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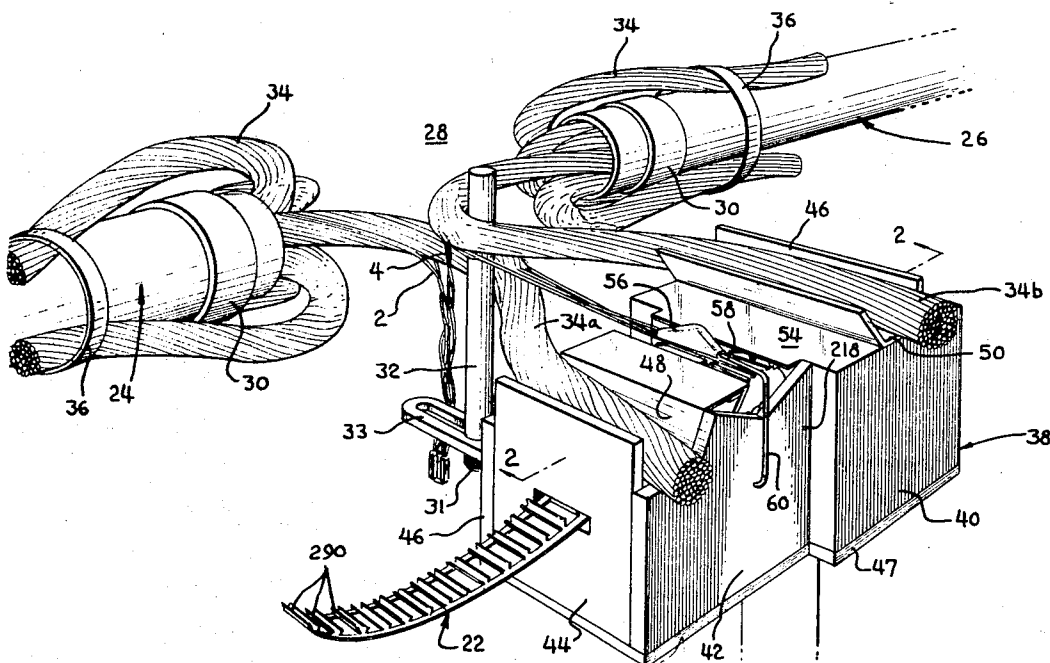
[54] **METHOD AND APPARATUS FOR CONNECTING
 PAIRS OF CONDUCTORS**
19 Claims, 22 Drawing Figs.

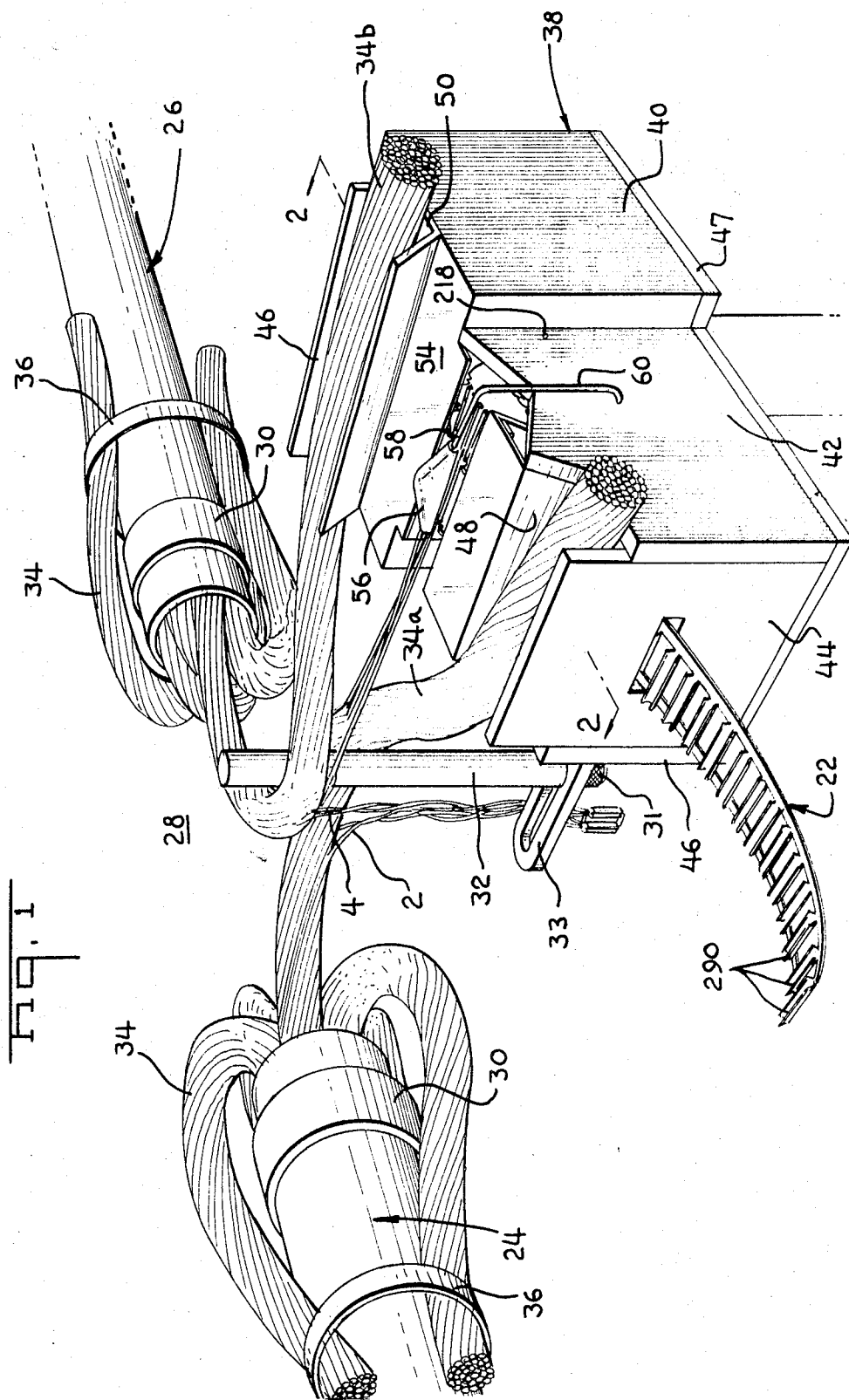
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 29/203 D, 29/203 MW, 29/461
 [51] Int. Cl. **H01r 43/00,**
 H01r 43/04, B23d 25/00
 [50] Field of Search. 29/203, 203
 D, 628, 203 H, 461; 140/111

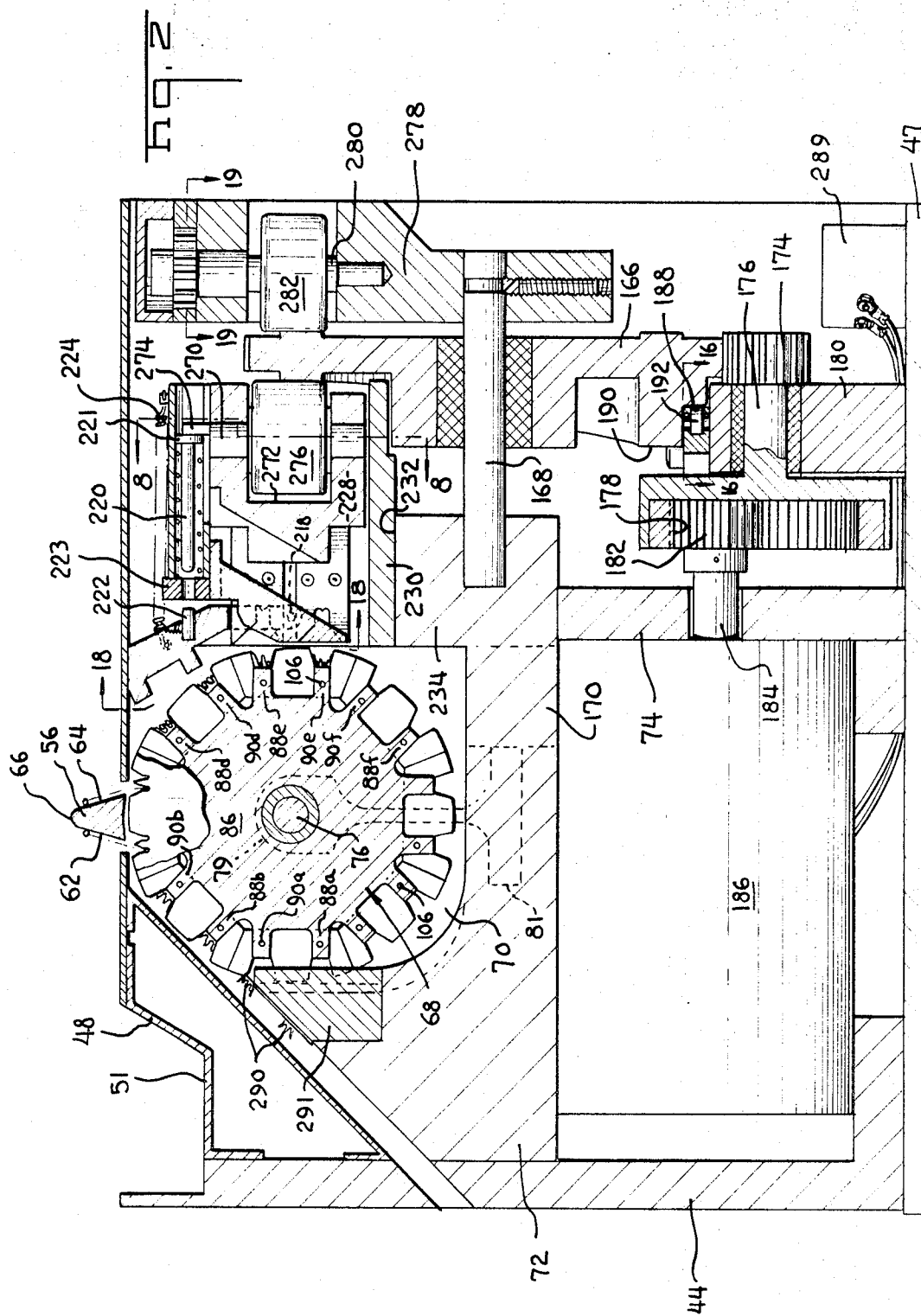
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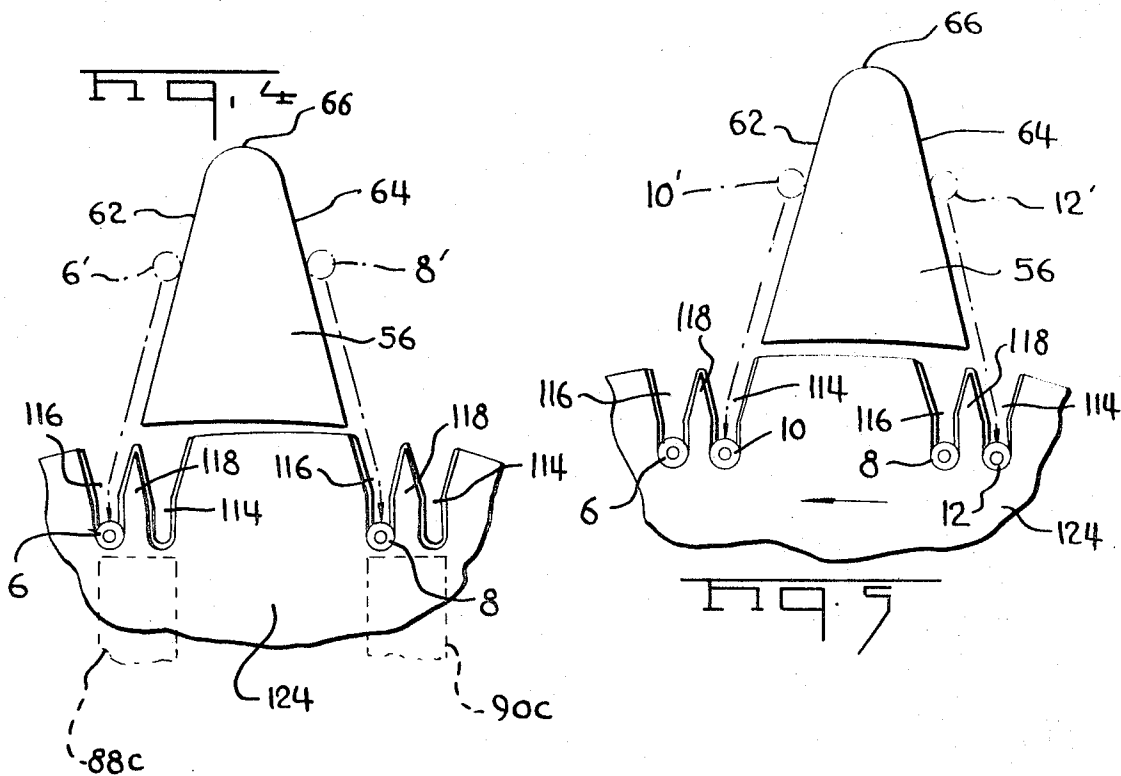
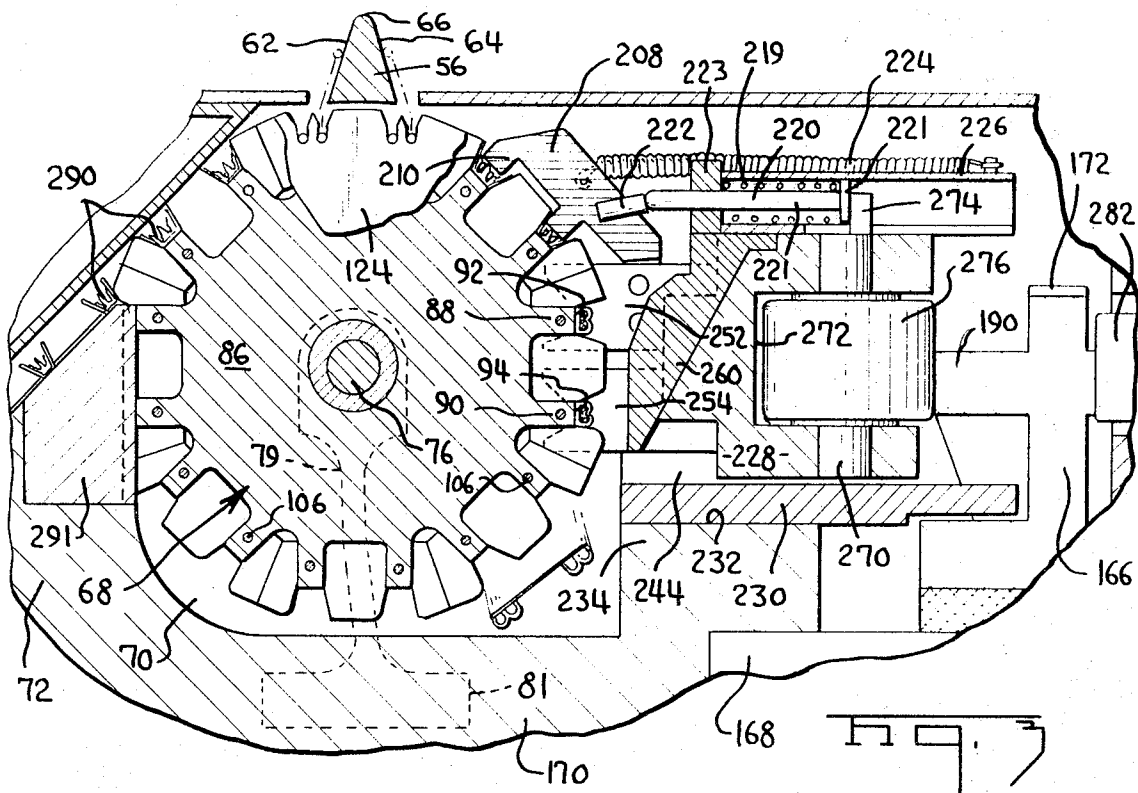
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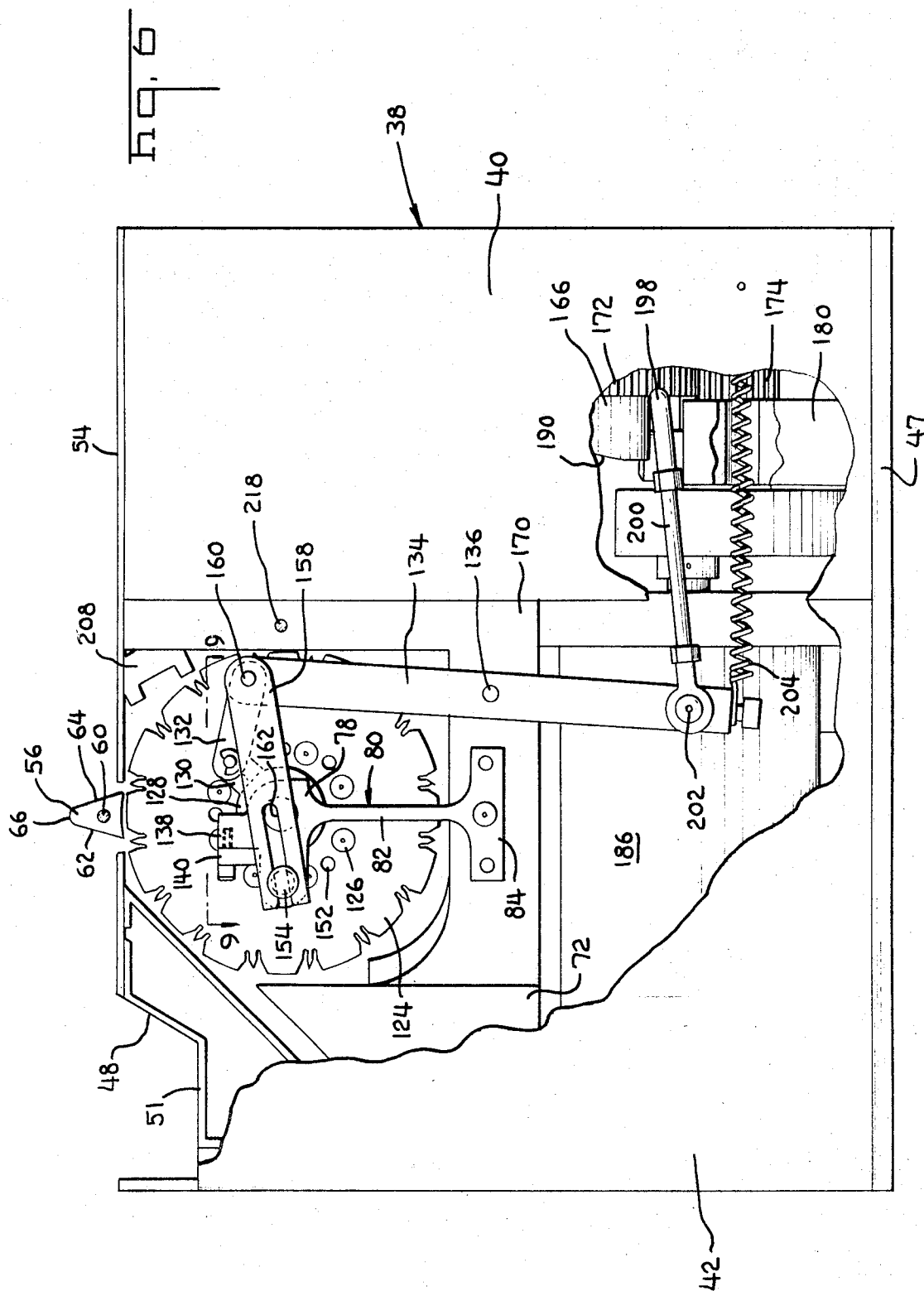
ABSTRACT: Corresponding wires of two pairs of wires are electrically connected to each other in separate electric connections by means of crimping apparatus comprising two spaced apart anvils which are adapted to support open U-type connectors. A pyramidal separator, for separating the wires of a pair, is located between and above the anvils so that the two wires of one pair can be lowered over the separator and the individual wires of the pair will each be guided into one of the connectors. After the wires of the two pairs have been located in the connectors, the connectors are moved along an arcuate path to an inserting station where the wires are stuffed into insulation-piercing slots in the connectors. Thereafter, the connectors are moved to a crimping station at which the connectors are crimped onto the wires. In accordance with the method aspect of the invention, the wire pairs are transferred from bundle trays disposed on each side of the crimping dies to a position above the separator to locate the wires of the pairs in the individual connectors in a manner such that numerous pairs of conductors in the ends of two multipair cables can be connected to each other in a relatively short time.

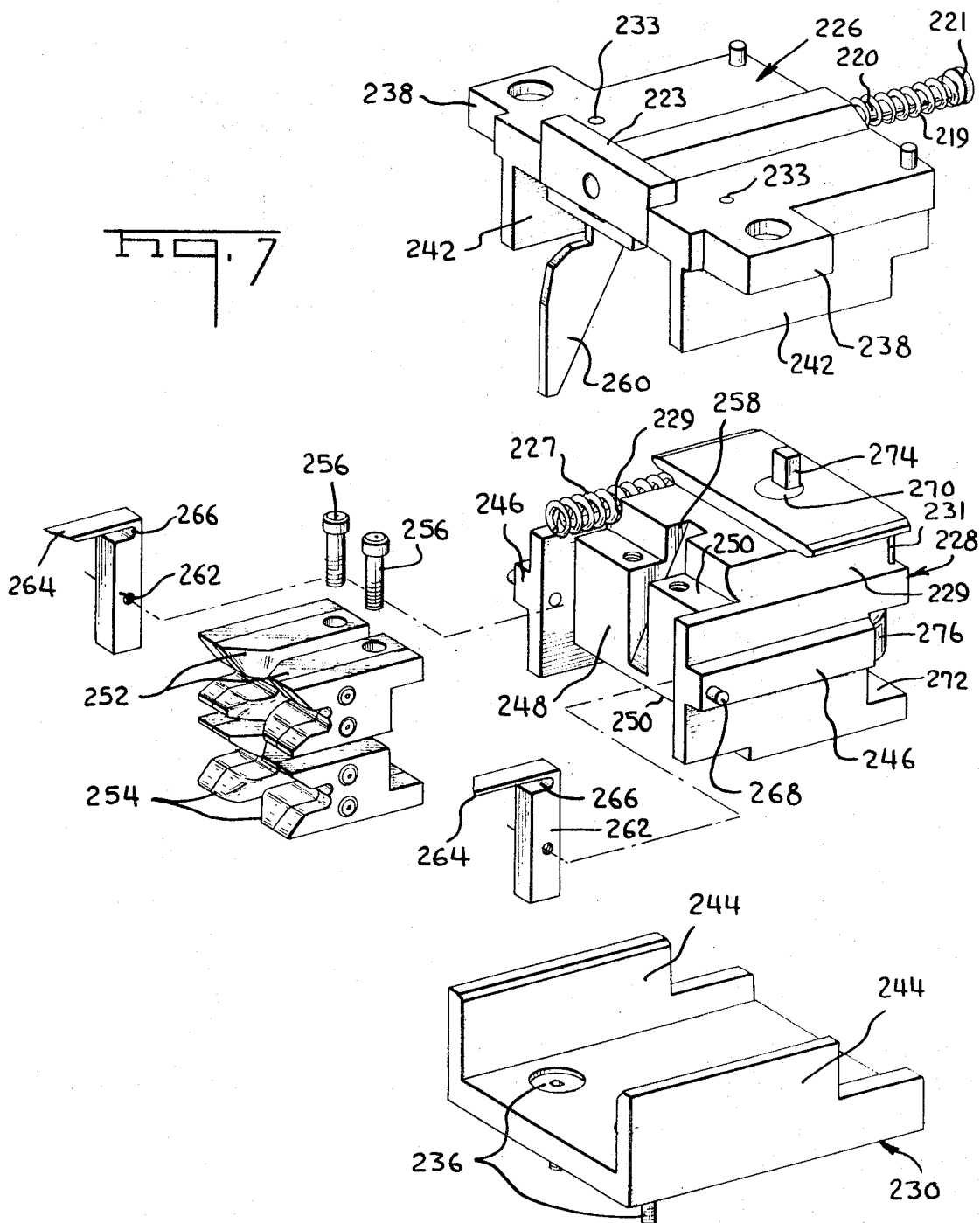


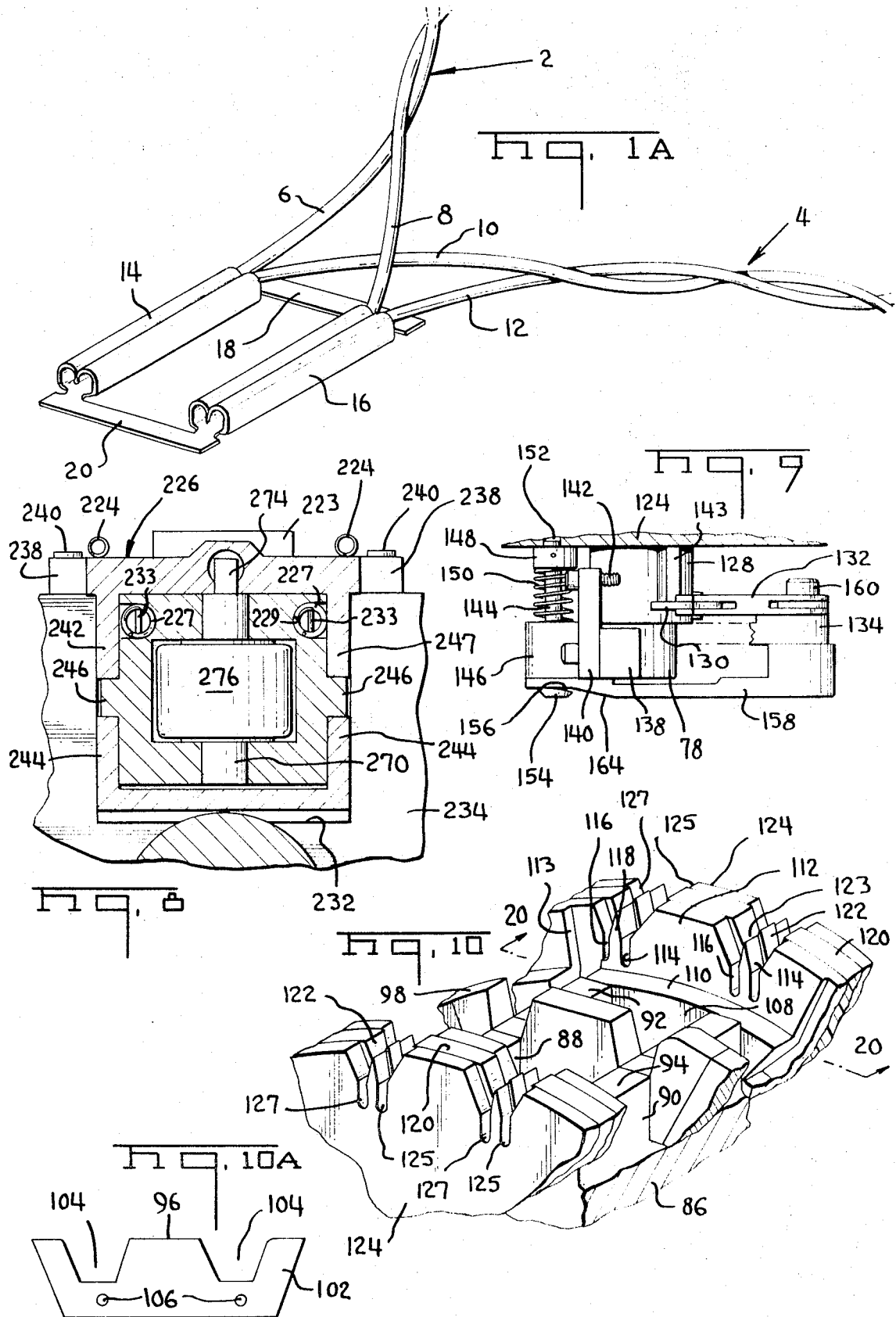


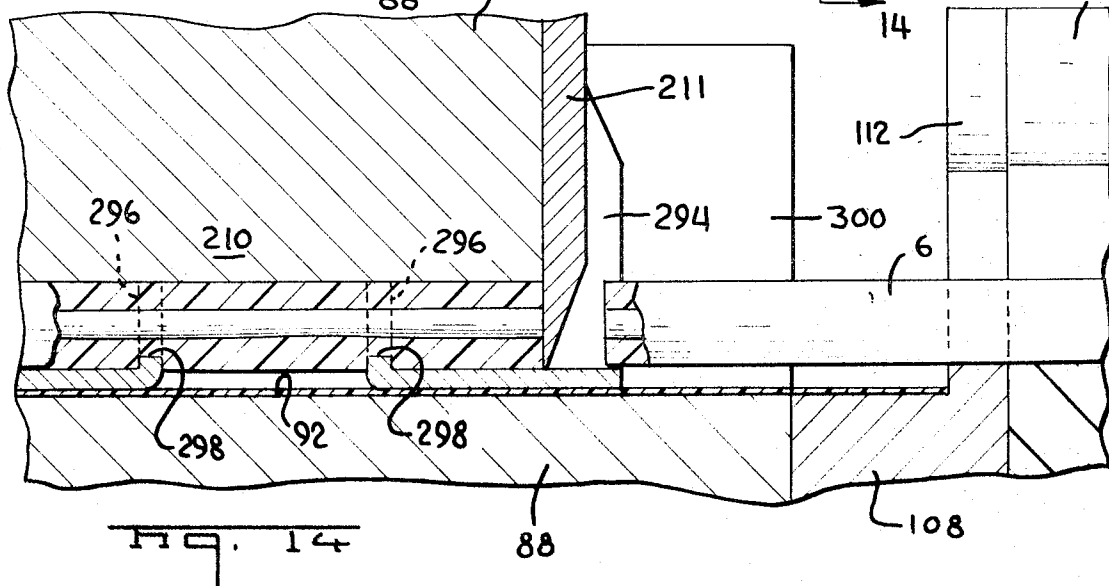
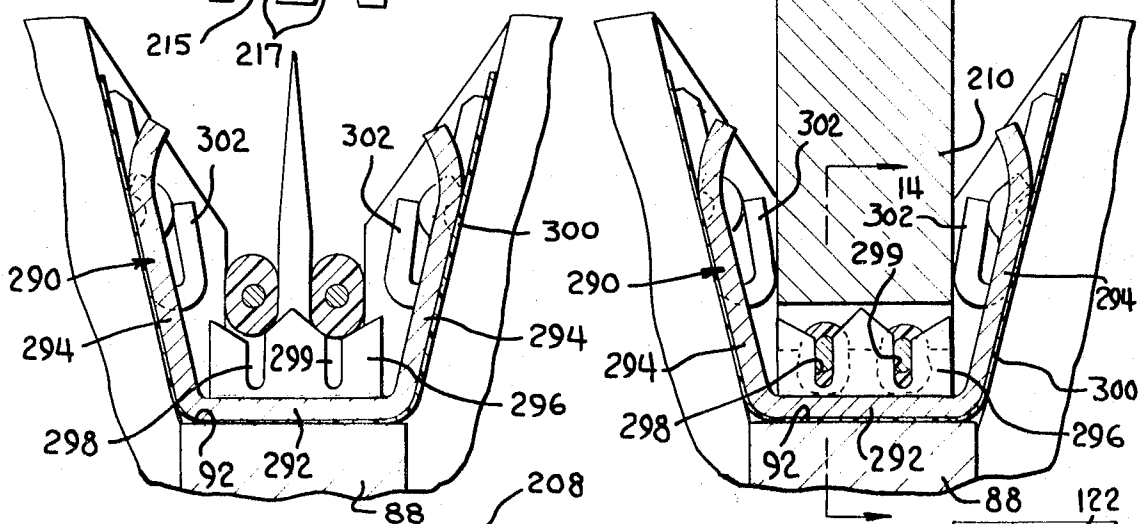
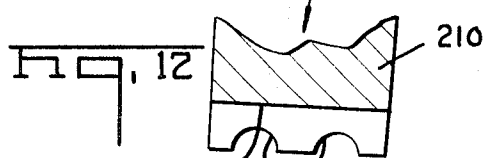
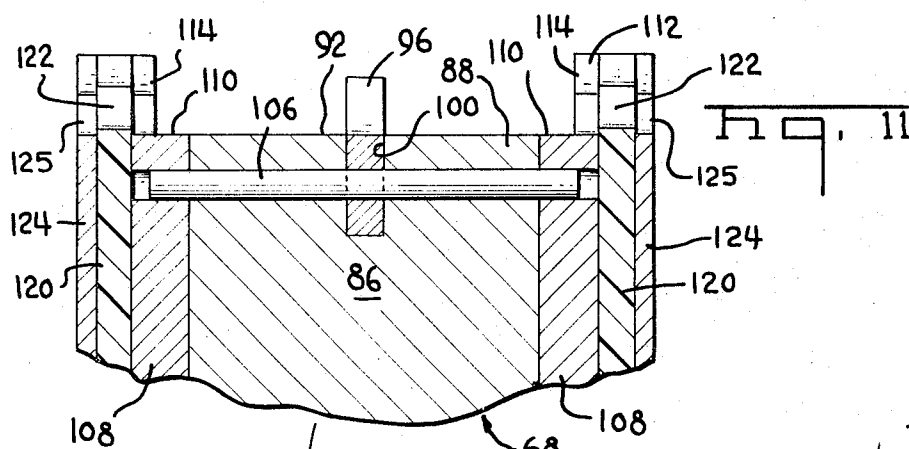


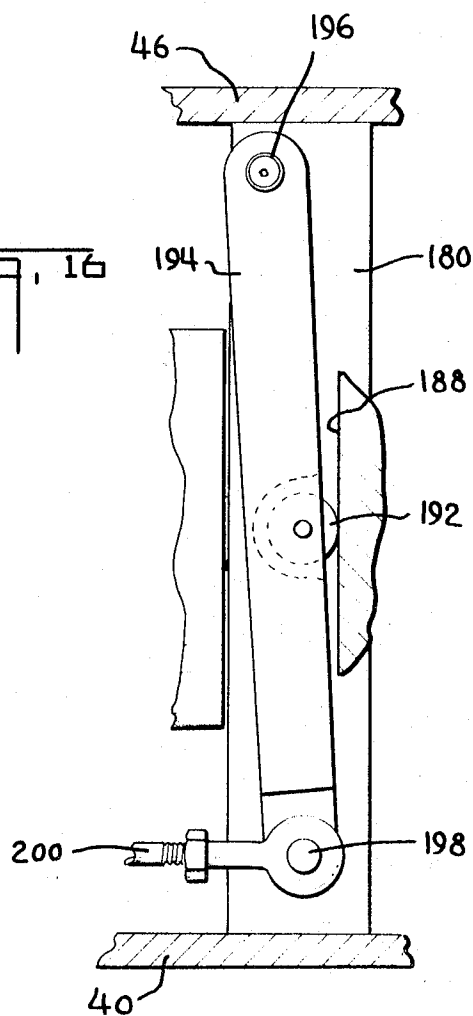
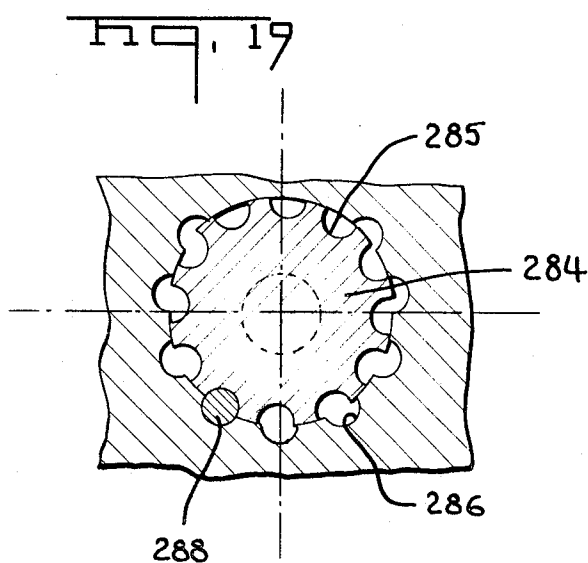
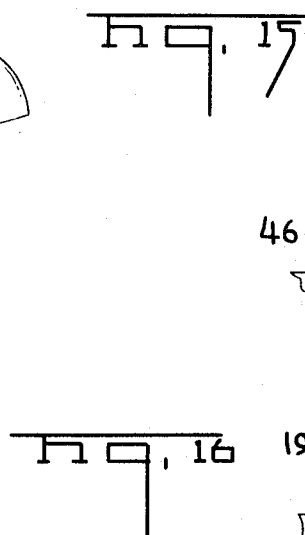
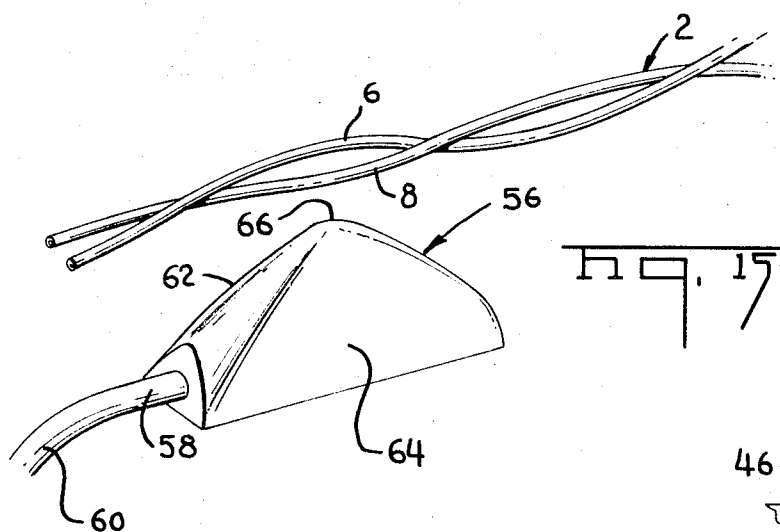












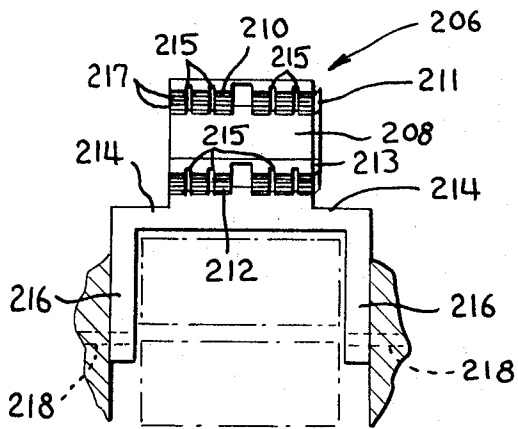


Fig. 16

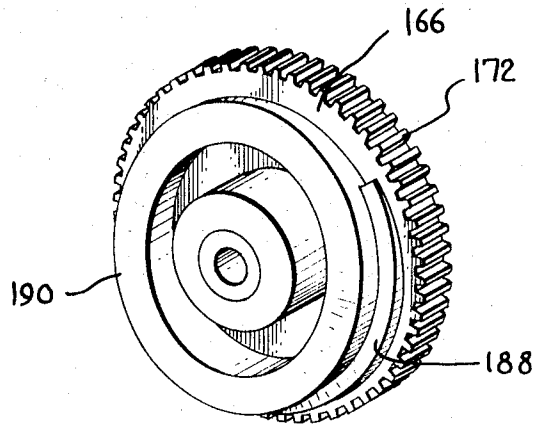


Fig. 17

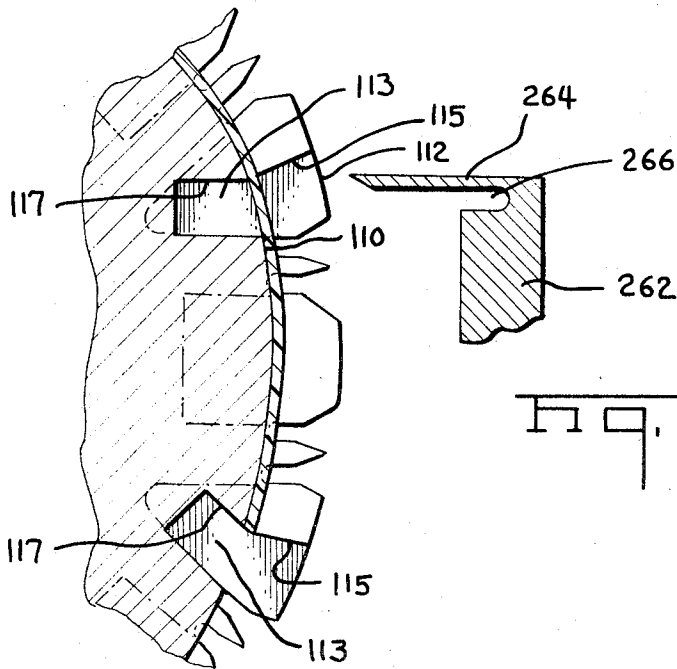


Fig. 20

METHOD AND APPARATUS FOR CONNECTING PAIRS OF CONDUCTORS

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for electrically connecting the corresponding wires of two pairs of wires to each other. The invention is herein disclosed and described with reference to the splicing of multipair telephone cables to each other although the invention is not so limited and other applications of the principles of the invention will be apparent to those skilled in the art.

Conventional communication cable, of the type commonly used in the telephone and data transmission fields, comprises a plurality of separate bundles of conductors, each bundle consisting of a plurality of associated pairs of wires which are helically twisted together. Each pair constitutes a single circuit, one wire of the pair serving as the ground conductor and the other wire serving as the signal conductor. The several bundles of wires in a cable are covered with a relatively thick insulating sheath of heavy rubber or the like to protect the cable against physical damage from abrasion or handling and to retard or prevent chemical deterioration of the insulation on the individual wires. Cables of this type are manufactured in varying sizes, that is containing varying numbers of wires, one common cable size presently available containing 2700 pairs of wires or 5,400 individual wires.

Communication cables of the type described above are manufactured in lengths of several hundred feet and are supplied on relatively large reels to the user. When a new telephone cable is being installed it is thus necessary to splice the cable every several hundred feet to connect the individual wires in the end of one cable section to the wires in the end of the next cable section. Also, it is sometimes necessary to splice cables because of damage thereto or during wiring modifications. Communications cable may be installed as aerial cable suspended from utility poles or, in urban areas, may be installed in underground conduits with the splices between adjacent cable ends being made in manholes at periodic intervals along the length of the cable. The instant invention is disclosed in a manhole environment with the cable-splicing apparatus mounted adjacent to the ends of two cable ends located in a manhole. It will be understood, however, that the principles of the invention can also be employed in the splicing of aerial communication cables.

Until recently, it has been common practice to form splices between the ends of two cable ends by simply telescoping short lengths of cotton sleeving onto the wires of one cable end, twisting the individual wires together, and then locating the cotton sleeves over the twisted connections. This prior art method is time consuming and tedious and has been supplanted, to some extent, by the use of preinsulated crimpable connectors which can be directly applied to the wire ends. The herein disclosed embodiment of the present invention is particularly directed to a method and apparatus for splicing the associated pairs of wires in a multiconductor cable by means of crimpable connectors in which the corresponding wires of two pairs of wires (one pair being in each cable end) are electrically connected during a single operating cycle of the apparatus by two repetitive, relatively simple, manipulative steps. A significant feature of the invention, as will be apparent from the detailed description which follows, is that the two wires in each wire pair are not separated and treated as individual wires, but are rather treated and handled as a pair during the splicing operation. This feature of the invention, coupled with the simplicity of the method steps involved in the splicing operation, results in a substantial increase in the productivity of the technician splicing cable ends to each other and reduces the amount of manipulative skill required on the part of the technician.

It is accordingly an object of the invention to provide improved method and apparatus for connecting the corresponding wires of two wire pairs to each other. A further object is to

provide a compact cable-splicing apparatus which can be used in a manhole or on an aerial platform where cable ends are spliced to each other. A further object is to provide a cable-splicing apparatus in which the two electrical connections, by means of which the corresponding wires of two pairs of wires are connected to each other, are physically attached to each other. A further object is to provide a method and apparatus by means of which reliable connectors can be made between twisted wire pairs with a minimum of skill and in a minimum of time.

These and other objects of the invention are achieved in a preferred apparatus embodiment comprising a pair of spaced apart anvils which are adapted to support open U-type electrical connectors. A pyramidal pair splitter or separator is located between the anvils in a position such that an operator, sitting in front of the apparatus, need only move a twisted pair downwardly over the separator to locate each wire of the pair in one of the uncrimped connectors supported on the anvils. The operator can thus locate the corresponding wires of two pairs of wires in separate electrical connectors by simply moving the first pair over the separator then picking up the second pair and moving it over the same separator. In accordance with a preferred embodiment of the invention, the anvils supporting the two electrical connectors are laterally shifted, by a very short distance, during the interval between loading the first pair and loading the second pair so that the wires in each connector will be accurately located in parallel side-by-side relationship.

The anvils are then moved to a stuffing or inserting station at which the wires in the connectors are pushed against, and into, insulation piercing means provided on the webs of the connectors. The portions of the wires which extend beyond the connectors towards the wire ends are also trimmed at this stuffing station by means of wire cutters mounted against the stuffing means. The connectors are then moved to a crimping station at which the connectors are crimped onto the wires to produce the finished electrical connections.

During each operating cycle of the apparatus, all three of the operations described above are carried out; in other words, the technician will locate the four wires of two wire pairs in each of two connectors at the loading station. During the portion of the operating cycle in which these wires are positioned in the connectors, the wires in two connectors at the stuffing station will be moved into the insulation-piercing means and the wire ends will be trimmed. At the same time, the two connectors located at the crimping station will be crimped onto the wires disposed in the connectors at this crimping station. The operator or technician thus need concern himself only with the operation of selecting the wire pairs from suitable supporting means on each side of the apparatus and moving the wire pairs over the wire separator.

In the description which follows, a preferred form of apparatus for carrying out the invention is disclosed, however, it will be understood that the manipulative steps disclosed and described below can also be carried out in conjunction with other types of apparatus to achieve the time and motion advantages which are inherent in the invention.

In the drawing:

FIG. 1 is a perspective pictorial view showing an apparatus in accordance with the invention mounted in a manhole adjacent to the ends of two cable sections which are to be spliced and illustrating the manner in which the wire pairs are handled by the technician during the splicing operation.

FIG. 1A is a perspective view of two connectors crimped onto the corresponding wires of two twisted pairs of wires.

FIG. 2 is a sectional front view, taken along the lines 2-2 of FIG. 1, showing the positions of the parts at the beginning of the operating cycle and illustrating the manner in which the wires of a first pair of wires are located in connectors supported at the loading station.

FIG. 3 is a fragmentary view similar to FIG. 2, but illustrating the manner in which the second pair of wires are located in the connectors, this view also illustrating the action of the wire-stuffing means and the connector crimping means.

FIGS. 4 and 5 are fragmentary views, on an enlarged scale, illustrating the manner in which the wires of the two pairs are accurately located in connectors at the loading station.

FIG. 6 is a front view, with parts broken away, showing the indexing means for indexing the feed wheel of the apparatus.

FIG. 7 is a perspective exploded view of the crimping means and the housing in which the crimping means are mounted.

FIG. 8 is a view taken along the lines 8-8 of FIG. 2.

FIG. 9 is a view taken along the lines 9-9 of FIG. 6.

FIG. 10 is a fragmentary perspective view showing a portion of the feed wheel and illustrating details thereof.

FIG. 10A is a plan view of one of the connector locators mounted in the feed wheel.

FIG. 11 is fragmentary sectional view showing a portion of the periphery of the feed wheel.

FIG. 12 is an enlarged fragmentary end view of a connector at the stuffing or inserting station showing the positions of the points prior to stuffing of the wires into the connector.

FIG. 13 is a view similar to FIG. 12 but showing the position of the parts after the wires have been stuffed into the connector.

FIG. 14 is a view taken along the lines 14-14 of FIG. 13.

FIG. 15 is a fragmentary perspective view of the wire separator or splitter and illustrating the manner in which the wire pair is moved over the wire splitter during operation.

FIG. 16 is a view taken along the lines 16-16 of FIG. 2.

FIG. 17 is a perspective view of an actuating cam which actuates the indexing means and the crimping means.

FIGS. 18 and 19 are views taken along the lines 18-18 and 19-19 of FIG. 2.

FIG. 20 is a fragmentary sectional side view of the right-hand portion of the feed wheel illustrating the cutting of the carrier strip at the crimping stations.

Referring first to FIG. 1 and 1A, communications cables 24, 26 of the type used in the telephone industry commonly contain a plurality of bundles 34 of wires, each bundle in turn comprising a plurality of pairs 2, 4 of wires which are helically twisted together. The bundles are loosely bound and are contained in the insulating sheaths of heavy rubber or other suitable material covering of the cable. When the end of the cable 24 is to be connected to the end of the cable 26, it is therefore necessary to form numerous individual electrical connections, each pair of connections functioning to electrically connect the corresponding wires of two pairs of wires to each other. In FIG. 1A, the wires 6, 8 of the pair 2 are connected respectively to the wires 10, 12 of the pair 4 by means of crimped electrical connections 14, 16. The two crimped connections are physically joined to each other by means of carrier strips 18, 20 which are left on the two connections at the time of crimping as will be described below.

The disclosed embodiment of the invention is adapted to crimp connectors 290 of the type known in U.S. Pat. No. 3,320,354 onto wires, connectors of this type comprising (FIG. 12) a metallic web 292 having upstanding sidewalls 294 and having a suitable insulating film 300 such as Mylar (polyethylene terephthalate) bonded to its external surface. A plurality of tongues or lances 296 are struck from the web 292 and are provided with side-by-side downwardly extending slots 298, 299 the width of these slots being slightly less than the diameters of the metallic cores of the wires being connected. The sidewalls 294 are provided with upwardly turned ears 302 which function to force the wires into the slots, when the sidewalls are bent downwardly, and to hold the wires in the slots after crimping as fully discussed in the above identified U.S. Pat. No. 3,320,354. Connectors of this type are advantageously manufactured in the form of a continuous strip 22 (FIG. 1) which is supplied from a suitable reel to the crimping apparatus. At the time of crimping, two crimped connectors are severed from the strip but portions of the carrier strips 18, 20 are left on the connectors to physically connect the two connections which join the two pairs 2, 4.

In FIG. 1, an apparatus in accordance with the invention is showing in an underground manhole, the apparatus being located between, and in front of, the ends of two cables 24, 26.

The cables are supported on the manhole wall by suitable straps 30 and the apparatus itself may be supported on a suitable table or support (not specifically shown). While relatively simple straps 30 are shown as supporting the cable ends, it should be mentioned that it is also common practice to support the cables by means of brackets which are mounted on bracket supports secured to the manhole wall as shown generally in the U.S. Pat. No. 3,287,790. The individual bundles 34 are bent rearwardly over their respective cables 24, 26 and temporarily tied in position by bindings 30, 36. A bundle from each cable end 24, 26 is led around a guide post 32 and supported on bundle supporting trays 48, 46 while the wires of these bundles 34a, 34b are being connected.

The apparatus in accordance with the invention comprises a generally rectangular housing 38 having front panels 40, 42, a side panel 44, and internal frame blocks described below, these panels and the frame blocks being supported on a suitable base plate 47. The bundle tray 48, which supports the bundle 34a, comprises a formed panel 51 of sheet metal which is secured to the upper end of front panel 42. A cover panel 54 is provided on the right-hand side of the apparatus and a channel-shaped bundle tray 46 is mounted on the upper surface of this cover panel 54.

The guide post 32 may be supported in any suitable manner so long as it is located between the cable ends and in back of the housing 38. In the disclosed embodiment, the guide post has a reduced diameter lower end which extends through a slot in a bracket 33 which is secured to the housing as by welding. A locking screw 31 is threaded into the lower end of the post and functions to lock the post in any desired position of adjustment. The guide post is adjustably mounted for the reason that its position determines, to some extent, the amount of slack in the wires after they are connected and it is desirable to change the amount of slack periodically as the cable-splicing operation proceeds.

The pair separator 56, by means of which the two wires of an individual pair are separated and moved downwardly into the connectors, comprises a generally pyramidal block having sloping sides 62, 64 (FIG. 4) and having an apex 66. This separator block 56 is mounted on the end of an arm 58 which extends forwardly past the front panel 42 and downwardly as shown in 60, the lower end of this arm being suitably secured to the front panel.

Separator block 56 is disposed above an indexing feed wheel generally indicated at 68, which is mounted in a recess 70 of a frame block 72, 170, 234. As will become apparent from the description which follows, wheel 68 serves as a conveyor in that it carries the connectors to the several operating stations of the apparatus. The frame block 72, 170, 234 is supported on a fixed vertical frame plate 74 within the housing and by the previously identified side panels of the housing. Feed wheel 68 is mounted on a shaft 76 which is supported in the enlarged upper ends 78, 79 of front and rear pedestals 80, 81. Both of these pedestals have a relatively thin column portion 82 (FIG. 6) and a base portion 84 which is secured to the front and rear surfaces of the central portion 170 of the frame block. As will be explained below, the column sections 82 of the pedestals are designed such that they are capable of flexing during the crimping operation to displace the entire feed wheel leftwardly as viewed in FIG. 2 and 6 in order to accurately locate the wires in the connectors.

The feed wheel 68 is a composite structure comprising a body portion 86 having pairs of radially extending anvils 88, 90 on its periphery, these anvil pairs being identified as 88a, 90a, 88b, 90b etc. depending on their positions. The anvils have connector supporting surfaces 92, 94 which are dimensioned to firmly support the web portions 292 of the connectors as they are carried past the loading station, stuffing or inserting station, and the crimping station. The sidewalls of the connectors are additionally supported by means of connector locator blocks 96 (FIG. 10A) which are mounted in transversely extending slots 100 in the anvils. Each block 96 has a pair of spaced-apart notches 104, the distance separating these

notches being equal to the distance separating the anvils of the respective anvil pairs of the feed wheel so that the notches will be aligned with the anvils when they are mounted on the feed wheel, see FIG. 10. The blocks 96 are designed such that the upstanding arms 102 on their ends will abut the arms of adjacent blocks when the blocks are secured to the feed wheel by means of pins 106 (FIG. 11) which extend through openings in the anvil, openings in the blocks 96, and into openings in face plates 108 described immediately below.

Circular face plates 108 are secured against the faces of the body portion 86 of the feed wheel and have radially extending flanges 112 which define circumferentially extending supporting surfaces 110 for the carrier strips 18, 20 of the connector strip 22. Inwardly extending notches 114, 116 (FIG. 10) are provided in the flanges 112 of the face plates in alignment with the anvils 88, 90 and in alignment with the spaced apart slots 298, 299 of the individual connectors supported on these anvils. The slots are relatively wider at their outer ends than at their inner ends to assist in guiding the wires into the connectors. The projection 118 which separates each pair of slots 114, 116 is pointed at its upper end to further assist in separating the wires in individual pairs.

Discs 120 of rubber material, such as polyurethane, are mounted against the faces of the plates 108 and are also provided with notches 122, 123 which are in alignment with the notches 114, 116 of the face plates. The notches 122, 123 are relatively narrow at their inner ends so that when the wires are moved downwardly into these slots, the portions of the wire disposed in the discs 120 will be resiliently held on each side of the body portion of the feed wheel until the wires are stuffed into the connectors as will be described below. The discs 120 thus serve as wire retaining means for holding the wires at each end of the associated connector.

The rubberlike discs 120 and the face plates 108 are held against the faces of the body portion of the wheel by clamping plates 124 which are secured to the body portion by suitable fasteners 126. These clamping plate 124 are also provided with notches 125, 127 as shown best in FIG. 10 to permit movement of the wires into the connectors and into the slots of the plastic discs at the loading station.

The operation of positioning the wires 6, 8, 10, 12, of two wire pairs 2, 4, in two connectors can now be understood from a review of FIGS. 1, 2, 4, and 5. At the beginning of the loading operation, the operator selects a pair 2 from the bundle 34a in FIG. 1 which is on his left. He locates this pair above the pair separator block 56 (FIG. 1A) and moves the wires downwardly (FIGS. 2 and 4) so that the wire 6 travels past apex 66 and down the side 62 of the separator while the wire 8 travels past the apex 66 and down the side 64 of the splitter. At the beginning of the operating cycle, the feed wheel will be located such that the wires will be guided from the positions 6', 8' (FIG. 4) into the slots 116 which are associated with each of the two anvils 88c, 90c, disposed at the loading station. This operation is carried out by forming a small gap in the pair 2, moving the pair downwardly until the apex 66 of the separator extends through the gap, then pulling the wires downwardly while holding them under a slight tension. The tension in the wires will cause them to guide smoothly over the surfaces 62, 64, and accurately into the notches 116 in plate 124 and into the corresponding notches 123 and 127 in the disc 120 and the clamping plate 124. The wires are held in these aligned notches by the narrow notch in the rubbery disc 12. Since these notches are in precise alignment with the slots 298 which are on the left-hand sides of the lances 296 of the connectors, the wires will be accurately positioned above the left-hand slots of the connectors.

After the wires 6, 8 of the pair 2 have been located in the connectors, the feed wheel is displaced leftwardly, in a manner in which will be described below, to locate the notches 114 on each side of the separator in alignment with the sloping sides 62, 64 of the separator. The slots 299 in the connectors are also located in alignment with the surface 62, 64 since these slots are in alignment with the notches 114. The

operator then selects the pair 4 of wires from the bundle 34b and repeats the operations of moving the wires of the pair downwardly past the apex 66 of the separator while maintaining a slight tension on the wires, over the surfaces 62, 64 of the separator so that the wires will travel from the position shown at 10', 12' to their final positions at the roots of the notches 114 and in the corresponding notches 122 and 125 in the disc 120 and clamping plate 124. After the wires have been moved downwardly as shown in FIG. 5, they are held in their proper positions by the rubberlike disc 120 which, as previously noted, have relatively narrow notches capable of gripping the wires and holding them in position.

Referring now to FIGS. 6 and 9, the feed wheel 68 is periodically indexed by means of a link 132, this link being pivotally connected to an arm 130 which is integral with, and extends from, a conventional one way spray-type clutch 128. The structural details of this clutch are not shown because of the fact that such clutches are commonly known to the art and are readily commercially available. This clutch couples the body portion 86 of the feed wheel to the shaft 76 on which the feed wheel was mounted in a manner such that only clockwise rotation of the feed wheel (as viewed in FIG. 6) can take place. The link 132 is pivotally connected at 160 to a vertically extending lever 134 which, in turn, is pivotally mounted intermediate its ends at 136 on the frame block portion 170. When lever 134 is oscillated about its pivotal axis 136, clockwise motion of this lever causes the clutch and the feed wheel to be moved through a slight clockwise arc while counterclockwise motion of the lever does not affect the feed wheel by virtue of the one-way clutch 128. Counterclockwise movement of the clutch is limited by means of a stop screw 142 which is threaded through a plate 140 secured to a projection 138 on the enlarged upper end 78 of the pedestal 80. This stop screw engages a rib 143 on the clutch which extends behind the arm 130 towards the front clamping plate 124 of the feed wheel. The manner in which the lever 134 is oscillated about its pivotal axis 136 is described below.

It is desirable to lock the feed wheel precisely in position while it is at rest in order to accurately locate the connectors at the loading station, the stuffing station, and the crimping station for the several operations being carried out at those stations. Such locking of the feed wheel is achieved by means of a locking pin 144 (FIG. 9) which extends slidably through an additional ear 146 on the enlarged upper end 78 of the front pedestal 80. The end of this locking pin has a collar 148 mounted thereon and a spring 150 is interposed between this collar and the rearward side of the projection 146 to bias the pin towards the feed wheel. The feed wheel is provided with a plurality of spaced apart openings 152 arranged in a circular pattern around its axis and located such that the locking pin upon, entering upon one of these openings, locks the feed wheel in a precisely predetermined location to accurately locate the anvils with respect to the tooling. When the feed wheel is indexed, it is necessary to slide the locking pin out of the opening in which it is located to permit rotation of the wheel and this is accomplished by means of a camming member 158 which has a slot 162 extending inwardly from its end. The shank portion of the locking pin extends through this slot and the head 154 of the pin is disposed against the surface of the camming member 158, this surface being tapered towards its end as shown on 164. The underside 156 of the head 154 of the pin is also inclined to facilitate the camming action described below. It will be apparent from FIG. 6 that upon leftward movement of the camming member relative to the head 154 of the pin, the pin will be cammed outwardly from the feed wheel thus disengaging the end of the pin from the opening in the feed wheel in which it was disposed and freeing the wheel for indexing.

Turning now to FIG. 2, 6, and 16, indexing of the feed wheel is achieved by means of a cam 166 having gear teeth 172 on its periphery. This cam is mounted for free rotation on a shaft 168 extending from the frame portion 170. The leftwardly facing surface of this cam as viewed in FIG. 2, is provided with

two cam tracks 188, 190 (see FIG. 17) the cam track 188 being in engagement with a cam roller 192 (FIG. 16) which is journaled in a lever 194. Lever 194 is pivoted at its rearward end 196 on a pin extending from a fixed block 180, (FIG. 2) mounted the base plate 47. The forward end of lever 194 is pivoted at 198 to a connecting rod 200 which extends to, and is pivoted at 202 to, the lower end of the lever 134. The contour of the cam track 188 is such that during each complete revolution of the cam 166, the lever 134 will be swung first through a slight clockwise arc to advance the feed wheel 68, and then through a slight counterclockwise arc to return the parts to their starting positions. Advantageously, the lower end of the lever 134 is biased rightwardly as viewed in FIG. 6 by means of a spring 204 secured at one end to the lower end of the lever and at its other end to a suitable fixed pin in the frame. This spring assures a smooth operation of the indexing mechanism and compensates for tolerance variations in the various parts thereof.

The stuffing or inserting means for stuffing the wires into the slots 298 of the connectors supported on the anvils at the stuffing station comprises a plate 208 (FIG. 18) having a pair of integral projections 210, 212 thereon which extend transversely with respect to the feed wheel and are in alignment with the anvils 88d, 90d which are positioned at the stuffing station. The wires are forced into the connectors when the stuffing member moves from the position of FIG. 2 to the position of FIG. 3 and the projections move towards the anvils and between the sidewalls of the connectors supported thereon. Each stuffing projection has four transverse slots 215 extending thereacross which are located such that they will receive the tongues 296 of the connectors when the stuffing projections move into the connectors at the stuffing station as shown in FIGS. 12-14. The faces of the stuffing or inserting projections are also provided with longitudinally extending shallow grooves 217 to assist in maintaining proper location of the wires during the stuffing operation. Each stuffing projection 210, 212 also has a wirecutting blade 211, 213 secured against its side which is proximate to the front of the feed wheel. During movement of the projections into the connectors (FIGS. 12 and 13) these knives also move between the sidewalls of the connectors and against the webs of the connectors. The knives thus move against the portions of wire which extend beyond the connectors and sever these portions from the wire ends as illustrated in FIG. 14. The wires are thus trimmed neatly at the time of stuffing to the desired lengths.

As shown in FIG. 18, the plate 208 has lateral extensions 214 on its lower end which merge with integral legs 216. The ends of these legs are pivoted at 218 to the panel 42 and to the back panel 46 of the housing to permit the arcuate movement of the insertion member or stuffer member from the position of FIG. 2 to the position of FIG. 3. The legs 216 straddle a crimping slide housing 226, 230 as will be described below.

The stuffing member is normally biased in a clockwise direction to the position of FIG. 2 by means of springs 224 (FIG. 2) which have one of their ends attached to the plate 208 and have their other ends mounted on a portion 226 of a housing part described below. The stuffer is moved through a counterclockwise arc against the biasing force of these springs by means of a plunger 220 which moves leftwardly in FIGS. 2 and 3 to engage a pin 222 mounted on the rightwardly facing side of the plate 208. Plunger 220 is contained in a passageway in housing part 226 and projects through a plate 223 mounted on the front end of this housing part. A helical spring 219 surrounds the plunger shaft and biases it rearwardly as viewed in FIG. 3 against an extension 274 of a stationary shaft which is described below. At this point it is sufficient to say that upon leftward movement of a slide member 228, the shaft extension 274 moves against the head 221 of the plunger and moves it leftwardly from the position of FIG. 2 to the position of FIG. 3.

The upper housing part 226 is complimentary to a lower housing part 230, both of these housing parts being mounted in a recess 232 in a section 234 of the previously identified frame block shown best in FIG. 2. Upper housing part 226 has

depending spaced apart sidewalls 242 which are in alignment with upstanding sidewalls 244 of the lower housing part, the opposed edges of these sidewalls being spaced apart to define a guide track for guide ribs 246 on the sides of the slide 228. The lower housing part 230 is secured to the frame block portion 234 by means of suitable fasteners 236 while the upper housing part 226 has laterally extending ears 238 which extend over the frame part and which are secured thereto by suitable fasteners.

The connectors supported at the crimping station on the anvils 88e, 90e, are crimped by means of crimping die sets 252, 254 (FIG. 7) mounted on the left-hand side of the slide block 228. Each crimping die set is formed in two sections which are mounted on shoulders 250 adjoining the front face 248 of the slide by means of fasteners 256. These sections of the die sets 252, 254 are normally spaced apart so that a slot remains into which a knockout device 260 projects. This knockout device is integral with, and depends from the previously identified plate 223, the function of this knockout device being to remove the crimped connectors from the forming cavities of the dies 252, 254 when the slide moves rightwardly (from the position of FIG. 3 to the position of FIG. 2). In order to provide clearance for this knockout device 260, an inclined slot 258 is provided on the left-hand side of the slide 228 which intersects the front face 248 of the slide as shown. By virtue of the presence of this slot, the slide 228 can move leftwardly in FIG. 3 to the extent necessary to bottom the dies with respect to the uncrimped connectors and completely crimp the connectors supported on the anvils.

It will be recalled that the connectors are supplied to the applicator in the form of a continuous strip 22 with each connector being connected to the adjacent connectors by means of continuous carrier strips 18, 20. At the time of crimping, the carrier strips are cut in a manner such that the two crimped connections formed during a single operating cycle will be physically joined to each other although they will be separated from the remainder of the carrier strips. The cutters for accomplishing this severing operation 262 (FIGS. 7 and 20) comprise blocks 262 which are mounted on pins 268 extending from the sides of the slide ribs 246 on the slide member. Blocks 262 have laterally extending arms 264, the ends of which are sharpened to provide cutting edges. In order to accurately guide these cutting blades against the surface 110 and to cut the strip clearly, radially extending slots 113 are provided on the inner surfaces of the flanges 112, the blades being adapted to enter these slots as the crimping dies move against the anvils and perform the carrier strip-cutting operation at the time of crimping. As shown best in FIG. 20, one side of each slot 113 extends substantially radially at 115 from the periphery of the flange 112 while the inner portion 117 extends angularly with respect to the portion 115. The side portion 115 of the slot 113 functions a lead-in and guides the associated arm 264 into the slot. This arm is flexed slightly during movement into slot 113 that its sharpened leading edge bears resiliently against the side 117 of the slot. This arrangement assures the achievement of a positive clean cut of the carrier strip as the blade moves into the slot. Undercuts 266 are provided beneath the arms 264 to permit this limited flexure of these arms as they enter the slots 113. It should be added that these slots are designed such that the arms will be flexed slightly and will be resiliently held against one side of the slot so that a clean cut of the carrier strip material will be achieved. These cutters are mounted on suitable pins 268 which extend from the guide ribs 246 on each side of the slide member.

If desired, cutting knives of other forms can be mounted on the slide member to effect complete severing of the crimped connections from the carrier strips thereby to produce two physically separate the crimped connections. When multiconductor cables are spliced, it is desirable to retain the carrier strip sections showing FIG. 1A for tracing purposes but the removal of these strips may be preferred under some circumstances.

The slide member 228 is moved towards the feed wheel 68 during each operating cycle by the previously identified cam track 190 on the cam wheel 166. The cam track 190 engages a cam follower 276 which is mounted on a shaft 270 in a recess 272 in the slide block. It will thus be apparent that during each revolution of the cam wheel 166, the slide block will be moved leftwardly to crimp the terminals positioned at the crimping station.

The return of slide 228 is effected by coil springs 227 (FIG. 7 and 8) which are contained in semicylindrical recesses 229 on each side of the slide. These springs are interpose between pins 231, which extend transversely across the rearward ends of the recesses 229, and pins 233 which are mounted in, and extend downwardly from, the laterally extending ears 238 of the upper housing part 226. The springs 227 are thus compressed when the slide is moved towards the wheel 68 by the cam means 190, 166 and return the slide to its retracted position when they are permitted to decompress.

It is desirable to be able precisely to adjust the limit of leftward movement of the slide block as viewed in FIGS. 2 and 3, in order to control the crimping of the connectors supported on the anvils 88e, 90e at the crimping station. Crimping operations are generally considered to be precise operations and precise adjustment of the crimp height (i.e. the shut height of the dies) is desirable for best results. In the disclosed embodiment, adjustment of the crimp height is achieved by means of a roller 282 (FIG. 2), which is supported on an eccentric shaft 280 contained in a frame block portion 278 mounted between the front and ear housing panels. This roller functions as a backup device to support the rearward side of the cam wheel 166 and thereby control the precise location of the cam wheel 166 on the shaft 168. It will be understood that the cam wheel is permitted to move axially in either direction a short distance on the shaft 168 for adjustment purposes. In order to precisely adjust the positions of the roller 282, a vernier device (FIG. 19) is provided on the end of the shaft 280, comprising a circular plate 284 having semicircular notches 285 on its periphery at spaced intervals of, for example, 13°. These notches can be aligned with notches 286 on a fixed plate which surrounds the shaft and which are spaced apart by, for example, 15°. Shaft 280, is locked in any desired position of adjustment by a pin 288 which is inserted into the opening defined by an aligned pair of the notches 285, 286. This vernier-type adjusting and locking means permits precise adjustments of the rotational position of shaft 280 thereby to move the rollers 282 leftwardly or rightwardly. The roller moves the wheel 166 leftwardly or rightwardly along shaft 168 to bring about a change in the limits of movement of the block 228 on which the crimping dies are mounted.

It will be understood that any desired type of motor control for the disclosed embodiment can be provided. It is preferred to provide a relatively simple switching device which drives the motor through a number of revolutions sufficient to drive the gear wheel 166 through one-half of a revolution every time a foot switch is tripped, the foot switch in turn controlling a solenoid as indicated at 289.

The operation of the disclosed embodiment is briefly as follows. At the beginning of the operating cycle, the technician selects a pair of conductors from the left hand bundle tray 48, splits the pair, and moves the pair down over the separator 56 to position the wires of this pair on the left-hand sides of the connectors located on each side of the separator. The operator then trips the foot switch driving the motor 186 through a number of revolutions sufficient to rotate the cam wheel 166 through an angle of 180°. During such rotation of the gear wheel, the cam 190 drives the slide 228 leftwardly from the position of FIG. 2 to the position of FIG. 3 thereby moving the stuffers into the connectors supported on the anvils 88d, 90d and moving the crimping dies against the connectors supported on the anvils 88e, 90e. At the end of this half-revolution of the gear wheel, the crimping dies will be bottomed, that is, they will have reached the limit of their leftward travel, and will be imposing a substantial force on the feed wheel 86. The

force imposed on the feed wheel is transmitted to the shaft 76 thence to the thin column portions 82 of the pedestals which are deflected as illustrated in FIG. 3. The deflection of the central sections 82 of the pedestals has the affect of moving the feed wheel 68 leftwardly until the anvils 88a and 90a on the feed wheel periphery which is opposite to the crimping station move against a stop block 291 mounted in the frame block 72 as an insert, the precise position at which the feed wheel 68 is stopped being critical so that the block 291 must be carefully dimensioned. The leftward movement of the feed wheel 68 has the affect of displacing the connectors at the loading station leftwardly by an amount equal to the spacing between the slots 298, 299 of an individual connector so that the operator can now select a pair of conductors from the right-hand bundle tray 46, move this pair downwardly over the splitter, and accurately locate the wires on the right-hand sides of the connectors as previously explained.

It will be understood that after the cam wheel 166 is rotated through one-half of a revolution, the motor 186 is deenergized and the parts remain in the position described above, that is, with the slide member 228 at the limit of its leftward stroke and with the central section of the pedestal flexed as illustrated in FIG. 3. After the operator has positioned the second pair of wires in the connector, he again trips the foot switch to again energize the motor 186 causing the gear wheel 166 to be rotated through an additional one-half of a revolution. During this final portion of the cycle, the slide 228 is returned to its starting position, the stuffing member returns to the position of FIG. 2, and the feed wheel 68 is indexed to locate two uncrimped connectors at the crimping station, to locate the connectors which were previously loaded at the stuffing station, and to locate two new connectors at the loading station. The previously crimped connectors are carried downwardly as viewed in FIG. 2, fall from the feed wheel and can be removed through the back of the apparatus as shown in FIG. 1. The completed connections as shown in FIG. 1, may thus hang from the ends of the cable and will subsequently be repositioned and bound or lashed into bundles.

It will be appreciated that a cable splice will inevitably have a diameter which is greater than the cable diameter for the reason that a crimped connector always has a cross-sectional area which is greater than the cross-sectional area of the wires being connected. The increase in diameter at the splice can be minimized if the crimped connectors are located in side-by-side groups along the length of the splice. In the disclosed embodiment, an arrangement of groups of crimped connectors can be achieved by changing the position of the splicing apparatus in the direction of the cable axis and/or by moving the guide post 32 towards or away from the cable. Moving the entire apparatus one way or another along the cable axis has the effect of increasing the length of wire extending from one of the cable ends and reducing the length of wire extending from the other cable end thereby changing the relative position of the crimped connection. Moving the guide post 32 towards or away from the cable axis reduces or increases the amount of slack wire on each side of the crimped connector so that when the wires and the crimped and the connectors are laid against the cable, the positions of the crimped connectors will be displaced from the positions of previously crimped connectors.

A salient advantage of the invention, both as to its method aspects and its apparatus aspects, is that the wires which are being joined to each other are conveniently located with respect to the operator (who will be positioned to the right of the front of the applicator as viewed in FIG. 1) and the manipulative steps required of the operator are minimal. The only manipulative steps required are the selection and positioning of the first wire pair, the tripping of a switch, the selection and positioning of the second wire pair, and a repetition of the switch-tripping step. The remaining operations of stuffing the wires, cutting the excess wire from the wire ends, crimping the connectors onto the trimmed wires, and severing the pairs of crimped connectors from the connector strip 22, are carried out in the apparatus without further effort on the

part of the operator. As a result, completed cable splices can be made in a shorter time than was heretofore possible.

It will be apparent that the method aspect of the invention is applicable to wire-connecting methods other than the crimping method. In other words, the wire-handling technique, by means of which the wires are placed in the apparatus 38, can be employed with alternative types of wire-connecting apparatus such as a welding or wire-twisting apparatus. It will also be apparent that the invention can be employed under circumstances where more than two wires are placed in each connector or where three connectors are each crimped onto the corresponding wires of two trio's of wires.

Changes in construction will occur to those skilled in the art and various apparently different modifications and embodiments may be made without departing from the scope of the invention. The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only. The actual scope of the invention is intended to be defined in the following claims when viewed in their proper perspective against the prior art.

I claim:

1. Apparatus for connecting the corresponding wires of first and second pairs of wires to each other comprising:

frame means,

first and second wire-joining means disposed in side-by-side spaced apart relationship on said frame means,

pair separator means between said first and second wire-joining means, said pair separator means having continuous divergent guide surface portions extending towards said wire joining means which are effective to separate the two wires of a pair upon movement of the pair laterally of its axis past said pair separator means and into said first and second wire joining means whereby each wire of said first pair is located in one of said wire-joining means and upon lateral movement of said first pair towards and over said pair separator means and each wire of said second pair is located in one of said wire-joining means upon lateral movement of said second pair towards and over said pair separator means.

2. Apparatus as set forth in claim 1 wherein said pair separator means is generally pyramidal, said guide surface portions comprises sides of said separator sloping away from the apex thereof.

3. Apparatus as set forth in claim 1 including displacing means for displacing said first and second wire-joining means relatively laterally with respect to said pair separator means by an amount substantially equal to the desired spacing between wires located in said wire-joining means, said pair separator means being operable during the interval between movement of said first pair into said wire-joining means and movement of said second pair into said wire-joining means whereby said corresponding wires of said two pair are located in side-by-side relationship in said wire-joining means.

4. Apparatus as set forth in claim 3 including an index wheel, said first and second wire-joining means being on said index wheel, said displacing means comprising means for displacing said index wheel with respect to said separator means.

5. Apparatus as set forth in claim 1 wherein said wire-joining means comprises first and second open U-type crimpable connecting devices.

6. Apparatus as set forth in claim 5 including conveyor means for supporting said connecting devices, a crimping station disposed along the path of movement of said conveyor means, and means at said crimping station for crimping said connecting devices onto said wires.

7. Apparatus as set forth in claim 1 wherein said first and second wire-joining means comprises first and second crimpable connectors, said apparatus including a conveyor and a crimping station, said conveyor being movable past said crimping station whereby said connecting devices are crimped onto said wires.

8. An apparatus for crimping open U-type electrical connecting devices onto wires comprising

conveyor means for carrying a series of said devices from a loading station to an inserting station,

means on each side of said conveyor for holding said wires in alignment with said connecting devices and

means at said inserting station for moving said wires into said connecting devices whereby, said wires can be positioned in parallel relationship at said loading station and will be located in parallel relationship in said connector after being moved into said connector at said inserting station.

9. An apparatus for crimping open U-type connecting devices onto wires comprising

conveyor means for carrying a series of said connecting devices along a predetermined path,

a wire-loading station, a wire-inserting station, and a connector-crimping station on said path,

wire-holding means for holding wires, loaded at said loading station, in alignment with an adjacent connector on said conveyor,

inserting means at said inserting station for moving said wires laterally of their axes into said adjacent connector, and

crimping means at said crimping station for crimping said adjacent connector onto said wires whereby, said wires can be positioned in parallel relationship at said loading station and will be located in parallel relationship in said connector at said inserting station after being moved into said adjacent connector.

10. Apparatus as set forth in claim 9 wherein said conveyor comprises an indexable wheel.

11. Apparatus as set forth in claim 9 wherein said wire-holding means comprises gripping means on each side of said conveyor, said gripping means being adapted to hold said wires on each side of, and in alignment with, said associated connector.

12. Apparatus as set forth in claim 9 wherein said connectors have insulation-piercing means therein for piercing the insulation of said wires, said inserting means functioning to move said wires into engagement with said insulation-piercing means thereby to establish electrical contact between said wires and said connectors.

13. Apparatus as set forth in claim 9 wherein said conveyor is adapted to carry said connecting devices in associated pairs and including, means at said loading station, for separating the two wires of a wire pair and guiding one wire into each connector of the associated pair of connectors at said loading station.

14. Apparatus as set forth in claim 9 wherein said inserting means comprises means engageable with said wires and movable between the sidewalls of said connectors, thereby to push said wires into said connectors, said inserting means having wirecutting means mounted thereon, said wirecutting means being movable against the web portion of said connector to trim the ends of said wires.

15. An apparatus for trimming the ends of at least two wires and crimping an open U-type electrical connector onto the trimmed wire ends comprising

wire-holding means for holding said wires on each side of said connector and in alignment with the open side thereof,

wirecutting means moveable relatively towards said connector and against the web thereof to cut said wires at locations intermediate the ends of said connector whereby, said wires are trimmed intermediate the ends of said connector and the ends of said wires are recessed from the end portions of said connector after crimping.

16. Apparatus for splicing a first cable to a second cable, each of said cables containing a plurality of associated pairs of conductors, said cables being disposed in substantial axial alignment with their ends adjacent to each other, said apparatus comprising

first and second conductor supports, said supports being spaced apart and each being adapted to support a bundle of conductors from said first and second cables respec-

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tively with the axes of said conductors extending in a common direction which is transverse with respect to the common axis of said cables,

first and second connector supports, said connector supports being disposed adjacent to said first and second conductor supports respectively and between said conductor supports, said connector supports being adapted to support open-sided connectors with the axes of said connectors extending parallel to, and beside, the axes of conductors supported in said conductor supports,

conductor separator means between said connector supports, said separator means being effective, upon extraction of a pair from one of said supports and transfer of said pair laterally onto said separator means, to separate the conductors of an associated pair of conductors and position each of said conductors in a connector supported on each of said connector supports,

means for severing the end portions of conductors positioned in said connectors which extend beyond said connectors, and

means for crimping said connectors onto conductors positioned therein whereby, upon selecting an associated pair of conductors from said first conductor support and transferring said pair to said separator means, repeating said selecting and transferring operations for a pair of conductors in said second conductor support, and actuating said trimming means and said crimping means, the corresponding conductors of the two selected pairs are electrically connected to each other by said connectors.

17. A method of electrically connecting the conductors of a first pair of conductors to the conductors of a second pair of conductors by means of two electrical connectors comprising the steps of:

positioning said connectors in parallel side-by-side relationship,

separating the conductors of said first pair and locating each of said wires in one of said connectors with the ends of said wires extending in a common direction,

separating the wires of said second pair and

locating each of said wires in one of said connectors with the ends of said wires extending in said common direction,

severing said wires in a plane extending transversely through said connectors whereby the severed ends of said conductors lie between the ends of said connectors and crimping said connectors onto said wires.

18. A method of electrically connecting the conductors of a first associated pair of conductors to the conductors of a second associated pair of conductors, said first pair of conductors being contained in a first cable and said second pair of conductors being contained in a second cable, said cables extending axially towards each other with their ends proximate

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to each other, said method comprising the steps of:

positioning a connecting means proximate to said ends, said connecting means comprising at least two side-by-side metallic connecting members each of which has slot means adapted to receive at least two conductors,

selecting said first pair from said first cable,

locating said first conductor of said first pair in one of said metallic connecting members and locating said second conductor of said first pair in the other one of said metallic connecting members with the ends of said conductors extending laterally in a common direction,

selecting said second pair from said second cable,

locating said first conductor of said second pair in said one metallic connecting member and locating said second conductor of said second pair in said other metallic connecting member with the ends of said conductors extending in said common direction,

forcing said conductors into said slot means and concomitantly trimming the ends of said wires which extend beyond said connecting members whereby said first conductors of said first and second pairs are electrically connected to each other and said second conductors of said first and second pairs are electrically connected to said each other.

19. A method of electrically connecting a first plurality of conductors in a first multiconductor cable to a second plurality of conductors in a second multiconductor cable by means of a plurality of connecting members said connecting members each comprising a metallic member having slot means adapted to receive two conductors, said first and second multiconductor cables extending axially towards each other with their ends proximate to each other, said method comprising the steps of:

positioning a plurality of said connecting members proximate to said ends in an orientation such that said slot means extend transversely of the axes of said multiconductor cables,

selecting said first plurality of conductors from said first multiconductor cable,

locating each of the conductors of said first plurality of conductors in one of said connecting members,

selecting said second plurality of conductors from said second multiconductor cable,

locating each of said conductors of said second plurality of conductors in one of said connecting member, and

forcing said conductors into slot means and concomitantly trimming the ends of said conductors which extend beyond said connecting means whereby, the individual conductors of said first plurality of conductors are electrically connected to the individual conductors of said second plurality of conductors.

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