United States Patent [19]

Long et al.

[11] **3,885,287**

[45] **May 27, 1975**

[54] **HARNESS MANUFACTURING APPARATUS INCORPORATING HARNESS TESTING MEANS**

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[73] Assignee: **AMP Incorporated**, Harrisburg, Pa.

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[21] Appl. No.: **459,155**

[52] **U.S. Cl.** ..... **29/203 MW**; 29/203 HT

[51] **Int. Cl.** **H01r 43/00**

[58] **Field of Search**.... 29/203 MW, 203 P, 203 HT, 29/628, 33 M, 203 H

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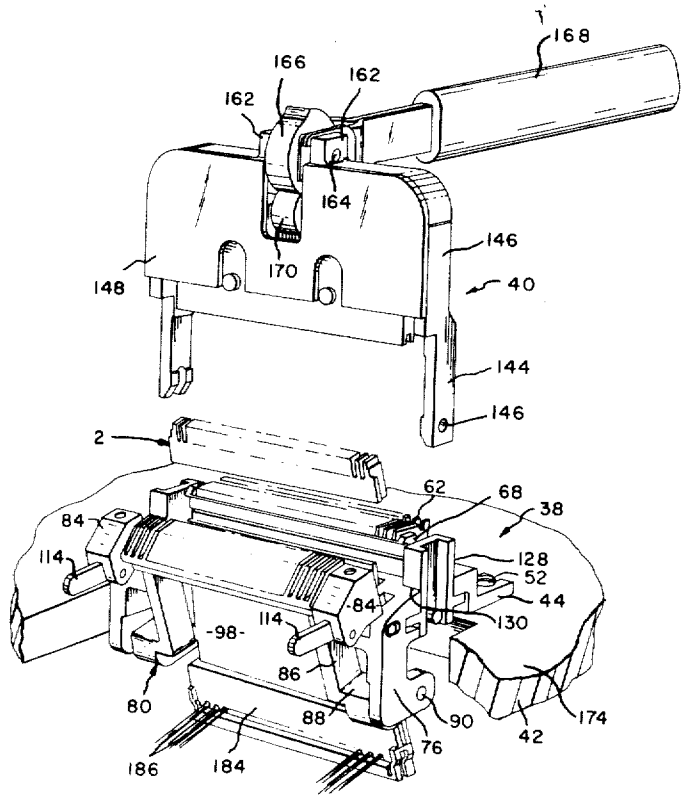
Primary Examiner—Thomas H. Eager

Attorney, Agent, or Firm—F. W. Raring; J. L. Seitchik; W. J. Keating

[57] **ABSTRACT**

Apparatus for inserting wires into the wire-receiving portions of contact terminals which are contained in a multi-contact electrical connector has a panel-like member upon which the connector is mounted and which serves to locate the connector in the apparatus during wire insertion. The panel-like member is readily removable from the apparatus so that it can be replaced by another panel-like member which is dimensioned to support a different size connector in the apparatus. In one preferred embodiment, the panel-like member is a printed circuit board which has conductors which contact the terminals in the connector being wired. These PC board conductors are connected to further conductors which extend to an electrical testing apparatus so that the connector can be electrically tested in situ.

18 Claims, 17 Drawing Figures



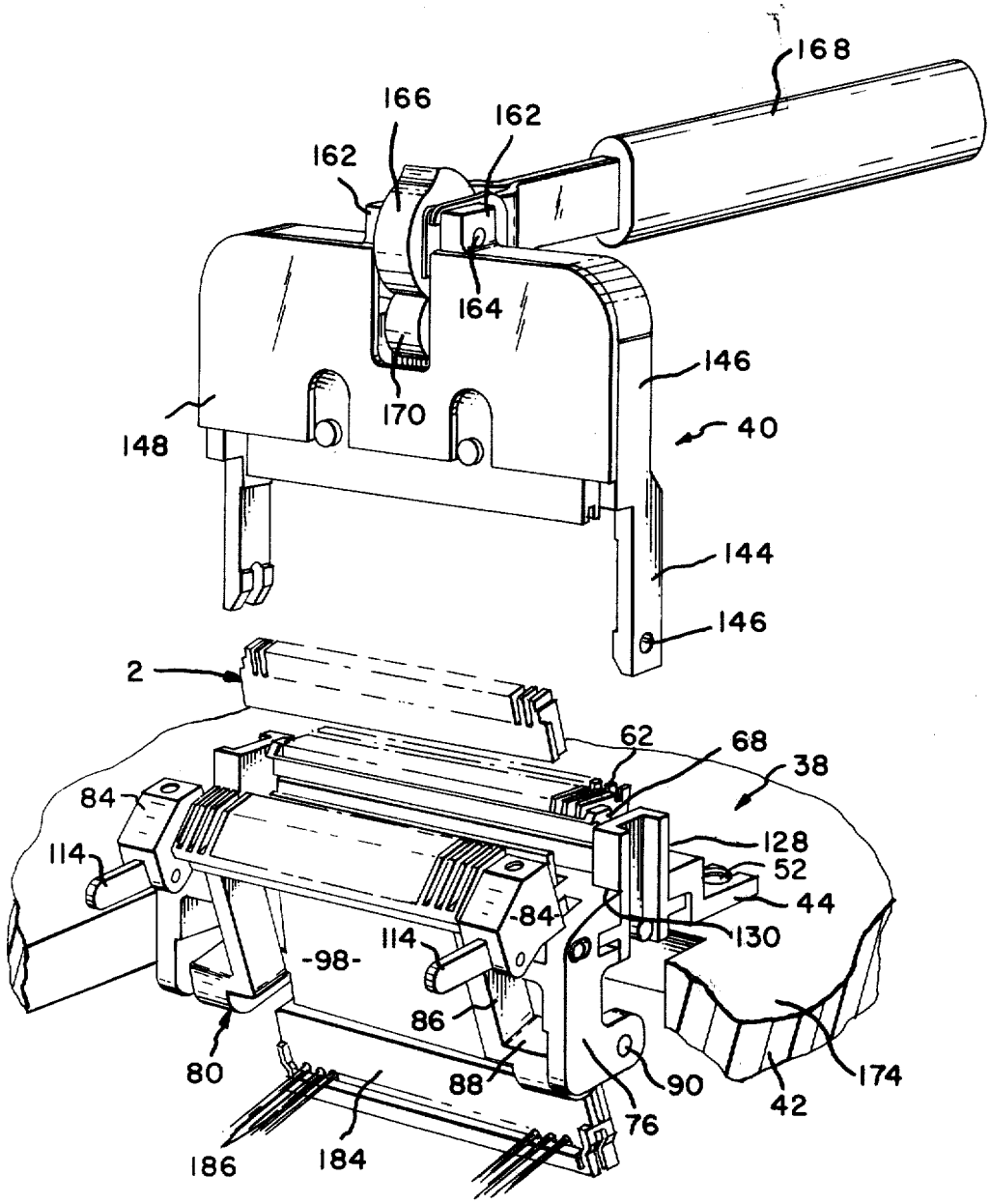

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FIG 1

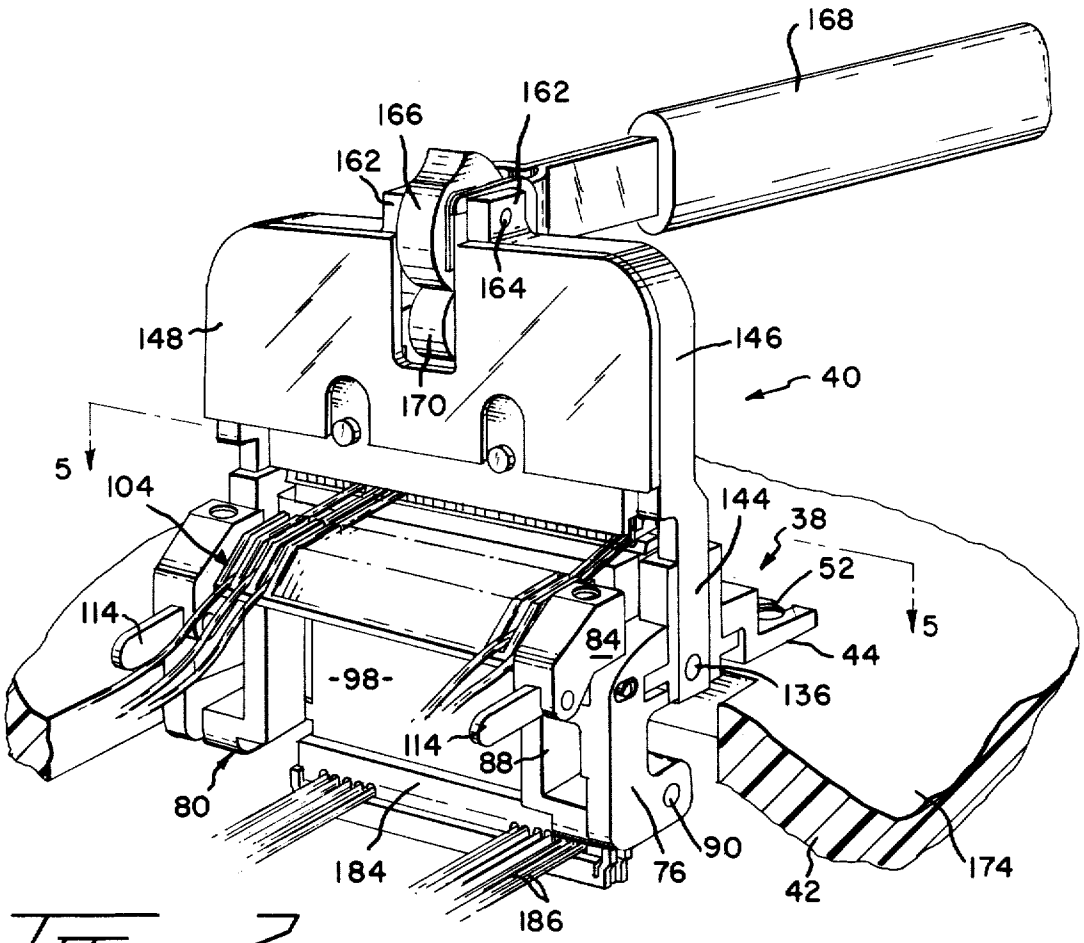
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FIG. 2

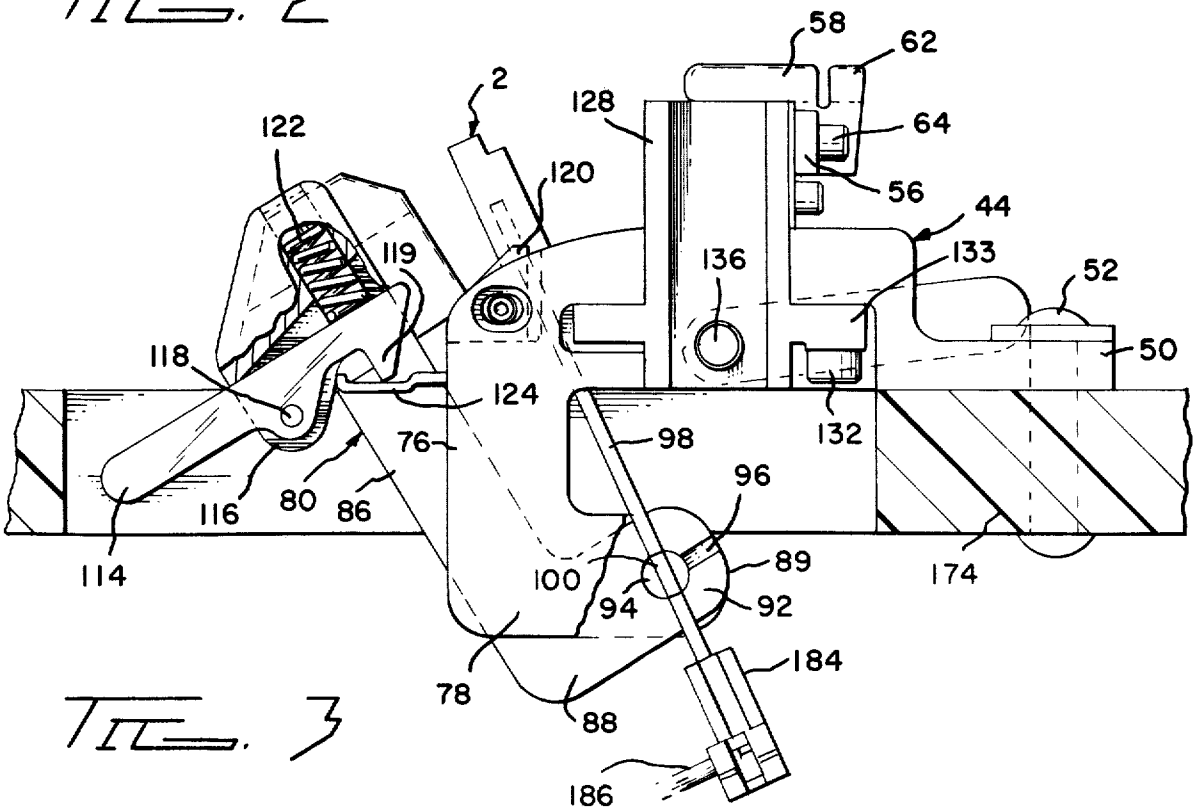
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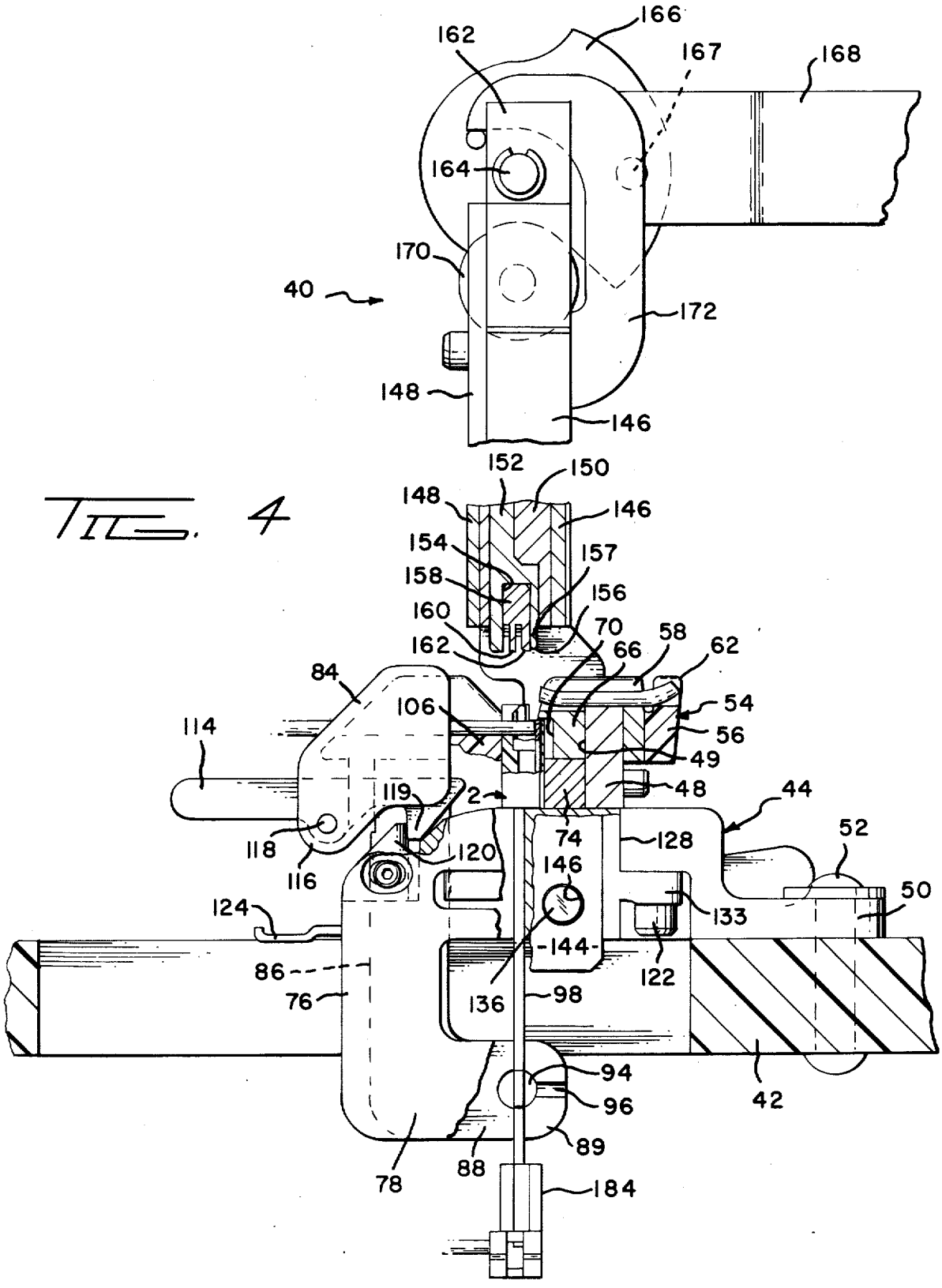
FIG. 3

FIG. 4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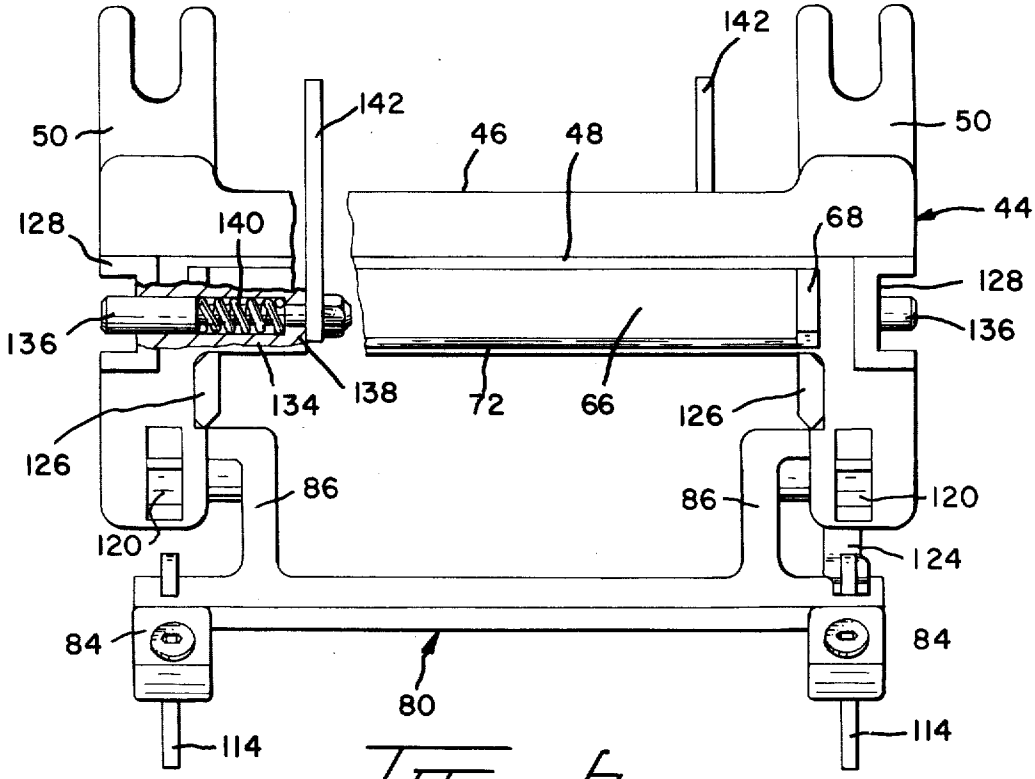
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FIG. 6

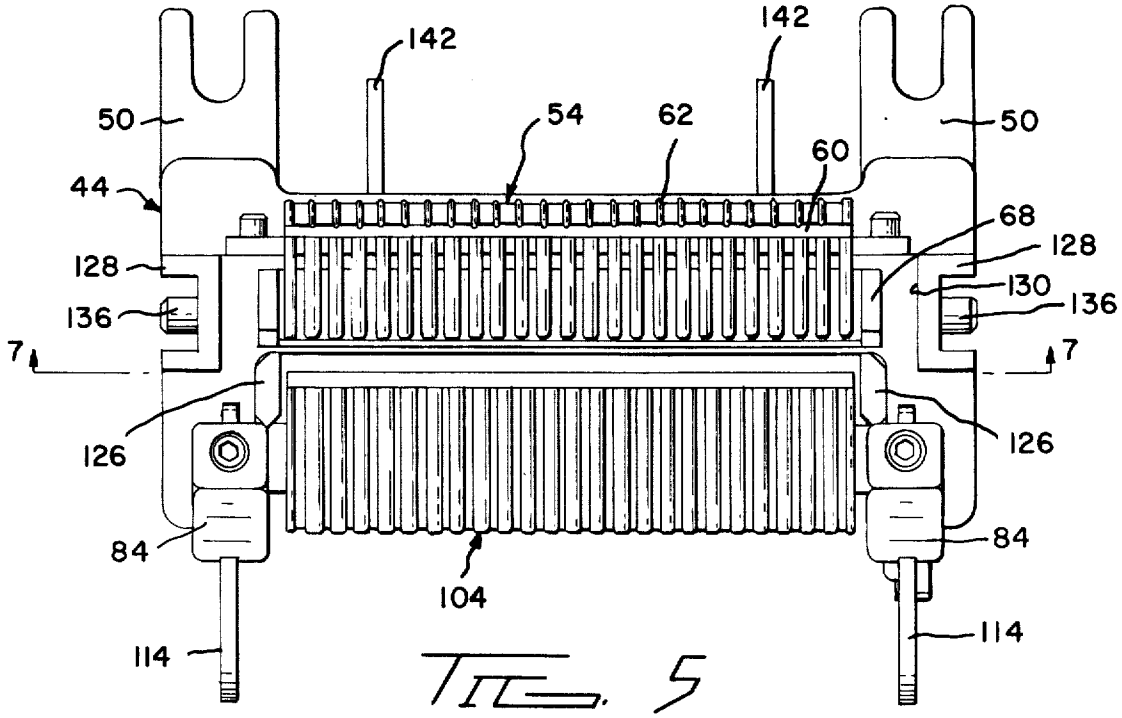
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FIG. 5

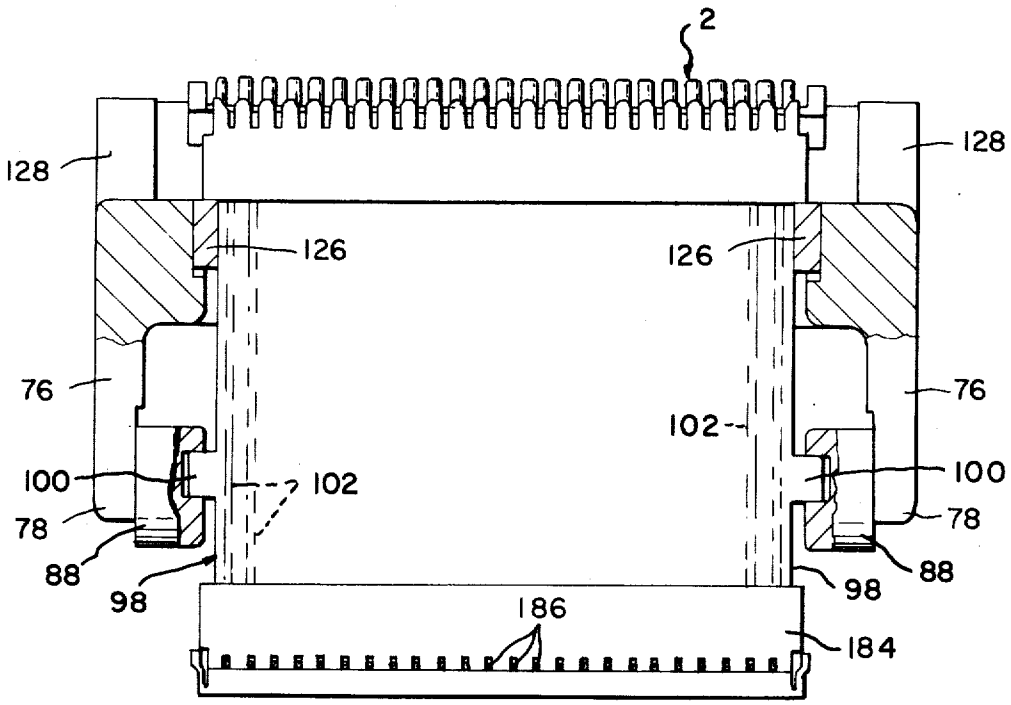
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FIG. 7

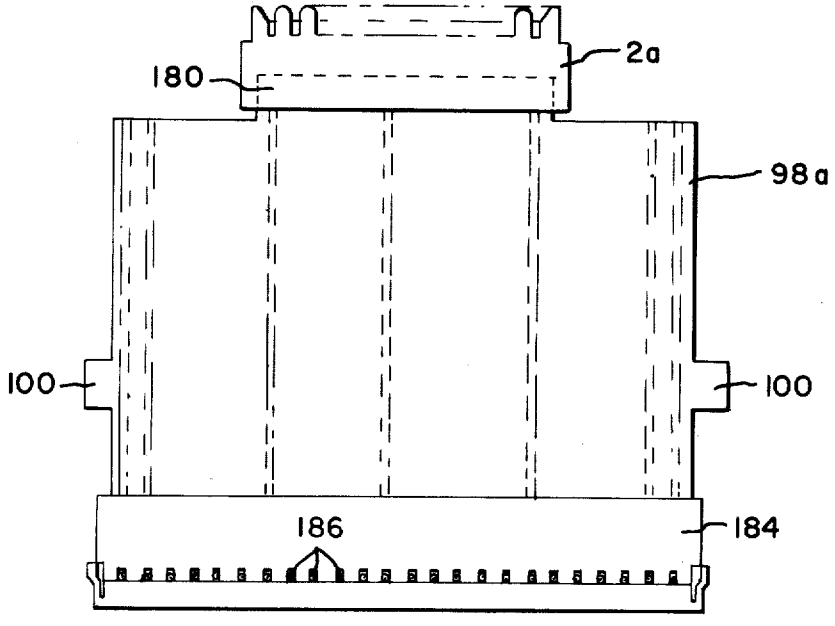
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FIG. 8

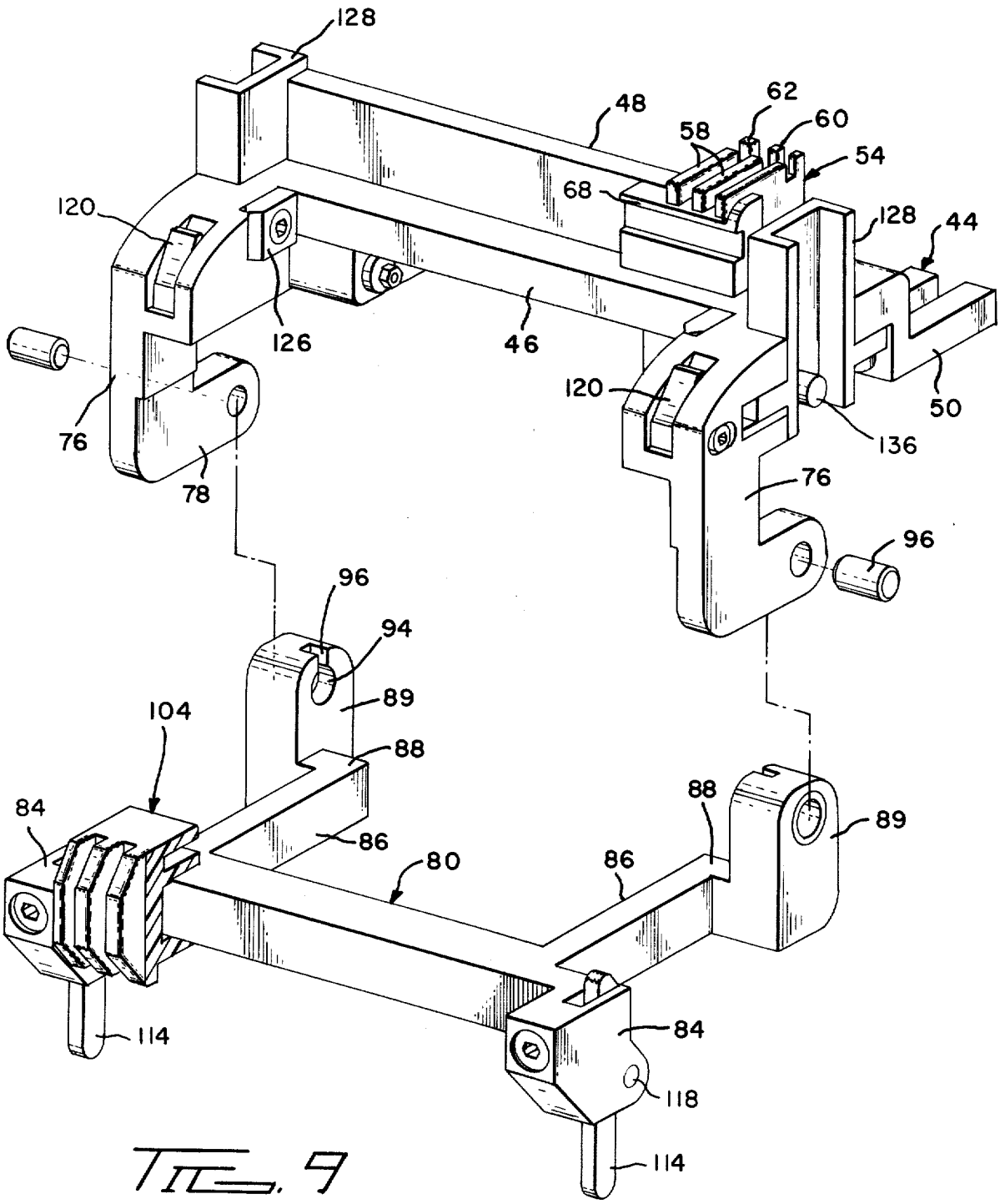
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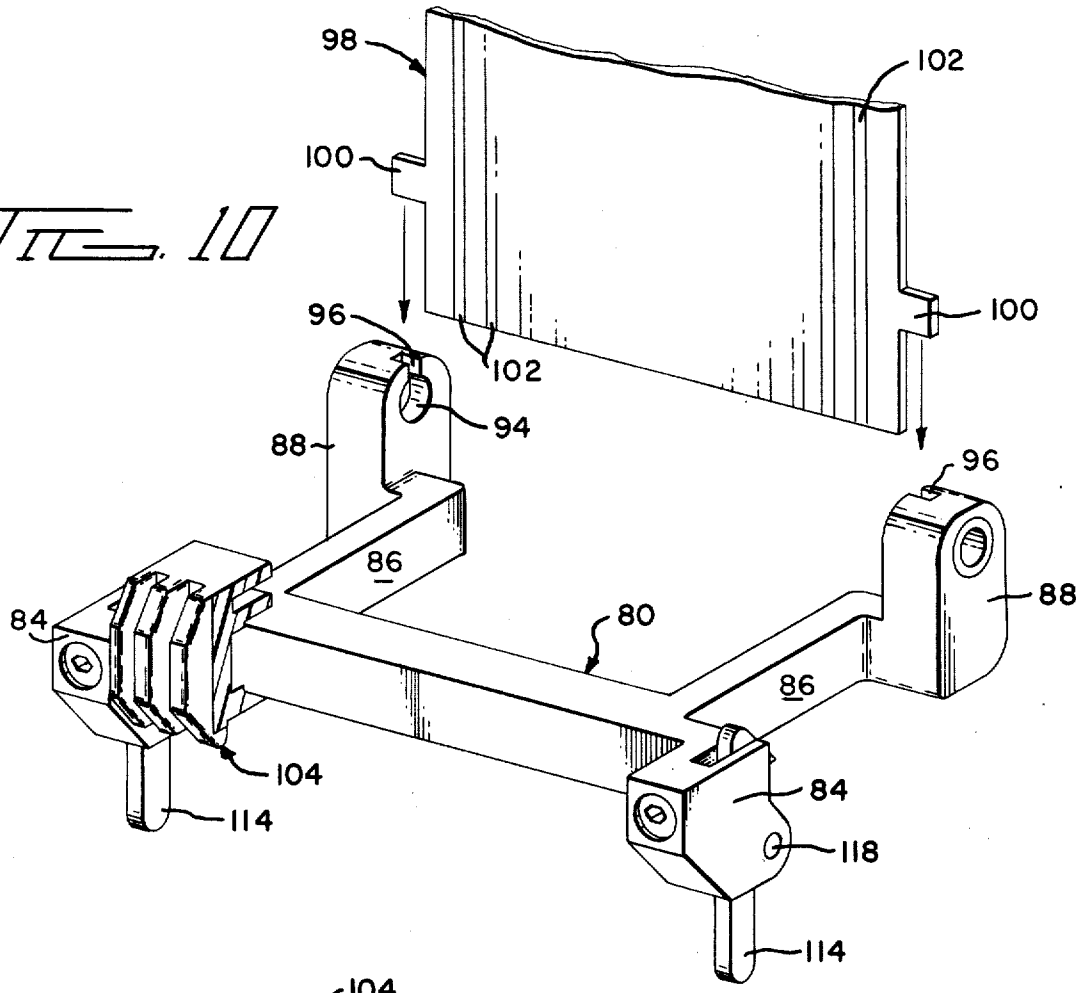
FIG. 9

FIG. 10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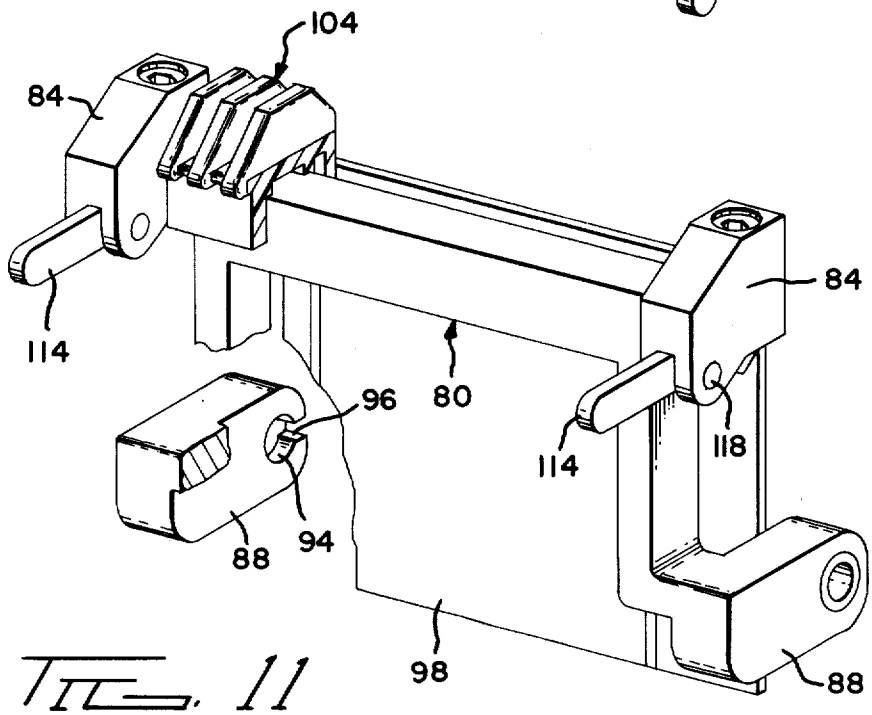
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FIG. 11

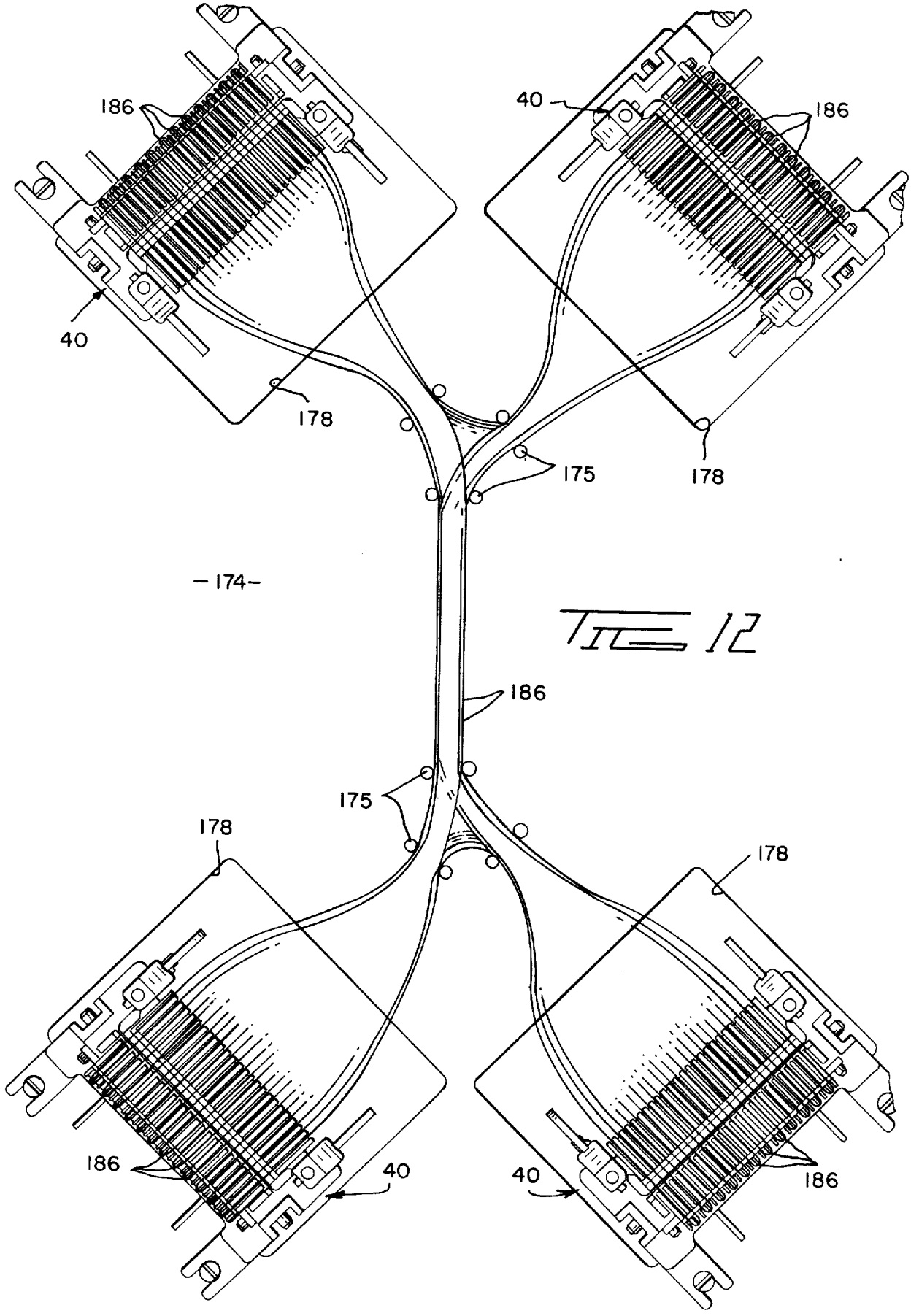

FIG 12

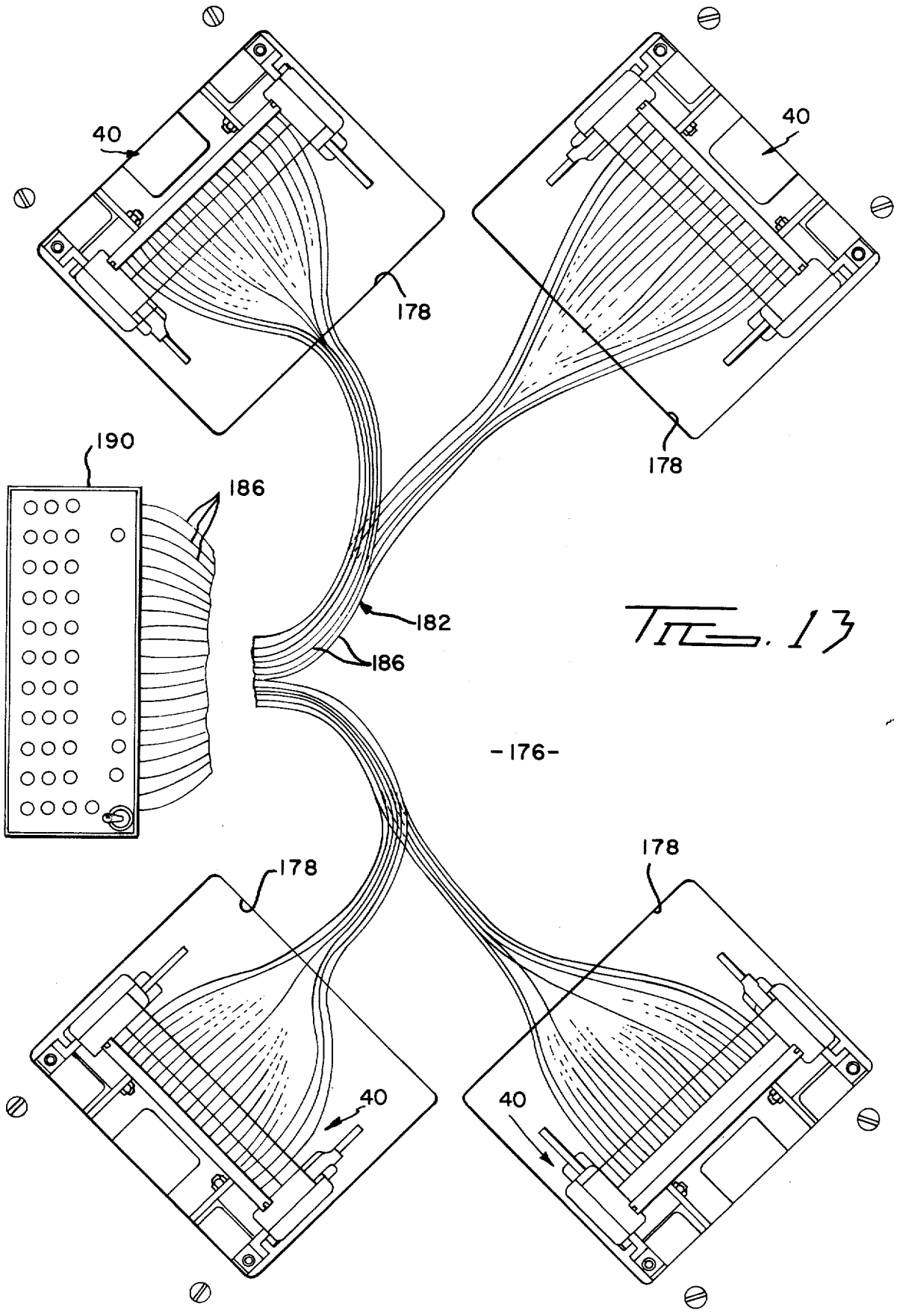

FIG. 13

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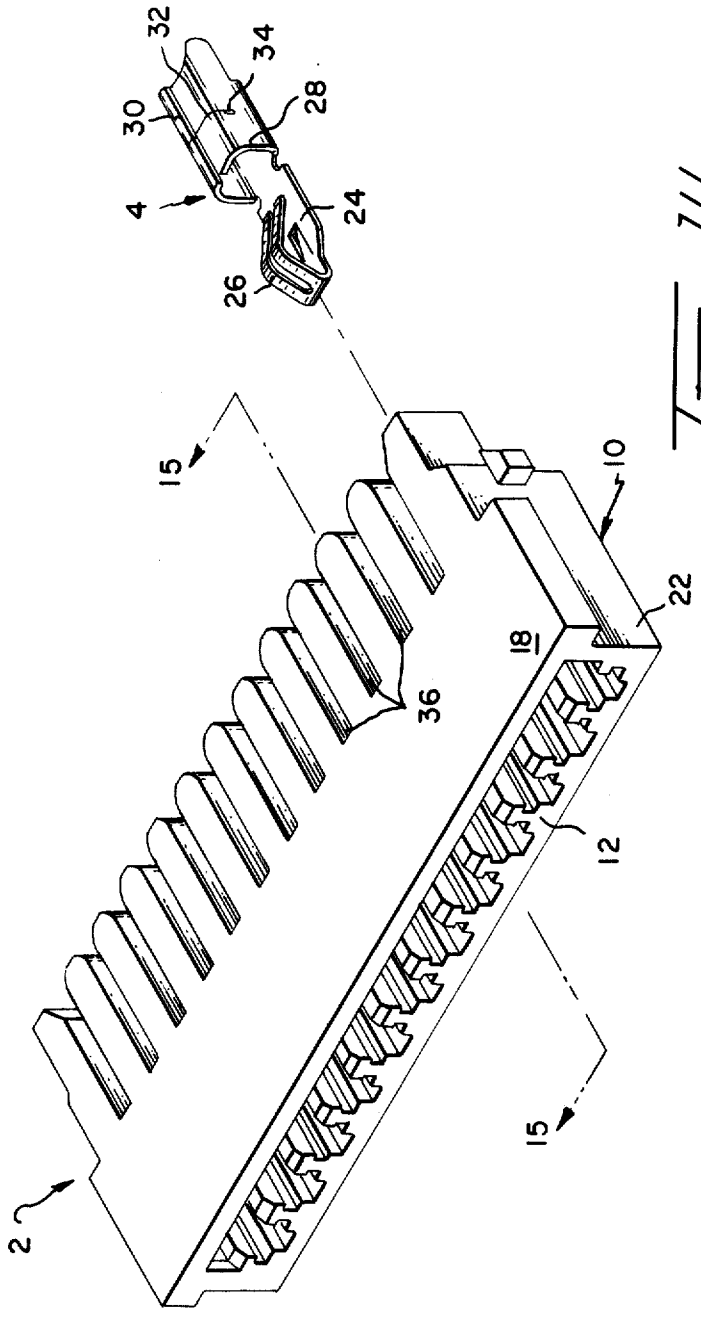

FIG 14

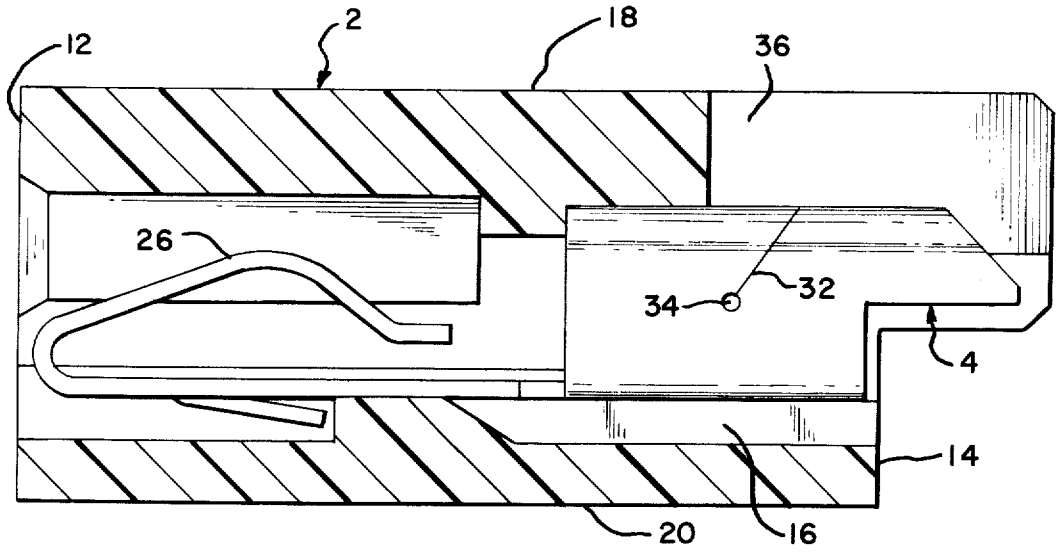

FIG. 15

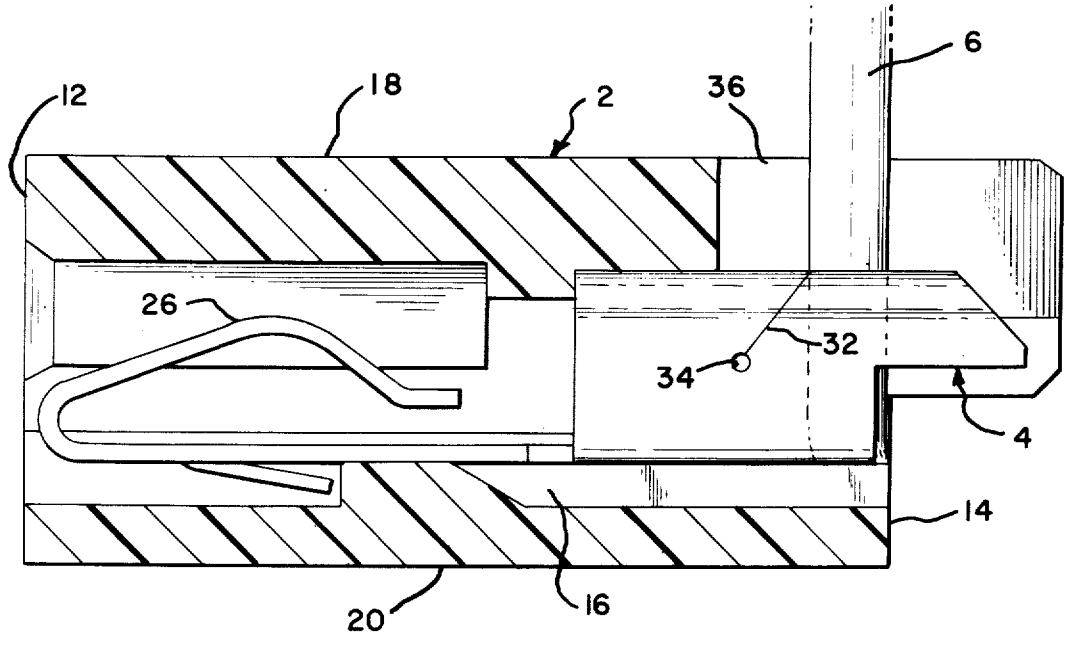

FIG. 16

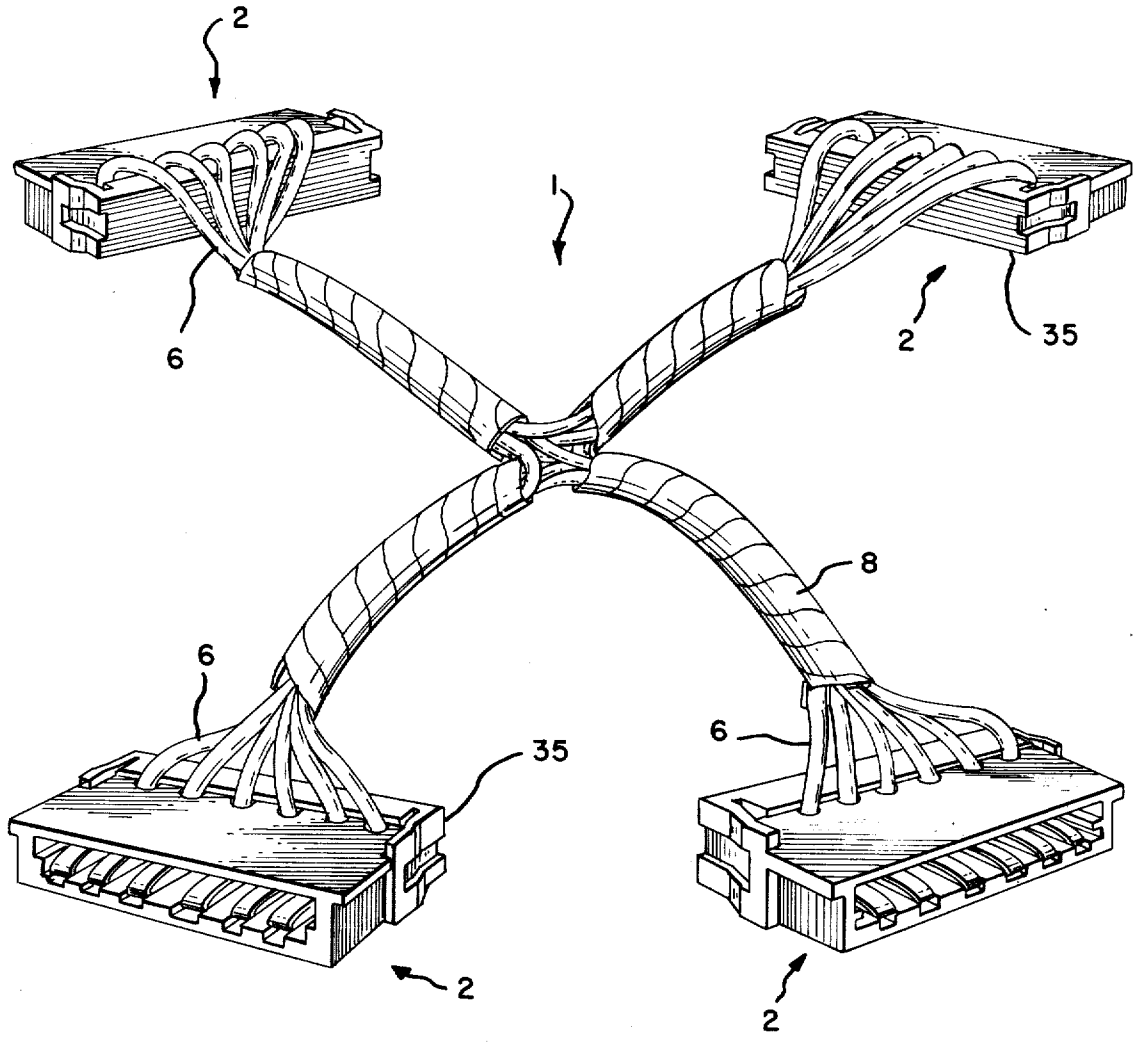

FIG. 17

HARNESS MANUFACTURING APPARATUS INCORPORATING HARNESS TESTING MEANS

BACKGROUND OF THE INVENTION

This invention relates to an apparatus of the general type disclosed in application Ser. No. 347,965, now U.S. Pat. No. 3,845,535, for connecting wires to the terminals in an electrical connector. The instant invention is also related to applications Ser. No. 347,956 and 347,957 as will be more fully explained below.

Application Ser. No. 347,965, now U.S. Pat. No. 3,845,535, discloses and claims an apparatus for trimming the ends of wires and inserting the trimmed ends into the electrical contact terminals in a multi-contact electrical connector. One distinguishing feature of some embodiments of the apparatus disclosed in application Ser. No. 347,965, now U.S. Pat. No. 3,845,535, is that the portion of the apparatus which holds the connector is separate from the portion which inserts the wires into the terminals in the connector, the later part of the apparatus hving means to permit its being mounted on the former. This feature of my prior apparatus particularly adapts it for having in a harness making method and apparatus is disclosed in application Ser. No. 347,957 which teaches that a completed harness can be manufactured by lacing wires over a harness board in accordance with the wiring plan of the harness in a manner such that portions of the wires extend adjacent to connectors contained in the apparatus of application Ser. No. 347,965.When the wires are inserted by the apparatus into the terminals in the connector the harness is substantially completed and can be removed from the harness board and, after testing, put to use.

The instant invention is directed to an improved apparatus having a means, which may be in the form of a printed circuit board, for holding the connector to which wires are to be connected. This feature facilitates the use of the prior apparatus and permits it to accommodate connectors of different sizes by merely changing the printed circuit board thereby increasing its usefulness. In accordance with a further aspect of the instant invention, the printed circuit board upon which the connector is mounted has conductors thereon that engage the contact terminals in the connector being wired. These printed circuit board conductors are, in turn, connected to wires which extend to, and form a part of, an electrical testing means so that the connector can be electrically tested and immediately after the wires have been connected thereto. This capability of the instant invention in turn permits the testing, at the time of manufacture, of a completed electrical harness as will be described below.

It is accordingly an object of the invention to provide an improved apparatus for inserting conductors into terminals in a multi-contact electrical connector. A further object is to provide a conductor inserting apparatus having improved means for holding the electrical connector to which the conductors are to be connected. A still further object is to provide a conductor inserting apparatus having means for electrically testing the connector after the conductors have been inserted into the terminals in the connector. A still further object is to provide a harness making method and apparatus having means for testing the entire harness immediately after the manufacture thereof and while the harness is mounted on a harness board.

These and other objects of the invention are achieved in preferred embodiments thereof which are briefly described in the foregoing abstract, which are described in detail below, and which are shown in accompanying drawings in which:

FIG. **1** is a perspective view of a preferred form of apparatus in accordance with the invention showing the insertion or upper tooling removed and exploded from the fixed lower tooling, showing the fixed tooling in its open condition, and showing a connector exploded from the fixed tooling.

FIG. **2** is a view similar to FIG. **1** but showing the parts in fully assembled relationship immediately prior to insertion of the wires into the terminals.

FIG. **3** is a side view of the fixed tooling portion of the apparatus showing the parts in their opened condition.

FIG. **4** is sectional sideview showing the positions of the parts after insertion of the conductors into the terminals in the connector.

FIG. **5** is a top plan view of a fixed tooling taken along lines **5—5** of FIG. **2.**

FIG. **6** is a view similar to FIG. **5** but showing the pivoted carrier frame in its open position with the wire positioning jigs removed from the fixed tooling.

FIG. **7** is a view taken along the line **7—7** of FIG. **5.**

FIG. **8** is a plan view of an alternative form of printed circuit board which serves as a holding and locating means for the connector to which wires are to be connected.

FIG. **9** is a perspective view of the lower or fixed tooling frame and the fixed tooling carrier arm with the parts exploded from each other.

FIG. **10** is a perspective view of the carrier arm with a printed circuit board exploded therefrom, this view showing the orientation of the carrier while the printed circuit board is being assembled thereto.

FIG. **11** is a perspective view of the carrier arm having a printed circuit board assembled thereto, this view showing the orientation of the arm when it is in its closed position relative to the fixed tooling frame.

FIG. **12** is a plan view of a harness board having a plurality of conductor inserting apparatus mounted thereon, this view showing the positions of the parts after wires have been laced over the board and between and among the several wire inserting tools.

FIG. **13** is a plan view of the underside of the harness board showing features of the harness testing means.

FIG. **14** is a perspective view of a multi-contact electrical connector of a type for which the instant disclosed embodiment is intended.

FIG. **15** is a view taken along the lines **15—15** of FIG. **14.**

FIG. **16** is a view similar to FIG. **15** but showing a wire connected to the terminal.

FIG. **17** is a perspective view of a relatively simple electrical harness.

By way of background information for the description of the instant invention, FIGS. **14–17** show features of a connector **2** which is adapted to be used in the disclosed embodiment of the invention and an electrical harness I which can be manufactured and tested in accordance with the principles of the invention. The harness I comprises a plurality of electrical connectors **2** each of which contains electrical contact terminals to which conductors **6** are connected. The conductors extend between and among the connectors in accordance with a predetermined wiring plan so that when the har-

ness connectors 2 are attached to complementary connectors in an electrical apparatus, the motors, switches, control devices, etc. of the apparatus will be interconnected. The harness shown in FIG. 17 has suitable wrapping material 8 wound over the conductors as is common practice in the harness making art.

Each connector 2 (FIGS. 14–16) comprises an insulating housing 10 having a mating face 12 and a rearward face 14. The housing has an upper surface 18 (as viewed in the drawing) and a lower surface 20 and end surfaces 22. A plurality of contact receiving cavities extend through the housing and each cavity contains an electrical contact terminal 4.

Each terminal 4 has an elongated web 24 from the forward end of which reversely bent contact arms 26 extend for engagement with conductors on a printed circuit board. At its rearward end, each terminal has sidewalls 28 which are bent inwardly towards each other to define an open seam 30 which serves as a wire receiving slot. Advantageously, the sidewalls are partially transversely sheared on each side of the seam 30, these shear lines extending to punched holes 34 to prevent perpetration of cracks at the ends of the shear lines. As shown in FIG. 16, after a wire has been connected to the terminal, it will be received between the edges of the slot 30 and the edges penetrate the insulation of the wire and establish contact with the conducting core. The wire 6 extends laterally from the connector through an opening in the upper surface 18 which communicates with cavity in which the terminal is contained. A back cover 35 is advantageously fitted over each connector and serves as a strain relief for the wires as described in detail in the above-identified application Ser. No. 347,956.

A preferred form of inserting apparatus in accordance with the invention (FIGS. 1 and 2) comprises a fixed base section 38, which is mounted on a harness board 42, and an actuator or insertor 40 which can be affixed to the base section 38 when the operation of inserting the wires into the terminals 4 in the connector is being carried out. Before proceeding with a detailed description of the structural details of this apparatus, it should be explained that when a harness is manufactured, a plurality of base sections 36 are mounted on a harness board 42 (FIG. 12). Connectors 2 are mounted in each base section 38 and wires are laced over the board and between connectors. After the wire lacing operation has been completed, the actuator 40 is assembled to each of the base sections in turn and the wires are trimmed and inserted into the terminals in the connectors.

The fixed base section 38 comprises a frame 44 having a central body 46 (FIG. 9) on which there is provided an upstanding transversely extending integral rib 48 of rectangular cross-section. Feet 50 extend rearwardly as viewed in FIGS. 1 and 9 from the central body and are secured to the upper surface 174 of the harness board by suitable fasteners 52. The central and forward portions of the base section overhand, and extend into, an opening 178 in the harness board for reasons which will be explained below.

A rear wire jig or comb 54 is mounted on transverse rib 48 and comprises an elongated bar 56 which is disposed against the rightwardly facing side of rib 48 as shown best in FIG. 9. A plurality of spaced apart barriers 58 are provided on the upper surface of the bar 56 and extend leftwardly as viewed in FIG. 4 over and beyond the upper surface of the rib 48 of the frame.

The forwardly extending portions of these barriers (which are on the left in FIG. 4) are relatively more thick than the end portions 62 as shown in FIG. 5 so that the space between the forward portions of the barriers is somewhat more narrow than the space between adjacent barriers at the rearward ends thereof. Advantageously, the spacing between adjacent barriers 58 is such that when two wires are located between two adjacent barriers, one wire will be above the other so that the two wires will be guided into the associated contact terminal as is also described below. It will be noted that the barriers are notched as shown at 60 adjacent to rearward ends 62 thereof. This notch facilitates removal of scrap wire from the comb or jig after a wire inserting operation has been carried out.

The wires are trimmed concomitantly with insertion into the terminals by means of a fixed shear bar 66 which has a generally rectangular cross-section and which has upwardly extending ears 68 at its ends, these ears being disposed against the end barriers 58 of the wire jig 54. Fixed shear 66 is secured against the leftwardly facing side, as viewed in FIG. 4, of the rib 48 and the leftwardly facing surface of the shear member is undercut as shown in 70 to define a fixed shearing edge 72 which extends parallel to, and is immediately beneath, the ends of the barriers 58. This fixed shear member cooperates with a movable shearing means mounted on the insertion tooling to cut the wires as will be later described. It is preferred practice to locate the fixed shear such that the wire enters the upper portion of the terminal before cutting of the wire is completed to ensure accurate placement of the wire.

A spacer block 74 having a rectangular cross-section is mounted against the leftwardly facing surface 49 of rib 48 immediately beneath the fixed shear 66. As will be apparent from FIG. 4, when the parts are in the positions that occupy during a wire inserting operation, the surface 18 of the housing of the connector is located against this spacer block 74. Since the connector must be precisely located with reference to the wire insertion tooling, the location of spacer 74 is important or even critical for best results. The shear bar 66 must also be precisely located so that the wires will be cut at the desired locations. Advantageously, the spacer 74 and the shear bar 66 are both secured to the rib 48 by means of set screws which permit these members to be moved leftwardly under very precisely controlled conditions from the positions shown in FIG. 4.

The frame 44 has a pair of depending arms 76 on its lefhand end which extend into the opening 178 in the harness board and the lower ends 78 of these arms extend rightwardly as viewed in FIG. 4 so that they are substantially beneath the insertion tooling. A carrier frame 80 is pivoted on these arms in a manner described below and comprises a transversely extending bar 82 having integral latch housing blocks 84 on its ends. A pair of depending arms 86 extend downwardly from the bar 82 and are locating inwardly from the latch housing blocks 84, the lower ends of the arms 88 being outwardly offset and extending rightwardly as viewed in FIG. 4. The lower end portions 88 of the arms 86 are provided with integral bosses 89 which are disposed against the rightwardly portions 78 of the depending arms 76 of the static . . . section of the frame. The carrier frame 80 is pivotally connected to the end

portion **78** of the static portion of the frame by pivot pins **90** as shown so that the carrier frame can be swung along a counterclockwise arc from the position shown in FIG. **4.**

The inwardly or opposed surfaces **92** of the bosses **89** are counterbored at **94** and slots **96** extend from these counterbores radially to the ends of the arms. These counter bores receive laterally extending ears **100** on the side edges of a printed circuit board **98** as shown in FIG. **7.** The printed circuit board thus is located between the depending arms **86** of the carrier frame **80** and lies in a plane which is between the transverse bar **82** of the carrier frame and the central body portion of the fixed frame **44.** The widths of the ears **100** are slightly less than the diameter of the counterbores so that the printed circuit can be swung about an axis extending between the centers of the counterbores. The slots **96** are provided to permit removal of the printed circuit board as will be described at a more appropriate time. It will also be noted that the printed circuit board has parallel conductors **102** on its surface and these conductors are used during testing as is also described below. The connector **2,** to which wires are to be connected is simply mounted on the upper end of the printed circuit board **102** so that the board serves as a mounting means for the connector during operation.

A front wire jig or comb **104** is mounted on the transverse bar **82** of the carrier frame **80.** This front wire jig comprises a generally channel-shaped member having a central web **106,** and depending flanges **108, 110.** On its upper surface, there are provided a plurality of spaced apart barriers **112** which have the appearance of trunkcated triangles but which may be rectangular if desired. These barriers are spaced apart by distances corresponding to the spacing between the barriers on the rear wire jig **54** so that wires placed between aligned barriers in the two-wire jigs will be located above the terminals contained in the connector in FIG. **4.** The wire jig **104** is secured to the rib or bar **82** by suitable fasteners with the web against the upper surface of the bar and depending flanges **108, 110** straddling the bar **82.**

Latching means are provided for latching the carrier frame **80** in its closed position as shown in FIGS. **2** and **4,** this latching means comprising latch levers **114** which are pivotally mounted in slots **116** on the downwardly facing sides of the latch housings **84** on the ends of the transverse bar **82** of the carrier frame **80.** The forward ends of the levers are hooked as shown at **119** and are adapted to engage latch dogs **120** mounted in recesses on the upwardly facing surfaces of the frame member **44.** The levers **114** are resiliently biased in a clockwise direction as viewed in FIGS. **3** and **4** by springs **122** which are contained in recesses in the housing blocks **84** and which bear against the latch arms adjacent to the hooked ends thereof.

As shown in FIGS. **3** and **4,** an additional latch dog **124** is provided which extends horizontally from one of the depending arms **76** of the fixed frame **44.** This horizontally extending latch dog comprises a stamped plate-like member and prevents the carrier frame **80** from swinging in a counterclockwise direction beyond the position shown in FIG. **3.** The latch arm **114** which engages the fixed latch dog **124** can be disengaged from the dog when it is desired to swing the carrier frame through a further counterclockwise arc to change the printed circuit board **78.**

It should be explained at this point that the fixed or lower tooling is loaded with a connector **2** by opening the carrier frame **80** to the position of FIG. **3.** The printed circuit board **98** is swung through a slight counterclockwise arc so that it is directed obliquely upwardly between the carrier frame **80** and the central portion of the fixed frame **54.** A connector **2** is then mounted on the upper end of the printed circuit board **102** and the carrier frame is then swung through a clockwise arc to its closed position and the latch arms **114** engage the latch dogs **120.** The printed circuit board is precisely centered when the parts are in their closed positions by positioning blocks **126** which are mounted against the opposed surfaces of the frame **44** adjacent to the central portion thereof. The edges of the printed circuit board move over these positioning blocks **126** and the board is thereby precisely centered and the connector will also be precisely centered with its contact terminals in alignment with the spaces between barriers in the wire jigs and in alignment with the insertion punches **160** in the insertion tooling described below.

The actuator or movable tooling member **40** is mounted on the frame **44** by means of channels **128** which have inwardly directed cylindrical housings **134** and laterally extending arms **133** on their sidewalls. These mounting channels are secured in notches **130** in the oppositely facing sides of the central portion of the frame by fasteners **132** which extend through the mounting arms **133** in the channels and into the frame. The mounting means for the upper tooling comprises, in each channel, a pin **136** is contained in the housing **134** and which extends through an opening in the web of the channel, pin **136** has a reduced diameter end portion which extends through a central opening in the end wall of the cylindrical housing **134** on the channel. A spring **140** is interposed between the end wall of housing **134** and a shoulder on the pin. This spring normally biases the pins outwardly through the web but these pins can be moved inwardly against the compression of the springs **140** by suitable handles **142** provided on the ends of the pins **136.**

The upper portion **40** of the tooling is mounted on the lower tooling assembly **38** by merely locating the upper tooling above the lower tooling as shown in FIG. **1** and moving the lowering the upper tooling in the position of FIG. **2** so that the legs **144** move into the channels **128** and cam pins **136** inwardly. The pins then move through the webs of the channels and into openings **146** on the lower ends of the mounting arms **144.** The upper tooling is removed by retracing the pins by means of the handles **142.**

The upper tooling comprises a housing **146** having a cover plate **148** in which a slide member **150** is contained and guided. Slide **150** has an insertion tool holder **152** secured to and extending across, its lower end and a channel **154** is provided in this tool holder in which the inserter **158** is mounted. The rightwardly facing flange as viewed in FIG. **4** on the lower end of tool holder **152** provides a shearing edge **156** which, during descent of the slide, moves past the fixed shearing edge **72** to shear the wires which have previously been positioned in the wire jigs **54.** The inserter **158** has a series of pairs of depending inserting punches **160** and **162** which are so dimensioned that they will push the trimmed wire into the terminal with which they are associated as shown in FIG. **4.** The left hand flange **157**

of the tool holder **152** cooperates in this wire inserting step so that after the slide **150** has reached the lower most limit of its travel, the wire will be located in the slot **30** of the associated terminal.

The slide **150** is resiliently biased upwardly by suitable spring means (not specifically shown) and is moved downwardly on by a cam **166** which is mounted on a pin **164** which is supported in extending bearing portions **162** of the housing **146.** A handle **168** is supported on the pin **164** and is secured to the cam **166** by a pin **167** so that if the handle **168** is swung through a counterclockwise arc from the position of FIG. **4,** the contoured surface of the cam will engage a cam follower **170.** This cam follower is mounted in the upper end of the slide **150** so that the slide and the inserter, which is carried thereon, will be moved to its lowered position. It is desirable to provide auxiliary means for lifting the slide from its lowered position and to this end, I provide crescent shaped lifts **172** on each side of the cam **166.** These lifts are so contoured that they will engage pins on the cam **166** and lift the slide when the handle **168** is returned to the position shown in FIG. **4.**

FIG. **9** shows the upper surface **174** of a harness board on which four lower tooling assembles **38** have been mounted adjacent to openings **178** in the harness board. A harness board so arranged might be used to produce extremely simple harness as shown in FIG. **14.** To produce such harness, each of the lower tooling assemblies are loaded with a connector **2** and the tooling assemblies are closed as described above, that is the carrier **80** is swung to its closed position (FIG. **4**) and latched. Wire or wires are then laced over the harness board between suitable guide and retaining pegs **175** between and among the several tooling assemblies in accordance with the desired wiring plan. The wire is not cut at the fixed tooling assemblies **38** but is laced "in and out" through each assembly. In other words, the wire enters an assembly adjacent to the board openg **178,** is laced between aligned barriers **112, 58** in the wire jigs **104, 54** and then is reversed and laid between another pair of aligned barriers in the same assembly. Thereafter, it is laid on the board along a path extending to another pre-determined lower tooling assembly **38** and the process is repeated. Ocassionally, it may be necessary to cut a wire at a tooling assembly and start anew as explained in the above identified application Ser. No. 347,957. The wire for the lacing operation may be drawn from an endless source such as a reel.

After the wires have been laced over the board, the upper tooling assembly **40** is assembled to each of the four lower tooling assemblies **38** in turn and the handle **168** is swung to cut the wires and insert the cut ends into the terminals in the connectors **2.** The cutting operation will result in the production of loops of scrap wire adjacent to the rearward wire jigs **54** and these can be removed by passing a thin awl-like tool through the notches between the barriers **62, 58.** After the upper tooling assembly has been assembled to all of the lower tooling assemblies and the wires have been cut and inserted into the terminals in the connectors **2,** the harness will have been completed and testing of the harness can be carried out as described immediately below.

Referring now to FIG. **10,** the underside **176** of the wiring board has a testing harness **182** supported or suspended thereon comprising wires **186** which extend from suitable testing circuits which may include indicator lights in a housing **190** which may be located remote from the underside of the board for maximum operator convenience. The wires **186** extend to connectors **184** which may be identical to the previously identified connectors **2.** The contact terminals in the connectors **184,** engage the conductors **102** on the printed circuit boards and, since these conductors extend to and contact the terminals in the connectors **2** on the upper surface of the board which are now part of the completed harness, the harness can be tested by merely energizing the testing circuits in the housing **190.** Any "opens" or misplaced wires in the harness can be readily detected during this very brief testing procedure and the harness can be repaired or "reworked" in a very brief time. The practice of the invention thus eliminates the need for a time-consuming and costly final electrical test which is usually made by plugging the connectors of the harness with connectors or printed circuit boards of the testing apparatus.

It is desirable to have the capability in the apparatus to accommodate varying sizes of connectors, that is connectors having different numbers of contact terminals therein. If, for example, it is desired to connect wires to a relatively smaller connector **2A** (FIG. **8**) then the connectors previously described, it is merely necessary to remove the printed circuit board **102** from the apparatus and substitute a printed circuit board **102** which has a tongue **180** extending from its upper edge as viewed in FIG. **8.** This tongue is dimensioned to fit into the mating face of the connector **2A** and to center and support it in the tool or apparatus in the manner previously described. It will thus be apparent that the apparatus can be modified to accept varying sizes of connectors by simply changing the printed circuit board.

The board is changed by simply opening the carrier frame **80** until its accurate movement is stopped by the latch dog **124.** The lever **114** which engages this latch dog is then depressed so that disengagement from latch dog **124** takes place and the carrier is swung through a further counterclockwise arc until the slots **96** extend vertically upwardly. The printed circuit board **98** is then swung normally of its own plane until the ears **100** are in alignment with the slots **96.** The board can then be moved upwardly with the ears biasing through the slots and the printed circuit board **98***a* can be similarly assembled to the carrier.

The invention presents several salient features and advantages which may be employed with beneficial results individually or in combination with each other in the harness making art and in processes where wires are simply being connected to the terminals in a single connector. For example, the printed circuit board **98** serves as a support for the connector to which wires are being connected and can be replaced to accommodate different sizes of connectors as noted above. Under some circumstances, it may not be required that the electrical connections be tested at the time the wires are inserted into the terminals and under such circumstances, the panel-like member can be in the form of a simple board which has supporting means for the connector. This feature of the invention may be used in a wire inserting apparatus which is not specifically intended for use in the harness making art but it is used only to connect wires in a cable to the terminals in a connector.

Under other circumstances, it may be desirable to test the connector electrically even though the apparatus is not being used for harness making as described above. It will be apparent that such electrical tests can be conducted by the practice of the invention where individual wires are being connected to terminals in a connector and the wires are not part of an electrical harness as disclosed herein.

Finally, the testing procedure disclosed herein may be used with other types of connectors such as connectors of the type disclosed in U.S. Pat. No. 3,760,335. To carry out such electrical tests, the connector to which wires are being connected would be mated with a complementary connector would have wires extending from its terminals to a test apparatus as explained above. Such in situ electrical testing can be carried out with wire inserting apparatus of types other than that shown in the instant application, for example, wire inserting apparatus of the type shown in U.S. Pat. No. 3,758,935 and 3,766,622.

What is claimed is:

1. Apparatus for inserting conductors into the conductor-receiving portions of electrical contact terminals which are contained in an electrical connector, said connector being mateable with a complementary connecting device, said apparatus comprising:

frame means,

connector holding means on said frame means for holding said connector in a predetermined position, said connector holding means comprising a complementary connecting device removably mounted on said frame means,

conductor holding means for holding conductors adjacent to, and in alignment with, said conductor receiving portions preparatory to inserting of said conductors into said conductor-receiving portions,

conductor insertion means for moving conductors in said conductor holding means from said conductor holding means into said conductor receiving portions of a connector mounted on said connector holding means whereby,

upon mounting a connector on said connector holding means, locating conductors in said conductor holding means, and actuating said conductor insertion means, said conductors are inserted into said conductor-receiving portions of said terminals in said connector, said apparatus being adaptable to use with connectors of varying sizes upon removal of said complementary connecting device therefrom and replacement thereof with a different complementary connecting device.

2. Apparatus as set forth in claim **1**, said complementary connecting device comprising a panel-like member having the dimensions of a printed circuit board, said apparatus being intended for use with a printed circuit board connector which is mateable with said panel-like member.

3. Apparatus as set forth in claim **2**, said panel-like member comprising a printed circuit board.

4. Apparatus as set forth in claim **3**, said printed circuit board having printed circuit conductors thereon which are engageable with said contact terminals in said connector, said apparatus including electrical testing means for testing connections between said wires and said terminals, said printed circuit conductors extending to said testing means.

5. Apparatus for inserting conductors into the conductor-receiving portions of electrical contact terminals which are contained in an electrical connector, said contact terminals having contact portions, said connector being mateable with a complementary connecting device having complementary contact portions which are engageable with said contact portions, said apparatus comprising:

frame means,

connector holding means on said frame means for holding said connector in a predetermined position, said connector holding means comprising a complementary connecting device whereby, upon mounting said connector on said holding means, said contact portions of said connector are engaged with said complementary contact portions,

conductor holding means on said frame means for holding conductors adjacent to, and in alignment with, said conductor receiving portions of a connector mounted on said connector holding means preparatory to inserting said conductors into said conductor-receiving portions,

conductor insertion means for moving conductos in said conductor holding means from said conductor holding means into said conductor receiving portions of a connector mounted on said connector holding means, and

test circuit means comprising test circuitry for testing electrical connections, and conductors extending from said test circuitry to said complementary contact portions on said complementary connecting device whereby,

upon mounting a connector on said connector holding means, locating conductors in said conductor holding means, actuating said conductor insertion means to insert said conductors into said conductor receiving portions of said terminals in said connector, and energizing said test circuit means, the electrical connections between said conductors and said conductor-receiving means are tested in situ.

6. Apparatus as set forth in claim **5** said connector being of the type adapted to be coupled to a panel-like member such as a printed circuit board, said complementary connecting device comprising a printed circuit board.

7. Apparatus as set forth in claim **6**, said printed circuit board having printed circuit conductors thereon, said printed circuit conductors having contact portions which constitute said complementary contact portions.

8. Apparatus as set forth in claim **7**, said conductor holding means comprising wire comb means on said frame means.

9. Apparatus as set forth in claim **7**, said frame means comprising a static frame member and a carrier arm pivotally mounted on said static frame member, said printed circuit board being supported on said carrier arm.

10. Apparatus as set forth in claim **7**, said frame means comprising a static frame member and a carrier arm pivotally mounted on said static frame member, said conductor holding means comprising first and second wire combs on said static frame member and said carrier arm, said printed circuit board being pivotally mounted on said frame means and extending between said carrier arm and said static frame member, said carrier arm being pivotally movable between open and closed positions relative to said static frame member to permit placement of said connector on said printed circuit board when said carrier arm is in said open posi-

tion and location of said connector in alignment with said insertion means when said carrier arm is in said closed condition.

11. Apparatus as set forth in claim **5,** said conductor insertion means being removably mounted on said frame means.

12. Apparatus for inserting wires into the wire-receiving portions of electrical contact terminals which are contained in an electrial connector and for testing said connectors after said wires are inserted, said wire-receiving portions being arranged in side-by-side relationship in a row, said apparatus comprising:

frame means,

connector holding means on said frame means for holding said connector in a predetermined position,

wire locating means on said frame means, said wire locating comprising means for locating a plurality of wires in side-by-side parallel relationship and in alignment with said wire-receiving portions of contact terminals in a connector mounted on said connector holding means,

insertion tooling means for inserting wires contained in said wire locating means into said wire receiving slots in said connectors,

contacting means on said frame means, said contacting means being in electrical contact with said contact terminals in a connector mounted in said holding means, and

test circuit means, said test circuit means being connected to said contacting means whereby,

upon insertion of wires into said wire-receiving portions of terminals in a connector mounted on said connector holding means, the wired connector can be tested in situ.

13. Electrical harness manufacturing and testing apparatus for manufacturing and testing an electrical harness of the type comprising a plurality of electrical connectors having conductors extending between and among terminals contained in said connectors said apparatus comprising:

a plurality of connector jigs for holding connectors in positions, relative to each other, which they will occupy in the finished harness whereby harness conductors can be connected to the terminals in said connectors in accordance with the wiring plan of said harness,

test circuit means comprising connecting means for removably connecting test circuit conductors to the individual terminals in connectors in said connector jigs whereby,

after said harness conductors have been connected to said terminals, said test circuit means can be energized to test said harness for conformity to said wiring plan.

14. Electrical harness manufacturing and testing apparatus for manufacturing and testing an electrical harness of the type comprising a plurality of electrical connectors and conductors extending between and among said connectors, said connectors having a plurality of electrical contact terminals therein, each of said terminals having a conductor receiving portion and a contact portion, said apparatus comprising;

supporting means,

a plurality jig members mounted on said supporting means at locations corresponding to the locations of the connectors in the harness being manufactured, each of said jig members having connector holding means and conductor holding and locating means for locating conductors in alignment with said conductor receiving portions of contact terminals in a connector mounted on said connector holding means,

said connector holding means comprising a complementary connecting device which is mateable with one of said connectors, said complementary connecting device having external conductors which are engageable with said contact portions of said terminals in one of said connectors, and

test circuit means for testing said harness, said external conductors comprising part of said test circuit means whereby,

upon locating connectors on said connector holding means, locating conductors in said conductor holding means, and moving said conductors from said conductor holding means into said conductor-receiving portions of said terminals, said harness is assembled, and upon thereafter energizing said test circuit means, said harness is electrically tested.

15. Apparatus as set forth in claim **14,** said supporting means comprising a harness board.

16. Apparatus as set forth in claim **15,** said conductors in said harness comprising wires.

17. Apparatus as set forth in claim **16,** said conductor holding and locating means comprising wire comb means for holding wires in parallel side-by-side relationship.

18. Apparatus as set forth in claim **14** each of said jig members having means for mounting an insertion tool thereon of the type capable of moving conductors from said conductor holding means and into the conductor-receiving portions of terminals contained in a connector held in said connector holding means.

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