



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 071 173 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.01.2001 Bulletin 2001/04

(51) Int. Cl.⁷: **H01R 43/048**

(21) Application number: **00115749.4**

(22) Date of filing: **21.07.2000**

(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

(30) Priority: **23.07.1999 JP 20873999**

(71) Applicant: **Yazaki Corporation**
Minato-ku, Tokyo 108-0073 (JP)

(72) Inventors:
• **Ishibashi, Teruyuki,**
c/o Yazaki Parts Co., Ltd.
Haibara-gun, Shizuoka 421-0407 (JP)
• **Tomikawa, Kazuyoshi,**
c/o Yazaki Parts Co., Ltd.
Haibara-gun, Shizuoka 421-0407 (JP)

(74) Representative:
Viering, Jentschura & Partner
Postfach 22 14 43
80504 München (DE)

(54) **Terminal crimping quality decision method/device and frictional wear state detection method of crimping die**

(57) The terminal crimping quality decision device determines the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus. The device uses a characteristic value envelop obtained when the terminal is crimped on the core. A reference value envelop is obtained from a characteristic value envelop obtained when a terminal is correctly crimped on the core. An increment envelop of the reference value envelop is calculated to obtain at least one singular point of the reference value envelop. The quality of a terminal crimped by the terminal crimping apparatus based on a characteristic value envelop of the crimped terminal. The characteristic value envelop is obtained in an envelop division separated by the singular point.

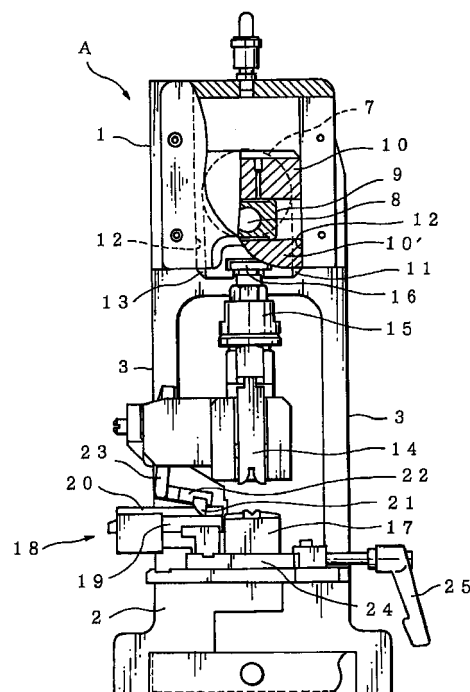


FIG. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a terminal crimping apparatus for a terminal-equipped electrical wire constituting a wiring harness or the like, a method/device for determining a terminal crimping quality, and a frictional wear state detection device of a crimping die that is important to determine the terminal crimping quality when the terminal is crimped by a terminal crimping apparatus.

2. Related Art

[0002] In a conventional terminal crimping apparatus, a terminal is crimped to an electrical cable by crimping a crimping barrel of the terminal on a core of the electrical cable. This crimping step has a possibility of incorrect crimping. Thus, there is provided an incorrect-crimping detection device for detecting the incorrect crimping of the terminal. This device, for example, samples characteristic values such as a load of the terminal crimping apparatus in time sequence during the crimping step, thereby obtaining a characteristic value envelop. The characteristic value envelop is compared with a reference value envelop preliminarily obtained from an acceptable crimped terminal product to determine acceptance or unacceptance of the crimped terminal. That is, for example as shown in FIG. 21, the acceptance or unacceptance of the crimped terminal is determined based on the difference between the reference value envelop and the characteristic value envelop of the crimped terminal, because a time-varying characteristic value such as a load of the crimping apparatus is different between a normal crimped state and an incorrect crimped state of the terminal.

[0003] However, there is a variation in the difference between the reference value envelop and the characteristic value envelop of the crimped terminal since the incorrectness degree of the crimped terminal is variable. For example, as illustrated in FIG. 22A, when a core wire portion of an electrical wire is not striped and an insulation portion of the electrical wire is crimped by a crimping barrel of a terminal, the difference between the reference value envelop and the characteristic value envelop becomes large as illustrated in FIG. 22B. Similarly, as illustrated in FIG. 23A, when the core wire portion is cut off at an end of the insulation layer of the electrical cable and a crimping barrel of a terminal is crimped, the electrical wire is crimped by a crimping barrel of a terminal, the difference between the reference value envelop and the characteristic value envelop becomes large as illustrated in FIG. 23B. Such serious defect leads easily to an unacceptance decision of the crimped terminal. However, as illustrated in FIG. 24A,

when a core wire portion of a terminal has core wires less than its normal number (for example, there is one lost wire), the difference between the reference value envelop and the characteristic value envelop becomes small as illustrated in FIG. 24B so that it is difficult to distinguish the unacceptable crimped terminal from an acceptable product.

[0004] Furthermore, for discriminating an acceptable product from an unacceptable product of crimped terminals, there has been proposed a method of comparing an area defined by a characteristic value envelop with a reference area defined by a reference value envelop. This method can find a serious defect of the crimped terminals which provides a large difference from the reference area, but can not find a defective crimped terminal because the area difference is not found, when the characteristic value envelop of a crimped terminal is greater in a former stage and smaller in a latter stage of the crimping than the reference value envelop.

[0005] Therefore, to improve the discrimination method, it has been tried that a divisional part of the envelop is used or that the envelop is divided in two or more parts for comparing with the corresponding reference value envelop. This provides a little improvement in the discrimination method but is insufficient. In addition, which part of the envelop should be selected or how the envelop should be divided to obtain a preset decision criteria has been decided mostly based on empirical knowledge of the art. Therefore, the decision criteria depends on the skill of personnel who preset it. Moreover, such preset criteria varies with types of the terminal, sizes (or types) of the electrical cable, and the combination thereof.

[0006] That is, how to preset the decision criteria has been determined by a trial and error method. For example, reference data is predetermined, and the reference data is modified according to results of test crimping of acceptance and unacceptable products. This requires much experience at much expense in time and effort. This causes a variability of the decision criteria with personnel who determine it. That is, it is difficult to set an appropriate decision criteria. To easily preset a decision criteria, if a threshold is commonly applied to each division or if the divisions are defined by a rough, uniform method, a rough decision criteria for a general purpose for productivity is obtained. However, such rough decision criteria does not improve the decision quality of crimped terminals.

[0007] As described above, the conventional incorrect-crimping detection device and the conventional crimping quality decision method can not find an unacceptable product having a small defect. Thus, such detection device has been used mainly to find a seriously defective product and is difficult to produce efficiently products having a correctly crimped terminal.

[0008] Meanwhile, a crimping die (a crimper or an anvil) is designed according to a design criteria pro-

vided for a crimping barrel of a terminal and for crimping the crimping barrel to a core wire portion of an electrical cable. The quality evaluation of the crimping die is mainly based on a mechanical characteristics and an electrical characteristics of resultant data of crimped terminals. No real-time evaluation of the crimping die has not been carried out, because it is difficult to capture dynamic motions of the terminal and the electrical cable during the crimping step. A larger frictional wear of the crimping die generally causes a larger flash (undesirable pushed-off portion in crimping) and may provide an undesirable crack in the crimped barrel, degrading the electrical or mechanical performance of the terminal.

[0009] Moreover, since it is difficult to directly measure the frictional wear degree of the crimping die, the wear degree has been determined by counting the number of crimping as a TPM (technical performance measurement) or by monitoring the size of a flash (undesirable pushed-off portion) of the crimped portion. However, the relation between the number of crimping and the frictional wear of the crimping die varies with types of the terminals, sizes of the electrical cables, and the combination thereof. Thus, the number of crimping is unsatisfactorily applied by itself to the measure of the frictional wear. Furthermore, since it is difficult to preset a definite tolerance of the back flash, a crimped portion of the terminal has been cut out so that the cut-out piece has been distinguished microscopically whether there is a crack therein. This method requires an expense in time and effort and can not make a real-time decision of the frictional wear.

[0010] Moreover, in the conventional incorrect-crimping detection device, reference value envelopes for acceptance/unacceptance decision of crimped terminals have been obtained by sampling characteristic value envelopes of the crimped terminals during the crimping steps before a normal mass production. The reference value envelopes have been replaced by new ones for each lot of the terminals. This may produce a large amount of incorrectly crimped terminals if the crimping die becomes in an abnormal state which is not easily found.

SUMMARY OF THE INVENTION

[0011] In view of the aforementioned disadvantages, an object of the present invention is to enable a reliable acceptance/unacceptance decision of crimped terminals in quality and to surely find even a crimped terminal having a small incorrectness. Furthermore, the present invention allows a sure, efficient recognition of a frictional wear state of a crimping die, enabling an efficient production of the crimped terminals of satisfactory quality.

[0012] For achieving the object, a first aspect of the present invention is a terminal crimping quality decision method for determining the quality of a terminal crimped

on a core of an electrical cable by a terminal crimping apparatus. The method uses a characteristic value envelop of characteristic values obtained when the terminal is crimped on the core. In the method, a reference value envelop of characteristic values is obtained when a terminal is correctly crimped on the core. An increment envelop of the reference value envelop is calculated to obtain at least one singular point of the reference value envelop. The quality of a terminal crimped on the core is determined based on a characteristic value envelop which is obtained in a division separated by the singular point.

[0013] During the crimping step, a load of the terminal crimping apparatus or a deflection of a component of the apparatus varies characteristically at a point where a crimping force for crimping the terminal varies from an increase stage to a decrease stage at an initial deflection step of the terminal, at a point where the terminal begins to contact the core so that the crimping force varies again to an increase stage, at a point where the crimping force varies from the increase stage to a decrease stage during a step for crimping the terminal on the core, and at a point where the crimping force reaches zero. It has been found that these points each appear as a singular point on a characteristic value envelop obtained during the crimping step. These singular points are obtained by calculating the increment envelop of the reference value envelop.

[0014] The divisions defined by the singular points each correspond to one of the sequential crimping steps. Thus, the method of the first aspect makes a quality decision of the crimped terminal in one of the divisions of the characteristic value envelop, allowing an reliable acceptance /unacceptance decision of the crimped terminal quality and recognizing a crimped terminal having a small incorrectness. Thus, an efficient production of products each acceptable in the crimping quality of a terminal is achieved.

[0015] A second aspect of the present invention is a terminal crimping quality decision method for determining the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus. The method uses a characteristic value envelop obtained when the terminal is crimped on the core. In the method, a reference value envelop is defined from a characteristic value envelop obtained when a terminal is correctly crimped on the core. An increment envelop of the reference value envelop is calculated to obtain a singular point of the reference value envelop. The quality of a terminal crimped on the core is determined based on a characteristic value envelop which is obtained in a former division defined by a peak related to the singular point.

[0016] In the method of the second aspect, the former division positioned backward from the peak of the characteristic value envelop is used for determining the crimping quality. This improves in resolution of the characteristic value envelop to provide a decision more

accurate than when all the characteristic value envelop is used.

[0017] A third aspect of the present invention is the method described in the first aspect. In the step of determining the crimping quality of a terminal, a difference between the reference value envelop and a characteristic value envelop obtained of the terminal is calculated to obtain a ratio of the difference to the reference value envelop. The ratio is compared with a predetermined threshold in respect of the division.

[0018] The method of the third aspect provides the same operational effects as the first aspect of the present invention. In addition, the ratio of the difference of the characteristic value envelop to the reference value envelop is compared with the predetermined threshold. The threshold which is a decision criteria constant within the division is advantageous for calculation to evaluate the crimped terminal quality.

[0019] A fourth aspect of the present invention is the method described in the third aspect. The crimping quality of the terminal is determined based on an extent of the ratio exceeding the threshold in respect of the division.

[0020] The method of the fourth aspect provides the same operational effects as the third aspect of the present invention. In addition, the ratio of the difference of the characteristic value envelop to the reference value envelop is greater than the threshold to an extent which is used for the crimping quality decision. This eliminates a detection error of the characteristic value envelop due to an external disturbance like a noise, allowing a reliable quality decision of the crimped terminals.

[0021] A fifth aspect of the present invention is the method described in the third or fourth aspect. The terminal crimping apparatus comprises a computer having a decision criteria presetting program and a terminal crimping quality decision program, and the reference value envelop and the threshold are preset by executing the decision criteria presetting program, while the quality of the crimped terminal is determined by executing the terminal crimping quality decision program.

[0022] The method of the fifth aspect provides the same operational effects as the third or fourth aspect of the present invention. In addition, the terminal crimping quality decision apparatus includes the computer that executes the decision criteria presetting program and the terminal crimping quality decision program, allowing an efficient work in preset of the reference value envelop and the threshold and in detection of an incorrectly crimped terminal.

[0023] A sixth aspect of the present invention is a terminal crimping quality decision device for determining the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus. The device uses a characteristic value envelop obtained when the terminal is crimped on the core. In the device, a reference value envelop is defined from characteristic

values obtained when a terminal is correctly crimped on the core. An increment envelop of the reference value envelop is calculated to obtain at least one singular point of the reference value envelop. The crimping quality of a terminal crimped on the core is determined based on a characteristic value envelop which is obtained in a division separated by the singular point. The terminal crimping quality decision apparatus provides the same operational effects as the first aspect of the invention.

[0024] A seventh aspect of the present invention is a terminal crimping quality decision device for determining the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus. The device uses a characteristic value envelop of characteristic values obtained when the terminal is crimped on the core. In the device, a reference value envelop is obtained from characteristic values sensed when a terminal is correctly crimped on the electrical cable. An increment envelop of the reference value envelop is calculated to obtain at least one singular point of the reference value envelop. The crimping quality of a terminal crimped on the core is determined based on a characteristic value envelop which is obtained in a former division defined by a peak related to the singular point. The terminal crimping quality decision apparatus provides the same operational effects as the second aspect of the invention.

[0025] An eighth aspect of the present invention is the apparatus described in the sixth aspect. The decision means calculates a difference between the reference value envelop and a characteristic value envelop obtained of the terminal, and the decision means obtains a ratio of the difference to the reference value envelop to compare the ratio with a predetermined threshold in respect of the division. The terminal crimping quality decision apparatus provides the same operational effects as the third and sixth aspects of the invention.

[0026] A ninth aspect of the present invention is the apparatus described in the eighth aspect. The decision means determines the crimping quality of the terminal based on an extent of the ratio over the threshold in respect of the division. The terminal crimping quality decision apparatus provides the same operational effects as the fourth and eighth aspects of the invention.

[0027] A tenth aspect of the present invention is a frictional wear state detection method for detecting a frictional wear of a crimping die used in a terminal crimping apparatus. In the method, a terminal is crimped on a core of an electrical cable by using a normal crimping die to store a characteristic value envelop obtained in the crimping step as a reference value envelop. Then, a terminal is correctly crimped on a core of an electrical cable by using an actual crimping die to obtain a characteristic value envelop. The characteristic value envelop obtained when the actual crimping die is used is compared with the stored reference value

envelop.

[0028] The reference value envelop is preset based on the characteristic value envelop of the terminal correctly crimped by the terminal crimping apparatus. A characteristic value envelop obtained during a crimping step of a terminal is compared with the reference value envelop to determine whether the terminal is incorrectly crimped. However, the reference value envelop that is newly preset varies with the frictional wear of the crimping die of the terminal crimping apparatus. Thus, in the frictional wear state detection method of the crimping die, the reference value envelop obtained by using a crimping die having a frictional wear is different from a stored initial reference value envelop that has been obtained when the crimping die was in a normal state. The difference suggests the frictional wear of the crimping die, allowing efficient replacement of the crimping die to prevent abnormal crimping of the terminals. Thus, an efficient production of products each acceptable in the crimping quality of a terminal is achieved.

[0029] An eleventh aspect of the present invention is a frictional wear state detection method of a crimping die used in a plurality of terminal crimping apparatuses. Each of the terminal crimping apparatuses has a detection device for detecting incorrect crimping of a terminal. The detection devices constitute a network with a computer. In the method, a terminal is crimped on a core of an electrical cable by using a normal crimping die mounted on one of the terminal crimping apparatuses to store a characteristic value envelop obtained in a crimping step as a reference value envelop. A terminal is correctly crimped on a core of an electrical cable by using an actual crimping die mounted in one of the terminal crimping apparatuses to obtain a characteristic value envelop. The characteristic value envelop obtained when the actual crimping die is used is compared with the stored reference value envelop. The reference value envelop obtained in the one of terminal crimping apparatuses can be used for any of the terminal crimping apparatuses for detecting a frictional wear of a crimping die.

[0030] In the method of the eleventh aspect, the plurality of terminal crimping apparatuses can transmit reference value envelopes among the apparatuses. This is advantageous for knowing whether a present reference value envelop is appropriate during a production step of crimped terminals and for detecting a frictional wear state of a crimping die, allowing efficient replacement of the crimping die to prevent abnormal crimping of terminals. In addition, the computer, for example, can analyze the reference value envelop in detail. Thus, an efficient production of products each acceptable in the crimping quality of a terminal is achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

FIG. 1 is a front view showing a terminal crimping apparatus according to the present invention;

FIG. 2 is a side view showing the terminal crimping apparatus;

FIG. 3 is a view illustrating a state in which a position sensing device is provided in an embodiment of the present invention;

FIG. 4 is a block diagram showing an incorrect-crimping detection device B related to the embodiment;

FIGS. 5A, 5B each are a graph of a reference value envelop or of an increment envelop of the reference value envelop according to the present invention, the graphs showing singular points of the reference value envelop;

FIGS. 6A to 6E each are a sectional view showing a crimper, an anvil, a crimping barrel of a terminal, and core wires in a crimping step of the embodiment;

FIGS. 7A, 7B each are a graph related to the embodiment and showing a characteristic value envelop corresponding to an incorrectly crimped terminal, in which the singular points of the reference value envelop are indicated;

FIG. 8 is a graph related to the embodiment and showing a ratio envelop obtained by an acceptable product, the graph also showing a plurality of threshold lines;

FIG. 9 is a graph related to the embodiment and showing a ratio envelop corresponding to an unacceptable product in which one-third length of a crimping barrel of a terminal is striking through an insulation of an associated cable, the graph also showing a plurality of threshold lines;

FIG. 10 is a graph related to the embodiment and showing a ratio envelop corresponding to an unacceptable product in which a half length of a crimping barrel of a terminal is striking through an insulation of an associated cable, the graph also showing a plurality of threshold lines;

FIG. 11 is a graph related to the embodiment and showing a ratio envelop corresponding to an unacceptable product in which one-seventh number of core wires of a cable are cut away, the graph also showing a plurality of threshold lines;

FIG. 12 is a graph related to the embodiment and showing a ratio envelop corresponding to an unacceptable product in which one-third length of a crimping barrel of a terminal has no core wires to be crimped, the graph also showing a plurality of threshold lines;

FIG. 13 is a graph related to the embodiment for showing an increment envelop of characteristic values obtained when a crimping barrel or a crimping die is in an undesirable state, the graph also showing a plurality of singular points;

FIG. 14 is a flowchart of a decision criteria presetting program of the embodiment;

FIG. 15 is a flowchart of a terminal crimping quality decision program of the embodiment;

FIGS. 16A to 16C each are a graph showing a print-out of ratio envelopes for presetting a decision criteria of the embodiment;

FIG. 17 is a general diagrammatic illustration showing a network system including a plurality of incorrect-crimping detection devices and a processing computer of the embodiment;

FIG. 18 is a graph showing reference value envelopes each corresponding to a new crimping die or an old one for comparison thereof;

FIG. 19 is a diagrammatic view showing a constitution for sensing a deflection of a frame of a terminal crimping apparatus in the embodiment;

FIG. 20 is a graph related to the embodiment and showing another increment envelop of a crimping characteristics, the graph also showing singular points of the crimping characteristics;

FIG. 21 is a graph showing characteristic value envelopes each related to a correct crimped state or an incorrect crimped state for comparison thereof;

FIG. 22A is a view showing an incorrect crimped state in which an insulation layer of a cable is struck through, and FIG. 22B is a graph for showing a difference between a reference value envelop and a characteristic value envelop ;

FIG. 23A is a view showing an incorrect crimped state in which there are no core wires to be crimped, and FIG. 23B is a graph for showing a difference between a reference value envelop and a characteristic value envelop of the incorrect crimped state; and

FIG. 24A is a view an incorrect crimped state in which some core wires to be crimped are cut away, and FIG. 24B is a graph for showing a difference between a reference value envelop and a characteristic value envelop of the incorrect crimped state.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0032] Referring to the accompanied drawings, an embodiment of the present invention will be discussed. FIG. 1 is a front view showing a terminal crimping apparatus according to the present invention. FIG. 2 is a side view showing the terminal crimping apparatus. In the drawing, denoted 1 is a casing of a terminal crimping apparatus A. The casing has a base plate 2 and each side plate 3, 3 rising from the base plate 2. In a position backward from upper parts of side plates 3, 3, there is disposed a servomotor 4 having a reduction gear 5 to be fixed to the casing. The reduction gear 5 has an output shaft 6 engaged with a circular plate 7 having a decentered pin (crank shaft) 8. The decentered pin 8 is engaged with a sliding block 9. The sliding block 9 is positioned between a pair of upper and lower retainers 10 and 10' fitted to a ram 11, so that the turning of the

circular plate 7 moves the sliding block 9 in a horizontal direction between the retainers 10, 10' to move the ram 11 vertically. The ram 11 can slide vertically between a pair of ram guides 12, 12 each provided on an inner surface of each of the side plates 3, 3. The circular plate 7, the sliding block 9, the retainers 10, 10', the ram 11, and the ram guides 12, 12 constitute a piston-crank mechanism.

[0033] The ram 11 has an engagement concave 13 at a lower end thereof. The concave 13 removably receives an engagement convex 16 of a crimper holder 15 retaining a crimper (crimping die) 14. With opposed to the crimper 14, there is provided an anvil 17 under the crimper 14. The anvil 17 is fixed to an anvil mounting plate 24 mounted on the base plate 2. As illustrated in FIG. 3, the ram 11 is formed with a horizontal notch 11a which defines a lower body 11A, an upper body 11B, and a connection portion 11c to provide a resiliency to the ram 11. This resilient ram 11 allow a vertical deflection thereof in response to a load exerted on the ram 11. That is, the lower body 11A deflects toward the upper body 11B (in directions shown by arrow heads). The upper body 11B has a position sensing device 100 fitted thereon. The sensing device 100 has a probe 100a contacting an upper surface 11A-1 of the lower body 11A, and the position sensing device 100 is connected to an incorrect-crimping detection device B. The incorrect-crimping detection device B receives an output signal from the position sensing device 100 to calculate a crimping stroke distance (that is, a deflection amount of the ram 11) of the lower body 11A. The calculated crimper stroke distance is used as a characteristic value obtained during the crimping step.

[0034] In FIG. 1, denoted 18 is a terminal supply unit of a known constitution, which has a terminal guide 19 supporting a chain of terminals (not shown), a terminal cover 20, a terminal feed arm 22 having a feed hock 21 at a leading end thereof, a swing link 23 moving the arm 22 forward and backward, etc. The swing link 23 swings forward and backward in response to an upward and downward movement of the ram 11, so that the terminal feed hock 21 feeds the terminals (not shown) one by one on the anvil 17. The anvil 17 can be easily moved by means of a handle 25 provided in the anvil fitting plate 24 to adjust the alignment with the crimper 14. In addition, the anvil 17 is removed and replaced with ease.

[0035] The servomotor 4 can rotates forward and backward to move the ram 11, that is, the crimper 14 downward and upward through the piston-crank mechanism. The servomotor 4 is electrically connected to a driver 32 for controlling the rotation of the motor 4. The upward and downward movement of the crimper 14 crimps a terminal onto an electrical cable between the crimper 14 and the anvil 17. The driver 32 is electrically connected to a reference data input section 33 to receive reference data such as a terminal specification (or size), size of an associated electrical cable, a crimp

height, and load (electric current) applied to the servomotor 4. The servomotor 4 has an output shaft (not shown) fitted with an encoder 31 that senses the rotation number of the motor to know the position of the crimper 14, which is fed back to the driver 32.

[0036] FIG. 4 is a block diagram of an incorrect-crimping detection device B related to the embodiment of the present invention. The incorrect-crimping detection device B has an amplifier 41 for amplifying an output signal of the position sensing device 100, an A/D converter 42 for converting an analog voltage signal output from the amplifier 41 to digital voltage data, an input section 43, a CPU 44, a ROM 45, a RAM 46, a display section 47, and a communication interface 48. The input section 43, the CPU 44, the ROM 45, the RAM 46, the display section 47, and the communication interface 48 constitute a micro computer. The CPU 44 uses a work area of the RAM 46 for control according to a control program stored in the ROM 45. More specifically, the CPU 44 samples crimper stroke distance data, which is obtained by means of the position sensing device 100 and is supplied through the A/D converter 42 as a characteristic value of the crimping process. Furthermore, based on the sampled characteristics, the CPU 44 executes processes such as a reference value envelop generation, a calculation of a singular point of the reference value envelop, input of a threshold (or a threshold line) and an allowance of the threshold, decision of incorrect crimping, and detection of a frictional wear state of the crimping dies (crimper 14 and anvil 17). The process results are indicated in the display section 47.

[0037] During the terminal crimping step, the characteristics of the crimper stroke distance data such as a characteristic value envelop as illustrated in FIG. 5A is obtained from the position sensing device 100. The characteristic value envelop of FIG. 5A is an envelop obtained when a terminal is correctly crimped. A plurality of such characteristic value envelops of correctly crimped terminals are stored in the RAM 46 in a predetermined format. Meanwhile, the A/D converter 42 outputs converted digital data at every predetermined conversion cycle, so that the CPU 44, for example, can sample the characteristics data in time sequence according to the output timing of the converted digital data. The characteristic value envelop data can be stored in time sequence in the RAM 46. For example, an average of the plurality of characteristic value envelops of the normally crimped terminals is obtained to provide data of a reference value envelop in the RAM 46. In the following discussion, the characteristic value envelop illustrated in FIG. 5A is described as a reference value envelop. Furthermore, the term of a characteristic value envelop is used for a correctly crimped terminal and also for an incorrectly crimped terminal, and the term of a reference value envelop is used an envelop which is obtained from a characteristic value envelop of a correctly crimped terminal.

[0038] From data of a reference value envelop as illustrated in FIG. 5A, the CPU 44 calculates an increment envelop as a function of time in respect of the reference value envelop to obtain an increment envelop as illustrated in FIG. 5B. Next, with respect to the increment envelop, extremal points and a zero-crossing point (on a time-axis) are found. These points are singular points in a terminal crimping step which are denoted as points A, B, C, and D in FIG. 5B. The increment envelop has extremal points other than the four points. However, the four points each are related to a specific event in one crimping cycle of the terminal as described later, so that the four points can be recognized with ease in the increment envelop.

[0039] FIGS. 6A to 6E are sectional views each illustrating the crimper 14, the anvil 17, a crimping barrel 50 of a terminal, and core wires 60 in a crimping step. For clear view of each of the Figures, a section indicating shade has been partially omitted. FIGS. 6A to 6D each show a crimped state corresponding to each of the four singular points, and FIG. 6E shows an initial state just before the crimping. The four singular points are discussed as follows:

Point A: a point at which the crimping force varies from an increase zone to a decrease zone during a step where an upper inner curved surface of the crimper 14 is bending the crimping barrel 50 as illustrated in FIG. 6A.

Point B: a point at which the crimping force varies again to an increase zone as the crimping barrel 50 begins to abut against the core wires 60 as illustrated in FIG. 6B.

Point C: a point at which the crimping force varies again from an increase zone to a decrease zone during a step where the crimping barrel 50 crimps the core wires 60 as illustrated in FIG. 6C.

Point D: a point at which the crimping force reaches a peak since the crimping barrel 50 has completely crimped the core wires 60 as illustrated in FIG. 6D.

[0040] The reference value envelop with its increment envelop can be handled as time sequence data in the same way as a characteristic value envelop of a crimped terminal. In addition, the positions of the above-mentioned singular points can be stored as timing point data related to the time sequence data.

[0041] Next, the reference value envelop is divided by these singular points to preset three divisions between the points A, B, between the points B, C, and between the points C, D. Within each of the three divisions, a correct/incorrect crimping decision is provided based on the characteristic value envelop. Since the decision is provided in every division, correct/incorrect crimping (acceptable/unacceptable product) may be reliably determined based on the characteristic value envelop of each division. For example, an incorrect crimping state, in which a terminal strikes through an

insulation layer of an electrical cable, provides a characteristic value envelop that is greater than the reference value envelop between the points A, B and between the points B, C. Meanwhile, the incorrect crimping state provides a characteristic value envelop that is smaller than the reference value envelop between the points C, D as illustrated in FIG. 7A. On the contrary, another incorrect crimping state, in which all or several core wires has been cut away at a stripped end of an electrical cable, provides a characteristic value envelop with no difference from the reference value envelop between the points A, B. Meanwhile, the another incorrect crimping state provides a characteristic value envelop that is smaller than the reference value envelop between the points B, C and between the points C, D as illustrated in FIG. 7B. Thus, the analysis of the characteristic value envelop in each division separated by the singular points can find a specific performance of each incorrect crimping, improving the decision in quality. In addition, as illustrated in FIGS. 7A and 7B, the point D may be replaced by a mechanical bottom dead center of the piston-crank mechanism. However, the point D is defined as a singular point in the following discussion.

[0042] In each of the divisions between the points A, B, between the points B, C, and between the points C, D, an correct/incorrect crimping decision is made based on the characteristic value envelop. This corresponds to the second aspect invention described in the summary of the invention. In the second aspect invention, an correct/incorrect crimping decision is made based on a part of the characteristic value envelop which is substantially former than the peak (point D). The characteristics of the crimped terminal may be sampled only in the former part (between points A, D). The RAM 46 may store the characteristic data sampled with an interval smaller than when all the characteristic value envelop is applied if the RAM 46 has a limited capacity. This is advantageous for the decision in quality. Meanwhile, if the sampling interval is the same as when all the characteristic value envelop is applied, a smaller number of sampling data may be stored.

[0043] Next, for discussing more concretely the third, fourth, eighth, and ninth invention aspects described in the summary of the invention, an incorrect-crimping detection method of each division stated above will be discussed. At first, a characteristic value is sampled at a sampling point of an obtained characteristic value envelop, and a reference value is sampled at the same sampling point in respect of the reference value envelop. A difference between the characteristic value and the reference value is calculated. A ratio of the difference to the reference value is defined as a first ratio. The first ratio is a plus or minus percentage value and is minus when the reference value is larger than the characteristics value. The first ratio is calculated at a plurality of sampling points, and the calculated ratios are stored in the RAM 46.

[0044] Meanwhile, each division is provided with a

predetermined threshold line of the first ratio. In each division, it is determined whether the absolute value of the first ratio is larger than the threshold line. Next, the number of sampling points, at which the absolute value of the first ratio is larger than the threshold line, is counted. Such sampling points each are called as a potential abnormal point hereinafter. Meanwhile, the number of all sampling points in the division is determined based on the division range. In each division, a ratio of the number of the potential abnormal points to the number of all the sampling points is calculated to be defined as a second ratio. Next, the second ratio is compared with a predetermined allowable limit which is a percentage basis threshold (for example, 50%). When the second ratio is larger than the allowable limit in at least one of the divisions, it is determined that the crimping has been incorrect. The threshold line is predetermined by referring the first ratios of various kinds of incorrectly crimped terminals, and the allowable limit is determined in consideration of the threshold line. Note that each threshold line corresponds to "a threshold" that will be described in claims.

[0045] Next, referring to FIGS. 8 to 12, the preset of the threshold line which is a decision criteria in each division will be discussed. Time sequence data of the first ratios each obtained at each sampling point of the characteristic value envelop provides an envelop as illustrated in FIGS. 8 to 12. FIG. 8 shows an envelop of an acceptable product, and FIG. 9 shows an envelop of an unacceptable product, in which one-third length of the crimping barrel is striking through the insulation. FIG. 10 shows an envelop of an unacceptable product, in which a half length of the crimping barrel is striking through the insulation. FIG. 11 shows an envelop of an unacceptable product, in which one-seventh of core wires in number are undesirably cut away. FIG. 12 shows an envelop of an unacceptable product, in which one-third length of the crimping barrel has no core wires to be drawn therein. Such envelops of the first ratios appear generally in plus and minus sides of the coordinate thereof. Regarding an unacceptable crimped terminal, the first ratio envelop appears mainly in the plus side between the points A, B as illustrated in FIGS. 9, 10. Between the points B, C, the first ratio envelop appears in the plus side as illustrated in FIGS. 9, 10 or in the minus side as illustrated in FIGS. 11, 12. Between the points C, D, the first ratio envelop appears mainly in the minus side as illustrated in FIGS. 10, 12.

[0046] Therefore, there are preset a first threshold line in the plus side of the first ratio coordinate between the points A, B, a pair of second threshold lines each in the plus or minus side between the points B, C, and a third threshold line in the minus side between the points C, D. These first to third threshold lines are applied to the associated division of the first ratio envelop, enabling a reliable decision of almost all kinds of incorrect crimping of the terminals. In addition, the combination of incorrect decisions in the divisions may recognize the

cause or nature of the unacceptable product. Note that the above-mentioned envelop of a ratio is called as "a ratio envelop" hereinafter.

[0047] A method for presetting the above-mentioned threshold lines will be discussed hereinafter. An incorrect-crimping detection device B executes a control program which samples crimping data regarding a plurality of crimped terminals having the same incorrectness to obtain ratio envelops thereof. The ratio envelops are superimposed each other to be plotted on a single graph. These are applied to an acceptable product and to the above-mentioned kinds of unacceptable products, for example, to obtain printed results shown in FIGS. 16A to 16C. FIG. 16A shows ratio envelops of three acceptable crimped terminal products. FIG. 16B shows ratio envelops of three unacceptable crimped terminals which are striking through cable insulation layers. FIG. 16C shows ratio envelops of three unacceptable crimped terminals which have no core wires to be crimped. The control program also samples data of ratio envelops other than illustrated in FIGS. 16A to 16C. Then, a threshold of each division is determined by referring the printed graphs in consideration of a predetermined percentage allowable limit (for example, 50%). Note that such threshold may be automatically preset by applying a statistical technique calculation or the like to the ratio envelop data.

[0048] Note that an analysis of a graph showing the increment envelop of the characteristic value envelop and the singular points thereof can evaluate terminal crimping barrels, crimping dies, and the combination thereof to be satisfactory in design. For example, as illustrated in FIG. 5B, a better design of the barrels and dies provides an envelop having a comparatively smooth profile with clear singular points A, B, C. On the contrary, an undesirable state of the crimping barrels and crimping dies provides several undesirable peaks and valleys around the points A, B, for example, as illustrated in FIG. 13.

[0049] FIGS. 14, 15 each show a flow chart of a control program used in the incorrect-crimping detection device B. The flow chart of FIG. 14 is of a decision criteria presetting program, and the flow chart of FIG. 15 is of a terminal crimping quality decision program. The incorrect-crimping detection device B has a main flow program (not shown) to select any of several operation modes of the detection device B. For example, selection of a decision criteria preset mode which is an operation mode carried out prior to an actual crimping work (production) executes the decision criteria presetting program, and selection of a terminal crimping quality decision mode which is an operation mode for a terminal crimping work executes the terminal crimping quality decision program.

[0050] First, the decision criteria presetting program of FIG. 14 starts, and a step S11 executes read of reference value envelop data. The reference value envelop data is obtained, for example, by averaging characteris-

tic values at each sampling point regarding characteristic value envelops of a plurality of acceptable products. The RAM 46 stores the reference value envelop data. A next step S12 carries out a test crimping in a predetermined state (a typical incorrect or correct state) and samples characteristic data to store it in the RAM 46. A next step S13 calculates a difference between the sampled characteristic data and the reference value envelop data at each sampling point to obtain a ratio (a first ratio) of the difference to the reference value envelop data at the sampling point. An envelop of the calculated first ratios is stored in the RAM 46.

[0051] Then, a step S14 determines whether such sampling for the first ratio envelop related to a present crimping state is continued. When the input section 43 has input a continuation signal of the sampling, the program returns to the step S12, while the program returns to a step S15 when the input section 43 has input a completion signal of the sampling. The step S15 prints out the sampled ratio envelops on a single graph, which is related to the present crimping state. A next step S16 determines whether such sampling for a first ratio envelop related to another crimping state is continued. When the input section 43 has input a continuation signal of the sampling, the program returns to the step S12, while the program cares to an end when the input section 43 has input a completion signal of the program.

[0052] The above-mentioned process provides a printout result of a plurality of the ratio envelops respectively for a correct crimping state and for each of several incorrect crimping states. These ratio envelops are used for determining the threshold lines and the allowable percentage limits as described above.

[0053] Next, the terminal crimping quality decision program of FIG. 15 starts, and a step S21 executes a preset process of the reference value envelop. This reference value envelop preset process presets the reference value envelop data which has been stored in the RAM 46 at the reference value envelop read process of the step S11 of the decision criteria presetting program. The preset reference value envelop data is used for a crimping quality decision process. Then, a step S22 executes an input process for an operator to input a decision criteria including the threshold line data and the allowable percentage limit described above.

[0054] Next, a step S23 carries out crimping of a terminal and samples characteristic data of the crimping to store the data in the RAM 46. Then, a step S24 makes an acceptance or unacceptance decision of the crimping based on the reference value envelop, the characteristic value envelop, the singular points thereof, etc. When an unacceptance decision (NG) is made, a step S25 outputs a signal showing the presence of an unacceptable product and a step S26 indicates the characteristic value envelop thereof and the unacceptance decision. Note that the signal showing the presence of an unacceptable product, for example, may be used for giving an alarm by way of a device (not

shown). When an acceptance decision (OK) is made, a step S26 indicates the characteristic value envelop thereof and the acceptance decision. Then, a step S27 determines whether the crimping will be continued. When a continuation signal has been input, the program returns to the step S23, and when a production completion signal has been input, the program comes to an end.

[0055] As mentioned above, The provision of the decision criteria presetting program and the terminal crimping quality decision program enables easy preset of the decision criteria and an reliable acceptance or unacceptance decision of the crimping quality.

[0056] The above-mentioned incorrect-crimping detection device B may connect to a network system by using the communication interface 48. For example, as illustrated in FIG. 17, a plurality of the terminal crimping apparatuses A each having the incorrect-crimping detection device B are connected to a processing computer C through a network N. Each incorrect-crimping detection device B presets the reference value envelop data which is transmitted to the processing computer C. The reference value envelop data is stored in a hard disc or the like provided in the processing computer C. The processing computer C handles each reference value envelop data of each incorrect-crimping detection device B.

[0057] Furthermore, each incorrect-crimping detection device B may make a decision of a frictional wear state of a crimping die (crimper 14 or anvil 17) provided in each terminal crimping apparatus. That is, when the crimping die is replaced by a new one, new reference value envelop data is obtained by carrying out a crimping operation to get a plurality of acceptable products. The new reference value envelop data is transmitted to the processing computer C through the network N and is stored in the hard disc of the processing computer C. Each incorrect-crimping detection device B compares a present reference value envelop, which is preset before a crimping operation of any product, with the reference value envelop data stored in the processing computer C.

[0058] This allows to make a decision of a frictional wear state of the crimping die. Between a new crimping die and an old one, there is a difference of the reference value envelops thereof, for example, as illustrated in FIG. 18. Both the reference value envelops are superimposed each other to be indicated in the display section 47, which enables to make a real-time decision of a frictional wear state of the crimping die with ease. Thus, it is possible to know efficiently reliably a frictional wear state of the crimping die, allowing an efficient production of acceptable products in the crimping quality of terminals.

[0059] In addition, through the network N, the reference value envelop data may be transmitted among the plurality of incorrect-crimping detection devices B. The processing computer C enables to know whether a

present reference value envelop is satisfactory or not in a production section where a terminal crimping apparatuses A or an incorrect-crimping detection device B is provided. Meanwhile, a production management section having the processing computer C can make a detail analysis of the production in quality. Hence, for example, it is possible to replace a crimping die prior to the occurrence of an abnormal state thereof by analyzing a data base which includes types of the terminals, sizes of the electrical cables, the repeated number of the crimping operation, frictional wear states of the crimping dies, the flash of the crimped cables, and characteristic value envelops obtained in the terminal crimping.

[0060] The above-mentioned embodiment applies a vertical crimper stroke distance, that is, a sensed vertical deflection value of the lower body 11A of the ram 11 as a crimping characteristics. Alternatively, for example, as illustrated in FIG. 19, a position sensing device 100 may be provided between the casing 1 constituting upper and lower frames of the terminal crimping apparatus and the side plate 3. Because, the frames are deflected by a reaction force against a crimping force of the terminal crimping apparatus. Since the deflection amount varies with stiffness of the frames, it varies with types of the terminal crimping apparatuses. The different terminal crimping apparatuses each provide generally a deflection amount different from each other. Note that a practical terminal crimping apparatus provides such deflection which is used as a crimping characteristics. The deflection is known by measuring the deflection of the frames of the terminal crimping apparatus. Moreover, a sensing portion of the deflection may be provided in the terminal crimping apparatus, for example, by providing a notch in the piston-crank mechanism to have a spring performance similar to the ram of the embodiment.

[0061] In place of the position sensing device, an acceleration sensor may be provided to measure the motion of the frames. The measurement is used as a crimping characteristic value envelop, providing a sufficient data set for discrimination of an acceptable product and an unacceptable product.

[0062] Furthermore, in the present invention, the crimping characteristics is not limited to a deflection amount of the ram or the frames described in the embodiment during the crimping, but a pressure (load) may be used as the characteristics. For example, a pressure exerted on the anvil, the crimper, or the ram may be measured by means of a pressure sensor to be used as the characteristics.

[0063] Note that the obtained characteristics varies with types of sensors for sensing the characteristics so that the increment envelop illustrated in FIG. 5B also varies together, for example, to become such an envelop as illustrated in FIG. 20. However, even in the envelop of FIG. 20, the points A to D are obtained as specific points within one crimping cycle in the same

way as the envelop of FIG. 6 by finding zero-crossing points and peaks.

[0064] In the embodiment, the second ratio, which is a ratio the number of potential abnormal points to the number of all sampling points in each division, is obtained for finding an incorrect crimped product. When the second ratio is larger than an allowable percentage limit, it is determined that the product is unacceptable. Alternatively, another method for an acceptance/unacceptance decision of a product may be prepared. For example, a difference amount of the first ratio from the threshold is obtained at each sampling point, and all the difference amounts within a division are summed to obtain the sum thereof. Furthermore, the first ratio at each sampling point within the division is obtained, and all the first ratios are summed within the division to get the sum of the first ratios. A ratio of the sum of the difference amounts to the sum of the first ratios is calculated. An acceptance/unacceptance decision may be made base on whether the ratio is larger than a predetermined allowable limit.

[0065] Note that an incorrect-crimping decision method according to the present invention is not limited to one described in the embodiment. For example, singular points may be obtained from a reference value envelop, and the singular points may be used to define divisions for the crimping quality decision. In addition, all the characteristics values of a crimping step within a division may be summed to obtain the sum of the characteristics values, and a sum of the characteristics values of the reference value envelop is preparatorily obtained within the division. The comparison of both the sums may be used for an acceptance/unacceptance decision of the product. This decision method is similar to a method in which an area enclosed by a characteristic value envelop is compared with an area enclosed by a reference value envelop.

[0066] Note that the present invention may be also applied to any crimping mechanism other than the terminal crimping apparatus of the embodiment in which the driving force of the servomotor is used for the crimping.

Claims

1. A terminal crimping quality decision method for determining the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus, said method using a characteristic value envelop of characteristic values obtained when the terminal is crimped on the core, said method comprising the steps of:

obtaining a reference value envelop of characteristic values obtained when a terminal is correctly crimped on the core,
calculating an increment envelop of said reference value envelop to obtain at least one sin-

gular point of said reference value envelop, and determining the quality of a terminal crimped by the terminal crimping apparatus based on a characteristic value envelop of said crimped terminal, said characteristic value envelop being obtained in an envelop division separated by said at least one singular point.

2. A terminal crimping quality decision method for determining the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus, said method using a characteristic value envelop obtained when the terminal is crimped on the core, said method comprising the steps of:

obtaining a reference value envelop from a characteristic value envelop obtained when a terminal is correctly crimped on the core,
calculating an increment envelop of said reference value envelop to obtain a singular point of said reference value envelop,
determining the quality of a terminal crimped by the terminal crimping apparatus based on a characteristic value envelop of said crimped terminal, said characteristic value envelop being obtained in a former envelop division separated by a peak related to said singular point.

3. The method set forth in claim 1 wherein the step of determining the crimping quality of a terminal includes:

calculating a difference between said reference value envelop and a characteristic value envelop obtained of the terminal,
obtaining a ratio of the difference to said reference value envelop, and
comparing the ratio with a predetermined threshold in respect of said division.

4. The method set forth in claim 3 wherein the crimping quality of said terminal is determined based on an extent of said ratio exceeding said threshold in respect of said division.

5. The method set forth in claim 3 or 4 wherein said terminal crimping apparatus comprises a computer having a decision criteria presetting program and a terminal crimping quality decision program, and said reference value envelop and said threshold are preset by executing said decision criteria presetting program, while the quality of the crimped terminal is determined by executing said terminal crimping quality decision program.

6. A terminal crimping quality decision device for determining the quality of a terminal crimped on a

core of an electrical cable by a terminal crimping apparatus, said device using a characteristic value envelop obtained when the terminal is crimped on the core, said device comprising:

a sensing means for obtaining a reference value envelop from characteristic values obtained when a terminal is correctly crimped on the core,

a calculation means for providing an increment envelop of said reference value envelop to obtain at least one singular point of said reference value envelop, and

a decision mean for determining the quality of a terminal crimped by the terminal crimping apparatus based on a characteristic value envelop of said crimped terminal, said characteristic value envelop being obtained in an envelop division separated by said at least one singular point.

7. A terminal crimping quality decision device for determining the quality of a terminal crimped on a core of an electrical cable by a terminal crimping apparatus, said device using a characteristic value envelop of characteristic values obtained when the terminal is crimped on the core, said device comprising:

a sensing means for obtaining a reference value envelop from characteristic values sensed when a terminal is correctly crimped on the electrical cable,

a calculation means for providing an increment envelop of said reference value envelop to obtain at least one singular point of said reference value envelop, and

a decision mean for determining the quality of a terminal crimped by the terminal crimping apparatus based on a characteristic value envelop of said crimped terminal, said characteristic value envelop being obtained in a former envelop division separated by a peak related to said singular point.

8. The device set forth in claim 6 wherein said decision means calculates a difference between said reference value envelop and a characteristic value envelop obtained of the terminal, and said decision means obtains a ratio of the difference to said reference value envelop to compare the ratio with a predetermined threshold in respect of said division.

9. The device set forth in claim 8 wherein said decision means determines the crimping quality of the terminal based on an extent of said ratio over said threshold in respect of said division.

10. A frictional wear state detection method for detecting a frictional wear of a crimping die used in a terminal crimping apparatus, the method comprising the steps of:

crimping a terminal on a core of an electrical cable by using a normal crimping die to store a characteristic value envelop obtained in the crimping step as a reference value envelop, correctly crimping a terminal on a core of an electrical cable by using an actual crimping die to obtain a characteristic value envelop, and comparing the characteristic value envelop obtained by the actual crimping die with said stored reference value envelop.

11. A frictional wear state detection method for detecting a frictional wear of a crimping die used in a plurality of terminal crimping apparatuses, each of the terminal crimping apparatuses having a detection device for detecting incorrect crimping of a terminal, the detection devices constituting a network with a computer, the method comprising the steps of:

crimping a terminal on a core of an electrical cable by using a normal crimping die mounted on one of the terminal crimping apparatuses, to store a characteristic value envelop obtained in a crimping step as a reference value envelop, correctly crimping a terminal on a core of an electrical cable by using an actual crimping die mounted in one of said terminal crimping apparatuses to obtain a characteristic value envelop, and comparing the characteristic value envelop obtained by the actual crimping die with said stored reference value envelop, wherein said reference value envelop obtained in said one of terminal crimping apparatuses can be used for any of the terminal crimping apparatuses for detecting a frictional wear of a crimping die.

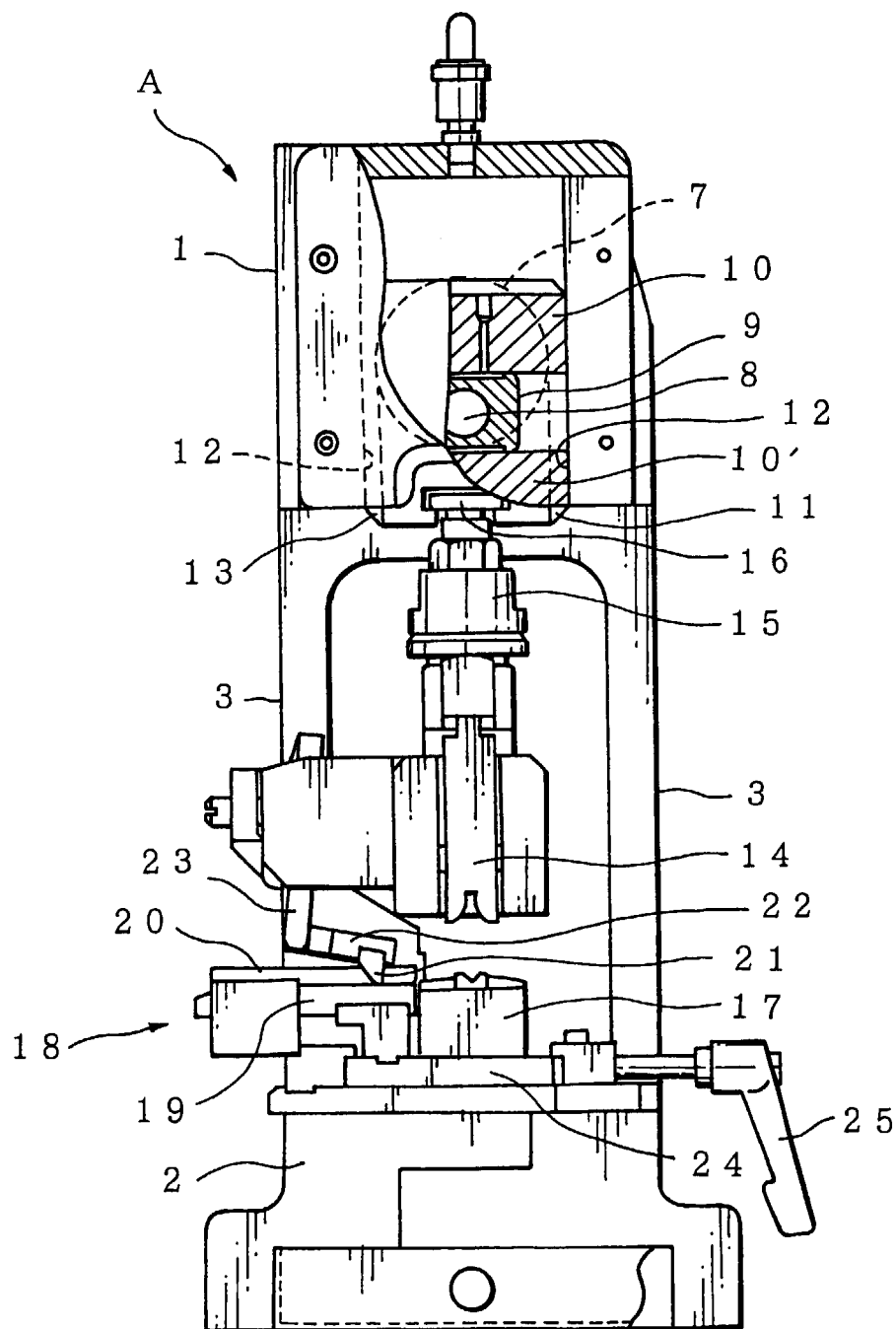


FIG. 1

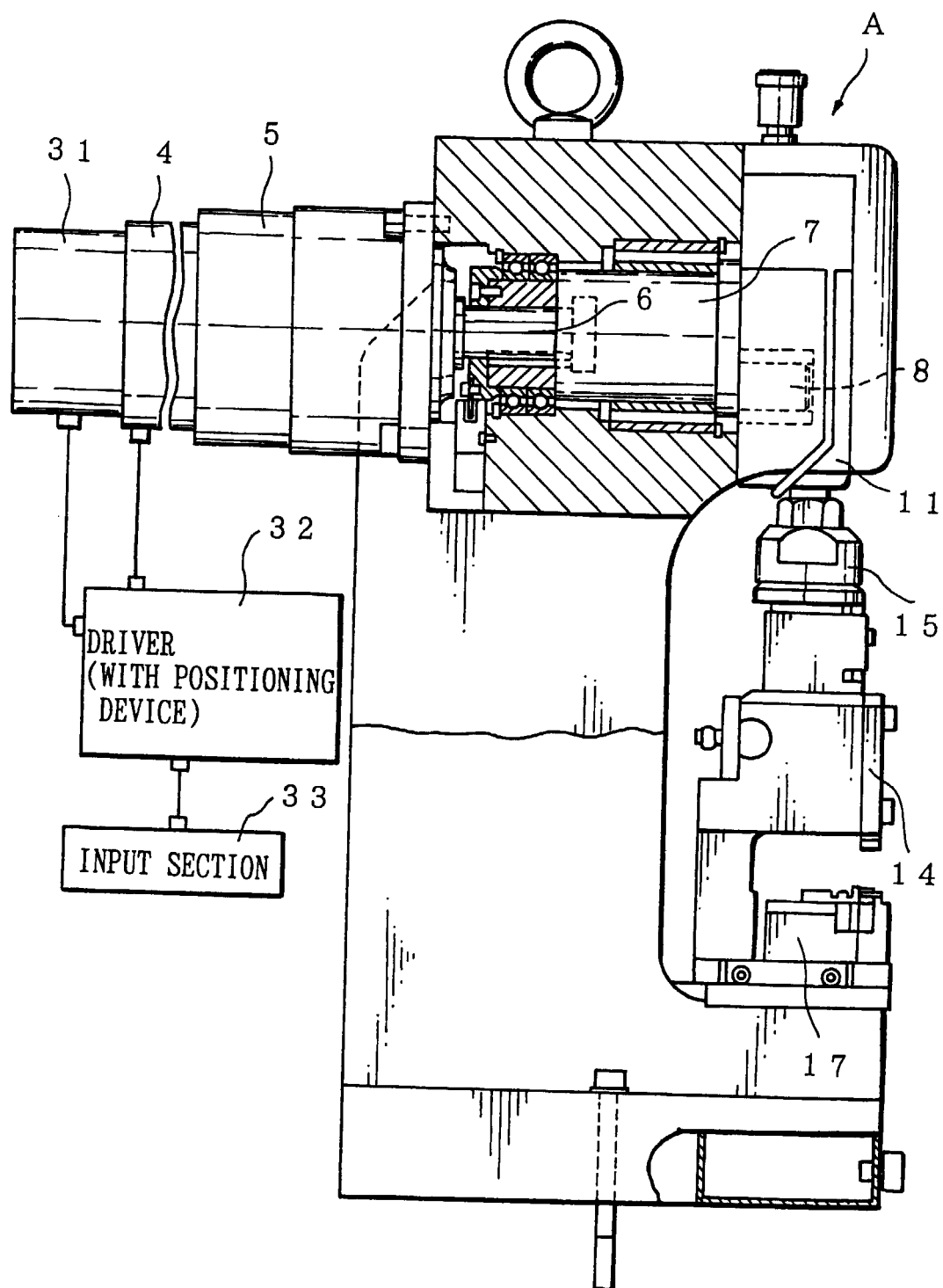


FIG. 2

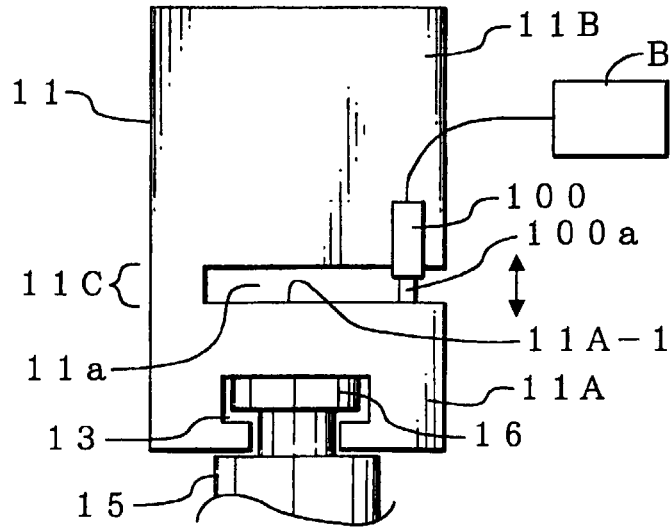


FIG. 3

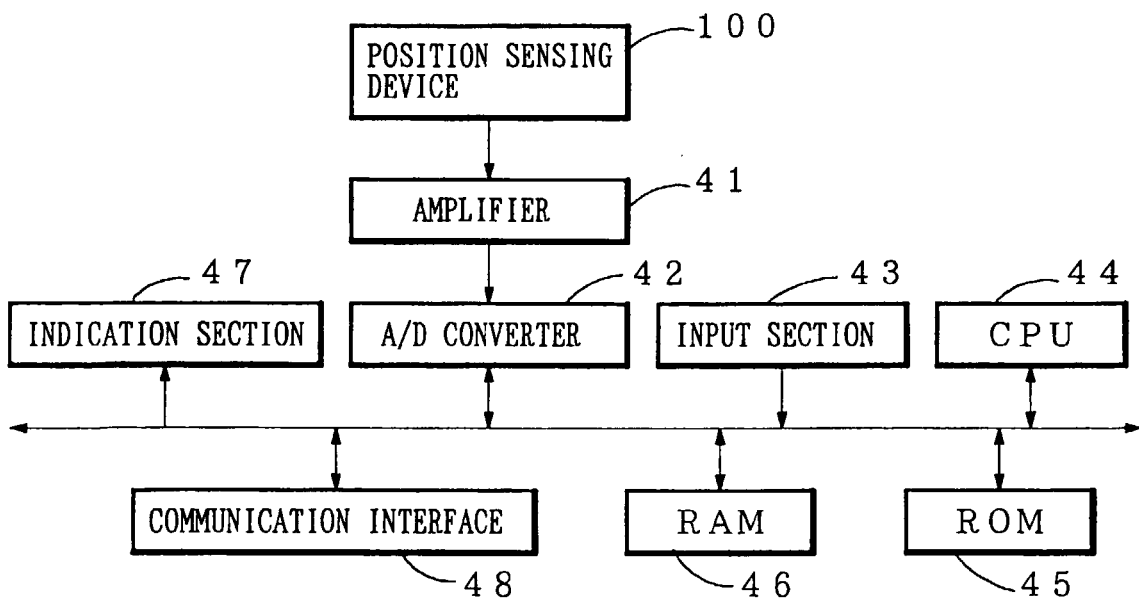


FIG. 4

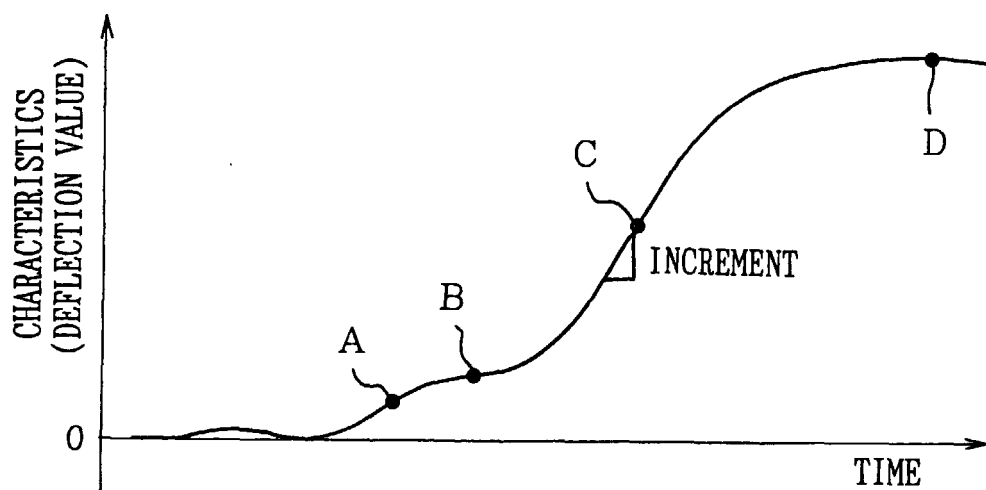


FIG. 5A

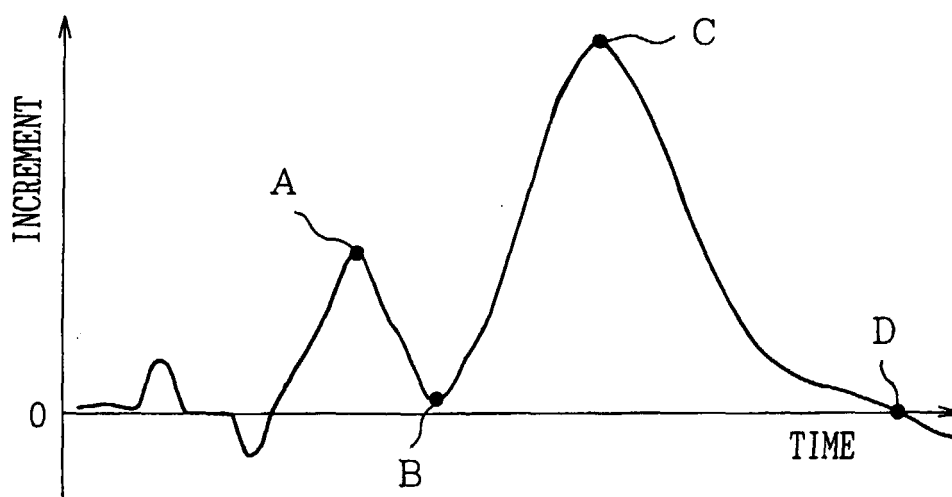
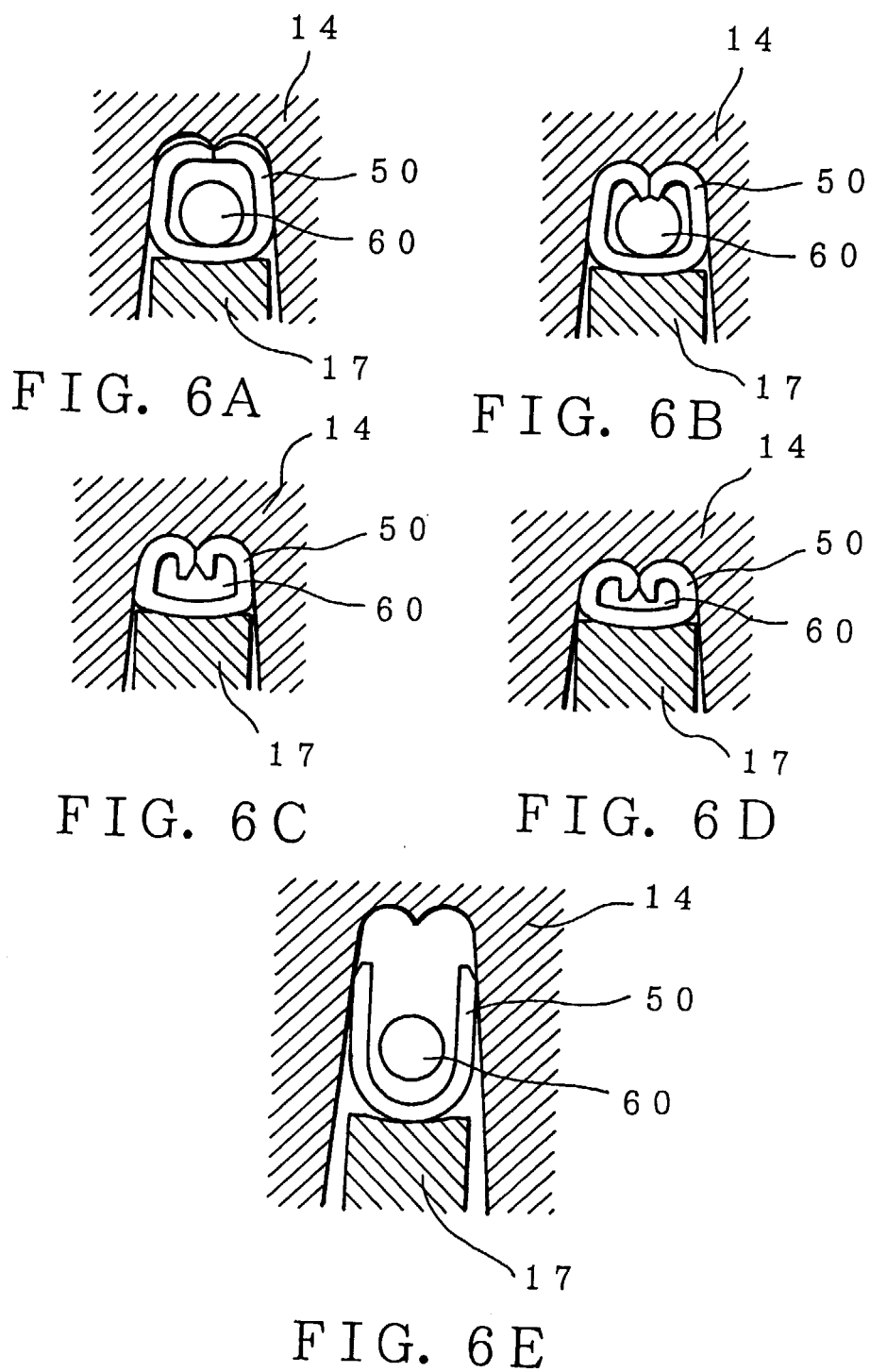


FIG. 5B



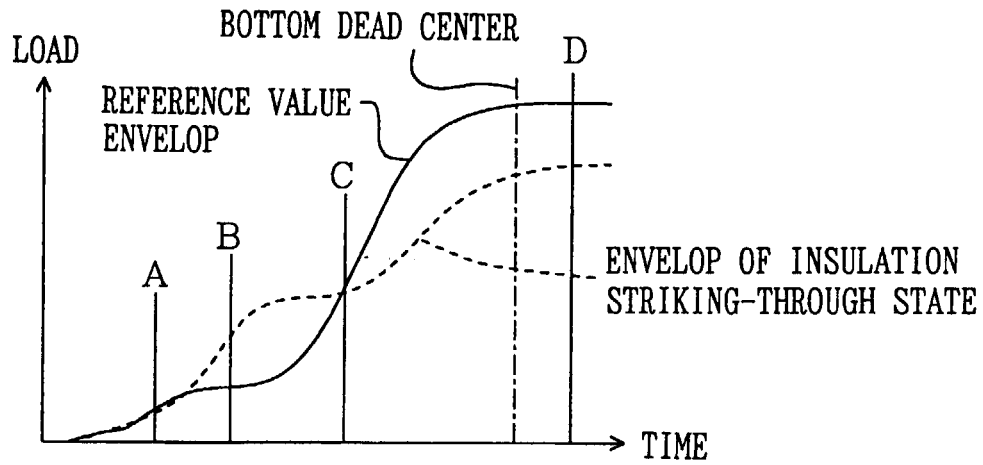


FIG. 7A

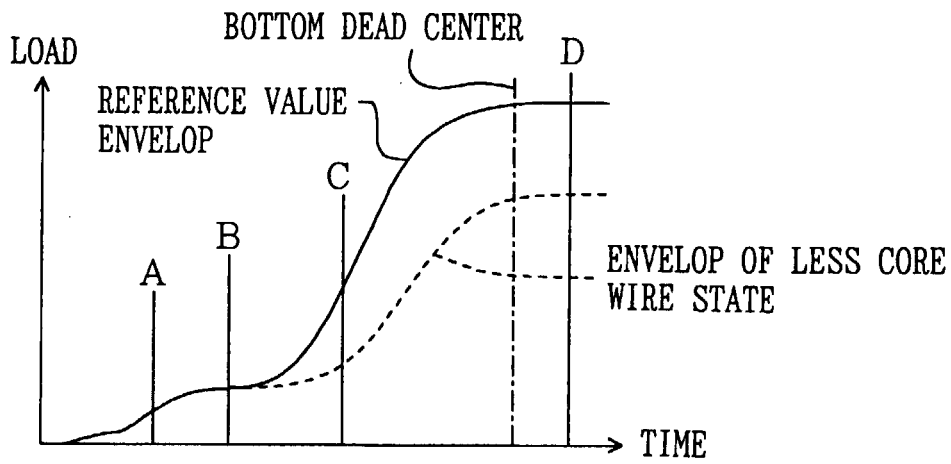


FIG. 7B

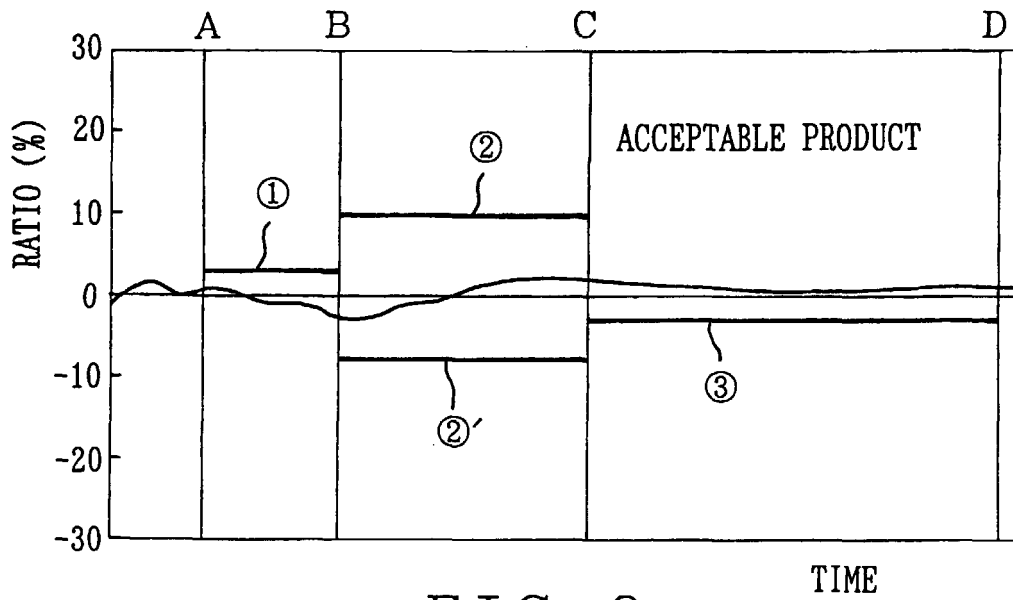


FIG. 8

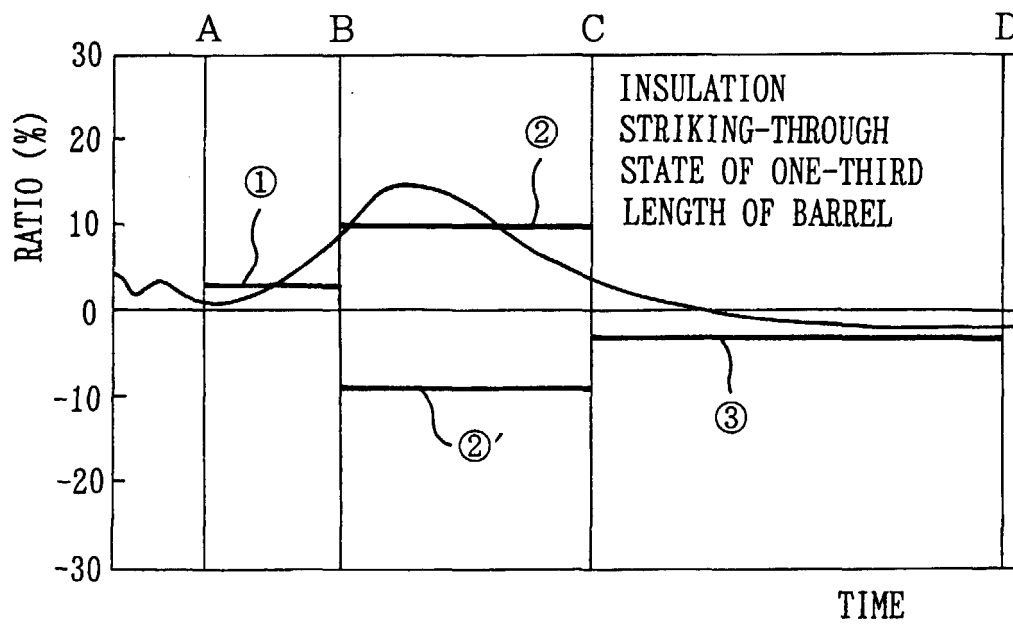


FIG. 9

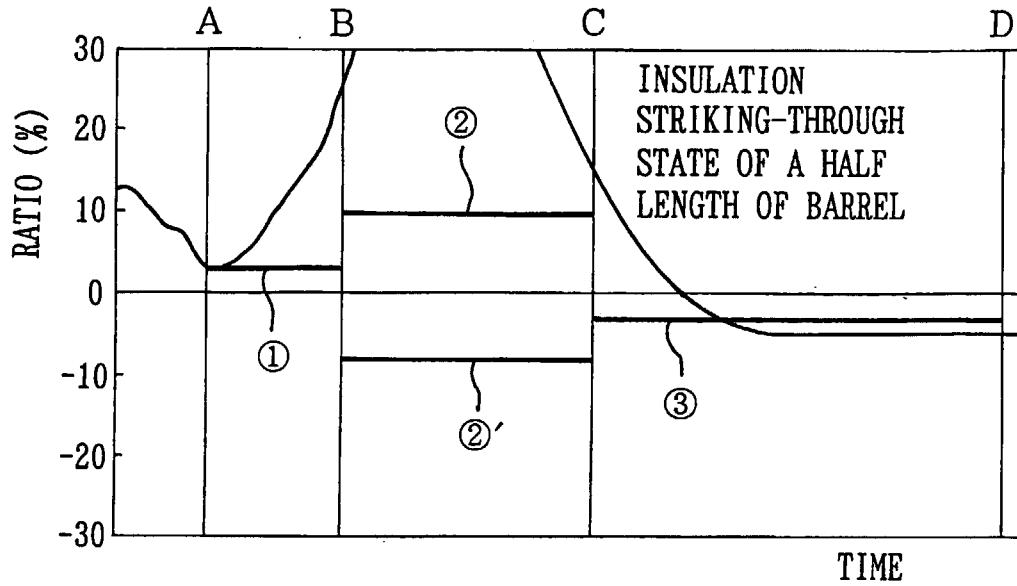


FIG. 10

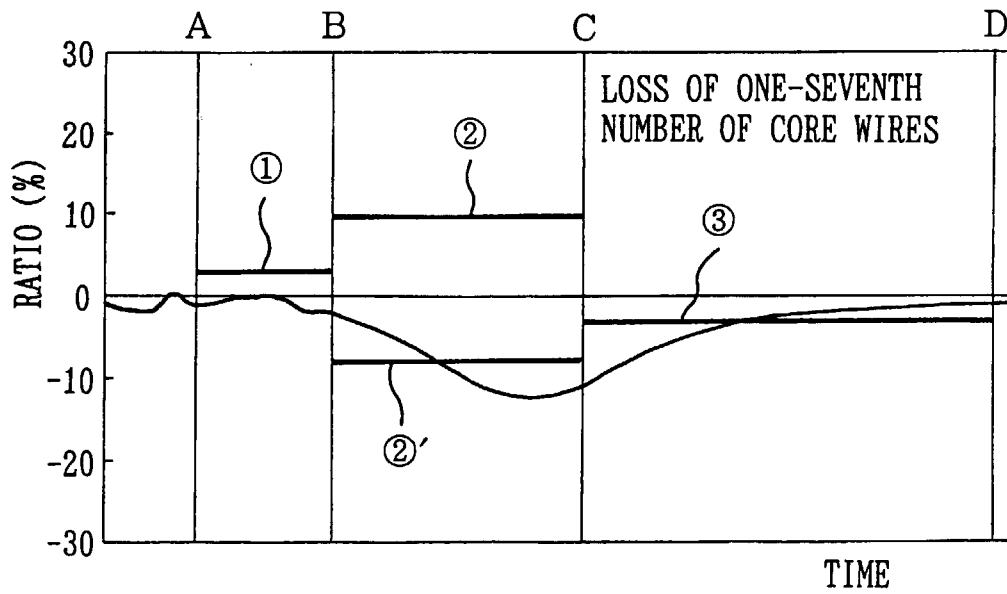


FIG. 11

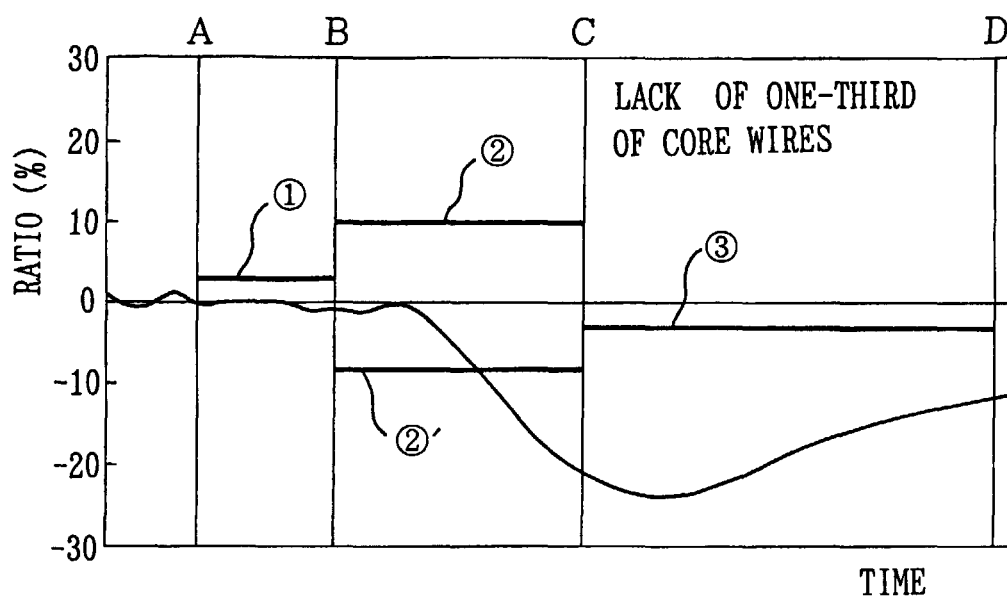


FIG. 12

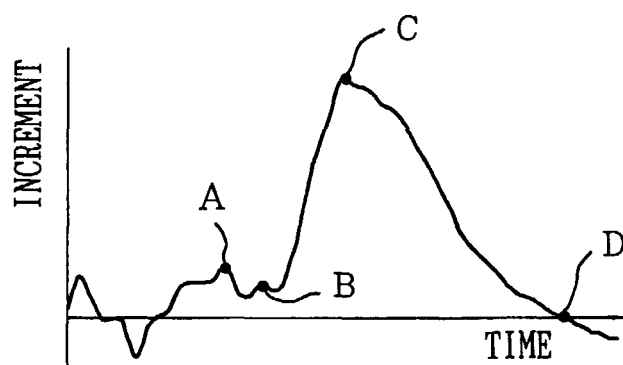


FIG. 13

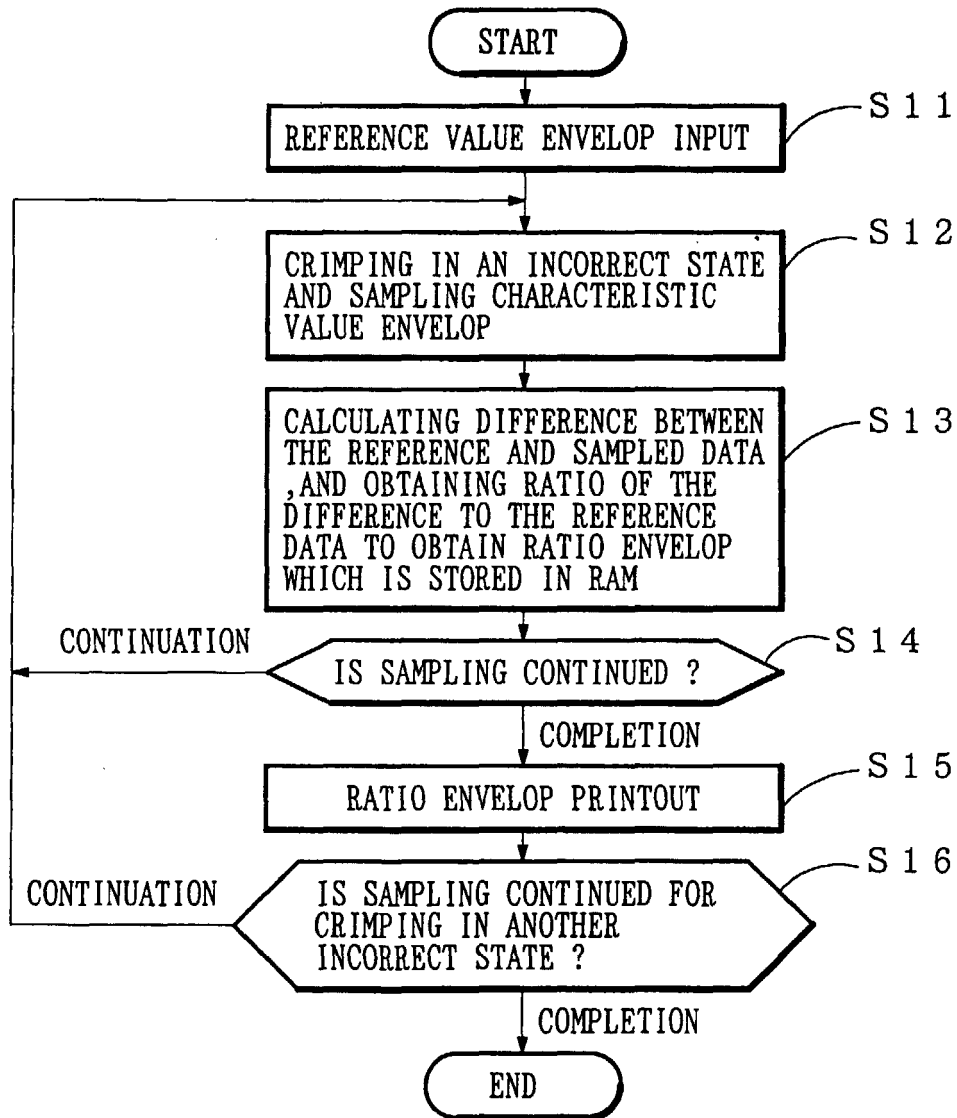


FIG. 14

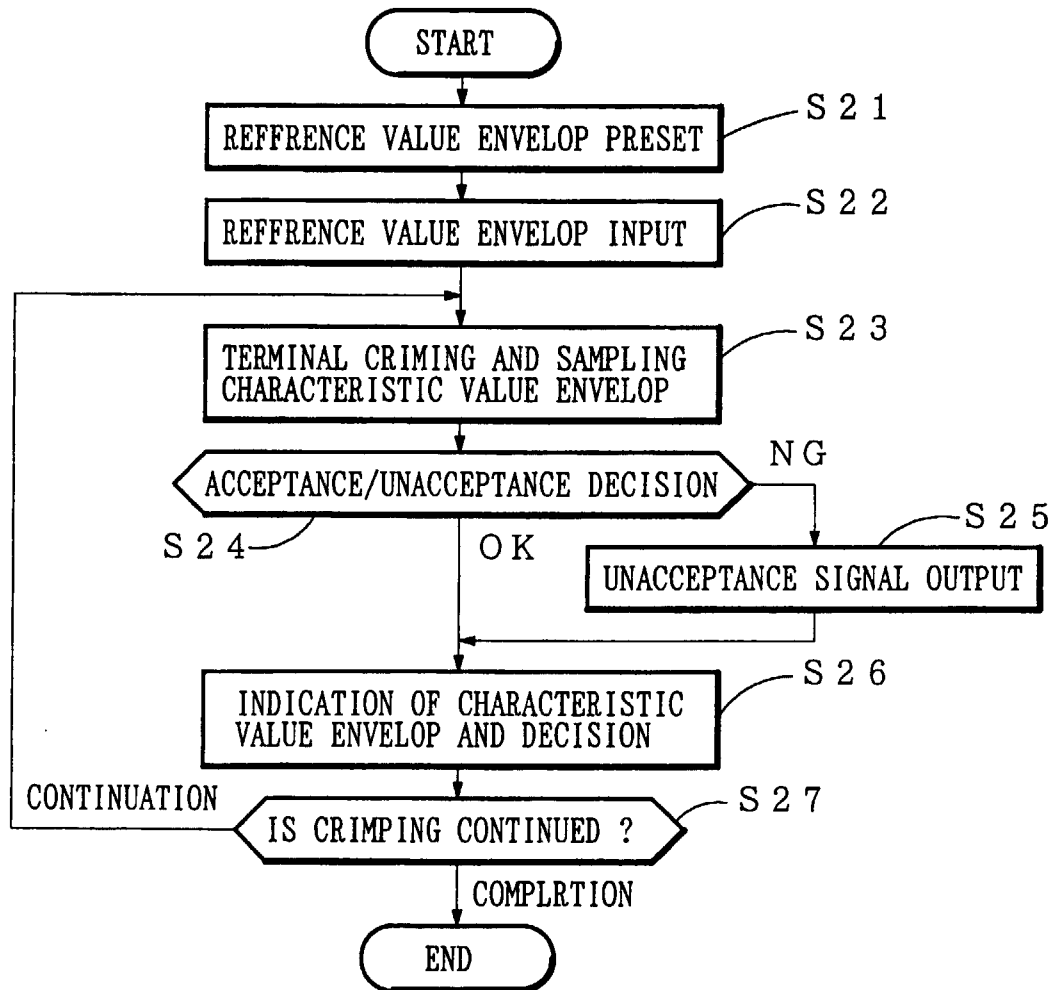
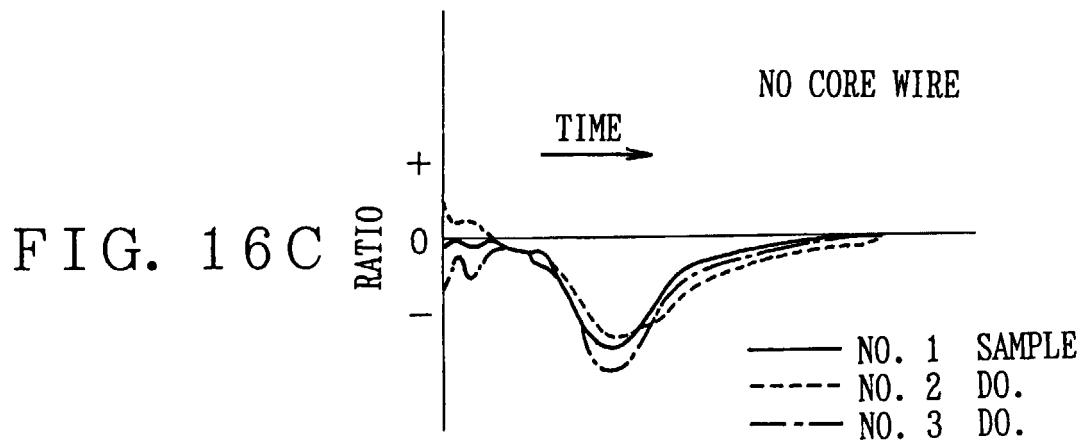
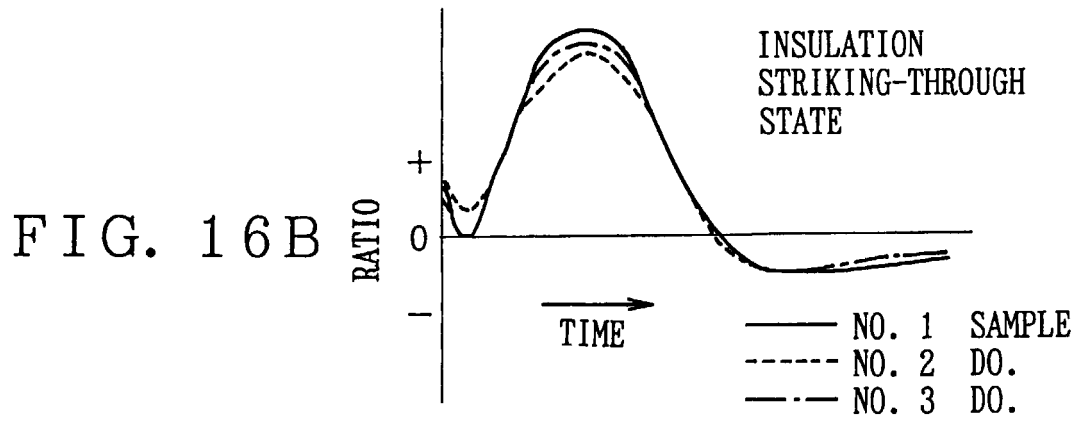
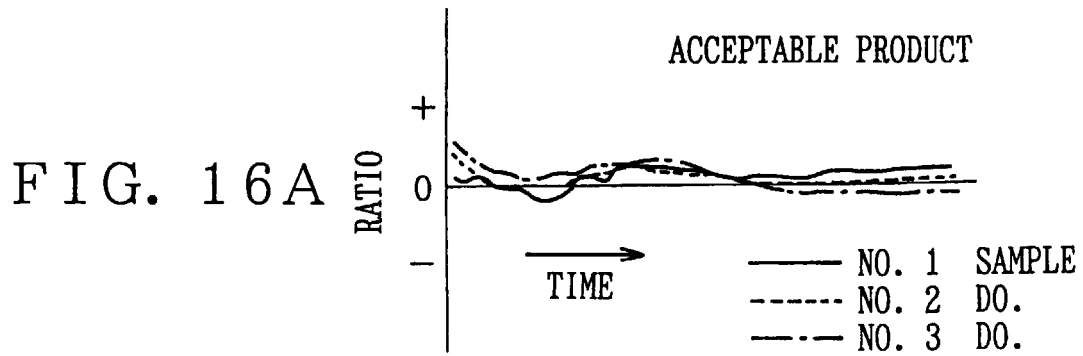


FIG. 15



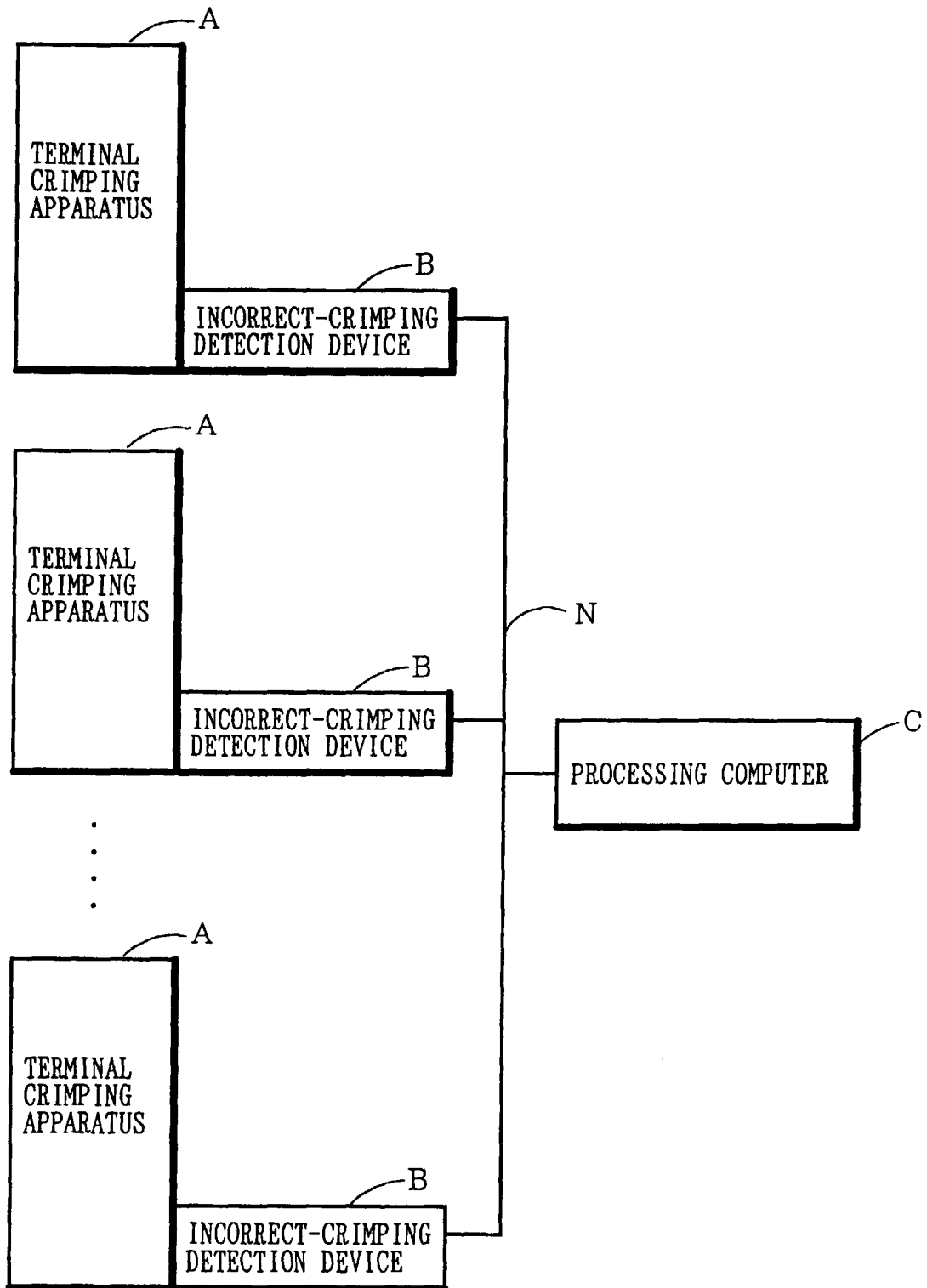


FIG. 17

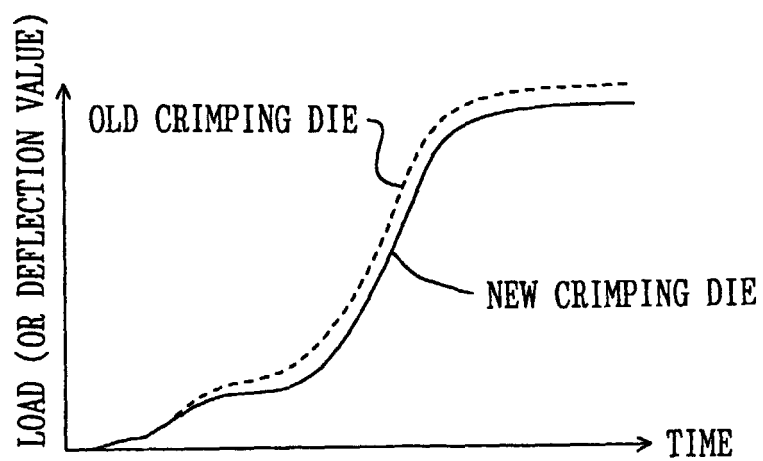


FIG. 18

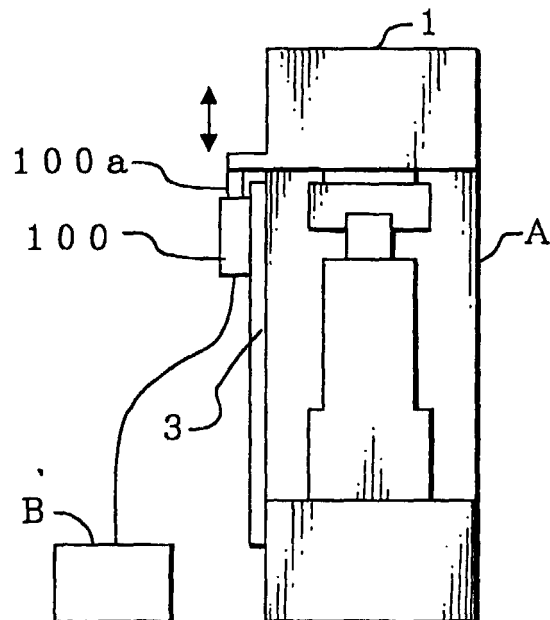


FIG. 19

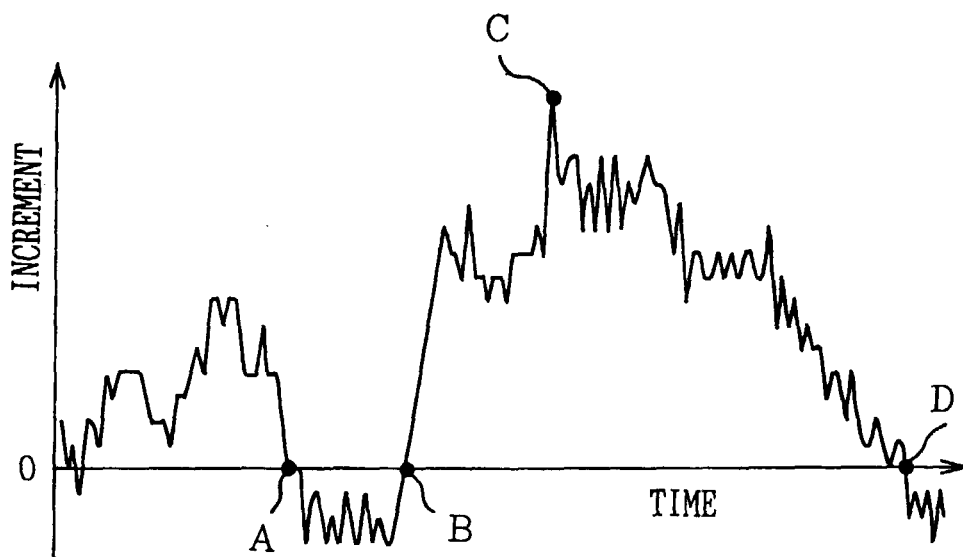


FIG. 20

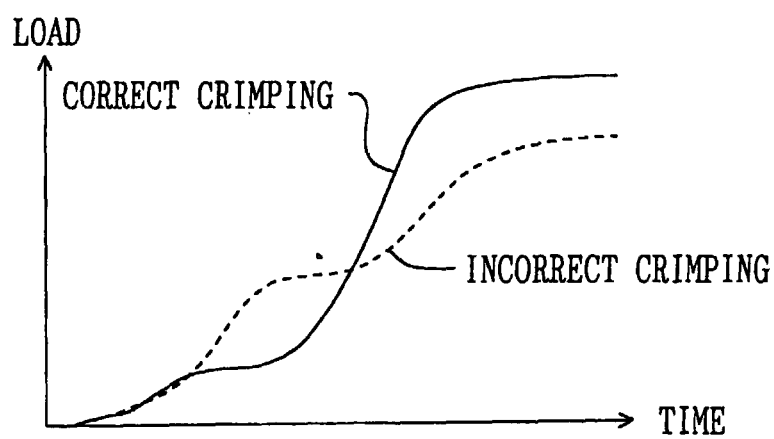


FIG. 21

