams. The recess **210** in upper ram **150** provides a seat to receive a tool piece **212**, secured therein as by screws. The recess in lower ram **152** provides an edge surface **214** and an end shoulder **216**, the recess receiving a flat workpiece jig **218** in a removable manner as will be hereinafter fully described, the jig being illustrated in FIGURE 9. The flat jig plate **218** fits in the machine assembly with its planar form disposed perpendicular to the plane face **104** of machine bed **102** and results in

the major extent of jig **218** projecting up above the top surface of ram **152** (see FIGURE 6). Because the jig **218** is freely placed in the lower ram recess and is not rigidly secured therein, two gusset blocks **220** and **222** provide backing support for a jig located in the lower ram. The front edges of the two gusset blocks **220** and **222** are planar and disposed in the same plane as the base face **214** of the lower ram recess thus the back surface of jig **218** when placed in the lower ram recess will be firmly supported against the two gusset blocks. The gusset blocks are secured to ram **152** by screws which can be inserted from and countersunk into the underside of the lower ram.

An elongate aperture (slot) disposed laterally in the machine bed **102** approximately at its mid position enables a tool device subassembly **228** (FIGURE 8) to be inserted in the machine bed **102** from the underneath side of the bed. The tool subassembly **228** will be described in detail hereinafter, sufficient at this point to note that the width of the tool assembly **228** is correlated to the width of the opening **226** to provide a smooth sliding fit as the tool subassembly is inserted into position whereas the length of the tool subassembly **228** is sufficiently shorter than the length of opening **226** to provide a slight amount of lateral adjusting movement of the tool subassembly for purposes to be described. The tool **228** is rigidly secured by means of screws **230** on the underside of bed **102**.

Triangular brackets **232** and plates **233** and **234** are secured together and to the bed **102** by screw to form a mounting arrangement whereby the machine can be secured in inclined disposition on the edge of a production work bench **235**.

The two rams **150** and **152** are slidable in paths which are coplanar and cross the flat face **104** of bed **102** to converge with simultaneous movement of both rams at a 90° angle. Both rams move relative to the tool assembly **228** which is fixed in bed **102**. Thus upper ram **150** moves in a path which, relative to the elongate extent of tool assembly **228** is 45° and in a similar manner the lower ram **152** also moves in a path which is 45° relative to the elongate extent of tool assembly **228**.

The pneumatic actuating system provided for the four motors **112** through **118** can be a simple basic pneumatic system such as illustrated schematically in FIGURE 13. The control valve **240** can be conventional two way spool valve spring loaded in one direction and operated in the opposite sense against the spring biasing force by a button or pedal unit **242**, depending on whether the operator operates it by hand or by foot. A pressure line **244** and return line **246** in fluid communication with a pneumatic pressure source are connected to valve **240** and thereby directed in a known manner to system main lines **248** and **250**. With valve **240** in its normal spring biased position, main line **248** is a pneumatic exhaust line and main line **250** becomes the line subjected to pneumatic pressure. Via connections from main line **250** through appropriate branch conduits **252** and **254** the pneumatic pressure condition from line **250** is connected in parallel to the retract side of the pistons on all four of the pneumatic motors **112**, **114**, **116** and **118**. The other main line conduit **248** connects through branch line **256** to the second expansible chambers of upper ram motors **112** and **114** and, through a second branch conduit **258**, to the second expansible chambers of the lower ram motors **116** and **118**. Thus with the control valve **240** in its spring biased condition pneumatic fluid under pressure through line **244** is directed to the expansible chambers of all four pneumatic motors forcing the pistons back into the motor chambers and exhausting the second expansible chambers through the two branches **256** and **258** into main line conduit **248** through control valve **242** exhaust. Thus all four motors will retract and pull their associated rams **150** and **152** to a retract limit position.

To operate the crimping rams through their work strokes, pressure on button **242** will shift the control valve which diverts the pneumatic fluid under pressure from line **244** into main line **248** and connects the main line conduit **250** to the exhaust conduit **246**. This condition of the control valve permits the first chambers of all four motors to be connected through the main line conduit **250** to exhaust and at the same time pressurizes the main line conduit **248** and both of its branch conduits **256** and **258** to apply pneumatic fluid under pressure to the second expansible chambers of all four motors **112**, **114**, **116** and **118**. If no force resists the movement of rams **150** and **152** all four motors should move at the same speed. However, due to intricities and different reactive forces during the crimping operations, as will be later described, there may be more force resisting movement of one of the rams than there is resisting the movement of the other rams. To attend to such differences in operating forces a pressure regulating valve such as valve **260** can be inserted in one of the branch lines from main line conduit **248** to provide desired control of variation in pressure between the two branch lines **256** and **258** to the respective sets of upper motors and lower motors.

A still more accurate control between pressures which are applied to the upper set of motors **112** and **114** and to the lower set of motors **116** and **118** can be accomplished by adding a second pressure regulator valve **262** in the branch conduit **258** directed to the second expansible chambers of the two lower motors **116** and **118**. In this manner accurate control of the pressures in each of the branch lines **256** and **258** can be adjusted regardless of variations in the pneumatic pressure source entering through line **244**.

Variations in the pressure applied to the upper set of motors and to the lower set of motors may be required due to thicknesses of wire which are used to make the crimped spring clips or to the size of the clips which are being made or to similar causes. Similarly there may be desired variations in the length of strokes of each of the two rams **150** and **152** dependent upon the thickness and extent of bends desired in the spring clips. The length of stroke can be changed very readily by using different sets of stop blocks **186** and **188**. For example in one embodiment of clip being made the stop blocks are shaped to provide an upper ram stroke travel of .296 inch and a lower ram stroke travel of .281 inch in order that the lower ram complete its stroke an instant sooner than does the upper ram. This relationship is desirable particularly with very small clips as it enables the plastic workpiece body with its tool abutment protuberances to be fully seated at the end of the stroke just before the steel teeth press the open reflex clip end down tight as will be more fully described. These examples are given merely to show that the stroke of both rams is not necessarily the same although it very well could be depending upon the thickness and the precise shape of clip which is desired.

Turning now to FIGURES 7, 8 and 9, FIGURE 7 illustrates the toothed tool piece **212**, FIGURE 8 illustrates the mandrel or stud tool assembly **228** and FIGURE 9 illustrates the jig **218** together with a connector workpiece **270**. The jig **218** and workpiece **270** are used together and provide an effective third tool assembly.

The tool piece **212** which, as previously described, is secured to the recess **210** in upper ram **150** is made from air hardened tool steel having two countersunk screw holes **272**, one formed adjacent each end of the tool piece. The rear face **274** of tool **212** is flat and in assembly is abutted squarely against the flat face or recess **218** in upper ram **150** and held securely by screws as described. The free face of tool **212** is provided with a series of tooth like vertically extended parallel abutments **276** arranged in a saw tooth manner, each tooth abutment **276** having a similar shape. In the tool piece shown in FIGURE 7, there are 9 such tooth abutments although more or less could be utilized depending upon the size of the machine and the number of clips which appear on a connector and which are desired to be simultaneously shaped. The peaks of each

of tooth abutments **276** are rounded and are all spaced an equal distance from the adjacent toothed abutment. The vertical width of tool piece **212** can vary and may even be constructed slightly greater than the thickness of its associated ram **150**, however, in the illustrated embodiment the tool piece **212** is the same thickness of that of ram **150**.

The tool assembly **228** shown in FIGURE 8 is also made of air hardened tool steel, the cross sectional shape of which permits insertion of piece **228** into the elongate hole **226** previously described in the machine bed **102** to provide a smooth snug sliding fit across the width of tool piece **228** and yet permit slight play lengthwise relative to the hole **226**. The vertical depth of the piece **228** is greater than the thickness through the plane portion of bed **102**; however, the distance from the top face **280** of tool piece **228** down to the shoulders of the forked end lugs **282** and **284** is substantially equal to the thickness of machine bed **102**. When the tool piece **228** is inserted from beneath the machine bed **102** into the hole **226** the end lugs **282** and **284** will limit the extent of insertion so that the top face **280** of the tool piece **228** is disposed level with the plane working surface **104** of the bed **102**. The aforedescribed screws **230** which secure the tool piece **228** to the bed **102** cooperate with the forked lugs **228** and **284** and thereby clamp the tool piece **228** to bed **102**.

The tool piece **228**, before being hardened, is drilled at a plurality of locations equidistinctly spaced apart extending vertically through the piece **228** and being disposed in a straight line centrally located along the elongate extent of the tool piece **228**. The axes of all such drilled openings lie in a common plane and each such opening receives a short length of drill rod **286** to serve as a mandrel. Each of the plurality of drill rods **286** extends to the bottom of tool piece **228** and is secured in position by a set screw **288**. The set screws for alternate ones of the drill rods **286** are placed on opposite sides of the tool piece **228** for clearance purposes. The spacing relationships shown in FIGURE 7 and in FIGURE 8 are such that the distance between each of the toothed abutments **276** is twice as great as a distance between each of the drill rods **286** and that relationship is more clearly apparent in FIGURE 12. The reason for this relationship will become apparent as the description proceeds.

FIGURE 9 illustrates jig **218** holding a preliminarily formed connector workpiece **270**. While the connectors made by the crimping machine hereindescribed are utilized for the same purpose as the connectors shown in United States Patents Nos. 3,181,109 and 3,188,603, the connectors shown in those patents are made by hand, using several individual hand tools to form the shape of each of the clips. As is true of the connector members shown in those patents the connector member **270** of the present invention is initially made with an elongated, preferably rectangular base member **290** desirably formed of a rigid plastic material which serves as an insulator for electric current. The base member **290** can be made of other suitable insulation materials. Base **290** is preferably rather thin and several (three being shown) metal conductors **292**, **294** and **296** have elongated center portions embedded in the plastic material. As shown, it is preferable that the conductor materials are made from flat strips of a metallic material having a relatively high electrical conductivity. For example this material can be made with a copper core having a silver coating. Each of the plurality of conductors **292** through **296** has two terminal end portions, **292***a* and **292***b* for conductor strip **292**, **294***a* and **294***b* for conductor strip **294** and **296***a* and **296***b* for conductor strip **296**. These terminal end portions project out from one face of the plastic member **290** and in a preformed workpiece, such as **270** in FIGURE 9 and **270'** in FIGURE 2 wherein equivalent components are referenced with primed numbers, they project at 90° to the flat face.

Formed integral with the plastic surface of the base member strip **290** is a stop lug **298**, the purpose of which is not part of the present invention. However, the stop lug **298** is located approximately half way between two projecting terminal end portions and is an integral part of the plastic strip **290**.

An important aspect of the present invention over the clips shown in FIGURE 4 of U.S. Patents Nos. 3,181,109 and 3,188,603 is the provision of semi-cylindrical abutments **300** for connector **270** and **300'** for connector **270'**, integral with the plastic strip **290** and located immediately adjacent the base ends of the conductor terminal end portions **292***a*, **292***b*, **294***a*, **294***b*, **296***a* and **296***b*. These small plastic abutments are shaped as half cylinders having substantially the same diameter as the diameter of drill rod or mandrel pieces **286** in tool assembly **228** and provide several distinctive functions. First, during the machine crimping of the terminal end portions of the connector strips **292**. **294** and **296**, the semi-cylindrical abutments **300** serve as tool members which aid in the crimping and shaping of the terminal end portions into spring clips (see FIGURES 11 and 12). Second, they serve as curved backup members for each spring clip on a complete connector as shown in FIGURE 4. This backup abutment is located adjacent the location where each clip projects out of the plastic strip material, a location of concentrated stress and strain due to flexing of the clips during installation and removable of the connector members. The curved abutment provides a surface which spreads stress and strain over a great extent of the clip material and increases useful clip life.

As can be seen in FIGURE 9, the plastic body **290** of the preformed connector **270** may be longer than necessary for the final connector. This might be desired primarily for ease in handling and shaping, the excess plastic material being easily trimmed off in a final operation along the dotted line **302**.

A workpiece jig **218** (FIGURE 9) has a major body portion **304** made of a flat rectangular piece of tool steel approximately ¼-inch thick, i.e., the thickness is equal to the depth of the recess shoulder **216** in lower ram **152**. One end of jig **218** has a pressure edge which is acted upon by shoulder **216** of the recess in ram **152**. Because that pressure edge gets the greatest wear, a replaceable strip **306** is secured to that end of the main jig body **304** by countersunk screws **308**. Thus when the maximum wear on jig **218** is reached, the pressure strip **306** can be replaced, avoiding the necessity of replacing a complete jig.

Along the lower front face of jig **218** a rabbeted groove is provided to receive the plastic body **290** of a preformed workpiece **270**. The depth of the rabbeted groove **310** is approximately the same as the thickness of the plastic body **290** of the workpiece and the width of groove **310** is equal to the width of the plastic body **290**. As seen in FIGURE 9, the left hand end of rabbeted groove **310** is provided with a notched recess shaped to coact with the notched end of body **290** of workpiece **270**. If that end of the workpiece **270** were squared the end of the recess **310** could be squared, i.e., the left hand of the recess as shown in FIGURE 9 can be made in a shape to correspond with the shape of the end of the workpiece.

Two spring clips **312** and **314** are secured as fingers by screws **316** and **318** to the front face of jig body **304**. The two clips are sprung to create a friction against a workpiece **270** placed in the rabbeted groove **310**. However, an operator can pivot the two fingers away from engagement over the rabbeted groove **310** enabling insertion and removable of the workpiece **270**. Engagement of the two spring fingers with a workpiece **270** should be adjacent the ends of the workpiece in order to clear the tool portions **212** and **228** during shaping of the clips on the connector. If the preformed workpiece **270** has the termnial end portions of the conductors spaced further apart than shown in FIGURE 9, the right hand spring finger **314** might have to be shifted to the adjacent screw hole **320**. It is to be understood that different sized jigs are used for different widths of connectors to be made. For example it is apparent that

the preformed connector workpiece **270** shown in FIGURE 9 has a width which is about ⅔ of the width of the connector workpiece **270'** shown in FIGURE 2. Accordingly, the width of the rabbetted groove in a jig intended to carry the connector workpiece **270'** would be wider and possibly deeper than the illustrated rabbetted groove **310** shown in FIGURE 9.

Forming operation

As shown in FIGURE 10, both the upper ram **150** and the lower ram **152** are in their fully retracted positions which is the same positon as that shown in FIGURE 5. In such position, and with a workpiece **270** inserted in the jig in the manner shown in FIGURE 9, the jig **218** with a preformed workpiece is placed against wall **214** and shoulder **216** of the recess in the lower ram **152** with the jig **218** resting against the gusset blocks **220** and **222**. Insertion of the combination jig and workpiece in such manner will place the terminal end portions **292***a*, **294***a*, etc. extending perpendicularly from the face of jig **218** and parallel to the plane surface **104** of machine bed **102**. So positioned, each of the terminal end portions **292***a*, etc., extends and lightly tangentially engages one of the drill rod mandrel studs **286** which extend up perpendicular from the plane of the machine bed surface **104**.

Six of the conductor terminal end portions are shown in FIGURE 10 and are so spaced along the length of a plastic body **290** that they consecutively engage the front straight face of six of the toothed abutments **276** on the upper ram workpiece **212**. The intermediate connecting portion of the terminal end portions are of course embedded in the plastic body to **90**, but where they exit from that plastic body each of those terminal portions is backed on its right hand side by one of the semi-cylindrical plastic protuberances **300** integral with the plastic body **290**. Since plastic body **290** is securely received and held in the rabbeted recess **310** of jig **218** and jig **218** is securely disposed in the recess of the lower ram **152**, the protuberances **300** in effect become workpiece abutments. Upon movement of the lower ram in the direction of the arrows (see FIGURES 10, 11 and 12) along the guide tracks **174** and **182**, the plastic protuberances **300** will tend to shift the base ends of the terminal end portions **292***a*, etc. simultaneously toward the left of the machine and also up toward the line of drill rod studs **286**. Also, the ends of each of the conductor terminal end portions **292***a* etc., which project up and engage the straight sides of toothed abutments **276** will be forced toward the left hand side of the machine upon working movement of the upper ram **150** in the direction of the arrows along guide tracks **168** and **172**. That ram movement forces the upper ends of the terminal end portions toward the left and down toward the line of drill rod studs **286**.

The spacing between each of the conductor terminal end portions **292***a*, etc., and their associated half cylindrical protuberances **300** is equal to or in multiples of the distance between each of the toothed abutments **276** on tool piece **212**. The preformed connector workpiece **270** is so constructed that when it is disposed in its associated jig **218** and the jig is placed in proper position in the lower ram **152**, each of the perpendicular conductor end portions **292***a*, etc., will be touching the front face of an associated toothed abutment on the same side as that terminal end portion's associated backup protuberance **300**. Each conductor end portion extends past and beyond an associated drill rod stud **286** a distance sufficient, when the end is bent over, to extend over two adjacent drill rod studs and has its left or other side touching the left hand adjacent drill rod stud **286**.

As previously described, there are two drill rod studs located in a space equivalent to the spaces between the toothed abutments **276**. Therefore if two of the conductor terminal end portions such as portions **292***a* and **294***a* extend into engagement with the front faces of two adjacent toothed abutments **276** there will be a non-engaged drill rod stud **286** located between the two drill rod studs **286** which are in tangential engagement with those two conductor terminal end portions **292***a* and **294***a*. This condition is clearly shown in FIGURE 10. If the connector piece is so designed, more than one conductor terminal end portion can be located at the same lengthwise position although spaced apart across the width of the plastic body **290**. Therefore, more than one terminal end portion can be formed into a spring clip in one operation by the same toothed abutment **276** and the same drill rod studs **286**. Thus the location of the finally formed spring clips will depend upon the desired design configuration of the complete connector.

With jig **218** and its contained preformed connector workpiece **270** placed in the position shown in FIGURE 10, the machine is ready to be operated through a work stroke and retract cycle. The operator manipulates control valve **240** (FIGURE 13) and energizes the four ram motors to operate and shift the rams **150** and **152** toward their abutment stops **200** and **204**.

FIGURE 11 illustrates an intermediate machine condition in which the two rams **150** and **152** have shifted through approximately ⅔ of their work stroke. In FIGURE 11 the part of each conductor terminal end portion **292***a*, etc., which was in engagement tangentially with an associated drill rod stud **286** stays in essentially the same position with no effective shift relative to the drill rod stud. However, the part of the conductor terminal end portion closest to the plastic body strip **290** is shifted to the left and at the same time moved closer to the row of drill rod studs by the work stroke movement of the lower ram **152**. Simultaneously, the end portion which extends beyond the drill rod pins and into engagement with the front surfaces of toothed abutments **276** is also being shifted to the left and down toward the row of drill rod studs **286** with its free end overlying the next adjacent drill rod stud **286** to the left. This movement is due to the work stroke of the upper ram **150** which shifts the tool piece **212** toward the left and closer to the drill rod studs.

As clearly shown in FIGURE 11, these two simultaneous shifting movements of rams **150** and **152** form the initial C or U-bend or bight of each terminal end portion and FIGURE 11 also shows the initial, smoothly curved bend of the terminal end portions adjacent the position where they exist from the plastic strip **290**, the initial bend being formed over the half cylindrical protuberances **300**.

Note in both of FIGURES 10 and 11 that the lower ram **152** has a shorter stroke to its abutment stop **204** than does the upper ram **150** to its abutment stop shoulder **200** and therefore the lower ram completes its stroke a minute increment before the upper ram finishes its stroke. This relationship permits the initial bend of the clip to be completely formed by the plastic protuberance **300** without having interference from the matching abutment tooth. The tooth **276** being made of steel can finish its stroke, after the lower ram stroke is completed, and assure shaping of the clip reflex end without a deformation of the steel tooth whereas, if the plastic protuberance had to force the initial bend of the conductor up between studs against a fully seated steel tooth, the plastic protuberance **300** could be deformed with resultant improper initial bend shape for the clip.

Both of the rams **150** and **152** continue their simultaneous shift as they move from the position shown in FIGURE 11 to the final stop or termination position of the work stroke shown in FIGURE 12. During this shifting movement, the rounded ends of the toothed abutments **276** slide along the horizontal bent ends of each terminal end portion as they shift slightly toward the left and at the same time force the center of that small end down between the two engaged drill rod studs **286** thereby forming a reflex curve in the end of each conductor terminal end portion as the tip of each toothed abutment moves into a position somewhat between the adjacent

drill rod studs **286** as seen in FIGURE 12. During and before completion of the just described movement of upper ram **150** the lower ram **152** completes its movement shifting further toward the left and up closer to the drill rod pins. Such action results in the formation of a reflex curve in the conductor terminal end strip adjacent the plastic strip **290**. That reflex curve is formed between the drill rod stud **286** which is located in the bight of the spring clip and the half cylindrical protuberances **300** which tend to force the base portion of the terminal end portions up between two adjacent drill rod pins where it is almost immediately engaged by the reflexed terminal end which is being pushed down between the same two studs by the curved end of the associated toothed abutment **276**. Protuberances **300** being made of the same plastic material as is the body **290**, can be somewhat deformed during this final stage operation thus preventing rupture or destruction of the tool parts, however the initial bend in the clip has been fully formed at this stage and pressure by the seating steel tooth does not thereafter deform the set of the initial bend.

In the condition as shown in FIGURE 12, both rams **150** and **152** are in abutment with the stop blocks **186** and **188** respectively and the shaped terminal end clips are tightly encircling the drill rod pins **286**. If these clips remained in that shape there would be difficulty in removing the connector piece from the drill rod pins. However, the metallic conductors which provide the terminal end portions have an inherent springiness and while the shapes formed in FIGURE 12 remain somewhat as shown, the clips tend to spring back a slight amount when the two rams are retracted to a retract position. That effect serves to loosen all of the shaped spring clips on their associated drill rod pins. Nevertheless, because the clips now encircle the pins, the connector piece **270** cannot be pulled back away from the drill rod pins as the lower ram **152** moves back to its retract position and because the connector **270***x* (FIGURE 12) is held in the rabbeted recess **310** of jig **218** the jig itself cannot move back with retraction of ram **152**. Therefore, the combination jig **218** and finished connector workpiece remains on the drill rod pins **286**. However, because they are loose on the pins, the operator can remove the jig and the connector piece **270***x* by vertically sliding the clips up off the drill rod pins. Thereafter the spring fingers **312** and **314** can be pivoted to one side and the substantially finished connector piece **270***x* removed from the jig and trimmed as described.

If it is desired that the work and retract strokes be automatically timed a suitable timer **264**, FIGURE 13, can be connected to control the release and return position of the system control valve **240**. Such timers can be mechanical or electrical, their use on cycle control valves for pneumatic forming machines is well-known, and such timers are commercially available as off-the-shelf items.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. A machine for crimping a terminal end of a conductor mounted in a dielectric base comprising: three relatively shiftable tool devices, means on said base forming part of one of said tool devices, said three tool devices comprising means for forming, in one cyclic operation, a serpentine connector clip on said terminal end, and power means and control means for cycling said tool devices through a cycle of operation.

2. A connector crimping machine as defined in claim **1**, wherein means are included in cooperation with said power means and control means enabling said one of said tool devices to complete its work stroke portion of the operating cycle prior to completion of the work stroke portion of the operating cycle of the combined set of the other two tool devices.

3. A machine for making terminal end clips on conductors by crimping, said machine comprising: three relatively shiftable tool devices; a common base mounting said three tool devices so that the first and second said tool devices are shiftable relative to each other and relative to the third one of said tool devices; power means connected to said first and second tool devices for so shifting said tool devices; said third tool device comprising a plurality of abutment means about at least one of which is formed the bight of a crimped end clip; shifting movement of said first and said second of said tool devices resulting in engagement with and forcing of the terminal end portion of a conductor against and bending it around an associated said abutment means of said third tool device and, in cooperation with said associated abutment means and a next adjacent one of said abutment means of said third tool device, shaping reflex bends in the legs of the formed clip on both sides of the clip bight.

4. In a machine as defined in claim **3**, one of said first and second tool devices including a jig member adapted to hold an elongate semi-rigid dielectric base means, said base means having a side surface and having a strip conductor therein with at least one terminal end portion of said conductor projecting normal from said side surface to be made into a C-shaped conductor end clip disposed parallel to the side of and along the long dimension of said base means with the opening of said C-shaped clip, when formed, facing one end of said base means, and said base means including a semi-cylindrical protuberance structurally integral therewith adjacent to and engaging said projecting terminal end portion of said conductor on the side opposite the opening of a clip when formed.

5. A machine as defined in claim **3** comprising: multiple tool elements in each of said three tool devices to enable simultaneously making of C-shaped conductor end clips from a plurality of terminal end portions of conductors projecting in parallel arrangement from and normal to a side face of a single common, semi-rigid, elongate dielectric base means of a workpiece.

6. In a machine as defined in claim **5**, said tool elements each having sufficient dimension to accommodate a plurality of such conductor end portions at predetermined spaced apart positions across the width of said base means and at the same location in the elongate dimension of said base means.

7. A machine for crimping at least one substantially straight terminal end portion of at least one length of metal into a clip element extending from a base portion into a transverse C-shape crimp, said machine comprising: three relatively shiftable tool means, a first one of said tool means having at least a portion with a curved surface for initially tangentially engaging a part of the terminal end portion of the length of metal at a location offset from its terminal end and about which location the bight of the C-shape crimp is formed, the second and third ones of said tool means being respectively disposed on opposite sides of said first tool means; means mounting all three of said tool means enabling shifting movement of said second and third tool means relative to each other and to said first tool means along planar paths disposed in a common plane, the directions of said paths being inclined relative to said tangential disposition of the straight terminal end portion and which paths intersect each other; power means connected to said tool means to enable said relative shifting movements of said second and third tool means toward and away from each other; means on each of said second and third tool means for engaging second and third portions of the terminal end portion of the length of metal and during relative

shifting movement of said second and third members along said paths to bend the second and third portions of the terminal end portion around said first tool means and toward each other as clip leg parts; and cooperating means located partially on said first tool means and partially on at least one of the other of said tool means for engaging and forming a reflex bend in a part of at least one of said second and third portions of the terminal end portion remote from the bight of the C-shape crimp.

8. A machine as defined in claim 7, wherein said cooperating means includes means located on said first tool means, means located on said second tool means and means located on said third tool means and said cooperating means engages and forms independent reflex bends, relative to the bight of the C-shape crimp, one reflex bend being in a part of each of said second and third portions of the terminal end portion and spaced away from the bight of the C-shaped crimped clip.

9. A machine as defined in claim 7, wherein a workpiece includes a planar base means, said base means rigidly mounts said length of metal with the substantially straight terminal end portion thereof extending transverse from said planar base, and said base is temporarily secured in and becomes a part of one of said second and third tool means.

10. A machine as defined in claim 7 for concurrently crimping a plurality of substantially straight terminal end portions of at least one length of metal, wherein said first tool means includes a plurality of spaced apart stud mandrel means extending normal to said common plane of the paths of movement of said second and third tool means and each stud mandrel means provides a said curved surface capable of providing a said tangential engagement at the ultimate bight portion of at least one of said associated straight terminal end portions, said second and said third tool means each respectively include a plurality of similar means for engaging respective second and third portions of said terminal end portions and, during relative shifting movement of said second and third tool means, to bend associated said second and third portions of each said terminal end portion around the engaged one of said stud means and toward each other.

11. A machine as defined in claim 7, wherein said first tool means includes a plurality of spaced apart round stud mandrels projecting from said common plane, disposed in a row extending normal to the location of the straight terminal end portion and one of said stud mandrels being said portion of said first means which initially tangentially engages the part of the terminal end portion; the next adjacent one of said stud mandrels in the direction of bend of the terminal end portion from the stud mandrel which forms the bight of the associated terminal end portion serves as an abutment for one leg part of the associated terminal end portion and each of said engaging means of said second and third tool means is shifted partially into the spaces between said adjacent ones of said stud mandrels to thereby force the two leg parts into reflex bends between adjacent stud means.

12. In a machine for crimping a plurality of terminal ends of conductors mounted in a common dielectric base member and wherein each conductor has at least one of said terminal ends, the combination including: power means, control means, and three relatively shiftable tool means operable thereby for simultaneously forming, in one cyclic operation, a serpentine connector clip on each of said terminal ends.

13. A connector crimping machine as defined in claim 12 including a support base and, wherein two of said three tool means are directly connected to said power means and are shiftable relative to said base along intersecting opposed paths and the third of said tool means is stationary relative to said base and located between said other two tool means.

14. A connector crimping machine as defined in claim 12, wherein each said tool means has a plurality of tool mandrel and forming elements enabling forming of connector clips on multiple conductor end portions spaced along the common base member as well as enabling forming of several conductor end portions spaced side by side in the base member, during a single cyclic operation of said machine.

15. A connector crimping machine as defined in claim 14, wherein at least two of said tool means comprise separable units each of which units include a plurality of said tool mandrel and forming elements.

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JOHN F. CAMPBELL, *Primary Examiner.*

THOMAS H. EAGER, *Examiner.*