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(54) Electrical harness fabrication method and apparatus.

(57) A double-ended electrical cable harness is produced in which the wires (40) of a first end thereof are mass terminated to an electrical connector (14) having a plurality of insulation displacement terminals (18) (see Figure 9b). A connector (14) is loaded onto a first transport assembly (50), and the first ends of the wires (40) are terminated to the connector at a termination station (58). The second harness end is prepared by removably mounting one of a plurality of different modules (68) to a second transport assembly (52), and actuating the module at the termination station (58) to finish the second harness end. The apparatus performs various operations on a connector (14) having at least two rows of terminal receiving cavities (32), stacked one on top of the other in a staggered fashion, so that wires (40) may be inserted in each of the cavities from a common connector surface (20). The operations include elevating the connector (14) toward an array of wires (40) so as to form and align the wires for simultaneous termination in all of the cavities (32). Other operations include separating a connector stick into a number of independent connector modules (46) (see Figure 8c), by removing web portions (44) integrally molded with the connector modules (46). Another operation includes removing polarizing pegs (116) (Figure 7) extending from one end of a connector stick, prior to its separation into individual modules (46).

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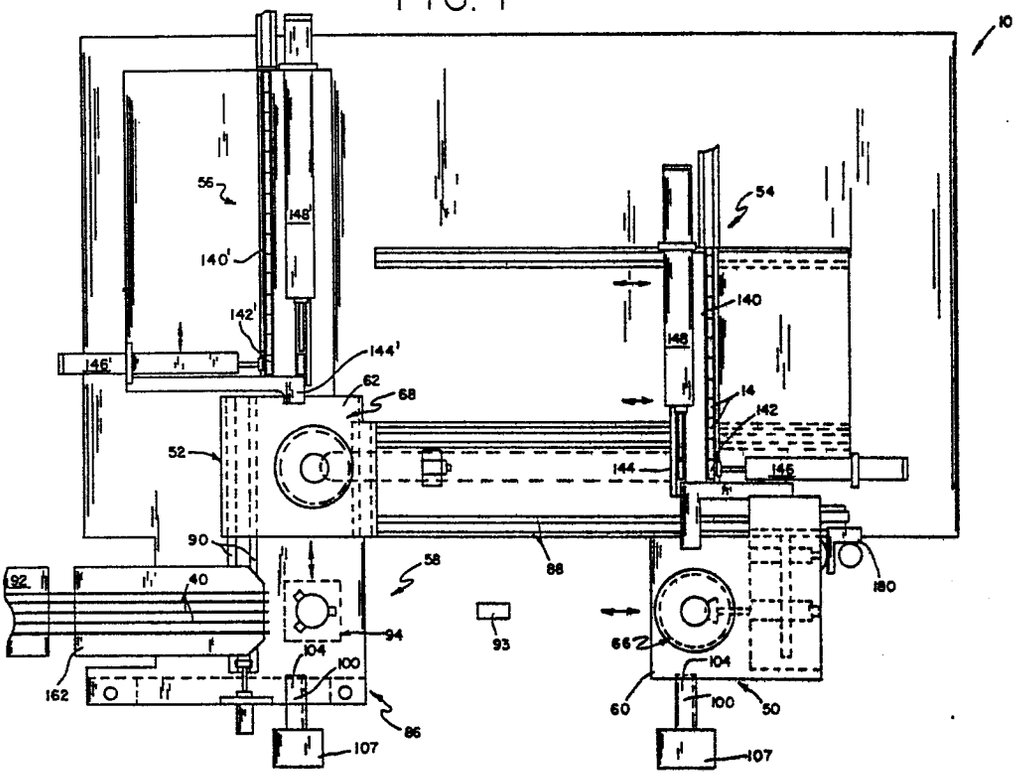
FIG. 1


10
54
56
148'
140'
142'
144'
146'
62
68
52
90
92
40
162
94
104
100
86
107
58
88
93
66
140
148
14
142
144
146
180
60
50

ELECTRICAL HARNESS FABRICATION METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to methods and apparatus for making an electrical harness of the type including a connector having a housing with insulation displacement type contacts loaded therein, each contact connected to an insulation clad wire.

2. Brief Description of the Prior Art

Manufacturers of electronic products today are relying on electrical harnesses employing insulation displacement type contacts to provide the efficiencies and cost reductions necessary in a competitive marketplace. A typical electrical harness employed today is one which generally comprises a connector having a housing with insulation displacement type contacts loaded therein. Each contact is connected to an insulation clad wire. The wires may be an associated group of discrete conductors, or may comprise a flat ribbon cable assembly of the type having either flat or round conductors.

Because of the desireability of eliminating labor costs, automatic equipment is now being employed to produce electrical harnesses of the type described above. One example of such a machine is disclosed in commonly owned United States patent No. 4,235,015 which was granted on November 25, 1980.

Generally, US-A-4,235,015 discloses a method and apparatus of making an electrical harness of the type described which:

positions the connector on a first station,

holds at least a number of wires corresponding to the number of contacts at a second station remote from the first station,

moves the connector to the second station so that each contact is in alignment with each held wire,

simultaneously inserts each wire to its corresponding contact at the second station,

moves the connector back to the first station and simultaneously draws a predetermined length of wire between the connector and the second station, and

cuts and strips all of the held wires at a second station.

The machine of United States Patent 4,235,015 has been fitted for making double-ended harnesses, but change-over for accommodating different connectors or wire configurations requires significant modification to the machine. Also, the wires of the trailing harness end must be cut free and then moved into position over the second connector.

This is sometimes undesirable, as in the case where the connector of EP-A-85308215.4 (described below) is employed.

Another harness making machine is disclosed in commonly owned EP-A-85300074.3 filed 4th January, 1985. Briefly, the machine includes first and second connector nests each movable from their respective connector loading station to a common termination station. Arrangements must be provided for properly aligning the connector of each harness end with the ends of the harness wires to which it is terminated. Also, consideration in aligning each connector relative to the termination head must be made to account for the oppositely facing connector orientations at each harness end. Although generally satisfactory, the machine in use today is not suitable for terminating double-ended harnesses where the connectors are not symmetric with respect to an axis of the wire array. An example of this type of connector is described below with respect to EP-A-85308215.4. Like the machine of United States Patent No. 4,235,015, this machine is not readily reconfigurable if the connector style or the wire array is changed.

One particular type of electrical connector

in use today is described in commonly owned EP-A-85308215.4 filed 12th November, 1985. Disclosed therein is a modular multi-row electrical connector which mates with an array of pins. The connector has an integrally formed housing with opposed top and bottom surfaces extending between opposed forward mating and rearward end walls, and with two rows of axially extending terminal receiving cavities. Each cavity is defined by spaced-apart sidewalls extending between the forward mating and rearward end walls, a bottom wall, and a top wall opening to the top housing surface, so that all of the wires can be inserted for termination from the upper housing surface. The two rows

of terminal receiving cavities are stacked one on top of the other in a staggered configuration, so that the terminal receiving cavities of the lower rows are located between the terminal receiving cavities of their upper rows. The rows are joined together by selectively removeable web portions to form a plurality of commonly joined separable connector modules, each module including at least one upper row cavity and at least one lower row cavity.

United States Patent No. 4,091,531 issued May 30, 1978 discloses a bench tool for terminating a dual-row connector having opposed mating and wire receiving ends. The terminals at the mating end of the connector are aligned such that the top and bottom rows are directly above and below each other. The wire receiving end of the terminals, however, are aligned in staggered rows as described above, so that wires of both rows can be inserted from a single direction. An arbor press is provided having upper and lower tooling members with the upper member being driven toward the lower member during termination. The upper member receives a connector with terminals having insulation displacing slots opening in a downward direction. The bottom tooling member has a series of stacked plates with particularly configured upper saw tooth-like edges. A flat ribbon cable is inserted between the upper and lower tooling members, and the arbor press is activated to terminate both rows simultaneously. After termination, an operator releases the press and withdraws the terminated cable harness from the machine.

The machine of United States Patent No. 4,091,531 is manually

operable, requiring an operator to load the connectors and cable, to terminate one to the other, and to remove the cable harness. It is desirable to provide a fully automatic method and machine for terminating a connector having terminals with wire receiving portions arranged in staggered rows.

SUMMARY OF THE INVENTION

The present invention provides a method of making an electrical harness of the type comprising at least one connector having a housing with insulation displacement type contacts loaded therein, each contact connected to an insulation clad wire. The method produces an electrical cable harness by mass terminating a plurality of insulation-clad wires to a connector having a plurality of insulation displacement terminals, and includes the steps of producing a double-ended electrical cable harness, by mass terminating the first ends of a plurality of double-ended insulation-clad wires to a connector having a plurality of insulation displacement terminals, including the steps of, loading a connector onto a first transport assembly, feeding and measuring wires so that the first ends thereof are positioned adjacent said connector,

terminating first ends of said wires to said connector to form a first finished end of said harness, removably mounting one of a plurality of different selectively actuable harness finishing modules to a second transport assembly, moving said second transport assembly adjacent said second wire ends, and actuating said one module to simultaneously finish the second wire ends to form a second finished harness end.

The present invention also provides an apparatus for producing a double-ended electrical cable harness by mass terminating the first ends of a plurality of double-ended insulation-clad wires to a connector having a plurality of insulation displacement terminals including a connector transport assembly for receiving and moving the connector between stations, means for loading the connector onto said connector transport assembly, wire feeding means for feeding and measuring the wires so that the first ends thereof are associated with the connector, wire termination means for terminating the first ends of the wires to said connector to form a first finished end of said harness, harness finishing means including a frame assembly for removably mounting one of a plurality

of harness finishing modules to said apparatus, and one of a plurality of different harness finishing modules removably mounted on said frame assembly, said one module having a wire operation station whereat second ends of the wires are simultaneously finished to form a second finished harness end.

The apparatus of the present invention may include means for removing polarizing members extending from a connector housing. The polarizing members comprise locating pegs which project from the top and bottom surfaces of the above-described connector so as to extend beyond, but not overlie, the mating end wall thereof. The apparatus may comprise means for presenting at least one rotated connector to a peg removal station and means for selectively removing at least one of said pegs in said axial direction immediately adjacent one of said top and bottom surfaces.

The apparatus of the present invention may also include means for processing the above-described connector of EP-A-85308215.4. Thus the apparatus may include means for rotating the connector so that the forward mating end is upwardly directed, with the wires of a completed harness assembly extending in a downward direction, and a series

of knife-like selectively programmable web separating members to be driven in to the housing in an axial direction so as to selectively remove at least one of the webs connecting the connector rows. When completed, each connector module comprises a separate connector terminated to a predetermined number of wires, so as to form a separate harness therewith.

The apparatus of the present invention may still further include an arrangement for transporting terminated harnesses from one work station to another, wherein the connectors have a plurality of aligning tabs extending from their mating end wall to form a channel extending along the mating end wall. A track is provided with a first rail complementarily shaped with the channel, and opposing second and third spaced apart rail members opposing the first rail. The connector is slid along the track, such that the first rail is received in the channel, and the second and third rails engage the rearward connector end wall adjacent the top and bottom connector surfaces.

The present invention also provides a harness making machine for presenting the wires to the terminals in each of the staggered rows of a

connector of EP-A-85308215.4, in a simple fully automatic two-step operation. The wires are fed to the termination station at a first predetermined level, and a wire preparation module having upper and lower portions is positioned at the termination station, so that the wire is positioned between the portions. The lower portion includes a connector nest receiving a connector of the type wherein rows of terminal receiving cavities are staggered with all of the cavities open in an upward direction, so that all of the wires can be inserted for termination from the upper connector housing surface. The cavities of the lower rows are positioned between the cavities of their upper rows, with the cavity sidewalls of upper rows acting as wire guides to aid in the passage of wires to lower rows for termination therein.

An elevator is provided at the termination station so that, with the module placed over the elevator, the connector nest can be raised to engage the wires with the connector housing, such that the wires to be terminated in the upper row are bent with a predetermined upward angular deflection. The module also includes wire insertion blades disposed above the connector nest, in

alignment with the wires. Upon lowering of the insertion blades, and subsequent termination of the wires to the terminals, the wires terminated to the lower row have an equal but downwardly directed angular deflection.

Some ways of carrying out the present invention in both its method and apparatus aspects will now be described by way of example and not by way of limitation with reference to drawings which show specific embodiments of apparatus according to the present invention.

In the drawings, wherein like elements are referenced alike,

FIG. 1 is a plan view of a machine of the present invention;

FIG. 2 is an elevation view of the machine of FIG. 1;

FIG. 3 is a schematic flow diagram illustraing a method of the present invention, wherein a connector is terminated at a first termination station;

FIG. 4 is a schematic flow diagram illustrating a method of the present invention wherein a connector is terminated at a second termination station;

FIG. 5 illustrates the automatic harness ejection;

FIG. 6 shows an optional wire stripping assembly for use at the second termination station;

FIG. 7 shows a polarizing projection removal station;

FIG. 8 shows a web removal station for splitting a connector stick into separate connector modules;

FIG. 9 shows the connector stick of FIG. 8 in greater detail; and

FIG. 10 shows the modularization of the termination stations.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

I. Introduction

FIGS. 1 to 5 show an electrical harness machine of the present invention, generally designated at 10. Machine 10 automatically produces a completed electrical harness, generally designated 12, as shown in Fig. 7a. The electrical harness 12 includes at least one connector, generally designated 14 and a plurality of insulation-clad wires 40. The connector is described in commonly owned EP-A-85308215.4 filed 12th November, 1985, which is herein incorporated by reference to the extent necessary for an understanding of the present invention.

Referring to FIGS. 9a, 9b, connector 14

comprises an insulated housing 16 having a plurality of preloaded insulation displacement contacts 18. Housing 16 is integrally molded with opposed top and bottom surfaces 20, 22 extending between opposed forward mating and rearward end walls 24, 26. The connector includes an upper row 28 and a lower row 30 of axially extending terminal receiving cavities 32. Each cavity 32 is defined by spaced-apart sidewalls 34 extending between the forward mating and rearward end walls 24, 26. Each cavity further includes a bottom wall 36 and an opposed top wall 38 opening to the top housing surface 20, so that all of the wires 40 can be inserted for termination from the upper housing surface 20.

The rows 28, 30 are stacked one on top of the other in a staggered configuration, so that the terminal receiving cavities of lower row 30 are located between the terminal receiving cavities of its upper row 28, with the sidewalls 34 of the upper row acting as wire guiding channels 42 to aid in the passage of wires to be terminated in the lower row 30.

As further disclosed in EP-A-85308215.4 the rows 28, 30 are joined together by selectively

removable web portions 44 so as to form a plurality of commonly joined separator connector modules 46, each module including at least one upper row cavity 32U, and at least one lower row cavity 32L.

The wires 40 can comprise an array of discrete insulation clad conductors, or alternatively may comprise suitably prepared flat ribbon cable, as is known in the art.

Each cavity 32 receives a metallic terminal 18 having a conventional insulation displacement slot which is adapted to slice through the insulation of insulation clad wires 40. The connector modules, generally designated at 46, may comprise any convenient number of upper row cavities which need not be the same as the number of lower row cavities. For example, a connector module may comprise only a single upper row cavity, disposed between two lower row cavities, to form a three-circuit connector. Further, multiple modules may be left attached to each other to form a larger circuit connector, if desired.

II. Brief Description of the Electrical Harness Making Machine

Looking once again at Figs. 1 and 2, the machine 10 is seen to generally include first and second transport assemblies 50, 52, which carry connectors 14 between first and second loading stations 54, 56 and a common termination station 58. The transport assemblies include frames or carriers 60, 62 on which selectively manually dismountable wire preparation modules generally indicated at 66, 68 are provided for each assembly 50, 52, respectively. As can be seen in Figs. 2-4, each wire preparation module 66, 68 includes a connector nest 70, 72 which maintains a connector 14 in a fixed predetermined orientation. Wire preparation modules 66, 68 further include wire insertion blades 74, 76 opposing connector 14 in alignment with the terminals thereof. Each wire preparation module also includes means for actuating the insertion blades, typically taking the form of an air cylinder, an electric solenoid or other selectively actuable drive means 78, 80.

Referring to FIG. 1, each transport assembly 50, 52 is mounted for travel between a respective connector loading station 54, 56 and a common termination station 58. Transport assembly 50, for example, is mounted for reciprocation along track rails 88 extending between loading station 54 and termination station 58. Similarly, transport assembly 52 is mounted for reciprocation on track rails 90 between the second loading station 56 and termination station 58.

Wires 40 extend from a wire supply 92 to termination station 86 where they are alternately terminated to connectors carried on the two transport assemblies 50, 52.

As indicated in Figs. 1 and 2, a transport elevator 94 of the toggle-lock type is the only operative device located at termination station 58, all other necessary equipment being brought to the termination station by carriers 60, 62. The transport elevator 94 alternately raises each carrier 60, 62 and the wire preparation modules 66, 68 carried thereon.

Each module 66, 68 includes spaced-apart upper and lower wire preparation module portions designated by the suffixes "U" and "L", respectively. Wire receiving gaps 96, 98 are formed between opposing upper and lower wire preparation module portions. Upon positioning at termination station 58, the carrier beds 60', 62' are raised by transport elevator 94, to bring the lower preparation module portion into engagement with wires 40 to assist in the termination. Carrier beds 60', 62' are elevated by guide rods 82, 83 which contact elevator 94. To ensure a return downward movement of the lower wire preparation module portions, each lower portion is provided with a pull-down solenoid 84, 85.

III. Method of Cable Harness Fabrication

Referring initially to FIGS. 1-3, at the initial cycle of cable harness fabrication, wires 40 are extended from wire supply 92 such that their free ends are predeterminedly positioned at termination station 58 (see FIGS. 1 and 2). A first transport assembly 50, after receiving a connector 14, is moved from loading station 54 to termination station

58 such that wires 40 are received in gap 96 of its associated wire preparation module 66. The connector nest 70 is initially located below wires 40, and insertion blades 74 are located above the wires, in alignment therewith (FIG. 2). Referring to FIG. 3a, transport elevator 94 raises the lower portion of wire preparation module 66, so as to advance connector nest 70 and the connector 14 carried therein, upwardly toward wires 40. At the topmost extent of its travel, connector 14 displaces every other wire 40 with an upward angular deflection, as illustrated in Fig. 3b. That is, the upwardly deflected wires 40U are engaged by the sidewalls 34 of the upper terminal-receiving cavities 32. The wires 40L to be terminated in the lower row 30 are received in channels 42 formed between adjacent upper row cavities 32. Thereafter, actuator 78 is energized so as to drive insertion blades 74 in a downward direction, so as to insert and thereby mass terminate wires 40 in connector terminals 18. Transport assembly 50 then returns to loading station 54, thereby drawing a predetermined length of wire from wire supply 92, past termination station 58.

Thereafter, the second transport assembly 52 is loaded with a connector at second loading station 56, and is advanced to termination station 58, where it is elevated by transport elevator 94. For the purpose of this introduction, the second wire prepartion module 68 can be assumed to be functionally identical to that of the first module 66, in that it mass terminates wires 40 to a second connector 14. As will be described hereinafter in greater detail, wire preparation

module 68 differs in its wire handling and other related capabilities. For example, the second wire preparation module contains a travelling wire comb to ensure proper alignment between wires 40 and the terminals 18 of the connector carried thereon.

With wires 40 and terminals 18 aligned, and with the top of connector nest 72 engaging wires 40, actuator 80 is energized to lower wire insertion blades 76 (FIGS. 4d, 4e). Wires 40 are severed by insertion blades 76 as they are pinched between the blades and the upper die-like portion of nest 72 (FIG. 4d). Thereafter, the second or trailing end of the newly formed wire segments are terminated in both rows of connector 14, simultaneously (FIG. 4e).

With the harness thereby being fully formed, automatic ejection arms 100, 102 are cycled to extract connectors 14 from their respective nests 70, 72, (FIG. 5) for transport along ejection tracks to remote work stations.

The second transport assembly 52 is thereafter retracted to the second loading station 56, leaving the free ends of wires 40 extending from supply 92, at the predetermined position above termination station 58, and harness machine 10 is ready to begin another harness making cycle.

Immediately after ejection, connectors 14 and the length of wires 40 extending therebetween, are transported to a conventional work station 107 (see FIG. 1) where the connectors 14 are rotated 90 degrees (as indicated in FIG. 5b), such that their mating ends 24 are upwardly directed as indicated in Figs. 7, 8. After being placed in

their rotated position, connectors 14 are slid along transport tracks 110 which extend to a peg removal station indicated generally at 112 (FIG. 7), and a web removal station indicated generally at 114 (FIG. 8). At station 112, the upwardly directed locating pegs 116, projecting from mating end wall 24, are severed by a selected array of blades 118. Thereafter, while preserving the rotated orientation, connectors 14 are advanced to station 114 (FIG. 8) wherein the selected web portions are removed by blades 120 to form a plurality of finished harness products.

Referring briefly to Fig. 6, an optional wire preparation module 122 is shown carried on second carrier member 62. Although the optional transport assembly formed thereby, designated by the numeral 52', is moveable to and from the second loading station 56, it has no useful interaction therewith, as it does not carry a connector. Instead, the optional transport assembly 52' is provided when only a single-ended harness is desired, the second or trailing end of the harness being prepared by only cutting, or alternatively, cutting and stripping, the trailing ends of wires 40 at termination station 58. After termination to a first connector 14, the first transport assembly 50 is returned to the first loading station 54, and conductors 40 are paid out, across termination station 58. Transport assembly 52', as before, follows the same path to termination station 58, and upon arrival, actuator 80' is energized to lower cutting and stripping blades 124, 126, respectively (FIG. 6d). With wires 40 cut by blades 124, and the insulation cladding thereof at least partially

severed by blades 126, an actuator 128 is energized to extend moveable wire clamp 130 toward the first transport assembly 50, thereby stripping the second end of the newly formed wire segments (FIG. 6 Alternatively, stripping blades 126, actuator 128, and wire clamp 130 may be omitted if only cutting, and not wire stripping, is required at the second end of the cable harness.

As has been outlined above, a choice of two wire preparation modules 68 or 122 is available for the second transport assembly 52 (see FIG. 10). Carriers 60, 62 act as a frame assemblies for locating (see pins 61) and locking (see bolt-receiving mounting holes 63) a selected wire preparation module for movement therewith. More elaborate frame assemblies 66', 68' and 122' are illustrated in FIG. 10.

The various module styles described herein provide a finished second harness end having either a connector mass terminated to the wires, or second wire ends which are either cut or cut-and-stripped, in whatever form is desired by the end user. Those skilled in the art will readily appreciate that other styles of wire preparation modules can be employed with the present invention. For example, a module for gang crimping of the second wire ends to a crimp-type connector can be provided. If the wires comprise a flat flexible cable for example, the wire preparation modules can provide clinching of suitably formed terminals to the flat flexible cable. Also, a cable notching module can be provided if the wires are associated in a conventional ribbon

cable. No matter what style of wire preparation module is required, the particular module can be quickly and easily bolted and unbolted from the threaded mounting holes 63 of carriers 60, 62, by simply installing and removing four mounting bolts for each module.

Throughout this application, the term "wire preparation module" will be employed to describe any of the above mentioned different styles of modules including wire finishing assemblies which may comprise equipment for terminating the trailing wire ends to a connector. Even though the term "wire finishing assembly" may alternately be employed to avoid any suggestion of excluding a module style wherein the wires are terminated in a connector, for the sake of simplicity, the term "wire preparation module" will be employed to cover those styles of modules which not only cut, strip or notch and perform like operations on the second wire ends, but also terminate or otherwise prepare for termination of those ends to a connector. In either event, the feature highlighted here is that at each of the modules, whatever their style, be quickly and easily mounted to either carrier 60 or 62 by the simple installation and removeable of four mounting bolts. It should be expressly understood that other particular combinations of modules and mounting frames other than those that set forth in FIG. 10, and elsewhere herein will become apparent to those skilled in the art upon studying the description herein, and such arrangements are regarded as being included in the present invention.

Further, it should also be expressly understood that the present

invention includes not only modularization of the entire wire preparation module, but also any portion thereof. For example, the modular concept

upper and/or a lower wire preparation portion, for example. Alternatively, the concept also covers the modular interchangeability of wire insertion blades, wire clamping means, or other subparts of a transport assembly 50 or 52.

IV. First Modular Transport Assembly

Turning now to Figs. 1 and 2, the first modular transport assembly 50 receives a connector 14 from the first loading station 54, and is moved to termination station 58 by carrier 60. As can be seen in FIG. 1, the first loading station 54 comprises an accumulator track 140 which receives a single row of connectors, placed end-to-end, from a source not shown. The leading connector is moved by shuttle 142 to a delivery track 144 under the action of transfer solenoid 146. Thereafter, delivery solenoid 148 advances the connector along delivery track 144 to connector nest 70, where it is prepared for transfer to the termination station.

With reference to Fig. 2, the wire preparation module 66 of the first transport assembly 50 includes wire insertion blades 74 inserted in a moveable head 150, which is mounted for reciprocation about guide pins 152 under the force of double acting air cylinder referred to above as actuator 78. Also mounted on head 150 are a series of wire separator blades 154 which to align wires 40, just prior to termination.

The first modular transport assembly 50 is advanced to termination station 58 at a lower level than that of the wire feed of wires 40, as indicated in Figs. 2 and 3a. Wire supply 92 includes an associated power feed, for directing the wires 40 through a wire guide 162 having a delivery end located immediately adjacent termination station 58. Upon delivery of carrier 60 to the termination station 58, transport elevator 94 is activated to raise the rods 82, thereby elevating the lower wire preparation module portion 66L located thereon.

Other arrangements for elevating the wire preparation module will become apparent to those skilled in the art, in light of the description herein. For example, the entire wire preparation module may be raised a first amount with an optional double-acting solenoid 84 raising 60' an additional amount.

As connector nest 70 is raised, the upper surface of connector housing 16 carried therein contacts wires 40, deflecting every other wire with the upper row of terminals, to produce a predetermined angular deflection (see Fig. 3b). The upwardly deflected wires 40U are those aligned for termination in the upper row 28 of connector 14. The remaining set of wires 40L, to be terminated to the lower connector row 30, are positioned in channels 42, extending between the terminal receiving cavities of upper row 28. Channels 42 guide wires 40L to terminals located on the lower connector row 30.

Electrical sensors not shown in the figures, initiate energization of elevator 94, upon arrival of carrier 60 at termination station 58. Sequencing control 170 transmits the actuation signal to elevator 94.

Further sensor switches, not shown in the figures, can be provided within solenoid 84 to indicate when carrier bed 60', and hence lower wire preparation module portion 66L, is raised to its uppermost height. These switches send a signal to sequencing control 170 which deenergizes elevator 94 and initiates downward movement of actuator 78, simultaneously inserting both sets of wires 40U, 40L in connector rows 28, 30. Wires 40L, upon full extension of insertion blades 74, take an equal but downwardly directed angular offset (see Fig. 3c). As indicated in the present embodiment of Fig. 3c, connector 14 is preferrably centered about the level of wire feed, with the angular offsets of the upper and lower rows of wires being equally displaced from that level of wire feed.

After full downward extension of upper module portion 66U, sequencing control 170 initiates a retraction signal to double acting solenoid 78, whereupon moving head 150 is returned in an upward direction. Solenoid 84 is energized to pull down the lower wire preparation module portion to its original, lower, position. As carrier 60 returns wire preparation module 66 to the first loading station 54, wires 40 terminated to the connector 14 carried in nest 70 are dereeled as they pass through termination station 58. If the frictional forces of dereeling are too great, or if the distance between the first loading station 54 and termination station 58 is not great enough, additional power dereeling can be provided at wire supply 92. Cable loops can be conveniently downwardly directed between the termination and loading stations.

Shortly before the return of transport assembly 50 to the first loading station 54, a test cylinder 174 is automatically activated to extend moveable bed 176 carrying test probes 178 (see FIG. 2) in an extended position toward the connector carried in nest 70. The left-hand free end of test probes 178 are thereby inserted in connector 14 in preparation for electrical testing of the harness. The right-hand free end of probes 178 are mated with a stationary connector block 180 located adjacent loading station 54. Connector block 180 contains suitable socket terminals for reception of probe 178, providing connection to an electrical test apparatus not shown in the drawings. Preferrably, each free end of test probes 178 is provided with retractable spring loading to provide easy mating between connector 14 and connector block 180. In the present embodiment, the electrical testing is performed only on single-ended harnesses (see Section VI, below) to detect any shorts between adjacent harness conductors. Other suitable electrical testing as is known in the art, may be performed on both single or double-ended harnesses being fabricated.

V. Second Modular Transport Assembly

The wire preparation module of the second modular transport assembly 52 can take at least three forms. If a double ended harness is required, a wire preparation module, similar in function to that described above, can be provided for mass termination to a second connector 14. However, if a single-ended harness is required, the wire preparation module need only contain a wire cutting device. Alternatively, if a single-ended harness having stripped electrical

wires at its free end is required, wire cutting and stripping equipment can be mounted to the second carrier 62. The numeral 68 has been applied to the mass termination wire preparation module of the present embodiment. The other wire preparation module described hereinbelow is designated by numeral 122 and includes wire cutting and stripping features.

Referring now to Fig. 4, a second modular transport assembly 52, adapted for mass termination to a second connector 14, is shown comprising a carrier 62 and a wire preparation module 68. A connector nest 72 carries a connector 14 from second loading station 56 to termination station 58. The first and second connector loading stations 54, 56 are functionally similar. Accordingly, the numerals 140 to 148 used to describe the first loading station are repeated for the second station 84, but appear therein as primed numerals. For example, the accumulator track at the second connector loading station is designated by numeral 140'.

In addition to the second connector nest 72, wire preparation module 68 includes upper and lower wire clamps 200, 202, respectively. Lower wire clamp 202 is mounted for retraction toward carrier 62 by double acting pulldown actuator 85. Carrier bed 62' is mounted for vertical reciprocal movement by guide pins 83. Also mounted to the lower portion 68L of module 68 is a travelling wire comb 208, the function of which will be described later. The upper module portion 68U consists of the aforementioned upper wire clamp 200, wire separator blades 210, wire cut-off and insertion blades 76 and a wire

clamp 214. The aforementioned components 76, 200 and 204-214 are mounted for common movement to a moveable head 216 which is driven by actuator 80 for movement about guide pins 220. The left most wire clamp 214 is mounted for independent movement with respect to head 216, by actuator 222, to press wires 40 against surface 72' (see FIG. 4a).

With reference now to FIGS. 4a to 4f, operation of the second transport assembly having a mass termination wire preparation module will be described. All operations take place at the common terminating station 58 whereat the first transport assembly 50 has dereeled wires 40 such that a continuous wire portion is positioned above termination station 58. Upon arrival of the second transport assembly 52 (FIG. 4a), carrier bed 62' is raised by elevator 94. Sensor switches associated with pull down solenoid 85 indicate to sequencing control 230 when carrier bed 62' has been elevated to a maximum height, whereat the top surface 72' of connector nest 72 comes in contact with wires 40 (FIG. 4b). Thereupon, energization of elevator 94 is discontinued by control 230 which then initiates independent movement of lower wire clamp 202 until it also contacts wires 40, which are maintained at their level of wire feed set by wire guide 162 (FIG. 4c). At this point control 230 can initiate the lowering of wire clamp 214 by energizing actuator 222. Thereafter, as indicated in FIG. 4c, travelling wire comb 208 is moved to the left, toward second connector 14, is lowered so as to engage wires 40, and is thereafter retracted past lower wire clamp 202.

Upon completion of the wire comb cycle, sequencing control 230 energizes actuator 80, to initiate depression of tooling head 216. As indicated in FIG. 4e, the termination cycle is shown at a time just after contact of upper and lower wire clamp members 200, 202. The lefthand edge 76c of wire cutting and insert blades 76 has just engaged a cooperating edge 72c of connector nest 72 so as to sever wires 40. Also, sequencing control 230 relieves back pressure on solenoid 85, to allow lower wire clamp 202 to be fully depressed by the downwardly moving wire clamp 200. Upon maximum downward extension of the upper module, as indicated by sensors located within solenoid 85, sequencing control 230 deenergizes solenoid 80 at a point where cut-off and insertion blades 212 have fully seated the newly formed wire segments in the terminals of the second connector 14. Immediately prior to the termination shown in FIG. 4d, wire separators 210 have engaged the freshly cut wire segments to aid in alignment with the terminals of connector 14. Thereafter, as shown in FIG. 4f, sequencing control control 230 initiates raising of upper wire preparation module 68U, by energizing double acting solenoid 80. Simultaneously, or at a convenient time thereafter, sequencing control 230 energizes double acting solenoid 85 to retract lower wire clamp 202, thereby pulling the carrier bed 62', with lower module portion 68L and connector nest 72, below the newly formed free end of supply wires 40. At sometime prior to the step shown in FIG. 4f, elevator 94 is retracted so as to retract the toggle lock mechanism allowing downward movement of carrier bed 62'.

The termination of the second connector 14 forms a double-ended harness ready for ejection from the transport assemblies 50, 52. Referring to FIGS. 1 and 5, ejection arms 100, are extended to overlie the connectors 14, their spring-loaded pawls 184 being retractable as they are passed over the connector housings. As pawls 184 clear the remote end of connectors 14, ejection arms 100 reverse direction and pawls 184 pull connectors 14 onto their respective eject tracks 104, for transport to 90 degree roll-over stations 107 (see FIG. 1).

An example of a roll-over station 107 is shown in FIG. 5a incorporated with an arm 100. In this figure, arm 100 is mounted for reciprocal extension and retraction indicated by arrow 240 under the driving force of actuator 242. In this optional arrangement of roll-over station 107, a second pawl 244 is provided to provide gripping of connector 14. The leading pawl 184 is preferably mounted on an extendable section 246 of eject arm 100, while the second pawl 244 is fixed in a stationary position. After gripping of connector 14 between pawls 184, 244, a motor 250 is energized to drive the gear 252. Actuator 242 and eject arm 100 are rotatably mounted at each end by rotatable supports 254, 256. As indicated, the leading support 254 is rotatably driven by gear 252. Accordingly, connector 14 is rotated 90 degrees in a plane extending perpendicular to eject track 104. Limit switches 260 deenergize motor 250, when the proper angular rotation is achieved. Upon rotation, actuator 242 is again energized to introduce connector 14 to a delivery track 110, which will be explained below with reference to FIG. 8a.

A second roll-over station 170 must be provided for a second connector 14, when a double-ended harness is produced. While a particular roll-over station 170 is shown in FIG. 5a, other arrangements will become apparent to those skilled in the art.

Upon leaving stations 107, connectors 14 are positioned with their mating ends 24 upwardly directed, and wires 12 extending between connectors 14 forming a downward loop, as shown in FIG. 7a.

VI. Alternative Second Modular Transport Assembly

As referred to above, an alternative embodiment of the second modular transport assembly, designated generally at 52', includes wire cutting and stripping tooling, rather than the mass termination tooling referred to above. Referring now to FIGS. 6a to 6e, operation of the cut and strip wire preparation module 122 will be described. As referred to above with reference to FIG. 4, wires 40 have been extended past termination station 58 by the first transport assembly 50, upon its retraction to a point adjacent loading station 54. Thereafter, as shown in FIG. 6a, opposed moving wire comb members 130, 132 are extended toward the wire supply 92. As indicated in FIG. 6b, the wire combs are brought into engagement with each other, and are thereafter retracted to their initial position, being moved toward first transport assembly 50. With this operation, wires 40 have been combed and aligned, ready for cutting and stripping operations. Sensors located in wire combs 130, 132 send a cycle completion signal to sequence control 240, upon returning to their initial position. Thereafter, sequencing control 240 energizes elevator 94, raising

tooling head 246 to engage wires 40, and raising lower wire clamp 248 to also engage wire 40. Tooling head 246 and wire clamp 248 are both contained on a moveable bed 250. Pull down solenoid 256 is in turn fastened to bed 250 to ensure retraction thereof at the proper time.

Sensors located within solenoid 256 indicating full upward extension of tooling head 246 send a signal to sequencing control 240, initiating downward extension of actuator 80' (FIG. 6c). At this time, control 240 energizes actuator 222 lowering wire clamp 214 to press wires 40 against the lower wire preparation module. Cutting blades 124 and stripping blades 126 are thereby lowered for engagement with cutting edge 246c and lower stripping blade 126', respectively. Also, upper wire clamp 249 is brought into engagement with its mating counterpart 248, so as to firmly engage wires 40. Upon the full downward extension of actuator 80', a signal is sent to sequencing control 240 to initiate the rightward extension of actuator 128. This action moves wire clamps 248, 249 toward the right, away from stripping blades 126, 126', to effectively strip the newly formed free ends of the harness wires, as indicated in FIG. 6e.

VII. Polarizing Peg Removal Station

Turning now to FIG. 7, connectors 14 are located at a peg removal station 112, whereat knife-like peg-removing blades 118 are lowered to sever selected polarizing pegs 116 from the upper and lower housing surfaces 20, 22, respectively. The pegs 116 have been positioned so as to extend beyond, but not overlie mating edge 24. The positioning of connectors 14, to withstand the force of severing blades 118 is

ensured by delivery track 110. Blades 118 are mounted to a press-like actuator 119 for downward movement across top and bottom connector surfaces 20, 22. Accordingly, it is important that track 110 is more narrow than the body of connector 14, and prevents sideways rocking of that body during peg removal.

VIII. Delivery Track

Referring now to FIG. 8a, the delivery track 110 will be explained in greater detail. Connectors 14 have alignment tabs 260 extending from mating end 24 to form an alignment channel 262 extending therealong. Track 110 has an upper rail member 266 complementarily shaped with channel 262, for a close-fitting reception therein. Track 110 further includes second and third rail members 270, 272 which engage and support the wire receiving end 26 of connector 14 immediately adjacent the top and bottom connector surfaces 20, 22. In effect, lower rails 272, 270 oppose upper rail 266 to form a connector receiving cavity corresponding to the profile of connector 14. With upper rail 266 received in channel 262, and lower rails 270, 272 supporting the opposed end wall 26, the connector is supported by track 110 to prevent rocking movement during the sliding travel of the connector therealong. The rocking movement referred to occurs a plane extending along the track, as well as the two directions mutually perpendicular thereto.

IX. Web Removal Station

Referring now to FIG. 8, connectors 14 are slid along track 110, for presentation to web removal station 114 which includes a

predetermined plurality of web removing blades 120. As indicated in FIG. 8b, the web removal blades are lowered into the mating end of connector 14, so as to remove selected web portions 44, to form a plurality of connector modules 46 as indicated by the dotted lines of FIG. 8c. The phantom lines 280 indicate the region of material removed from connector housing 16 by blades 120 corresponding to a web portion 44.

As indicated in FIG. 8c, the particular connector modules 46 formed by blades 120 have a vertically elongated side profile, particularly for a two-circuit connector comprising one upper terminal and one lower terminal. The arrangement of delivery track 110 is particularly advantageous in that it provides reliable sliding transport of the connector module, without rocking about any of its three mutually orthogonal axes, one of which lies in the direction of track 110.

CLAIMS:

1. A method of producing a double-ended electrical cable harness, by mass terminating the first ends of a plurality of double-ended insulation-clad wires to a connector having a plurality of insulation displacement terminals, including the steps of:

loading a connector onto a first transport assembly (50),

feeding and measuring wires so that the first ends thereof are positioned adjacent said connector,

terminating first ends of said wires to said connector to form a first finished end of said harness,

characterised by:

removably mounting one of a plurality of different selectively actuable harness finishing modules to a second transport assembly (52);

moving said second transport assembly adjacent said second wire ends; and

actuating said one module to simultaneously finish the second wire ends to form a second finished harness end.

2. The method of claim 1 including:

feeding the wires along a first level so that the first ends thereof are located at a predetermined position;

loading said connector to said first transport assembly (50) at a second lower level;

moving said first transport assembly along said second level to the predetermined position adjacent said first wire ends; and

elevating at least a portion of said first transport assembly so that said connector loaded thereon is placed immediately under said wires, so as to position said first wire ends for mass termination to said connector.

3. The method of claim 2 including:

moving said second transport assembly (52) along said second lower level to a position adjacent said second wire ends; and

elevating a portion of said second transport assembly to position said one harness finishing module immediately adjacent said wires, in association therewith for finishing said second wire ends upon preparation for actuation of said module.

4. The method of any preceding claim wherein:

said one harness finishing module comprises an arrangement for mass terminating the second

ends of said wires to a second connector having a plurality of insulation displacement terminals, to form the second finished end of said harness,

said one and said second connectors each have an integrally formed housing with opposed top and bottom surfaces extending in the axial direction between opposed forward mating and rearward end walls and at least two rows of axially extending terminal receiving cavities, said rows of cavities stacked one on top of the other in a staggered fashion so that the cavities of one row are positioned between the cavities of the other row, each cavity having an upwardly facing wire receiving slot opening to said top housing surface, so that all of said wires can be inserted for termination from said top housing surface,

the method including

loading said one and said second connectors onto said first and second wire preparation modules, respectively, so that the top connector surfaces of each connector are maintained facing the same direction during termination; and

terminating respective wire ends to the rows of each respective connector, simultaneously.

5. The method of claim 4 including:

rotating said one and said second connectors upon termination thereof, so that the forward mating ends thereof are upwardly directed, with the wires of said harness extending between said connectors forming a downwardly extending loop; and

transporting said harness to a remote work station by sliding the rearward end walls of said connectors along respective first and second transport tracks, each having slotted openings for receiving said wires.

6. A multi-station apparatus for producing a double-ended electrical cable harness by mass terminating the first ends of a plurality of double-ended insulation-clad wires, to a connector having a plurality of insulation displacement terminals, including

a connector transport assembly (50) for receiving and moving the connector between stations,

means for loading the connector onto said connector transport assembly,

wire feeding means for feeding and measuring the wires so that the first ends thereof are associated with the connector,

wire termination means for terminating the first ends of the wires to said connector to form

a first finished end of said harness,

characterised by harness finishing means including:

a frame assembly (62) having means for removably mounting one of a plurality of harness finishing modules (68) to said apparatus; and

one of a plurality of different harness finishing modules (68) removably mounted on said frame assembly, said one module having a wire operation station whereat second ends of the wires are simultaneously finished to form a second finished harness end.

7. The apparatus of claim 6 wherein:

said wire operation station includes opposed module portions with a gap (98) therebetween for receiving said second wire ends, said opposed module portions moveable toward each other to finish the second ends of the wires, thereby forming the second finished harness end; and

said apparatus further including module elevating means (94) for elevating at least one of said module portions toward said second wire ends to facilitate the finishing thereof.

8. The apparatus of claim 7, wherein

said connector transport assembly includes

a connector nest for receiving the connector, and the wire termination means includes projecting means for engaging and inserting the first ends of the wires into the terminals of the connector when those projecting means are advanced toward the connector nest and

said connector nest is mounted for movement to a position adjacent said module elevating means, and is engaged therewith for movement toward said first wire ends.

9. The apparatus of claim 7 or 8, wherein one of said module portions comprises a wire stripping die block and

the other module portion comprises wire stripping blades movable toward said wire stripping die block for cooperation therewith to strip the insulation from the second ends of said wires.

10. The apparatus of claim 7, 8 or 9, wherein

one of said module portions includes a connector nest for receiving a second connector having a plurality of insulation displacement terminals;

said other module portion comprises second wire termination means for mass terminating the second end of the wires to said second connector to form the second finished end of said harness; and

means for loading said second connector onto said second connector nest.

11. The apparatus of any of claims 7 to 10, wherein:

said connector has an integrally formed housing with opposed top and bottom surfaces extending between opposed forward mating and rearward end walls and at least two rows of axially extending terminal receiving cavities, said rows of cavities stacked one on top of the other in a staggered fashion so that the cavities of one row are positioned between the cavities of the other row, each cavity having an upwardly facing wire-receiving slot opening to said top housing surface, so that all of said wires can be inserted for termination from said top housing surface;

said loading means operable to load said connector so that said upper surface thereof is maintained in an upwardly facing direction during termination; and

said wire termination means is operable to terminate all of said wire first ends in terminals of respective rows of said connector, simultaneously.

12. The apparatus of claim 11, wherein the housing sidewalls of upper rows act as wire

guides to aid in the passage of wires to lower rows for termination therein, such that all of said wire ends can be inserted for termination from said upper housing surface,

said first wire ends are arranged in a common plane, with every other wire end being alternately terminated to terminals of different rows,

said connector transport assembly includes a connector nest for receiving the connector,

the wire termination means includes projecting means for engaging and inserting the first ends of the wires into the connector terminals when those projecting means are advanced toward the connector nest and

said connector nest is mounted for movement to a position adjacent said module elevating means, and is engageable therewith for movement toward said first wire ends, to cause the connector in said nest to bend the wires to be terminated in a first row with a predetermined upward angular deflection and, the wires to be terminated to the other row to have an equal downwardly directed angular deflection.

13. The apparatus of claim 11, further comprising

means for rotating said connector upon termination thereof, so that the forward mating end thereof is upwardly directed, with the wires of said harness extending in a downward direction,

a first transport track, having a slotted opening for receiving said wires, and surfaces for supporting the rearward end wall of the connector and

means for transporting said harness to a remote station by sliding said connector along said track.

14. The apparatus of claim 13 wherein said connector rows are at least partially joined together by selectively removable web portions to form a plurality of commonly joined separable connector modules, each module including at least one upper row cavity and at least one lower row cavity, and the remote station comprises a web removing station, the apparatus further comprising

means at the web removing station for selectively removing at least one of said webs in said axial direction so as to form a plurality of said connector modules, each connector module comprising a separate connector terminated to a predetermined number of said wires so as to form a separate harness therewith.

15. The apparatus of claim 13 or 14, said connector further including a plurality of locating pegs projecting from said top and bottom surfaces so as to extend beyond but not overlie said mating end wall, and the remote station comprises a peg removal station, the apparatus further comprising

means at said peg removal station for selectively removing at least one of said pegs in said axial direction, immediately adjacent one of said top and bottom surfaces.

16. The apparatus of claim 13, 14 or 15 said connector further including a plurality of aligning tabs extending from said mating end wall to form a channel extending along said mating end wall, and

said transport track includes a first rail complementarily shaped with and receivable in said channel, and second and third spaced-apart rail members opposing said first rail engageable with said connector for supporting said rearward end wall thereof,

whereby said connector is supported by said track to prevent rocking movement during travel therealong.

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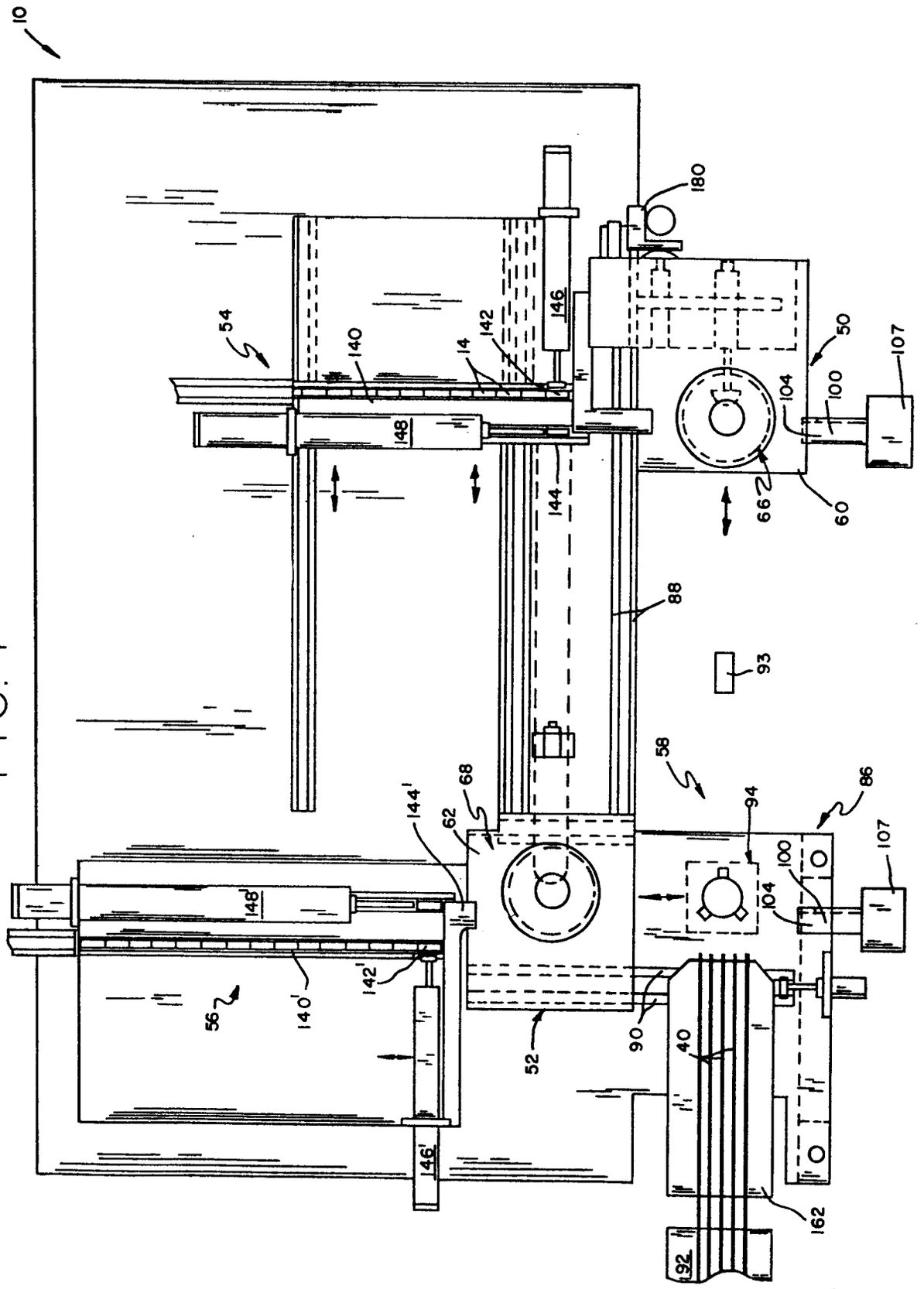
FIG. 1



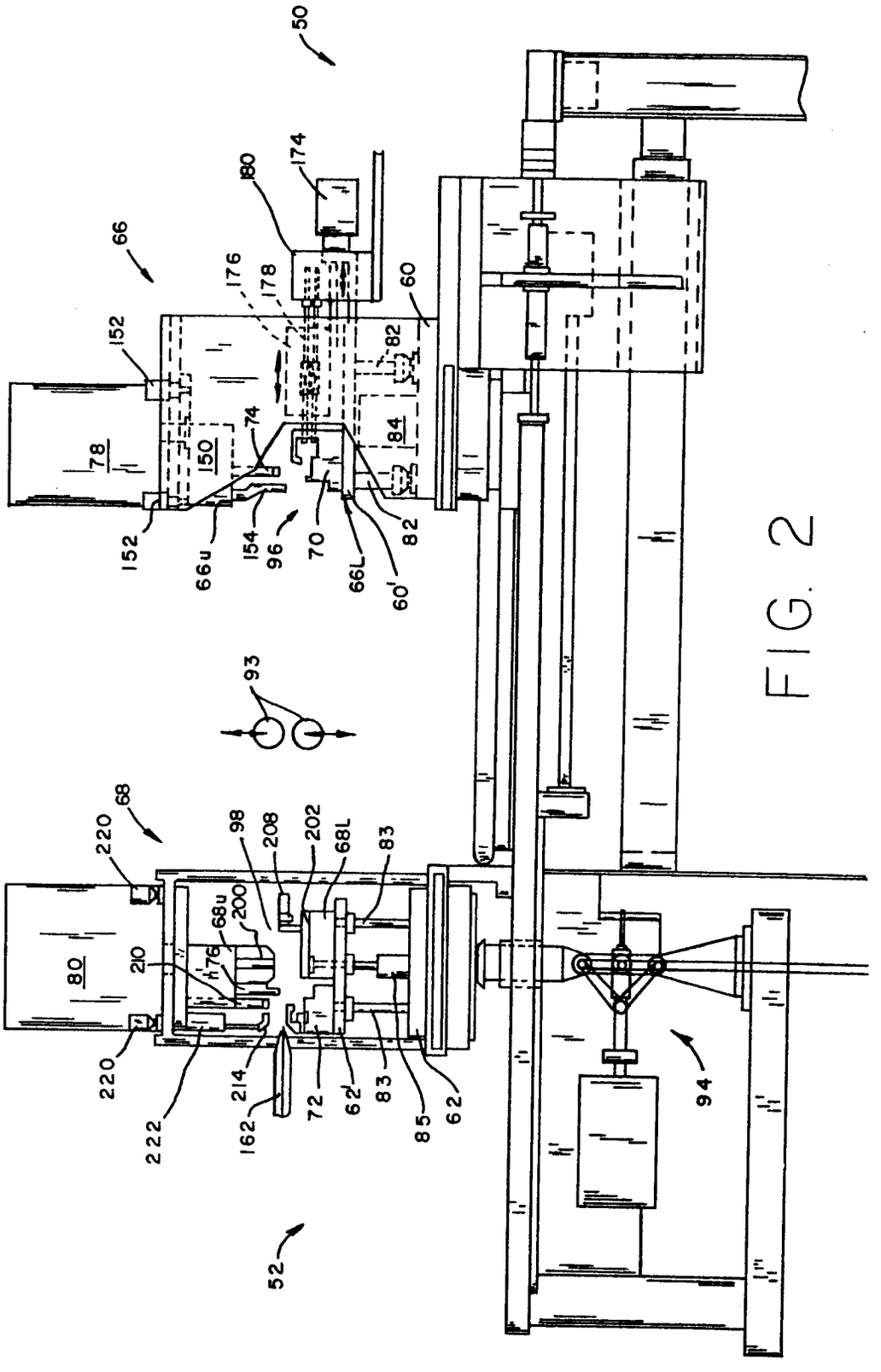

50
66
176
178
180
174
60
152
82
74
84
78
150
152
66u
154
96
70
66L
60'
82
93
68
220
98
208
202
68L
83
200
68u
210
176
80
220
214
72
62'
83
85
62
222
162
52
94

FIG. 2

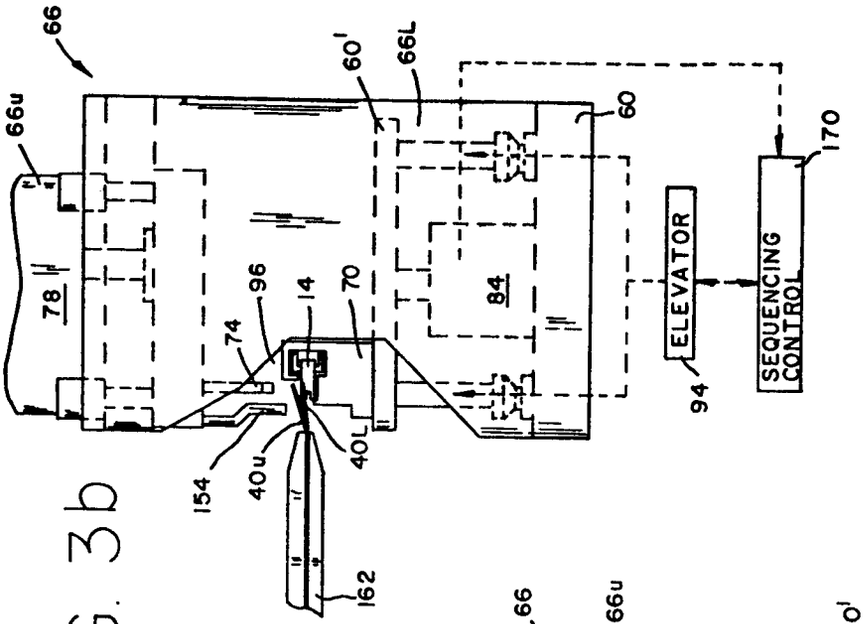


FIG. 3b

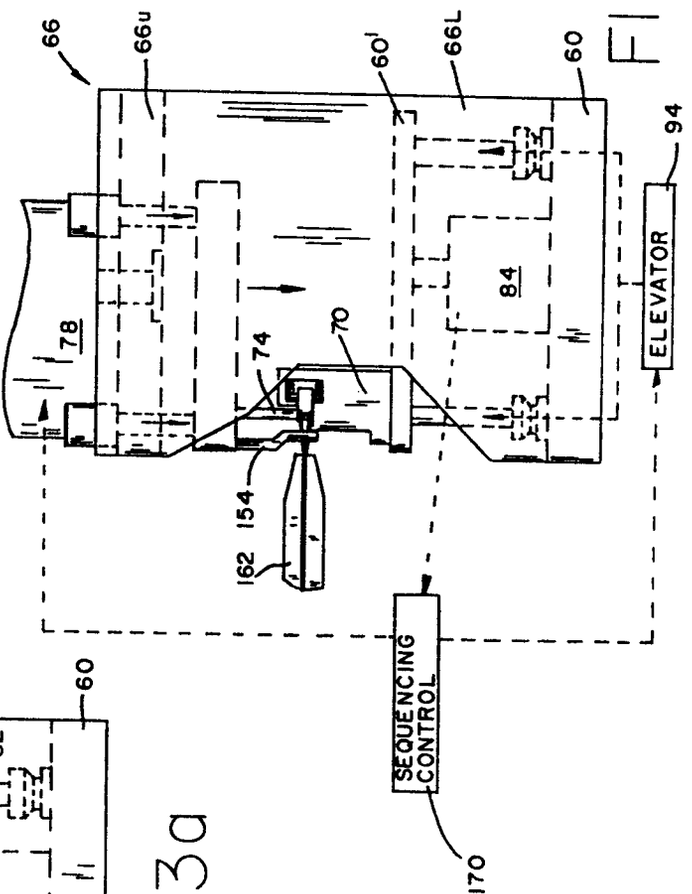


FIG. 3c

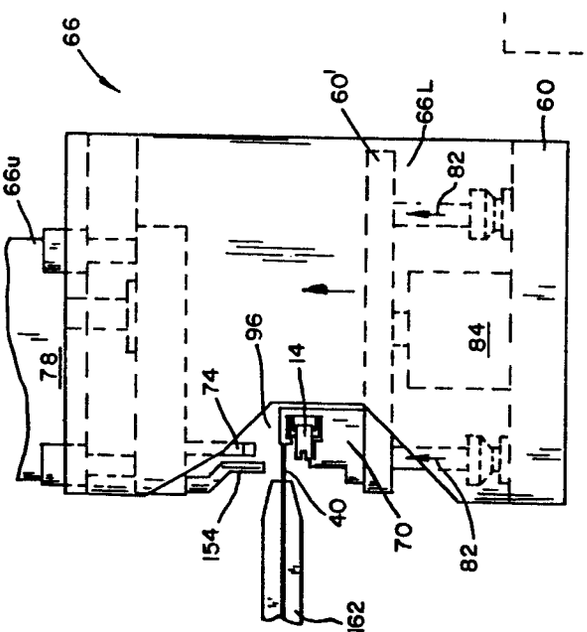


FIG. 3a

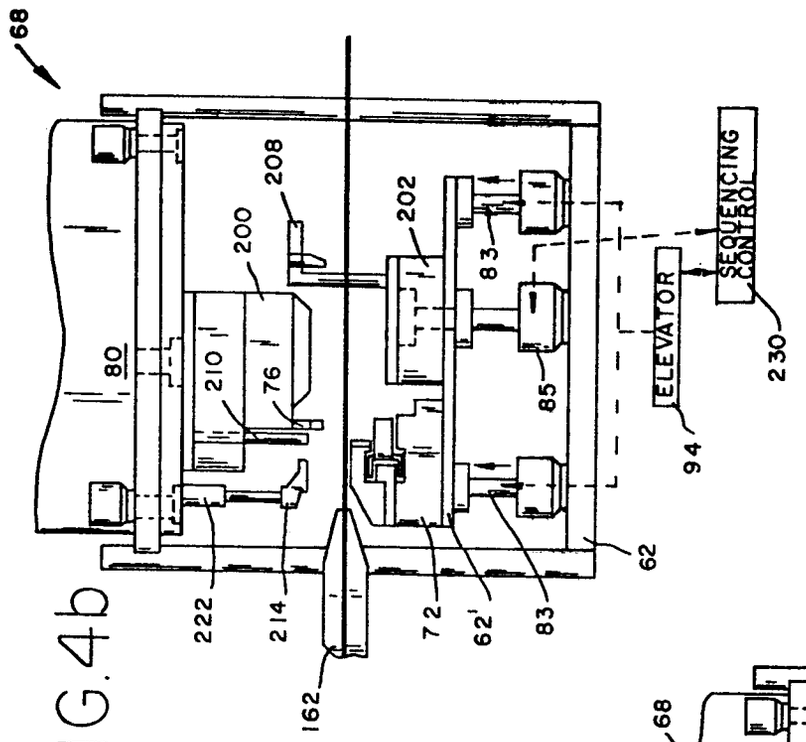


FIG. 4b

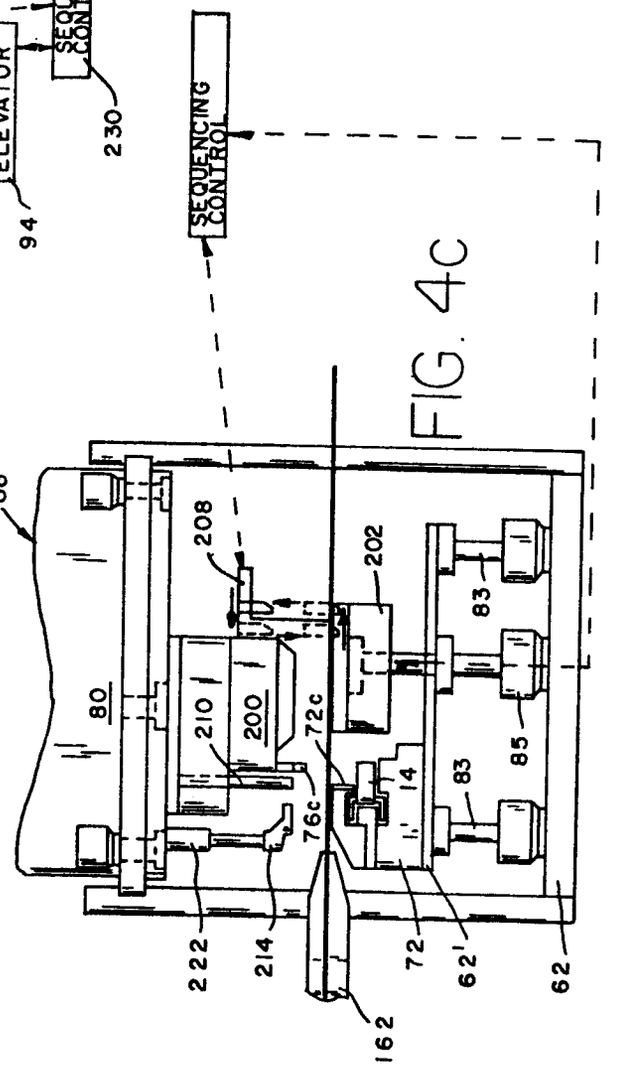


FIG. 4c

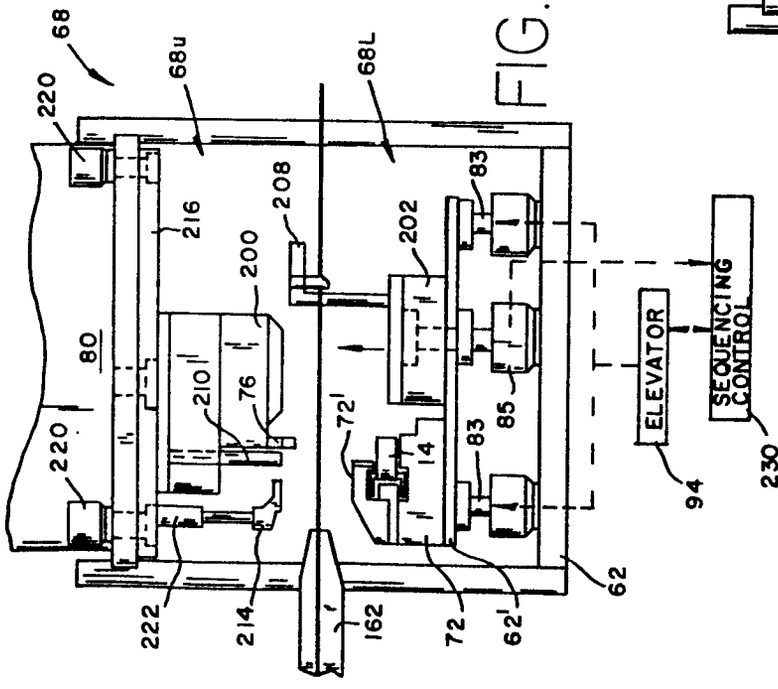


FIG. 4a

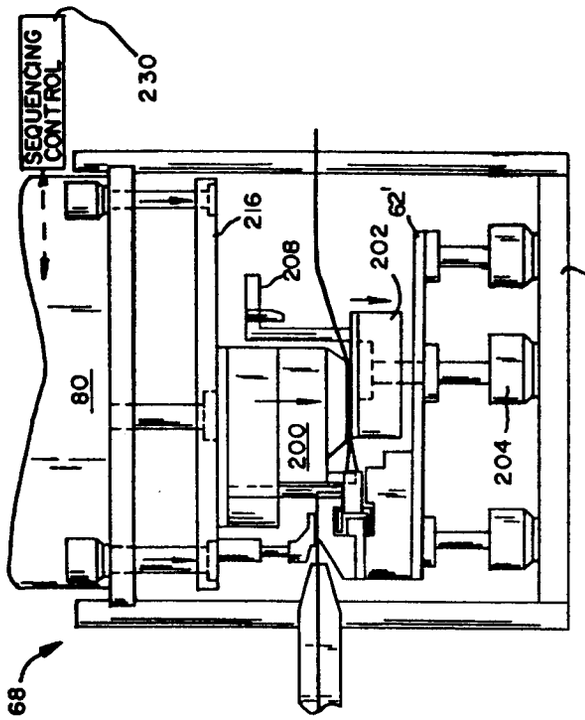


FIG. 4e

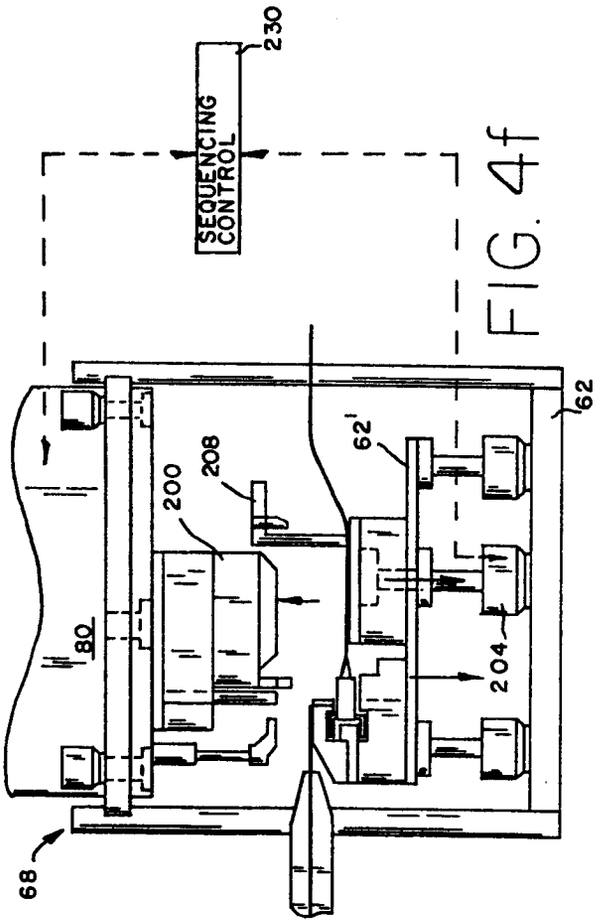


FIG. 4f

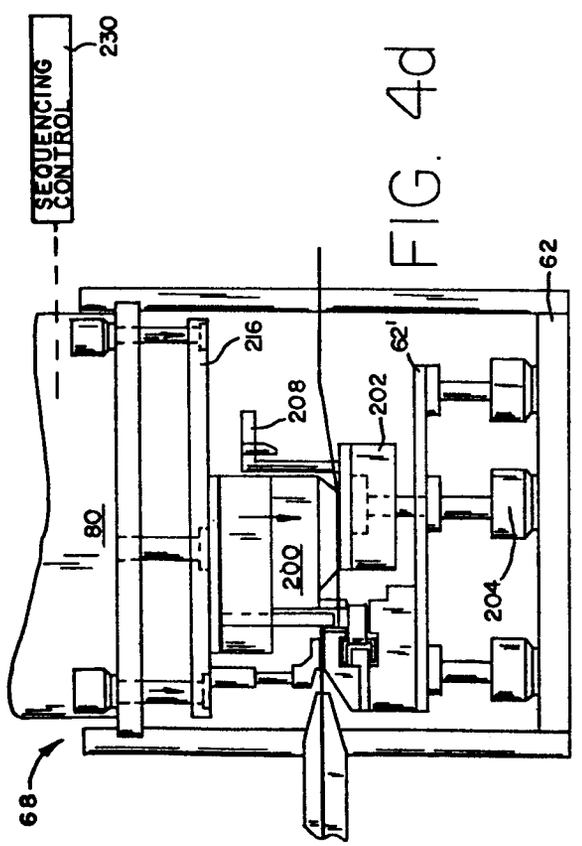


FIG. 4d

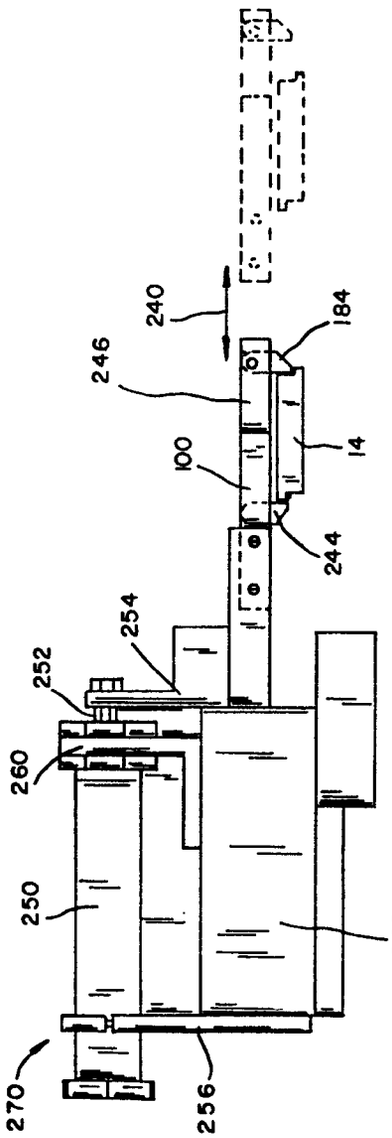


FIG. 5a

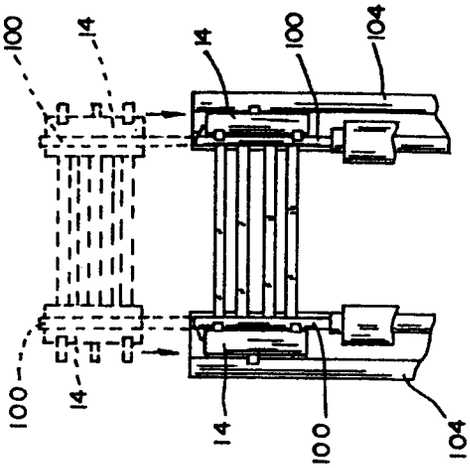


FIG. 5c

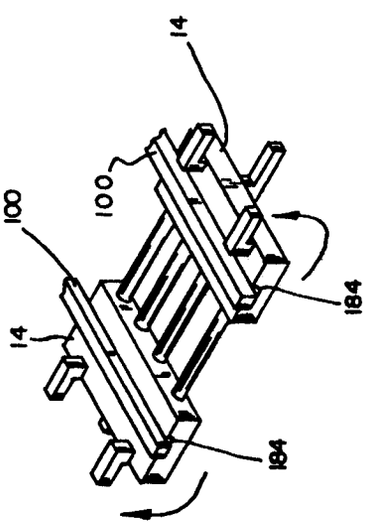


FIG. 5b

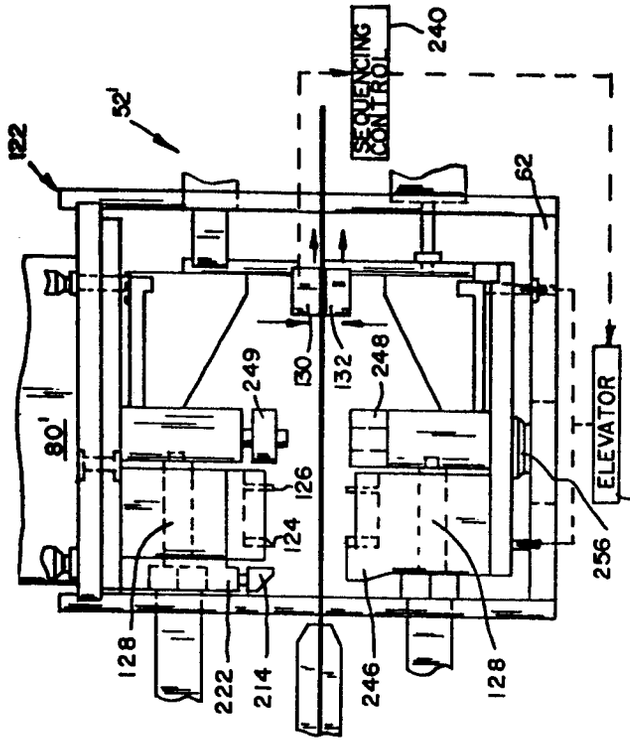


FIG. 6b

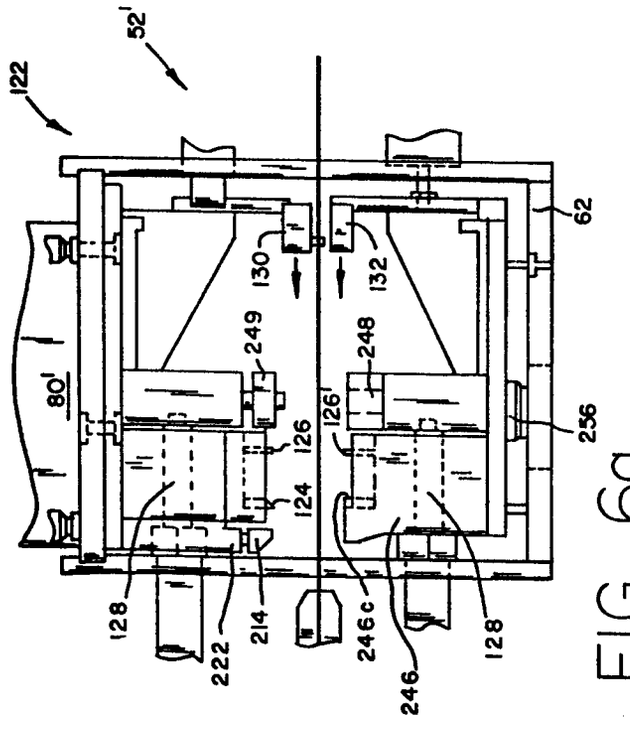


FIG. 6a

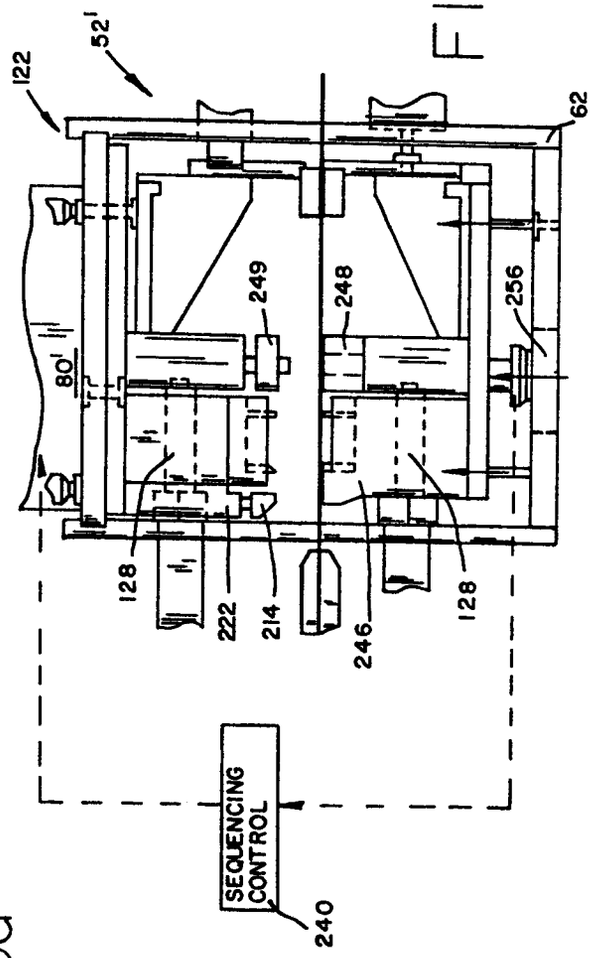


FIG. 6c

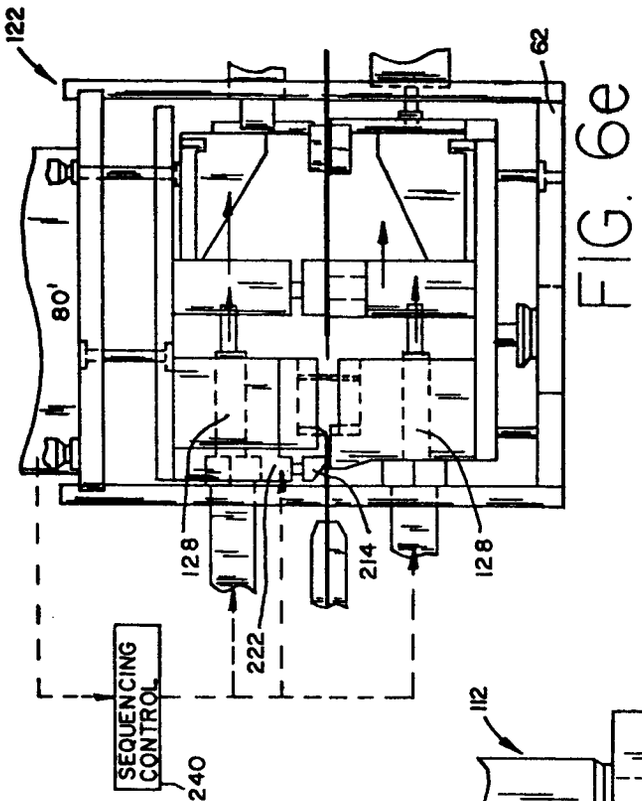


FIG. 6e

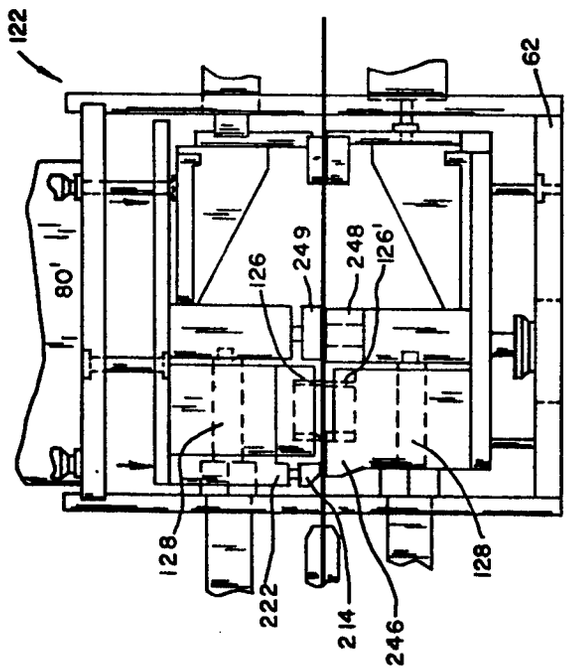


FIG. 6d

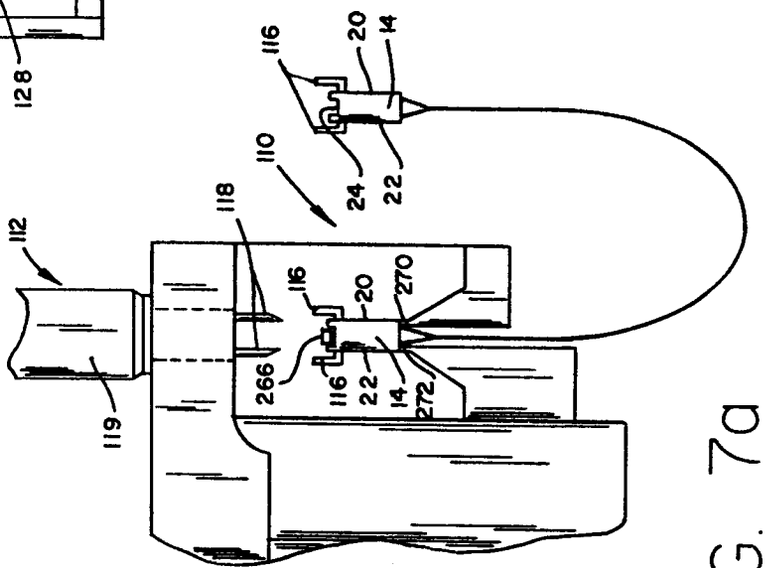


FIG. 7a

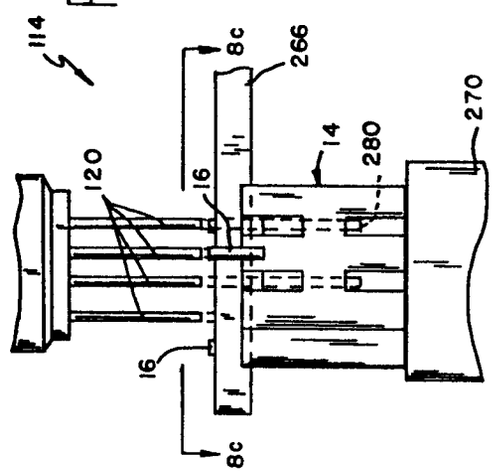


FIG. 8b

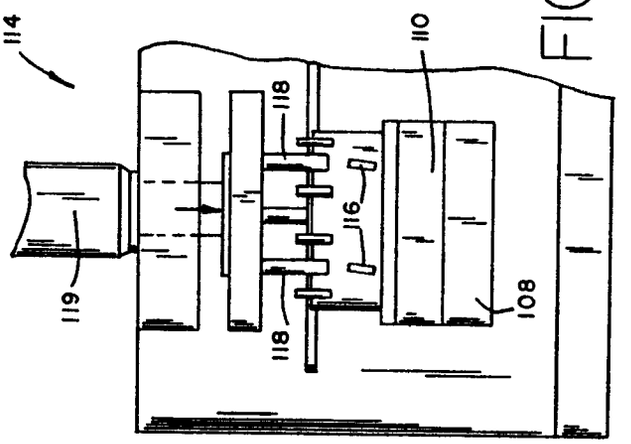


FIG. 7b

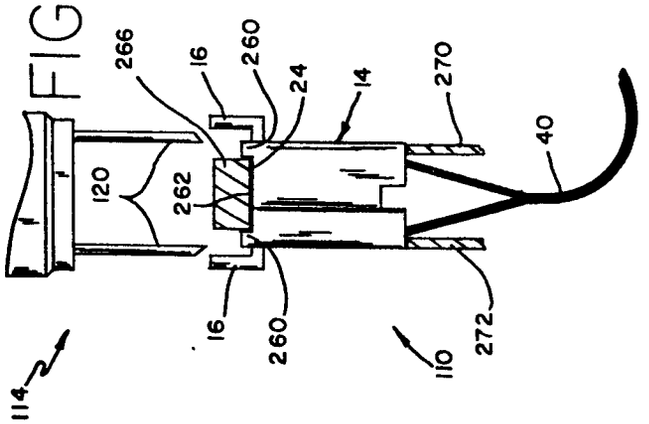


FIG. 8a

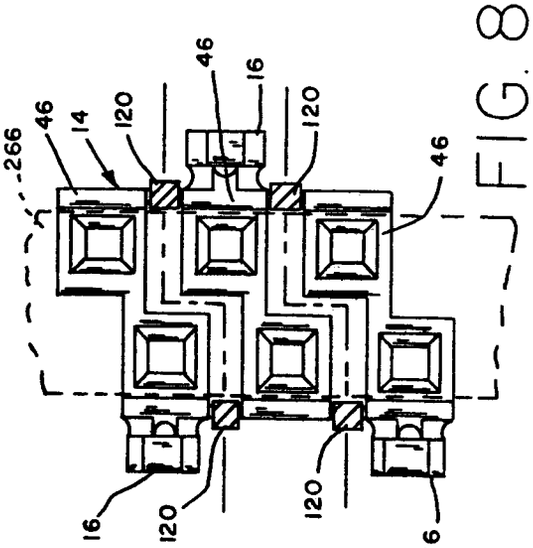


FIG. 8c

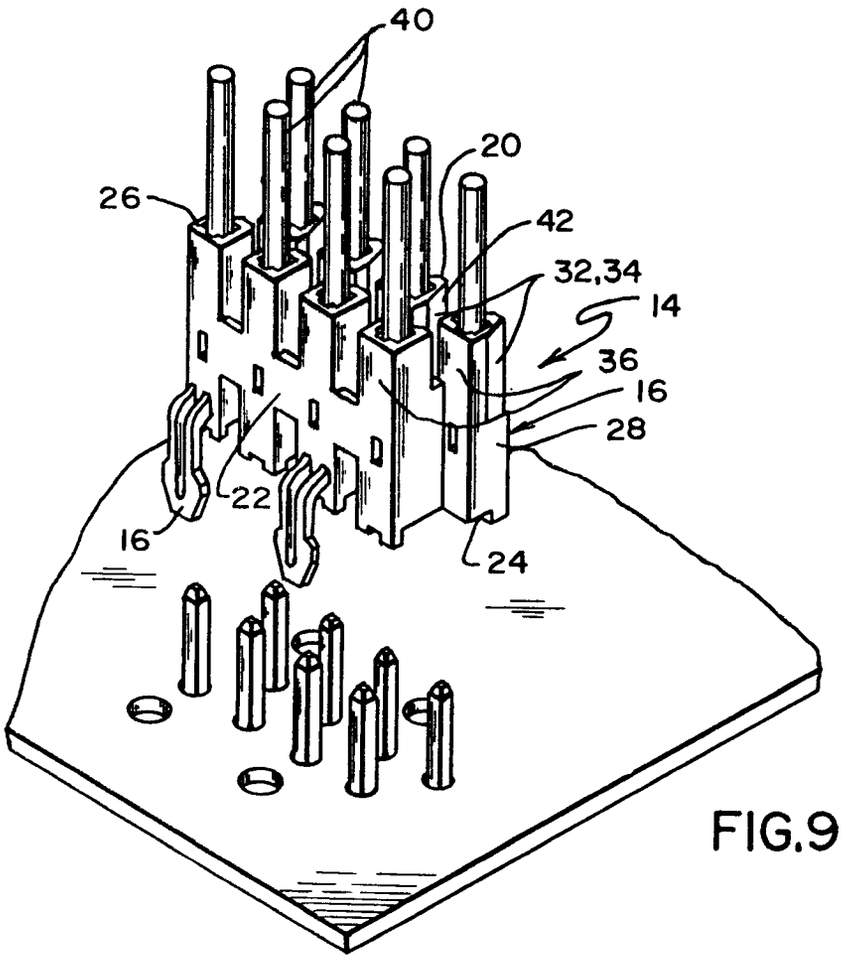

40
20
26
42
32,34
14
36
16
28
22
16
24

FIG.9a

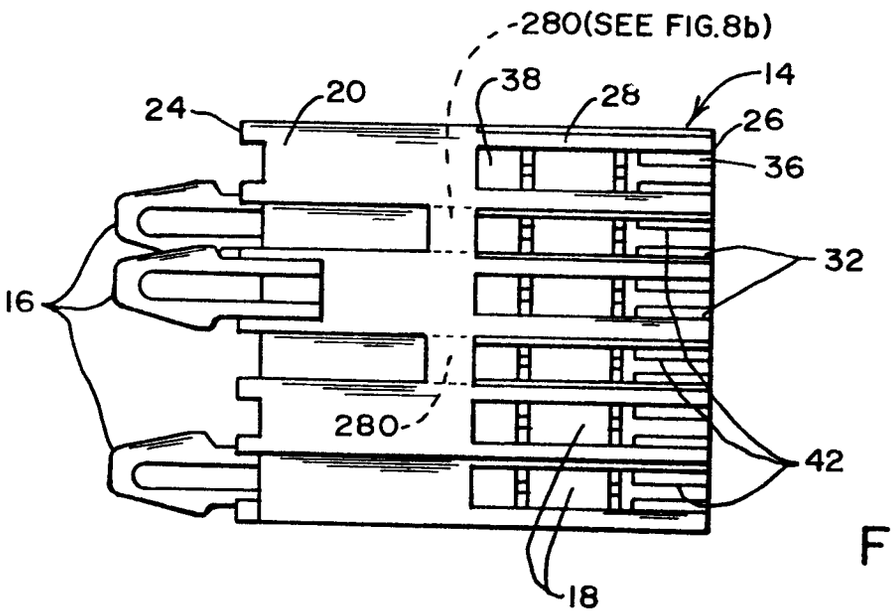

280(SEE FIG.8b)
38
14
24
20
28
26
36
32
16
280
42
18

FIG.9b

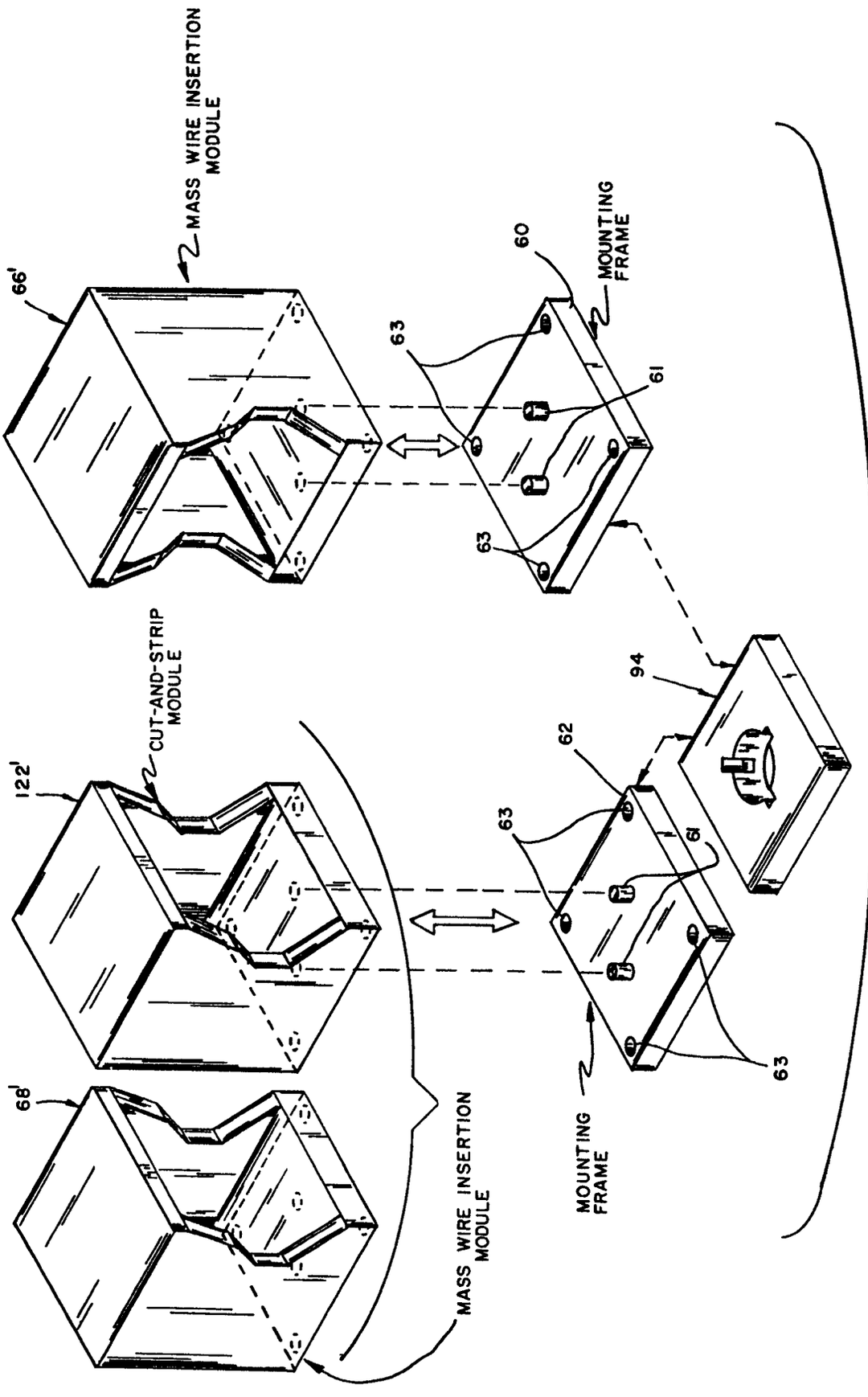

MASS WIRE INSERTION MODULE
66'
60
MOUNTING FRAME
63
61
63
CUT-AND-STRIP MODULE
122'
94
62
63
61
68'
MASS WIRE INSERTION MODULE
MOUNTING FRAME
63

FIG. 10

European Patent Office

EUROPEAN SEARCH REPORT

0216464
Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 86305723.8

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	AT - E - 6 181 (AMP) * Fig. 1 * --	1,6	H 01 R 43/00
A	AT - E - 5 287 (AMP) * Fig. 1; claim 1 * --	1	
A	AT - E - 9 423 (AMP) * Totality * --	1	
D,A	US - A - 4 235 015 (FUNCIK) * Fig. 1 * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

H 01 R 43/00
H 01 B 13/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	15-10-1986	SCHMIDT

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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