



(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:  
11.10.2000 Bulletin 2000/41

(51) Int. Cl.<sup>7</sup>: H01R 43/052

(21) Application number: 00105088.9

(22) Date of filing: 10.03.2000

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE  
Designated Extension States:  
AL LT LV MK RO SI

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(30) Priority: 06.04.1999 JP 9871699

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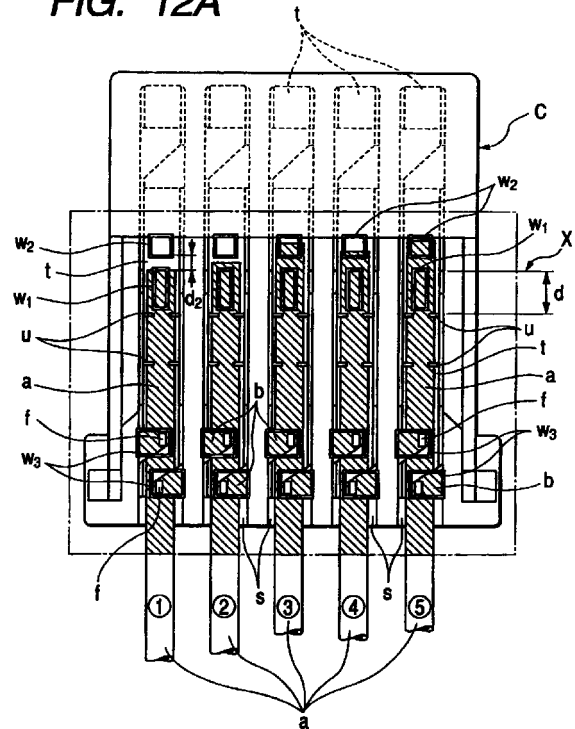
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(54) Apparatus for inspecting and manufacturing wire harness

(57) An image obtained by picking a pressed portion up is subjected to a binary-coding process so that the terminal  $t$  in a metal and luster portion is expressed with "white" pixels and the other non-luster portion, such as the sheath of the electric wire  $a$  and the connector  $C$ , is expressed with "black" pixels. A window  $w_1$  is set which is in contact with the leading end position  $X$  realized when the electric wire  $a$  of the binary image is normally pressed. Another window  $w_2$  distant at a deep portion of a cavity  $s$  is set. When pressing is normally performed, the inside portion in the first window  $w_1$  completely correspond to the sheath of the electric wire  $a$ . Therefore, pixels  $a$  are completely "black" pixels. Since the electric wire  $a$  is not introduced into the second window  $w_2$ , pixels are completely "black" pixels. A product deviated from the foregoing state is determined as a faulty product. Thus, the appearance inspection about the state of connection of the electric wire  $a$  can automatically be performed in a non-contact manner. As a result, reliable and efficient inspection can be performed.

FIG. 12A



## Description

### BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to a method of inspecting the connection between an electric wire and a terminal and an apparatus and a method of manufacturing a wire harness incorporating the electric wire and the terminal which are required in a process for manufacturing the wire harness which is mounted on an automobile or an electrostatic generator.

**[0002]** For example, a wire harness for an automobile, as shown in Fig. 19, incorporates an electric wire a connected to a plurality of connectors C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> (generic symbol C). In recent years, the electric wire and the terminal are frequently connected to each other by crimping connection (hereinafter simply called as "crimping") from a viewpoint of workability. A terminal t having a slot wall u and a barrel portion b structured as shown in Fig. 20 is crimped by using a crimping mold 22 (32) structured as shown in Fig. 21 and incorporating both of a pressing portion 22u (32u) for pressing-fitting an electric wire a into the slot wall u and a barrel crimping portion 22b (32b)

**[0003]** Hitherto, the correctness of the connection established by the crimping operation is determined by performing a mechanical inspection with which the strength of connection is detected and an electric inspection with which electrical conduction is determined.

**[0004]** For example, the mechanical inspection is performed such that determination is made in accordance with a fact whether or not force (fixing force) with which the electric wire is separated when force is exerted on the electric wire connected to the terminal t is not smaller than a rated value.

**[0005]** The foregoing determination method, however, suffers from the following problems.

**[0006]** If the electric wire is connected to the terminal t, the position of connection is sometimes shifted in the lengthwise direction of the electric wire. For example, the position of the connection is sometimes excessively shifted in the lengthwise direction of the electric wire over the leading end of the terminal t. In the foregoing case, there is apprehension that a wire harness W solely satisfying an electrical conduction inspection encounters short circuit after the wire harness is mounted on the body (an automobile) because the core wire in the shifted portion is brought into contact with another metal portion.

**[0007]** When pressing and crimping are performed simultaneously, unsatisfactory result of crimping of the barrel b in the crimping portion sometimes occurs in spite of satisfactory result of the pressing process. Also in the foregoing case, the mechanical and electrical inspections cannot sometimes detect the unsatisfactory result of crimping of the barrel portion b.

**[0008]** Since the mechanical and electric inspec-

tions are performed such that contact with the subject which must be inspected is established, there is apprehension that the product sustains damage.

**[0009]** Therefore, the correctness of the connection between the electric wire and the terminal must be inspected visually such that the appearance of the connected elements is visually inspected as well as or as a substitute for the mechanical and electrical inspections.

**[0010]** The visual operation which is performed manually is an inefficient operation, causing a problem to arise in that resulted reliability is unsatisfactory owing to dispersion in results of determination occurring among operators.

### SUMMARY OF THE INVENTION

**[0011]** Accordingly, an object of the present invention is to enable an appearance inspection of a state of the connection between the terminal of the wire harness and the electric wire of the same to reliably and efficiently be performed.

**[0012]** To solve the problem, according to the present invention, there is provided a method of inspecting the connection between an electric wire and a terminal of a wire harness, comprising the steps of: picking up and binary-coding the connected portion; determining, in the binary image, a determination element for use to determine correctness of the connection; setting a window enclosing the determination element; and making a comparison between a ratio of black or white pixels corresponding to the determination element in the window and a ratio which is realized when the connection is established normally so that the correctness of the connection is determined.

**[0013]** For example, the correctness of the connection is determined at the position of the leading end of the electric wire such that the surface of a sheath of the electric wire or the surface of the bottom of the terminal is employed as the determination element, the first window is set to enclose the determination element and disposed in contact with the position of the leading end realized when the electric wire is normally connected, a second window is set at a position in a region in which the first window is not present and apart from the position of the leading end of the electric wire for a predetermined distance, and when both of the ratio of black or white pixels in the second window and a ratio in the first window coincide with ratios which are realized when the connection is established normally within a predetermined tolerance, a determination is made that the connection is satisfactorily established. As for details, refer to an embodiment (see Figs. 11 to 14) to be described later.

**[0014]** The correctness of the connection is determined in accordance with a state of crimping of a barrel portion of the terminal such that the outer surface of the barrel in a state where the barrel is crimped is employed as a third determination element, the third window

enclosing the outer surface of the barrel is set; and when the ratio of black or white pixels in the third window coincides with a ratio which is realized when crimping of the barrel is normally performed within a predetermined tolerance, a determination is made that the connection is satisfactorily performed. As for details, refer to an embodiment (see Fig. 15) to be described later.

**[0015]** As a result, the appearance inspection of the crimped portion can automatically be performed in a non-contact manner so that reliable and efficient inspection is permitted.

**[0016]** Since the inspection method using an image process of the portion which must be inspected enables the inspection of the state of the connection between the electric wire and the terminal to be performed for a plurality of electric wires, the inspection efficiency can significantly be improved.

**[0017]** There is provided an apparatus for manufacturing a wire harness comprises: a terminal mounting machine for mounting a terminal on a connector; a pressing machine for pressing the electric wire to the mounted terminal; the inspection unit for performing inspection; and a connector-cover fitting machine for fitting a cover to the connector to which the electric wire is pressed, wherein the machines are disposed in series. Thus, the synchronous operations of the foregoing units enables a reliable wire harness to efficiently be manufactured.

**[0018]** The manufacturing apparatus enables selective fitting of the connector cover by the connector-cover fitting machine to only connectors determined in the inspection such that the connectors are satisfactorily pressed. As a result, unnecessary fitting of the cover to a faulty product can be prevented and the manufacturing process can be reduced and waste consumption of the material can be prevented. Moreover, the productivity can be improved.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0019]**

Fig. 1 is an overall perspective view showing an embodiment.

Fig. 2 is a diagram showing the operation of an essential portion of the embodiment.

Fig. 3 is a diagram showing the operation of an essential portion of the embodiment.

Fig. 4 is a diagram showing the operation of an essential portion of the embodiment.

Fig. 5 is a perspective view showing a state where the wire aligning device shown in Fig. 3 is removed.

Fig. 6 is a diagram showing the operation of an essential portion of the embodiment.

Fig. 7 is a perspective view showing another pressing machine according to the embodiment.

Fig. 8 is a perspective view showing a chucking por-

tion.

Fig. 9A is an exploded perspective view showing the chuck and Fig. 9B is a horizontal cross sectional view showing a state where an electric wire is chucked.

Fig. 10 is a plan view showing a connector housing. Fig. 11 is a plan view showing the connector housing in a state in which the electric wire is normally connected.

Fig. 12A shows a defective degree of projection (when it is long) of the electric wire and Fig. 12B is a plan view showing another example of the window.

Fig. 13 is a plan view showing a defective degree (when it is short) of the electric wire.

Fig. 14 is a plan view showing a state where no electric wire is present.

Fig. 15 is a plan view showing the defective degree of crimping of a barrel.

Fig. 16 is a schematic and perspective view showing an appearance inspection unit.

Fig. 17 is a perspective view showing a pallet portion.

Fig. 18 is a perspective view showing an engaging operation of the connector housing, in which Figs. 18A and 18B show a state before engagement and Fig. 18C shows a state after the engagement

Fig. 19 is a perspective view showing an example of a wire harness.

Fig. 20 is a perspective view showing a terminal.

Fig. 21 is a perspective view showing a pressing mold and its operation.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0020]** Referring to the drawings, an embodiment of the present invention will now be described. The same elements as those of the conventional structure are given the same reference numerals and the same elements are omitted from description. As shown in Fig. 18, a connector  $C_2$  incorporates an upper connector housing  $C_{21}$  and a lower connector housing  $C_{22}$ . As shown in Fig. 17, electric wires  $a$  are connected to terminals  $t$ , and then the two housings  $C_{21}$  and  $C_{22}$  are engaged to each other, as shown in Fig. 19. Thus, a wire harness  $W$  is obtained. The connectors  $C_2$  and  $C_3$  of the connectors  $C_1$ ,  $C_2$  and  $C_3$  of the wire harness  $W$  are structured as shown in Fig. 18. The connector  $C_1$  has terminals (cavities) by a number larger than the number of terminals of each of the connectors  $C_2$  and  $C_3$  by one.

**[0021]** The terminal  $t$  incorporates the slot wall  $u$  and the wire barrel portion  $b$  shown in Fig. 20. As shown in Fig. 18A, a required number of terminals  $t$  each of which is, by cutting, removed from a terminal band  $T$  formed by sequentially connecting the terminals  $t$  are inserted into a cavity  $s$  of the housing  $C$  from a horizon-

tal direction. An upper cover of the upper connector housings C<sub>11</sub>, C<sub>21</sub> and C<sub>31</sub> is engaged to the body as shown in Fig. 18C by cutting the joint n and flipping the upper cover vertically as indicated with an arrow shown in Fig. 18B (for details, refer to the Japanese Patent Application No. Hei 9-145328).

**[0022]** A pressing mold for connecting the electric wire a to the terminal t, as shown in Fig. 8 which will be described later, incorporates pressing blades 22a and 32a and thrust blades 22p and 32p. The leading end of each of the pressing blades 22a and 32a, as shown in Fig. 21, incorporates both of pressing portion 22u (32u) and barrel crimping portion 22b (32b). When the pressing mold 22 (32) is moved downwards, a pressing operation is performed.

**[0023]** Fig. 1 shows an example of a line for manufacturing the wire harness W. The lower left portion of Fig. 1 is the upstream portion of the line, while the upper right portion of the same is the downstream portion of the line. Rails R are laid on a frame H. The following units are sequentially disposed in series along the rails R: a terminal mounting machine A for mounting the terminal t on the connector (the housing) C; a wire pressing unit B for pressing the electric wire; and an inspection and assembling unit E for inspecting the appearance of the connected elements and joining the connector cover (engaging the upper connector).

**[0024]** The pressing unit B incorporates two pressing machines 20 and 30. A wire-length measuring and feeding machine 40 is provided for the upstream pressing machine 20. A setting portion D of a lower connector C and a stocker Q for the upper and lower connectors are provided for the trailing end of the like. The units of the manufacturing line are disposed as described above. The structure and operation of each unit will now be described in a direction of the flow of the processes which are performed along the foregoing line.

**[0025]** In the setting portion D, each connector (each housing) is manually engaged to (placed in) a recess of a pallet P shown in Fig. 17 from the stocker Q. A lifter and a conveyor (not shown) are operated to move the connector C to the terminal mounting unit A through the frame H as indicated with a dashed line.

**[0026]** The terminal mounting machine A incorporates a terminal reel 10 and a terminal cutting and inserting unit 11. A terminal band T having terminals t connected in series so as to be formed into an elongated shape is introduced from the terminal reel 10 into the terminal cutting and inserting unit 11. Thus, the terminals t are separated from one another by a cutting operation performed by the terminal cutting and inserting unit 11. Moreover, the terminal t is inserted into the cavity s in the housing C on the pallet P formed at a predetermined position. After the terminal t is inserted, the pallet P is moved for a predetermined distance by a conveying mechanism (not shown), such as a ball screw, so as to be moved to a wire pressing unit B disposed in the following step.

**[0027]** The wire pressing unit B incorporates: the two pressing machines 20 and 30; the wire-length measuring and feeding machine 40 provided for the upstream pressing machine 20; and a wire shifting and rotating unit 50. The wire-length measuring and feeding machine 40 incorporates a wire brake unit 41, an encoder unit 42 for detecting the amount of fed wire W and a wire feeding unit 43. Electric wires a by a required number and in required colors are moved to the upstream pressing machine 20 for a predetermined distance (as for the details of the wire-length measuring and feeding machine 40, refer to the Unexamined Japanese Patent Application Publication No. Hei 10-154423 and the Unexamined Japanese Patent Application Publication No. Hei 10-212063).

**[0028]** The upstream pressing machine 20, as shown in Figs. 2 to 5 in detail, incorporates a ball screw 21a arranged to be operated by a servo motor 21 to vertically move an arbitrary pressing mold 22 to connect the electric wire a to the terminal t in the cavity. As for the structure and operation of the pressing machine 20, refer to the Unexamined Japanese Patent Application Publication No. Hei 10-106374.

**[0029]** A wire guide 23 capable of moving vertically is disposed below the plural pressing molds 22. The wire guide 23 incorporates a vertical slit 24 through which the pressing mold 22 passes; and a lateral slit 25 formed perpendicular to the slit 24 and opened in the front and rear surfaces thereof. When the wire guide 23 is moved upwards, a required number of electric wires a are moved from the wire-length measuring and feeding machine 40. A wire aligning device 26 capable of moving vertically is disposed in front of the wire guide 23. When the wire aligning device 26 is moved downwards, the electric wires a inserted into the wire guide 23 are aligned. The wire guide 23 and the wire aligning device 26 are moved downwards simultaneously with the pressing operation (simultaneously with the downward movement of the pressing mold 22). The wire guide 23 has substantially the same structure as that of a chuck 53 to be described later. As for the structure, refer to Fig. 8 below and the Unexamined Japanese Patent Application Publication No. Hei 10-97888.

**[0030]** The downstream pressing machine 30, as shown in Figs. 6 and 7, comprises two units. Each of the pressing machines 30 has the same structure and operation as those of the upstream pressing machine 20. That is, a ball screw 31a arranged to be operated by a servo motor 31 vertically moves an arbitrary pressing mold 32 (also having the same shape as that of the pressing mold 22 and incorporating both of a pressing portion 22u (32u) and a barrel crimping portion 22b (32b)) to connect the electric wire a to the terminal t in the cavity. The reason why the two pressing machines 30 are provided lies in that a corresponding operation to different connector C in terms of the shape and the position must easily be performed. As indicated with an arrow shown in Fig. 6, the two downstream pressing

machines 30 are slid to be moved to positions on the pallet P corresponding to the position at which the housing C is pressed. The pressing machines 20 and 30 are provided with press dead-center stroke sensors 27 and 37 so that a predetermined depth which must be realized by pressing is detected and maintained.

**[0031]** The wire shifting rotating unit 50 incorporates a chuck 53 disposed at the leading end of an arm 52 capable of reciprocally rotating for an angular degree of 180° by a motor 51. The chuck 53, as shown in Figs. 8 and 9, incorporates: a vertical slit 54; a guide 56 having a slit 55 opened in the front and rear surfaces to be perpendicular to the vertical slit 54; and a slide plate 58 engaged to the guide 56 and having a slit 57. The slide plate 58 moves forwards/rearwards as indicated with an arrow shown in Fig. 8 by an air cylinder 59 so as to hold and chuck the electric wire a in cooperation with the guide 56, as shown in Fig. 9B.

**[0032]** The pressing molds 22 and 32, as shown in Fig. 8, incorporate pressing blades 22a and 32a for pressing and crimping the electric wire a; and the thrust blades 22p and 32p arranged to be brought into contact with the electric wire a projecting over the chuck 53 (the wire guide 23). Therefore, as the connecting operation (the pressing operation) proceeds, the pressing blades 22a and 32a are inserted into the slits 54 and 24 as indicated with a dashed line to press-fit the electric wire a disposed in the slits 54 and 24 to the slot wall u of the terminal t. Moreover, the barrel portion b of the terminal t is crimped and connected. Simultaneously, also the thrust blades 22p and 32p downwards move the projecting electric wire a following the foregoing connecting operation. Thus, undesirable movement of the electric wire a, such as bending of the electric wire a, can be prevented so that the connecting operation is performed smoothly.

**[0033]** After the pallet P is moved from the terminal mounting machine A to the wire pressing unit B, the arm 52 is rotated toward the upstream pressing machine 20, as shown in Fig. 2. Thus, the chuck 53 is placed along the wire guide 23. In the foregoing state, a required number of the electric wires a are introduced into the wire guide 23 and the chuck 53 (the slits 25 and 55) from the wire-length measuring and feeding machine 40. The leading end of the electric wire a is moved to realize a predetermined length which must be pressed when the chuck 53 to be described later corresponds to another pressing machine 30 by determining the distance of movement. The moved electric wire a is aligned by the wire aligning device 26 (see Fig. 3), and then the air cylinder 59 is operated so that the slide plate 58 sandwiches the electric wire a.

**[0034]** Thus, as shown in Fig. 4, the arm 52 is rotated toward the downstream pressing machine 30. Also the pallet P is moved to the downstream pressing machine 30. Note that the pallet P may previously be moved. At this time, the wire-length measuring and feeding machine 40 measures a predetermined length

of each electric wire a to feed the same. As shown in Fig. 6, the pressing machine 30 is operated after the chuck 53 is placed along the downstream pressing machine 30. At this time, the pallet P moves to the right and left so that either end of the electric wire a is connected to a required housing C and a required terminal t. Hereinafter the end of the electric wire a which is connected by the pressing machine 30 is simply called an end A. Another connected end is called an end B (as described later, the end B is connected to the terminal t by the upstream pressing machine 20). When the end A is connected, the sucking force of the air cylinder 59 is controlled to correspond to the number of electric wires which must be chucked. As a result, the connection operation is always performed with optimum holding force. After the ends A of all of the chucked electric wires a are completed, the pallet P is moved to the upstream pressing machine 20.

**[0035]** After the pallet P corresponds to the pressing machine 20, the pressing mold 22 is, together with the wire guide 23, moved downwards. In synchronization with this, the pallet P is moved to the right and left so that the end B of the electric wire a is connected to a required housing C and the terminal t. At this time, the electric wire a is cut by the pressing mold 22 as well as the connecting operation. That is, this embodiment has a structure that the pressing machine 20 also acts to cut the electric wire. As for the operation for cutting the electric wire by using the pressing mold 22, refer to the Unexamined Japanese Patent Application Publication No. Hei 10-106374.

**[0036]** After the ends B of all of the electric wires a fed from the wire guide 23 are connected, the arm 52 is again rotated to the upstream pressing machine 20, as shown in Fig. 2. Then, a similar operation is repeated so that the electric wire a is connected to the housing C. The pallet P having the electric wires a connected to the connectors is moved to a following inspection and assembling unit E. As for the operation for moving the pallet P to the pressing machines 20 and 30 and connecting the electric wires a into a cross shape, refer to the Unexamined Japanese Patent Application Publication No. Hei 10-241473.

**[0037]** In the inspection and assembling unit E, an appearance inspecting unit 60 disposed in the front portion of the inspection and assembling unit E performs an image process of the housing C placed on the pallet P to perform the appearance inspection (determination of the correctness of the connection) of the state where the electric wire a and the terminal t are connected to each other. An assembling unit disposed in the rear portion of the inspection and assembling unit E joins a cover (engages an upper connector) to the connector. Referring to Figs. 10 to 15, the inspection of the appearance which is performed in the front portion will now be described.

**[0038]** Fig. 10 is a plan view showing the connector C in a state before the electric wire a is connected. Sym-

bol s represents the cavity, t represents the terminal, u represents the slot wall of the terminal  $\underline{t}$  and  $\underline{b}$  represents the barrel.

**[0039]** The appearance inspection is performed such that the three following factors are detected in this embodiment.

(1) Position of Leading End of Electric Wire  $\underline{a}$

**[0040]** When the electric wire  $\underline{a}$  is normally pressed, the leading end of the electric wire  $\underline{a}$  must project over the end surface of the slot wall u toward the deep portion of the cavity s for a predetermined distance d, as shown in Fig. 11. The degree of projection of the electric wire  $\underline{a}$  is detected.

(2) Presence of Electric Wire  $\underline{a}$  in Terminal  $\underline{t}$

**[0041]** Whether or not the electric wire  $\underline{a}$  is present in the terminal  $\underline{t}$  is detected (an error in wiring is detected).

(3) Degree of Crimping of Barrel  $\underline{b}$

**[0042]** The foregoing three factors are inspected by the image process which is performed by the appearance inspecting unit 60. The appearance inspecting unit 60 incorporates an image input unit, an illuminating unit, an image output unit, an image processing unit and a host computer. The foregoing units will now be described.

**[0043]** As shown in Fig. 16, the image input unit incorporates a CCD camera 61 and a ring illumination 62 for realizing uniform illumination. Reference numeral 62a represents a cover for the ring illumination 62. The CCD camera 61 has an optical axis L made coincide with a vertical axis passing through the center of the ring of the ring illumination 62, the CCD camera 61 being disposed above the ring illumination 62. The ring illumination 62 illuminates the inspecting portion with downward light to light the terminal  $\underline{t}$  made of a metal material. Non-metal portions except for the terminal  $\underline{t}$ , that is, the sheath of the electric wire  $\underline{a}$  and the connector C, are not lighted.

**[0044]** An image photographed by the CCD camera 61 is binary-coded by the image processing unit so that the metal luster portions are expressed with "white" pixels and the other non-luster portions are expressed with "black" pixels. The host computer of the image processing unit is a personal computer 63. As a unit for outputting the binary image, a monitor 64 is employed.

**[0045]** Then, a determination element for determining correctness is determined in the binary-coded image, and then a window enclosing the determination element is set.

**[0046]** The detection of the "position of the leading end of the electric wire  $\underline{a}$ " in (1) is performed by providing two windows  $w_1$  and  $w_2$  as shown in Fig. 12. The

window  $w_1$  is formed into a rectangular frame having one side, the length of which is shorter than the outer diameter of the electric wire  $\underline{a}$ . The side is made coincide with the leading end position X realized when the electric wire  $\underline{a}$  is normally pressed. Moreover, the opposite side is disposed adjacent to the electric wire  $\underline{a}$ . The "determination element for determining the correctness of the connection" which is performed by using the first window  $w_1$  is the (outer surface of the ) sheath of the electric wire  $\underline{a}$ . The corresponding pixel is "black".

**[0047]** The second window  $w_2$  is formed by a rectangular frame disposed somewhat apart from the first window  $w_1$  for a short distance toward the deep position in the cavity s. The small frame has one side, the length of which is shorter than the outer diameter of the electric wire  $\underline{a}$ . The "determination element of the correctness" which is performed by using the second window  $w_2$  is the surface of the bottom of the terminal  $\underline{t}$ . The corresponding pixel is "white".

**[0048]** The reason why the sizes of the rectangular windows  $w_1$  and  $w_2$  are made to be smaller than the outer diameter of the electric wire  $\underline{a}$  lies in that the background of the image of each "determination element of the correctness" must be simplified to facilitate the determination. If the sizes of the windows  $w_1$  and  $w_2$  are too large to considerably deviate from the outer diameter of the electric wire  $\underline{a}$ , unnecessary factors, such as the side wall of the terminal  $\underline{t}$  or the wall of the cavity, are included in the window. Thus, a complicated process is required. The two windows  $w_1$  and  $w_2$  are used to determine the correctness of pressing as follows.

**[0049]** When the pressing operation is normally completed, the inside portion of the first window  $w_1$  completely corresponds to the (surface of the) electric wire  $\underline{a}$ , as shown in Fig. 11. Therefore, all of the pixel are "black". On the other hand, the electric wire  $\underline{a}$  is not introduced into the window  $w_2$ . Since the window  $w_2$  corresponds to the surface of the bottom of the terminal  $\underline{t}$ , all of the pixels are "white".

**[0050]** Therefore, the position of the leading end of the electric wire  $\underline{a}$  is determined as correct only when the pixels in the first  $w_1$  are completely "black" and the pixels in the second window  $w_2$  are completely "white". Thus, the correctness of the position of the leading end of the electric wire  $\underline{a}$  is determined.

**[0051]** Conversely, if one or more black pixels are present in the second window  $w_2$  in the cases of the electric wires a indicated with numerals (3), (4) and (5) shown in Fig. 12, it means a fact that the electric wire  $\underline{a}$  is excessively moved to the foregoing position.

**[0052]** In the cases of the electric wires a indicated with numerals (1), (2) and (3) shown in Fig. 13 where all of the pixels in the inside portion of the second window  $w_2$  are "white" and the pixels in the first window  $w_1$  are not completely "black", it means a fact that the electric wire  $\underline{a}$  does not reach a normal leading end position X. In this case, the degree of projection is insufficient.

**[0053]** The determination of insufficient degree of

projection of the electric wire a by using the windows  $w_1$  and  $w_2$  is performed as described above. The foregoing method is a basic determination method structured without any consideration of "tolerance". When "tolerance" is considered, the following method is employed.

**[0054]** For example, the window  $w_1$  is disposed on the inside of the electric wire a to enable "insufficient degree of projection" to be detected in accordance with the ratio of "black" pixels in the window  $w_1$ . When setting for the electric wire a indicated with numeral (3) shown in Fig. 13 is made such that a region for the leading end position to the position downwards extended from the normal leading end position X for a distance  $d_1$  is included in the "shorter tolerance of the degree of projection", the electric wire a having the leading end satisfying the foregoing region is included in a range of satisfactory products. In the foregoing case, the ratio of the black pixels are not completely "black" as shown in Fig. 13.

**[0055]** In a case where the "longer tolerance of the degree of projection" as indicated with the position of the electric wire a having symbol (1) shown in Fig. 12 is  $d_2$ , the window  $w_2$  is required to be disposed at a position apart from the normal leading end position X of the electric wire a for distance  $d_2$ . The electric wires a each having the leading end satisfying the region defined by  $d_2$  are satisfactory products. The electric wires a having the leading end which is introduced into the window  $w_2$  are "faulty products projecting excessively" deviated from the range of the tolerance. Therefore, satisfactory products must satisfy a fact that pixels in the window  $w_2$  are completely "white".

**[0056]** Although this embodiment is structured such that the windows  $w_1$  and  $w_2$  are set as described above, another setting of the windows  $w_1$  and  $w_2$  as shown in Fig. 12B may be employed.

**[0057]** That is, as a substitute for the foregoing window  $w_1$  disposed in contact with the leading end position X of the normal electric wire a and having the opposite side disposed on the inside of the electric wire a, a window  $w_1'$  is set which has the side opposite to the side which is in contact with the normal leading end position X and disposed in the upper portion (on the outside of the electric wire a and the surface of the bottom of the terminal t) in the drawing. As a substitute for the window  $w_2$  disposed on the outside of the electric wire a, a window  $w_2'$  is disposed on the inside of the electric wire a at a position apart from the normal leading end position X of the electric wire a for a distance corresponding to the shorter tolerance of the degree of projection. In the foregoing case, the basic determination method is arranged such that when the electric wire a is connected at the normal position, pixels in the window  $w_1'$  are completely "white" and those in the window  $w_2'$  are completely "black". The tolerance is used similarly to that in the foregoing case. Therefore, description of the method of using the tolerance is omitted.

**[0058]** To determine (2) "presence of electric wire",

the two windows  $w_1$  and  $w_2$  (or window  $w_1'$  and  $w_2'$ ) in (1) are as it is used. That is, when the electric wire a is not present in the terminal t as shown in Fig. 14, pixels in the two windows  $w_1$  and  $w_2$  corresponding to the surface of the bottom of the terminal t are completely "white". Therefore, when pixels in the two windows  $w_1$  and  $w_2$  are completely "white", a determination "no electric wire" is made.

**[0059]** The electric wire a given numeral (3) in the drawing is present in the cavity s. Pixels in the two windows  $w_1$  and  $w_2$  are completely "white". In the foregoing case, the state in (1) is realized in which the leading end position of the electric wire a is excessively withdrawn. Also the foregoing case is determined such that "electric wire is not present".

**[0060]** Also the "element for determining correctness of the connection" in (2) is the "sheath of the electric wire a" or the "surface of the bottom of the terminal t" in the two windows  $w_1$  and  $w_2$  (or the windows  $w_1'$  and  $w_2'$ ).

**[0061]** The "degree of crimping of the barrel b" in (3) is arranged such that the portion of "chamfering f" of the crimped barrel b is the "element for determining correctness of the connection", as shown in Fig. 15. Since the outer surface of the barrel b is a large area in projected surface when the barrel b is crimped and viewed in a plan view (projected to a plane), attention is focused on the foregoing fact to use it as the element for determining the correctness.

**[0062]** Since two barrels b are provided, rectangles enclosing the "chamfering f" at the foregoing positions which is the foregoing determination element are set to be windows  $w_3$ .

**[0063]** When the barrel b is completely and satisfactorily crimped as the electric wires a given numerals (1), (3) and (5), the corresponding portion of the "chamfering f" of the barrel b is present as "white pixels" in each windows  $w_3$ .

**[0064]** In the case of the electric wire a given numeral (2) or (4), substantially all pixels in the windows  $w_3$  are "black". Therefore, the foregoing factor corresponds to the sheath of the electric wire a and fact that the barrel b is not crimped. Therefore, a determination is made as "faulty crimping of the barrel b".

**[0065]** Also in the foregoing case, the satisfactory product does not always satisfy the fact that the ratio of the white pixels is 100% in consideration of the tolerance and the specification of the inspection accuracy when the ratio of the "white" pixels when an optimum degree of crimping is realized. In accordance with the tolerance, the value is set to be 100% or lower.

**[0066]** The inspection factors in (1) to (3) are determined as described above. When one connector C satisfies all of the factors, the connector C is determined as a "satisfactory product".

**[0067]** If a faulty state is detected in the appearance inspection about the state of the connection, occurrence of the faulty state is communicated. Moreover, the cover

is not fit to the faulty connector. Only satisfactory connectors are subjected to a process shown in Fig. 18 in which an operation (not shown) is performed. Thus, a pair of housings  $C_{11}$  and  $C_{12}$ , a pair of housings  $C_{21}$  and  $C_{22}$  and a pair of housings  $C_{31}$  and  $C_{32}$  are engaged so that a wire harness  $W$  shown in Fig. 19 is obtained. The connector housing  $C$  in which the connection of the electric wire  $a$  is unsatisfactorily completed is recovered as a faulty product in a state where the connection (faulty connection) of the electric wire  $a$  is maintained. Thus, unnecessary fitting of the cover to the faulty connector can be prevented in accordance with a result of the appearance inspection. Therefore, the availability can be improved and the material cost can be reduced. Note that the lowest point of the engagement of the upper connector housings  $C_{11}$ ,  $C_{21}$  and  $C_{31}$  is determined by a stroke sensor 71.

**[0068]** The pallet  $P$  on which the wire harness  $W$  manufactured because the covers  $C_{11}$ ,  $C_{21}$  and  $C_{31}$  are fit to the housings  $C_{12}$ ,  $C_{22}$  and  $C_{32}$  is moved to a setting portion  $D$ . Thus, the wire harness  $W$  is manually recovered. The pallet  $P$  from which the wire harness  $W$  is removed is supplied with new housings  $C_{12}$ ,  $C_{22}$  and  $C_{32}$ , and then the pallet  $P$  is moved to the terminal mounting machine  $A$ . The foregoing process is repeated so that the wire harnesses  $W$  shown in Fig. 19 are continuously manufactured.

**[0069]** The appearance inspection about the state of connection according to the embodiment employs the windows  $w_1$ ,  $w_2$  ( $w_1'$ ,  $w_2'$ ) and  $w_3$  set to inspect the contents of (1) to (3). Another method may be employed with which the window is set adjacent to the slot wall  $u$  to determine the correctness of the height of the pressed portion. That is, when downward light is applied to the slot wall  $u$  of the terminal  $t$  to which the electric wire  $a$  is press-fit, the upper surface of the slot wall  $u$  is illuminated. Therefore, "white pixels" appear in a binary image. If the pressing operation is formed normally, the electric wire  $a$  is moved below the slot wall  $u$ . Hence it follows that "white" pixels corresponding to the upper surface of the slot wall  $u$  appear in the window. When the electric wire  $a$  cannot satisfactorily be press-fit into the terminal  $t$  and the electric wire  $a$  is moved on the upper surface of the slot wall  $u$ , that is, when, for example, foreign matter is introduced into the slot or double pressing of the electric wire  $a$  occurs, the upper surface of the slot wall  $u$  is placed below the electric wire  $a$ . Thus, the image of the foregoing portion is the image of the sheath of the electric wire  $a$ , causing "black" pixels to appear. Hence it follows that no "white" pixel appears in the window and a solid image portion is formed. Therefore, the correctness of the "height of the pressed portion" can be determined.

**[0070]** As described above, the method according to the present invention comprises the steps of: picking up and binary-coding the connected portion; determining, in the binary image, a determination element for use to determine correctness of the connection; setting

a window enclosing the determination element; and making a comparison between a ratio of black or white pixels corresponding to the determination element in the window and a ratio which is realized when the connection is established normally so that the correctness of the connection is determined. Therefore, omission of determination experienced with the mechanical and electrical inspections can be prevented. The inspection can be performed in the non-contact and nondestructive manner. Since the inspection is not the manual visually inspection, the inspection can be performed with satisfactory reliability, high speed and excellent reproducibility.

**[0071]** For example, when the correctness of the connection is determined at the position of the leading end of the electric wire, the surface of a sheath of the electric wire or the surface of the bottom of the terminal is employed as the determination element, the first window is set to enclose the determination element and disposed in contact with the position of the leading end realized when the electric wire is normally connected, a second window is set at a position in a region in which the first window is not present and apart from the position of the leading end of the electric wire for a predetermined distance, and when both of the ratio of black or white pixels in the second window and a ratio in the first window coincide with ratios which are realized when the connection is established normally within a predetermined tolerance, a determination is made that the connection is satisfactorily established.

**[0072]** When the correctness of the connection is determined in accordance with a state of crimping of a barrel portion of the terminal, the outer surface of the barrel in a state where the barrel is crimped is employed as a third determination element, the third window enclosing the outer surface of the barrel is set; and when the ratio of black or white pixels in the third window coincides with a ratio which is realized when crimping of the barrel is normally performed within a predetermined tolerance, a determination is made that the connection is satisfactorily performed.

**[0073]** The inspection of the state of the connection between the electric wire and the terminal can be performed for a plurality of electric wires. Therefore, the inspection efficiency can significantly be improved.

**[0074]** The apparatus for manufacturing a wire harness comprising: the terminal mounting machine for mounting a terminal on a connector; the crimping machine for crimping the electric wire to the mounted terminal; the foregoing inspection unit for performing inspection; and the connector-cover fitting machine for fitting a cover to the connector to which the electric wire is crimped, wherein the machines are disposed in series. The synchronous operation of the units enables reliable and high-quality wire harness to efficiently be manufactured.

**[0075]** The connector cover is, by the connector cover joining machine of the manufacturing apparatus,

fit to only the connector determined in the inspection such that the connector is satisfactorily pressed. Thus, unnecessary fitting of the cover to the faulty product can be prevented. Thus, the manufacturing processes can be decreased and wasteful consumption of the material can be prevented. Moreover, the productivity can furthermore be improved.

### Claims

1. A method of inspecting the connection between an electric wire and a terminal of a wire harness, comprising the steps of:

picking up;  
 binary-coding the connected portion;  
 determining, in the binary image, a determination element for use to determine correctness of the connection;  
 setting a window enclosing said determination element; and  
 making a comparison between a ratio of black or white pixels corresponding to said determination element in the window and a ratio which is realized when the connection is established normally to determine the correctness of the connection.

2. The method of inspecting the connection between an electric wire and a terminal of a wire harness according to claim 1, wherein

the correctness of the connection is determined at the position of the leading end of said electric wire such that the surface of a sheath of said electric wire or the surface of the bottom of said terminal is employed as said determination element,  
 a first window is set to enclose said determination element and disposed in contact with the position of the leading end realized, when said electric wire is normally connected,  
 a second window is set at a position in a region in which the first window is not present and apart from said position of said leading end of said electric wire for a predetermined distance, and  
 when both of the ratio of black or white pixels in the second window and the ratio of black or white pixels in the first window coincide with a ratio which is realized when the connection is established normally within a predetermined tolerance,  
 a determination is made that the connection is satisfactorily established.

3. The method of inspecting the connection between an electric wire and a terminal of a wire harness

according to claim 1, wherein

the correctness of the connection is determined in accordance with a state of crimping of a barrel portion of said terminal such that the outer surface of said barrel in a state where said barrel is crimped is employed as a third determination element,  
 the third window enclosing said outer surface of said barrel is set; and  
 when the ratio of black or white pixels in the third window coincides with a ratio which is realized when crimping of said barrel is normally performed within a predetermined tolerance,  
 a determination is made that the connection is satisfactorily performed.

4. The method of inspecting the connection between an electric wire and a terminal of a wire harness according to claim 1, wherein

the inspection of the state of the connection between said electric wire and said terminal is performed for a plurality of electric wires.

5. The apparatus for manufacturing a wire harness comprising:

a terminal mounting machine for mounting a terminal on a connector;  
 a pressing machine for pressing said electric wire to said mounted terminal;  
 an inspection unit for performing inspection according to claim 1; and  
 a connector-cover fitting machine for fitting a cover to said connector to which said electric wire is pressed,  
 in series in this order.

6. The method of manufacturing a wire harness comprising the step of:

manufacturing said wire harness by operating said manufacturing apparatus claimed in claim 5, wherein  
 said connector cover is, after pressing, fit to only connectors determined in the inspection to press said connectors satisfactorily.

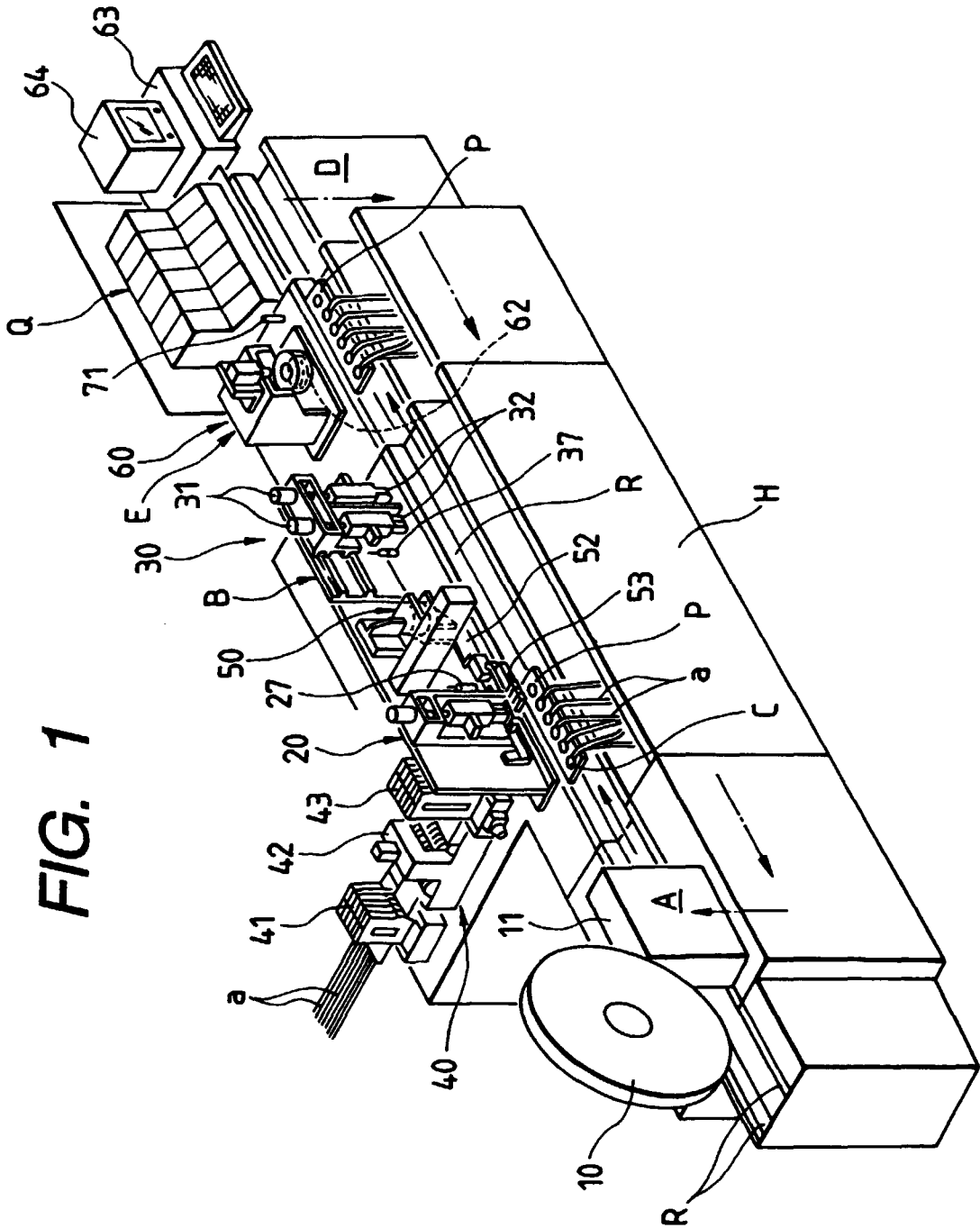
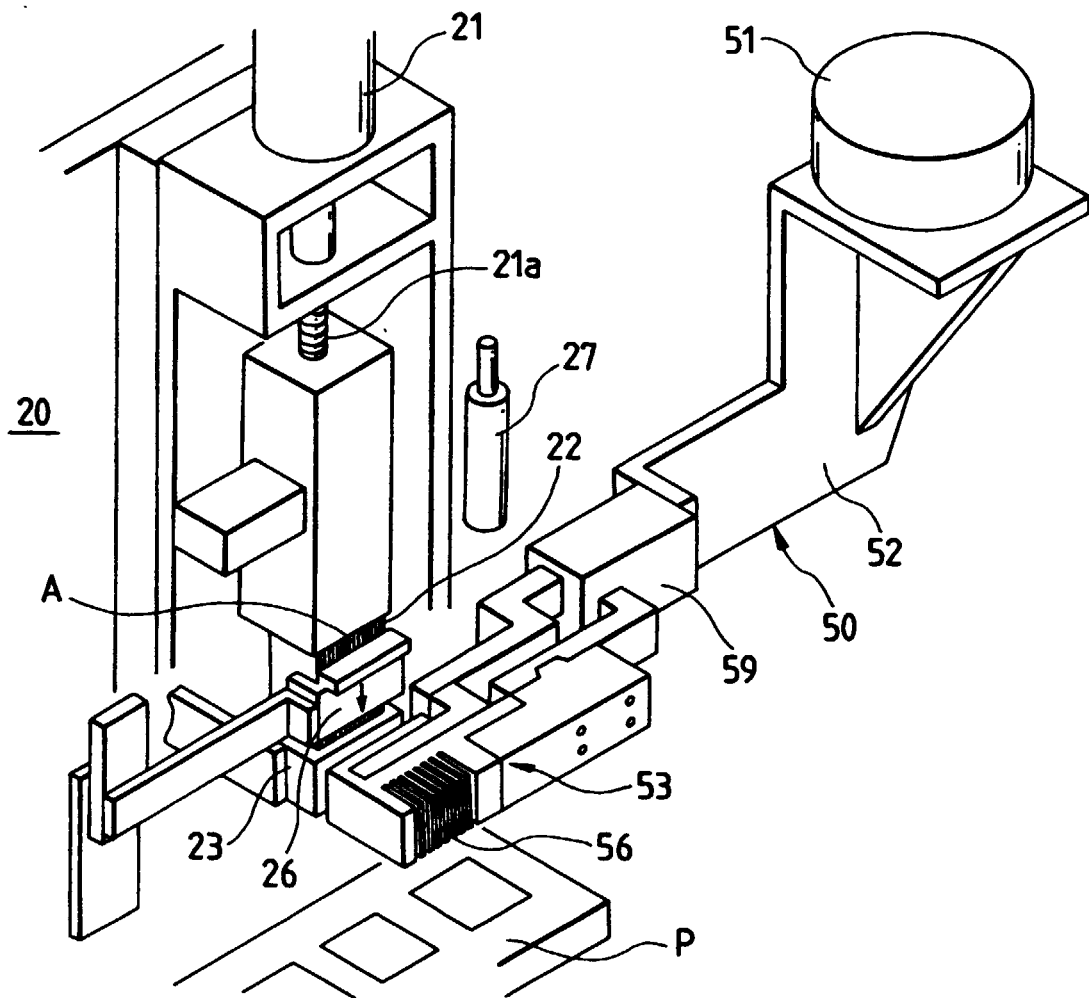
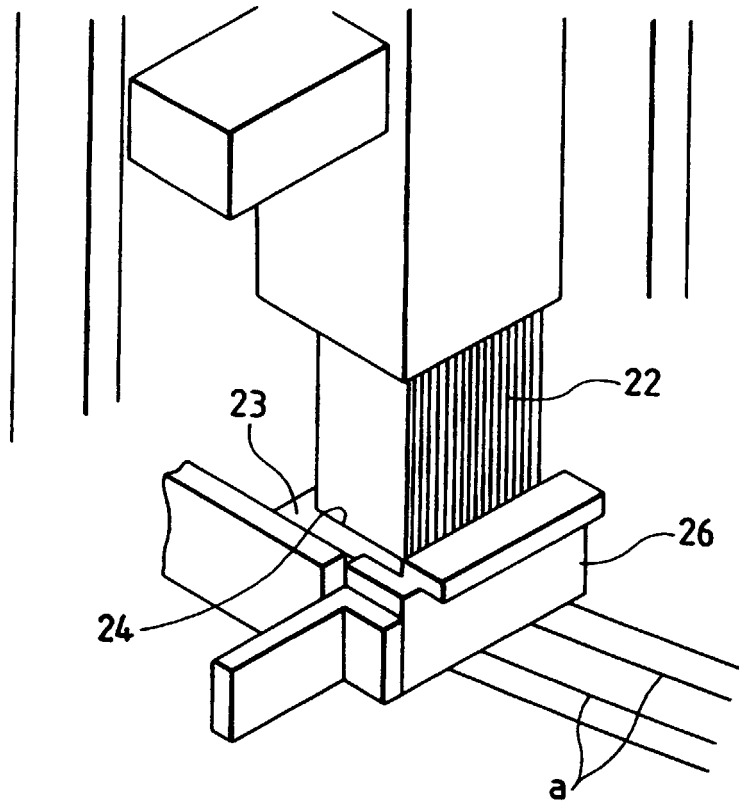


FIG. 2



**FIG. 3**



**FIG. 5**

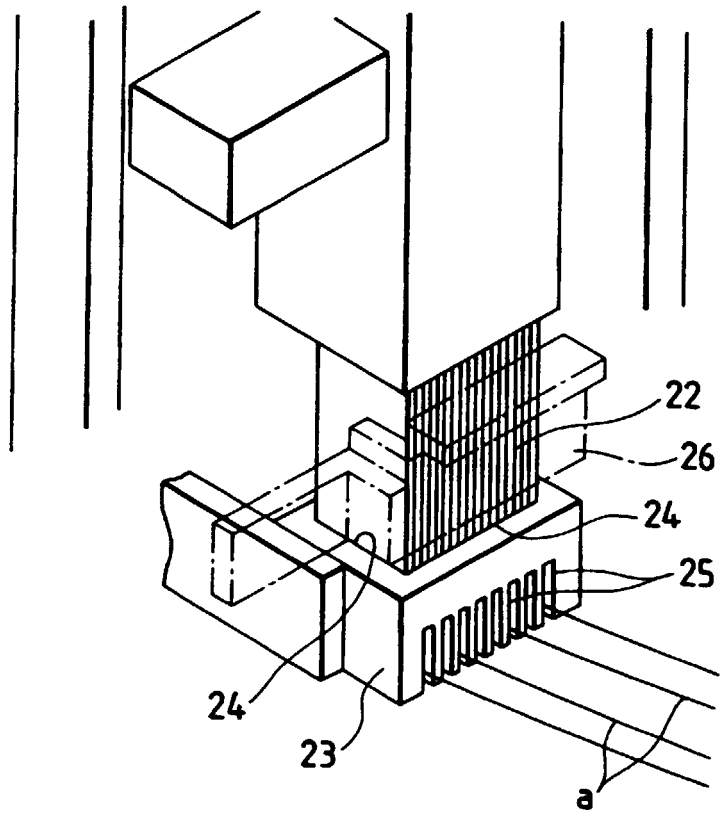


FIG. 4

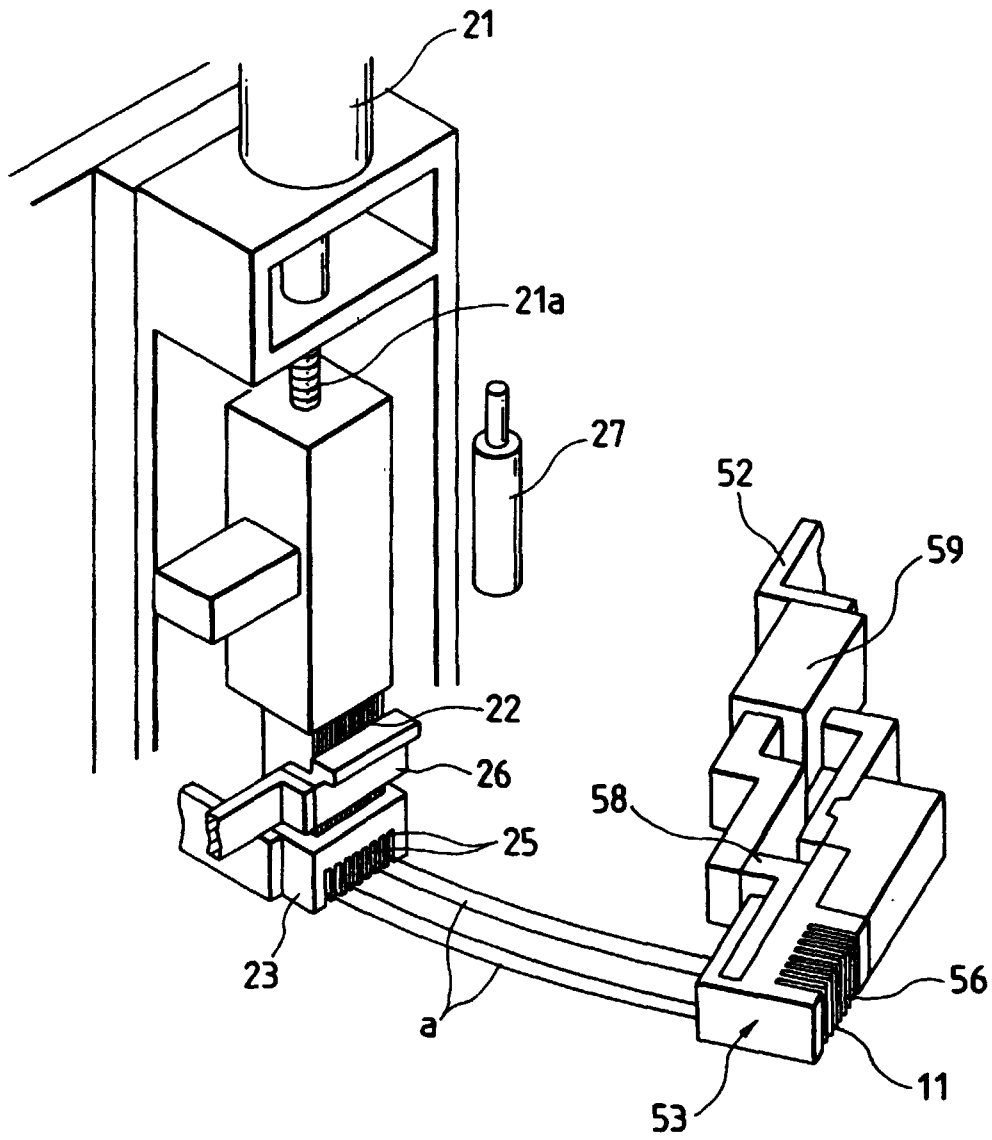


FIG. 6

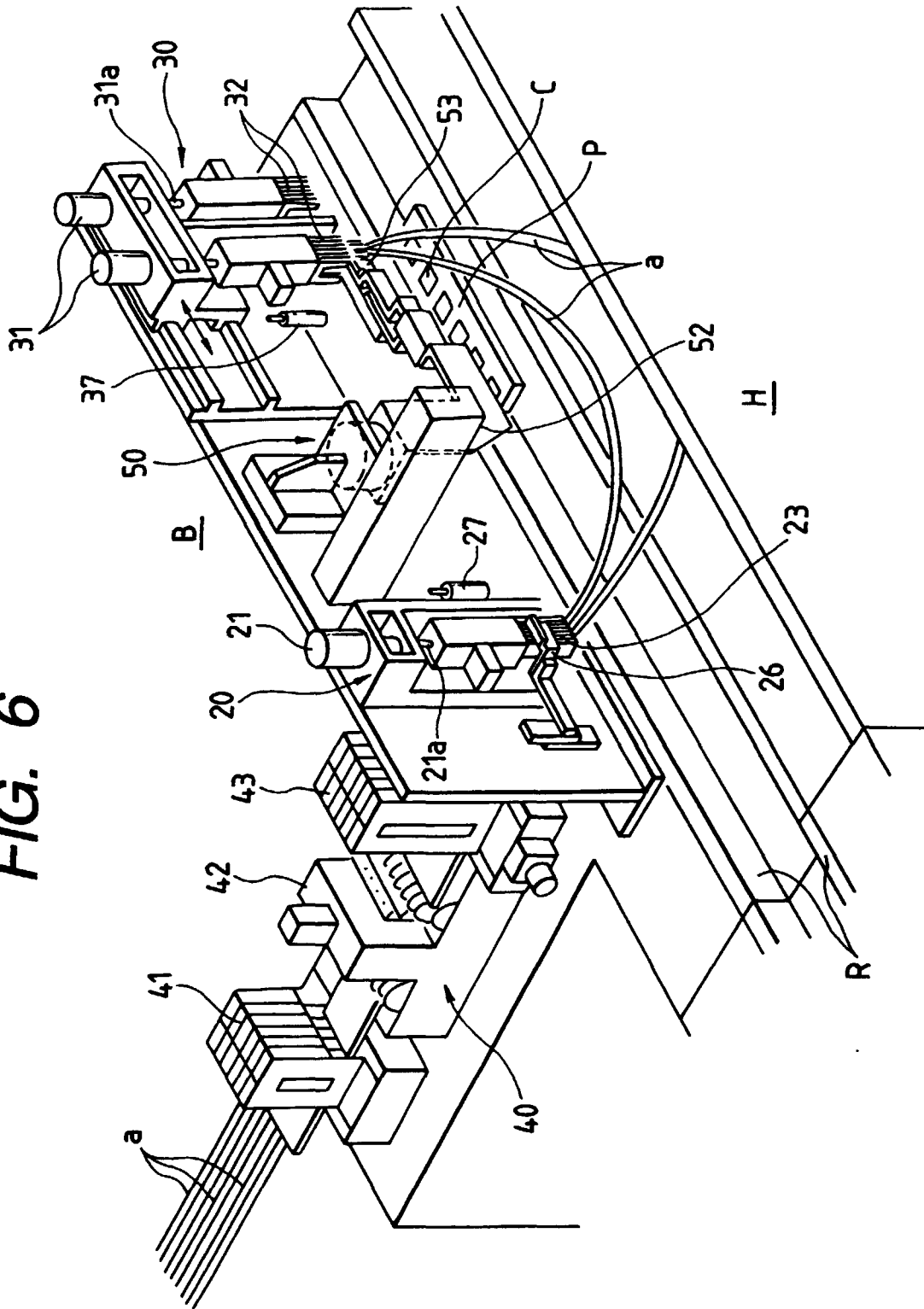


FIG. 7

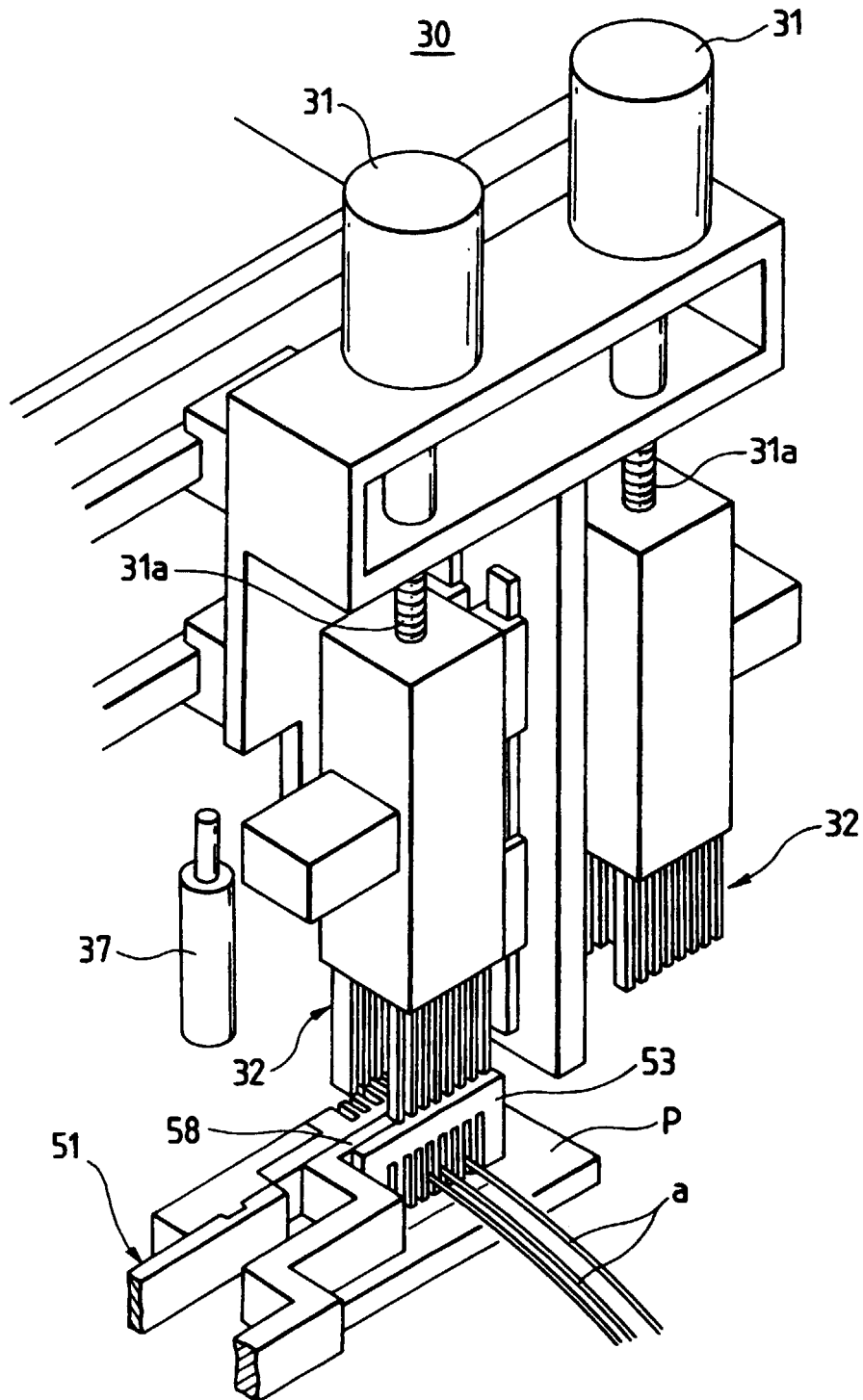
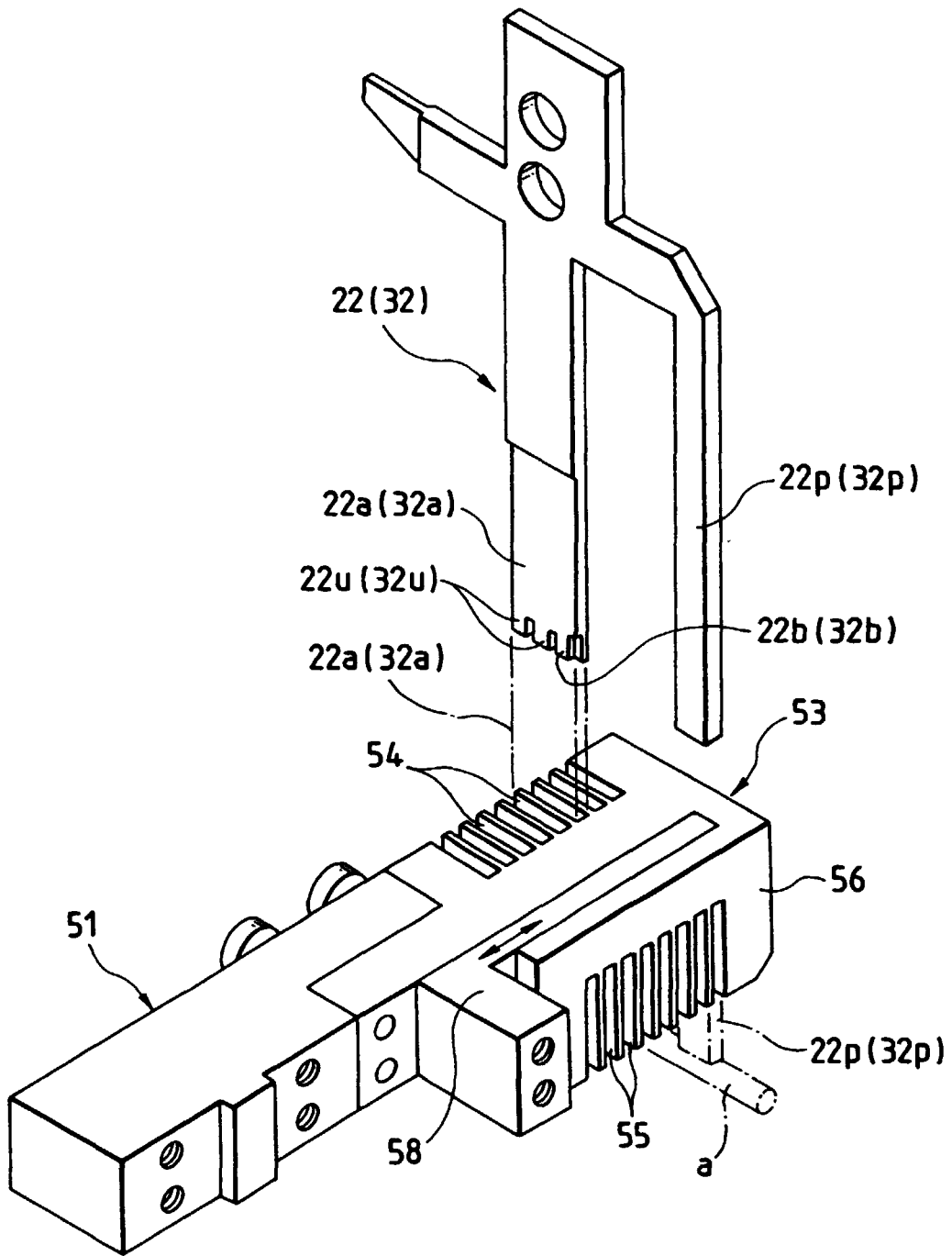
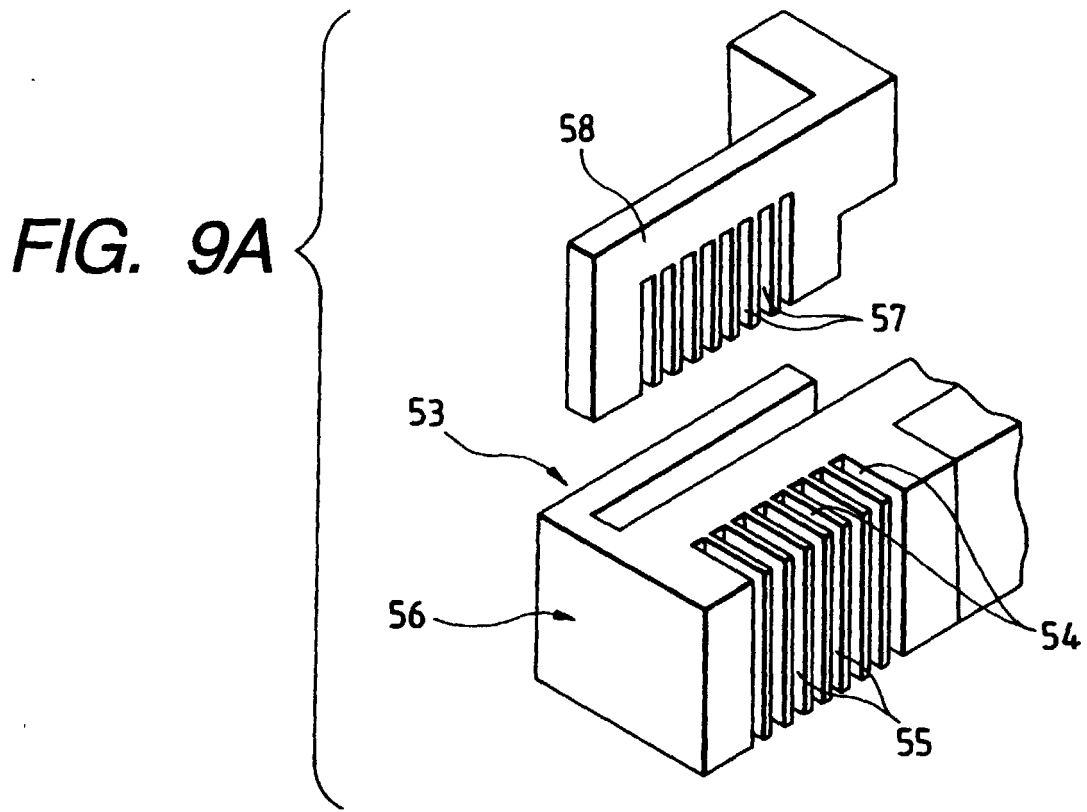


FIG. 8





**FIG. 9B**

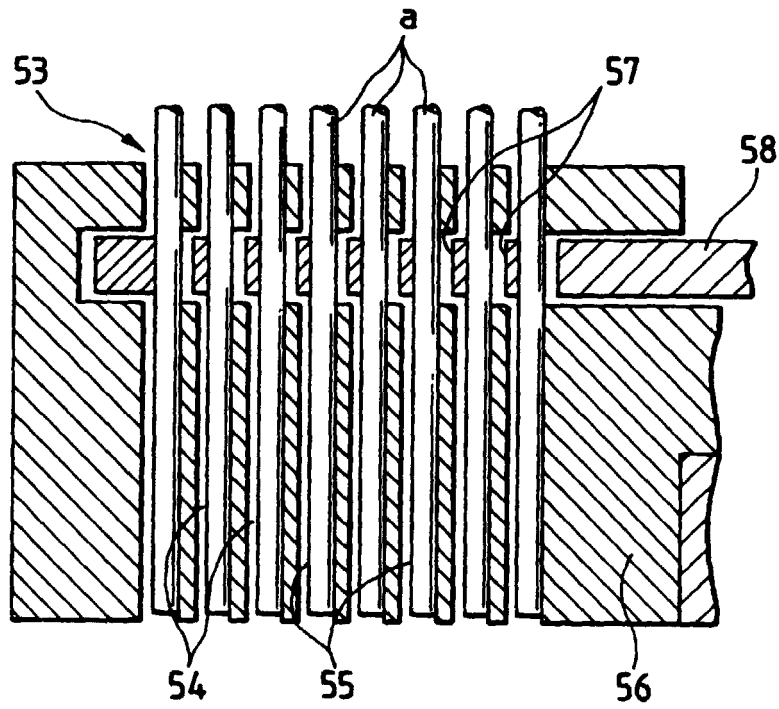


FIG. 10

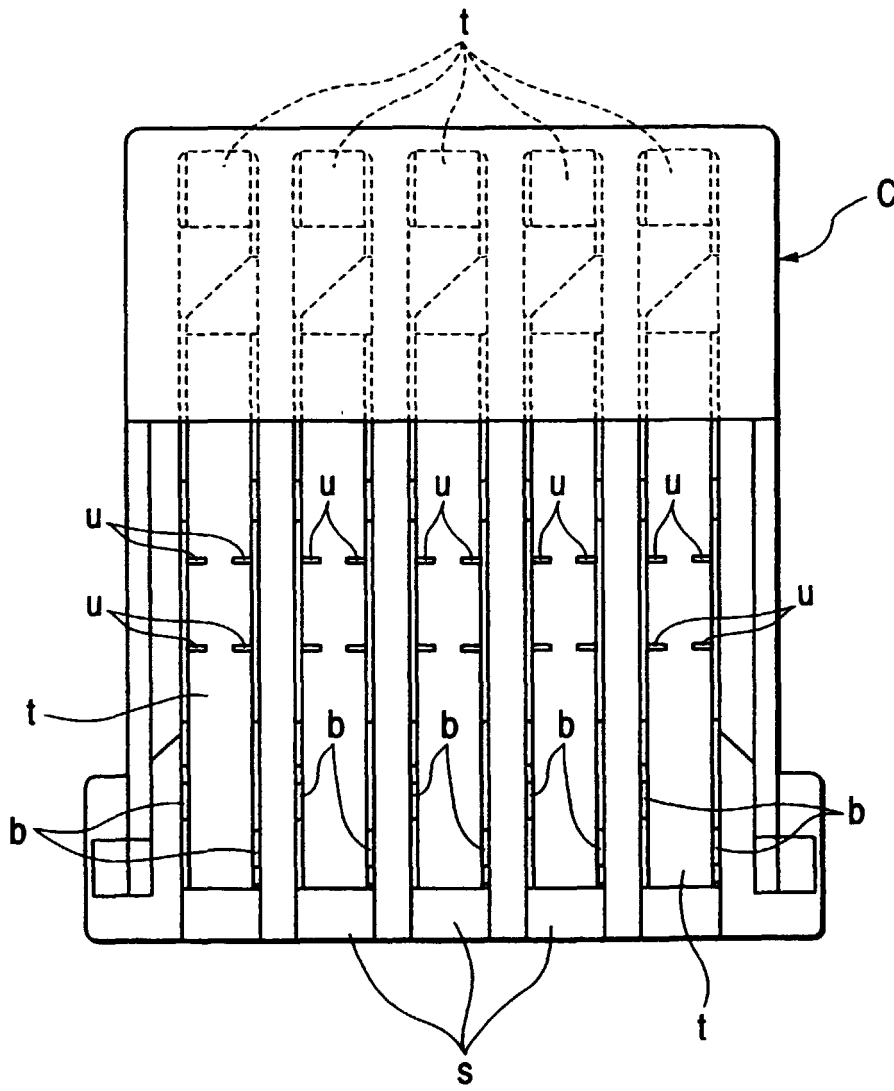


FIG. 11

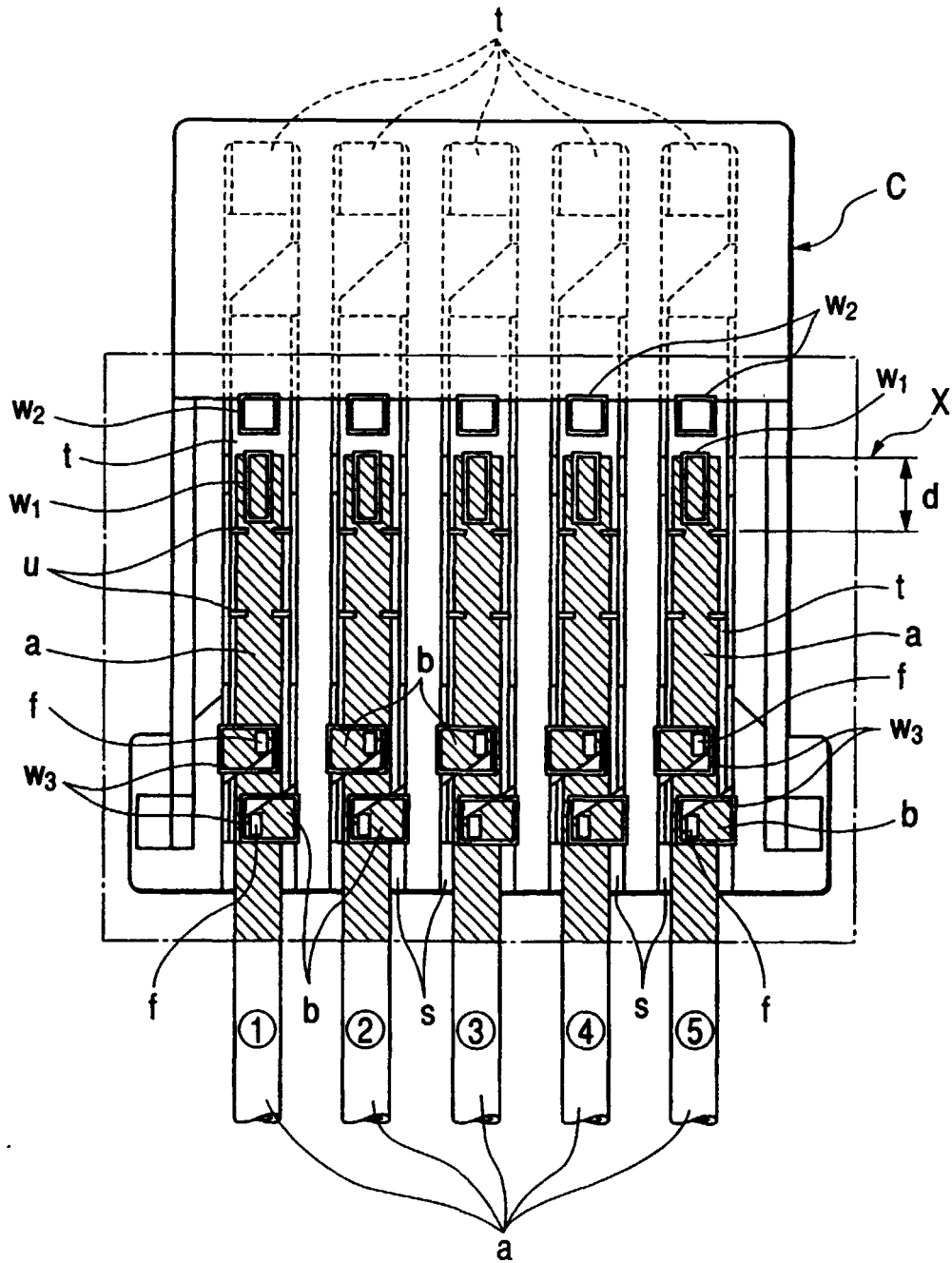


FIG. 12A

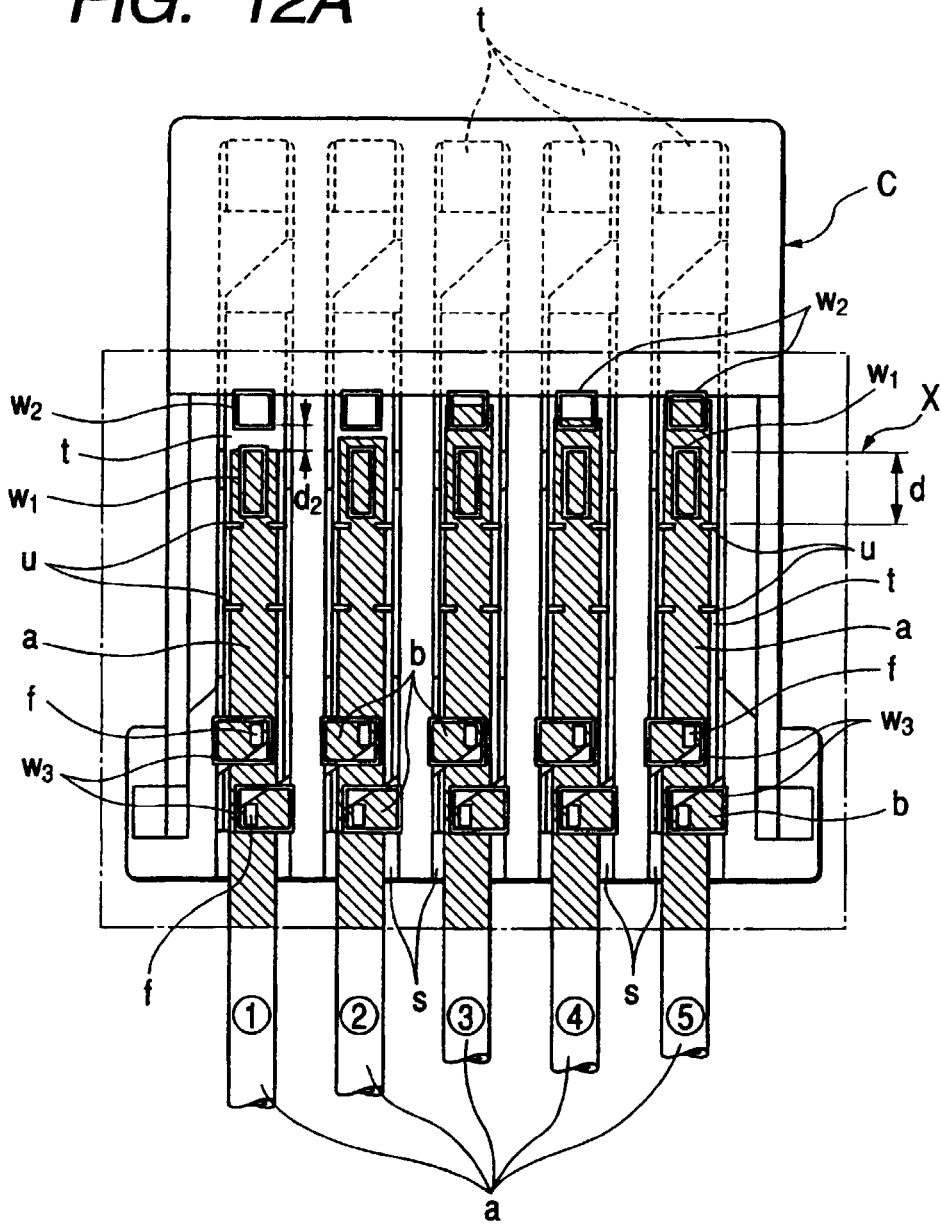


FIG. 12B

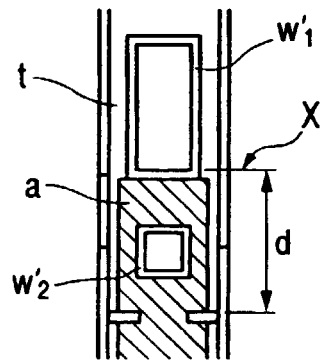


FIG. 13

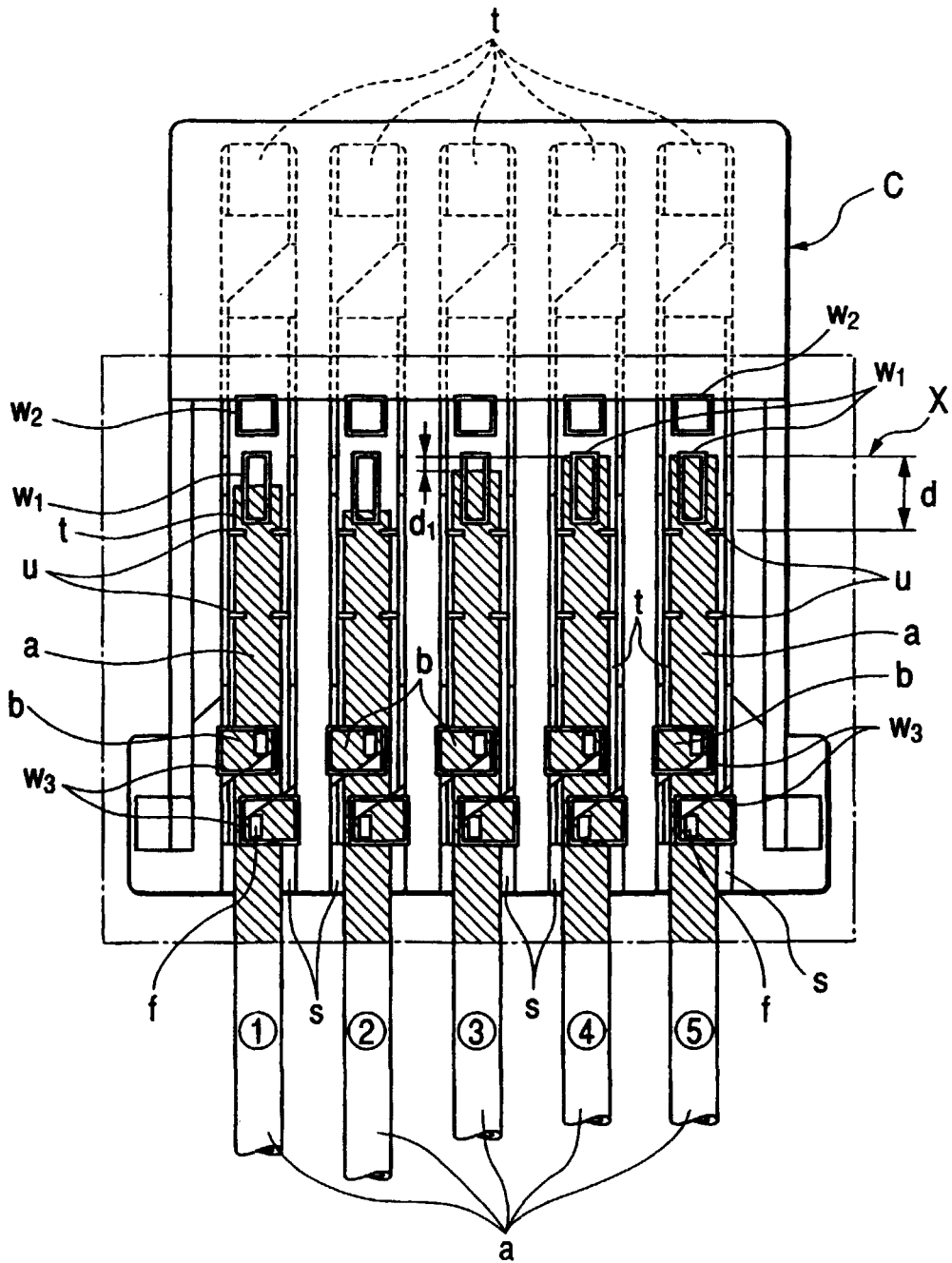


FIG. 14

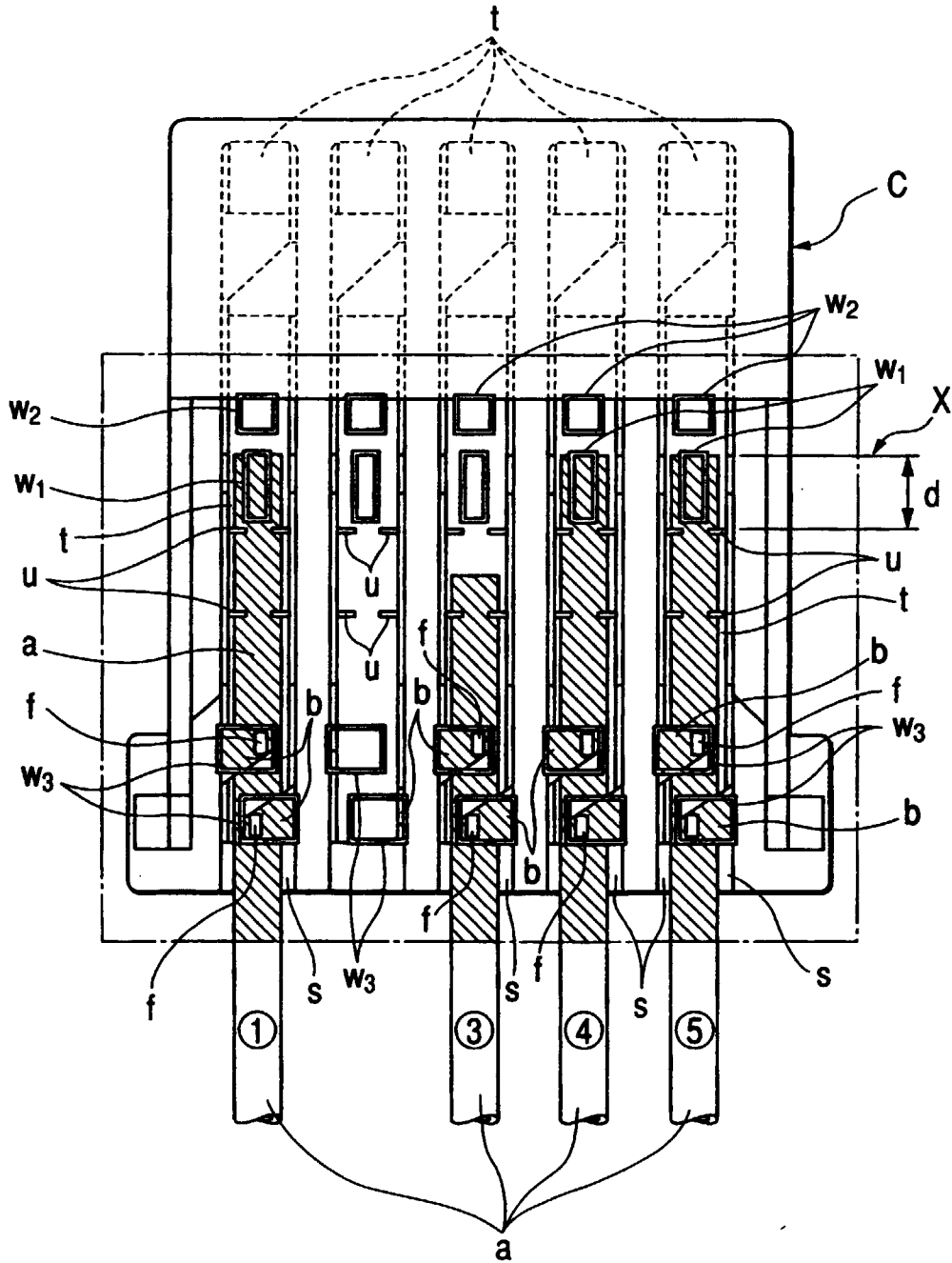


FIG. 15

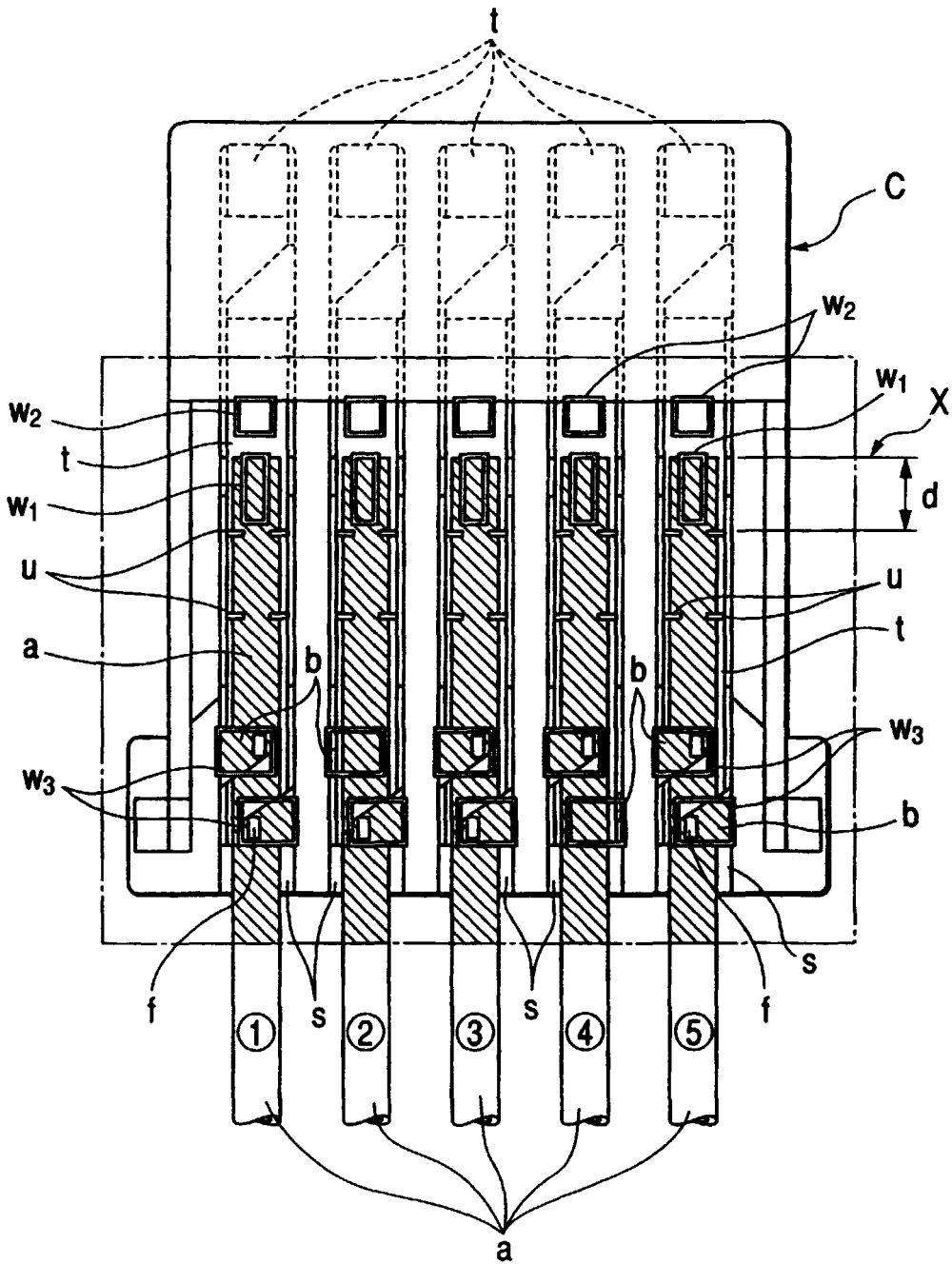
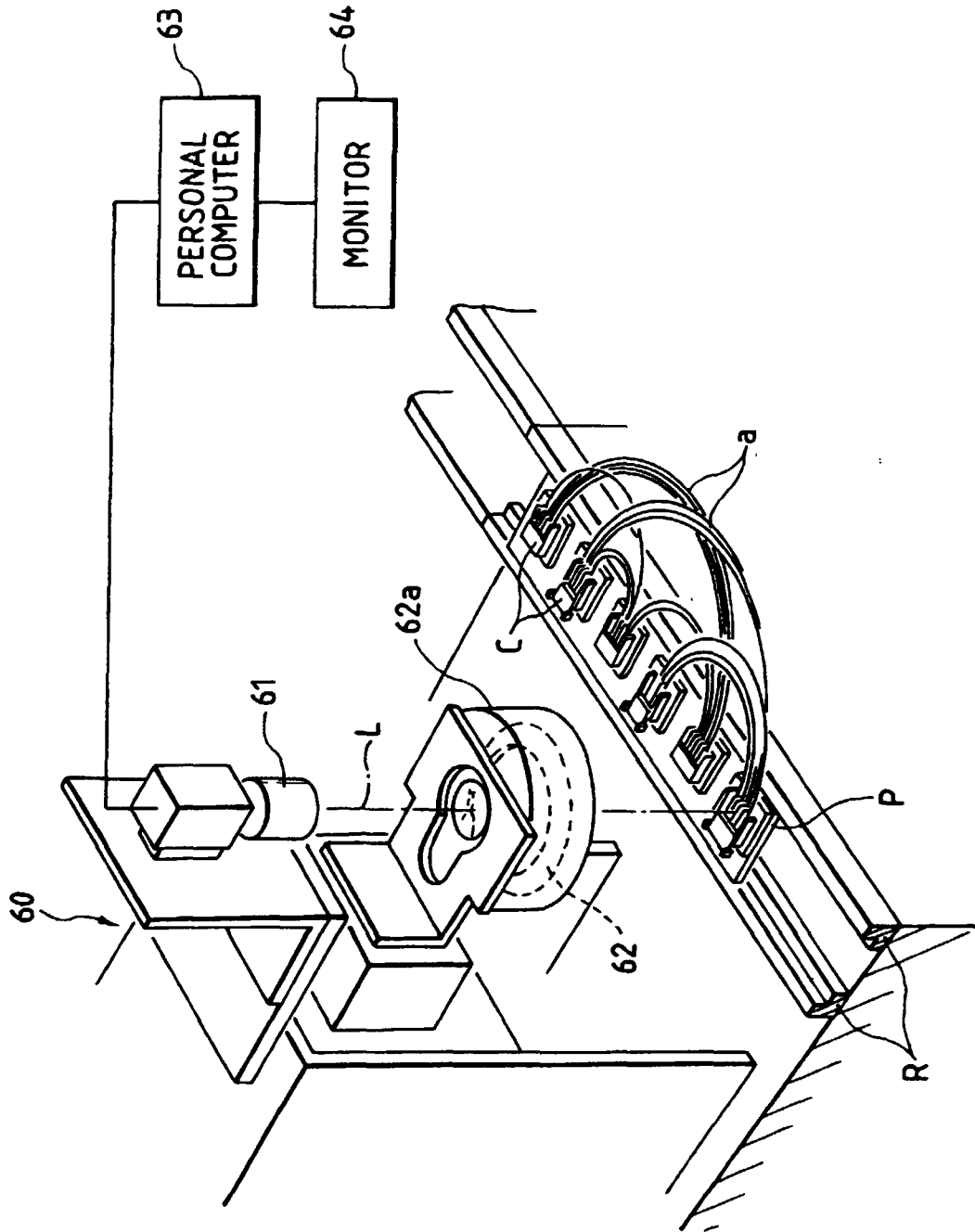


FIG. 16



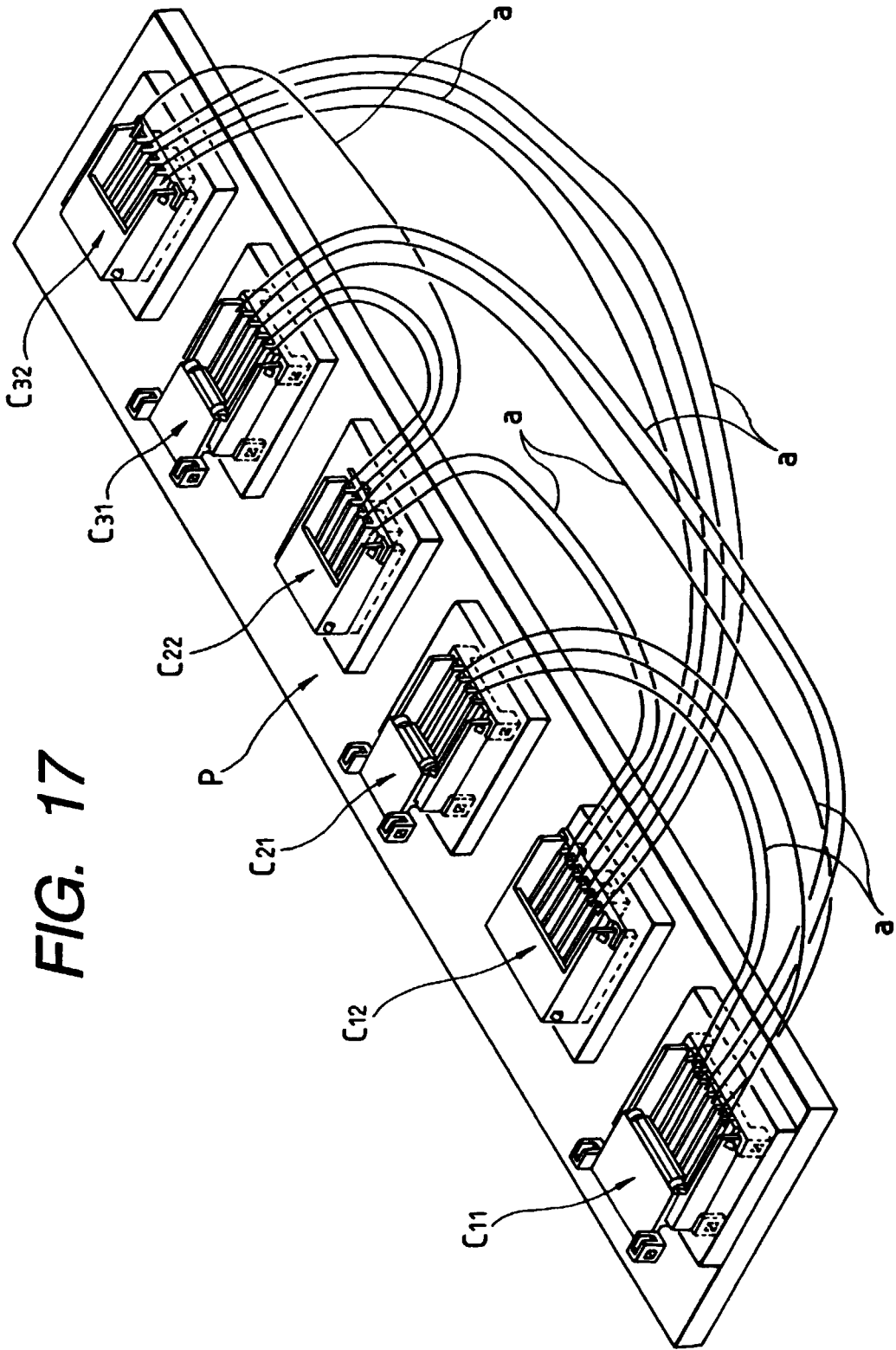
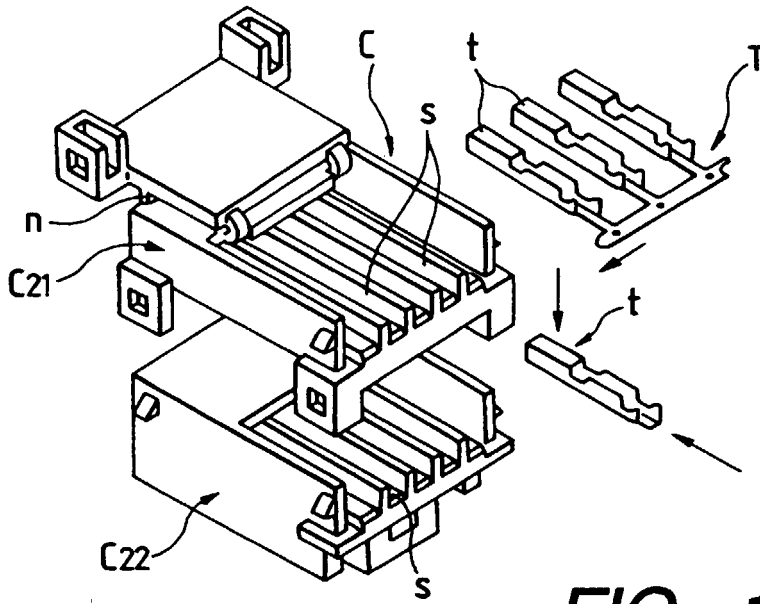
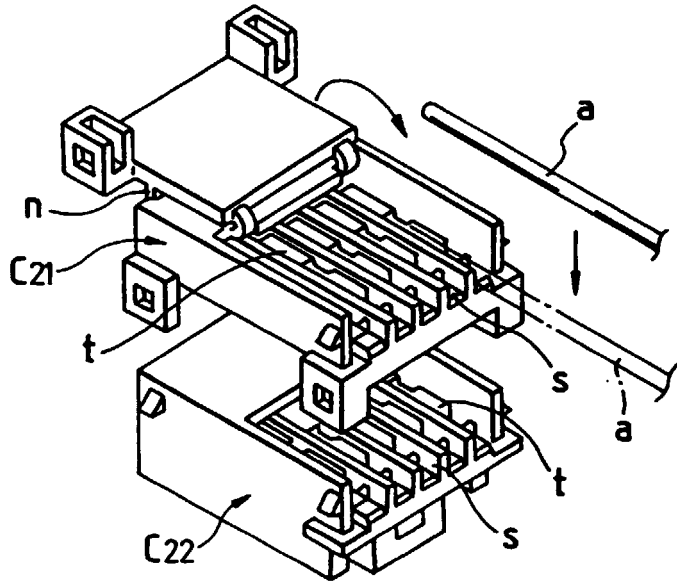


FIG. 17

**FIG. 18A**



**FIG. 18B**



**FIG. 18C**

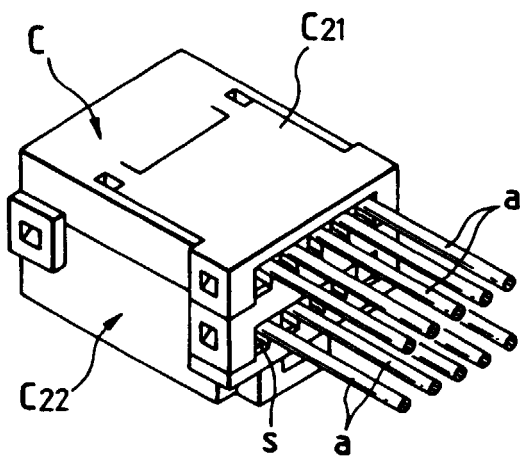
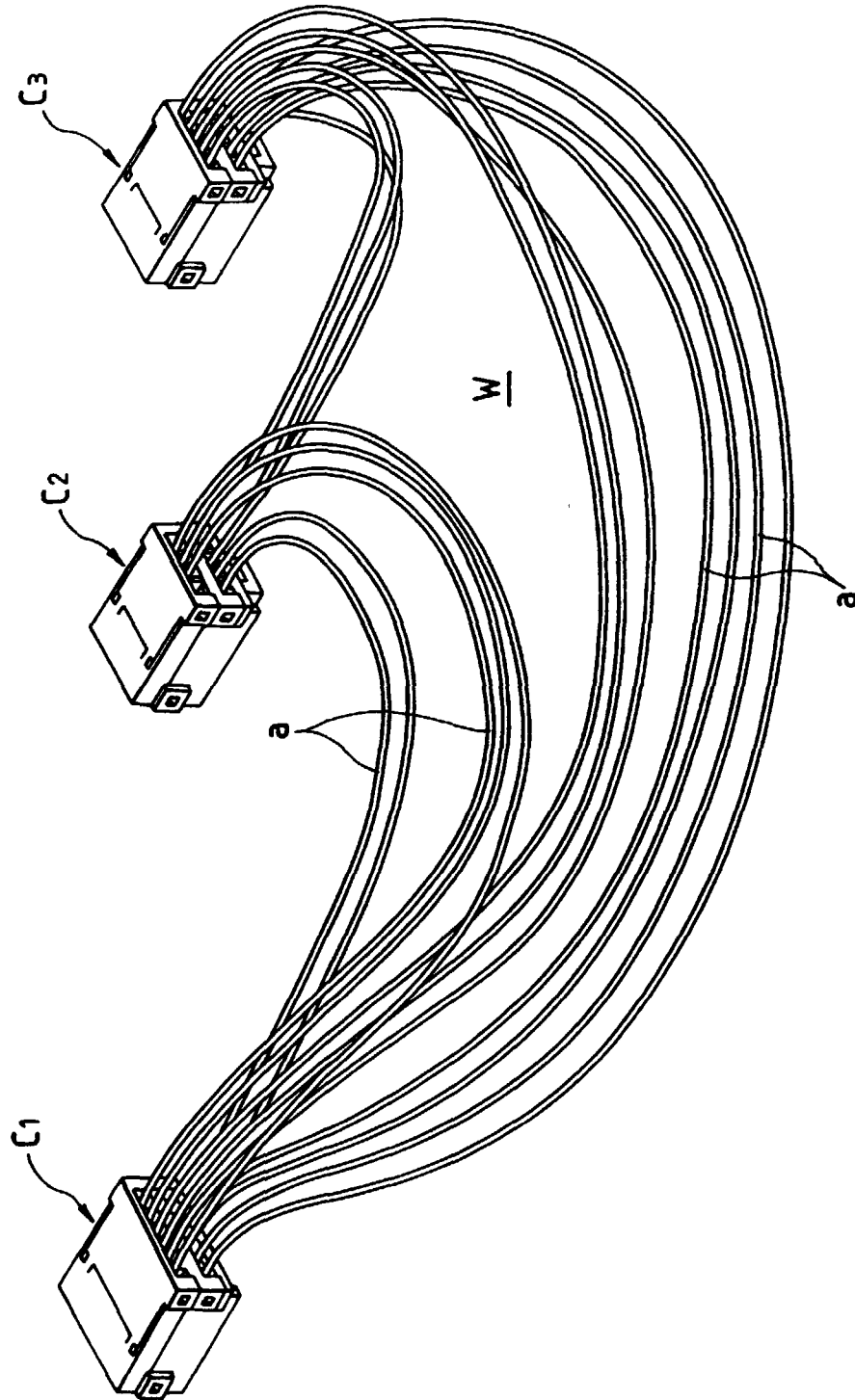
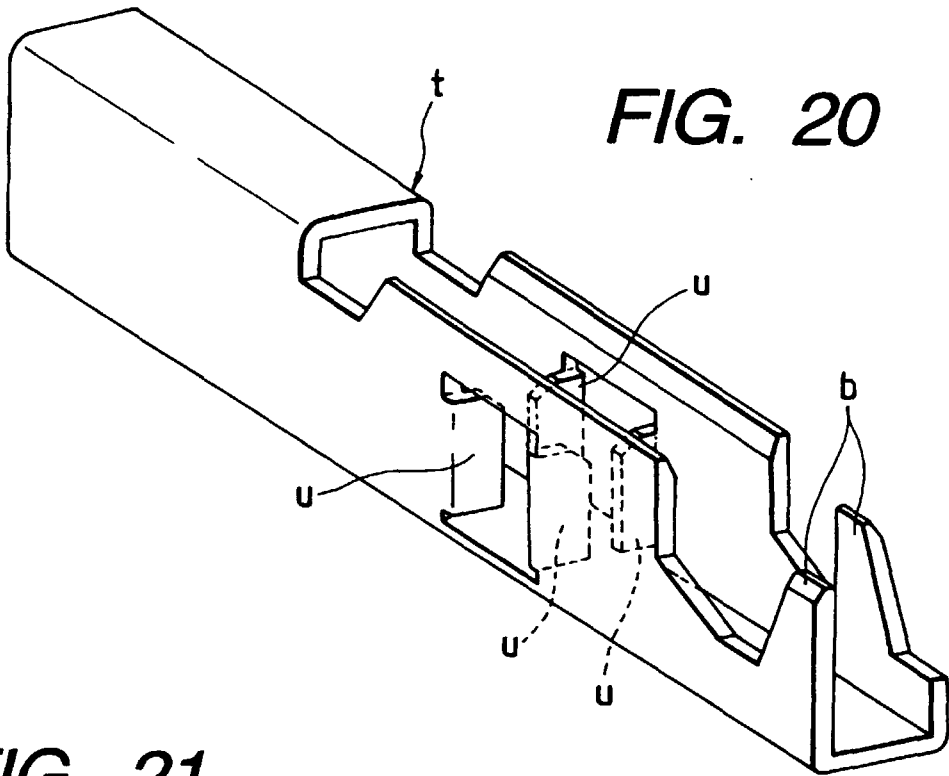
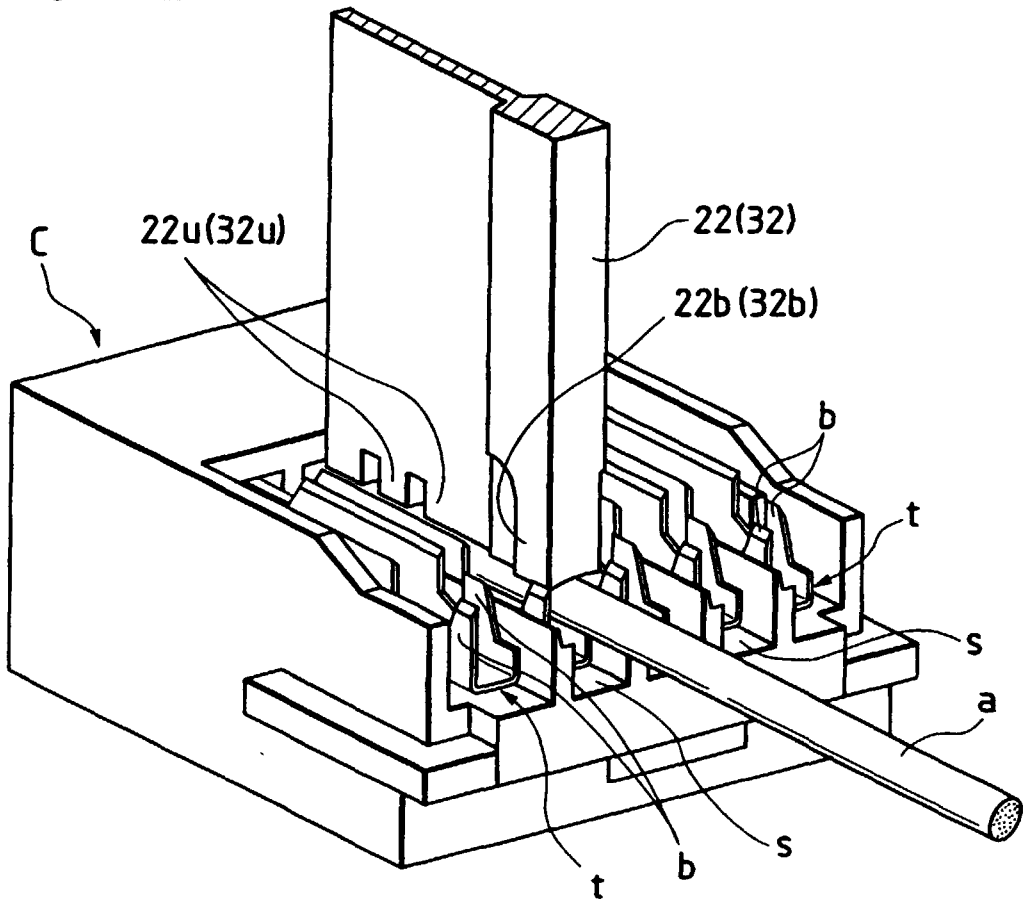


FIG. 19





**FIG. 21**





European Patent  
Office

EUROPEAN SEARCH REPORT

Application Number  
EP 00 10 5088

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Y	* figures 1,6,7,11-14,,17A,22 *	5,6	
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			H01R
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
BERLIN		12 July 2000	Marcolini, P
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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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EP 00 10 5088

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