



(22) Date de dépôt/Filing Date: 2002/03/28

(41) Mise à la disp. pub./Open to Public Insp.: 2002/09/29

(45) Date de délivrance/Issue Date: 2006/09/19

(30) Priorité/Priority: 2001/03/29 (JP2001-096223)

(51) Cl.Int./Int.Cl. *G06K 9/36* (2006.01),
G06K 9/64 (2006.01)

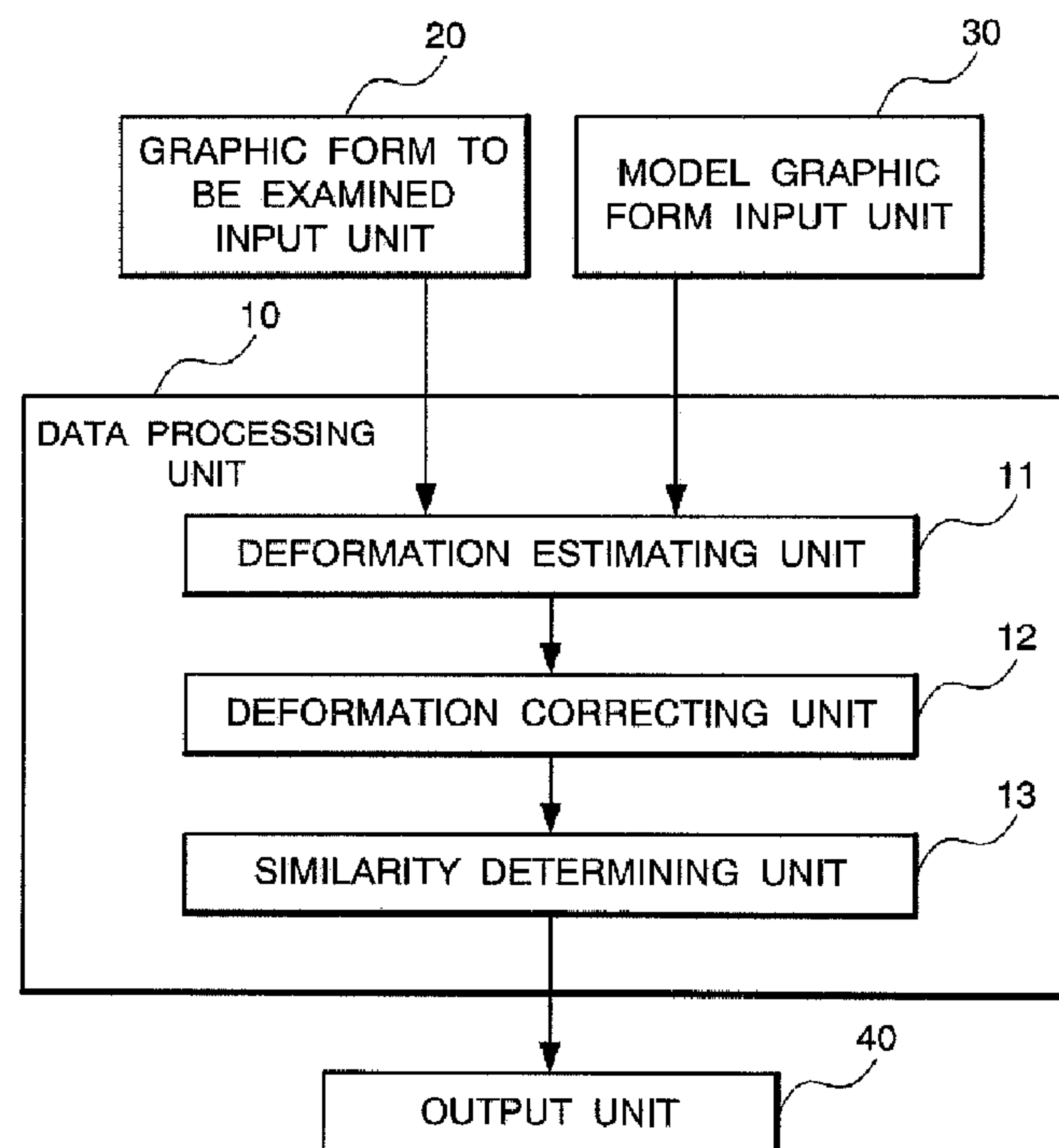
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(54) Titre : DISPOSITIF DE COLLATIONNEMENT DE MODELES ET METHODE ET PROGRAMME CONNEXES

(54) Title: PATTERN COLLATION DEVICE AND PATTERN COLLATING METHOD THEREOF, AND PATTERN COLLATION PROGRAM



(57) Abrégé/Abstract:

A pattern collation device for comparing and collating graphic forms includes a deformation estimating unit for estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and a model graphic form as a graphic form based on which comparison is made, a deformation correcting unit for correcting the graphic form to be examined in question based on information about the deformation estimated by the deformation estimating unit and a similarity determining unit for comparing the graphic form to be examined whose deformation is corrected by the deformation correcting unit with the model graphic form as a graphic form based on which comparison is made to calculate similarity therebetween.



ABSTRACT OF THE DISCLOSURE

A pattern collation device for comparing and collating graphic forms includes a deformation estimating unit for estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and a model graphic form as a graphic form based on which comparison is made, a deformation correcting unit for correcting the graphic form to be examined in question based on information about the deformation estimated by the deformation estimating unit and a similarity determining unit for comparing the graphic form to be examined whose deformation is corrected by the deformation correcting unit with the model graphic form as a graphic form based on which comparison is made to calculate similarity therebetween.

PATTERN COLLATION DEVICE AND PATTERN COLLATING METHOD
THEREOF, AND PATTERN COLLATION PROGRAM

BACKGROUND OF THE INVENTION

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FIELD OF THE INVENTION

The present invention relates to collation of
image data and, more particularly, to a pattern
collation device for identifying linear graphic forms
such as fingerprints and characters and a pattern
collating method thereof, and a pattern collation
program.

DESCRIPTION OF THE RELATED ART

As conventional devices for recognizing linear
image patterns such as fingerprints and characters, the
techniques are proposed in Japanese Patent Laying-Open
(Kokai) No. Heisei 10-240932 and Japanese Patent Laying-
Open (Kokai) No. Heisei 10-105703 in which using
features points such as an end point and a branch point
of a line, corresponding feature points are obtained and
overlapped with each other for comparison.

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Conventional techniques in which deformation of a
graphic form is corrected to compare images have been
proposed in Japanese Patent Laying-Open (Kokai) No.
Heisei 02-187885, Japanese Patent Laying-Open (Kokai) No.
Heisei 05-081412, Japanese Patent Laying-Open (Kokai) No.
Heisei 06-004671, Japanese Patent Laying-Open (Kokai) No.
Heisei 08-030783 and Japanese Patent Laying-Open (Kokai)

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No. Heisei 08-147411.

The conventional art, however, has the following shortcomings.

5 The conventional techniques recited in Japanese Patent Laying-Open No. Heisei 10-240932 and Japanese Patent Laying-Open No. Heisei 10-105703 have a problem that because the techniques employ a system of comparing graphic forms which are overlapped with each other as a whole, in such a case where a character is deformed or a
10 fingerprint is deformed at the time of fingerprinting, the patterns can not be properly discriminated.

On the other hand, according to the conventional techniques recited in Japanese Patent Laying-Open No. Heisei 02-187885, Japanese Patent Laying-Open No. Heisei
15 05-081412, Japanese Patent Laying-Open No. Heisei 06-004671, Japanese Patent Laying-Open No. Heisei 08-030783 and Japanese Patent Laying-Open No. Heisei 08-147411, even when a graphic form is deformed, if the graphic form has the same deformation as a whole, correcting the
20 deformation of the graphic form as a whole and comparing the same enables such a form to be coped with. However, in a case where each part has a different manner of deformation, an allowable difference should be increased to result in having inaccurate discrimination.

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SUMMARY OF THE INVENTION

An object of the present invention is to solve

the above-described conventional problems and provide a linear graphic form pattern collation device which is capable of strictly discriminating an applied graphic form even when it is deformed and a pattern collating method thereof, and a pattern collation program.

Even when a graphic form to be examined is deformed, the present invention enables the graphic form to be examined which is a graphic form as an object of examination and a model graphic form which is a graphic form based on which comparison is made to be strictly discriminated from each other by estimating deformation generated in the graphic form to be examined based on applied feature point information of the graphic form to be examined and applied feature point information of the model graphic form, correcting the estimated deformation and comparing the graphic form to be examined whose deformation has been corrected and the model graphic form to calculate similarity therebetween.

According to the first aspect of the invention, a pattern collation device for comparing and collating a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made, comprises

deformation estimating means for estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of

features in each of the graphic form to be examined in question and a model graphic form as a graphic form based on which comparison is made, and

5 deformation correcting means for correcting the graphic form to be examined in question based on information about the deformation estimated by the deformation estimating means.

10 In the preferred construction, the deformation estimating means correlates and pairs feature points in each of the graphic form to be examined and the model graphic form between which a difference in feature quantity indicative of a degree of features at the feature point is small and determines the contents of deformation of the graphic form to be examined which
15 best match correspondences between the respective feature points to estimate deformation generated in the graphic form to be examined in question.

In another preferred construction, the deformation estimating means selects the contents of deformation of the graphic form to be examined which
20 best match correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form from a plurality of deformation models indicative of the contents of deformation of image data which are prepared in advance.
25

In another preferred construction, the deformation estimating means has information of a

deformation model indicative of the contents of deformation of image data corresponding to a value designated by an individual parameter, and determines the contents of deformation of the graphic form to be examined by obtaining a value of each the parameter which provides the deformation model that best matches correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form.

10 In another preferred construction, the deformation estimating means re-estimates deformation using only feature point pairs left after excluding the paired feature points which go apart from each other by a distance equal to or greater than a predetermined threshold value when subjected to estimated deformation.

15 In another preferred construction, the deformation estimating means changes the deformation model in question to re-estimate deformation when the scale of estimated deformation is larger than a predetermined threshold value.

20 In another preferred construction, the deformation estimating means, after estimating deformation of the graphic form to be examined as a whole, divides the graphic form to be examined in question into small regions to estimate the contents of deformation at each the small region.

25 In another preferred construction, the

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deformation estimating means, after estimating deformation of the graphic form to be examined as a whole, refers, with respect to each feature point pair in question, to information of the feature point pairs in the vicinity to estimate and correct deformation in the vicinity of each the feature point pair.

In another preferred construction, as the deformation model, elastic deformation is used and as data indicative of the scale of deformation, elastic energy is used.

In another preferred construction, as the graphic form to be examined and the model graphic form, at least either a fingerprint image or a palmprint image is used.

According to another aspect of the invention, there is provided a deformation correcting device for comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct deformation, comprising:

deformation estimating means for estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and said model graphic form as a graphic form based on which comparison is made, and

deformation correcting means for correcting the graphic form to be examined in question based on

information about the deformation estimated by the deformation estimating means.

5 In the preferred construction, the deformation estimating means correlates and pairs feature points in each of the graphic form to be examined and the model graphic form between which a difference in feature quantity indicative of a degree of features at the feature point is small and determines the contents of deformation of the graphic form to be examined which
10 best match correspondences between the respective feature points to estimate deformation generated in the graphic form to be examined in question.

In another preferred construction, the deformation estimating means selects the contents of deformation of the graphic form to be examined which
15 best match correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form from a plurality of deformation models indicative of the contents of deformation of image data which are prepared in advance.
20

In another preferred construction, the deformation estimating means has information of a deformation model indicative of the contents of deformation of image data corresponding to a value designated by an individual parameter, and determines
25 the contents of deformation of the graphic form to be examined by obtaining a value of each the parameter

which provides the deformation model that best matches correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form.

5 In another preferred construction, the deformation estimating means re-estimates deformation using only feature point pairs left after excluding the paired feature points which go apart from each other by a distance equal to or greater than a predetermined
10 threshold value when subjected to estimated deformation.

 In another preferred construction, the deformation estimating means changes the deformation model in question to re-estimate deformation when the scale of estimated deformation is larger than a
15 predetermined threshold value.

 In another preferred construction, the deformation estimating means, after estimating deformation of the graphic form to be examined as a whole, divides the graphic form to be examined in
20 question into small regions to estimate the contents of deformation at each the small region.

 In another preferred construction, the deformation estimating means, after estimating deformation of the graphic form to be examined as a whole, refers, with respect to each feature point pair
25 in question, to information of the feature point pairs in the vicinity to estimate and correct deformation in

the vicinity of each the feature point pair.

In another preferred construction, as the deformation model, elastic deformation is used and as data indicative of the scale of deformation, elastic
5 energy is used.

In another preferred construction, as the graphic form to be examined and the model graphic form, at least either a fingerprint image or a palmprint image is used.

According to the third aspect of the invention, a
10 pattern collating method of comparing and collating a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made, comprising the steps of

the deformation estimating step of estimating
15 deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and a model graphic form as a graphic form
20 based on which comparison is made, and

the deformation correcting step of correcting the graphic form to be examined in question based on information about the estimated deformation.

In the preferred construction, at the deformation
25 estimating step, feature points in each of the graphic form to be examined and the model graphic form between which a difference in feature quantity indicative of a

degree of features at the feature point is small are correlated and paired to determine the contents of deformation of the graphic form to be examined which best match correspondences between the respective feature points, thereby estimating deformation generated in the graphic form to be examined in question.

In another preferred construction, at the deformation estimating step, the contents of deformation of the graphic form to be examined which best match correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form are selected from a plurality of deformation models indicative of the contents of deformation of image data which are prepared in advance.

In another preferred construction, at the deformation estimating step, based on information of a deformation model indicative of the contents of deformation of image data corresponding to a value designated by an individual parameter, the contents of deformation of the graphic form to be examined are determined by obtaining a value of each the parameter which provides the deformation model that best matches correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form.

In another preferred construction, at the deformation estimating step, deformation is re-estimated

using only feature point pairs left after excluding the paired feature points which go apart from each other by a distance equal to or greater than a predetermined threshold value when subjected to estimated deformation.

5 In another preferred construction, at the deformation estimating step, the deformation model in question is changed to re-estimate deformation when the scale of estimated deformation is larger than a predetermined threshold value.

10 In another preferred construction, at the deformation estimating step, after estimating deformation of the graphic form to be examined as a whole, the graphic form to be examined in question is divided into small regions to estimate the contents of deformation at each the small region.

15 In another preferred construction, at the deformation estimating step, after estimating deformation of the graphic form to be examined as a whole, with respect to each feature point pair in question, deformation in the vicinity of each the feature point pair is estimated and corrected by referring to information of the feature point pairs in the vicinity.

20 In another preferred construction, as the deformation model, elastic deformation is used and as data indicative of the scale of deformation, elastic energy is used.

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In another preferred construction, as the graphic form to be examined and the model graphic form, at least either a fingerprint image or a palmprint image is used.

According to another aspect of the invention, a
5 pattern collation program for comparing and collating a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made by controlling a computer, comprising the functions of

10 the deformation estimating function of estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and a model graphic form as a graphic form
15 based on which comparison is made, and

the deformation correcting function of correcting the graphic form to be examined in question based on information about the estimated deformation.

According to a further aspect of the invention,
20 there is provided a deformation correcting method of comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct deformation, comprising the steps of

25 the deformation estimating step of estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of

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features in each of the graphic form to be examined in question and said model graphic form as a graphic form based on which comparison is made, and

5 the deformation correcting step of correcting the graphic form to be examined based on information about the estimated deformation.

10 In the preferred construction, at the deformation estimating step, feature points in each of the graphic form to be examined and the model graphic form between which a difference in feature quantity indicative of a degree of features at the feature point is small are correlated and paired to determine the contents of deformation of the graphic form to be examined which best match correspondences between the respective
15 feature points, thereby estimating deformation generated in the graphic form to be examined in question.

20 In another preferred construction, at the deformation estimating step, the contents of deformation of the graphic form to be examined which best match correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form are selected from a plurality of deformation models indicative of the contents of deformation of image data which are prepared in advance.

25 In another preferred construction, at the deformation estimating step, based on information of a deformation model indicative of the contents of

deformation of image data corresponding to a value designated by an individual parameter, the contents of deformation of the graphic form to be examined are determined by obtaining a value of each the parameter which provides the deformation model that best matches correspondences between the respective feature points in each of the graphic form to be examined and the model graphic form.

In another preferred construction, at the deformation estimating step, deformation is re-estimated using only feature point pairs left after excluding the paired feature points which go apart from each other by a distance equal to or greater than a predetermined threshold value when subjected to estimated deformation.

In another preferred construction, at the deformation estimating step, the deformation model in question is changed to re-estimate deformation when the scale of estimated deformation is larger than a predetermined threshold value.

In another preferred construction, at the deformation estimating step, after estimating deformation of the graphic form to be examined as a whole, the graphic form to be examined in question is divided into small regions to estimate the contents of deformation at each the small region.

In another preferred construction, at the deformation estimating step, after estimating

deformation of the graphic form to be examined as a whole, with respect to each feature point pair in question, deformation in the vicinity of each the feature point pair is estimated and corrected by referring to information of the feature point pairs in the vicinity.

In another preferred construction, as the deformation model, elastic deformation is used and as data indicative of the scale of deformation, elastic energy is used.

In another preferred construction, as the graphic form to be examined and the model graphic form, at least either a fingerprint image or a palmprint image is used.

According to a still further aspect of the invention, a deformation correction program for comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct deformation by controlling a computer, comprising the functions of

the deformation estimating function of estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and a model graphic form as a graphic form based on which comparison is made, and

the deformation correcting function of correcting

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the graphic form to be examined in question based on information about the estimated deformation.

According to another aspect of the present invention, there is provided a computer-readable medium
5 storing deformation correction instructions executable by a computer for comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct deformation, said deformation correction instructions when executed performing a method
10 comprising a series of steps: a deformation estimating step of estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in
15 question and said model graphic form as a graphic form based on which comparison is made, and a deformation correcting step of correcting the graphic form to be examined in question based on information about said estimated deformation.

20 Other objects, features and advantages of the present invention will become clear from the detailed description given herebelow.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more
25 fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to be limitative to the invention, but are for explanation and understanding only.

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In the drawings:

Fig. 1 is a block diagram showing a structure of a pattern collation device according to a first embodiment of
5 the present invention;

Fig. 2 is a flow chart for use in explaining processing of pattern collation according to the first embodiment of the present invention;

Fig. 3 is a flow chart for use in explaining
10 processing of a deformation estimating unit according to the first embodiment of the present invention;

Fig. 4 is a diagram showing a list of feature point pairs for deformation estimation of one embodiment of the present invention;

15 Fig. 5 is a diagram showing a model graphic form

according to one embodiment of the present invention;

Fig. 6 is a diagram showing a graphic form to be examined according to one embodiment of the present invention;

5 Fig. 7 is a diagram showing a state where the model graphic form and the graphic form to be examined are overlapped with each other according to one embodiment of the present invention;

10 Fig. 8 is a diagram showing feature point pairs in the model graphic form and the graphic form to be examined according to one embodiment of the present invention;

15 Fig. 9 is a diagram showing a state where a model graphic form subjected to estimated deformation and the graphic form to be examined are overlapped with each other according to one embodiment of the present invention;

20 Fig. 10 is a diagram showing a state where the model graphic form shifted and the graphic form to be examined are overlapped with each other according to one embodiment of the present invention;

25 Fig. 11 is a diagram showing feature point pairs in the shifted model graphic form and the graphic form to be examined according to one embodiment of the present invention;

Fig. 12 is a diagram showing a state where the model graphic form subjected to estimated deformation

and the graphic form to be examined are overlapped with each other according to one embodiment of the present invention;

5 Fig. 13 is a block diagram showing a structure of a pattern collation device according to a second embodiment of the present invention;

Fig. 14 is a flow chart for use in explaining processing of pattern collation according to the second embodiment of the present invention;

10 Fig. 15 is a block diagram showing a structure of a pattern collation device according to a third embodiment of the present invention;

Fig. 16 is a flow chart for use in explaining processing of pattern collation according to the third
15 embodiment of the present invention;

Fig. 17 is a diagram for use in explaining measurement of a degree of concentration of feature points in the vicinity of a feature point in the third
embodiment of the present invention;

20 Fig. 18 is a diagram showing one embodiment of a structure of a device having a recording medium in which a pattern collation program is stored according to the present invention.

25

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention will be discussed hereinafter in detail with reference

to the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structures are not shown in detail in order to unnecessary obscure the present invention.

Fig. 1 is a block diagram showing a structure of a pattern collation device according to a first embodiment of the present invention.

With reference to Fig. 1, the pattern collation device according to the present embodiment includes a graphic form to be examined input unit 20 for receiving input of data of a graphic form to be examined which is a graphic form as an object of examination, a model graphic form input unit 30 for receiving input of data of a model graphic form as a graphic form based on which comparison is made, a data processing unit 10 for executing processing of pattern collation and an output unit 40 for outputting a processing result.

The data processing unit 10 includes a deformation estimating unit 11, a deformation correcting unit 12 and a similarity determining unit 13. These units operate in a manner as outlined in the following.

The deformation estimating unit 11 compares a feature point of a graphic form to be examined which is

input through the graphic form to be examined input unit
20 and a feature point of a model graphic form input
through the model graphic form input unit 30 to estimate
the contents of deformation generated as a whole in the
5 graphic form to be examined.

The deformation correcting unit 12, based on data
of the contents of the deformation estimated by the
deformation estimating unit 11, subjects the graphic
form to be examined to correction which eliminates the
10 deformation to generate a graphic form to be examined
whose deformation has been corrected.

The similarity determining unit 13 compares the
graphic form to be examined which is generated by the
deformation correcting unit 12 with its deformation
15 corrected and the model graphic form to calculate
similarity between the two graphic forms and outputs the
calculated similarity to the output unit 40.

Next, operation of the present embodiment will be
described in detail with reference to the drawings.

20 Fig. 2 is a flow chart for use in explaining
processing of pattern collation according to the present
embodiment. Fig. 3 is a flow chart for use in explaining
processing conducted by the deformation estimating unit
11 of the present embodiment.

25 With reference to Fig. 2, in the processing of
pattern collation according to the present embodiment,
first, a graphic form to be examined which is a graphic

form as an object of examination and a model graphic
form as a graphic form based on which comparison is made
are applied to the graphic form to be examined input
unit 20 and the model graphic form input unit 30,
5 respectively (Step 201).

Employed as the method of inputting the
respective graphic forms are, for example, that of
inputting information of a feature point indicative of
features of each graphic form which is extracted in
10 advance and that of inputting image data of each graphic
form and extracting information of its feature point on
the side of the graphic form to be examined input unit
20 and the model graphic form input unit 30 to output
extracted information to the data processing unit 10.

15 When applied to character recognition, for
example, a method can be adopted of inputting image data
of a character to be identified to the graphic form to
be examined input unit 20 and inputting character data
registered in a dictionary to the model graphic form
20 input unit 30.

When applied to fingerprint recognition, for
example, image data of a fingerprint whose owner is to
be found can be input to the graphic form to be examined
input unit 20 and fingerprint data registered in a
25 fingerprint data base can be input to the model graphic
form input unit 30.

In a manner as described above, the graphic form

to be examined input unit 20 may receive input of feature point information of a graphic form to be examined which is extracted in advance or may receive input of a graphic form to be examined itself and
5 extract information of a feature point at the graphic form to be examined input unit 20. Similarly, the model graphic input unit 30 may receive input of feature point information of a model graphic form which is extracted in advance or may receive input of a model graphic form
10 itself and extract information of a feature point at the model graphic form input unit 30.

Here, among possible feature points of a graphic form to be examined and a model graphic form are a point at which a line ceases (end point), a point at which a
15 line branches (branch point) and a point at which lines intersect with each other (intersection point). As a feature quantity which is data indicative of a degree of features at each feature point, such data as a position of a feature point and a direction of a line which
20 touches a feature point can be used. Also as a feature quantity, values of a curvature of a line which touches a point and a curvature of a line adjacent to the same or information such as location of surrounding feature points and the number of lines crossing between
25 surrounding feature points may be added.

Next, the data of each graphic form applied to the graphic form to be examined input unit 20 and the

model graphic form input unit 30 is transferred to the deformation estimating unit 11 of the data processing unit 10. The deformation estimating unit 11 compares feature point information of the graphic form to be examined which is input through the graphic form to be examined input unit 20 and feature point information of the model graphic form input through the model graphic form input unit 30 to estimate deformation generated in the graphic form to be examined (Step 202).

10 The deformation estimating unit 11 selects a pair of feature points which can be considered to be the same feature point in the two graphic forms and based on a difference in position between these feature points in the two graphic forms, estimates deformation generated in the graphic form to be examined.

15 As to deformation generated in a graphic form here, in a case of comparison for character recognition between a character registered in a dictionary and a character input by a camera or the like, for example, an image of a character shot by a camera or the like which is input to the graphic form to be examined input unit 20 will be optically distorted at the time of input. In fingerprint recognition, in a case where data of a fingerprint whose owner is to be found is input to the graphic form to be examined input unit 20 and fingerprint data registered at a fingerprint data base is input to the model graphic input unit 30, a graphic

form to be examined and a model graphic form are both deformed at the time of fingerprinting

Here, while only with a graphic form to be examined and a model graphic form, deformation which the graphic form to be examined suffers and deformation which the model graphic suffers can not be obtained, detecting a difference in positional relationship of each individual feature point in both the graphic forms results in detecting deformation combining deformation inverse to the deformation which the model graphic form suffers and the deformation which the graphic form to be examined suffers, so that as deformation applying the detected deformation in a reverse direction, deformation for matching the graphic form to be examined with the model graphic form can be estimated.

Next, the deformation correcting unit 12 corrects the deformation of the graphic form to be examined by subjecting the graphic form to be examined to deformation having a reverse relationship with the deformation estimated by the deformation estimating unit 11 (Step 203).

Next, the similarity determining unit 13 compares the graphic form to be examined which is obtained with its deformation corrected by the deformation correcting unit 12 and the model graphic form to calculate similarity between the two graphic forms (Step 204).

Then, the output unit 40 outputs the similarity

calculated at the similarity determining unit 13 (Step 205).

At Step 203, other than a method of subjecting the graphic form to be examined to deformation in reverse relationship with the deformation estimated at the deformation estimating unit 11, thereby correcting the deformation of the graphic form to be examined, a method can be adopted of subjecting the model graphic form to the deformation estimated at the deformation estimating unit 11, thereby matching deformation of the model graphic form and that of the graphic form to be examined with each other. This method enables comparison of the two graphic forms to calculate similarity between the two graphic forms at Step 204 in the same manner as described above.

Next, with reference to Fig. 3, detailed description will be made of deformation estimating processing at Step 202 of Fig. 2.

With reference to Fig. 3, first, compare feature point information of the graphic form to be examined which is applied through the graphic form to be examined input unit 20 and feature point information of the model graphic form which is applied through the model graphic form input unit 30 and sequentially register a pair of feature points determined to be corresponding feature points as a feature point pair for deformation estimation to create a list of feature point pairs for

deformation estimation (Step 301).

At Step 301, for example, select one arbitrary feature point "a" from among feature points of the graphic form to be examined and one arbitrary feature point "b" from among feature points of the model graphic form to obtain a difference between a feature quantity of the feature point "a" and that of the feature point "b" and when the difference between these feature quantities is not greater than a predetermined threshold value, determine that they are corresponding feature points to register the pair of the feature points, the feature point "a" of the graphic form to be examined and the feature point "b" of the model graphic form which are determined to be corresponding feature points, at the list of feature point pairs for deformation estimation.

In the list of feature point pairs for deformation estimation, a pair of corresponding feature points composed of the feature point "a" of the graphic form to be examined and the feature point "b" of the model graphic is registered as illustrated in the example of Fig. 4.

Next, estimate deformation which best matches feature points as a pair registered in the list of feature point pairs for deformation estimation (Step 302).

Among methods which can be employed here are a

method of selecting, from among deformation models
indicative of the contents of deformation prepared in
advance according to nature of a graphic form to be
applied, a model which makes feature points of a pair be
5 best matched from a plurality of deformation models and
a method of obtaining, from among deformation models
prepared in advance corresponding to values of various
kinds of parameters, a value of a parameter which best
matches feature points of each pair.

10 When applied to fingerprint recognition, for
example, assuming that a finger is an elastic body,
express its elastic deformation as a parameter (parallel
displacement, shrinkage/expansion, rotation, shearing)
and register, at the list of feature point pairs for
15 deformation estimation, a position of each feature point
obtained when a fingerprint input through the graphic
form to be examined input unit 20 is subjected to
elastic deformation indicated by each parameter to
determine a parameter of elastic deformation such that
20 the elastic deformation makes the positions of the
feature points best match with each other.

Next, verify the estimated deformation and when
the deformation is appropriate, output the deformation
(Step 303).

25 At the verification of the appropriateness at
Step 303, in a case, for example, where an elastic
energy of the estimate deformation is larger than a

predetermined value, considering that the estimated deformation is too large, the deformation model for use can be changed to try again to create a list of feature point pairs for deformation estimation.

5 Next, deformation estimating processing by the deformation estimating unit 11 according to the present embodiment will be described with respect to a more specific embodiment.

10 Here, using one example of a model graphic form illustrated in Fig. 5 and one example of a graphic form to be examined shown in Fig. 6, description will be made of processing of estimating deformation of the graphic form to be examined to check whether the graphic form to be examined is the same as the model graphic form.

15 Assume that in the model graphic form shown in Fig. 5, a1 to a4 are feature points of the model graphic form and that b1 to b4 in the graphic form to be examined shown in Fig. 6 are feature points of the graphic form to be examined.

20 First, overlap the graphic form to be examined and the model graphic form in a manner as illustrated in Fig. 7 to compare the feature points a1 to a4 of the model graphic form and the feature points b1 to b4 of the graphic form to be examined and pair those which can
25 be considered to be the same feature points such as (a1, b1), (a2, b4), (a3, b2), (a4, b4) and (a4, b5). These pairs are illustrated in Fig. 8.

Although taking the fact that the graphic form to be examined is deformed into consideration here, an error to some degree should be expected and there might be a case where a corresponding relationship between feature points can not be completely found, correlate those which seem to be corresponding to each other irrespective of overlap such as (a2, b4), (a4, b4) and (a4, b5). Then, as illustrated in Fig. 4, record a list, a list CL of point pairs for deformation estimation, where these pairs p1:(a1, b1), p2:(a2, b4), p3:(a3, b2), p4:(a4, b4) and p5:(a4, b5) are registered (Step 301).

Here, with coordinates at a feature point of the model graphic form represented as (x, y) and coordinates at a feature point of the graphic form to be examined as (X, Y), assume that the model graphic form as a whole is subjected to uniform elastic deformation as represented by the Mathematical Expression 1 using a 2x2 matrix α and a two-dimensional vector β .

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \alpha \begin{pmatrix} x \\ y \end{pmatrix} + \beta \quad [\text{expression 1}]$$

20

Assume that among the pairs p1 to p5 registered at the list of feature point pairs for deformation estimation, a position of a feature point in the model graphic form and a position of a feature point in the graphic form to be examined in an i-th pair pi are (xi,

25

yi) and (Xi, Yi), respectively. When subjected to elastic deformation as shown in the Mathematical Expression 1, the feature point at (xi, yi) on the model graphic form will shift to the position shown by the expression in Fig. 6.

$$\alpha \begin{pmatrix} x_i \\ y_i \end{pmatrix} + \beta \quad [\text{expression 2}]$$

Difference between the present position and (Xi, Yi), that is, a difference in position from the pair pi when the model graphic form is subjected to the deformation shown by the Mathematical Expression 1 will be ei in the Mathematical Expression 3.

$$\begin{pmatrix} X_i \\ Y_i \end{pmatrix} = \alpha \begin{pmatrix} x_i \\ y_i \end{pmatrix} + \beta + e_i \quad [\text{expression 3}]$$

A total E of positional differences (square thereof) of the pairs p1 to p5 registered at the list of feature point pairs for deformation estimation is expressed by the following Mathematical Expression 4.

$$E = \sum_i e_i^T e_i \quad [\text{expression 4}]$$

Assume that seeking α and β which minimize the total E of the positional differences results in obtaining A and b, respectively. Since a total of

differences of the corresponding feature points at this time is the minimum, deformation expressed by the Mathematical Expression 5 which is a formula using A and b will be deformation making points of pairs registered at the list of feature point pairs for deformation estimation be best matched.

$$\begin{pmatrix} X \\ Y \end{pmatrix} = A \begin{pmatrix} x \\ y \end{pmatrix} + b \quad [\text{expression 5}]$$

Therefore, the deformation generated in the graphic form to be examined can be estimated as that expressed by the Mathematical Expression 5 (Step 302). Result of overlap between the model graphic form subjected to the estimated deformation and the graphic form to be examined is as shown in Fig. 9.

Parameters and energy of the deformation are obtained in a manner as described in the following. The vector b in the Mathematical Expression 5 represents parallel displacement and the matrix A represents contraction/expansion, rotation and shearing. Expressing λ_0 , λ_1 and λ_2 as indicated in the Mathematical Expressions 6, 7 and 8, the elastic energy F will be expressed as shown in the Mathematical Expression 9 (in the Mathematical Expression 9, K represents a surrounding compression rate and μ represents a shearing rate, both of which are constants determined by their

materials).

$$\lambda_0 = \frac{1}{4} \left\{ \text{tr} A^T A \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - 2 \right\} \quad [\text{expression 6}]$$

$$\lambda_1 = \frac{1}{4} \text{tr} A^T A \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \quad [\text{expression 7}]$$

$$\lambda_2 = \frac{1}{4} \text{tr} A^T A \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad [\text{expression 8}]$$

$$F = 2K\lambda_0^2 + 2\mu(\lambda_1^2 + \lambda_2^2) \quad [\text{expression 9}]$$

5

Rotation and parallel displacement are simple shift of a position and neither of them contributes elastic energy. λ_0 is a parameter corresponding to contraction/expansion (which takes "0" when neither contraction nor expansion is generated, takes a negative value when contraction is generated and takes a positive value when expansion is generated), while λ_1 and λ_2 are parameters corresponding to shearing distortion (which takes "0" when no distortion is generated and takes a larger absolute value as distortion is enhanced).

10

15

When the here obtained parameters such as elastic energy and elastic deformation are too large for the deformation estimated for the graphic form to be examined, the deformation is inappropriate as deformation to be generated in the graphic form to be examined, whereby deformation will be again estimated

20

(Step 303).

5 In a case, for example, where a graphic form as
an object of examination is a fingerprint, a palmprint
or the like, because the examination target is not such
a highly extensible substance as rubber,
contraction/expansion is limited. Therefore, when λ_0
exceeds a range of possible contraction/expansion which
is predetermined for a finger, abandon the estimation.
10 In addition, since distortion of a fingerprint, a
palmprint and the like is also limited, when λ_1 or λ_2
exceeds a possible range of distortion for a fingerprint
or a palmprint, abandon the estimation as well. Also as
to elastic energy itself, when it fails to fall within
an assumed range for a fingerprint or a palmprint,
15 abandon the estimation.

Possible processing to be conducted subsequently
when estimation is abandoned are processing of changing
a deformation model, processing of executing estimation
of deformation again after changing a method of creating
20 a list of feature point pairs for deformation estimation
and other processing.

Here, description will be made of an example of
changing a deformation model.

25 Assume, for example, that a finger is a rigid
body on which severer constrain is placed than that on
an elastic body, consideration will be given to a
deformation model of the rigid body (because a rigid

body will not be deformed, the model includes only the parameters of parallel displacement and rotation). First, assuming that the model is a rigid body, convert a model graphic form and a graphic form to be examined such that a difference in position between paired feature points of each of the graphic forms becomes smaller. Overlap of the model graphic form and the graphic form to be examined based on the conversion result is as illustrated in Fig. 10.

Next, since in Fig. 10, a distance between paired feature points $p2:(a2, b4)$ and $p5:(a4, b5)$ registered in the list of feature point pairs for deformation estimation will be increased after deformation, delete the pairs from the list of feature point pairs for deformation estimation. In addition, as illustrated in Fig. 11, since $(a2, b3)$ come closer to each other after deformation, additionally register the pair at the list of feature point pairs for deformation estimation to make the list of feature point pairs for deformation estimation include $p1:(a1, b1)$, $p3:(a3, b2)$, $p4:(a4, b4)$ and $p6:(a2, b3)$.

While it is possible to end estimation processing here, it is also possible to conduct estimation again with respect to an elastic deformation model more similar to an actual finger which is used at first as a deformation model of a finger. Fig. 12 is a diagram showing the graphic forms subjected to elastic

deformation estimated using the modified list of feature point pairs for deformation estimation including p1:(a1, b1), p3:(a3, b2), p4: (a4, b4) and p6:(a2, b3).

5 By thus repeating each processing of pair selection, deformation estimation and deformation verification, appropriateness of selection of a feature point pair is gradually increased to estimate a pair of properly corresponding feature points and deformation generated in the graphic form to be examined.

10 Upon estimation of deformation, by subjecting the feature point (X, Y) of the graphic form to be examined to inversion of the formula of the Mathematical Expression 5 which inversion is represented by the formula of the Mathematical Expression 10, the
15 deformation will be corrected to convert the feature point to coordinates (x, y) of a feature point which can be directly compared with the model graphic form, so that by the comparison between the graphic form to be examined whose deformation has been corrected and the
20 model graphic form, similarity between the graphic form to be examined and the model graphic form is calculated to determine whether the graphic form to be examined and the model graphic form are the same graphic form or not.

$$\begin{pmatrix} x \\ y \end{pmatrix} = A^{-1} \left\{ \begin{pmatrix} X \\ Y \end{pmatrix} - b \right\} \quad [\text{expression 10}]$$

It is also possible to narrow down feature point pairs registered at the above-described list of feature point pairs for deformation estimation to those more reliable by deleting a pair of feature points which will go apart from each other by a distance greater than a predetermined threshold value when subjected to estimated deformation from the list of feature point pairs for deformation estimation and repeating estimation a predetermined number of times or until no further feature point pair to be deleted exists.

As described in the foregoing, since according to the present embodiment, deformation generated in a graphic form to be examined is estimated to correct the deformation and the graphic form to be examined whose deformation has been corrected and the model graphic form are compared to collate the two graphic forms, even when the graphic form to be examined has deformation (or when deformation of the graphic form to be examined is different from that of the model graphic form), the graphic form to be examined and the model graphic form can be strictly discriminated and collated with each other.

Next, a second embodiment of the present invention will be described in detail with reference to the drawings.

Fig. 13 is a block diagram showing a structure of a pattern collation device according to the present

embodiment, while Fig. 14 is a flow chart for use in explaining processing of pattern collation according to the present embodiment.

5 As illustrated in Figs. 13 and 14, the present embodiment differs from the first embodiment in the function of a deformation estimating unit 11a in a data processing unit 10a. Pattern collation processing of the present embodiment is the same as that of the first embodiment with the only difference being that new Steps
10 401 and 402 are added after Step 202.

In the deformation estimation processing according to the present embodiment shown in Fig. 14, first, the same processing as the deformation estimating processing of the first embodiment is executed to
15 estimate deformation generated in the graphic form to be examined as a whole (Step 202). Next, divide the graphic form into predetermined small regions (Step 401) and conduct deformation estimation processing on a region basis in the same manner as that of Step 202 to estimate
20 deformation at each region (Step 402).

Here, in a case where based on the deformation estimation result of each small region, the small region can not be assumed to singly have peculiar deformation in consideration of nature of an object of examination
25 (as in Step 303 of the first embodiment), appropriateness of the estimation may be verified. It is for example possible, after estimating deformation of

each small region, to evaluate appropriateness of the estimation by evaluating a relationship with deformation estimated with respect to a nearby region or a relationship with deformation estimated with respect to the whole region and when inappropriate deformation is being estimated, try estimation again.

Also possible is to sequentially repeat estimation processing with a target region area reduced after estimating deformation generated in the graphic form to be examined as a whole. When applied to fingerprint recognition, for example, there occurs a case where force is applied to a part of a finger at the time of fingerprinting to result in that each part has a different manner of deformation. In such a case, the processing of Steps 401 and 402 of the present embodiment enables estimation of deformation of each part.

As described in the foregoing, in addition to the effect attained by the first embodiment, the present embodiment has an effect of coping with a graphic form whose deformation manner differs in each part, thereby reducing a possibility of erroneous estimation of deformation.

Next, a third embodiment of the present invention will be described in detail with reference to the drawings.

Fig. 15 is a block diagram showing a structure of

a pattern collation device according to the present embodiment, while Fig. 16 is a flow chart for use in explaining processing of pattern collation according to the present embodiment.

5 As illustrated in Figs. 15 and 16, the present embodiment differs from the first embodiment in the function of a deformation estimating unit 11b in a data processing unit 10b. Pattern collation processing of the present embodiment is the same as that of the first
10 embodiment with the only difference being that Steps 601, 602 and 603 are newly added to Step 202.

 In the deformation estimation processing according to the present embodiment shown in Fig. 16, first, execute the same processing as the deformation
15 estimating processing of the first embodiment to estimate deformation generated in the graphic form to be examined as a whole (Step 202). Next, measure a degree of concentration of feature points in the vicinity of an arbitrary feature point (Step 601). As illustrated in
20 Fig. 17, this is the processing of, with a region of a predetermined size around a noted arbitrary feature point set to be a vicinity of the noted feature point, measuring a degree of concentration of feature points in the vicinity of the point.

25 Then, when there exist feature point pairs as many as or more than the number of a predetermined threshold value (Step 602), by applying the same

deformation estimating processing as that of Step 202 to the vicinity, estimate deformation in the vicinity of the feature point from nearby feature point pairs (Step 603).

5 By thus partially executing deformation estimating processing at a part where feature points concentrate, the present embodiment copes with a graphic form whose deformation manner varies with each part, thereby reducing a possibility of erroneous deformation
10 estimation.

 In addition, when feature point pairs fail to exist as many as or more than the number of the predetermined threshold value in the vicinity of feature point (Step 602), no processing of estimating
15 deformation in the vicinity is necessary and deformation estimated for the graphic form to be examined as a whole at Step 202 is used.

 Then, based on the deformation estimation made at Steps 202 and 603, deform the graphic form to be
20 examined (or model graphic form) (Step 203) to calculate similarity between the two graphic forms (Step 204).

 According to the present embodiment, deformation is estimated at each feature point to evaluate a relationship with deformation estimated in the vicinity
25 of the feature point or a relationship with deformation estimated as a whole, thereby evaluating appropriateness of the estimation (as is done at Step 303 of the first

embodiment) and when inappropriate deformation is estimated, the estimation can be tried again.

As described in the foregoing, in addition to the effect attained by the first embodiment, the present invention has an effect of coping with a graphic form whose deformation manner varies with each part, thereby reducing a possibility of erroneous deformation estimation.

Moreover, the above-described deformation estimating processing in the second and third embodiments can be implemented in combination.

In the pattern collation devices according to the above-described respective embodiments, the functions of the data processing units 10, 10a and 10b, the deformation estimating unit 11, the deformation estimating unit 11a, the deformation estimating unit 11b, the deformation correcting unit 12, the similarity determining unit 13 and the like and other functions can be realized not only by hardware but also by loading a pattern collation program which is a computer program having the respective functions into a memory of a computer processing device.

Fig. 18 is a diagram showing one embodiment of a structure having a recording medium in which a pattern collation program is recorded according to the present invention.

The pattern collation program is stored in a

recording medium 90 such as a magnetic disc or a semiconductor memory. Then, loading the program into a data processing unit 10c which is a computer processing device from the recording medium to control operation of the data processing unit 10c realizes the above-described functions. As a result, the data processing unit 10c executes the processing conducted by the data processing units 10, 10a and 10b in the first, second and third embodiments under the control of the pattern collation program.

Although the present invention has been described with respect to the preferred modes of implementation and embodiments, the present invention is not necessarily limited to the above-described modes and embodiments but realized in various forms within a scope of its technical ideas.

As described in the foregoing, the pattern collation device of the present invention attains the following effects.

First, according to the present invention, since deformation generated in a graphic form to be examined is estimated and corrected, the graphic form to the examined can be correctly identified even when the form is deformed. Moreover, the present invention enables a change of a feature quantity caused by deformation and an error of extraction of a feature quantity to be separated to realize accurate comparison of feature

quantities.

Secondly, according to the second embodiment of the present invention, by dividing a graphic form to be examined into small regions and estimating deformation at each small region, the graphic form to be examined can be correctly discriminated even when the form partly has different deformation.

Thirdly, according to the third embodiment of the present invention, when the number of nearby feature point pairs existing in a graphic form to be examined is more than a predetermined number, deformation around the feature points is estimated to reduce deformation estimation errors, so that even when the graphic form to be examined partly has different deformation, it can be discriminated correctly.

Although the invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodied within a scope encompassed and equivalents thereof with respect to the feature set out in the appended claims.

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CLAIMS:

1. A deformation correcting device for comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct
5 deformation, comprising:

deformation estimating means for estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in
10 each of the graphic form to be examined in question and said model graphic form as a graphic form based on which comparison is made, and

deformation correcting means for correcting the graphic form to be examined in question based on information
15 about the deformation estimated by said deformation estimating means.

2. The deformation correcting device as set forth in claim 1, wherein

said deformation estimating means

20 correlates and pairs feature points in each of said graphic form to be examined and said model graphic form between which a difference in feature quantity indicative of a degree of features at said feature point is small and determines contents of deformation of said graphic form to
25 be examined which best match correspondences between said respective feature points to estimate deformation generated in the graphic form to be examined in question.

3. The deformation correcting device as set forth in claim 2, wherein

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said deformation estimating means

selects the contents of deformation of said graphic form to be examined which best match correspondences between said respective feature points in each of said graphic form to be examined and said model graphic form from a plurality of deformation models indicative of contents of deformation of image data which are prepared in advance.

4. The deformation correcting device as set forth in claim 2, wherein

10 said deformation estimating means

has information of a deformation model indicative of contents of deformation of image data corresponding to a value designated by an individual parameter, and

determines the contents of deformation of said graphic form to be examined by obtaining a value of each said parameter which provides said deformation model that best matches correspondences between said respective feature points in each of said graphic form to be examined and said model graphic form.

20 5. The deformation correcting device as set forth in claim 2, wherein

said deformation estimating means

re-estimates deformation using only feature point pairs left after excluding said paired feature points which go apart from each other by a distance equal to or greater than a predetermined threshold value when subjected to estimated deformation.

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6. The deformation correcting device as set forth in claim 2, wherein

said deformation estimating means

changes a deformation model in question to re-
5 estimate deformation when a scale of estimated deformation is larger than a predetermined threshold value.

7. The deformation correcting device as set forth in claim 2, wherein

said deformation estimating means,

10 after estimating deformation of said graphic form to be examined as a whole,

divides the graphic form to be examined in question into small regions to estimate contents of deformation at each said small region.

15 8. The deformation correcting device as set forth in claim 2, wherein

said deformation estimating means,

after estimating deformation of said graphic form to be examined as a whole,

20 refers, with respect to each feature point pair in question, to information of said feature point pairs in the vicinity to estimate and correct deformation in the vicinity of each said feature point pair.

9. The deformation correcting device as set forth in
25 claim 2, wherein

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as a deformation model, elastic deformation is used and

as data indicative of a scale of deformation, elastic energy is used.

5 10. The deformation correcting device as set forth in claim 9, wherein

as said graphic form to be examined and said model graphic form, at least either a fingerprint image or a palmprint image is used.

10 11. A deformation correcting method of comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct deformation, comprising the steps of:

the deformation estimating step of estimating
15 deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in each of the graphic form to be examined in question and said model graphic form as a graphic form based on which
20 comparison is made, and

the deformation correcting step of correcting the graphic form to be examined based on information about said estimated deformation.

12. The deformation correcting method as set forth in
25 claim 11, wherein

at said deformation estimating step,

feature points in each of said graphic form to be examined and said model graphic form between which a

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difference in feature quantity indicative of a degree of features at said feature point is small are correlated and paired to determine contents of deformation of said graphic form to be examined which best match correspondences between
5 said respective feature points, thereby estimating deformation generated in the graphic form to be examined in question.

13. The deformation correcting method as set forth in claim 12, wherein

10 at said deformation estimating step,

the contents of deformation of said graphic form to be examined which best match correspondences between said respective feature points in each of said graphic form to be examined and said model graphic form are selected from a
15 plurality of deformation models indicative of contents of deformation of image data which are prepared in advance.

14. The deformation correcting method as set forth in claim 12, wherein

at said deformation estimating step,

20 based on information of a deformation model indicative of contents of deformation of image data corresponding to a value designated by an individual parameter,

the contents of deformation of said graphic form
25 to be examined are determined by obtaining a value of each said parameter which provides said deformation model that best matches correspondences between said respective feature points in each of said graphic form to be examined and said model graphic form.

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15. The deformation correcting method as set forth in claim 12, wherein

at said deformation estimating step,

5 deformation is re-estimated using only feature point pairs left after excluding said paired feature points which go apart from each other by a distance equal to or greater than a predetermined threshold value when subjected to estimated deformation.

16. The deformation correcting method as set forth in
10 claim 12, wherein

at said deformation estimating step,

a deformation model in question is changed to re-estimate deformation when a scale of estimated deformation is larger than a predetermined threshold value.

15 17. The deformation correcting method as set forth in claim 12, wherein

at said deformation estimating step,

after estimating deformation of said graphic form to be examined as a whole,

20 the graphic form to be examined in question is divided into small regions to estimate contents of deformation at each said small region.

18. The deformation correcting method as set forth in claim 12, wherein

25 at said deformation estimating step,

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after estimating deformation of said graphic form to be examined as a whole,

with respect to each feature point pair in question, deformation in the vicinity of each said feature point pair is estimated and corrected by referring to information of said feature point pairs in the vicinity.

19. The deformation correcting method as set forth in claim 12, wherein

as a deformation model, elastic deformation is used and

as data indicative of a scale of deformation, elastic energy is used.

20. The deformation correcting method as set forth in claim 12, wherein

as said graphic form to be examined and said model graphic form, at least either a fingerprint image or a palmprint image is used.

21. A computer-readable medium storing deformation correction instructions executable by a computer for comparing a graphic form to be examined and a model graphic form as a graphic form based on which comparison is made to correct deformation, said deformation correction instructions when executed performing a method comprising a series of steps:

a deformation estimating step of estimating deformation generated in a graphic form to be examined which is a graphic form as an object of examination based on information about a feature point indicative of features in

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each of the graphic form to be examined in question and said model graphic form as a graphic form based on which comparison is made, and

5 a deformation correcting step of correcting the graphic form to be examined in question based on information about said estimated deformation.

22. The computer-readable medium storing deformation correction instructions as set forth in claim 21, wherein

said deformation estimating step

10 executes processing of estimating deformation generated in the graphic form to be examined in question by correlating and pairing feature points in each of said graphic form to be examined and said model graphic form between which a difference in feature quantity indicative of
15 a degree of features at said feature point is small to determine contents of deformation of said graphic form to be examined which best match correspondences between said respective feature points.

23. The computer-readable medium storing deformation
20 correction instructions as set forth in claim 22, wherein

said deformation estimating step

executes processing of selecting the contents of deformation of said graphic form to be examined which best match correspondences between said respective feature points
25 in each of said graphic form to be examined and said model

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graphic form from a plurality of deformation models indicative of contents of deformation of image data which are prepared in advance.

24. The computer-readable medium storing deformation
5 correction instructions as set forth in claim 22, wherein

said deformation estimating step

executes, based on information of a deformation
model indicative of contents of deformation of image data
corresponding to a value designated by an individual
10 parameter,

processing of determining the contents of
deformation of said graphic form to be examined by obtaining
a value of each said parameter which provides said
deformation model that best matches correspondences between
15 said respective feature points in each of said graphic form
to be examined and said model graphic form.

25. The computer-readable medium storing deformation
correction instructions as set forth in claim 22, wherein

said deformation estimating step

20 executes processing of re-estimating deformation
using only feature point pairs left after excluding said
paired feature points which go apart from each other by a
distance equal to or greater than a predetermined threshold
value when subjected to estimated deformation.

25 26. The computer-readable medium storing deformation
correction instructions as set forth in claim 22,
wherein

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said deformation estimating step

executes processing of changing a deformation
model in question to re-estimate deformation when a scale of
estimated deformation is larger than a predetermined
5 threshold value.

27. The computer-readable medium storing deformation
correction instructions as set forth in claim 22, wherein

said deformation estimating step

executes, after estimating deformation of said
10 graphic form to be examined as a whole,

processing of dividing the graphic form to be
examined in question into small regions to estimate contents
of deformation at each said small region.

28. The computer-readable medium storing deformation
15 correction instructions as set forth in claim 22, wherein

said deformation estimating step

executes, after estimating deformation of said
graphic form to be examined as a whole,

processing of referring to, with respect to each
20 feature point pair in question, information of said feature
point pairs in the vicinity to estimate and correct
deformation in the vicinity of each said feature point pair.

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PATENT AGENTS

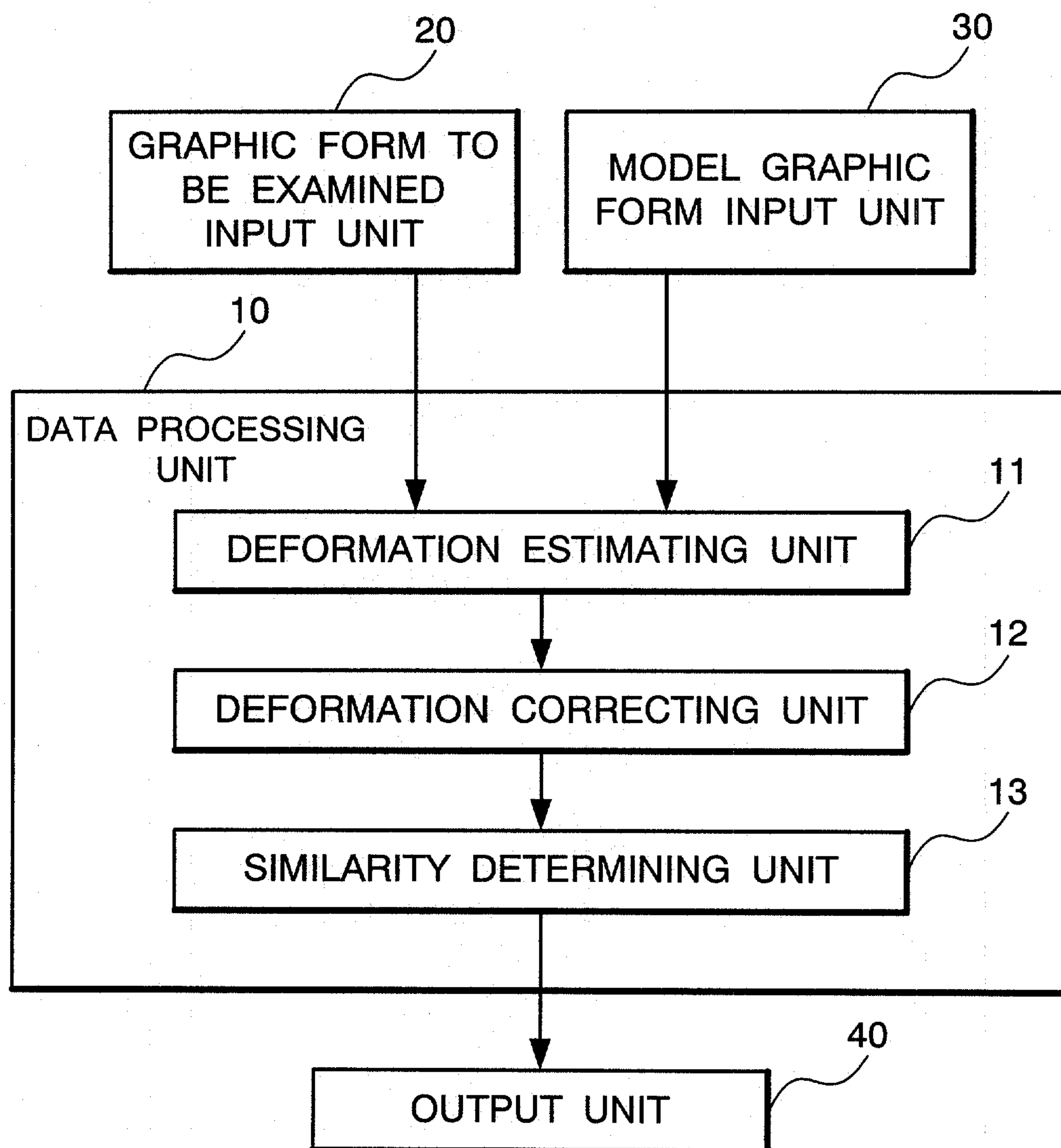
FIG. 1

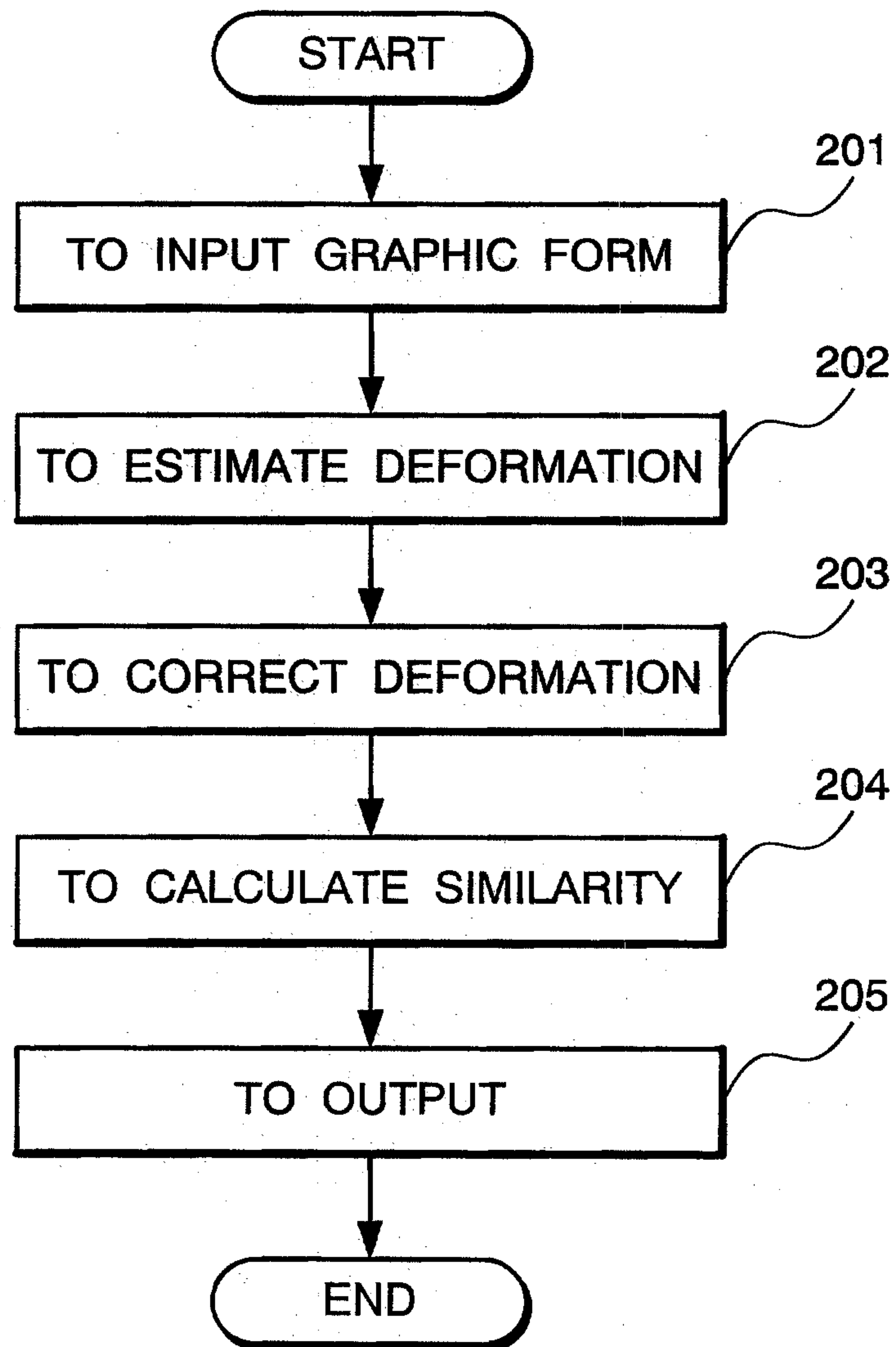
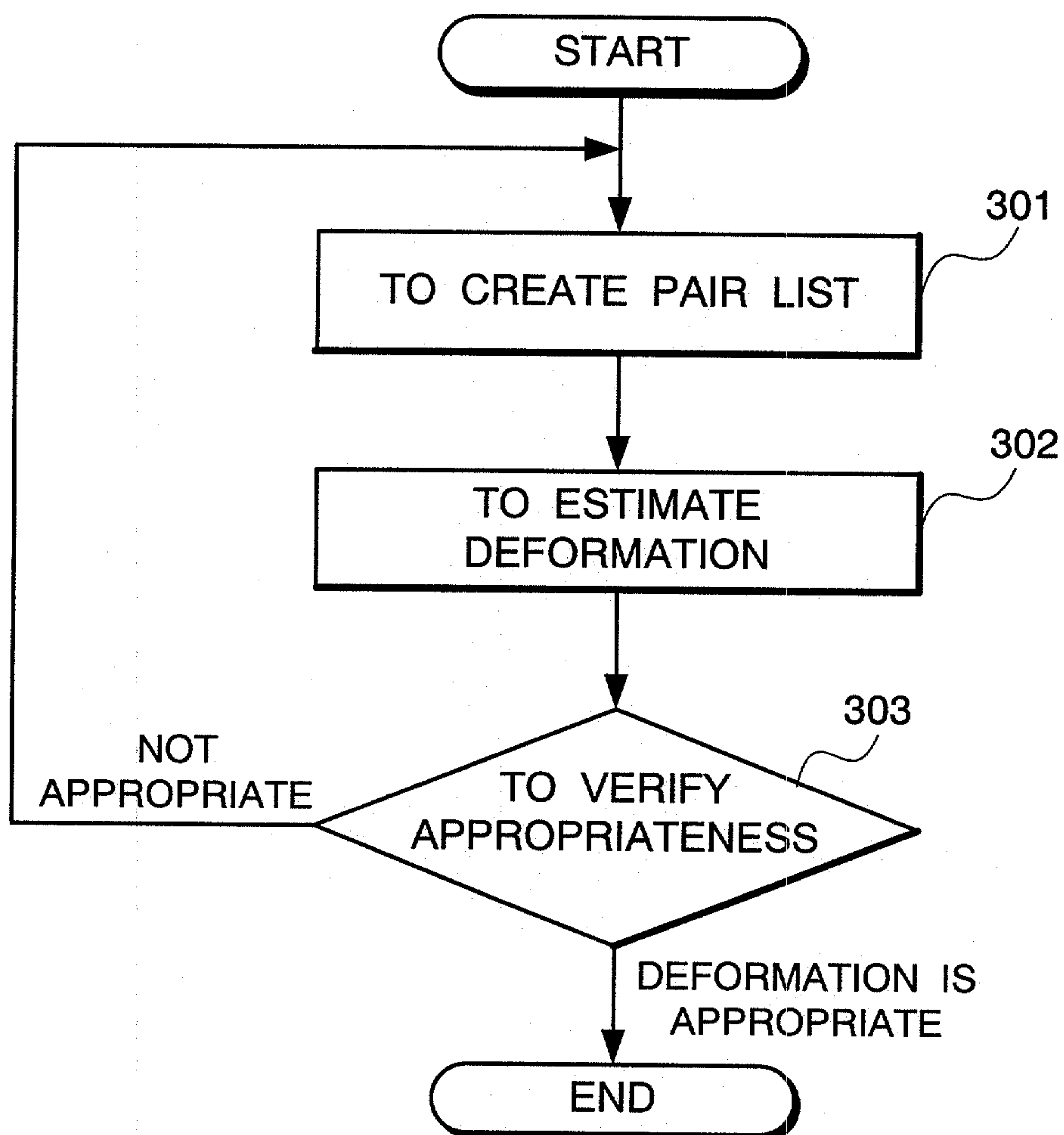
FIG. 2

FIG. 3**FIG. 4**

P1	(a_1, b_1)
P2	(a_2, b_4)
P3	(a_3, b_2)
P4	(a_4, b_4)
P5	(a_4, b_5)
⋮	⋮
⋮	⋮
⋮	⋮

CL

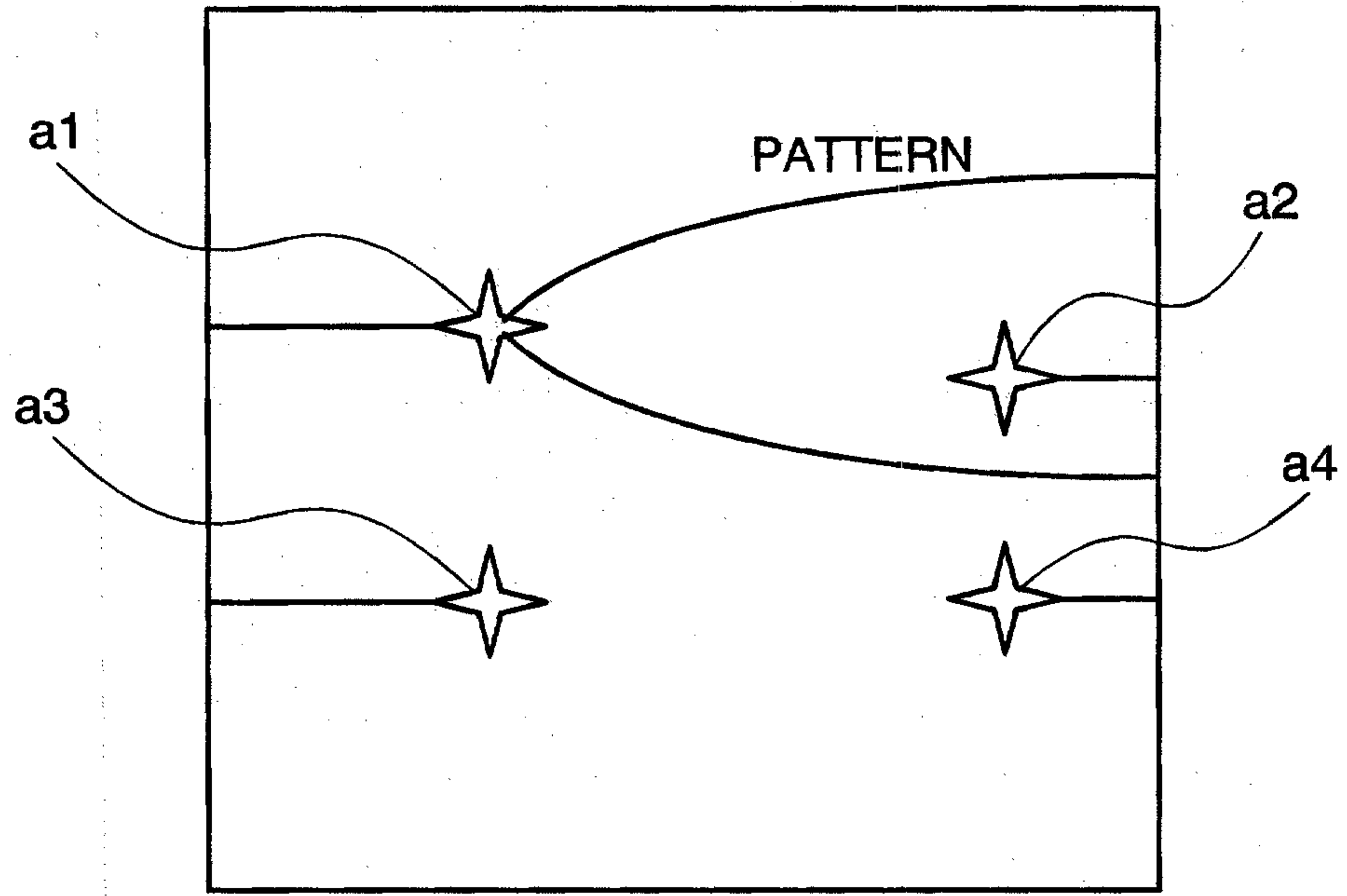
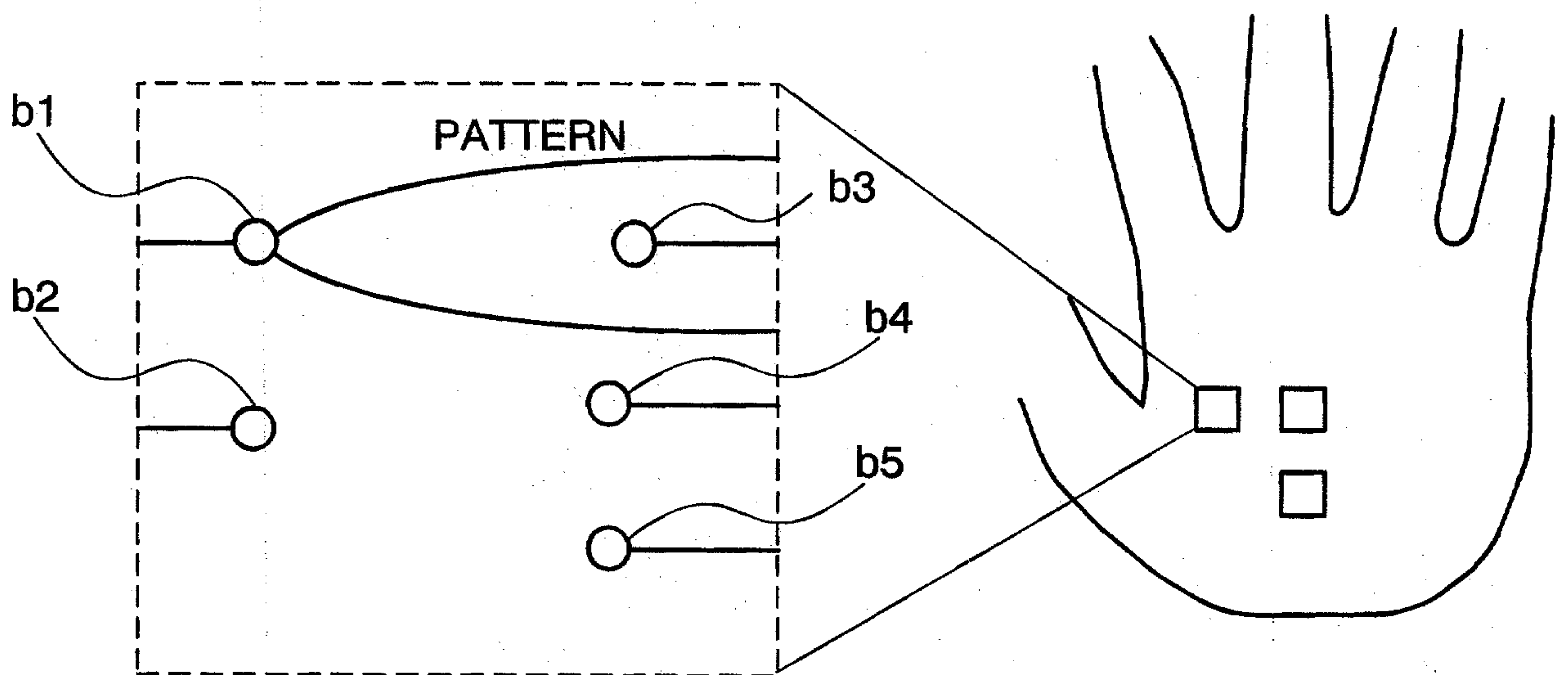
FIG. 5**FIG. 6**

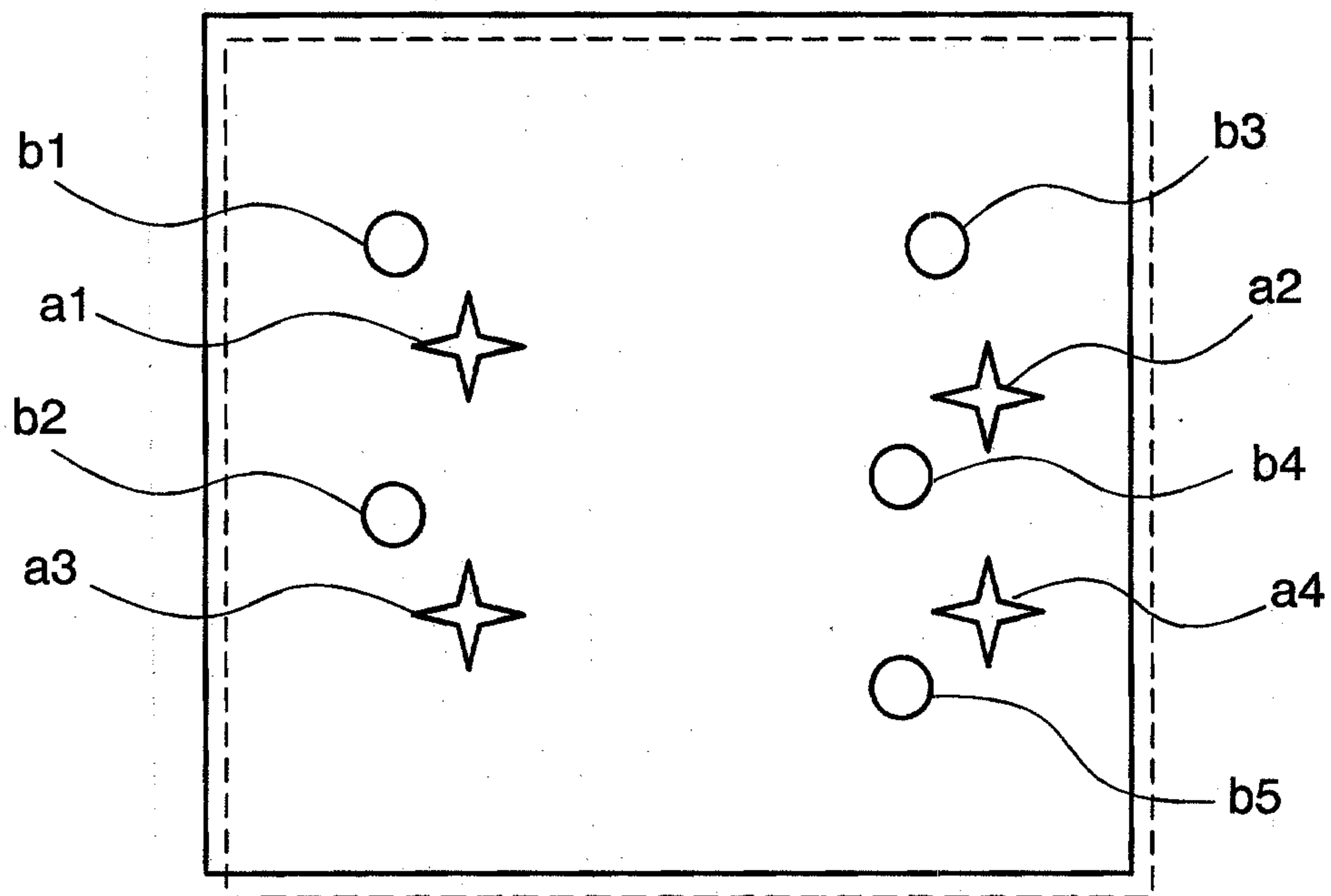
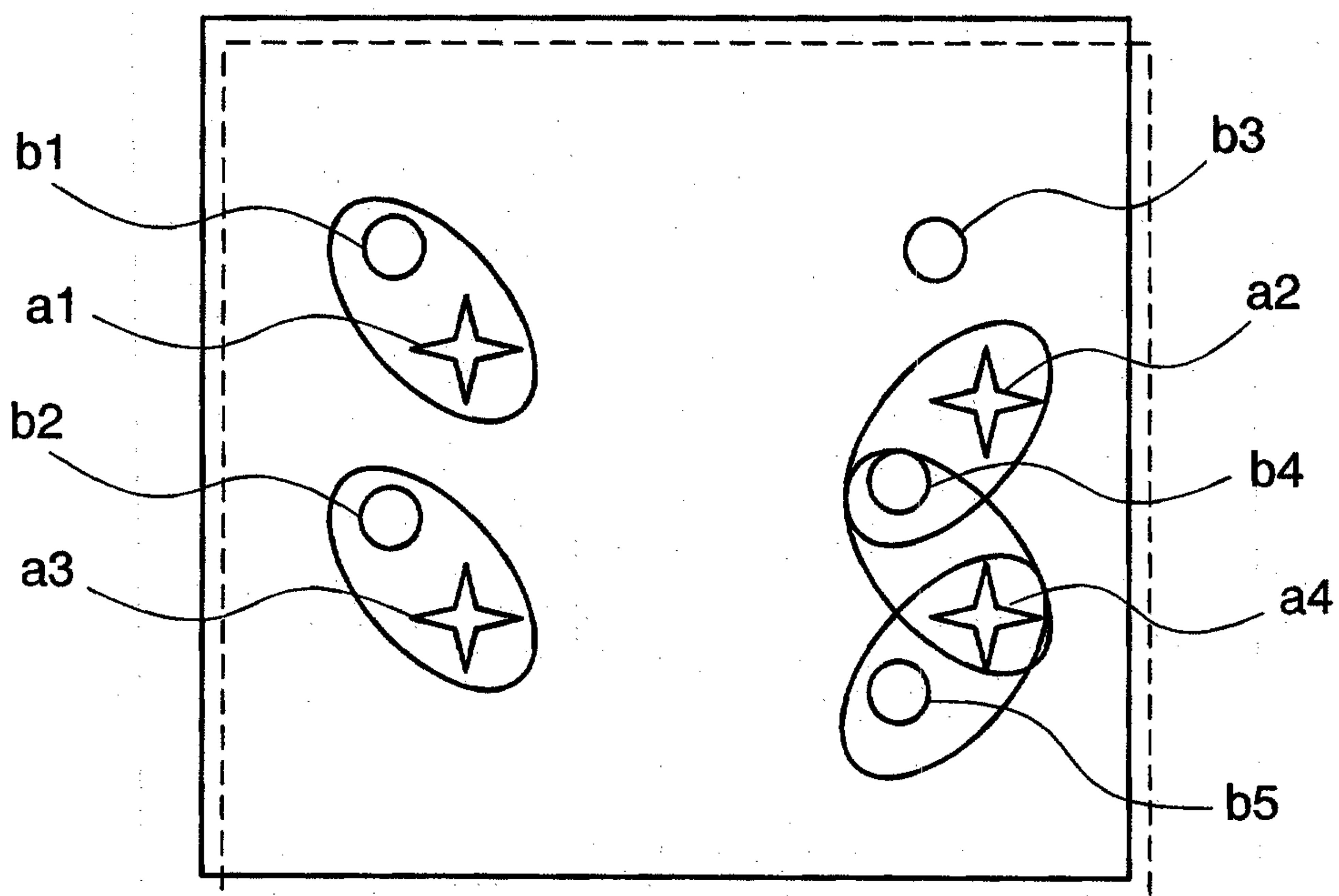
FIG. 7**FIG. 8**

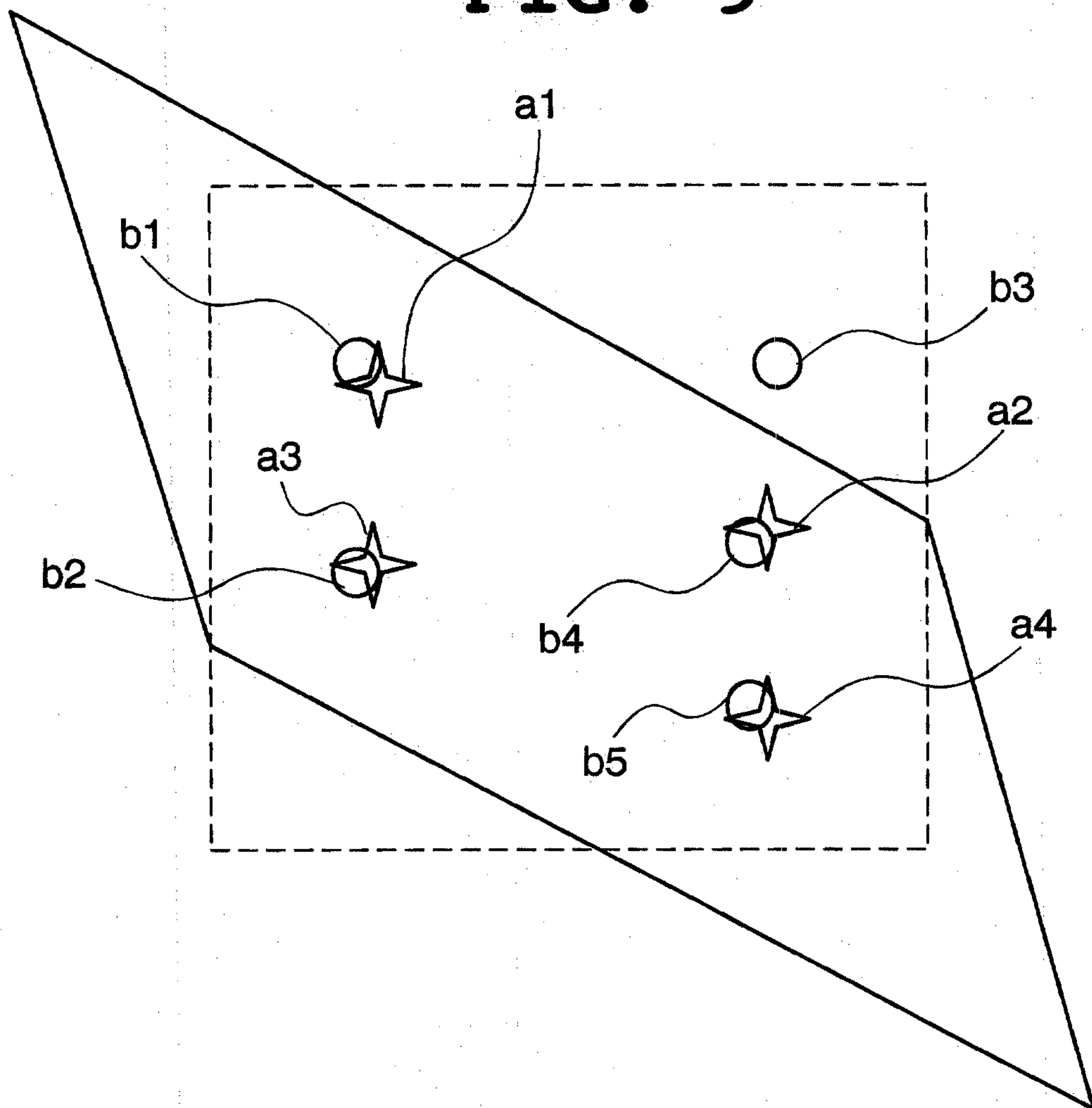
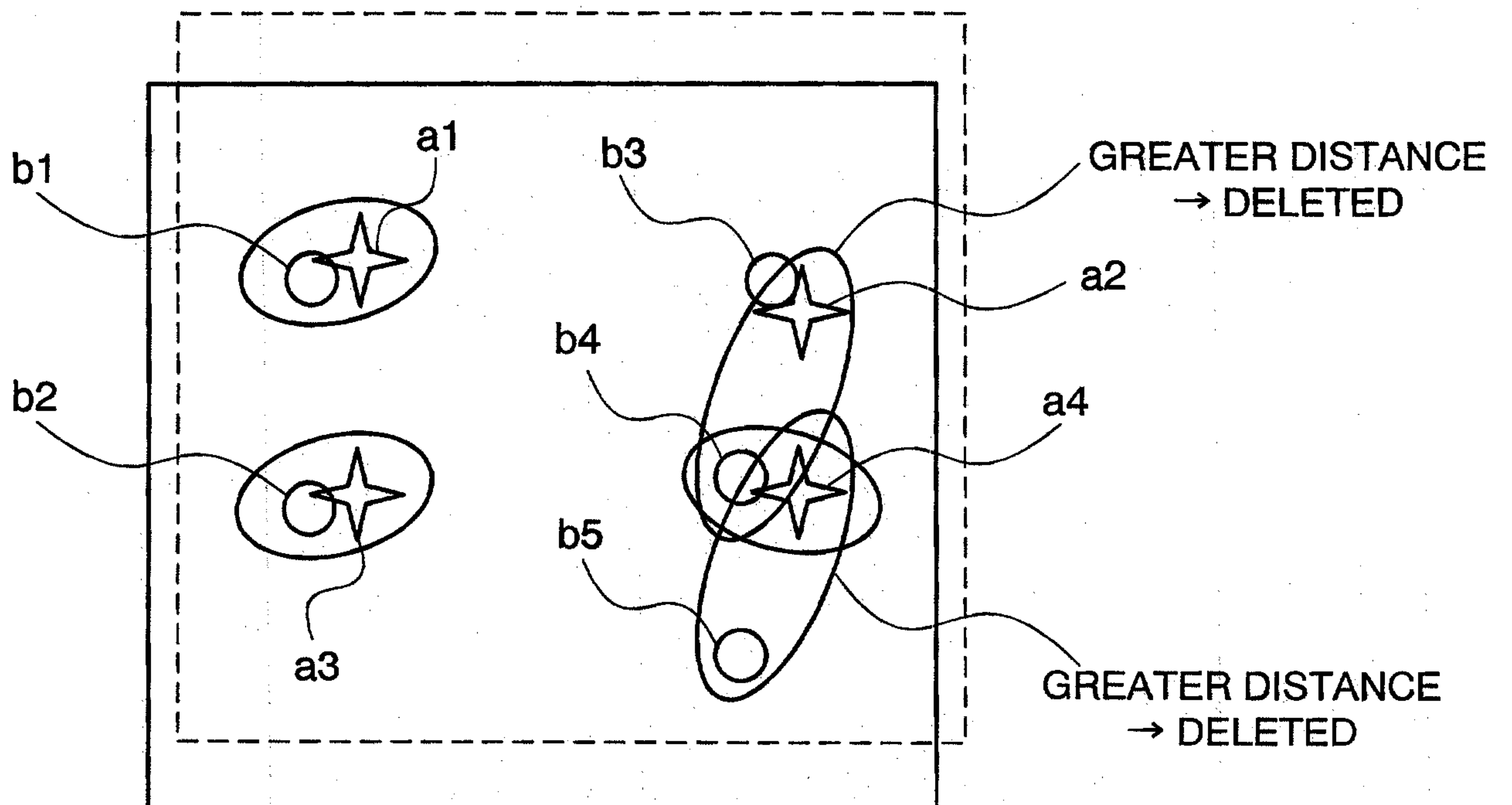
FIG. 9**FIG. 10**

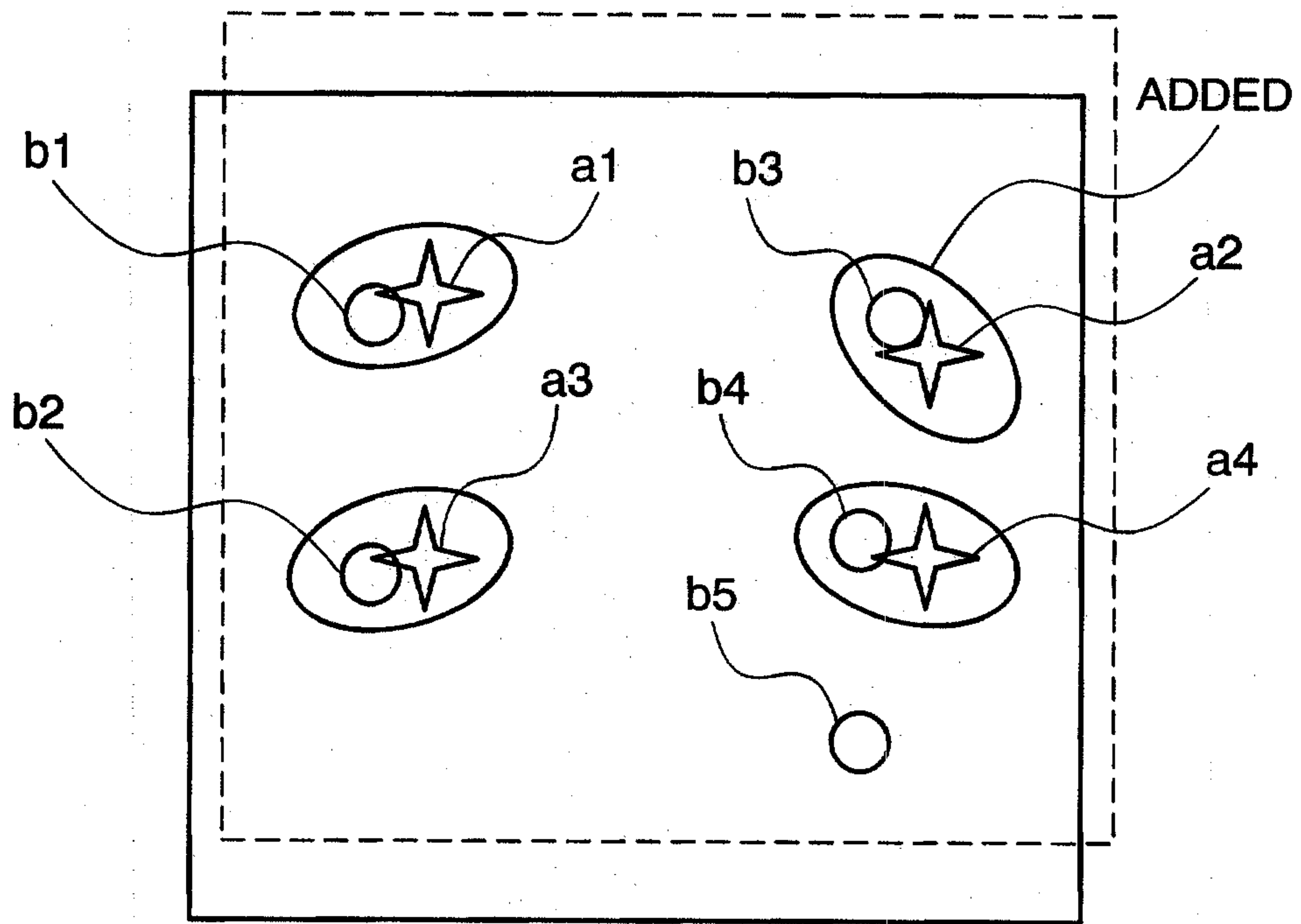
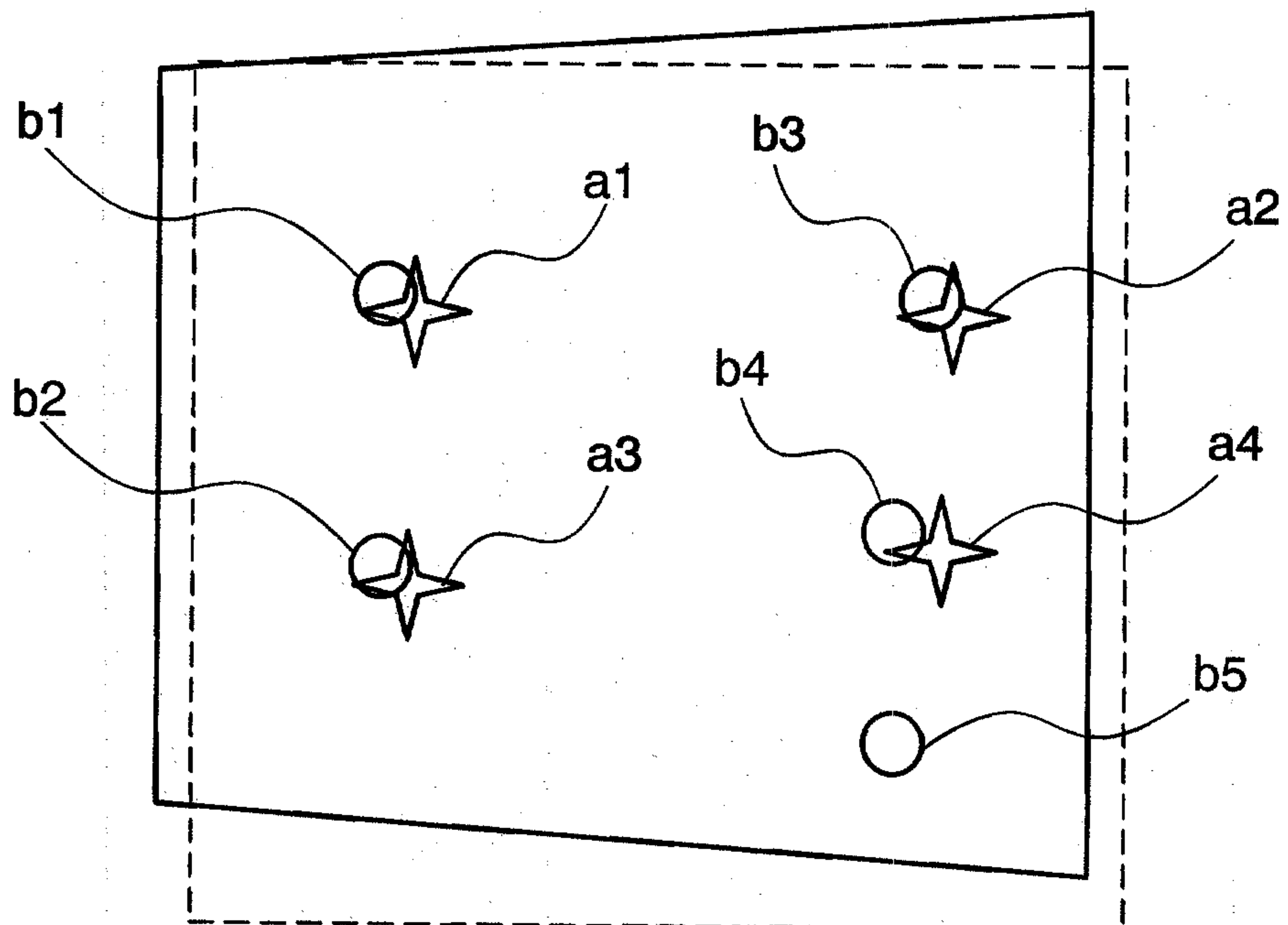
FIG. 11**FIG. 12**

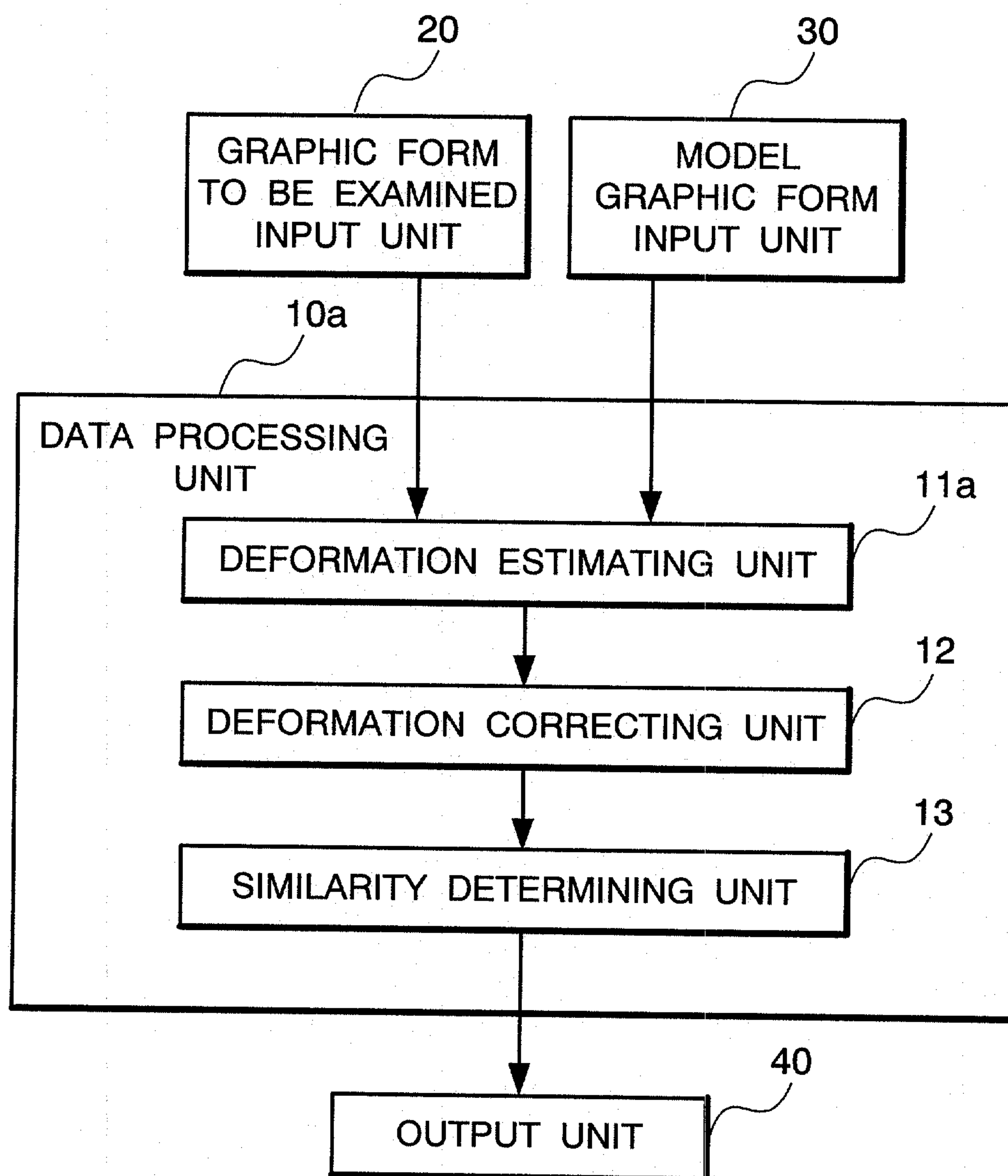
FIG. 13

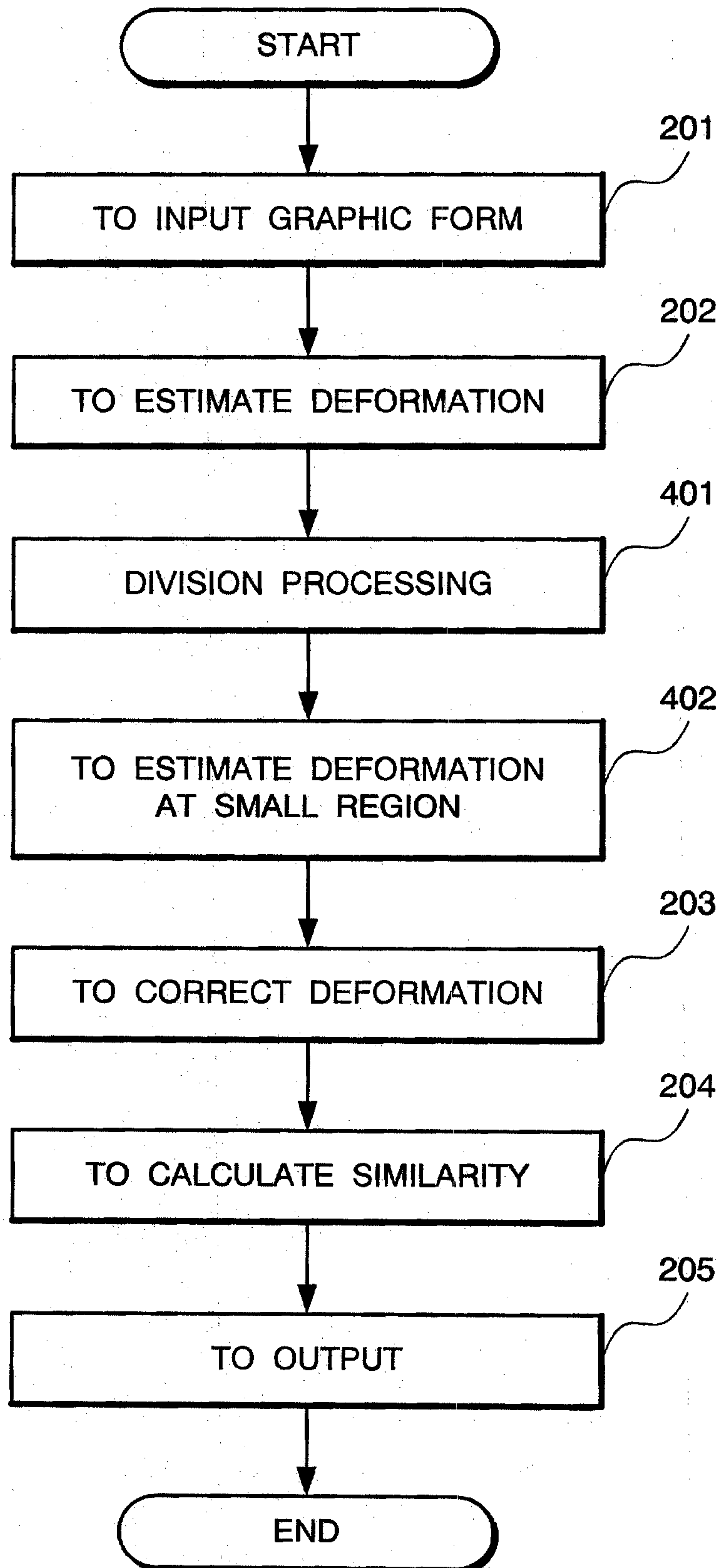
FIG. 14

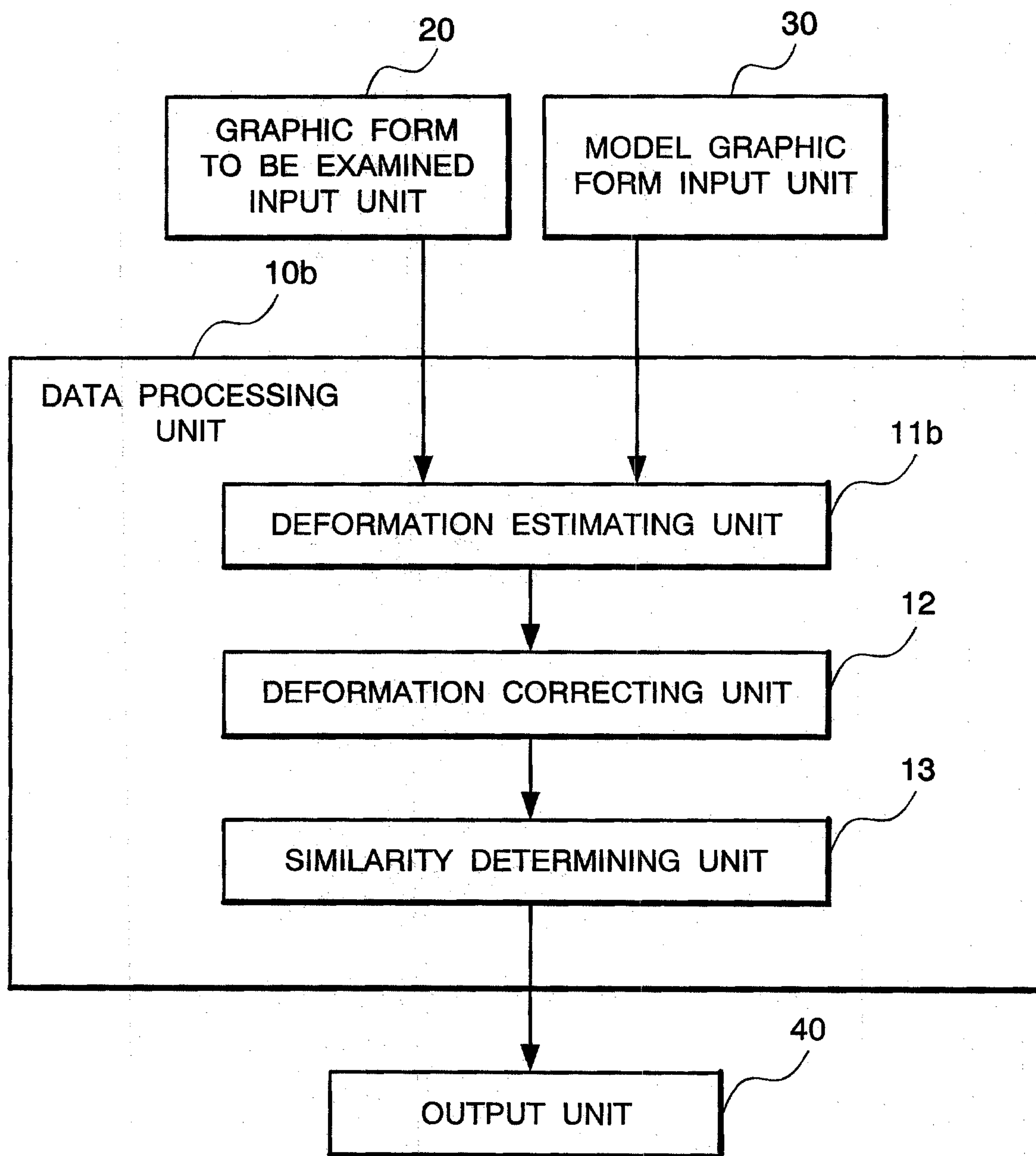
FIG. 15

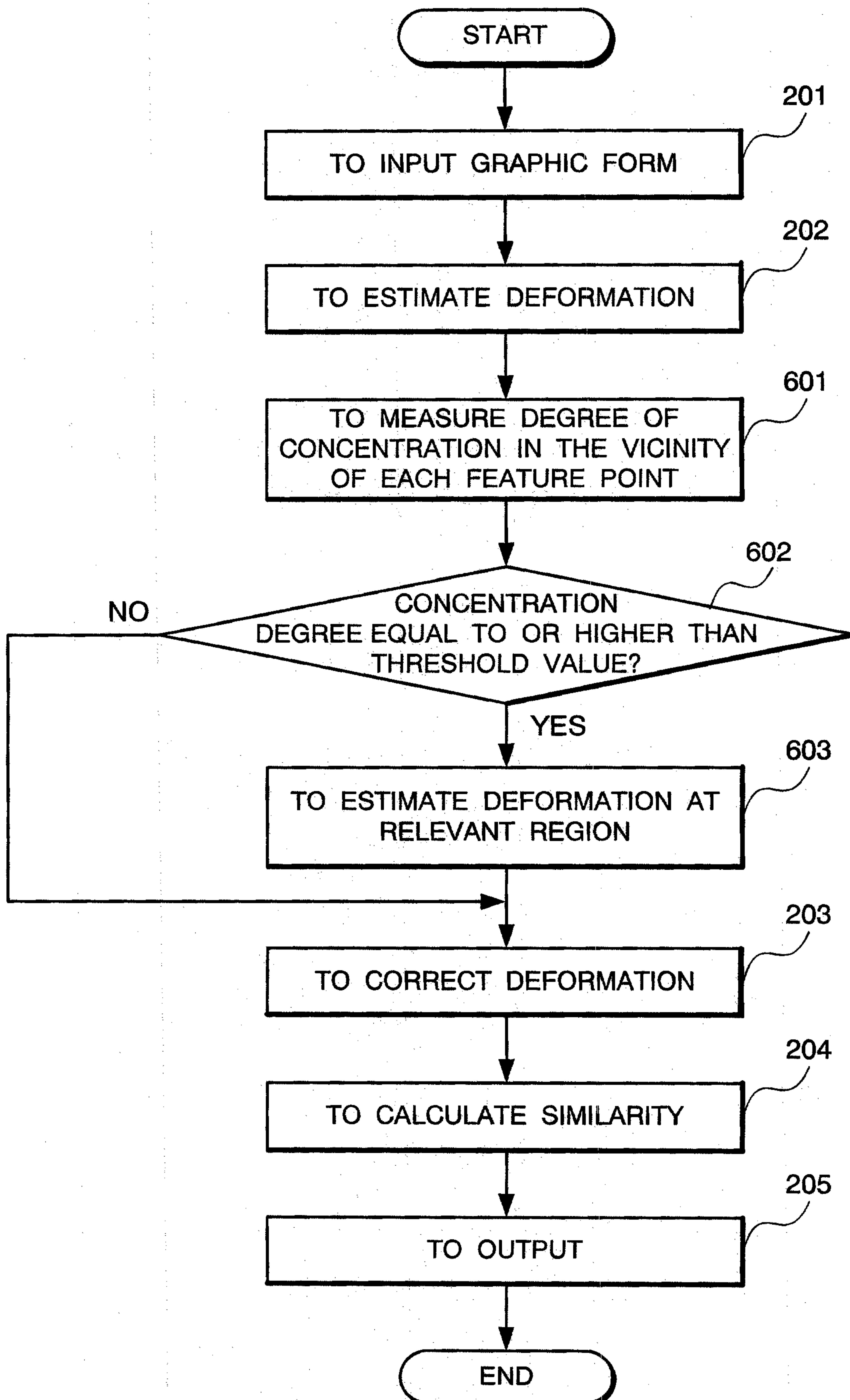
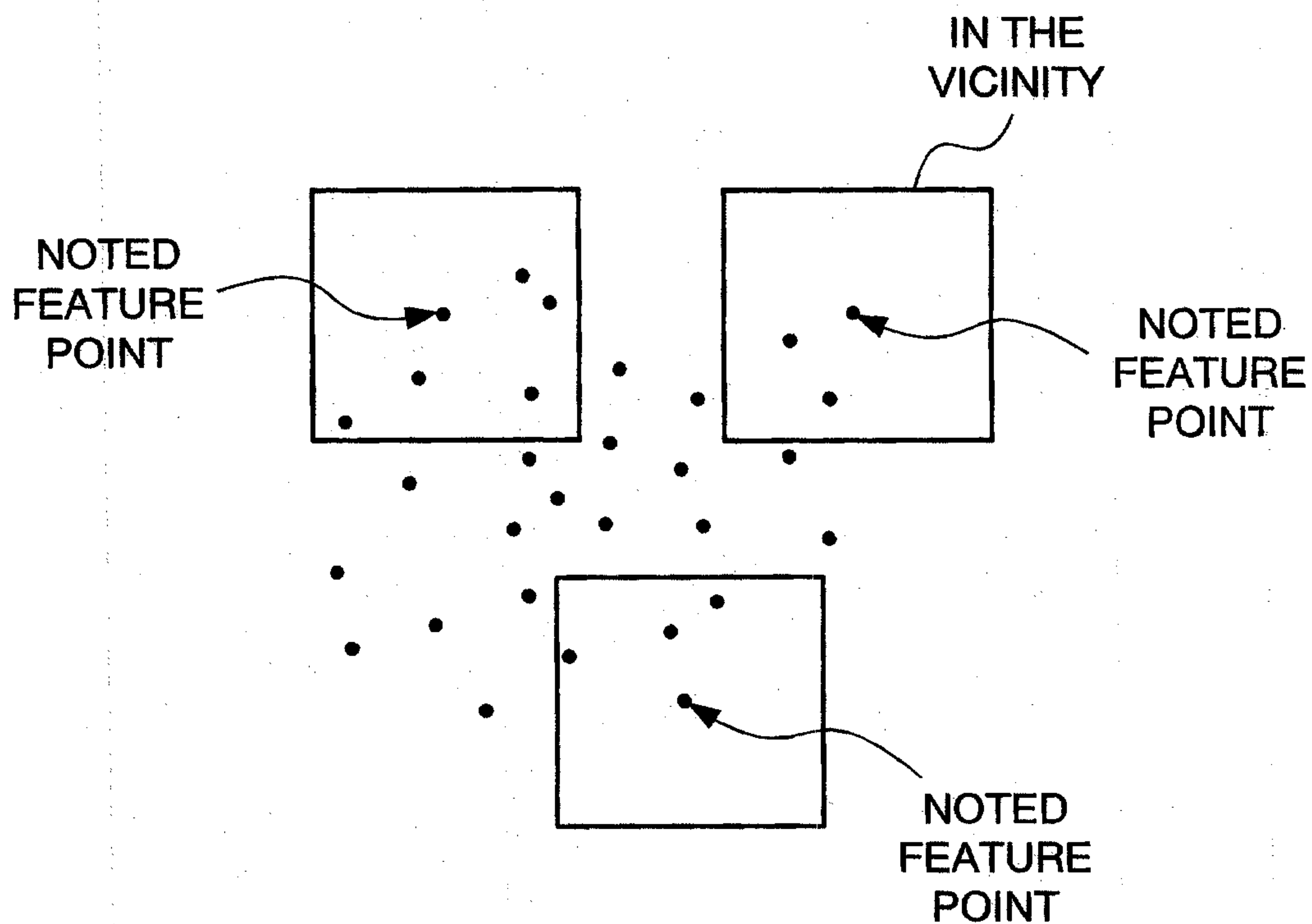
FIG. 16

FIG. 17**FIG. 18**