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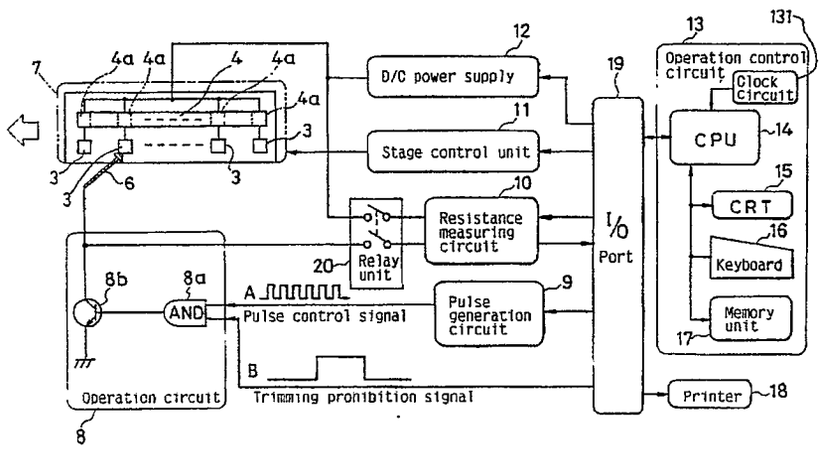
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(54) Thermal print head trimming apparatus and method for trimming resistance of a thermal print head.

(57) A thermal print head trimming apparatus trims the resistances of heating resistor elements (4a). The apparatus divides the measured resistance data into plural groups by their variation range, and applies pulse signal of high-voltage by a probe electrode (6) to the heating resistor elements (4a) in the plural groups except a group that includes the lowest resistance values of the heating resistor elements (4a). Thereby the whole resistances of the heating resistor elements (4a) in the thermal print head are trimmed to agree with the lowest resistance values.

FIG. 1



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FIELD OF THE INVENTION AND RELATED ART STATE

1.FIELD OF THE INVENTION

The present invention relates to a thermal print head trimming apparatus and method for trimming resistance of the thermal print head which is for use in a thermal recording apparatus, such as a printer, a facsimile terminal apparatus, and so force.

2.DESCRIPTION OF THE RELATED ART

In the thermal recording apparatus, such as the printer or the facsimile terminal apparatus, a thermal print head is utilized to record information on a thermosensible paper or a non-thermosensible paper overlapped to a thermosensible ink ribbon. A recording density (color density) of a printing, which is recorded by the thermal recording apparatus, is decided by the heating value per a unit volume of the heating resistor in the thermal print head. If heating resistor elements of the heating resistors for indicating plural dots have variations or lack of uniformity in the resistance, each heating resistor element for indicating a dot may generate different heating energy. As a result, the printing recorded by the thermal print head may not be uniformly printed lacking uniformity on the thermosensible paper etc.

In the conventional thick film type thermal print head which is formed by sinterring film of fritted ruthenium oxide etc. as resistor, the resistances of plural heating resistor elements for indicating plural dots has about fifteen percent of variation in the resistance for the same thermal print head. Generally, the conventional trimming operation for trimming the resistance of the beating resistor elements in order to decrease the variation is performed by known over-load trimming method. The over-load trimming method uses the characteristic of the heating resistor such that the resistance of the heating resistor is changed when a high-voltage pulse having a pulse duration of several μsec. is applied to the heating resistor.

The conventional over-load trimming method is such that the resistance of all heating resistor elements are measured, to set a target value of the resistance. Then, the conventional over-load trimming method performs the trimming operation in a manner that the above-mentioned high-voltage pulse is applied to each heating resistor elements, for a desired or at predetermined number of times. And, each resistance of the heating resistor elements is measured after the trimming operation is over. If the measured resistance of trimmed dots does not yet reach the predetermined target value of the resistance, the above-mentioned trimming operation is repeated. As a result of the repetitions, the conventional over-load trimming method converges the resistance of the heating resistor elements on the predetermined target value gradually. Accordingly, the conventional thermal print head trimming apparatus requires a considerably long time for trimming the resistance of the heating resistor of the conventional thermal print head.

OBJECT AND SUMMARY OF THE INVENTION

An object of the present invention is to provide a thermal print head trimming apparatus and method for trimming resistance of a thermal print head, which can precisely trim resistance of a heating resistor in a short time.

In order to achieve the above-mentioned object, the thermal print head trimming apparatus of the present invention comprises:

a power supply circuit for generating voltage of pulse signal for trimming operation;

a resistance measuring circuit for measuring resistance of a heating resistor;

a movable stage control unit for moving a movable stage holding thereon a thermal print head relatively with a probe electrode; and

an operation control unit for controlling the power supply circuit, the resistance measuring circuit and the stage control unit.

In another aspect, method for trimming resistance of the thermal print head of the present invention comprises steps of

dividing a heating resistor elements into predetermined groups based on resistance data of the heating resistor elements, and

applying pulse signal of a predetermined voltage to each group for trimming the resistance of the thermal print head.

While the novel features of the invention are set forth particularly in the appended claims, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features thereof, from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a block diagram of a first embodiment of the thermal print head trimming apparatus of the present invention;

FIG.2 shows a sectional side elevation view of the thermal print head and waveforms which show timing for the trimming operation of the first embodiment;

FIG.3 is an enlarged partial cutaway view showing a part of the thermal print head of the first

embodiment;

FIG.4 is a partial cutaway view showing a part of another thermal print head of the first embodiment;

FIG.5 is a graph showing resistance before a trimming operation of a second embodiment of the present invention;

FIG.6 is a graph showing resistance through the trimming operation of the second embodiment of the present invention;

FIG.7 is a partial cutaway view showing a part of the thermal print head in the second embodiment of the present invention;

FIG.8 is a graph showing distribution of the measured resistance of the thermal print head;

FIG.9 is a graph showing relation between a change rate of resistance and applied-voltage of pulse for trimming operation;

FIG.10 is a graph showing distribution of the trimmed resistance of the thermal print head;

FIG.11 is a graph showing distribution of another trimmed resistance of the thermal print head; and

FIG.12 is a flow chart showing the trimming operation of the second embodiment of the thermal print head trimming apparatus of the present invention.

It will be recognized that some or all of the Figures are schematic representations for purposes of illustration and do not necessarily depict the actual relative sizes or locations of the elements shown.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereafter, preferred embodiments of the thermal print head trimming apparatus in accordance with the present invention are elucidated with reference to the accompanying drawings of FIGs.1 to 4.

APPARATUS EMBODIMENT

⟨CONFIGURATION⟩

FIG.1 is a block diagram of the first embodiment of the thermal print head trimming apparatus in accordance with the present invention. FIG.2 shows the thermal print head with a probe electrode 6 shown in FIG.1, and shows waveforms of the corresponding timing for the trimming operation of the thermal print head.

In FIG.1, a heating resistor 4 to be trimmed in the thermal print head is connected to a DC (Direct current) power supply 12. Elements 4a of the heating resistor 4 are arranged to be connected to an operation circuit 8 through a probe electrode 6. In the operation circuit 8, a pulse control signal A which is output from a pulse generation circuit 9 and a trimming prohibition signal B which is output from an operation control unit 13 through an I/O port 19 are applied to an AND circuit 8a.

A resistance measuring circuit 10 is connected to the heating resistor 4 of the thermal print head through a relay unit 20. A stage control unit 11 for controlling motion of a known moving stage or table can slide the thermal print head on a stage 7 by using a driving unit, such as a pulse motor, in order to move the fixed probe electrode 6 relatively to the thermal print head elements 4a to be trimmed. The operation control unit 13, which comprises a CPU (central processing unit) 14, a CRT (cathode-ray tube) 15, a keyboard 16 and a memory unit 17, ccntrols the whole trimming operation. Results of the trimming operation are output by a printer 18.

The operation control unit 13 controls : the pulse generation circuit 9 thereby to output the pulse control signal A, the resistance measuring circuit 10 thereby to measure each resistance of the heating resistor elements 4a for indicating plural dots on a thermosensible paper etc., the stage control unit 11 thereby to slide the stage 7, and the D/C power supply 12 thereby to set a voltage of pulse for trimming. And operation control unit 13 issues a trimming prohibition signal B for stopping trimming operation.

And further, the operation control unit 13 collects the data which is measured by the resistance measuring circuit 10, and calculates an average of the measured resistance data of the heating resistor elements 4a. The measured resistance data and the calculated average data are stored in the memory unit 17.

⟨OPERATION⟩

Hereafter, the trimming operation for trimming the resistance of the heating resistor 4 in the first embodiment of the thermal print head trimming apparatus is elucidated with reference to the accompanying drawing of FIG.1 and FIG.2.

In First step of a measuring process in the trimming operation, the probe electrode 6 is arranged so as to contact to each of individual electrodes 3 which are connected to respective heating resistor element 4a for indicating a dot. Then, the stage 7 on which the thermal print head is mounted is slid at a constant velocity by the stage control unit 11. Therefore, the probe electrode 6 scans transversely across the plural individual electrodes 3 so as to contact to each heating resistor element 4a. In the above-mentioned state, the relay unit 20 is set to a close state, and the resistance measuring circuit 10 measures each resistance of respective heating resistor elements 4a in turn. Con-

sequently, average values of the respective resistance are calculated from the measured resistance data which are collected by the operation control unit 13, and finds heating resistor elements 4a which should be trimmed. The average value data and the position data of the heating resistor element 4a to be trimmed are stored in the memory unit 17.

The following is an explanation of a trimming process in the trimming operation.

In the first step of the trimming process, the relay unit 20 is turned to an open state, that is "OFF" state. The operation control unit 13 sets the output voltage of the DC power supply 12 to a predetermined voltage for trimming the resistance of the heating resistor elements 4a. The operation control unit 13 sets also a pulse frequency and a pulse duration of the pulse control signal A to predetermined values.

In the second step, a waveform of the trimming prohibition signal B is set to a logic "1" (high-level signal) at the position corresponding to the heating resistor elements 4a to be trimmed, and to a logic "0" (low-level signal) at the position corresponding to the other heating resistor elements 4a.

In the third step, the probe electrode 6 is arranged to contact again with each individual electrodes 3, and the stage 7 on which the thermal print head is mounted is slid to make contact between the probe electrode 6 and each individual electrode 3 in succession. When the probe electrode 6 is made contact with the individual electrode 3 which is connected to the heating resistor elements 4a to be trimmed, the logic "1" (high-level signal) of the trimming prohibition signal B is applied to the AND circuit 8a of the operation circuit 8 together with the pulse control signal A. Consequently, the pulse signals are applied to a switching device 8b for controlling the trimming operation. In other words, since the position of the probe electrode 6 is decided by the traveling intervals of the stage 7 and the arrangement interval of the individual electrodes 3, the pulse signal for the trimming operation can be applied at the desired timing to the heating resistor element 4a to be trimmed by in synchronism with the movement of the stage 7 and the trimming prohibition signal B by means of the common clock signal of a clock circuit 131 in the operation control unit 13.

Hereafter, timing in the trimming operation for the thermal print head is elucidated with reference to the accompanying drawing of FIG.2. FIG.2 shows the thermal print head which is in contact with the probe electrode 6, and shows waveforms of the timing for the trimming operation. The upper part (a) of FIG.2 shows a sectional side elevation view of the thermal print head on the stage 7, the middle part (b) thereof shows a waveform indicating the position state of the probe electrode 6, and the lower part (c) thereof shows a waveform of the timing for applying the pulse signal for the trimming operation. An interval L1 denotes the interval of contacting of the electrode 6 with the individual electrodes 3, and an interval L2 denotes the interval of non-contacting, that is breaking state wherein the probe electrode 6 is not in contact with any individual electrode 3. As shown in the waveform (c) of FIG.2, a few pulses for trimming are applied to the individual electrode 3 during each contacting interval L1. The probe electrode 6 traverses between the individual electrodes 3 during an interval time T4. As shown in FIG.2, each individual electrode 31, 32, 33, 34 is precisely arranged to have a predetermined interval (L1 + L2) therebetween. In case that two individual electrodes 31, 34 are connected to the heating resistor elements 4a to be trimmed respectively, a few pulses are applied to the individual electrodes 31, 34 through the probe electrode 6 after elapse of a delay time T1 from contacting of the probe electrode 6 with the individual electrode 31 or 34. And, the few pulse having pulse duration of below several μsec are applied during a time T2. Consequently, the predetermined pulse signal is applied to the heating resistor elements 4a to reduce the resistance thereof.

In the above-mentioned circumstance, a relative velocity V of the probe electrode 6 for scanning the thermal print head satisfies the condition which is shown by the following equations:

$$V = (L1 + L2) / T \quad (1),$$

where

$$T = (T1 + T2 + T3 + T4) \quad (2),$$

and

$$V \times (T1 + T2) < L1 \quad (3).$$

The trimming operation for the heating resistor 4 has been finished when the few pulses having a predetermined voltage for trimming are applied to the individual electrode 31. Then, the thermal print head on the stage 7 is automatically slid to contact between the probe electrode 6 and next individual electrode 34 which is connected to the heating resistor element 4a to be trimmed. The predetermined pulse signal for the trimming operation is applied to the individual electrode 34 through the probe electrode 6 when the delay time T1 elapsed from the contact of the probe electrode 6 with the individual electrode 34. The voltages of the two predetermined pulse signals, which are to be applied to the two individual electrodes 31 and 34,

may differ from those of the heating resistor elements 4a. The voltages of the pulse signals, which are to be applied to the heating resistor elements 4a to be trimmed, may be set at different resistance to make proper resistance of the heating resistor elements 4a.

In case that each interval (L1 + L2) of the individual electrodes 3 is set at 100μm length for printing to a thermosensible paper of A4 size, the delay time T1 is preferably to be set from 2 to 4 msec, and the applying time T2 is preferably to be set from 1 to 3 msec. Each of the heating resistor elements 4a may be partly trimmed by application of one pulse in a pulse signal, and the heating resistor elements 4a can be entirely trimmed by three pulses. In the above-mentioned case that the interval (L1 + L2) is set at 100μm length, time for total trimming made by applications of various pulses in turn takes 30 sec. or less, to finish the trimming operation according to our experiment. Therefore, resistance of the heating resistor 4 can be trimmed in a short time. In other words, the trimming operation is executed at such a high speed as ten times faster in comparison with the conventional one according to our experiment, because the pulse signal for the trimming operation can be applied during the while the probe electrode 6 is relatively scanning on the thermal print head.

Apart from the above-mentioned embodiment wherein one set of the probe electrode 6 is provided in the thermal print head trimming apparatus, a modified embodiment may be such that a plurality of probe electrodes, which are controlled by individual pulse signal, are provided so as to be scanned at parallelly the same time for executing the more fast trimming operation.

In the above-mentioned embodiment, the trimming operation is executed on the basis of the previously detected data which shows the resistance of the heating resistor elements 4a for indicating dots. In another modified embodiment, a target value of the desired resistance would have been previously set at a constant value. The actual resistance of the heating resistor element 4a is measured by scanning the probe electrode in the above-mentioned delay time T1 shown in FIG.2. If the detected actual resistance differs much from the predetermined target value, the heating resistor element for indicating a dot is decided to be trimmed to trim the resistance of the heating resistor element. And, the heating resistor of the thermal print head can be trimmed in the subsequent applying time T2 as shown in FIG.2.

Scanning of the prove electrode 6 of the thermal print head trimming apparatus is elucidated with reference to the accompanying drawing of FIG.3. FIG.3 is a partial cutaway view showing a part of the thermal print head of the embodiment in accordance with the present invention. Referring to FIG.3, a common electrode 2, which is connected to the D/C power supply 12 of FIG.1, and plural individual electrodes 3, which should be contacted with the probe electrode 6, are printed on an insulated substrate 1. The heating resistor 4 is formed on and between the common electrode 2 and the plural individual electrodes 3. Consequently, the heating resistor 4 is divided electrically into a plurality of heating resistor elements 4a for indicating dots. The upper surface of the heating resistor 4 is protected by a protective layer 5 of glass or the like. Probe contact portions 31a, 32a, 33a, 34a, 35a are configured in the individual electrodes 31, 32, 33, 34, 35 respectively, as shown in FIG.3. And individual electrode terminals 31b, 32b, 33b, 34b, 35b are also configured at the end parts of the individual electrodes 31, 32, 33, 34, 35, respectively.

The individual electrodes 31, 32, 33, 34, 35 are arranged to have short intervals therebetween, because integrated circuits (IC) need to be mounted on the thermal print head, and the thermal print head is manufactured by known tape-automated bonding (TAB). Therefore, the below-mentioned method is effective for scannings along the individual electrodes 31, 32, 33, 34, 35 in two ways shown by an arrow A and an arrow B in FIG.3.

One way (of arrow A) of scanning by the probe electrode 6 is arranged to transversely across the probe contact portions 31a, 32a, 33a, 34a, and 35a. Consequently, the individual electrodes 31, 32, 33, 34, 35 can be scanned by the probe electrode 6 which is relatively slid by utilizing a low precise positioning system, because each probe contact portions 31a, 32a, 33a, 34a, 35a are arranged to have wide face and uniform intervals therebetween. And the heating resistor 4 of the thermal print head can be stably and accurately trimmed by the thermal print head trimming apparatus in accordance with the present invention.

In case of a thermal print head having 8 dots per mm for recording paper of A4 size, the pitch interval (L1 + L2 of FIG. 2(b)) of the row of the above-mentioned probe contact portions 31a, 32a, 33a, 34a, 35a can be made so long as 125μm length. And, the contacting intervals (L1) of the probe contact portions 31a, 32a, 33a, 34a, 35a can set so long as 100μm or more. Therefore, the probe contact portions 31a, 32a, 33a, 34a, 35a are formed to have wide face for contacting the probe electrode 6, thereby enabling stable and certain application of the pulse signal for trimming.

The other way (of arrow B) of scanning by the probe electrode 6 is arranged to transversely across the individual terminals 31b, 32b, 33b, 34b, and 35b. Consequently, each heating resistor ele-

ments 4a of the heating resistor 4 can be more precisely trimmed to have uniform resistance, because each resistance of wiring of the individual electrodes 31, 32, 33, 34, 35 are taken account in executing the trimming operation.

Apart from the above-mentioned embodiment wherein the scanning ways are arranged parallel to the direction of the arrangement of the heating resistor 4, a modified embodiment may be as shown in FIG.4, such that two scanning ways, which are shown by an arrow C and an arrow D in FIG.4, are arranged to be at right angles to the direction of the arrangement of the heating resistor 4. And further, the two scanning ways can be executed by two probe electrodes individually at the same time, so that the trimming operation is executed more speedy than the above-mentioned embodiment.

The following is an explanation of a scanning method for relatively sliding the probe electrode 6. It is the speedy scanning method for relatively sliding the probe electrode 6 that the thermal print head on the stage 7 is moved in one direction at a constant velocity to make a contact between the probe electrode 6 and each individual electrode 3. The scanning method is effective for scanning the thermal print head in the afore-mentioned scanning ways shown with the arrow A and the arrow B in FIG.3.

In the above-mentioned scanning ways shown with the arrow C and the arrow D in FIG.4, the thermal print head held on the stage 7 must be moved in the directions of up and down of FIG.4 during trimming for every block of the gathered individual electrode terminals 131b, 132b, 133b and 134b, 135b, 136b in order to make scanning contact between the probe electrode 6 and each individual terminal 131b, 132b, 133b, 134b, 135b.

There is another scanning method of stepwise scanning. The stepwise scanning is effective in case that number of the heating resistor element 4a to be trimmed is not large. In the stepwise scanning, the probe electrode 6 is moved at a very high-speed between the probe contact parts in comparison with the above-mentioned uniform speed moving examples. And, the probe electrode 6 may be stopped or moves very slowly on each probe contact whereto the heating resistor element to be trimmed is connected.

According to the thermal print head trimming apparatus of the present invention, as the resistance of the heating resistor in the thermal print head can be precisely trimmed in a short time, the thermal print head having the high-precision heating resistor can be obtained.

EMBODIMENT OF TRIMMING

An actual example of executing the trimming in accordance with the present invention is elucidated with reference to the accompanying drawings of FIGs.5 to 12. The embodiment is elucidated describing a method for trimming resistance of a thermal print head by utilizing the thermal print head trimming apparatus of the foregoing embodiment elucidated with reference to FIG.1 through FIG.4. Corresponding parts and components to the foregoing embodiment are shown by the same numerals and marks, and the description thereon made in the foregoing embodiment similarly apply.

In the first, the principle of the method for trimming resistance is elucidated with reference to FIG.1 of the foregoing embodiment.

Each resistance of the heating resistor elements 4a for indicating plural dots is measured by the afore-mentioned resistance measuring circuit 10 through the probe electrode 6. Average data of the measured resistance are calculated by the operation control unit 13, and a target value and an allowable range of the resistance is set at a desired value taking account of the average data. For example, the allowable range is set at ±10% with regard to the target value of the resistance. In case that the heating resistor elements 4a having the variations of resistance as shown in FIG.5, the heating resistor elements 4a are divided into plural groups having different variation ranges of the detected resistance. FIG.5 is a distribution graph showing detected resistances of the heating resistor 4.

For example, the plural groups of variation range are defined as follows:

(1) +15% or more with regard to the target value;

(2) from +10 to +15% with regard to the target value;

(3) from -10% to +10% with regard to the target value; and

(4) below -10% with regard to the target value.

Then, the heating resistor elements (indicated by Δ) in the variation range (1) are trimmed to reduce the resistance by 20% of the measured resistance in the trimming operation. And the heating resistor elements (indicated by □) in the variation range (2) are trimmed to reduce the resistance by 10% of the detected resistance. As a result, distribution of the resistances of the whole heating resistor elements 4a becomes as shown in FIG.6. FIG.6 is a distribution graph showing the trimmed resistance of the heating resistor 4. The trimming operation is performed by applying the high-voltage (ab. 150V) pulse signal to the target heating resistor element as the afore-mentioned embodiment.

In the above-mentioned state, if the heating resistor element (indicated by ☒) which is included

in the variation range of +30% or more with regard to the target value exists, the heating resistor element (⊠) are not trimmed within the allowable range. And if the heating resistor element (indicated by ■) which is included in the variation range below -10% with regard to the target value exists, the heating resistor element (■) are not also trimmed. Consequently, when the resistance of the heating resistor elements are distributed within the range between +30% and -10% with regard to the target value, the whole heating resistor elements 4a are trimmed within the allowable variation range (±10% with regard to the target value) by the aforementioned two-step trimming method.

On the other hand, when the heating resistor elements 4a of the thermal print head is out of the range between +30% and -10%, the thermal print head may be treated as a defect product, or alternatively another trimming of the heating resistor elements 4a is made by setting a new target value and new allowable variation range.

The following is an explanation of an actual trimming operation in our experiment. In the actual trimming operation, the allowable variation range is set at ±3% with regard to the target value.

FIG.7 is a partial cutaway view showing a part of the thermal print head. As shown in FIG.7, a common electrode 2 and plural individual electrodes 3 are made of gold thick film onto the surface of the insulated substrate 1 (e.g. a glazed alumina substrate). And, the common electrode 2 and the individual electrodes 3, which are formed like a comb,are formed by photolithography followed by etching to indicate 8 dots per 1mm length of a recording paper. The heating resistor 4, which is made of the paste of ruthenium oxide and glass frits, is printed and fired on and between the common electrode 2 and the individual electrodes 3. The straight-line shaped heating resistor 4 is divided electrically into a plurality of heating resistor elements 4a. And, the upper surface of the heating resistor 4 is protected by a protective layer 5 which is formed by printing and firing of the glass paste.

FIG.8 is a distribution graph showing measured resistance of the heating resistor elements 4a in case of the heating resistor 4 having 384 dots per a line. In the above-mentioned experiment, the calculated average value in the measured resistance of the heating resistor 4 is 3250Ω, variations in the measured resistance is ±10% with regard to the average value, and a variance rate (deviation of the measured resistance against average of the resistance) is 0.03.

FIG.9 is a graph showing relations between a change rate of the resistance and applied-voltage of the pulse for trimming, while the pulse having the pulse duration of about 1μsec. is applied to the heating resistor elements 4a to be trimmed. As shown in FIG.9, when the pulse having voltage of 120V is applied to the heating resistor element 4a, the resistance is reduced by 90% of the measured resistance.

In case that the whole resistance of the heating resistor elements 4a are trimmed within ±3% with regard to the target value by utilizing the characteristic of the heating resistor 4 shown in FIG.9, the target value of the thermal print head having variations of the resistance shown in FIG.8 is set at the resistance of 3100Ω. The target value is decided to include the lowest value of the measured resistance within ±3% with regard to the target value. The heating resistor elements 4a are divided into the following four groups:

(1) from -3% to +3% with regard to the target value;

(2) from +3% to +5% with regard to the target value;

(3) from +5% to +10% with regard to the target value; and

(4) from +10% to +20% with regard to the target value.

Then, the heating resistor elements (33 dots) in the above-mentioned variation range (1) are not trimmed to reduce the resistance. The trimming operation is executed to the heating resistor elements (86 dots) in the variation range (2), by application of pulses of the voltage of 80V of the pulse, thereby to reduce the resistance by 4%. Pulses of voltage of 105V is applied to the heating resistor elements (155 dots) in the variation range (3) to reduce the resistance by 7%. By application of pulses of voltage of 120V to the heating resistor elements (10 dots) in the variance range (4), the resistance is reduced by 10%. FIG.10 is a distribution graph showing the resistance of the heating resistor 4 which has been trimmed by the above-mentioned trimming operation. As shown in FIG.10, the whole heating resistor elements 4a are trimmed to the resistance variation within ±3% with regard to the target value (3100Ω).

In order to trim the resistances so that the whole resistance of the heating resistor elements 4a have variations of the resistance of FIG.8 within ±5% with regard to the target value, the target value is set at the resistance of 3170Ω, and the heating resistor elements 4a are divided into the following three groups:

(1) from -5% to +5% with regard to the target value;

(2) from +3% to +10% with regard to the target value; and

(3) from +10% to +20% with regard to the target value.

Then, the heating resistor elements (297 dots) in the above-mentioned variation range (1) are not

trimmed to reduce the resistance. The trimming operation is executed to the heating resistor elements (84 dots) in the variation range (2), by application of pulses of the voltage of 105V of the pulse, thereby to reduce the resistance by 7%. By application of pulses of voltage of 120v to the heating resistor elements (3 dots) in the variation range (3) the resistance is reduced by 10%. FIG.11 is a distribution graph showing the resistance of the heating resistor 4 which has been trimmed by the above-mentioned trimming operation. As shown in FIG.11, resistances of the whole heating resistor elements 4a are trimmed to the resistance variation within ±5% with regard to the target value (3170Ω).

FIG.12 is a flow chart showing the trimming operation of the second embodiment in accordance with the present invention. In FIG.12, N denotes the number of the divided groups, such as 4 or 3 in the above-mentioned experiments.

In step 100, the whole resistances of the heating resistor elements 4a are measured. The heating resistor elements 4a are divided into N groups each having the afore-mentioned variation ranges of the detected resistance, in step 101. The voltage of pulse is set at an appropriate value to trim the resistance within allowable variation range in step 102. In step 103, the afore-mentioned trimming operation is executed to the heating resistor elements 4a in the group I (I =1 to N), and the flow goes to step 104. CPU in step 104 judges whether any other group to be trimmed exists or not. When another group exists, it returns to step 102. On the contrary, when any other group does not exist, the trimming operation has been finished.

According to the present invention, since the heating resistor elements in a line are trimmed with the trimming operation at a stretch, the required time for the trimming operation can be shortened drastically. According to our experiment, the trimming operation is executed as thirty times quick as the speed of the velocity that the conventional trimming operation.

In the above-mentioned experiments, the number (N) of the divided groups for the trimming operation was set at 4 or 3. However, the number (N) is preferably set at 10 or below, so that the trimming operation is executed at twice or triple high speed in comparison with the conventional one.

Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the arts after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

Claims

1. A thermal print head trimming apparatus comprising:
   a power supply circuit for generating voltage of pulse signal for trimming operation;
   a resistance measuring circuit for measuring resistance of a heating resistor;
   a movable stage control unit for moving a movable stage holding thereon a thermal print head relatively with a probe electrode; and
   an operation control unit for controlling said power supply circuit, said resistance measuring circuit and said stage control unit.

2. A thermal print head trimming apparatus in accordance with claim 1 wherein
   said operation control unit has a clock circuit for commonly synchronizing said power supply circuit and said stage control unit.

3. A thermal print head comprising;
   a common electrode which is formed on a substrate;
   individual electrodes which are formed on said substrate and have electrode terminals and probe contact portions for contacting a probe electrode; and
   a heating resistor which are formed on and between said common electrode and said individual electrodes to electrically connect therebetween;
   a protective layer which covers said heating resistor.

4. A method for trimming resistance of a thermal print head comprising steps of
   dividing heating resistor elements into predetermined groups based on resistance data of said heating resistor elements, and
   applying pulse signal of a predetermined voltage to each group for trimming resistance of the thermal print head.

5. A method for trimming resistance of a thermal print head in accordance with claim 4 wherein
   said application of pulse signal during a scanning of a probe electrode on individual electrodes formed on a substrate, to electrically connected to said heating resistor elements covered by a protective layer.

6. A method for trimming resistance of a thermal print head in accordance with claim 5 wherein
   said application of pulse signal are made at the same time as the scanning on said

individual electrodes.

7. A method for trimming resistance of a thermal print head in accordance with claim 5 wherein

said application of pulse signal is made only to those heating resistor elements which have resistance exceeding the predetermined range, after measuring resistance of the whole heating resistor elements of said thermal print head.

8. A method for trimming resistance of the thermal print head in accordance claim 5 wherein

said probe electrode scans in a stepwise scanning.

9. A method for trimming resistance of the thermal print head in accordance with claim 4 wherein

said dividing of said heating resistor elements is made after measuring resistance of the whole heating resistor elements of said thermal print head,

said application of pulse signal is made to each group except that which includes the lowest resistance value, thereby to trim the resistance of the whole heating resistor elements to the lowest resistance value.

FIG. 1

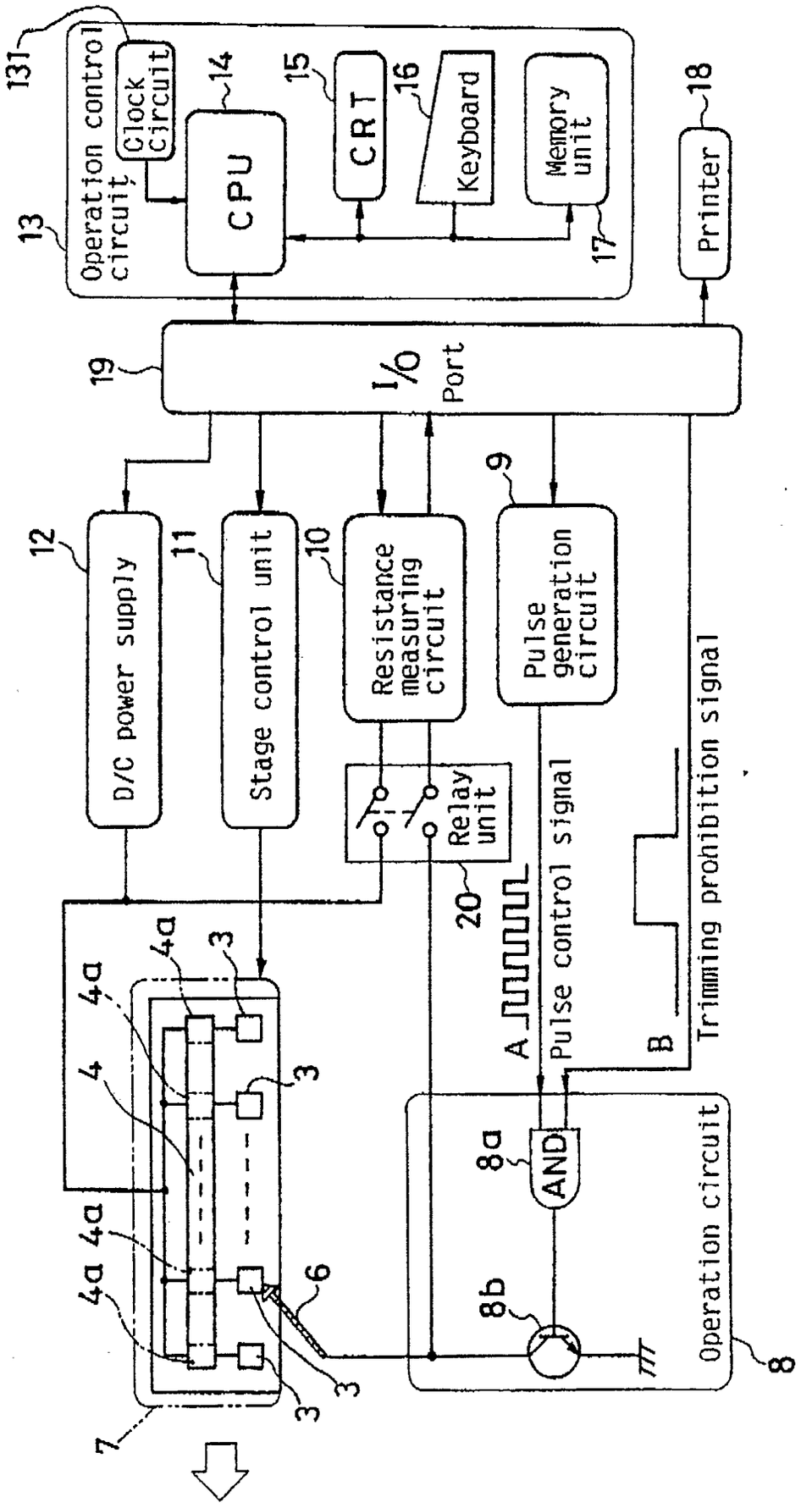

131
Operation control circuit
Clock Circuit
CPU
14
15
CRT
16
Keyboard
Memory unit
17
18
Printer
13
19
I/O Port
12
D/C power supply
11
Stage control unit
10
Resistance measuring circuit
9
Pulse generation circuit
Relay unit
20
A
Pulse control signal
B
Trimming prohibition signal
4a
4
3
6
7
8a
AND
8b
Operation circuit
8

FIG. 2

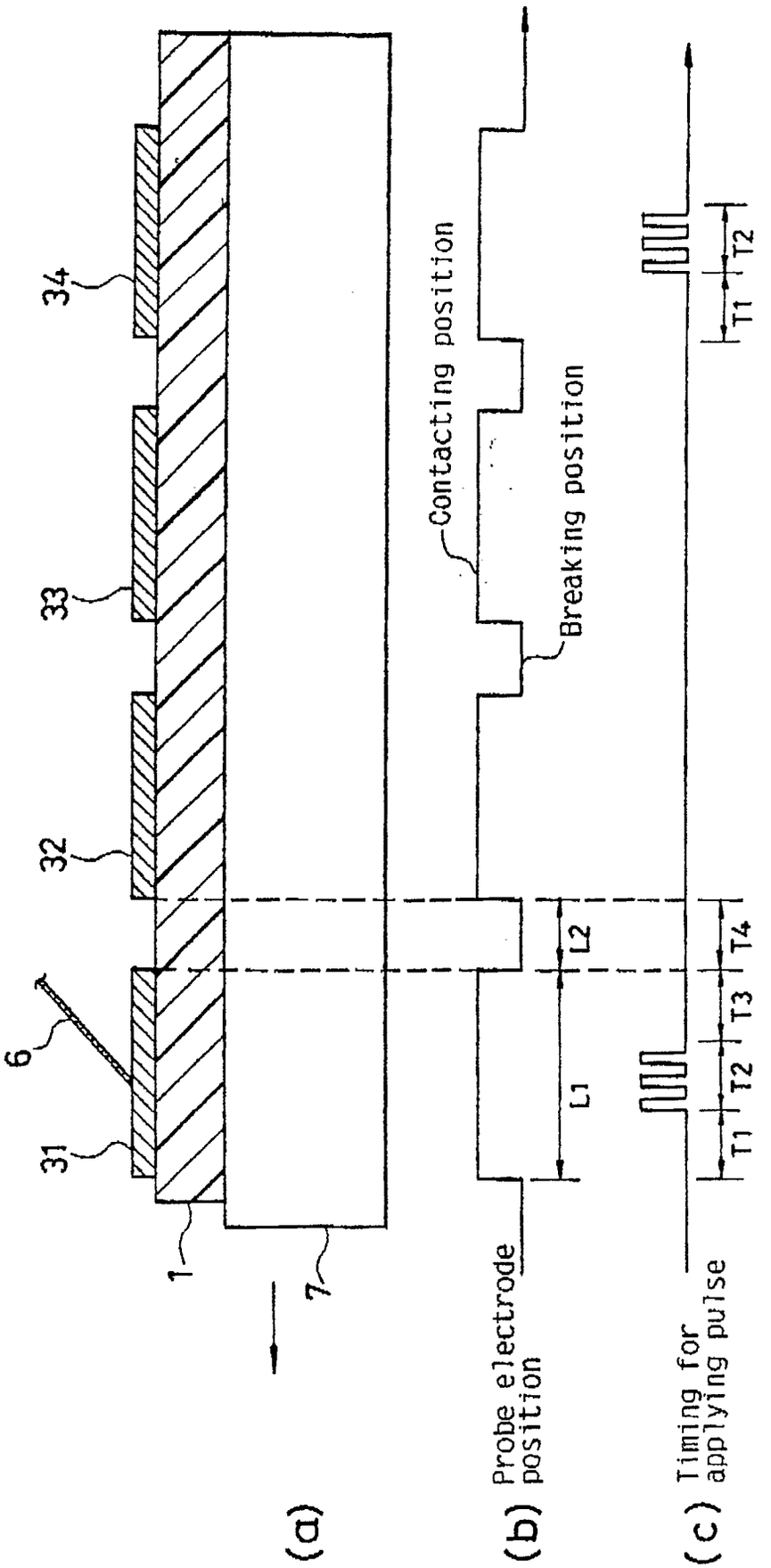

(a)
(b) Probe electrode position
(c) Timing for applying pulse
Contacting position
Breaking position
L1
L2
T1
T2
T3
T4
1
6
7
31
32
33
34

FIG. 3

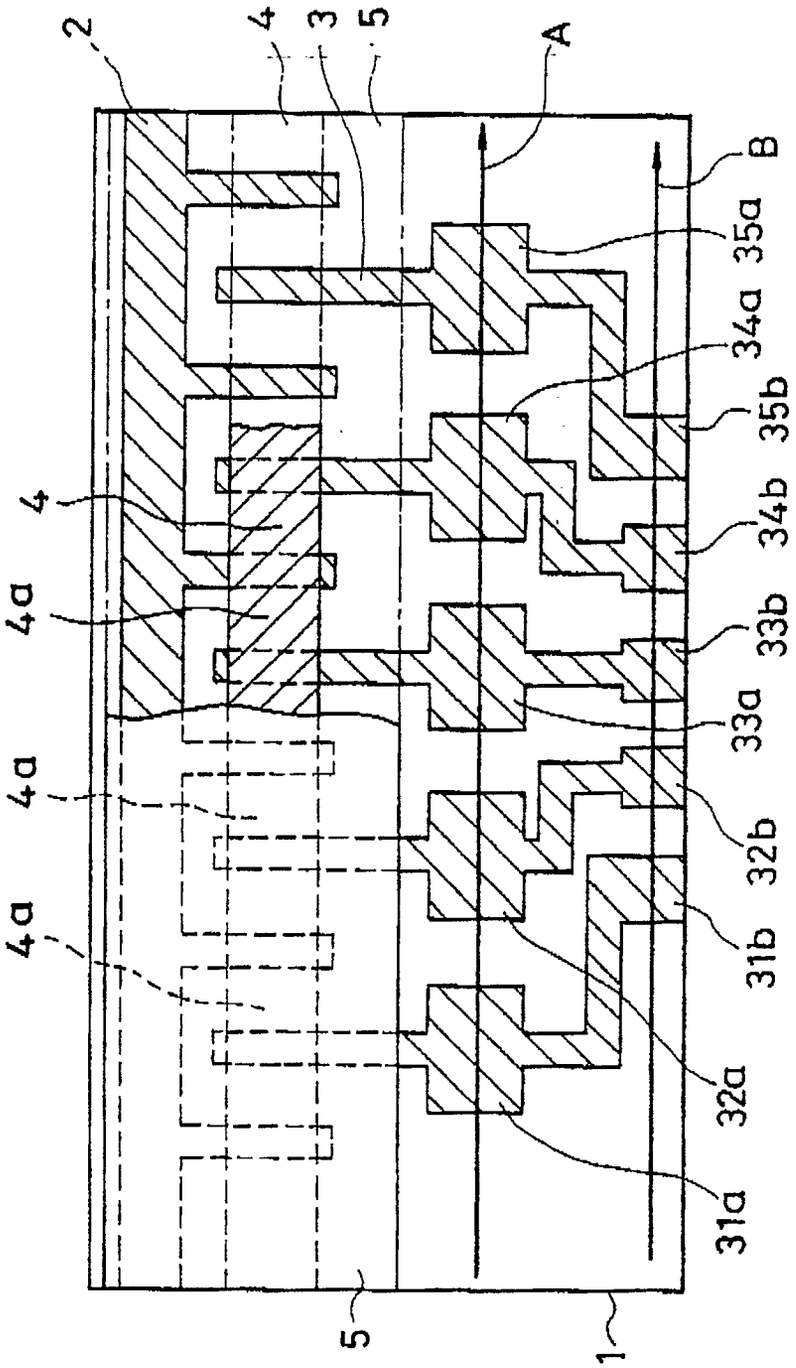


FIG. 4

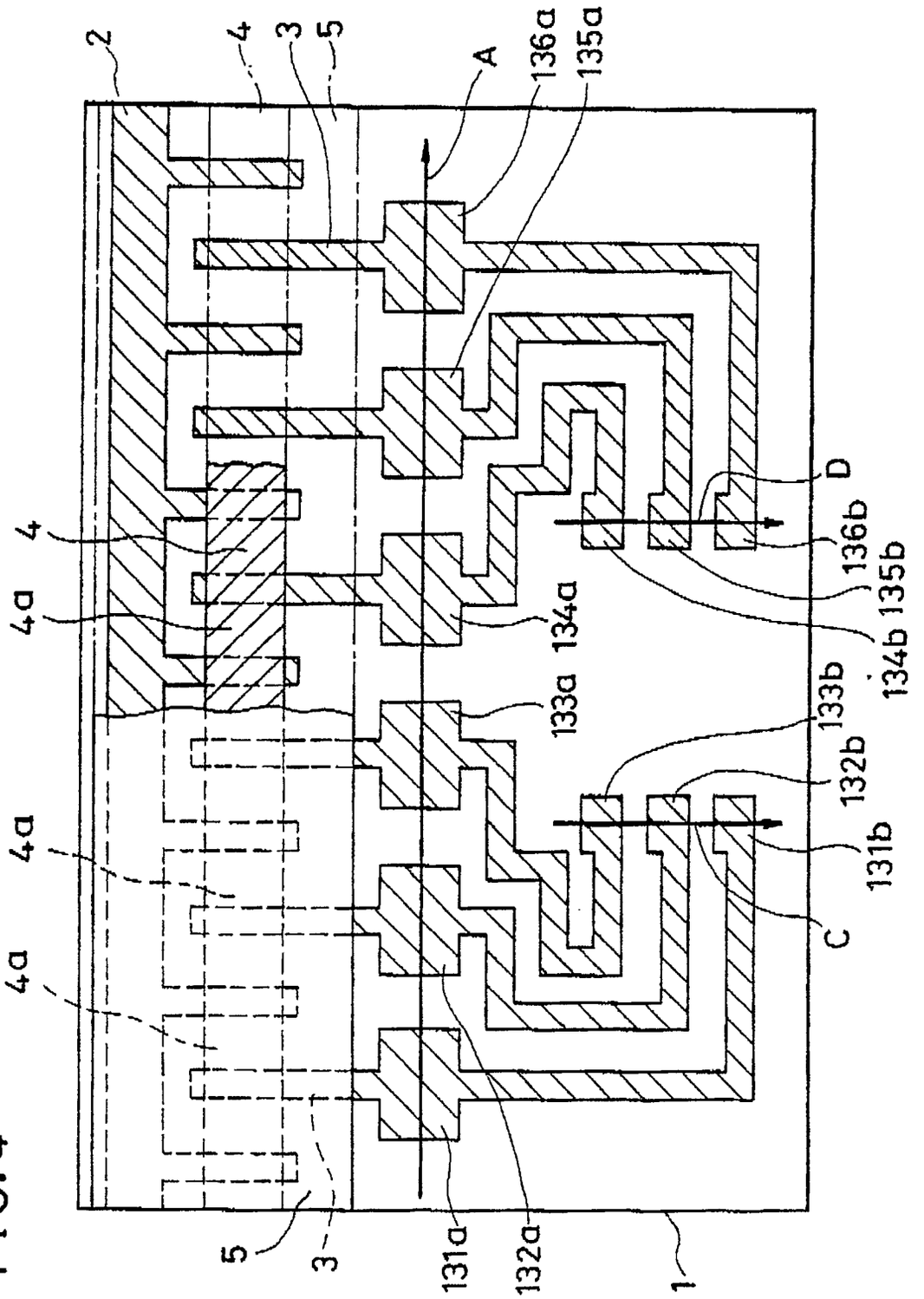

2
4
3
5
A
136a
135a
D
4
4a
136b
135b
134a
134b
133a
133b
132b
131b
C
4a
4a
5
3
131a
132a
1

FIG. 6

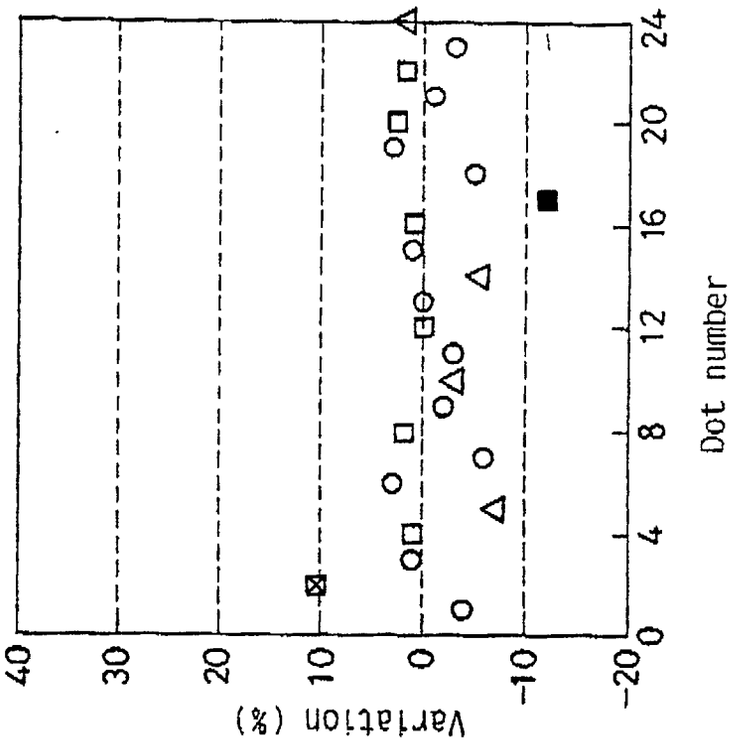

Variation (%)
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
Dot number

FIG. 5

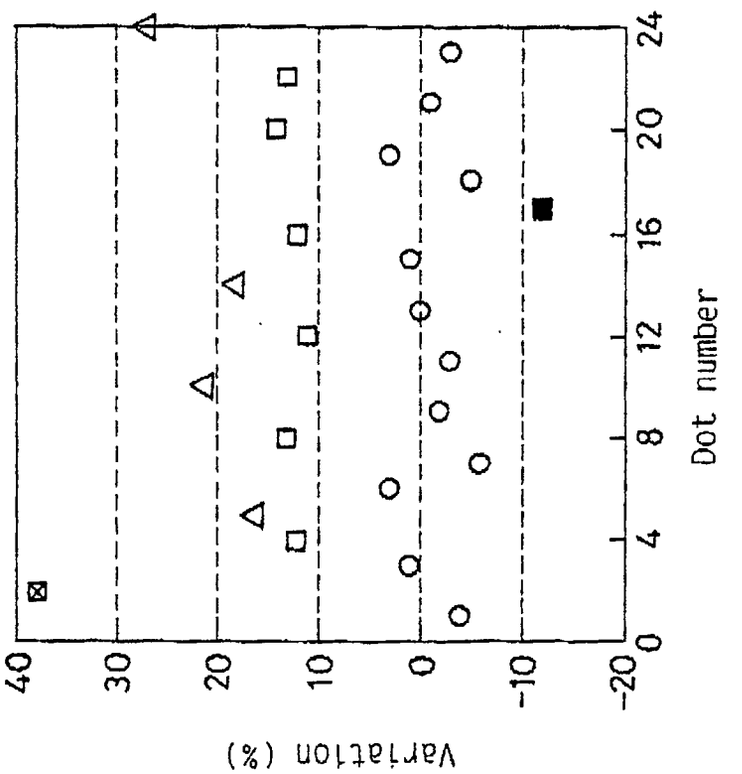

Variation (%)
40
30
20
10
0
-10
-20
0
4
8
12
16
20
24
Dot number

FIG. 7

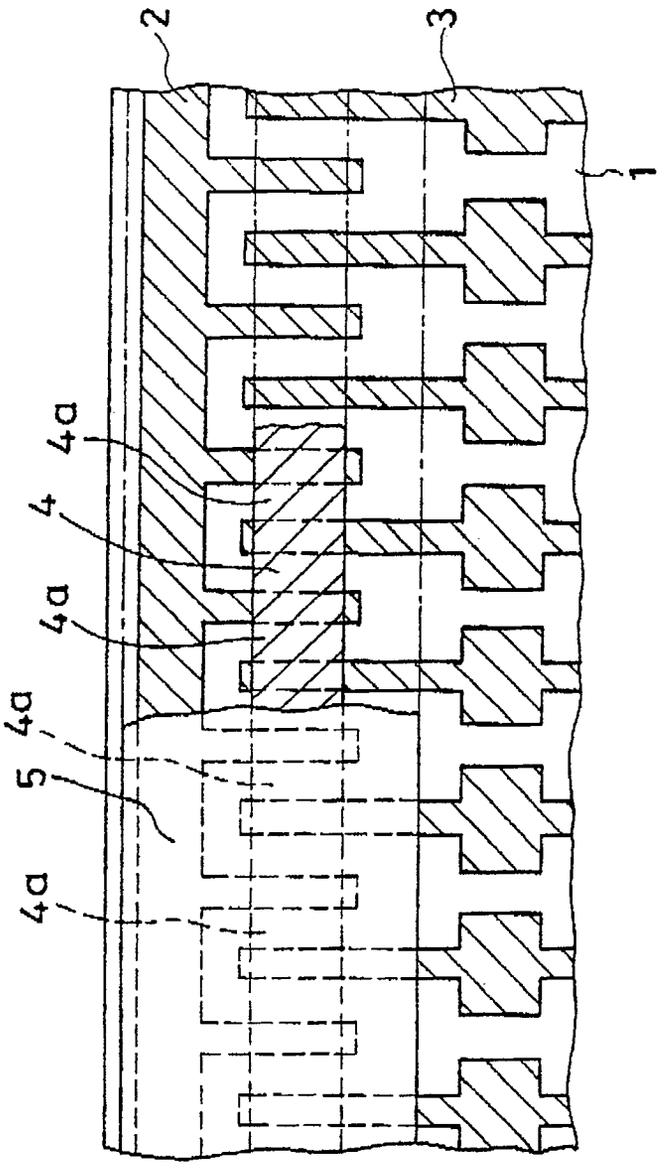


FIG. 8

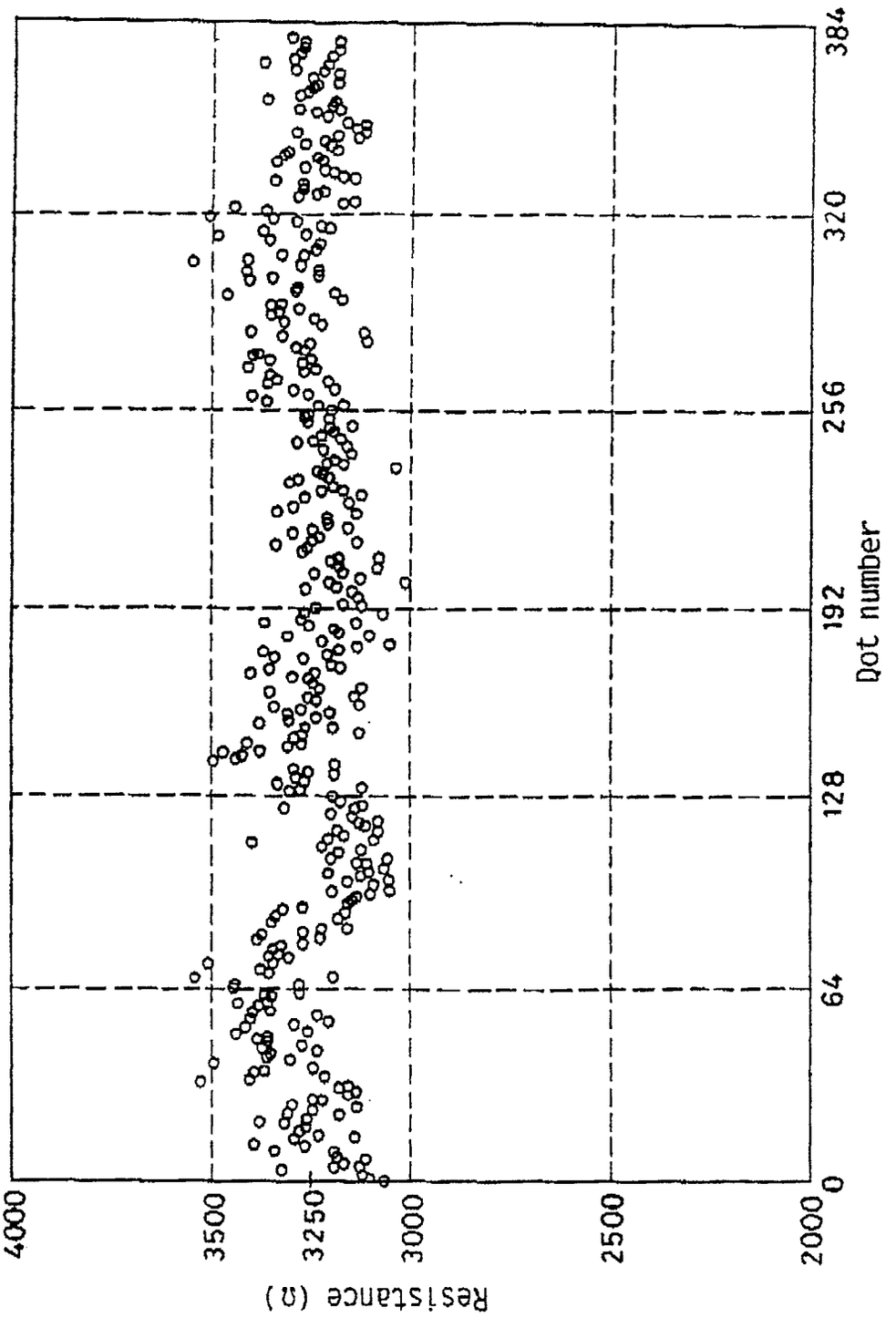

4000
3500
3250
3000
2500
2000
Resistance (Ω)
0
64
128
192
256
320
384
Dot number

FIG. 9

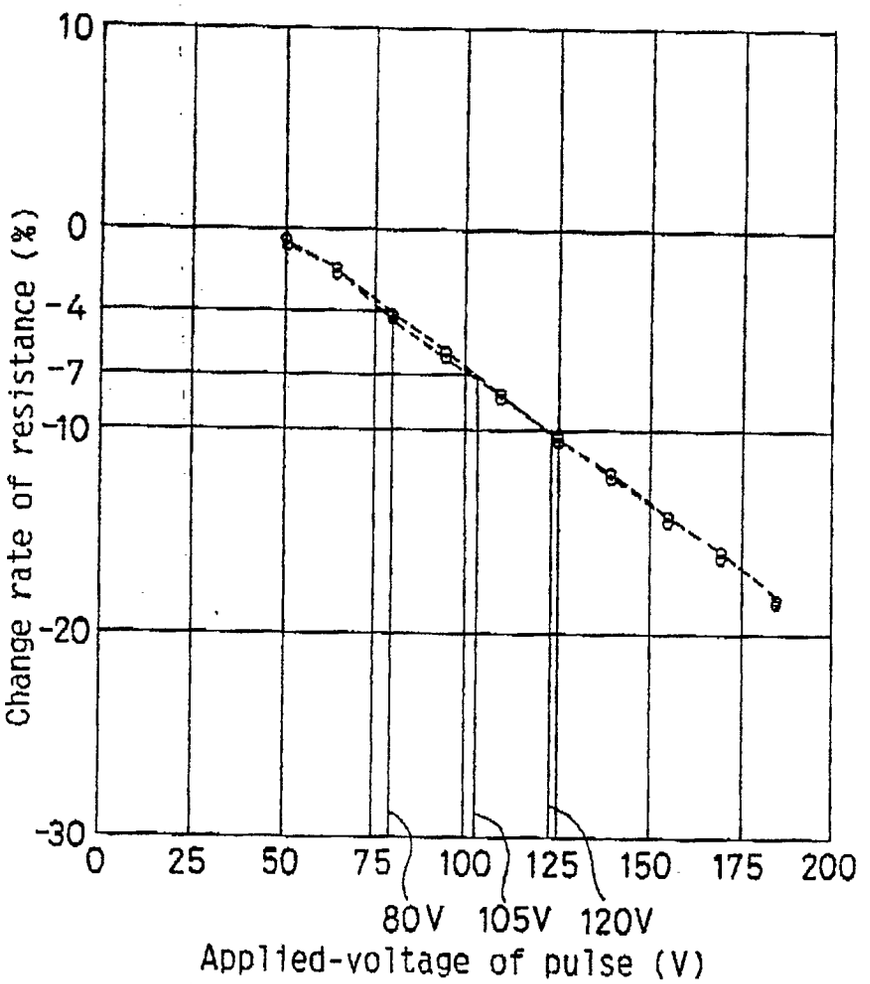

10
0
-4
-7
-10
-20
-30
Change rate of resistance (%)
0
25
50
75
100
125
150
175
200
80V
105V
120V
Applied-voltage of pulse (V)

FIG. 10

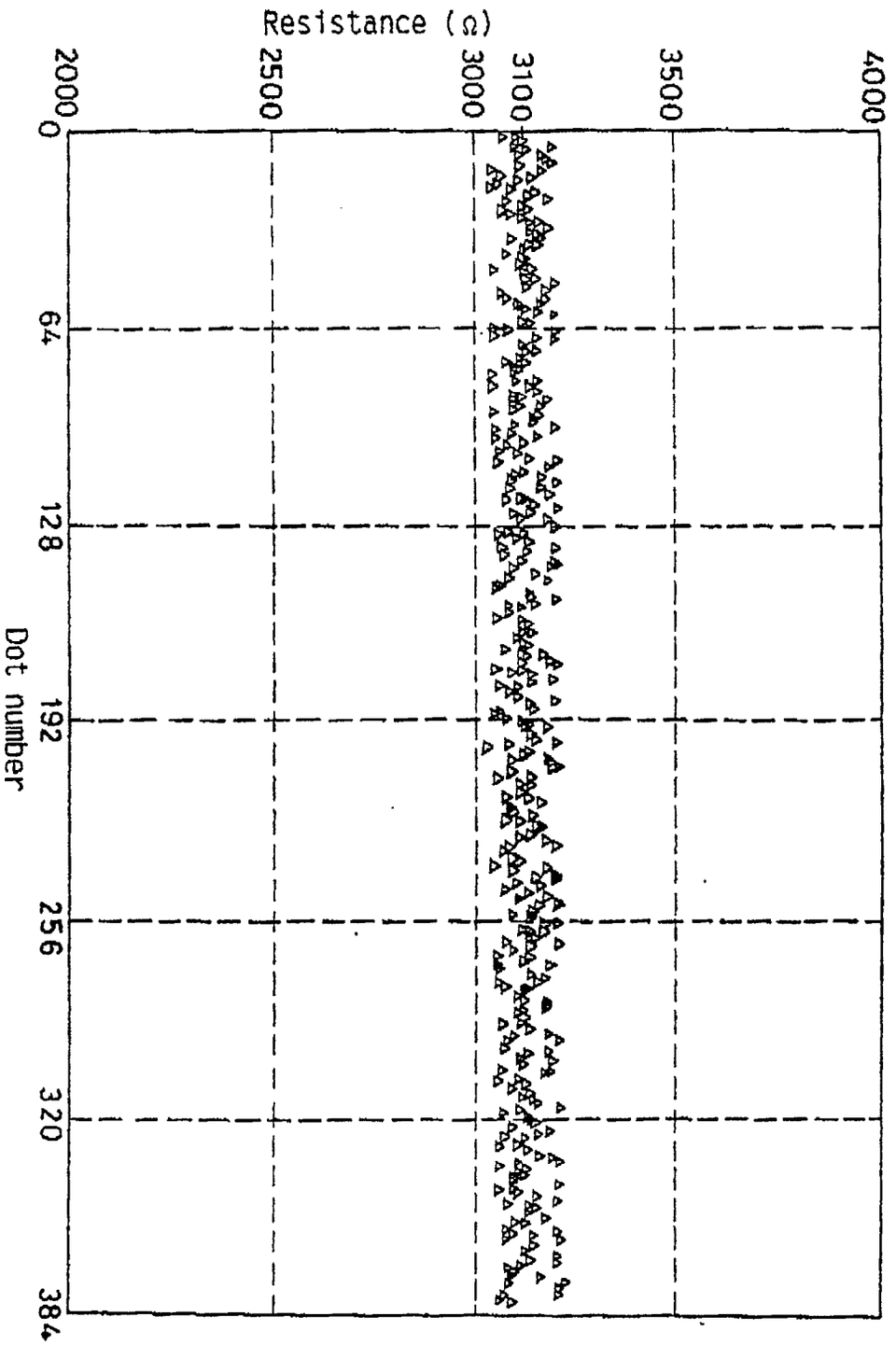

Resistance (Ω)
2000
2500
3000
3100
3500
4000
0
64
128
192
256
320
384
Dot number

FIG. 11

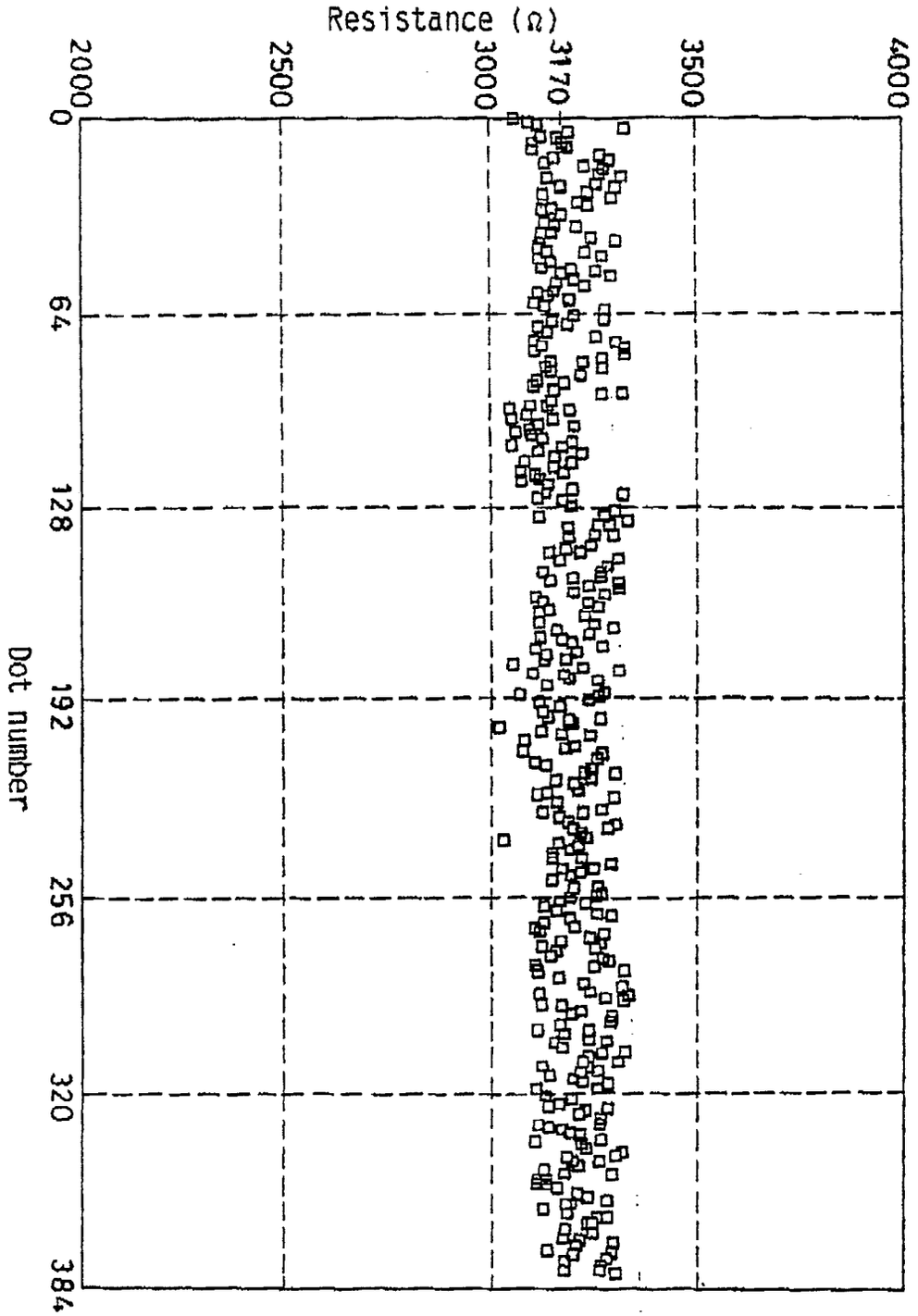
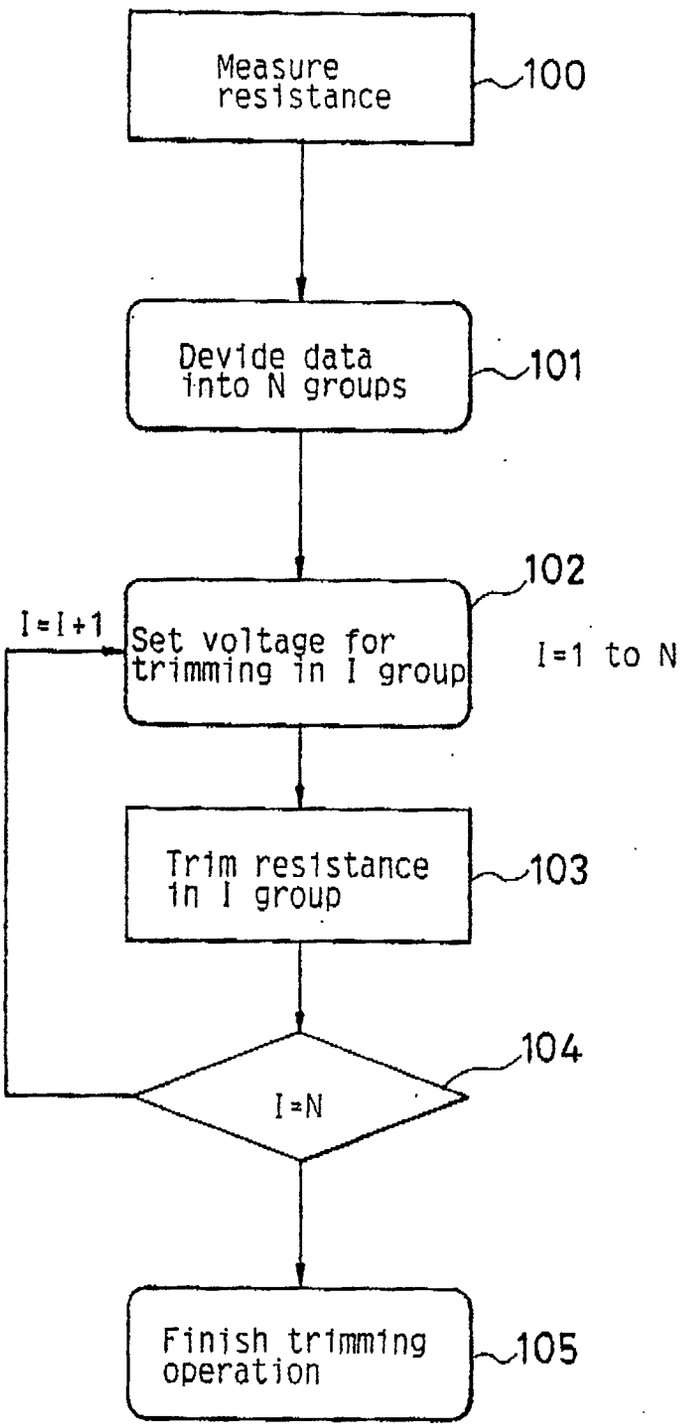

Resistance (Ω)
2000
2500
3000
3170
3500
4000
0
64
128
192
256
320
384
Dot number

FIG. 12


Measure resistance
100
Devide data into N groups
101
102
I=I+1
Set voltage for trimming in I group
I=1 to N
Trim resistance in I group
103
104
I=N
Finish trimming operation
105