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## (54) Apparatus for, and a method of, inserting electrical terminals into an electrical connector housing.

(57) Apparatus for, and a method of, inserting electrical terminals into an electrical connector housing.

The apparatus comprises a terminal rotation member (30) which is movable towards and away from a terminal insertion unit (50) having jaws (75) which pick up a wire (1 or 1') from the terminal rotation member (30) when that member is adjacent to the terminal insertion unit (50) and insert a terminal (3 or 3') on the wire (1 or 1') into a cavity in a connector housing (5) on a housing positioning unit (10).

For inserting the terminals (3 and 3') in pairs of oppositely oriented terminals (3 and 3') into the cavities of the housing (5), the rotation member (30) rotates one terminal (3) in a first sense about the axis of its wire (1) and the next following terminal (3') in the opposite sense about such axis, as the rotation member (30) is moved towards the terminal insertion unit (50).

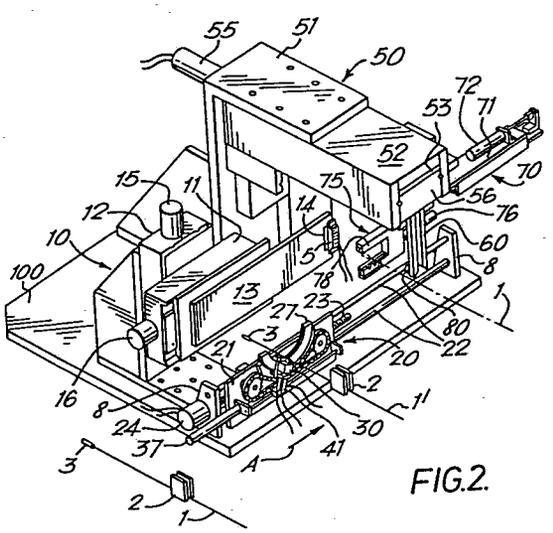


FIG.2.

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Apparatus for, and a method of, inserting electrical terminals into an electrical connector housing.

There is described in US-A-4,055,889 and US-A-4,087,908, apparatus for inserting electrical terminals connected to a wire, into respective cavities in an electrical connector housing, the apparatus comprising a housing positioning unit arranged to locate the housing in a predetermined terminal receiving position; a terminal insertion unit arranged to insert each terminal into its respective cavity in the housing, when the housing is located in its predetermined position; a terminal rotation member arranged to rotate each terminal prior to its insertion into its respective cavity, the terminal rotation member being movable towards and away from the terminal insertion unit, and means arranged to transfer each rotated terminal from the terminal rotation member to the terminal insertion unit.

In this known apparatus, the wires to which the terminals are connected are rotated from a position in which they extend at an acute angle relative to a horizontal plane, to a position in which they extend vertically so as to be aligned with their respective cavities. When the terminals have been inserted into their cavities, each terminal is in the same angular position as the remaining terminals about the longitudinal axis of the wire to which the terminal is connected.

The present invention is directed to the

problem of inserting terminals into cavities in a housing, for example, that of a printed circuit edge connector, in such a way that the terminals are arranged in pairs of oppositely oriented terminals.

According to one aspect of the invention, apparatus as defined in the first paragraph of this specification is characterised in that, the terminal rotation member is arranged to rotate a first terminal in one sense about the longitudinal axis of the wire to which the terminal is connected, in respect of a first traverse of the terminal rotation member towards the terminal insertion unit and to rotate a second terminal in the opposite sense about such axis in respect of a subsequent traverse of the terminal rotation member towards the terminal insertion unit, so that the first and second terminals are inserted into their cavities in oppositely oriented relationship.

According to another aspect of the invention, a method of inserting elongate electrical terminals into respective cavities in an electrical connector housing, comprising the steps of supplying respective terminals to terminal rotation means at a terminal receiving position thereof, operating the terminal rotation means to rotate each terminal, in the course of moving the terminal rotation means from its terminal receiving position, towards the housing and transferring each terminal from the terminal rotation means into a respective cavity on the housing; is characterised in that a first terminal is rotated by the terminal rotation means by $90^{o}$ about the longitudinal axis of the first terminal, in a first sense, and is transferred into the cavity whilst returning the terminal rotation means to its terminal receiving position; and a second terminal

is then supplied to the terminal rotating means, which is operated to rotate the second terminal through 90° about its longitudinal axis in a second sense opposite to the first sense, whilst moving the terminal rotating means towards the housing, and the second terminal is then transferred from the terminal rotating means into a second cavity in the housing, whereby the second terminal is oppositely angularly positioned in the housing with respect to the first terminal.

The invention can readily be applied to a harness making machine for producing wired printed circuit edge connectors, the terminals being crimped to the wires at a crimping station of the machine and being supplied to the terminal insertion apparatus by means of a wire conveyor. To this end, the terminal insertion apparatus can be constructed as a modular unit which can be detachably mounted to the harness making machine in place of a conventional terminal insertion apparatus thereof.

For a better understanding of the invention an example of an electrical terminal insertion apparatus embodying the invention will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view illustrating the manner in which the apparatus is arranged to insert electrical terminals crimped to wires, into cavities in an insulating housing;

Figure 2 is a diagrammatic, perspective view of the apparatus;

Figure 3 is a diagrammatic, elevational view of a terminal rotation unit of the apparatus, the unit comprising a wire clamp;

Figure 4 is a view taken on the lines IV - IV

of Figure 3;

Figures 5a to 5e are diagrams illustrating successive stages in the operation of the terminal rotation unit;

Figure 6 is an elevational view of the wire clamp shown partly in section;

Figure 7 is a partly schematic elevational view, shown mainly in vertical section, of a terminal insertion unit of the apparatus;

Figure 8 is a diagrammatic sectional view of a terminal positioning sub-unit of the terminal insertion unit;

Figure 8a is a diagram illustrating an aspect of the operation of the terminal positioning sub-unit;

Figures 9a and 9b are fragmentary, perspective views illustrating successive initial stages in the operation of terminal insertion jaws of the terminal insertion unit; and

Figures 10a to 10d are fragmentary, perspective views illustrating successive further, and final stages in the operation of the terminal insertion jaws, Figures 10a to 10c also showing terminal positioning arms of the terminal positioning sub-unit in co-operation with the terminal insertion jaws.

The apparatus to be described is, as illustrated in Figure 1, for inserting electrical terminals 3 into through cavities 5' in an insulating housing 5 of a printed circuit board edge connector. Each terminal 3, which has been connected by crimping to a wire 1 or 1', comprises a contact spring 3' which projects laterally from one side of the terminal 3.

As shown in Figure 1, the cavities 5' are arranged in pairs of cavities juxtaposed transversely of the housing 5, one cavity of each pair 5' being disposed on each side of a printed circuit board

receiving channel 5'' of the housing 5. In order to enable the contact springs 3' of a pair of terminals 3 inserted into the cavities 5' of a pair, to contact opposite sides of a printed circuit board (not shown) inserted into the channel 5'', the cavities 5' are such that terminals 3 can only be inserted into a pair of cavities 5' with the contact springs 3' of these terminals facing one another. The apparatus to be described is arranged to take each of a plurality of terminals 3 supplied to the apparatus, and to insert it into an individual cavity 5', after rotating the terminal through 90° about the longitudinal axis of its wire 1 to 1', correctly to orient the terminal 3 for insertion into its cavity 5'. The apparatus is accordingly arranged oppositely to rotate the terminals 3 to be inserted into the cavities 5' of each pair, as shown in Figure 1, prior to inserting these terminals into their individual cavities 5'.

The apparatus will now be described in outline with reference to Figure 2.

The apparatus comprises a base plate 100 on which are mounted; a housing positioning unit 10 for locating each connector housing 5 into which terminals 3 are to be inserted, at a predetermined terminal receiving position; a terminal rotation unit 20 for rotating, as described above, each terminal 3, which has been conveyed to the apparatus from a crimping station (not shown); and a terminal insertion unit 50 for inserting each terminal 3 into one of the cavities 5' after the terminal has been rotated through 90° by means of the unit 20.

The housing positioning unit 10 includes X-Y positioning tables 11 and 12 which are relatively movable at right angles to one another, by means of

electrical stepping motors 15 and 16, respectively, a housing support plate 13 connected to the table 11, and a housing holder 14 secured to the plate 13 and in which a housing 5 can be releasably engaged. In practice, a row of holders 14 extending longitudinally of the plate 13' is provided.

The terminal rotation unit 20 comprises a slide plate constituting a carriage 21 which is mounted to slide along horizontal guide rods 22 supported by brackets 8 on the base plate 100. The carriage 21 is provided, on its rear face, with a tapped eye (not shown) through which extends a screw threaded rod 23 which is connected to, and is intermittently rotatable by means of an electric motor 24 carried by one of the brackets 8, to move the carriage 21 along the guide rods 22. The carriage 21 is arranged to dwell at a terminal pick-up first position at which it receives, by means described below, a wire 1 or 1' to which a terminal 3 has previously been crimped. The carriage 21 is then moved to a terminal transfer second dwell position at which the wire, after the terminal 3 has been rotated through 90° on the carriage 21 (by means described below), is seized by terminal insertion jaws 60 of the insertion unit 50 which insert the terminal 3 into its individual cavity 5' with the aid of terminal gripping arms 78 of a terminal positioning sub-unit 70 of the unit 50, as described below.

The apparatus will now be described in detail.

As shown in Figures 3 and 4, the terminal rotation unit 20 comprises a block 25 secured to the carriage 21 and having formed integrally therewith a guide sector 27 having upper and lower V-section arcuate grooves 26 in which rotatably engage three rollers 28 (Figure 3) journalled in a block 29 which

is thereby movable along the sector shaped track defined by the grooves 26. A terminal rotation member in the form of a swingable, finger-shaped wire clamp 30 described in detail below with reference to Figure 6 and shown only schematically in Figures 2 and 4, is fixed to the side of the block 29 remote from the block 25. An endless chain 33 is engaged about two horizontally spaced sprocket wheels 32 rotatably supported by the carriage 21, and about the sector-shaped under side of a chain guide 34 depending from the block 25 as shown in Figure 4.

The chain 33 is connected to the block 29 by means of a bracket 31 (Figure 4) and to a slide block 36 by means of an attachment 35. The slide block 36 is drivable in reciprocating motion along a guide rod 38 by means of a pneumatic piston-and-cylinder device 37, to rotate the sprocket wheels 32 so as to swing the clamp wire 30 through a predetermined angle about the sector 27. When the slide block 36 is moved from one to another of its end positions, the wire clamp 30 is swung through $90^{o}$.

As shown in Figure 6, the wire clamp 30 includes a main, fixed clamp member 40 arranged to be driven in intermittent reciprocating axial movement in a support block 39, by means of a pneumatic piston-and-cylinder device 41, and a smaller, movable clamp member 42 having a clamping nose 49. The member 42 is pivotable, by means of a pneumatic piston-and-cylinder device 44, about a pin 46, in a clockwise (as seen in Figure 6) sense to clamp a wire when such is received therein in a recess 45 in the free end of the member 40, and in the opposite direction to release the wire from the recess 45.

The terminal insertion unit 50 (shown in detail in Figures 7 and 8) includes an L-shaped support

bracket 51 (Figure 2) secured to the base plate 100, and carrying a frame 52 supporting a slide plate 53. The plate 53 is connected to the piston rod of a pneumatic piston-and-cylinder device 55 by means of a bracket 54. A housing 56 slidably connected to the plate 53 contains a cranked lever 58 pivoted to a cross shaft 57 extending between opposed side walls of the housing 56. One end of the lever 58 is connected to the piston rod 59' of a pneumatic piston-and-cylinder device 59, the other end of the lever 58 being pivotally connected to the terminal insertion jaws 60 which have terminal stuffing projections 80 at their ends remote from the housing 56. The housing 56 has in its left hand (as seen in Figure 7) wall, an adjustable length stop 61 adapted to limit the rotation of the lever 58 in a clockwise (as seen in Figure 7) sense, as the piston rod 59' is retracted, so as to limit the descent of the jaws 60 which are mounted for vertical reciprocating movement relative to the housing 56.

In the vertical position in which they are shown in Figure 7, the jaws 60 are open as shown in Figure 9a. Further retraction of the piston rod 59' after the lever 58 has engaged the stop 61, causes the housing 56 to be retracted leftwardly (as seen in Figure 7) to close the insertion jaws 60 about a wire therebetween to grip it, by virtue of the engagement of the jaws 60 with cam surfaces (not shown) which are fixed relative to the frame 52.

The terminal positioning sub-unit 70 is secured to the slide plate 53 by means of a depending plate 53' and extends transversely of the frame 52, as best seen in Figure 2, being connected to the plate 53' through a slide base 71 (Figure (8). The slide base 71 carries the cylinder of a piston-and-cylinder device 72 for

driving horizontally a slide 73 connected to a slide plate 77 which supports a terminal positioner 75 having a housing 75'. The slide plate 77 is driven horizontally by a piston-and-cylinder device 74 fixed to the slide 73, in turn horizontally to drive the positioner 75 between a first position referenced (a) in Figure 8a and a second position referenced (b) in Figure 8a.

A piston-and-cylinder device 76 is arranged to open and close the terminal gripping arms 78, through a linkage 78'. Each arm 78 has, at its end remote from the housing 75', two recesses 79 and 79' having different configurations, each for receiving a terminal 3 in a different one of the two angular orientations, described above.

The electric motors and the piston-and-cylinder devices mentioned above are automatically operated according to a predetermined programme described below, by means of a conventional pneumatic or electronic control logic system (not shown).

The operation of the apparatus will now be described in detail.

The wires 1 and 1' are intermittently conveyed to the terminal rotation unit 20, one by one, in the direction of the arrow A in Figure 2, by means of pairs of wire clamp jaws 2 (Figure 2) of a conveyor (not shown), from a crimping station (not shown) upstream of the apparatus, at which station, the terminals 3 are crimped to the wires 1.

To receive a wire 1, the carriage 21 of the unit 20 is driven to its first position (Figure 5a) to dwell thereat, the wire clamp 30 having been simultaneously displaced by $45^{\circ}$ by the device 47 in a clockwise (as seen in Figures 5a and 5b) sense with respect to the centre of the guide sector 27 and being stationary.

When a wire 1 gripped by a pair of jaws 2 reaches

a position shown in Figure 5a, in which the wire 1 is located centrally of the sector 27, above the unit 20 and opposite to the recess 45 of the clamp 30, the main clamp member 40 is advanced by means of the device 41 so that the wire 1 is received in the recess 45 (Figure 5b) whereafter the device 44 is actuated to cause the movable clamp member 42 to clamp the wire 1 in the recess 45.

The jaws 2 are then opened to release the wire 1 and the motor 24 is simultaneously run to slide the carriage 21 to its second position (Figure 5c). The device 37 is operated simultaneously with the movement of the carriage 21 to its second position, to move the slide block 36 along the guide rod 38 to cause the chain 33 to rotate the wire clamp 30 in an anticlockwise (as seen in Figures 5a to 5c) sense through $90^{o}$, from its Figure 5a and b position to the position shown in Figure 5c, so that the terminal 3 is rotated about the longitudinal axis of the wire 1 and thus about its own longitudinal axis, through $90^{o}$, also in an anticlockwise sense.

When the carriage 21 has reached its second position, the motor 24 and the device 37 are stopped. The terminal insertion jaws 60 of the unit 50 are now moved downwards and leftwards (as seen in Figure 7) by means of the device 59, so that the jaws 60 are closed about the wire 1, after the lever 58 has engaged the stop 61, at a position just back from the terminal 3; as shown in Figures 9a and 9b. The nose 49 of the movable clamp member 42 is now retracted by operation of the device 44 to release the wire 1 from the recess 45, the main clamp member 40 is retracted (Figure 5d), and the motor 24 is simultaneously run in a reverse direction to return the carriage 21 to its first position, whereby the carriage 21 is positioned to receive the

next wire 1' (Figure 5e), from the next pair of conveyor jaws 2. Whilst the carriage 21 is being returned to its first position, the device 37 is maintained inoperative so that the wire clamp 30 remains in its fully anticlockwise position, as shown in Figure 5e. The main clamp member 40 is advanced again to receive the wire 1', the movable clamp member 42 is operated so that the wire 1' is gripped in the wire clamp 30, and the wire clamp 30 is returned to its Figure 5a position whilst the carriage 21 is being moved to its second position, whereby the terminal 3 on the wire 1' is rotated about its longitudinal axis by 90° in the opposite sense to that in which the terminal on the wire 1 was rotated. The wire 1' is then released from the wire clamp 30 when the jaws 60 have been closed about the wire 1'.

Upon the release of each wire 1 or 1' from the wire clamp 30, the insertion jaws 60 co-operate with the terminal positioner 75 to insert the terminal 3 on the wire 1 or 1' gripped by the jaws 60 into a corresponding cavity 5' of the connector housing 5, during the subsequent return movement of the carriage 21.

When the insertion jaws 60 have gripped a wire 1 or 1', the terminal positioner 75 is driven by the device 74 to bring the positioner 75 into its position (a) or its position (b) in Figure 8a in dependence upon the orientation of the terminal 3. The device 76 is then operated to close the arms 78, so that the crimped portion of the terminal 3 is received in the recesses 79' (Figure 10a) or 79 (Figure 10b), as the case may be of the arms 78. The device 55 is then operated to retract the slide plate 53 leftwardly (as seen in Figure 7) similarly to displace the terminal positioner 75 and the insertion jaws 60, to insert the terminal 3 into its individual cavity 5' of the connector

housing 5, as shown in Figure 10c. As the leading end of the terminal 3 enters the cavity 5', the device 76 is actuated to open the arms 78, and the device 2 is operated to move the slide 73 leftwardly (as seen in Figure 8) to retract the arms 78 from between the jaws 60 and the housing 5, the device 55 being still in operation, so that the jaws 60 fully insert the terminal 3 into the cavity 5' with the aid of the terminal stuffing projections 80 on the jaws 60, as shown in Figure 10d.

Following the terminal insertion operation, the devices 55 and 72 are actuated to return the slide plate 53 and the terminal positioner 75, respectively, to their starting positions and the tables 11 and 12 are shifted to position the housing 5 for the insertion of the next terminal 3 thereinto, whereby a cycle of operation of the apparatus has been completed.

Claims:

1. Apparatus for inserting electrical terminals (3 and 3') connected to a wire (1 or 1'), into respective cavities (5') in an electrical connector housing (5), the apparatus comprising a housing positioning unit (10) arranged to locate the housing (5) in a predetermined terminal receiving position; a terminal insertion unit (50) arranged to insert each terminal (3 and 3') into its respective cavity (5') in the housing (5), when the housing is located in its predetermined position; a terminal rotation member (30) arranged to rotate each terminal (3 or 3') prior to its insertion into its respective cavity (5'), the terminal rotation member (30) being movable towards and away from the terminal insertion unit (50), and means (60) arranged to transfer each rotated terminal from the terminal rotation member (30) to the terminal insertion unit (50), characterised in that the terminal rotation member (30) is arranged to rotate a first terminal (3) in one sense about the longitudinal axis of the wire (1) to which the terminal (3) is connected, in respect of a first traverse of the terminal rotation member (30) towards the terminal insertion unit (50) and to rotate a second terminal (3') in the opposite sense about such axis in respect of a subsequent traverse of the terminal rotation member (30) towards the terminal insertion unit (50), so that the first and second terminals (3 and 3') are inserted into their cavities (5') in oppositely oriented relationship.

2. Apparatus according to Claim 1, characterised in that the terminal rotation member (30) is mounted on a carriage (21) which is movable towards and away from the terminal insertion unit (50), each terminal (3 and 3') being received by the terminal rotation member (30) at the same terminal pick-up

position along the path of travel of the carriage (21) and being transferred to the terminal insertion unit (50) at the same terminal transfer position along the path of travel of the carriage (21).

3. Apparatus according to Claim 2, characterised in that the terminal rotation member (30) is mounted on the carriage (21) to swing about the axis of an arcuate guide surface (27) thereon, and is arranged to be swung in one sense about the axis of the guide surface (27) during the first traverse of the carriage (21) and in the opposite sense about such axis during the subsequent traverse of the carriage (21), the terminal rotation member (30) being stationary with respect to such axis during the intermediate return traverse of the carriage (21) away from the terminal insertion unit (30).

4. Apparatus according to Claim 3, characterised in that the terminal rotation member is in the form of an elongate wire clamp (30) one end (40, 49) of which is adapted releasably to receive a wire (1 or 1') and the other end of which is arranged to follow the arcuate guide surface which is provided by a guide sector (27) secured to the carriage (21), the wire clamp (30) being mounted on a block (29) which is swingable on bearings (26, 28) about the guide sector (27), the wire clamp (30) being driven through a chain (33) and sprocket (32) mechanism, and the carriage (21) being driven by a separate driving device (24).

5. Apparatus according to any one of the preceding claims, characterised in that the terminal transfer means comprises a pair of terminal insertion jaws (60) of the terminal insertion unit (50), which are movable towards and away from the terminal rotation member (30) transversely of the path of travel thereof, and a movable jaw (49) of the terminal rotation member (30), the

terminal insertion jaws (60) being arranged to grasp the wire (1 or 1') to which the terminal (3 or 3') is connected, at a position just back from the terminal (3 or 3'), the movable jaw (49) being adapted to release the wire (1 or 1') to allow the terminal insertion jaws (60) to carry the wire (1 or 1'), with the terminal (3 or 3') thereon, towards the housing (5), to insert the terminal (3 or 3') into the housing (5) with the aid of wire stuffer projections (80) on the terminal insertion jaws (60).

6. Apparatus according to any one of the preceding claims, characterised in that the terminal insertion unit (50) comprises a terminal positioning sub-unit (70) for accurately locating each terminal (3 or 3') in alignment with the cavity (5') into which it is to be inserted by the terminal insertion unit (50), the terminal positioning sub-unit (70) comprising a pair of terminal positioning arms (78) which are closeable about the terminal (3 or 3') and which are movable between a terminal position location between the terminal insertion jaws (60) and the housing (5), and a retracted position to allow the insertion of the terminal (3 or 3') into its cavity (5).

7. Apparatus according to Claim 6, characterised in that terminal positioning arms (78) are provided with two pairs of recesses (79 and 79') each shaped to receive a terminal (3 or 3') in a different angular position about the longitudinal axis of the wire (1 or 1') to which the terminal is connected, the terminal positioning arms (78) being provided with means (74) for moving them between first and second terminal receiving positions, in dependence upon the angular position of a terminal (3 or 3') grasped by the terminal insertions jaws (60).

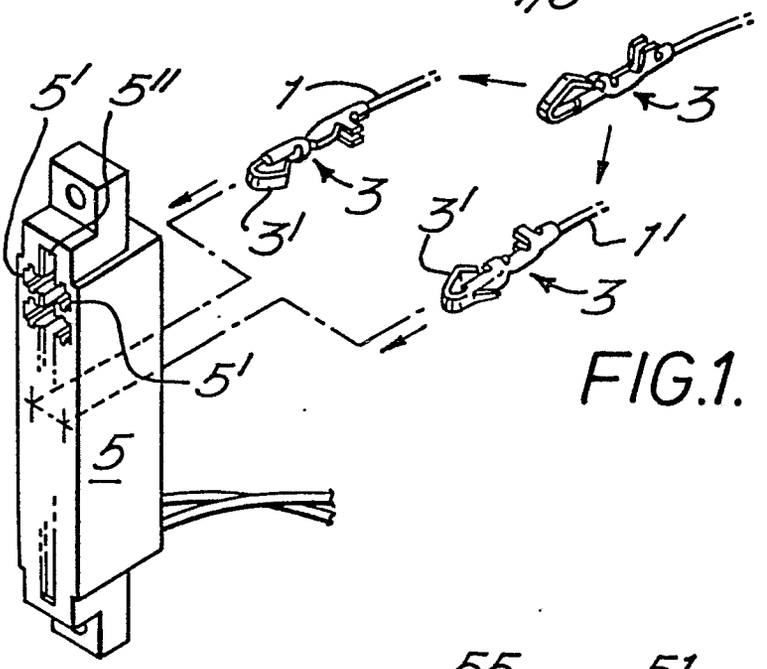
8. Apparatus according to Claim 7,

characterised in that the terminal positioning sub-unit (70) includes a first driving device (76) for opening and closing the terminal positioning arms (78), a second driving device (74) for moving the terminal positioning arms (78) between their first and second terminal receiving positions and a third driving device (72) for moving the terminal positioning arms (78) between their terminal receiving location and their retracted position.

9. Apparatus according to Claim 8, characterised in that the terminal insertion jaws (60) are secured to a first slide (53) which is in turn mounted to a frame (52) fixedly connected to a base plate (100) of the apparatus, the first slide (53) being slidable with respect to a slide base (71) carrying the positioning sub-unit (70), the third driving device (72) being mounted on the slide base (71) and the first and second driving devices (74 and 76) being carried by second and third slides (73 and 77) which are slidable with respect to the slide base (71), and with respect to one another, the first slide (53) being slidable transversely of the path of traverse of the terminal rotation member (30) and the second and third slides (73 and 77) being slidable in a direction parallel to such path.

10. A method of inserting elongate electrical terminals (3 and 3') into respective cavities (5') in an electrical connector housing (5), comprising the steps of supplying respective terminals (3) to terminal rotation means (30) at a terminal receiving position thereof, operating the terminal rotation means (30) to rotate each terminal (3), in the course of moving the terminal rotation means (30) from its terminal receiving position, towards the housing (5) and transferring each terminal (3) from the terminal

rotation means (30) into a respective cavity (5) of the housing (5); characterised in that a first terminal (3) is rotated by the terminal rotation means (30) by 90° about the longitudinal axis of the first terminal (3), in a first sense, and is transferred into the cavity (5') whilst returning the terminal rotation means (30) to its terminal receiving position; and a second terminal (3') is then supplied to the terminal rotating means (30), which is operated to rotate the second terminal (3') through 90° about its longitudinal axis in a second sense opposite to the first sense, whilst moving the terminal rotating means (30) towards the housing (5), the second terminal (3') is then transferred from the terminal rotating means (30) into a second cavity (5') in the housing (5), whereby the second terminal (3') is oppositely angularly positioned in the housing (5) with respect to the first terminal (3).


5'
5''
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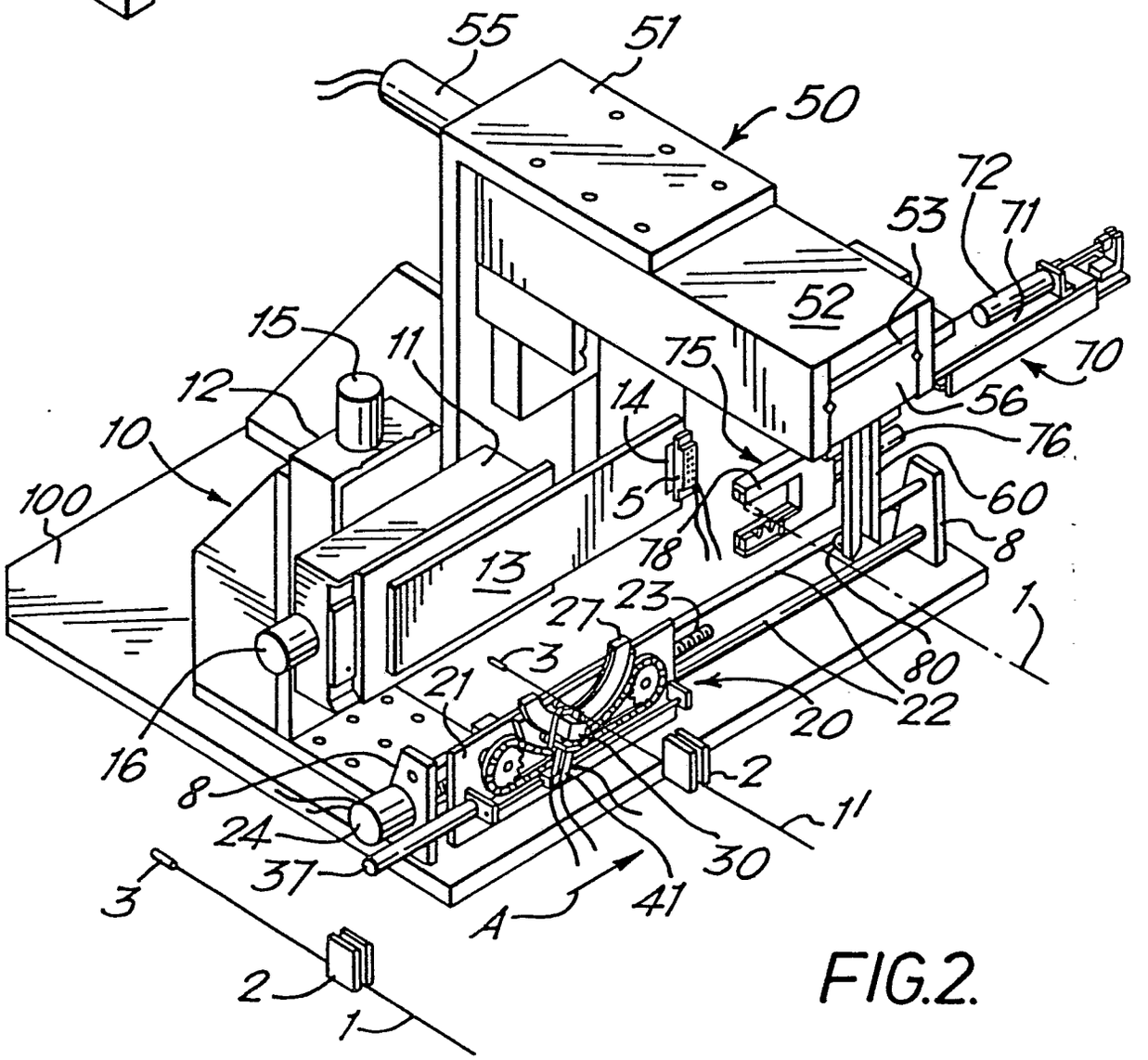
3
3'
1'
5
5'

FIG.1.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13
27
23
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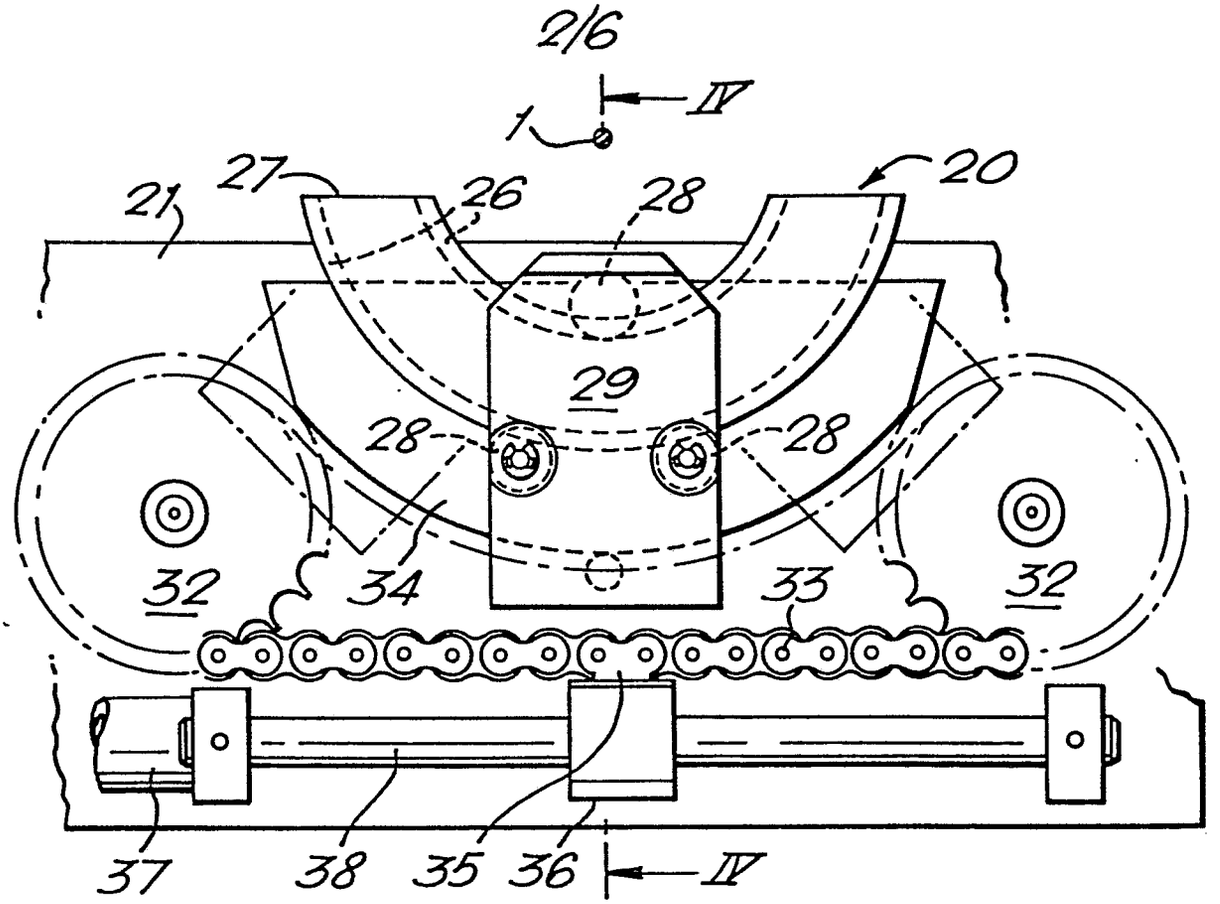
1

FIG.2.


2/6
IV
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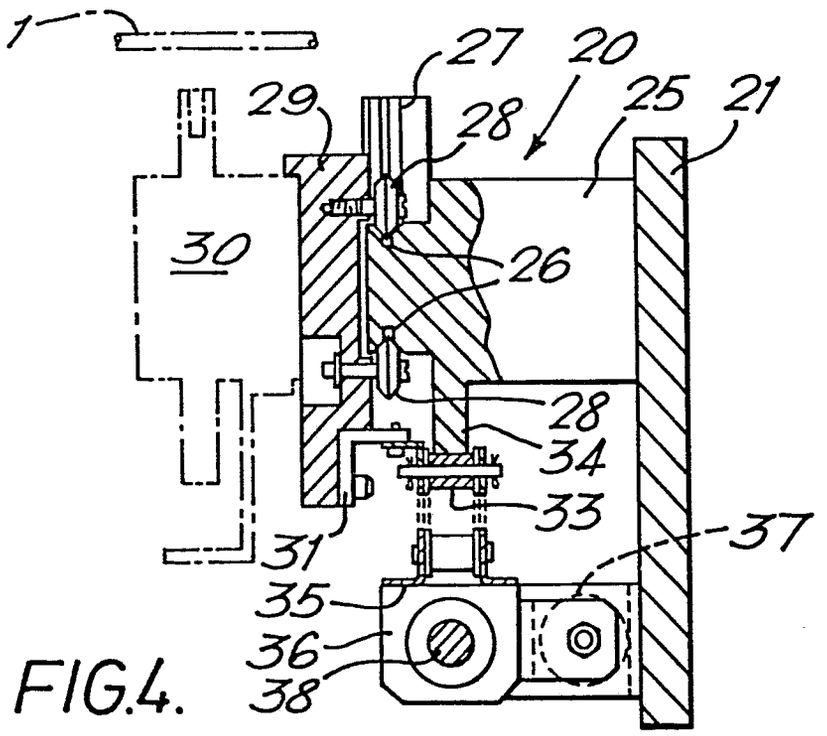
38
35
36
IV

FIG.3.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38

FIG.4.

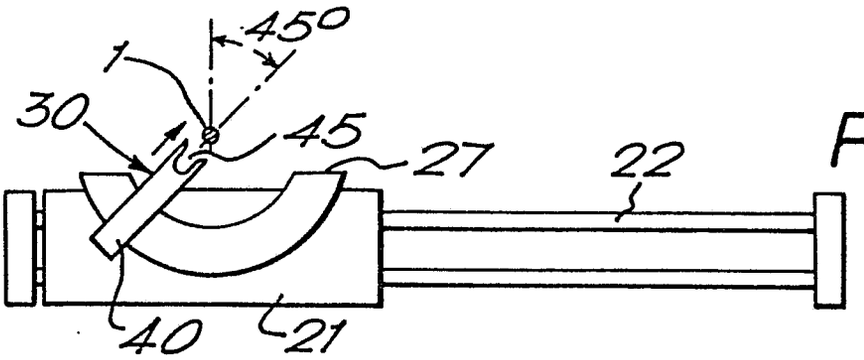



FIG.5a.

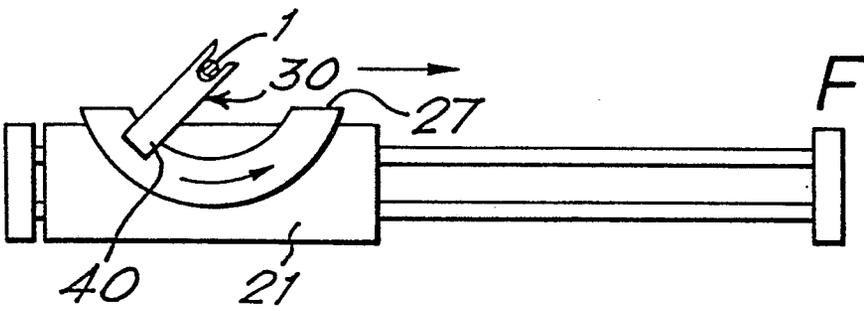



FIG.5b.

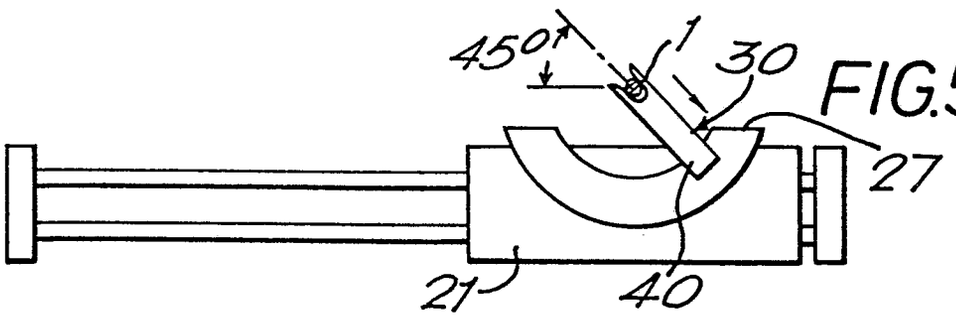



FIG.5c.

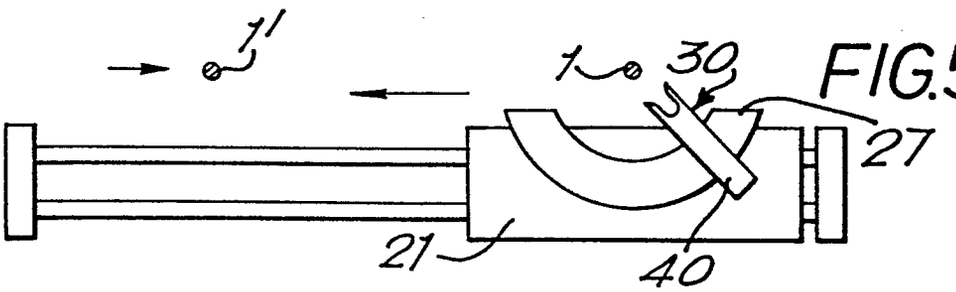



FIG.5d.

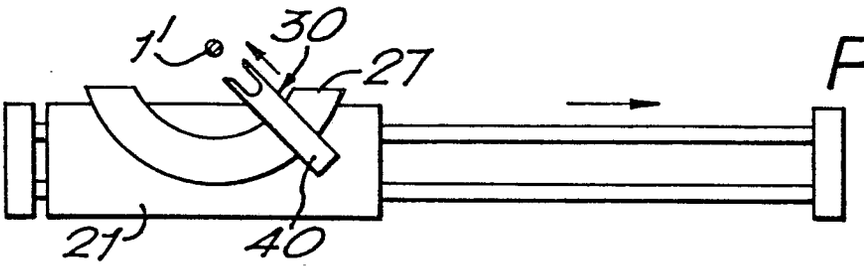
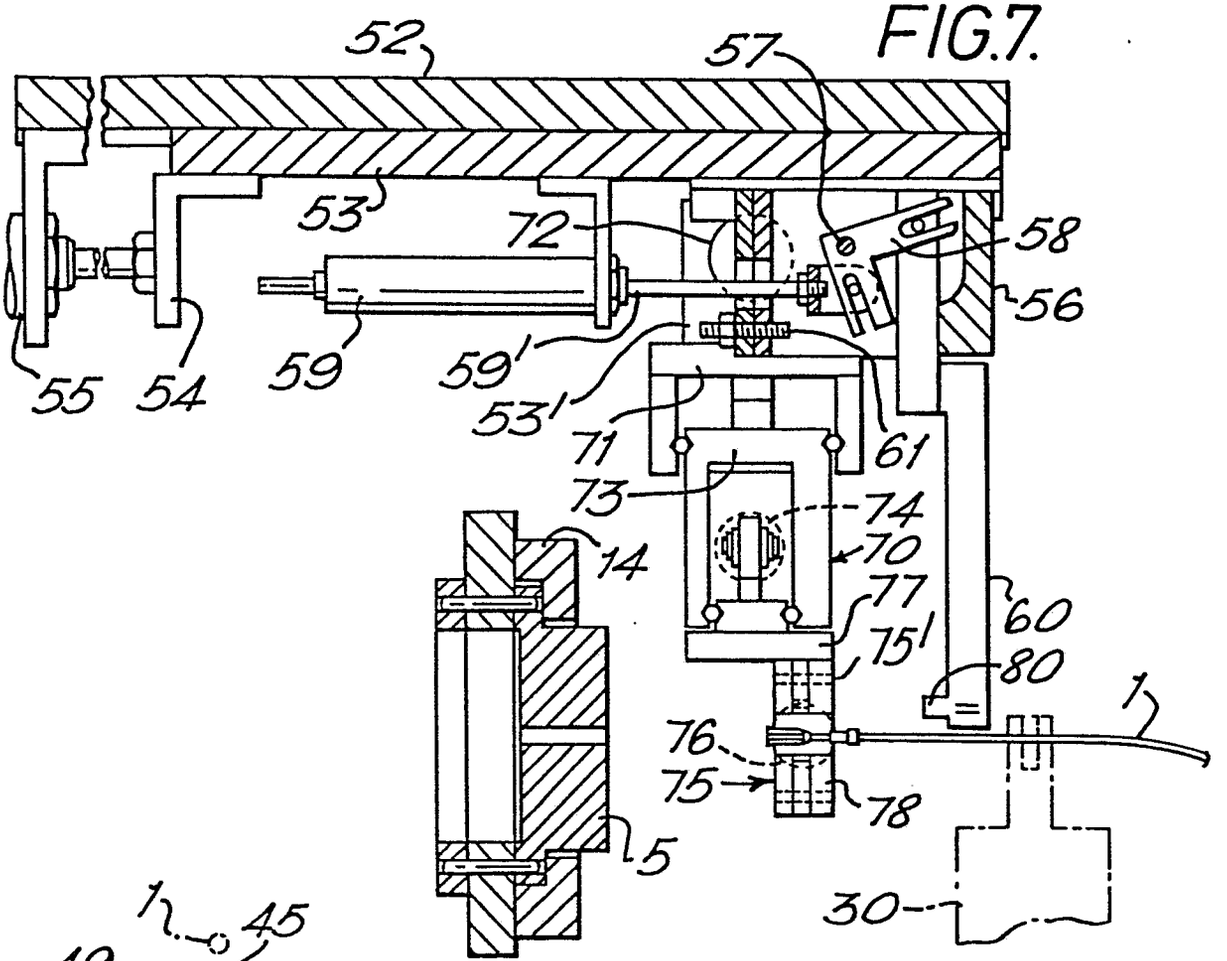



FIG.5e.

FIG.7.


52
57
53
72
58
56
55
54
59
59'
53'
71
61
73
74
70
14
77
60
75'
80
1
76
75
78
5
30

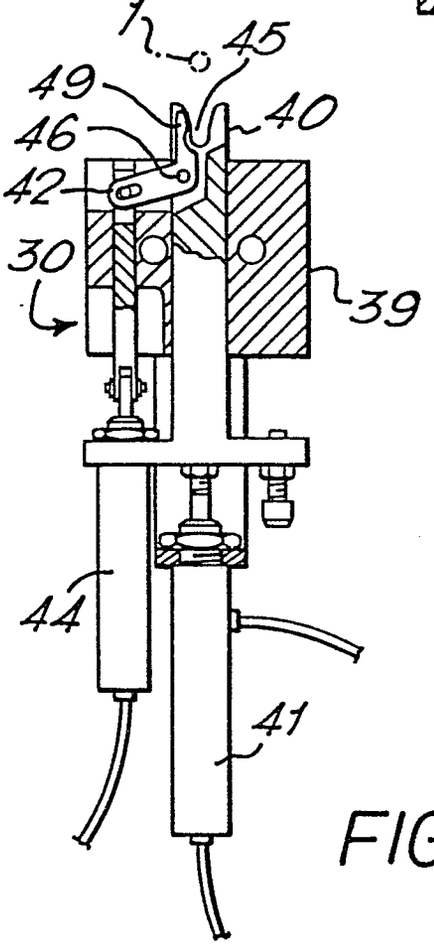

1
45
49
40
46
42
30
39
44
41

FIG.6.

FIG.8.

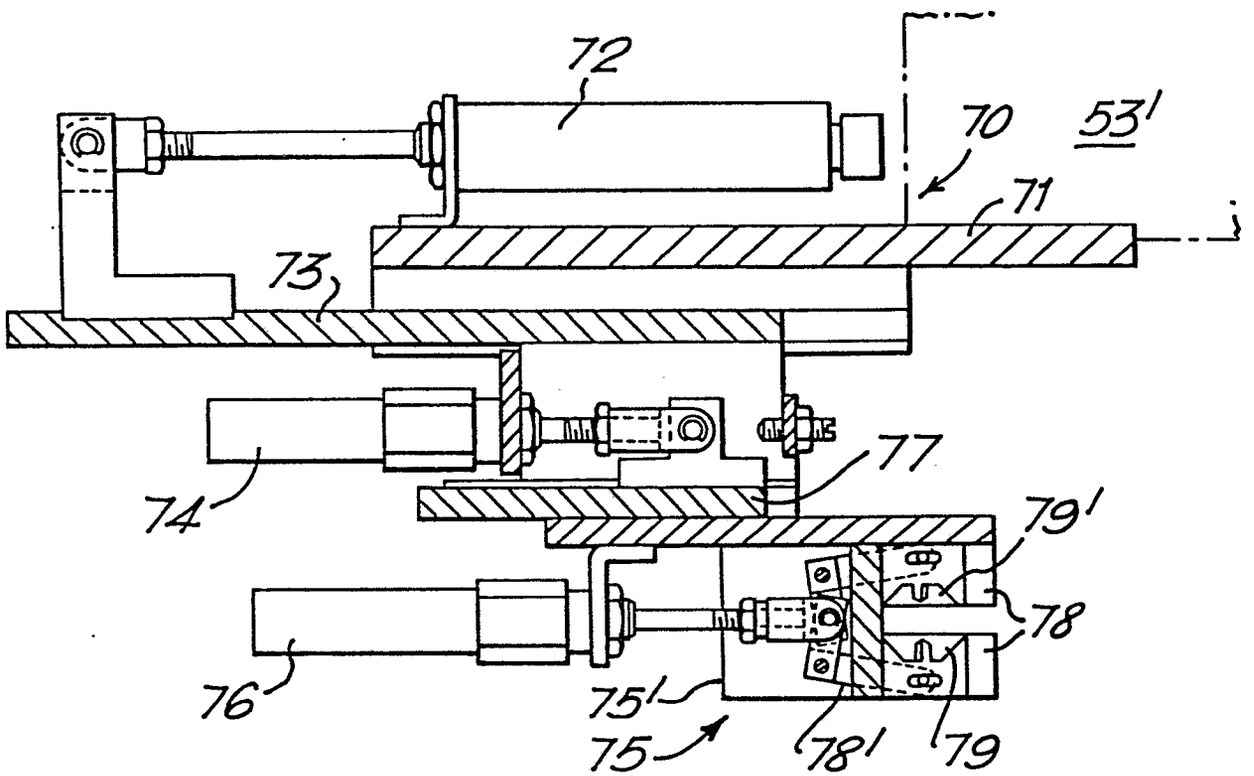
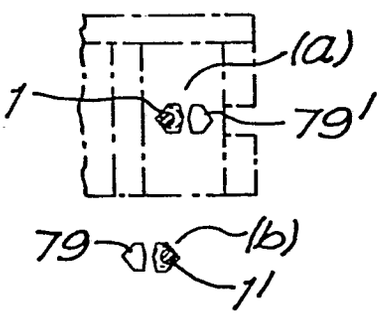



FIG.8a.



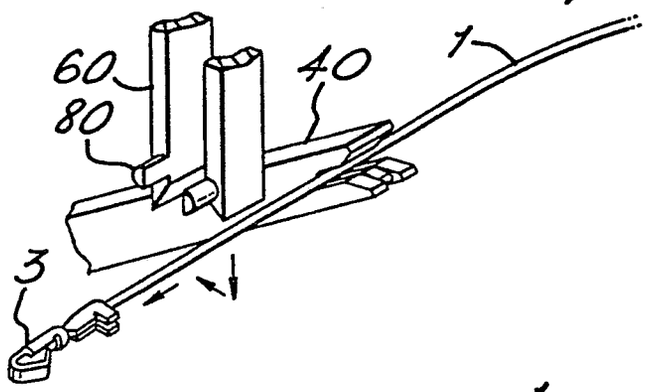



FIG. 9a

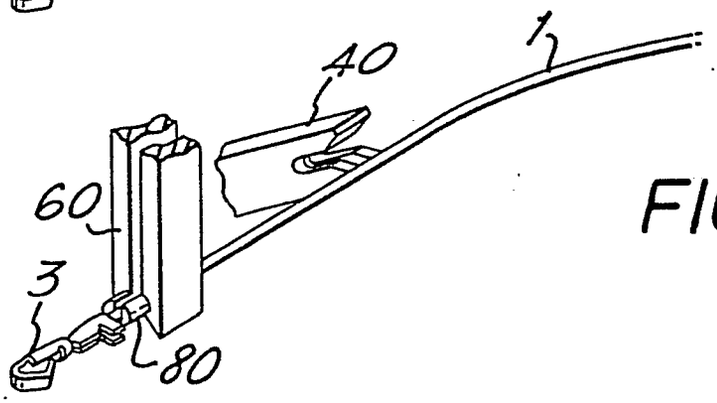



FIG. 9b

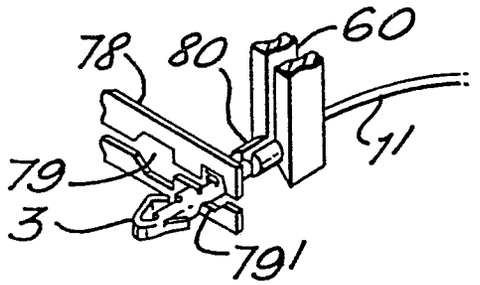



FIG. 10a

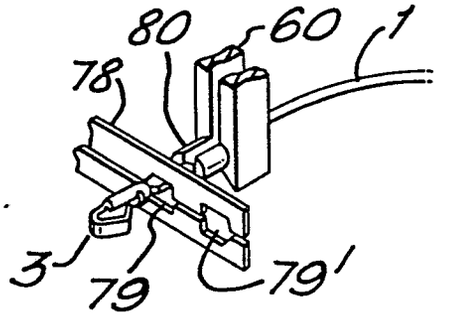



FIG. 10b

FIG. 10c

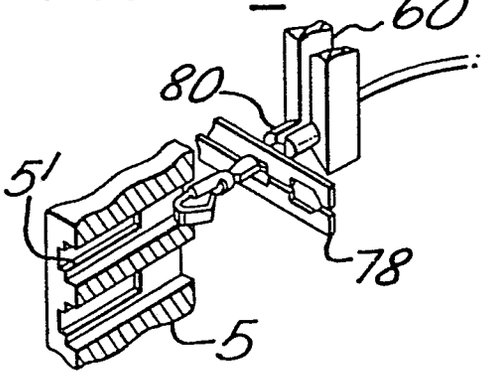



FIG. 10d