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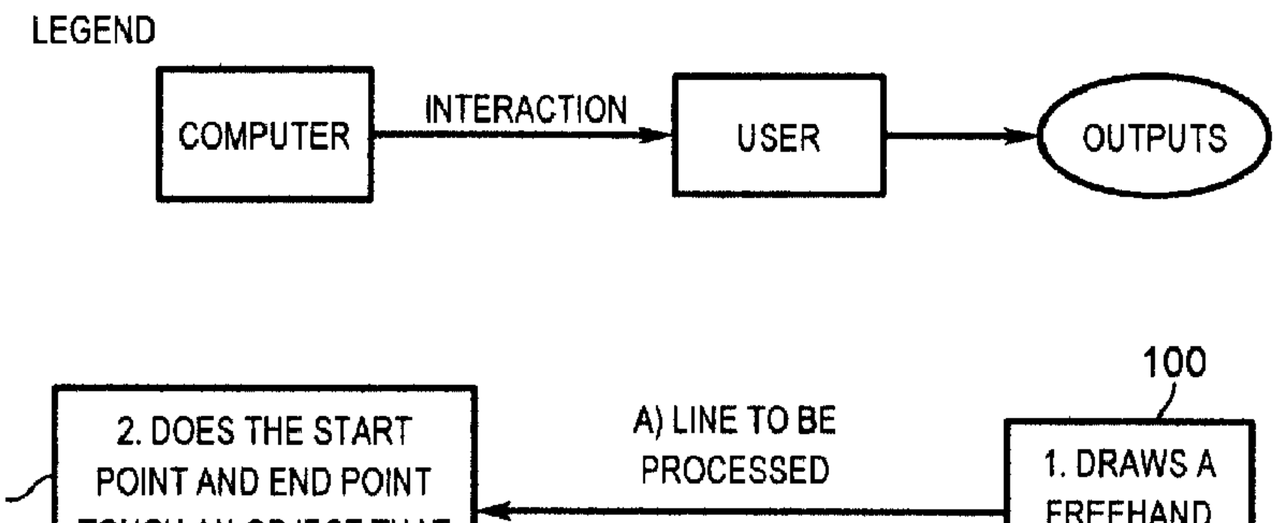
(54) Titre : SYSTEME ET METHODE DE RECONNAISSANCE DE MOUVEMENTS DE CONNECTEUR
(54) Title: SYSTEM AND METHOD FOR RECOGNIZING CONNECTOR GESTURES



(57) Abrégé/Abstract:
A touch system includes a touch panel having a touch surface and a projector presenting images onto the touch surface. A computer executing an applications program is coupled to the touch panel and the projector. The computer is responsive to

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(57) Abrégé(suite)/Abstract(continued):
contact output generated by the touch panel in response to proximity of a pointer to the touch surface and updates image data conveyed to the projector so that images presented on the touch surface reflect pointer activity. The computer executes a gesture connector recognition routine. The gesture connector recognition routine performs recognition to convert a freehand connector on the touch surface into a computer-generated connector approximating the freehand connector.

ABSTRACT

A touch system includes a touch panel having a touch surface and a projector presenting images onto the touch surface. A computer executing an applications program is coupled to the touch panel and the projector. The computer is responsive to contact output generated by the touch panel in response to proximity of a pointer to the touch surface and updates image data conveyed to the projector so that images presented on the touch surface reflect pointer activity. The computer executes a gesture connector recognition routine. The gesture connector recognition routine performs recognition to convert a freehand connector on the touch surface into a computer-generated connector approximating the freehand connector.

SYSTEM AND METHOD FOR RECOGNIZING CONNECTOR GESTURES

Field Of The Invention

[001] The present invention relates generally to touch systems and in particular to a system and method for recognizing connector gestures.

Background Of The Invention

[002] Touch systems are well known in the art and many variations exist. In all cases, touch systems include a touch panel having a touch surface on which contacts are made using a pointer. Pointer contacts with the touch surface are detected and are used to generate corresponding output that represent the positions on the touch surface where contacts are made. The contact position output is typically fed to a computer that executes one or more applications programs. The computer generates image data that is used to present images on the touch surface. The computer uses the contact position output to update the image data and thus, the images presented on the touch surface. In this manner, the images presented on the touch surface are updated to reflect the activity of the pointer on the touch surface.

[003] For example, U.S. Patent No. 5,448,263 to Martin, assigned to the assignee of the present invention, discloses a passive analog resistive touch panel coupled to a computer. The computer provides image data to a projector that projects images onto the touch surface of the touch panel. The touch panel includes a tool tray that supports a plurality of differently coloured pens. When a user contacts the touch surface either with a finger, other pointer or a pen, the touch panel outputs signals representing the contact position on the touch surface. The contact position data is conveyed to the computer and is mapped to the computer display. If a finger or other pointer is used to contact the touch surface, the touch system operates in a pointer mode and the contact position data is treated as a mouse event. This allows the user to operate the computer in a manner similar to using a computer mouse i.e. select menus, manipulate objects etc. simply by contacting the touch surface. If a pen is lifted from the tool tray and is used to contact the touch surface, the touch system operates in an ink mode and the contact position data is recorded as writing or drawing.

[004] When the computer is running an applications program in a Windows environment, a computer desktop image is presented on the touch surface that

includes icons representing the various applications programs available for selection. When an icon is selected, a window for the selected applications program is opened. The window typically includes a frame, one or more tool bars, optional scroll bars and an active area surrounded by the frame, tool bars and scroll bars. As mentioned above, in the pointer mode, contacts on the touch surface are treated as mouse event input to the computer desktop. The computer in response to the mouse event input controls the computer desktop or selected applications program according to the touch panel output and updates the image data conveyed to the projector for display to reflect the pointer activity.

[005] In the ink mode, an acetate image identical to the computer desktop image overlies the computer desktop image to provide a surface on which ink can be drawn. When a pen contacts the touch surface, the contact position data is treated as writing or drawing (herein referred to as "writing"). In this case, the computer updates the image data conveyed to the projector for display so that the writing is displayed on the acetate image.

[006] In the ink mode, users often draw two-dimensional diagrams on the touch surface such as flowcharts, schematics, process maps etc. in addition to writing text. These two-dimensional diagrams typically include a plurality of graphical objects such as rectangles, squares, diamonds, ovals and circles interconnected by straight, curved or serpentine lines. Generally, two-dimensional diagrams drawn by freehand are unclear. As a result software has been developed to assist users in the creation of two-dimensional diagrams.

[007] For example, computer-aided design (CAD) software programs are available to assist users in the creation of two-dimensional diagrams. One common CAD software program is sold by Autodesk Inc. under the name "AutoCAD". During use of this CAD software, a user creates a two-dimensional diagram either by placing an existing graphical object on a pallet that is taken from a collection or library of such graphical objects, or by creating a new graphical object. Interconnecting lines or connections, are then manually drawn from a point on or near the graphical object to the appropriate destinations. Every point along the path of the connection must be specified by the user. This is a very tedious process, and must be repeated every time

the position, rotational orientation, size or other parameter of any graphical object is changed.

[008] Software is also widely available that automates the manipulation and interconnection of graphical objects so that when a user changes the position or other parameter of a graphical object, all connections and/or graphical objects associated with that graphical object reconfigure themselves to maintain that association. Such software is available from Visio Corp. under the name "Visio Technical". Complex connections of this nature can be created between graphical objects by simply picking start and end points for the connections.

[009] Complex connections allow a user to edit a diagram more easily. However, the creation of complex connections requires several steps. Typically, the user must first select the graphical object where the complex connection is to originate and then select the graphical object where the complex connection is to terminate. Often, the user is required to specify the shape of the complex connection path between the two graphical objects. It is also common for the user to be required to specify the exact locations of the start and end points of the complex connection. As will be appreciated, alternative systems to enhance interpretation of connectors are desired.

[010] It is therefore an object of the present invention to provide a novel system and method for recognizing connector gestures.

Summary Of The Invention

[011] According to one aspect of the present invention there is provided a computerized method of recognizing a freehand connector input into a computer application, said method comprising the steps of:

examining points along said input freehand connector to determine the shape thereof;

replacing said input freehand connector with a computer-generated connector approximating said input freehand connector;

automatically joining each end of said computer-generated connector to a proximate graphical object if such a proximate graphical object exists; and

automatically generating a new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

[012-013] According to another aspect of the present invention there is provided a system for recognizing a freehand connector input into a computer application, said system comprising:

means for examining points along said input freehand connector to determine the shape thereof;

means for replacing said input freehand connector with a computer-generated connector approximating said input freehand connector;

means for automatically joining each end of said computer-generated connector to a proximate graphical object if it exists; and

means for automatically generating a new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

[014] According to yet another aspect of the present invention there is provided a touch system comprising:

a touch panel having a touch surface on which images are presented; and

a computer executing at least one applications program and being coupled to said touch panel, said computer being responsive to contact output generated by said touch panel in response to proximity of a pointer to said touch surface and updating image data so that images presented on said touch surface reflect pointer activity, said computer executing a connector gesture recognition routine, said connector gesture recognition routine performing recognition to convert a freehand connector drawn on said touch surface into a computer-generated connector approximating said freehand connector and for automatically connecting each end point of said computer-generated connector to a displayed graphical object if it exists, wherein said connector gesture recognition routine further generates automatically a new graphical object that is joined to at least one of the start and end points of the

computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

[015] According to still yet another aspect of the present invention there is provided a computer readable medium having a computer program embodied thereon for recognizing a freehand connector, said computer program comprising:

computer program code for examining points along said freehand connector to determine the shape thereof;

computer program code for replacing said freehand connector with a computer-generated connector approximating said freehand connector;

computer program code for automatically joining each end of said computer-generated connector to a proximate graphical object if such a proximate graphical object exists; and

computer program code for automatically generating a new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

[016] The present invention provides advantages in that freehand connectors are automatically recognized and replaced with computer-generated connectors. As a result user input during creation of diagrams is reduced. The freehand connector simply needs to be drawn by the user.

Brief Description Of The Drawings

[017] Embodiments of the present invention will now be described more fully with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of an interactive display system including a touch panel having a touch surface;

Figure 2 is a view of a computer desktop image together with an acetate image on the touch surface of the touch panel;

Figures 3a to 3c are flowcharts showing the steps performed by a connector gesture recognition routine; and

Figures 4 to 10 are views showing freehand connectors drawn on the touch surface and the connectors as recognized by the connector gesture recognition routine.

Detailed Description Of The Preferred Embodiment

[018] Turning now to Figure 1, an interactive touch system similar to that disclosed in U.S. Patent No. 5,448,263 to Martin is shown and is generally identified by reference numeral 10. As can be seen, touch system 10 includes a touch panel 12 having a touch surface 14. The touch panel 12 in this embodiment is of the analog resistive type and includes a tool tray 15 that supports a plurality of differently coloured pens (not shown). Touch panel 12 is responsive to contacts on the touch surface 14 made using either a finger, other pointer or pen and generates output representative of the locations on the touch surface 14 where contacts are made. The contact position output of the touch panel 12 is fed to a computer 16 executing one or more applications programs and is treated either as mouse events or writing depending on the object used to contact the touch surface 14. Specifically, the contact position output of the touch panel 12 is treated as mouse events if a finger or other pointer is

used to contact the touch surface 14. The contact position is however treated as writing when a pen is lifted from the tool tray 15 and is used to contact the touch surface 14. In this manner the touch system either operates in a pointer mode or ink mode depending on the object used to contact the touch surface 14. The computer 16 is also coupled to a front or rear projector 18 and provides image data to the projector. The projector 18 in turn presents images on the touch surface 14 of the touch panel. The touch panel 12, computer 16 and projector 18 form a closed-loop so that user contacts with the touch panel 12 can be recorded as writing or used to control execution of an applications program executed by the computer 16.

[019] In the present embodiment, the computer 16 runs in a Windows environment and provides image data to the projector 18 so that a computer desktop image is presented on the touch surface 14. The computer desktop image presents one or more icons that can be selected to open associated applications programs. When an applications program is selected, a window for the applications program is opened.

[020] Figure 2 shows an applications program window 30 including an active area 32 bordered by a frame and one or more tool bars 34 is shown presented on the touch surface 14. When a pen is used to contact the touch surface 14 and the touch system is conditioned to the ink mode, an acetate image 40 identical to the computer desktop image is displayed over the computer desktop image as shown Figure 2. The acetate image 40 provides a surface for writing (commonly referred to as "ink") so that the ink is not used by the computer 16 to update the underlying computer desktop image 30. Contact position data returned to the computer 16 by the touch panel 12 in response to pen contacts with the touch surface 14 are used by the computer to update the image data conveyed to the projector 18 so that the ink appears on the acetate image 40.

[021] When the touch system 10 is conditioned to the ink mode, the computer 16 can be conditioned to execute a connector gesture recognition routine to interpret freehand connectors drawn between graphical objects, if the user is using the pen to draw a two-dimensional diagram, by selecting an icon presented on the touch surface 14. Specifics of the connector gesture recognition routine will now be described with reference to Figures 3a to 3c.

[022] With the computer 16 is executing the gesture connector recognition routine, when a user draws a freehand line on the touch surface 14 (step 100) and the touch panel output is conveyed to the computer 16, the connector gesture recognition routine examines the start point and end point of the freehand line to determine if the start point and end point of the freehand line touch graphical objects displayed on the touch surface that can be connected (step 102). If the start point and end point of the freehand line do not touch graphical objects that can be connected, the freehand line is maintained in its original form (step 104). If the start point and end point of the freehand line touch graphical objects that can be connected, a connector gesture determination is made to determine the manner by which the freehand line is to be represented (step 106). The freehand line is then replaced by the determined computer-generated connector and the image data conveyed to the projector 18 is updated accordingly so that the computer-generated connector approximating the freehand line is presented on the touch surface 14 (step 108).

[023] During step 102 when the start point and end point of the freehand line are examined, initially the start point is examined to determine if it touches a graphical object (step 120). If the start point of the freehand line does not touch a graphical object, the user is presented with a prompt to determine if a new graphical object is to be created at the start point of the freehand line (step 122). If the user does not wish a new graphical object to be created, the connector gesture recognition routine proceeds to step 104.

[024] If the start point of the freehand line touches a graphical object or if the user conditions the connector gesture recognition routine to create a new graphical object at the start of the freehand line, the connector gesture recognition routine examines the end point of the freehand line to determine if it touches a graphical object (step 124). If not, the connector gesture recognition routine proceeds to step 122 to determine if the user wishes to create a new graphical object at the end of the freehand line. If the end point of the freehand line touches a graphical object or if the user conditions the connector gesture recognition routine to create a new graphical object at the end of the freehand line, the connector gesture recognition routine

proceeds to step 106 to determine how to represent the freehand line. Otherwise, the connector gesture recognition routine proceeds to step 104.

[025] During step 106, the connector gesture recognition routine sets the start and end points of the freehand line (step 130) and analyzes points along the freehand line in order to select an appropriate representation (step 132). Based on the analysis, if the freehand line is not a straight line and is determined to have an elbow along its length (step 134), the connector gesture recognition routine recognizes the freehand line as a right-angled line (step 136). If the line has a winding path (step 138), the connector gesture recognition routine recognizes the freehand line either as a polygonal, splined or circular line depending on the shape of the freehand line (step 140). If the freehand line is not straight nor winding (step 142), the connector gesture recognition routine recognizes the freehand line as a curved line (step 146). The curve is fitted using an apogee as the control knot (i.e. the furthest point out away from the graphical objects). If the freehand line is straight (step 148), the connector gesture recognition routine recognizes the freehand line as a straight line (step 150). Once the freehand line has been recognized, the connector gesture recognition routine replaces the freehand line with a computer-generated equivalent and updates the image data conveyed to the projector 18 so that the appropriate computer-generated connector is displayed on the touch surface 14.

[026] Turning now to Figures 4 to 10, examples of connector gesture recognitions are shown. As can be seen in Figure 4, a freehand line 200 interconnecting two graphical objects 202 and 204 is recognized as a straight line 206. In Figure 5, a freehand line 210 that is not straight and that has elbows is recognized as a right-angled line 216. In Figure 6, a non-straight freehand line 220 is recognized as a curved line 226 and in Figure 7, a winding line 230 is recognized as a circular line 236. Figure 8 shows a freehand straight line 240 having a start point adjacent a graphical object 242. The end point of the freehand line 240 does not touch a graphical object. In this case, the user at step 122 has requested the connector gesture recognition routine to create a new graphical object 244 at the end of the freehand line and the freehand line is recognized as a straight line 246.

[027] Figure 9 shows relationships between graphical objects 252 and 254 in an object oriented program. As shown, three separate curved computer-generated connectors 256a to 256c extend between the graphical objects. The computer-generated connectors are created in manner that has been described above. It will be appreciated that any number of connectors may extend between pairs of graphical objects. Figure 10 shows a computer-generated winding line 266 extending between a pair of graphical objects 262 and 264.

[028] It will also be appreciated that the computer-generated connectors can be created without arrow heads, with single arrow heads or with double arrow heads. In addition, the various computer-generated connectors can be displayed in different colours using a software color tool.

[029] Although the touch system has been described as switching between the pointer mode and the ink mode depending on the type of pointer used to contact the touch surface, this is for illustrative purposes only. For example, transitions between the pointer mode and ink mode can be achieved by selecting appropriate buttons on a small window that remains visible on the touch surface 14. In this manner, the same pointer can be used to generate mouse events or ink. The gesture responsive ink injection routine can be used in any touch system that includes a touch panel on which a computer image is presented. Such touch systems include active touch systems that make use of special pointers that emit signals such as infrared light, visible light, ultrasonic frequencies and electromagnetic frequencies in order to activate the touch surfaces. These touch systems also include passive surface acoustic wave or capacitive-type touch systems as well as camera-based touch systems such as that disclosed in International PCT Application No. WO 02/03316 to Smart Technologies Inc. et al., the assignee of the present invention.

[030] It will also be appreciated that the gesture connector recognition routine may be run on basically any computing device where freehand connectors joining graphical objects are entered. A mouse, trackball, touch pad, or other pointing device may be used to create the freehand connectors.

[031] During analysis of the freehand connectors, the freehand connectors need not touch graphical objects in order for the connector gesture recognition routine

to extend computer-generated connectors from them. Rather, the freehand connectors simply need to be within a threshold distance of graphical objects. In addition, prompting the user to determine whether new graphical objects are to be created at the start and end points of freehand lines is optional. This feature may be disabled or designated as a default. When designated as a default, the connector gesture recognition routine creates new graphical objects at the start and end points of freehand lines automatically without requiring user input.

[032] Although a preferred embodiment of the present invention has been described, those of skill in the art will appreciate that variations and modifications may be made without departing from the spirit and scope thereof as defined by the appended claims.

What is claimed is:

1. A computerized method of recognizing a freehand connector input into a computer application, said method comprising the steps of:

examining points along said input freehand connector to determine the shape thereof;

replacing said input freehand connector with a computer-generated connector approximating said input freehand connector;

automatically joining each end of said computer-generated connector to a proximate graphical object if such a proximate graphical object exists; and

automatically generating a new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

2. The computerized method of claim 1 wherein said freehand connector is input into said computer application in response to drawing made on a touch panel having a touch surface.

3. The computerized method of claim 1 or 2 wherein if neither the start point nor the end point is proximate to a graphical object, automatically generating new graphical objects, each of which is joined to a respective one of the start and end points.

4. The computerized of any one of claims 1 to 3 wherein a proximate graphical object exists if the computer-generated connector touches the graphical object.

5. The computerized method of any one of claims 1 to 4 wherein if the input freehand connector is a non-straight line and has an elbow along its length, during said replacing the input freehand connector is replaced with a computer-generated right-angled line.

6. The computerized method of any one of claims 1 to 5 wherein if the input freehand connection has a winding path, during said replacing the input freehand connector is replaced with one of a computer generated polygonal, splined and circular line.

7. The computerized method of any one of claims 1 to 6 wherein if the input freehand connector is a non-straight line and does not have a winding path, during said replacing the input freehand connector is replaced with a computer-generated curved line.

8. A system for recognizing a freehand connector input into a computer application, said system comprising:

means for examining points along said input freehand connector to determine the shape thereof;

means for replacing said input freehand connector with a computer-generated connector approximating said input freehand connector;

means for automatically joining each end of said computer-generated connector to a proximate graphical object if it exists; and

means for automatically generating a new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

9. A system according to claim 8 wherein said freehand connector is input into said computer application in response to drawing made on a touch panel having a touch surface.

10. A system according to claim 8 or 9 wherein if neither the start point nor the end point is proximate to a graphical object, new graphical objects, automatically generating each of which is joined to a respective one of the start and end points.

11. A system according to of any one of claims 8 to 10 wherein a proximate graphical object exists if the computer-generated connector touches the graphical object.

12. A system according to any one of any one of claims 8 to 11 wherein if the input freehand connector is a non-straight line and has an elbow along its length, during said replacing the input freehand connector is replaced with a computer-generated right-angled line.

13. A system according to any of any one of claims 8 to 12 wherein if the input freehand connection has a winding path, during said replacing the input freehand connector is replaced with one of a computer-generated polygonal, splined and circular line.

14. A system according to any one of any one of claims 8 to 13 wherein if the input freehand connector is a non-straight line and does not have a winding path, during said replacing the input freehand connector is replaced with a computer-generated curved line.

15. A touch system comprising:

a touch panel having a touch surface on which images are presented; and

a computer executing at least one applications program and being coupled to said touch panel, said computer being responsive to contact output generated by said touch panel in response to proximity of a pointer to said touch surface and updating image data so that images presented on said touch surface reflect pointer activity, said computer executing a connector gesture recognition routine, said connector gesture recognition routine performing recognition to convert a freehand connector drawn on said touch surface into a computer-generated connector approximating said freehand connector and for automatically connecting each end point of said computer-generated connector to a displayed graphical object if it exists, wherein said connector gesture recognition routine further generates automatically a

new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

16. The touch system of claim 15 wherein if neither the start point nor the end point is proximate to a graphical object, the connector gesture recognition routine automatically generates new graphical objects, each of which is joined to a respective one of the start and end points.

17. The touch system of claims 15 or 16 wherein a proximate graphical object exists of the computer-generated connector touches the graphical object.

18. The touch system of any one of claims 15 to 17 wherein if the input freehand connector is a non-straight line and has an elbow along its length, the connector gesture recognition routine replaces the input freehand connector with a computer-generated right-angled line.

19. The touch system of any one of claims 15 to 18 wherein if the input freehand connector has a winding path, the connector gesture recognition routine replaces the input freehand connector with one of a computer-generated polygonal, splined and circular line.

20. The touch system of any one of claims 15 to 19 wherein if the input freehand connector is a non-straight line and does not have a winding path, the connector gesture recognition routine replaces the input freehand connector with a computer-generated curved line.

21. The touch system of any one of claims 15 to 20 further comprising an image generating device coupled to the computer and generating the images presented on the touch surface in response to image data received from the computer.

22. The touch system of claim 21 wherein said image generating device is a projection device.

23. A computer readable medium having a computer program embodied thereon for recognizing a freehand connector, said computer program comprising:

computer program code for examining points along said freehand connector to determine the shape thereof;

computer program code for replacing said freehand connector with a computer-generated connector approximating said freehand connector;

computer program code for automatically joining each end of said computer-generated connector to a proximate graphical object if such a proximate graphical object exists; and

computer program code for automatically generating a new graphical object that is joined to at least one of the start and end points of the computer-generated connector if the at least one of the start and end points is not proximate to a graphical object.

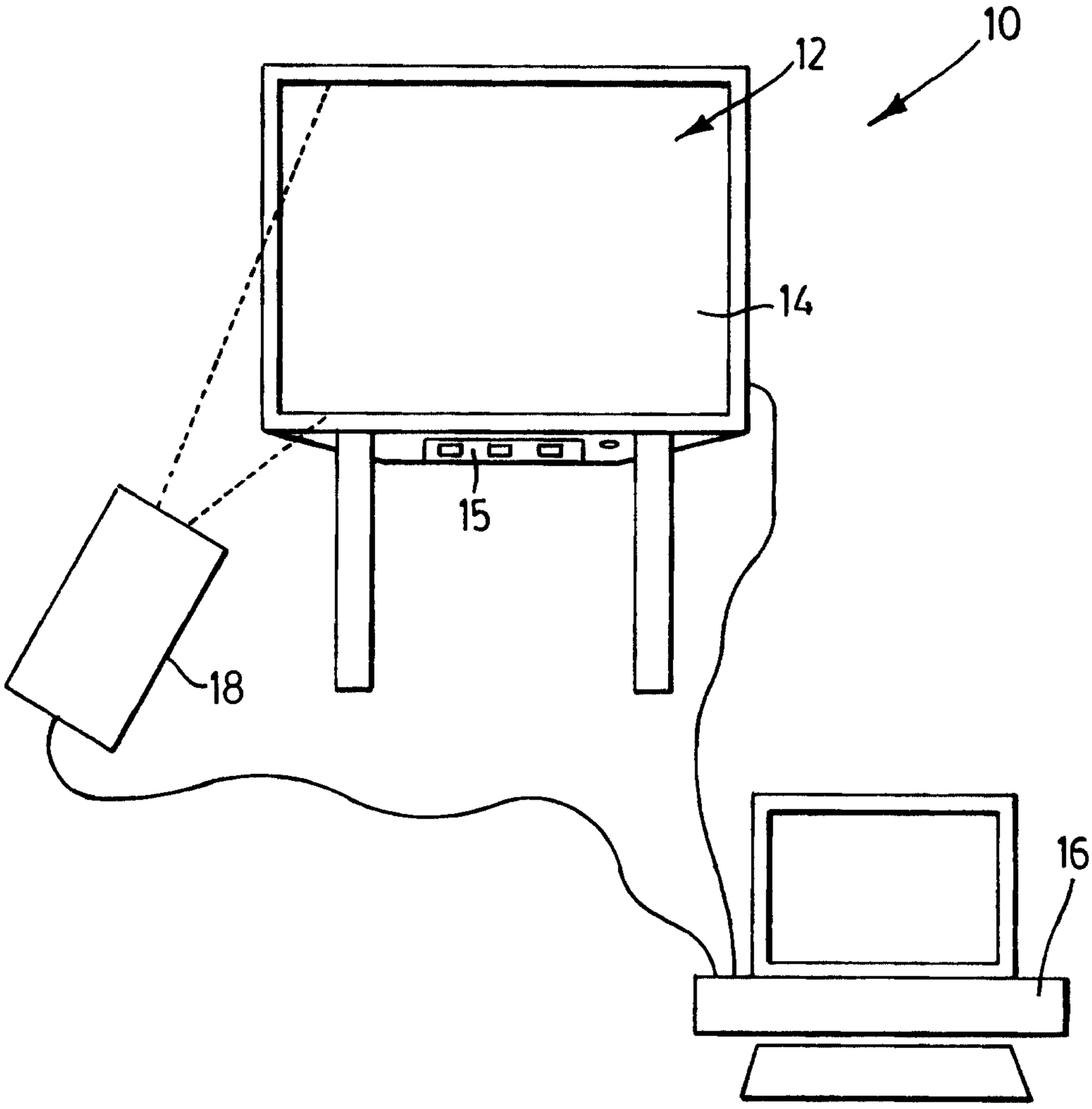


FIG. 1

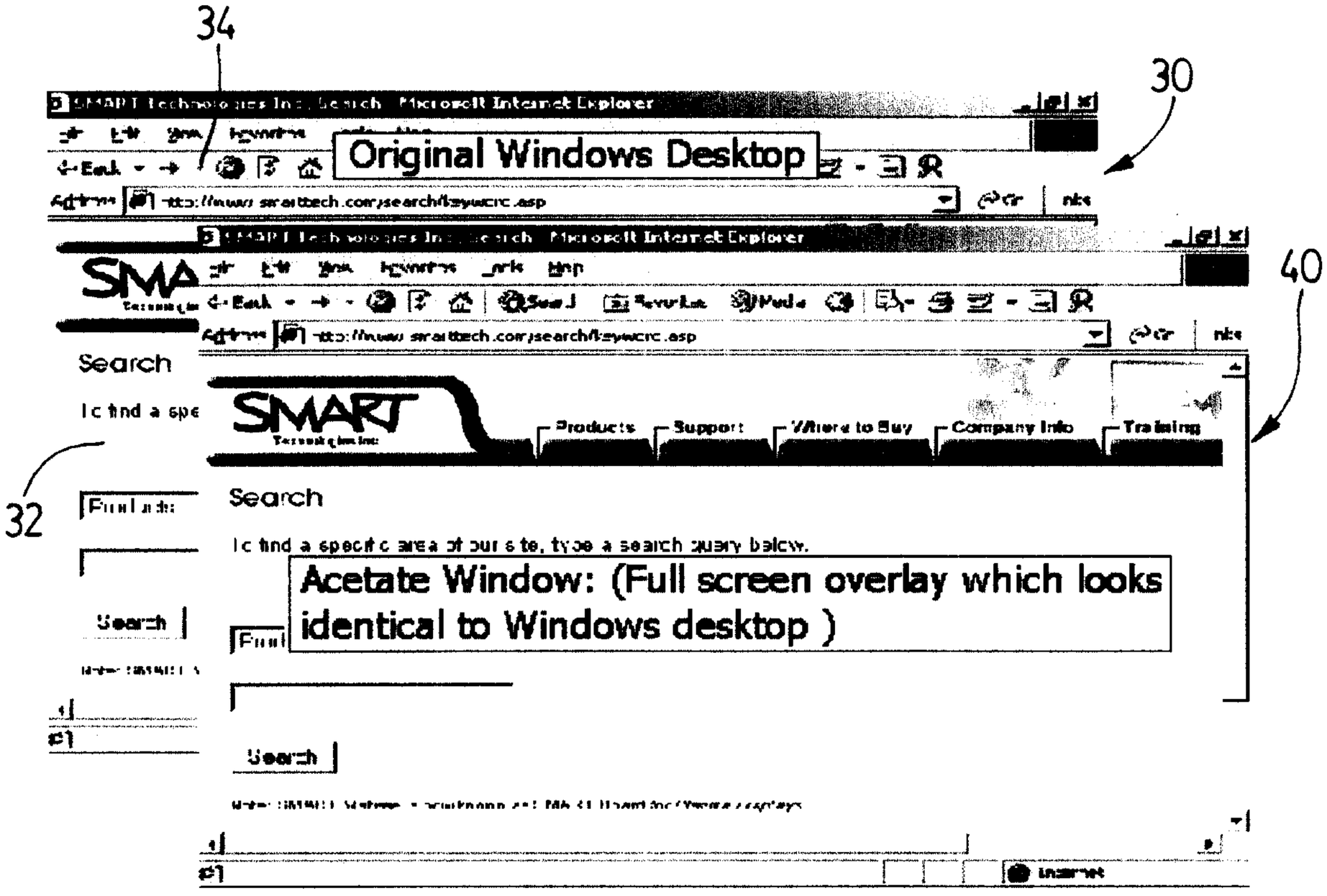

34
30
Original Windows Desktop
40
32
Search
Products
Support
Where to Buy
Company Info
Training
Search
Acetate Window: (Full screen overlay which looks identical to Windows desktop)
Internet

FIG. 2

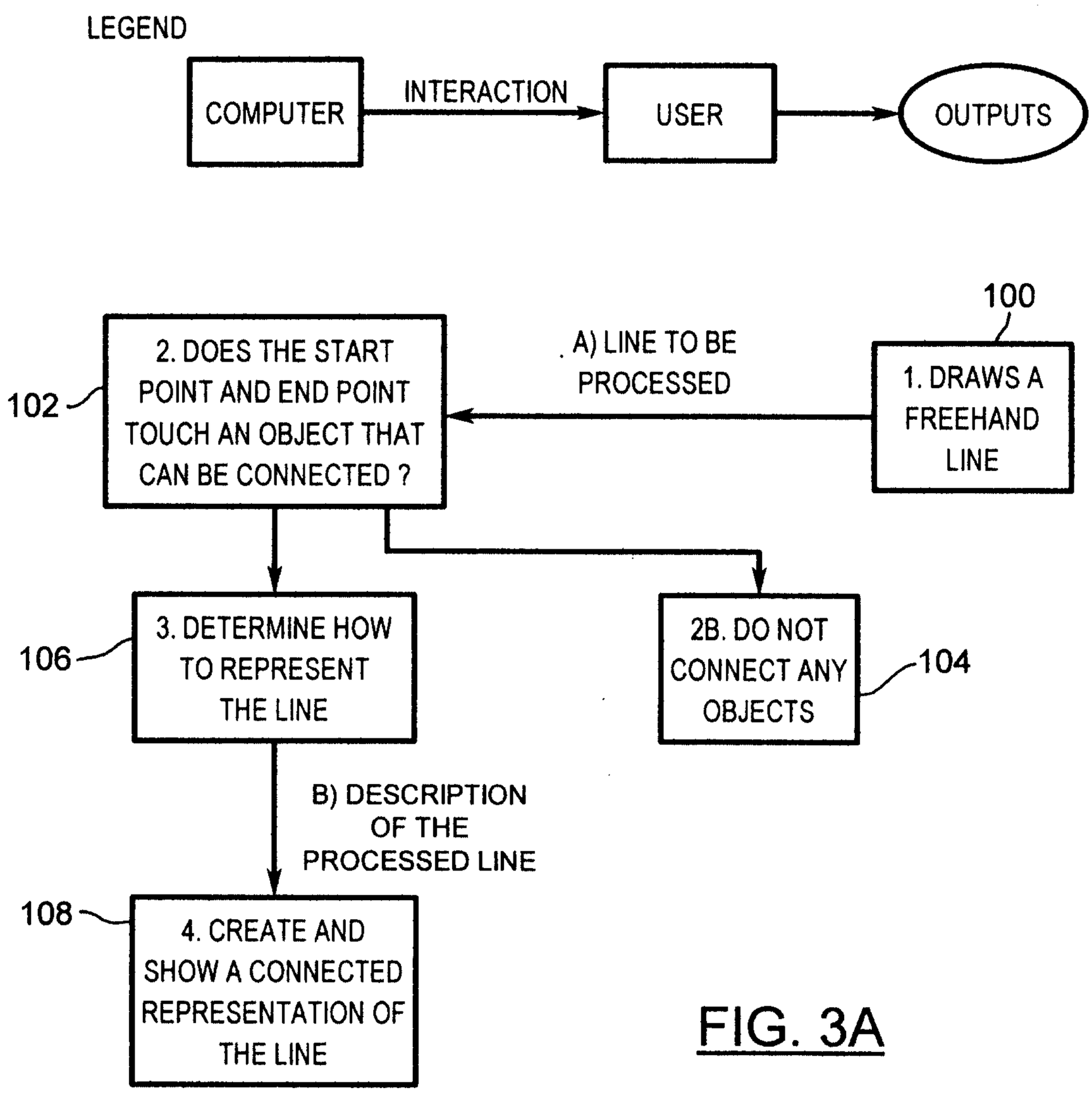

LEGEND
COMPUTER
INTERACTION
USER
OUTPUTS
100
2. DOES THE START POINT AND END POINT TOUCH AN OBJECT THAT CAN BE CONNECTED ?
102
A) LINE TO BE PROCESSED
1. DRAWS A FREEHAND LINE
3. DETERMINE HOW TO REPRESENT THE LINE
106
2B. DO NOT CONNECT ANY OBJECTS
104
B) DESCRIPTION OF THE PROCESSED LINE
4. CREATE AND SHOW A CONNECTED REPRESENTATION OF THE LINE
108

FIG. 3A

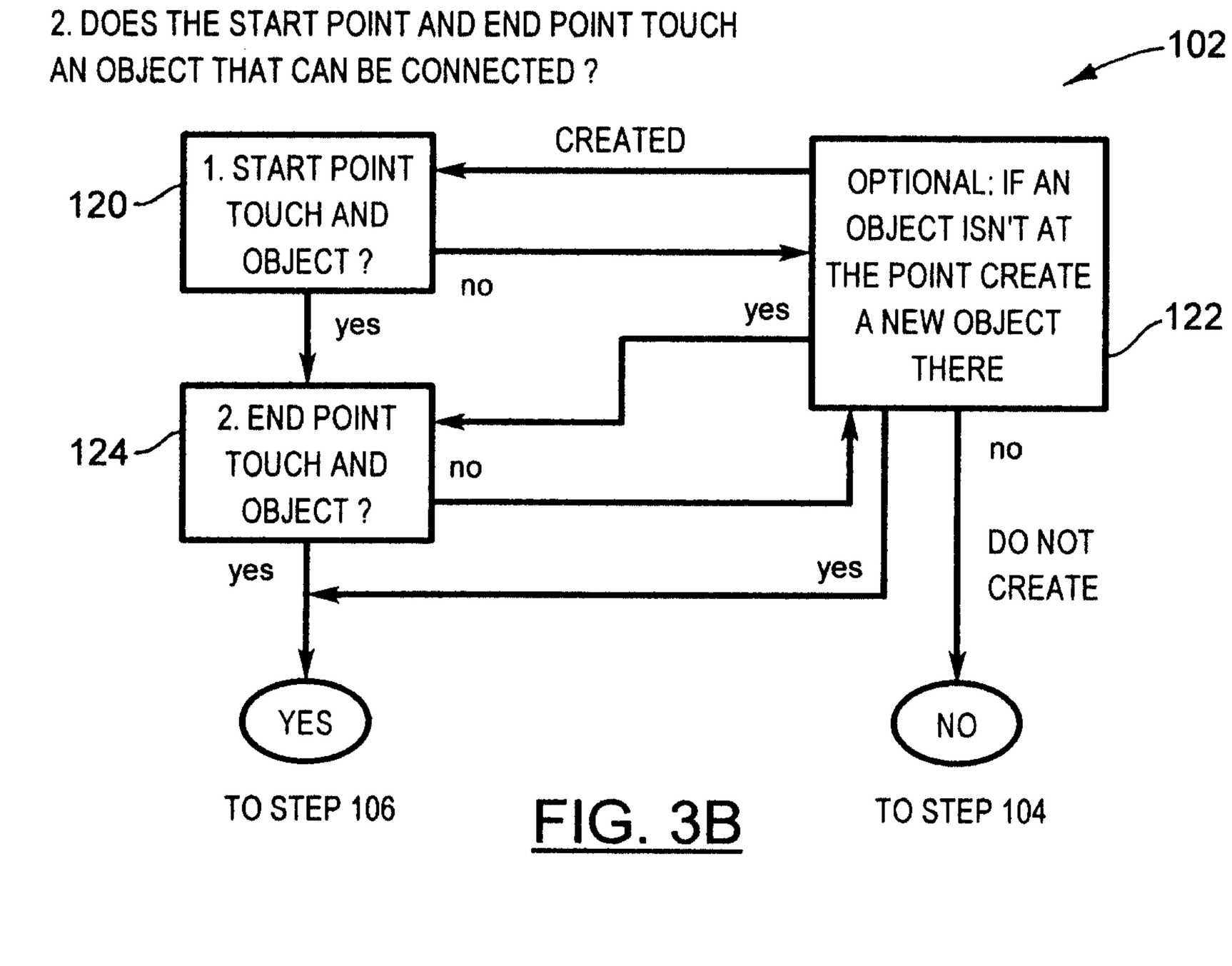

2. DOES THE START POINT AND END POINT TOUCH AN OBJECT THAT CAN BE CONNECTED ?
102
1. START POINT TOUCH AND OBJECT ?
120
CREATED
OPTIONAL: IF AN OBJECT ISN'T AT THE POINT CREATE A NEW OBJECT THERE
122
no
yes
yes
2. END POINT TOUCH AND OBJECT ?
124
no
yes
yes
no
DO NOT CREATE
YES
NO
TO STEP 106
TO STEP 104

FIG. 3B

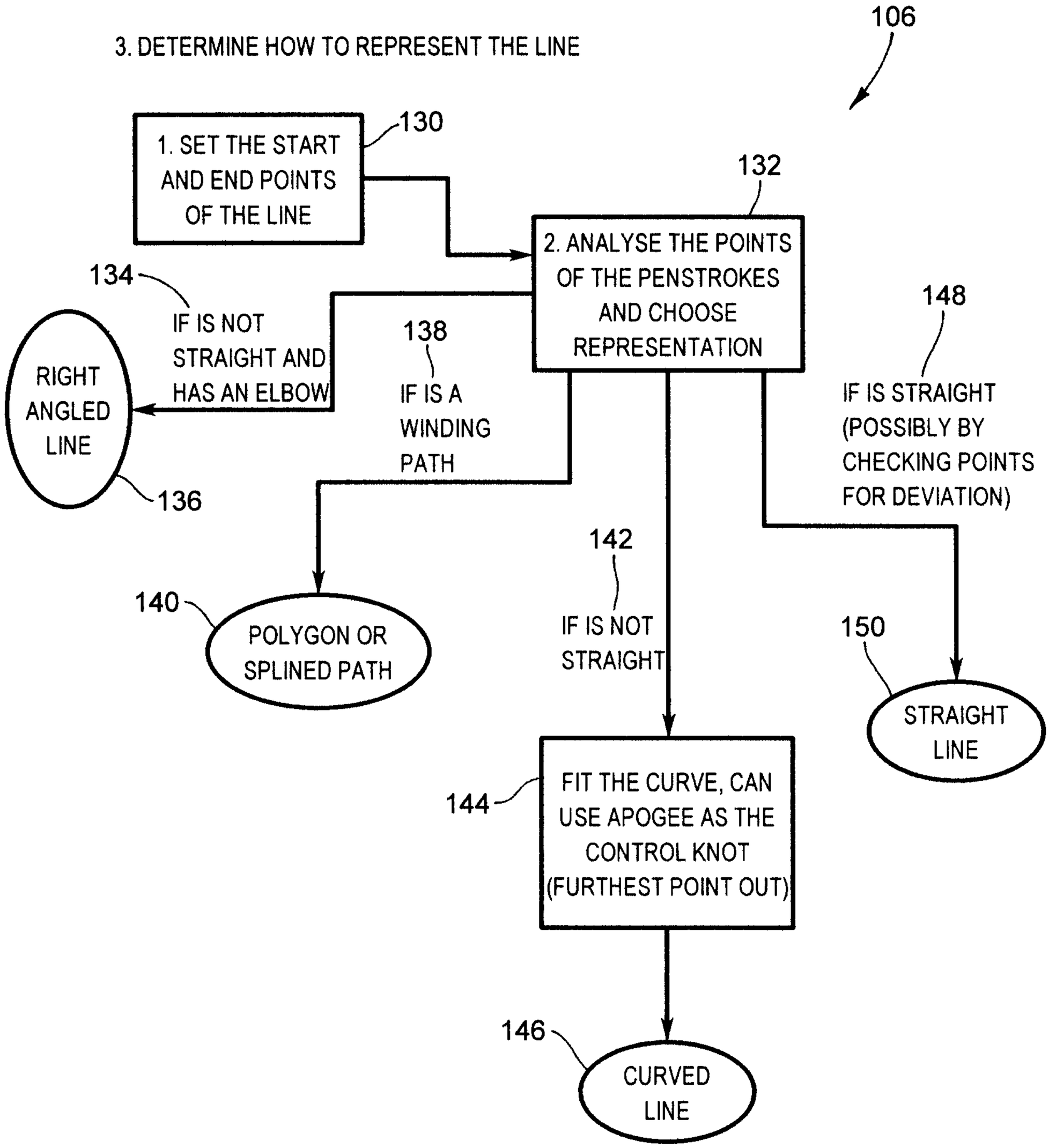

3. DETERMINE HOW TO REPRESENT THE LINE
106
1. SET THE START AND END POINTS OF THE LINE
130
2. ANALYSE THE POINTS OF THE PENSTROKES AND CHOOSE REPRESENTATION
132
134
IF IS NOT STRAIGHT AND HAS AN ELBOW
RIGHT ANGLED LINE
136
138
IF IS A WINDING PATH
140
POLYGON OR SPLINED PATH
142
IF IS NOT STRAIGHT
144
FIT THE CURVE, CAN USE APOGEE AS THE CONTROL KNOT (FURTHEST POINT OUT)
146
CURVED LINE
148
IF IS STRAIGHT (POSSIBLY BY CHECKING POINTS FOR DEVIATION)
150
STRAIGHT LINE

FIG. 3C

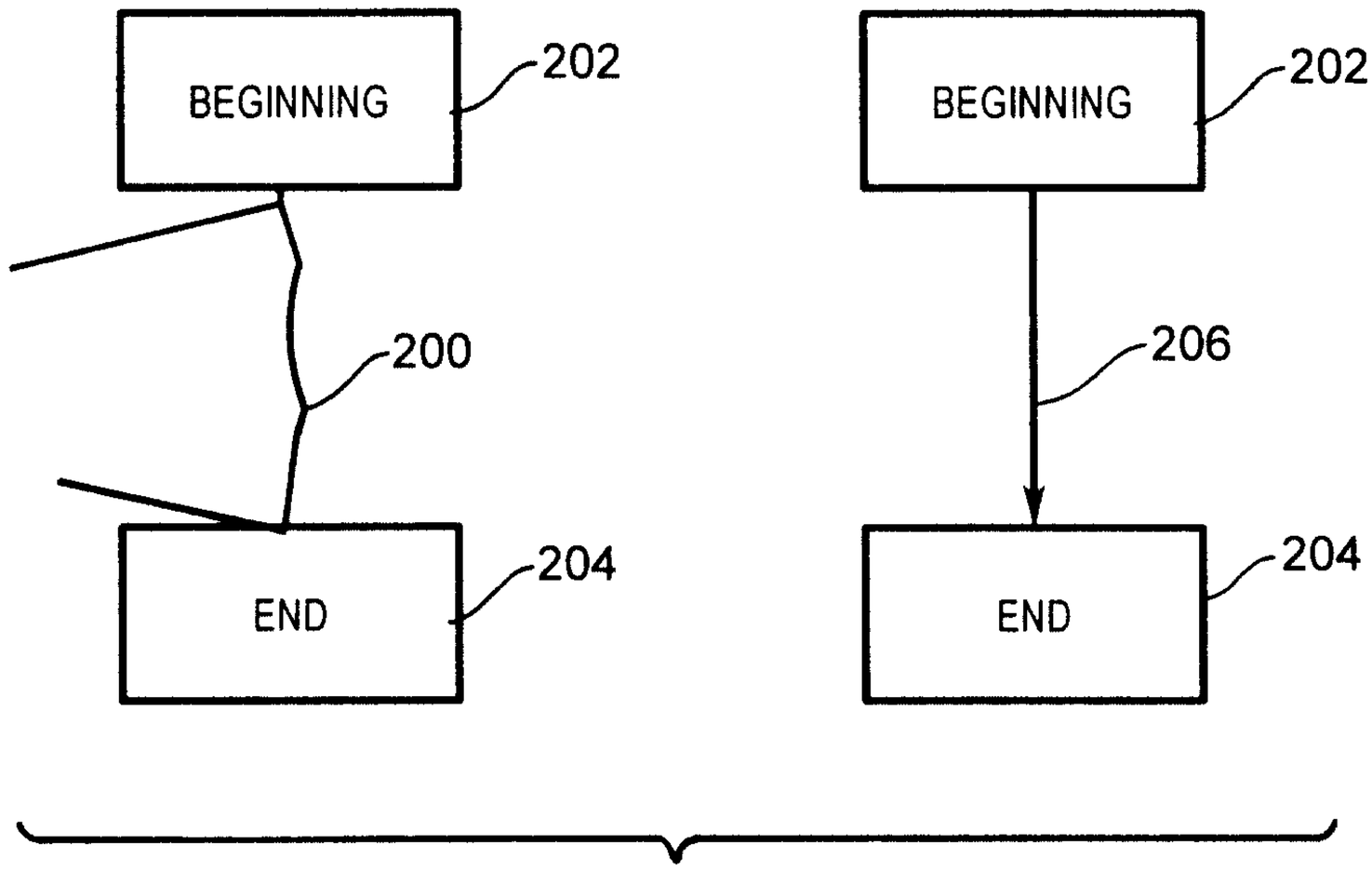

BEGINNING
202
200
END
204
BEGINNING
202
206
END
204

FIG. 4

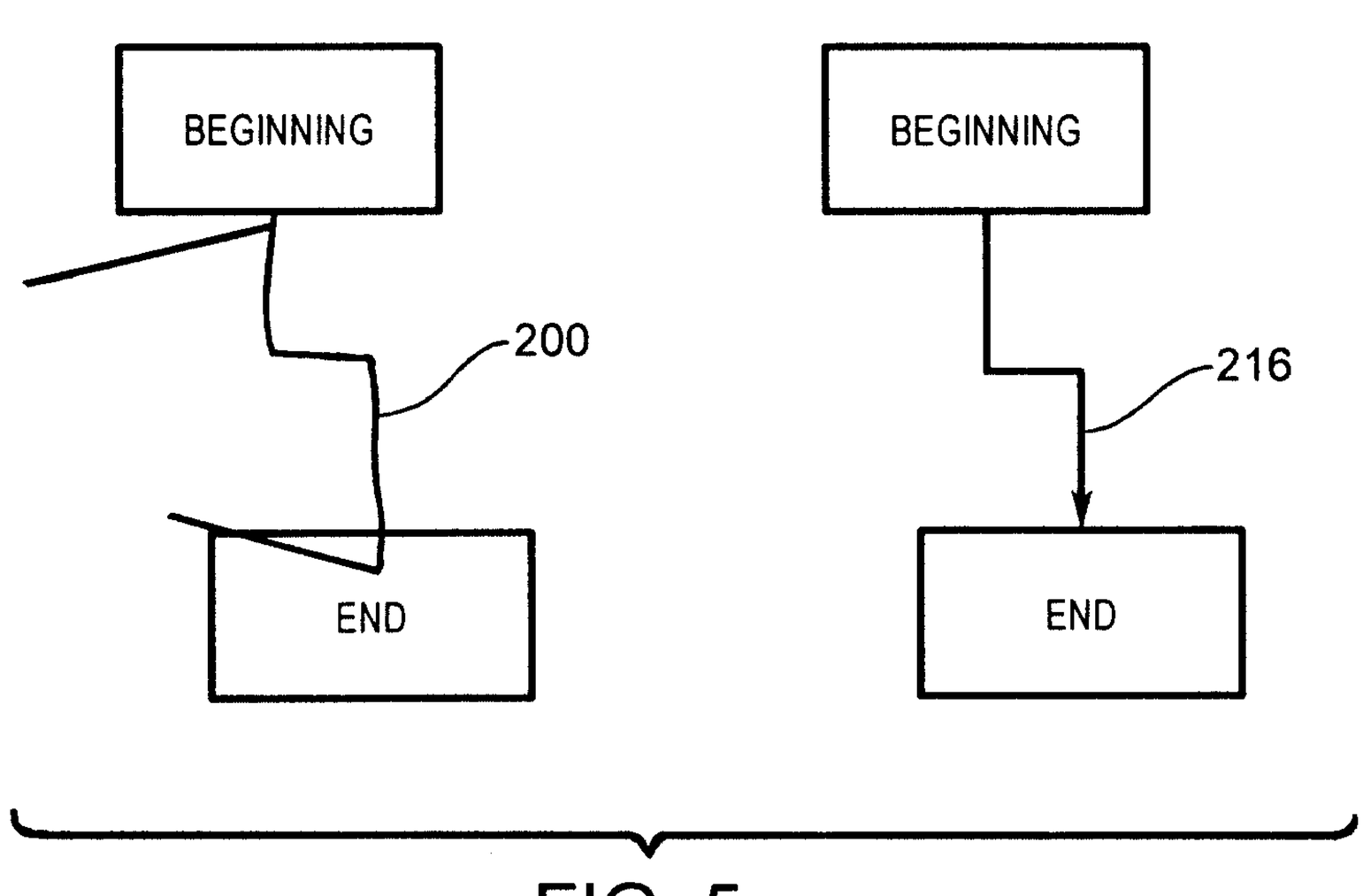

BEGINNING
200
END
BEGINNING
216
END

FIG. 5

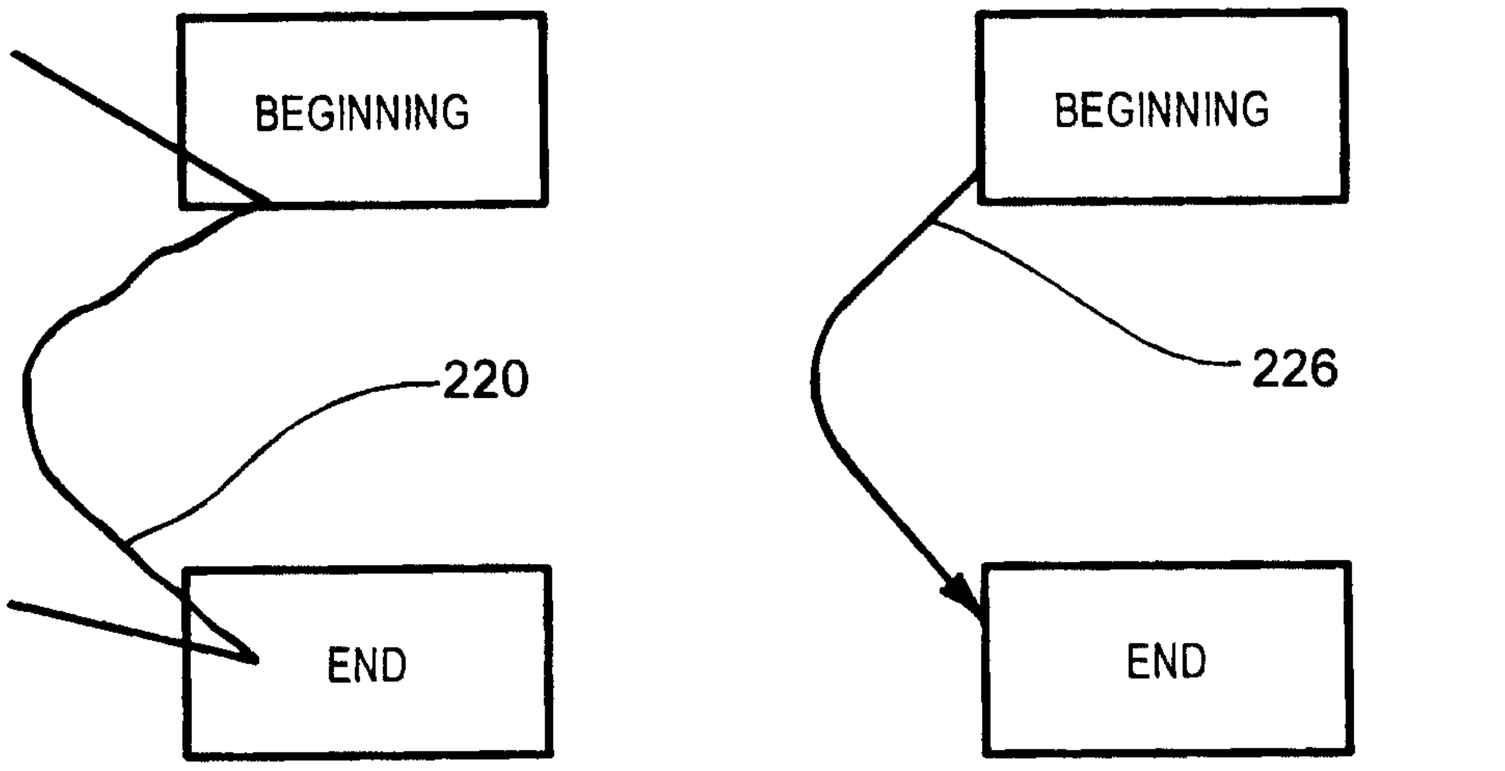


FIG. 6

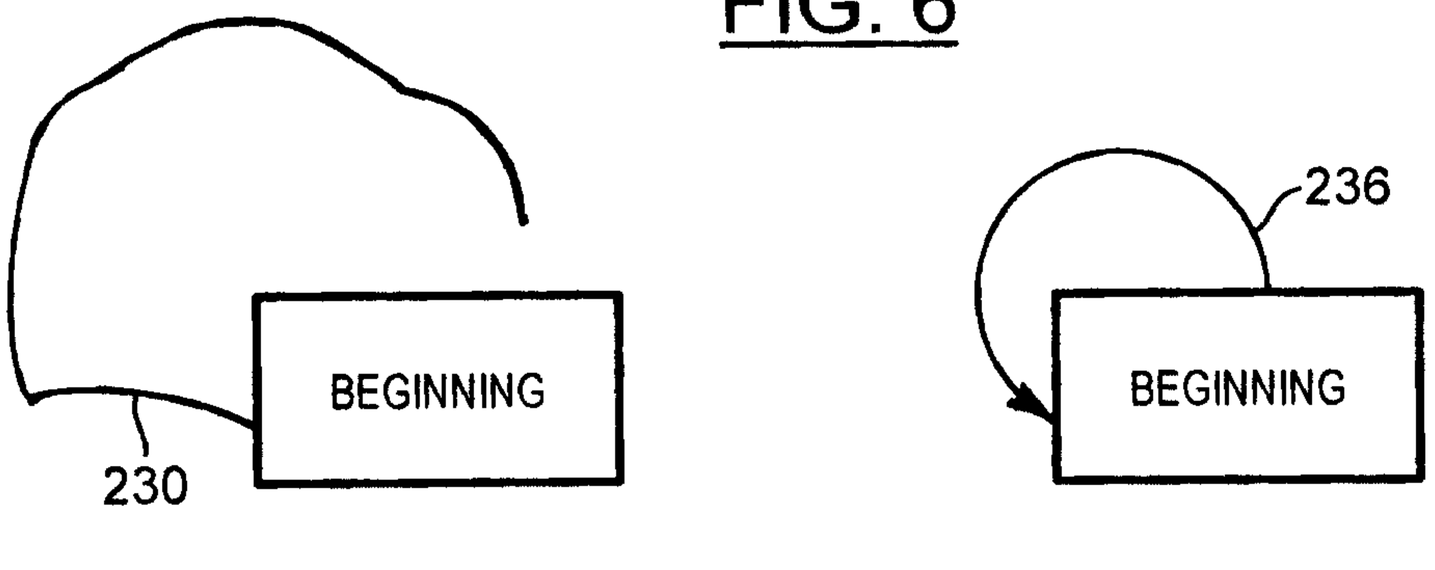


FIG. 7

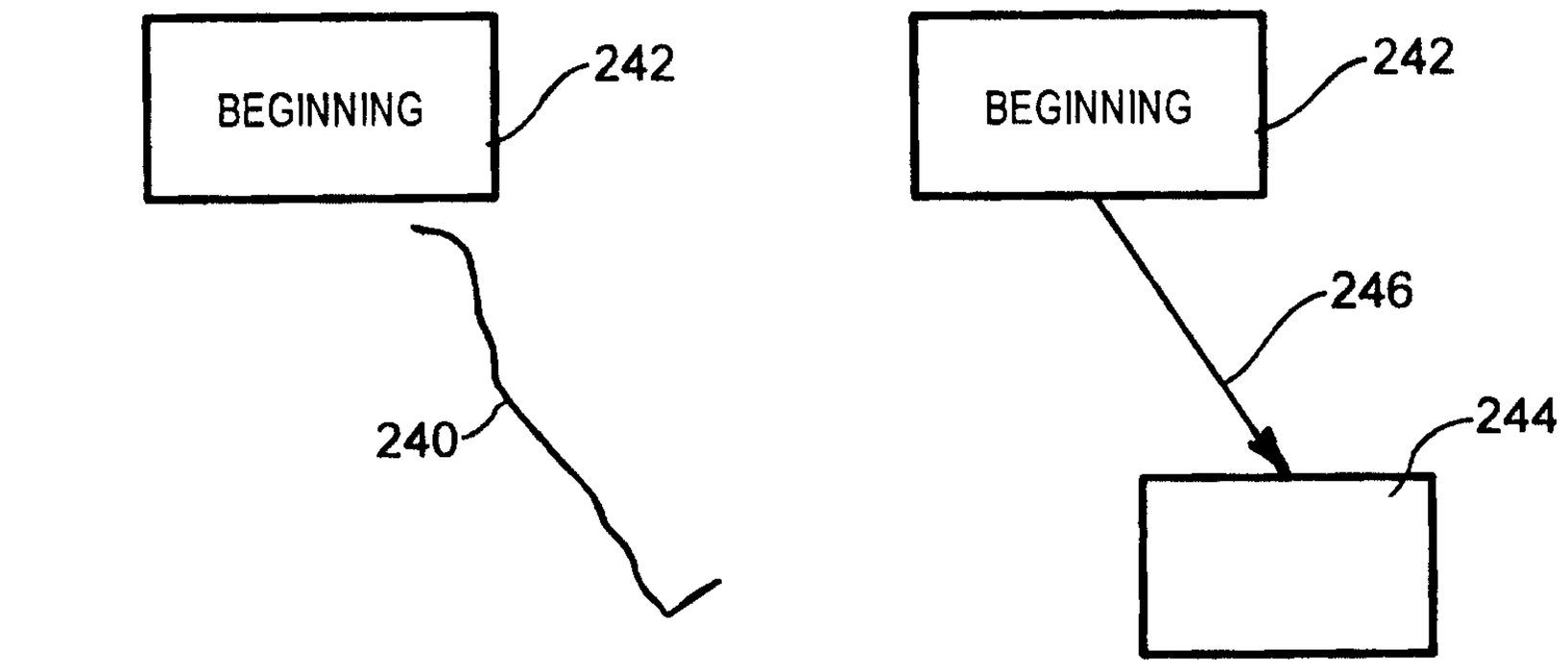


FIG. 8

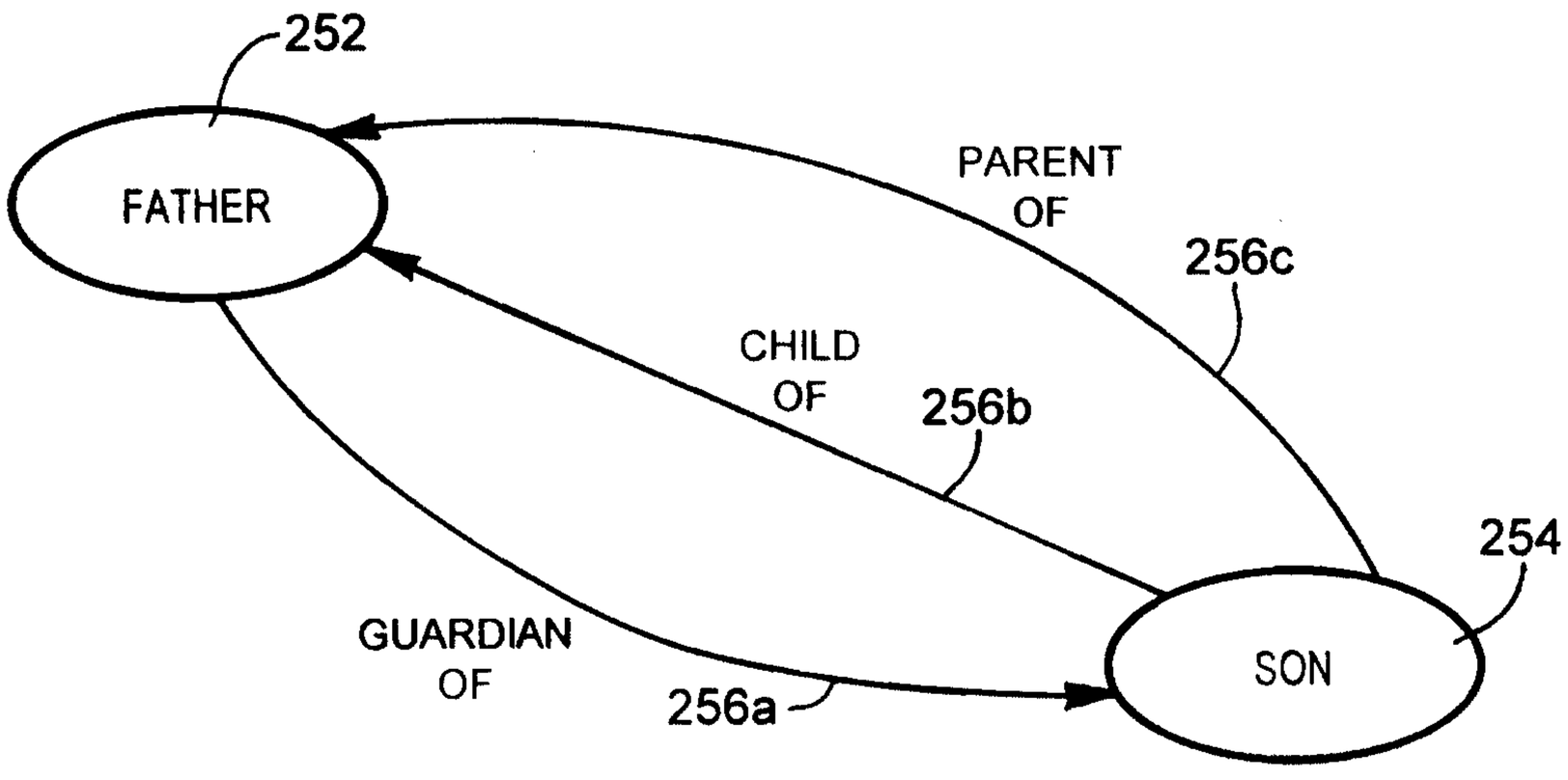

252
FATHER
PARENT
OF
256c
CHILD
OF
256b
254
SON
GUARDIAN
OF
256a

FIG. 9

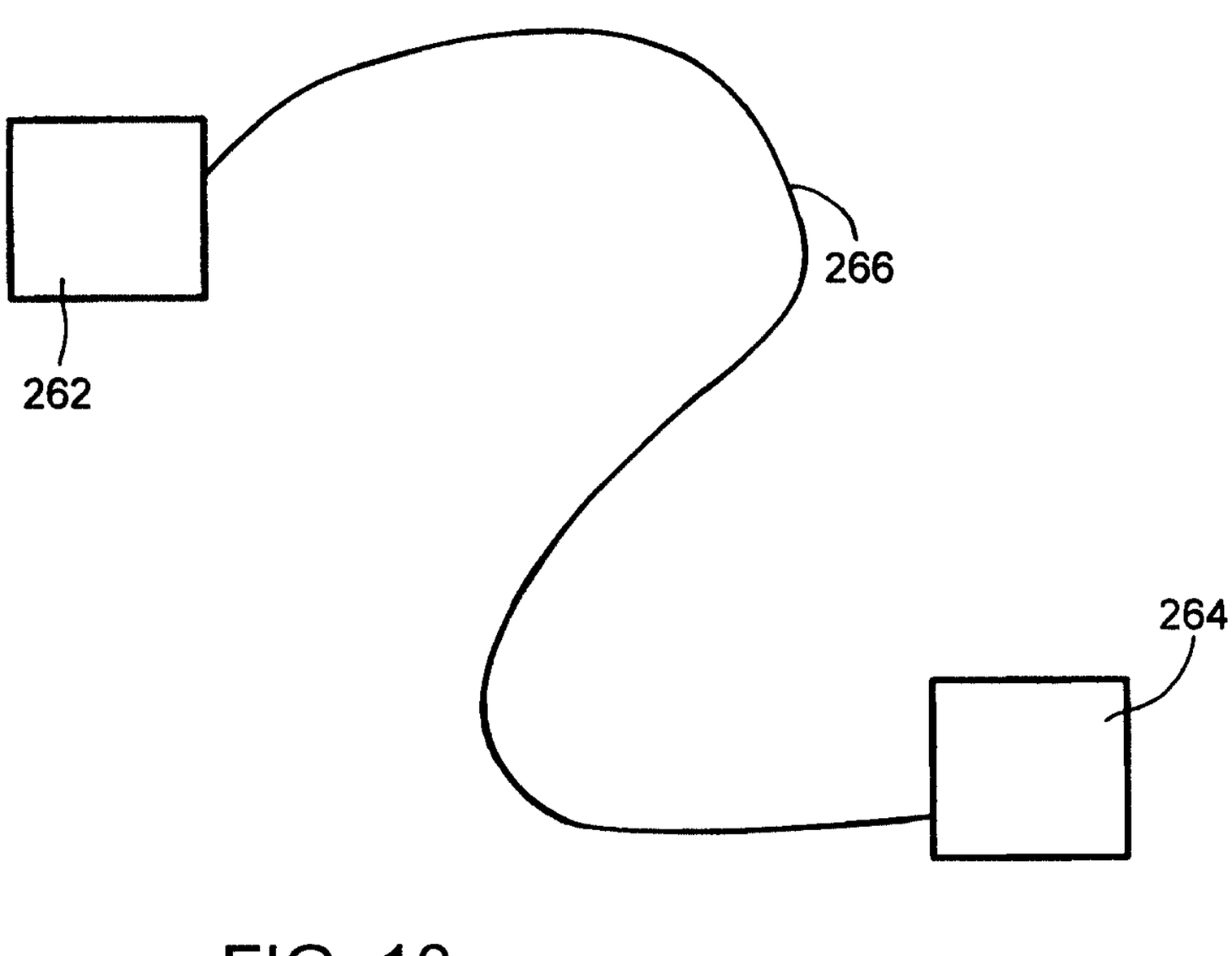
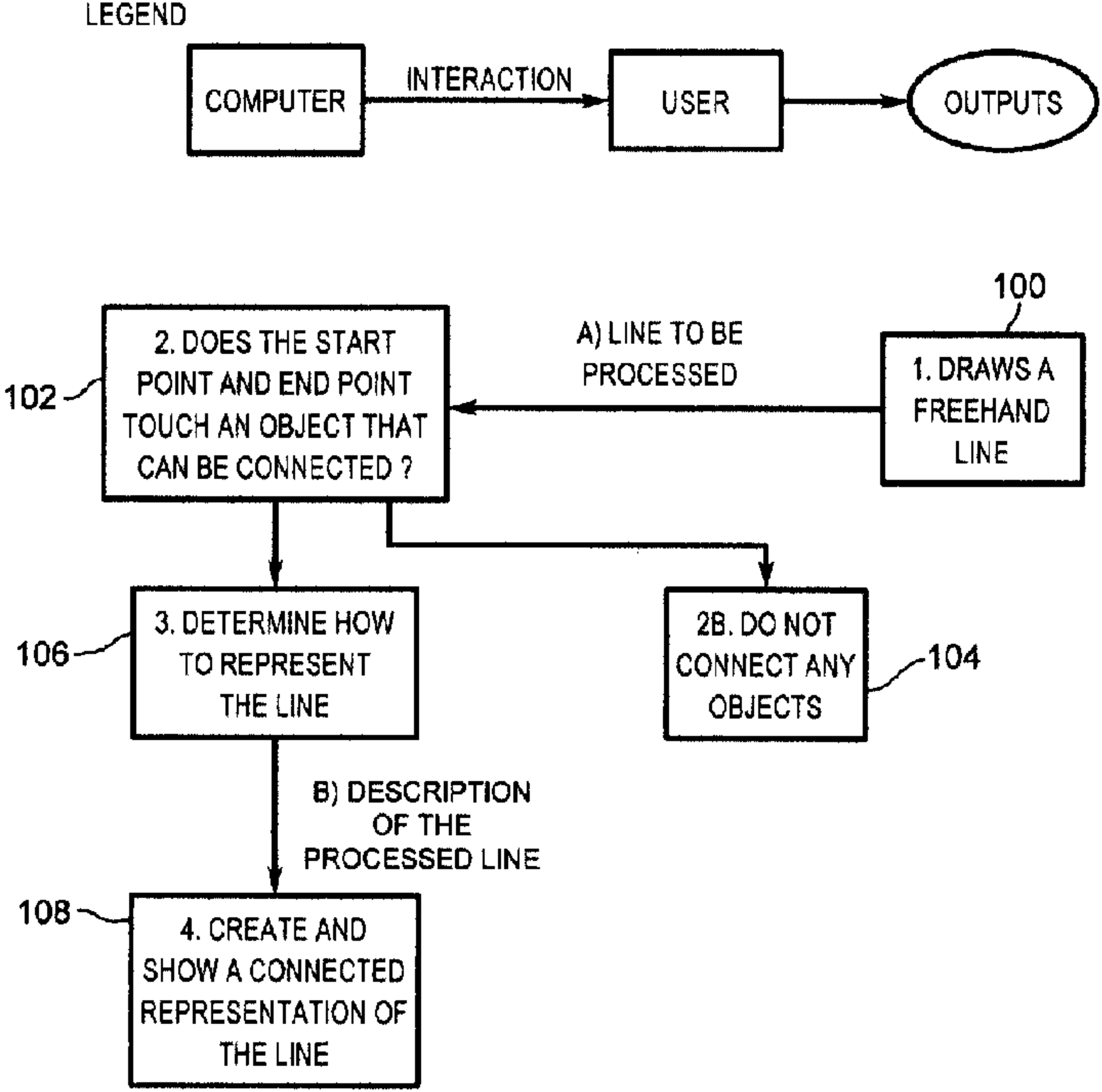

262
266
264

FIG. 10


LEGEND
COMPUTER
INTERACTION
USER
OUTPUTS
100
1. DRAWS A FREEHAND LINE
A) LINE TO BE PROCESSED
2. DOES THE START POINT AND END POINT TOUCH AN OBJECT THAT CAN BE CONNECTED ?
102
2B. DO NOT CONNECT ANY OBJECTS
104
3. DETERMINE HOW TO REPRESENT THE LINE
106
B) DESCRIPTION OF THE PROCESSED LINE
4. CREATE AND SHOW A CONNECTED REPRESENTATION OF THE LINE
108