US00RE39950E

(19) **United States**
(12) **Reissued Patent**
Gantt et al.
(10) **Patent Number: US RE39,950 E**
(45) **Date of Reissued Patent: Dec. 25, 2007**

(54) **METHOD AND APPARATUS FOR INTERACTIVELY MANIPULATING AND DISPLAYING PRESUMPTIVE RELATIONSHIPS BETWEEN GRAPHIC OBJECTS**

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(73) Assignee: **Autodesk, Inc.**, San Rafael, CA (US)

(21) Appl. No.: **09/186,270**

(22) Filed: **Nov. 4, 1998**

Related U.S. Patent Documents

Reissue of:
(64) Patent No.: **5,572,639**
Issued: **Nov. 5, 1996**
Appl. No.: **08/436,158**
Filed: **May 8, 1995**

(51) **Int. Cl.**
G09G 5/00 (2006.01)

(52) **U.S. Cl.** **345/651**; 345/652; 345/677; 345/678

(58) **Field of Classification Search** 345/433, 345/435, 437, 619, 629, 649
See application file for complete search history.

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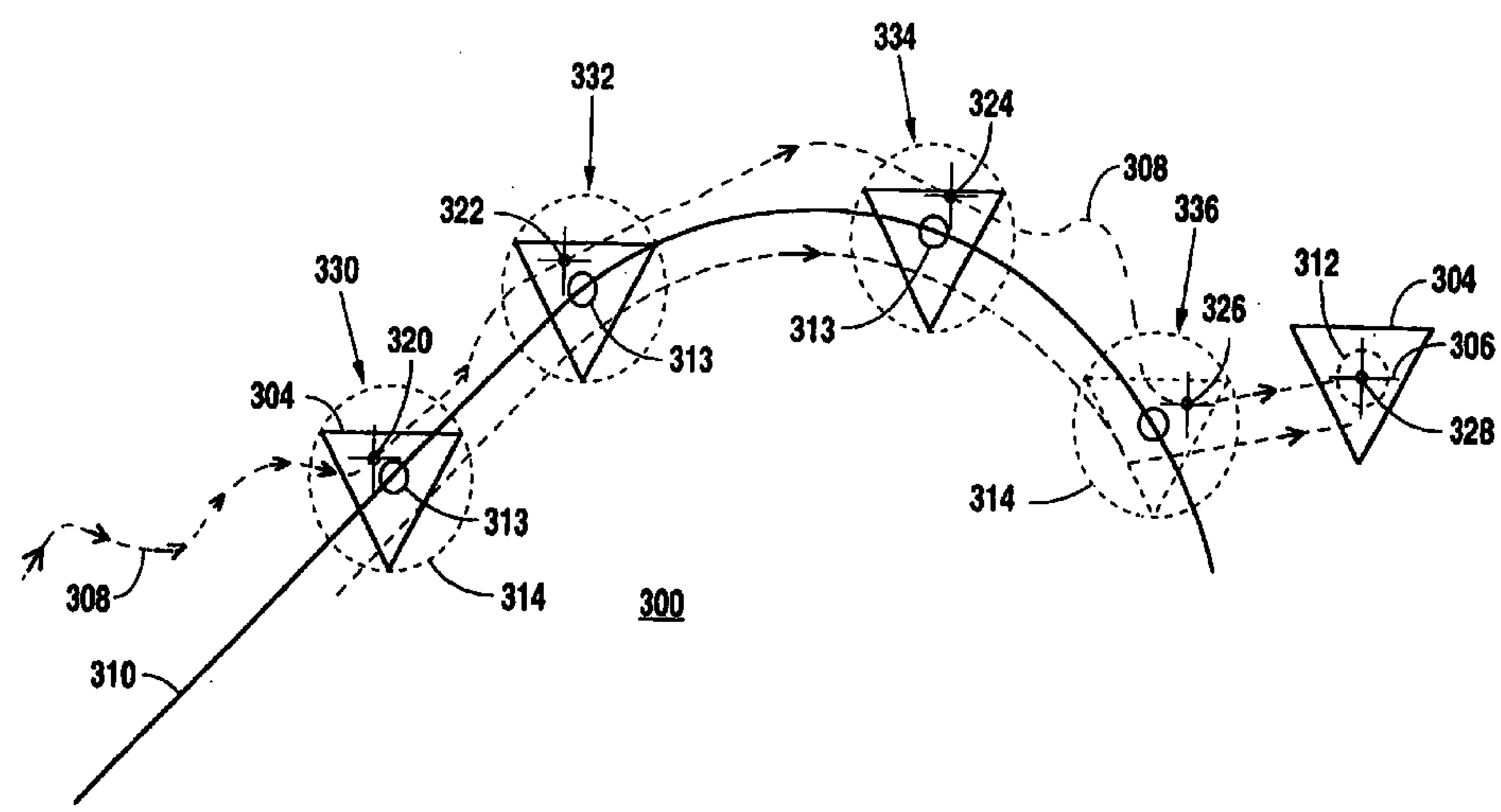
(74) *Attorney, Agent, or Firm*—Gates & Cooper LLP

(57) **ABSTRACT**

A presumptive mode computer aided design and drafting system for interactively manipulating and displaying graphic objects that employ predefined rules to govern the geometric layout and logical relationships representing a physical design, schematic or process flow diagram. The system is configured to comply with the rules employed by various design disciplines. Specific interactive computer graphics behavior is dynamically accessed to interactively update graphic object relationships according to rules of geometric conduct. The rules of geometric conduct may be stored in external databases along with parameters to verify the logical relationships of the graphic objects used in the drawing. Object orientation is employed in the software design of the system to allow new devcies or procedures to adopt the behavior of existing definitions. In the preferred embodiment, a selected object floats with a cursor in a graphic environment until located in proximity with underlying graphic objects. The selected object then aligns, jumps and clings to the underlying graphic object or objects according to predetermined rules. For example, the object is automatically rotated, orientated and positioned relative to a cling point into a correct relationship with the underlying object without further input by the operator. Further, the selected object slides along the underlying graphic object maintaining the correct geometric relationship while the operator moves the cursor in proximity with the underlying graphic. The operator either accepts the presumed relationship or moves the cursor away to uncling the selected object.

70 Claims, 13 Drawing Sheets



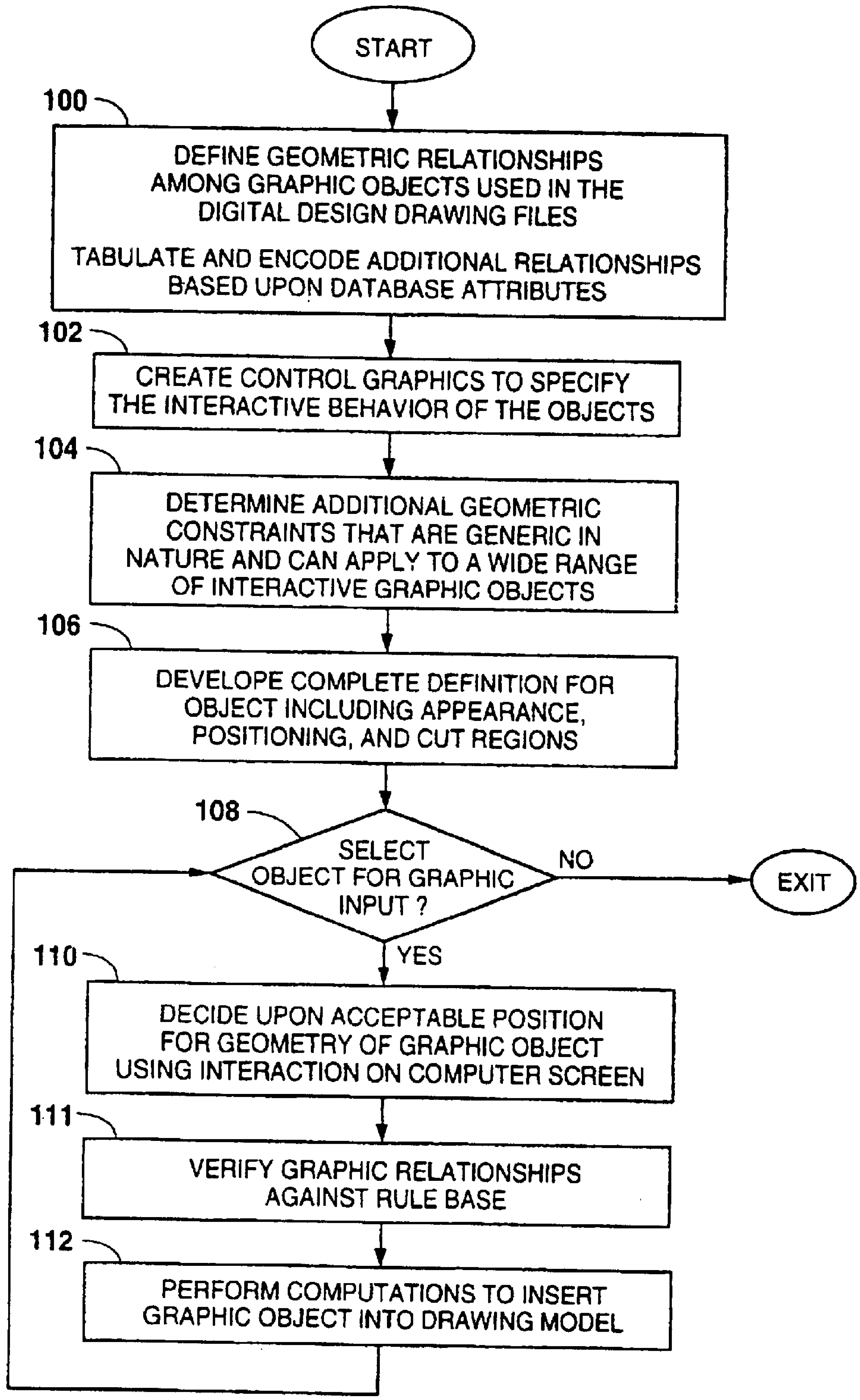

START
100
DEFINE GEOMETRIC RELATIONSHIPS AMONG GRAPHIC OBJECTS USED IN THE DIGITAL DESIGN DRAWING FILES
TABULATE AND ENCODE ADDITIONAL RELATIONSHIPS BASED UPON DATABASE ATTRIBUTES
102
CREATE CONTROL GRAPHICS TO SPECIFY THE INTERACTIVE BEHAVIOR OF THE OBJECTS
104
DETERMINE ADDITIONAL GEOMETRIC CONSTRAINTS THAT ARE GENERIC IN NATURE AND CAN APPLY TO A WIDE RANGE OF INTERACTIVE GRAPHIC OBJECTS
106
DEVELOPE COMPLETE DEFINITION FOR OBJECT INCLUDING APPEARANCE, POSITIONING, AND CUT REGIONS
108
SELECT OBJECT FOR GRAPHIC INPUT ?
NO
EXIT
YES
110
DECIDE UPON ACCEPTABLE POSITION FOR GEOMETRY OF GRAPHIC OBJECT USING INTERACTION ON COMPUTER SCREEN
111
VERIFY GRAPHIC RELATIONSHIPS AGAINST RULE BASE
112
PERFORM COMPUTATIONS TO INSERT GRAPHIC OBJECT INTO DRAWING MODEL

Fig. 1

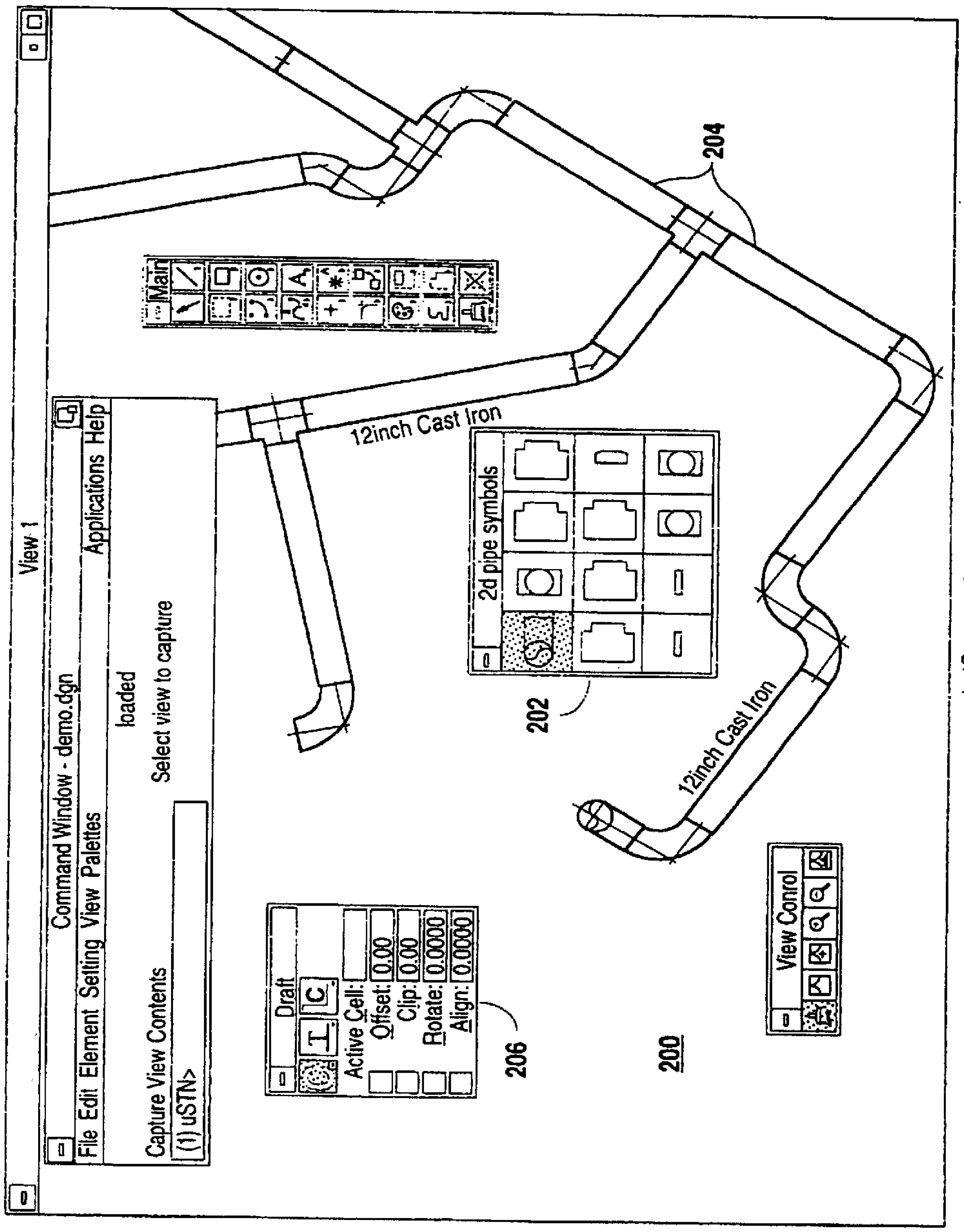
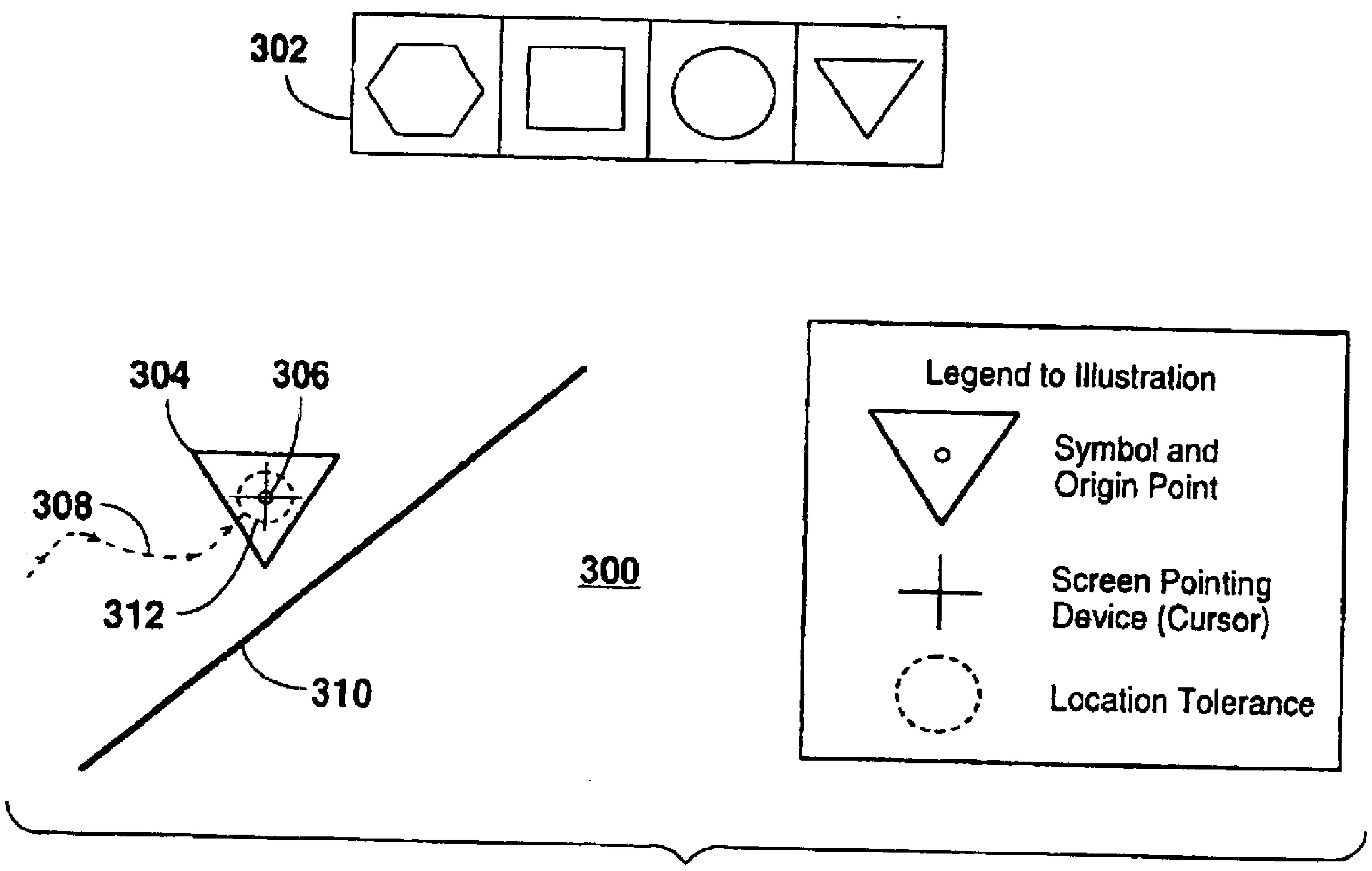

View 1
Command Window - demo.dgn
File Edit Element Setting View Palettes Applications Help
loaded
Capture View Contents
Select view to capture
(1) uSTN>
Main
12inch Cast Iron
2d pipe symbols
12inch Cast Iron
Draft
Active Cell:
Offset: 0.00
Clip: 0.00
Rotate: 0.0000
Align: 0.0000
View Conrol
200
202
204
206

Fig. 2


302
304
306
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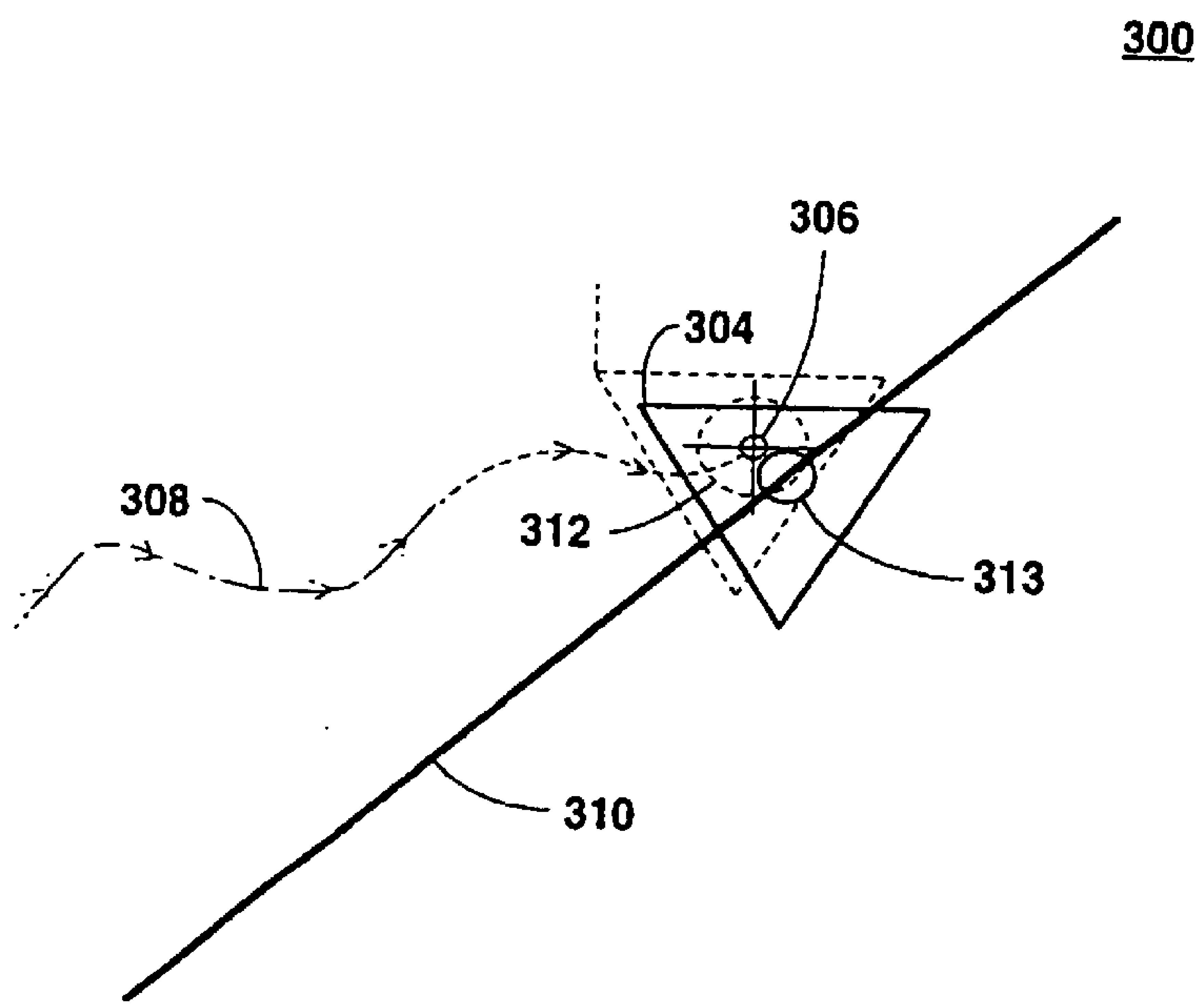
312
310
300
Legend to Illustration
Symbol and Origin Point
Screen Pointing Device (Cursor)
Location Tolerance

Fig. 3A


300
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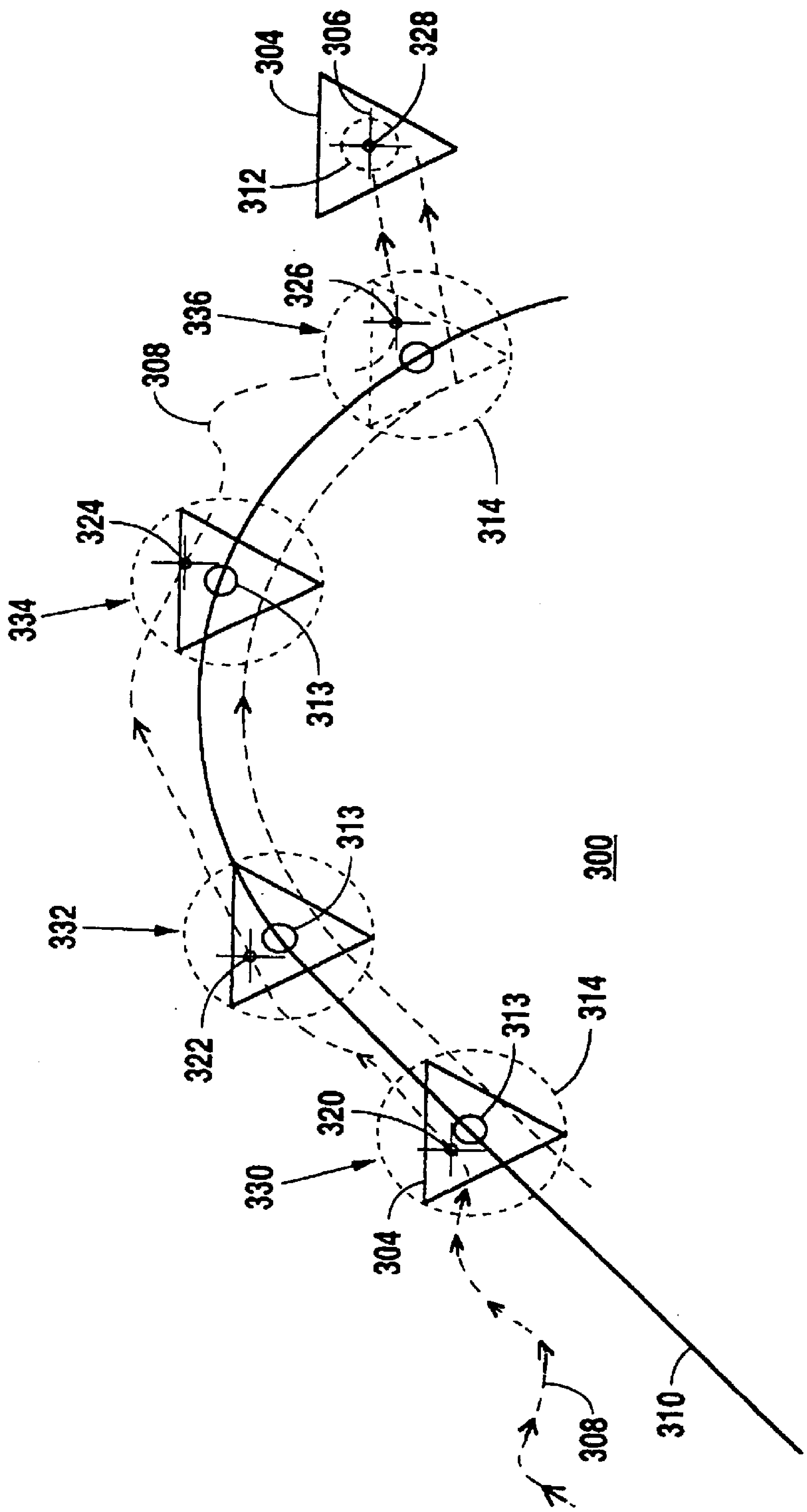
313
310

Fig. 3B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306
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336
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308
310

Fig. 3C

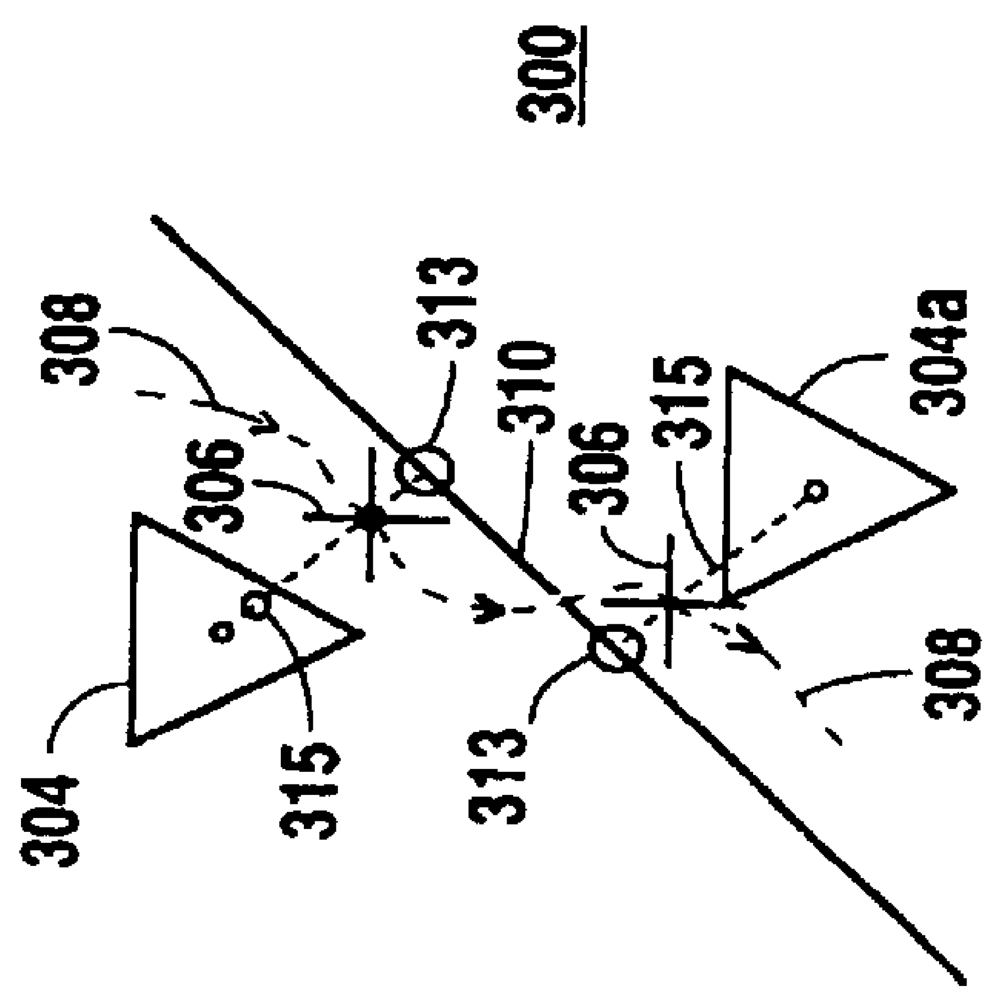

Fig. 3E

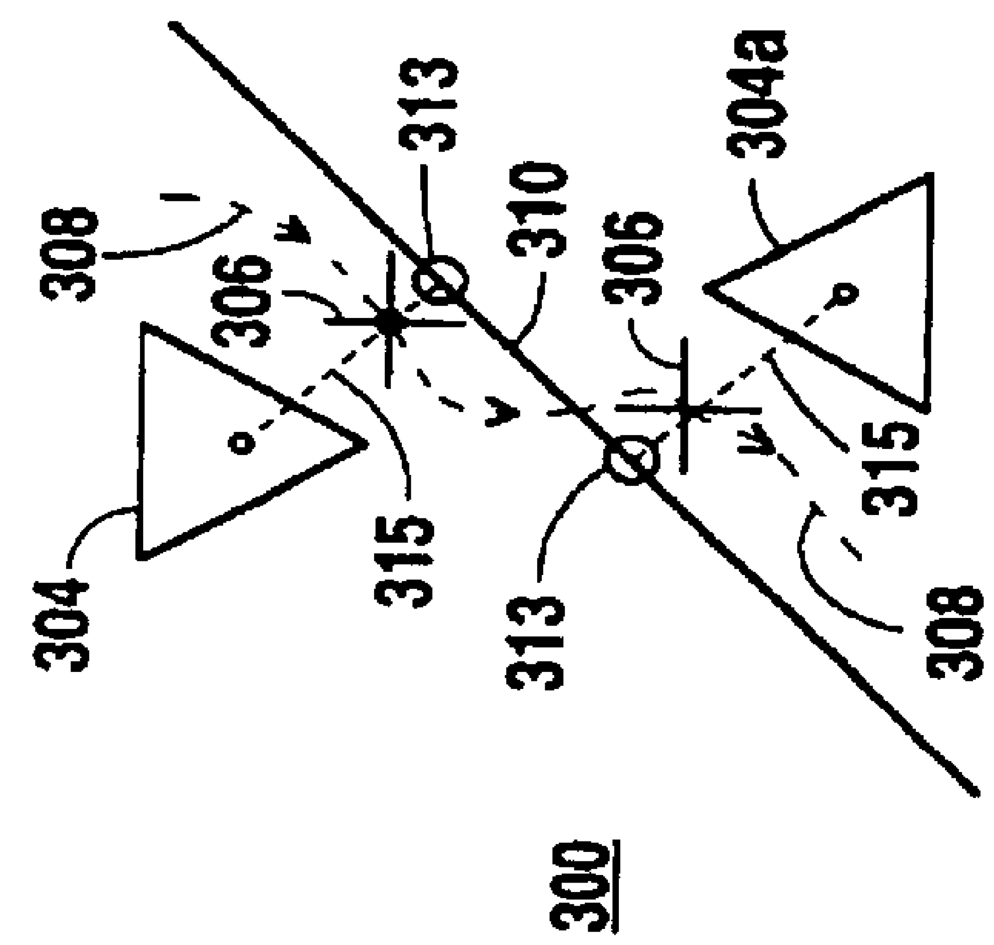

Fig. 3F

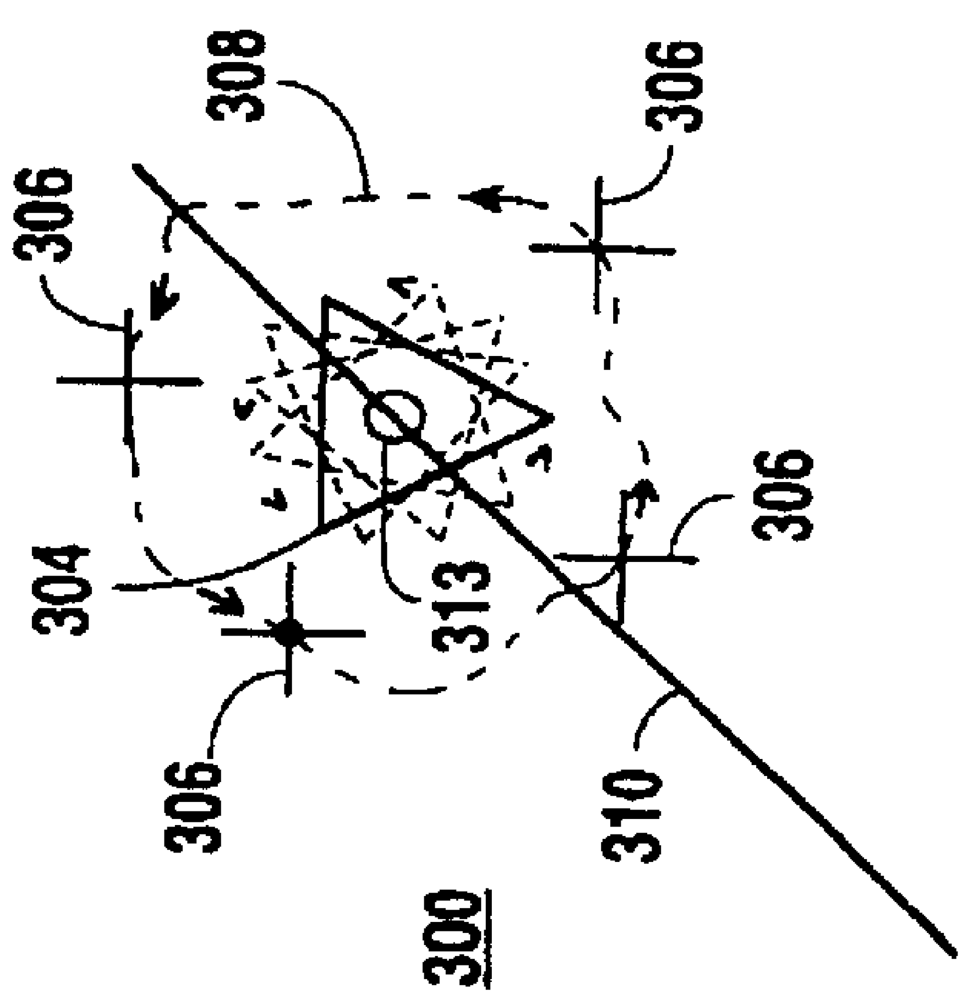

Fig. 3D

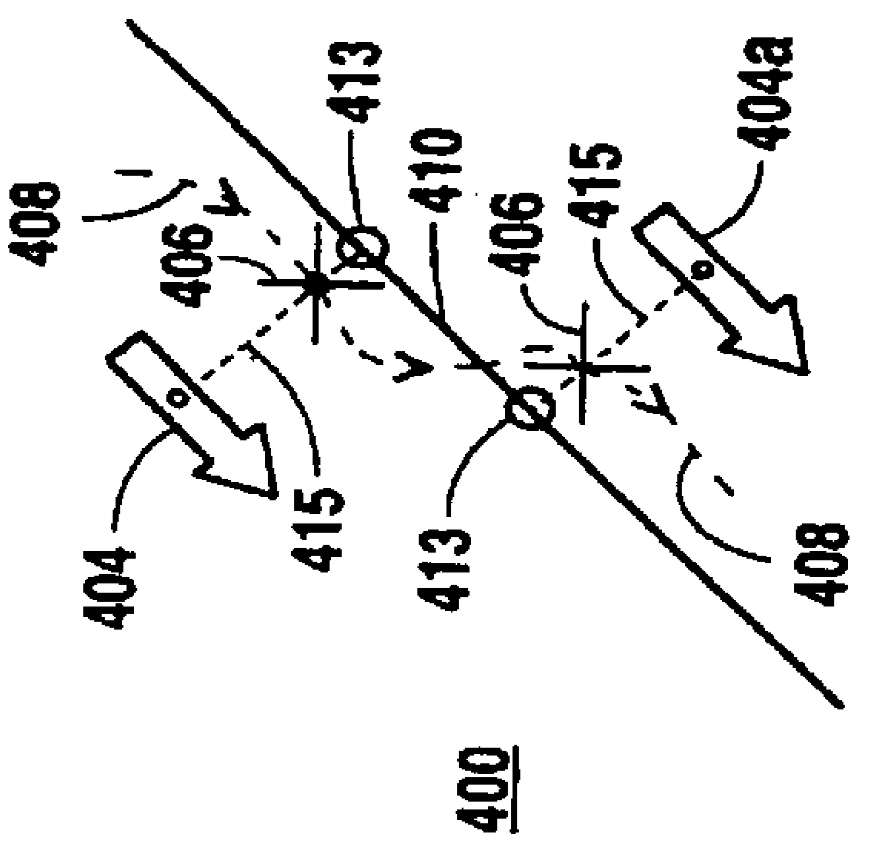

Fig. 4D

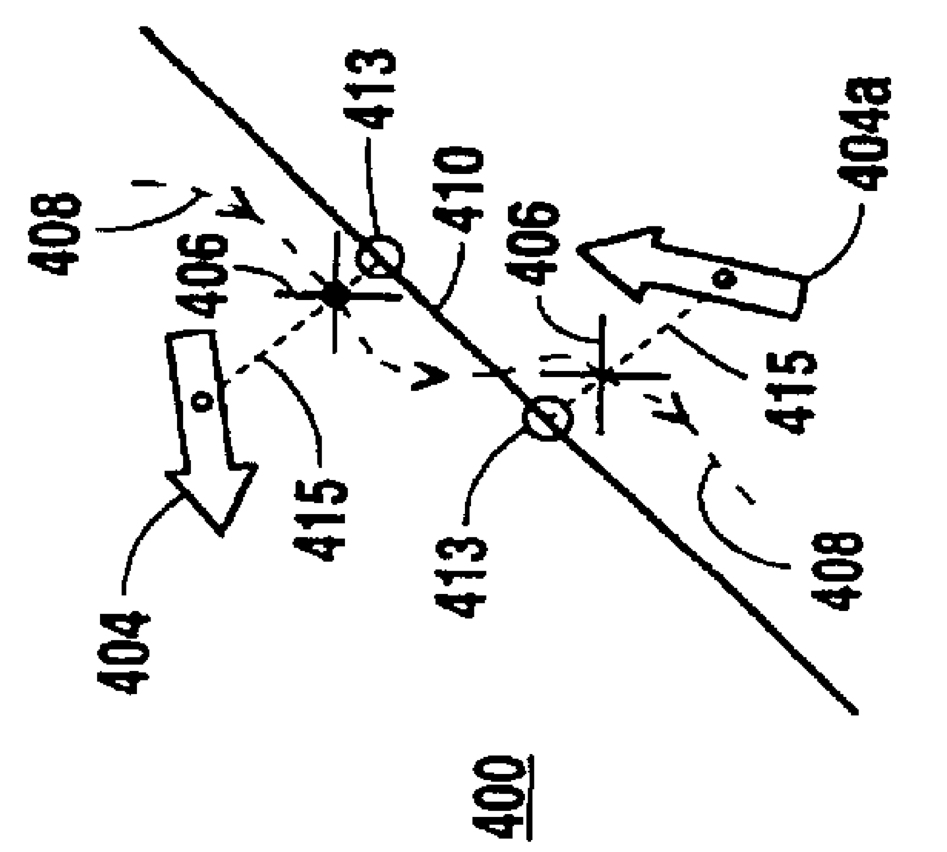

Fig. 4B

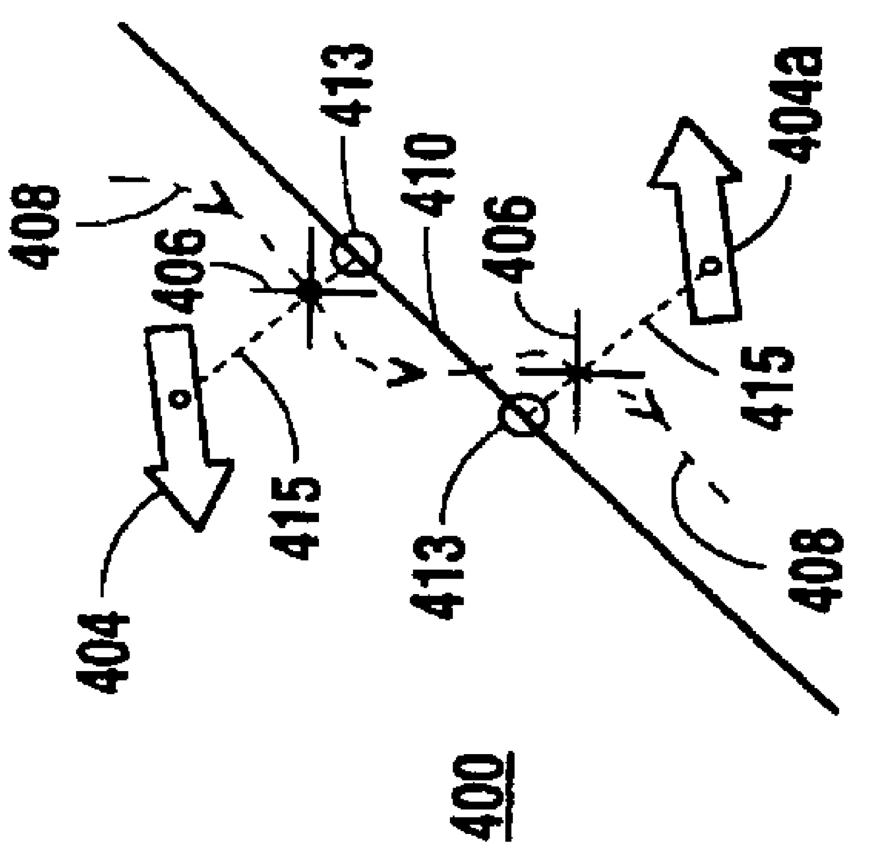

Fig. 4C

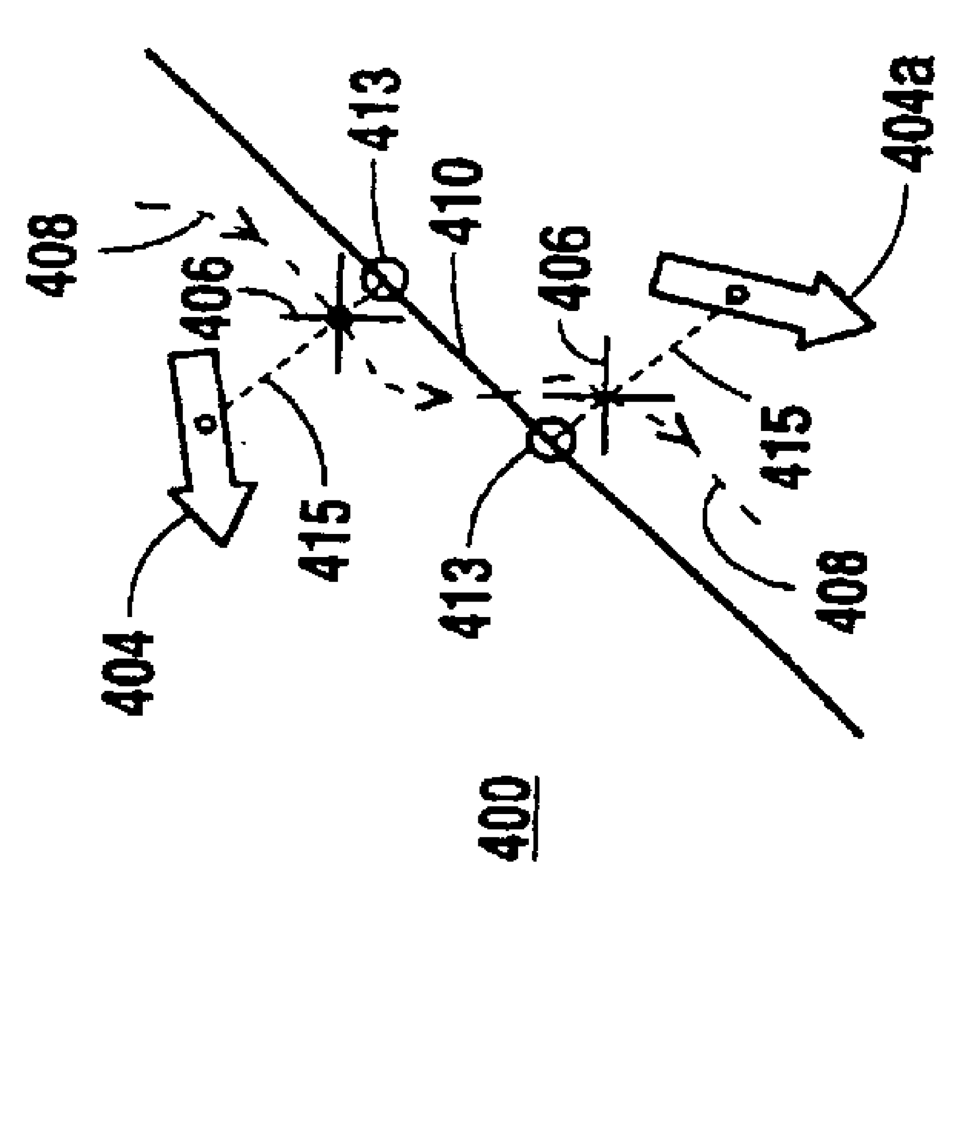

Fig. 4A

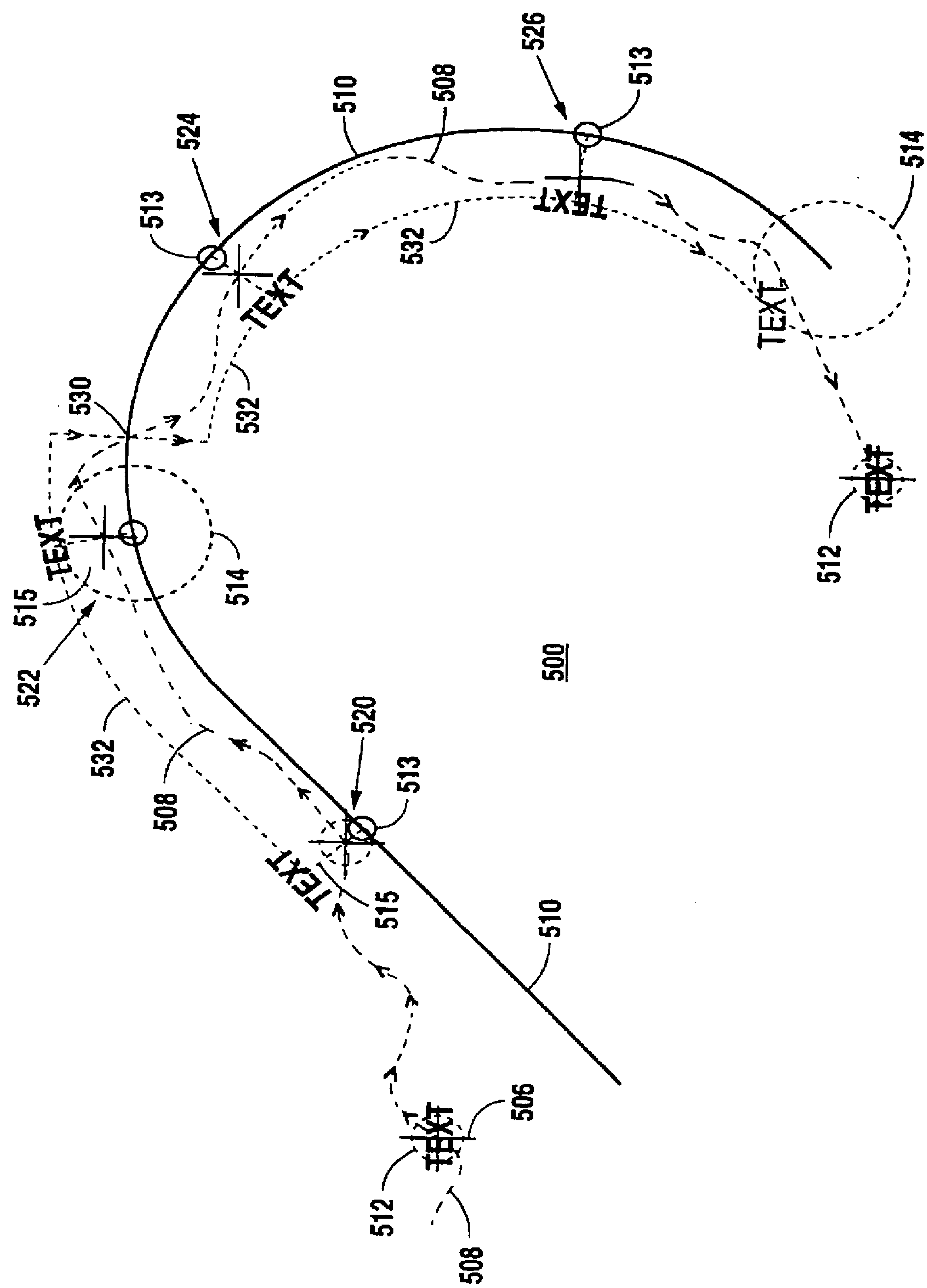

Fig. 5

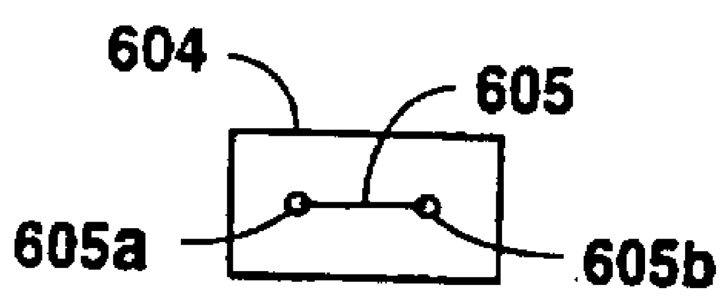

Fig. 6A

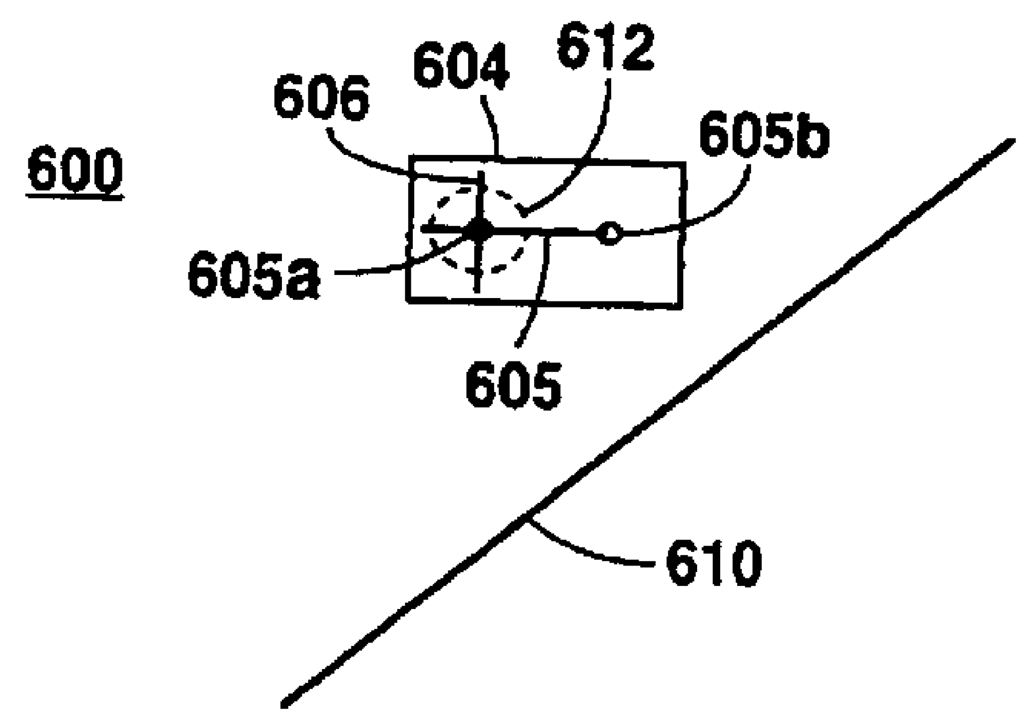

Fig. 6B

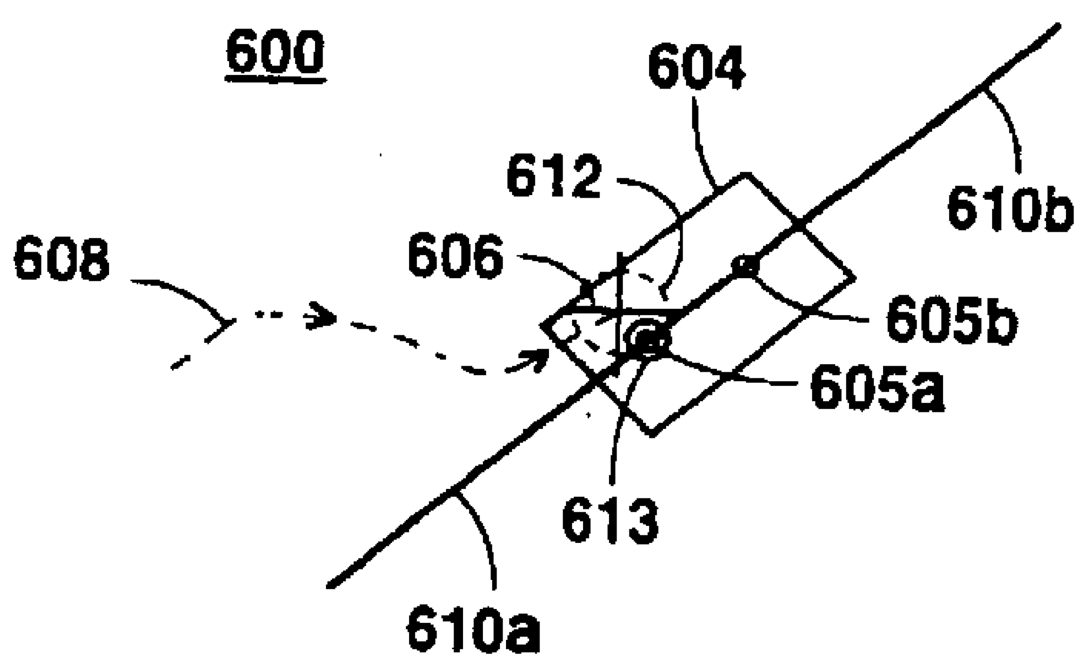

Fig. 6C

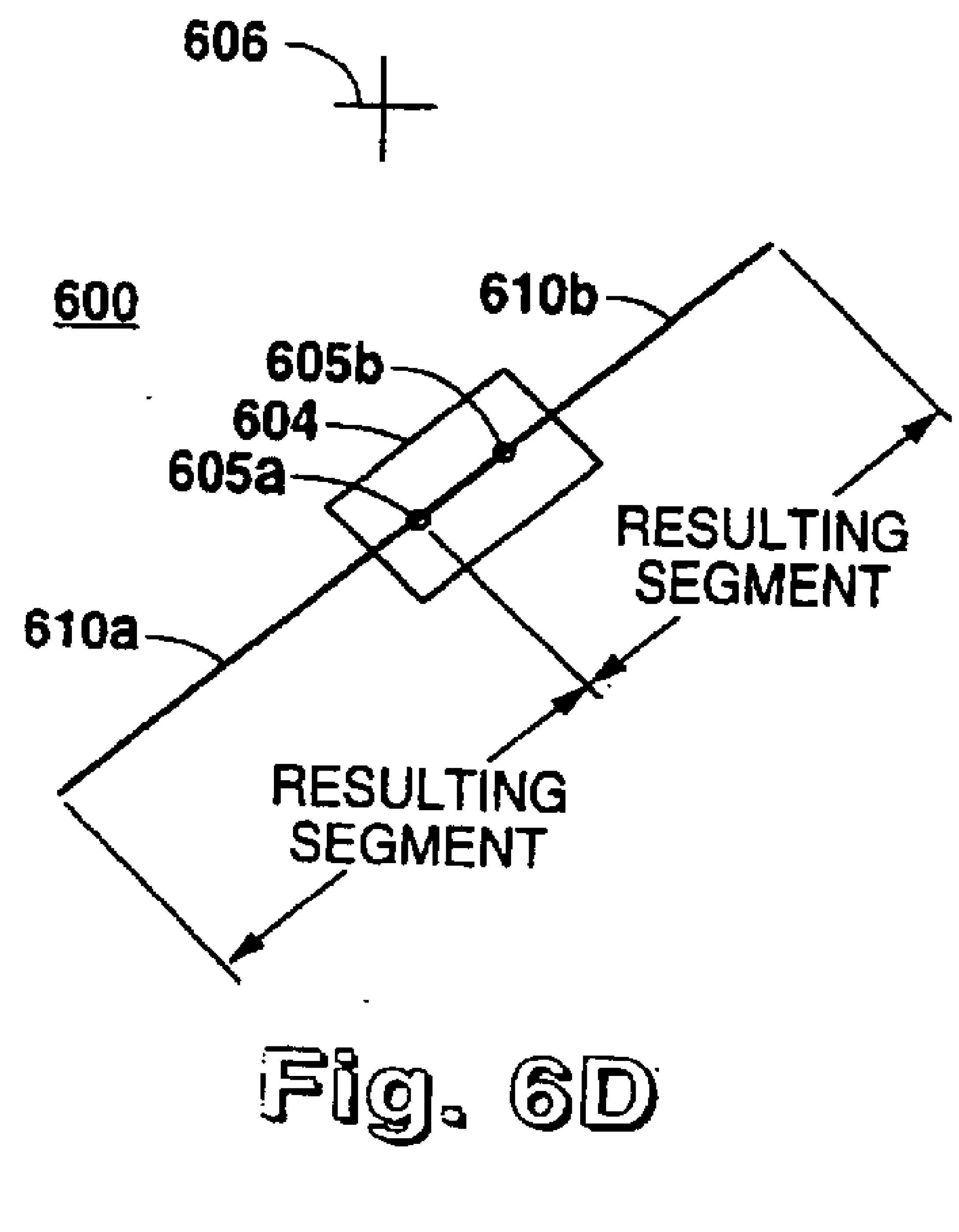

Fig. 6D

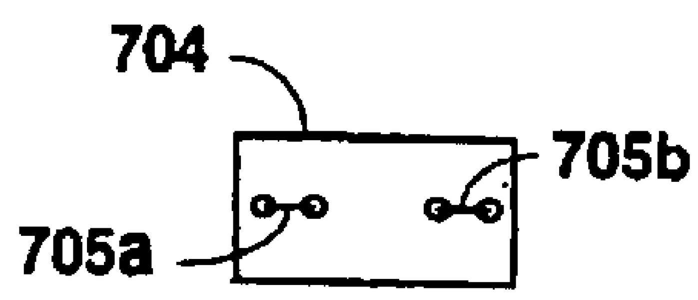

Fig. 7A

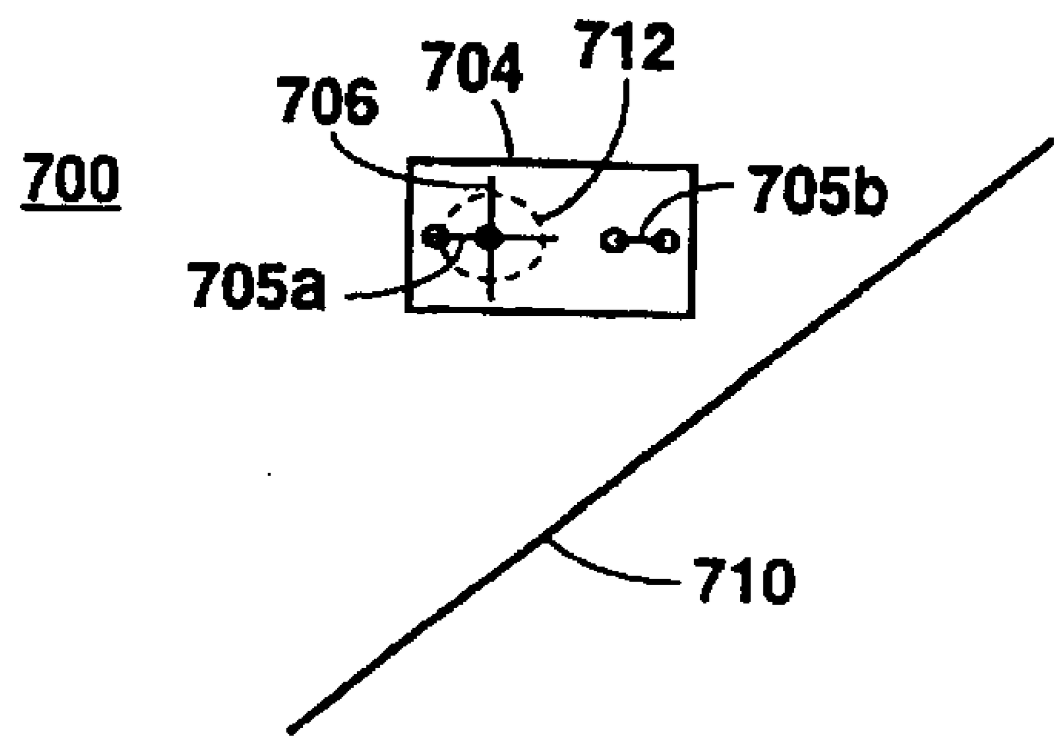

Fig. 7B

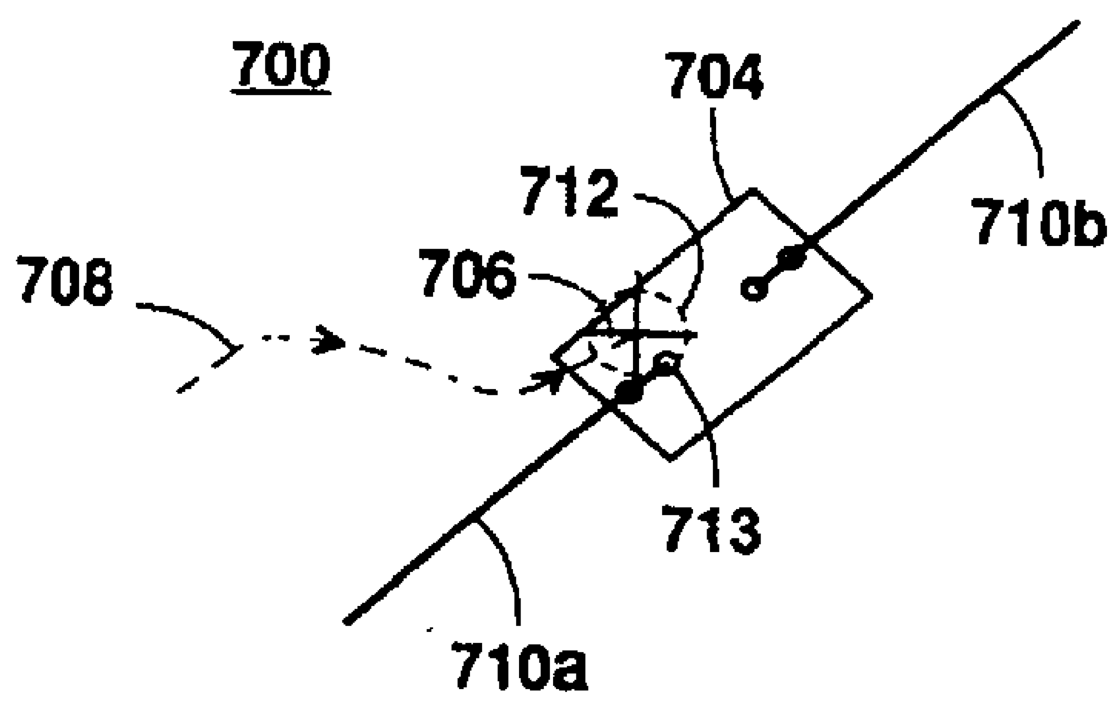

Fig. 7C

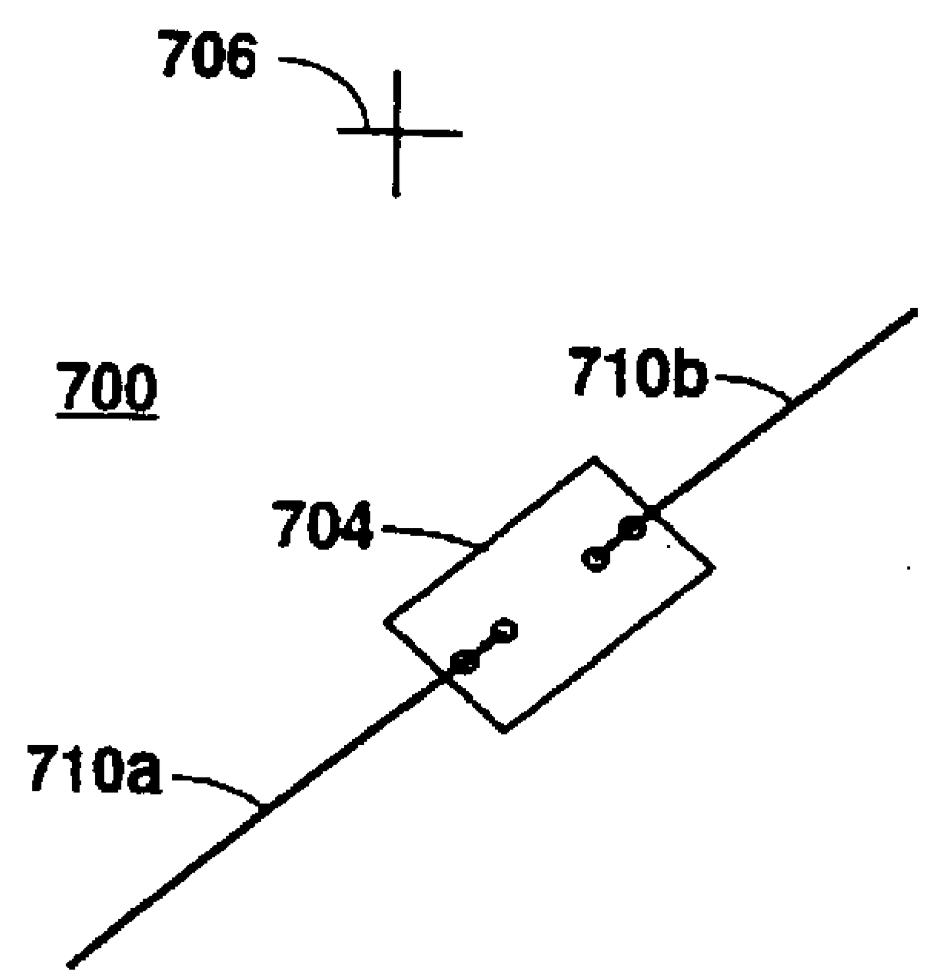

Fig. 7D

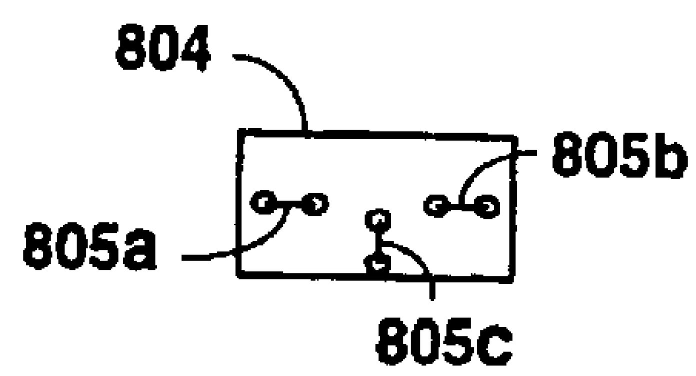

Fig. 8A

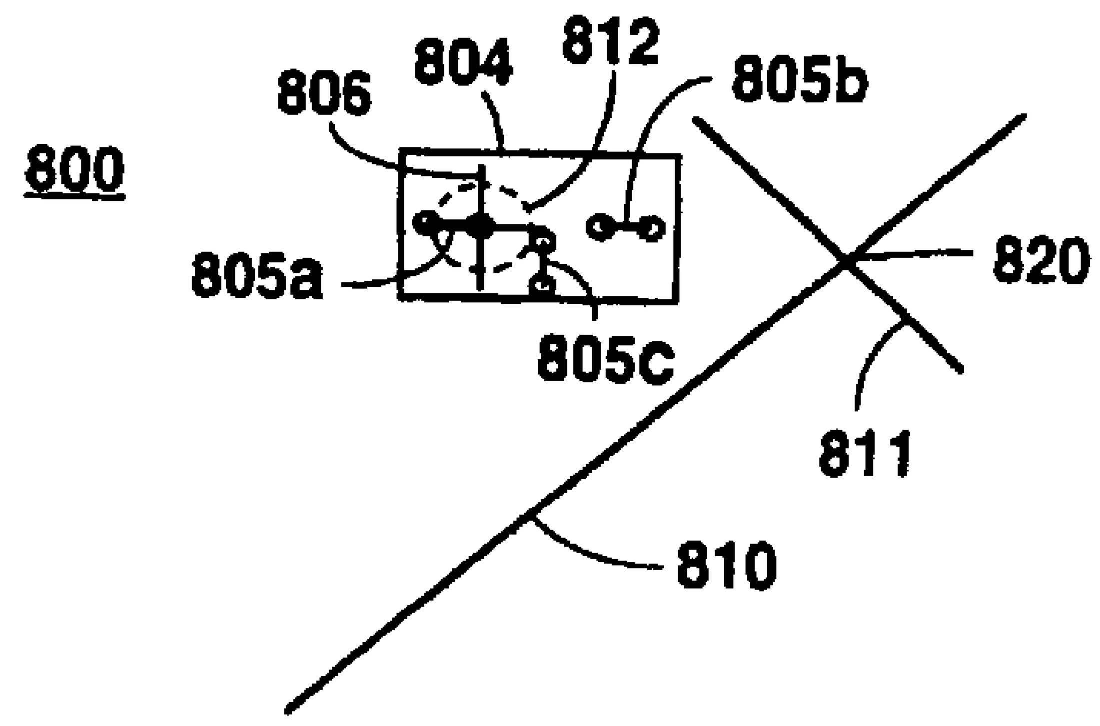

Fig. 8B

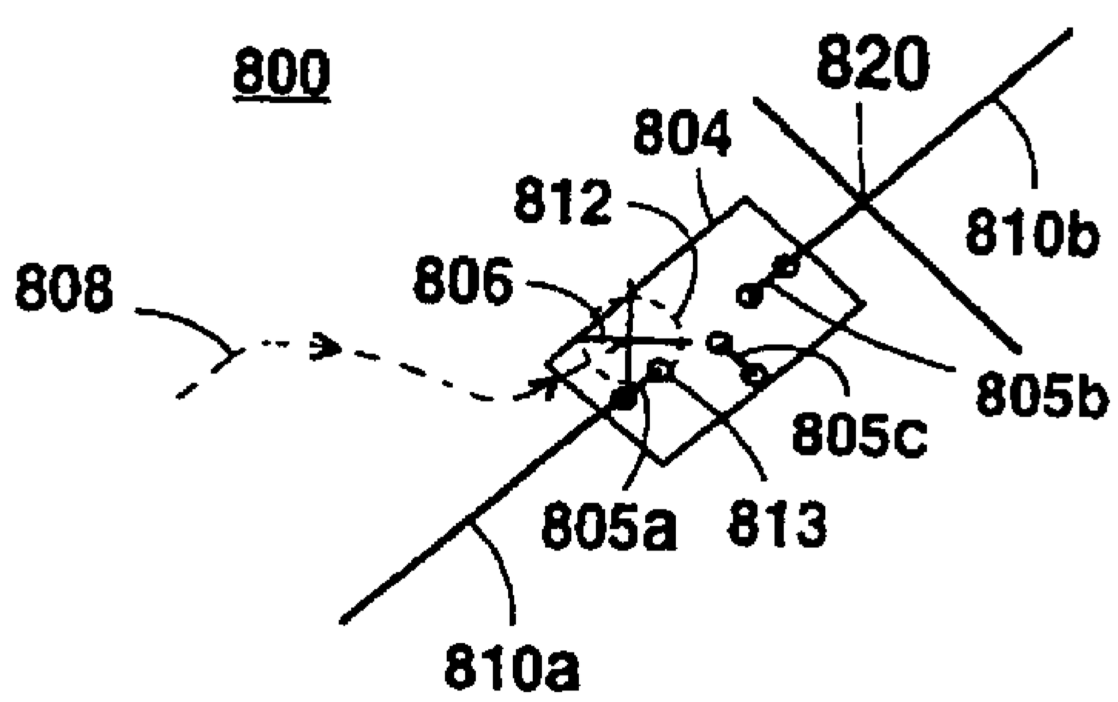

Fig. 8C

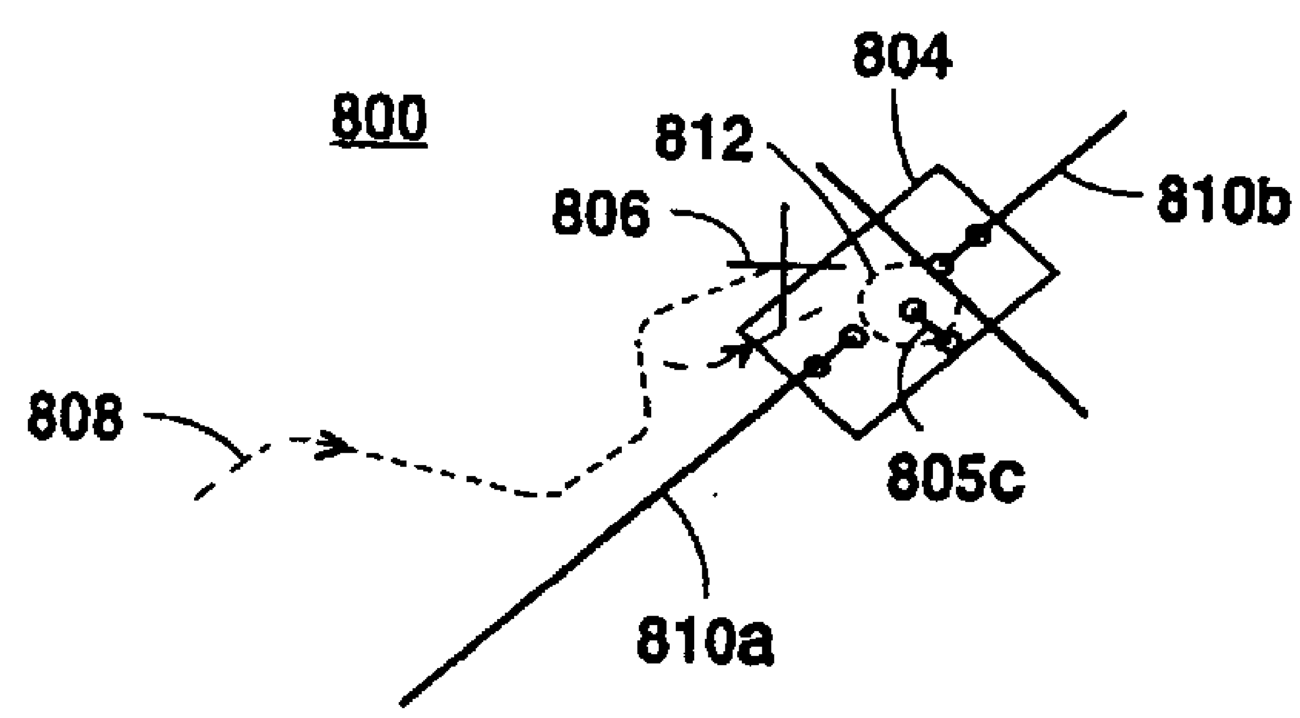

Fig. 8D

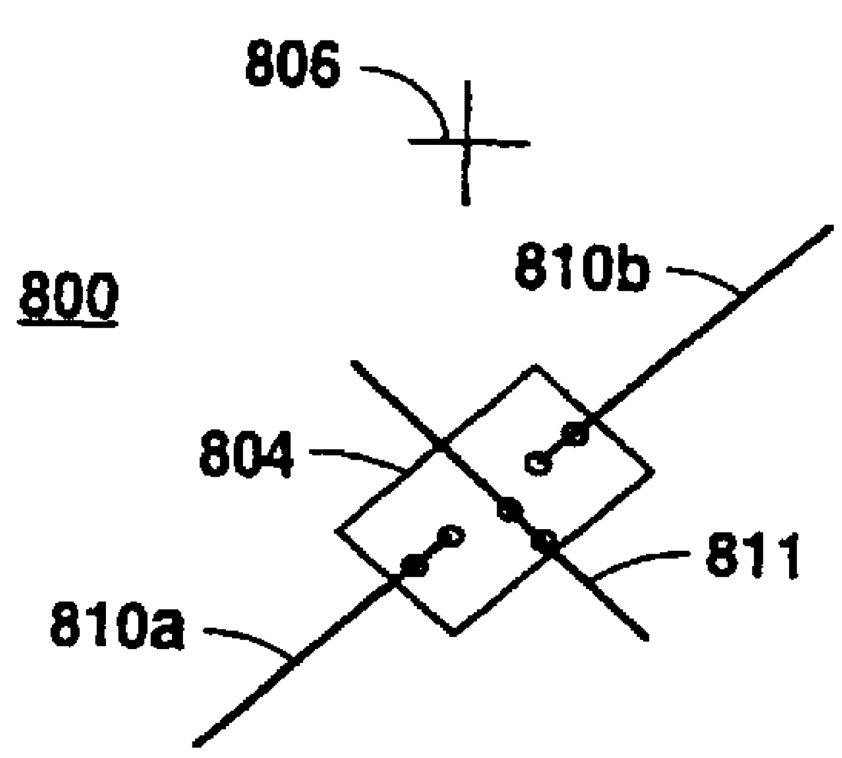

Fig. 8E

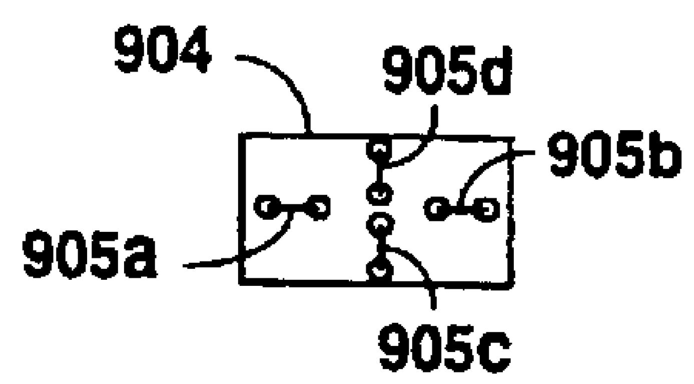

Fig. 9A

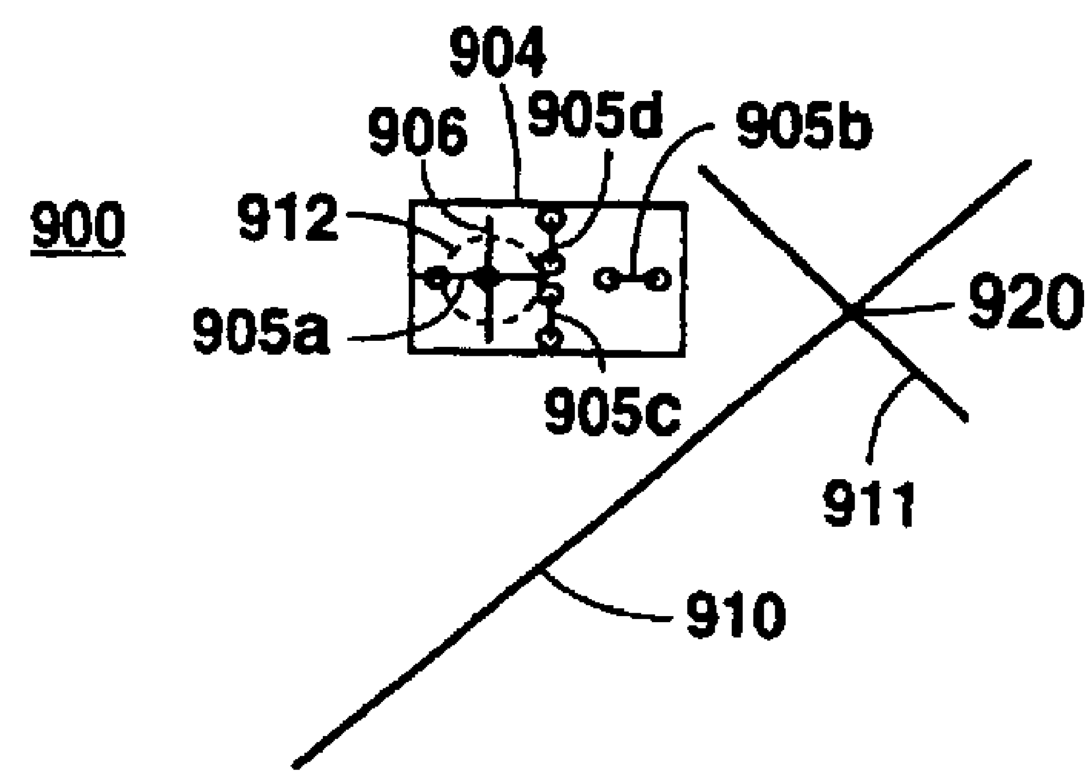

Fig. 9B

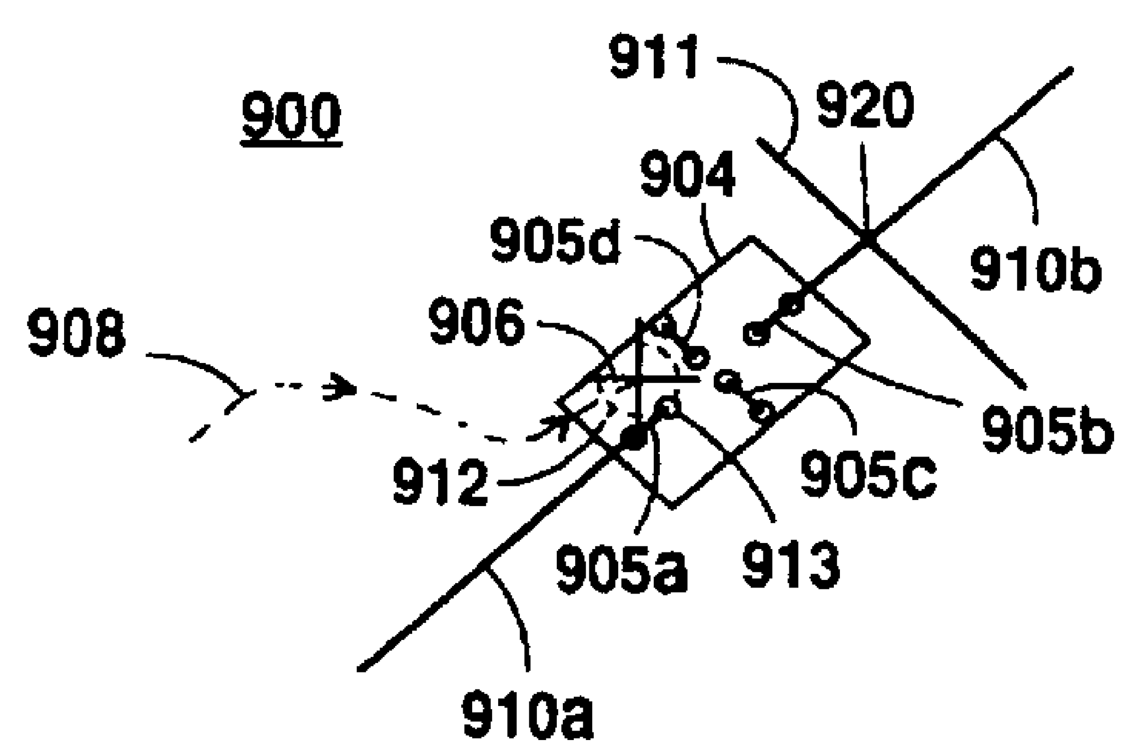

Fig. 9C

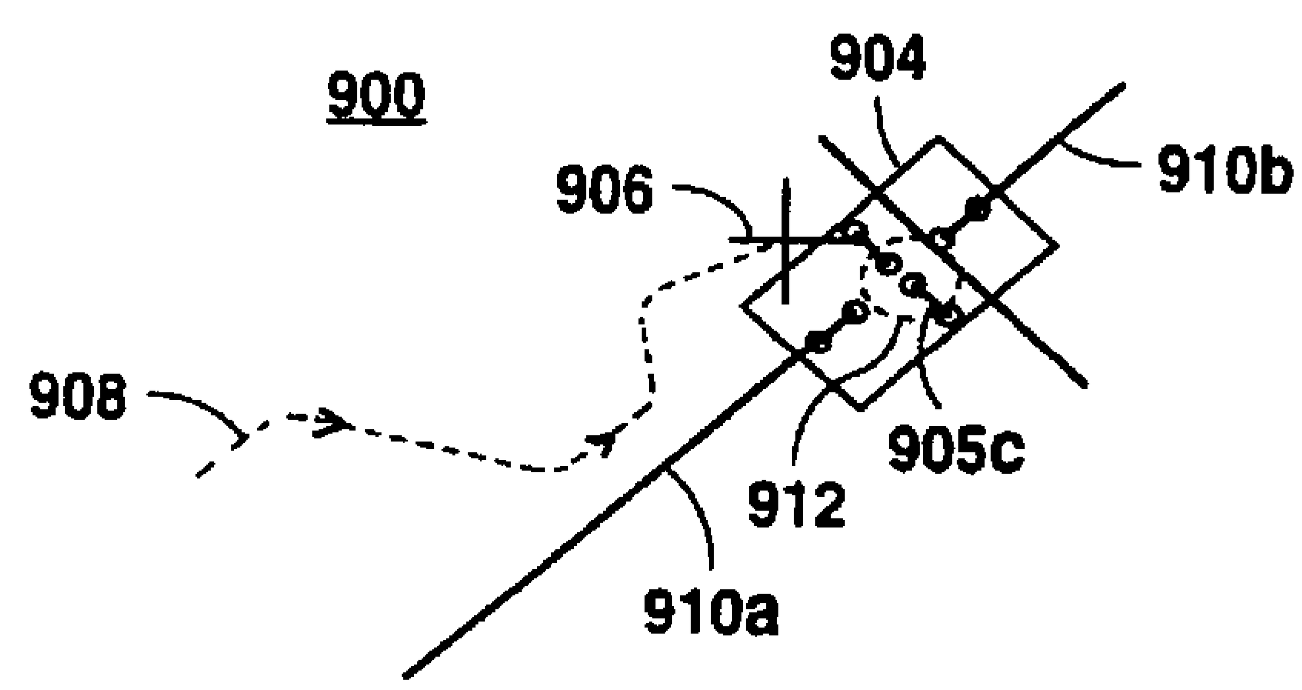

Fig. 9D

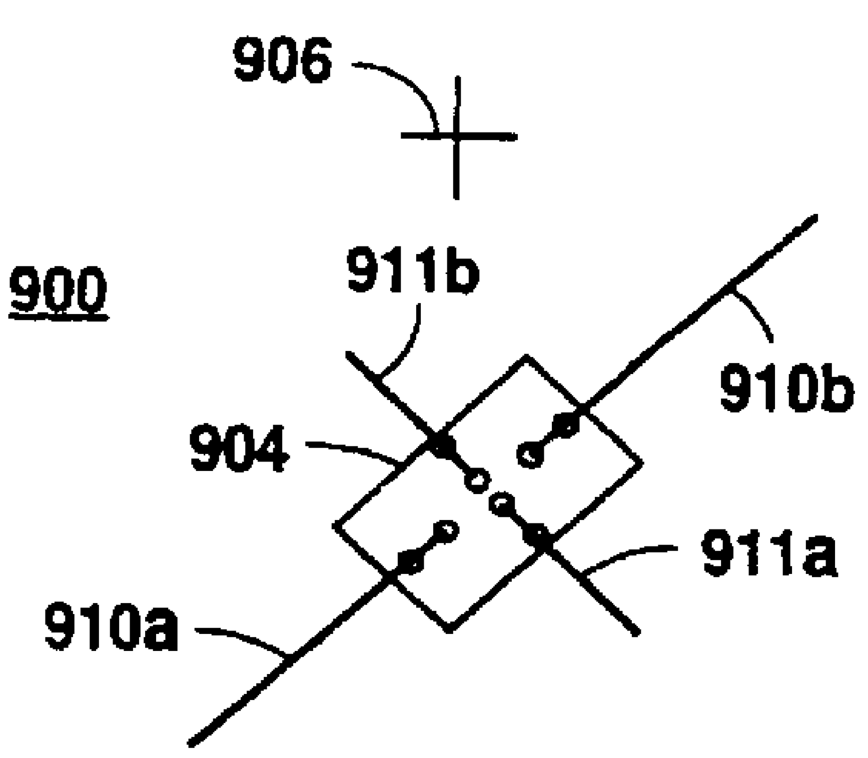

Fig. 9E

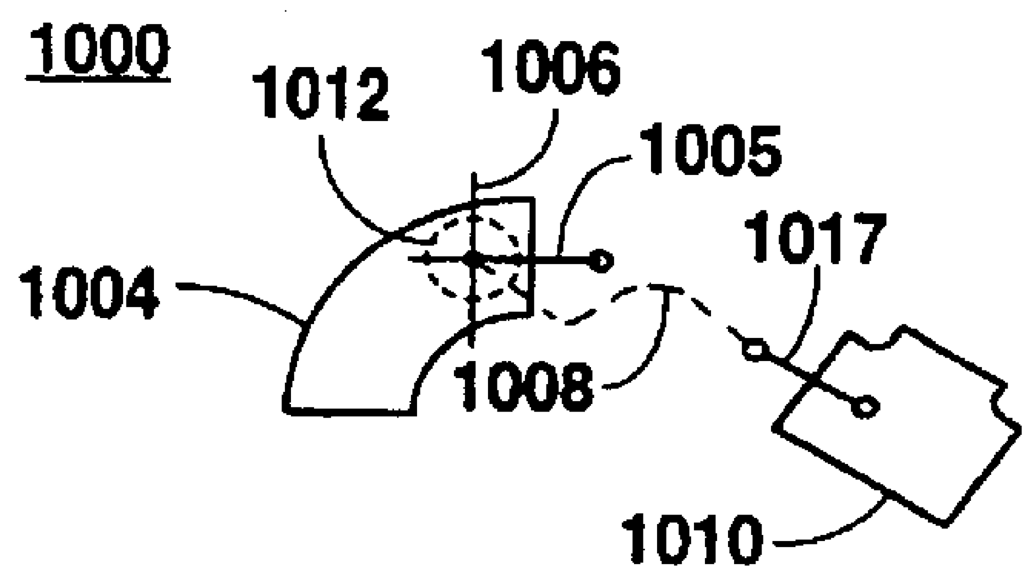

Fig. 10A

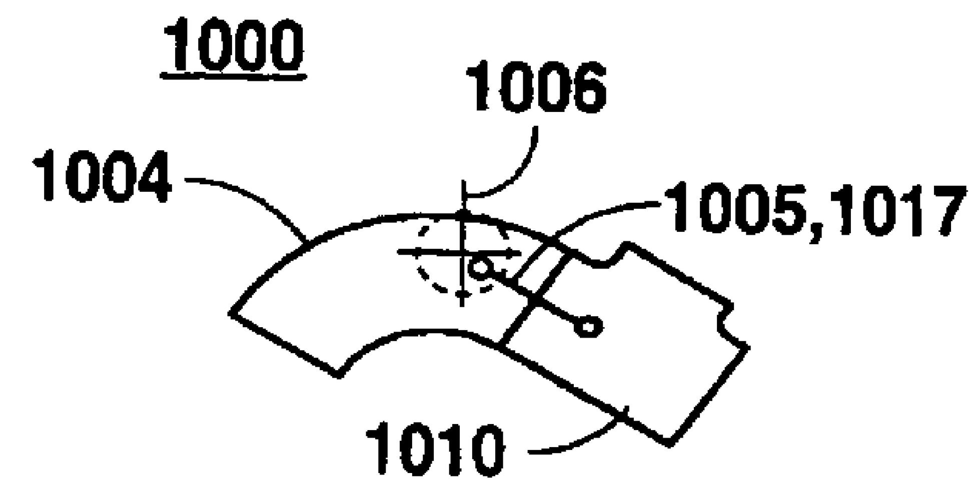

Fig. 10B

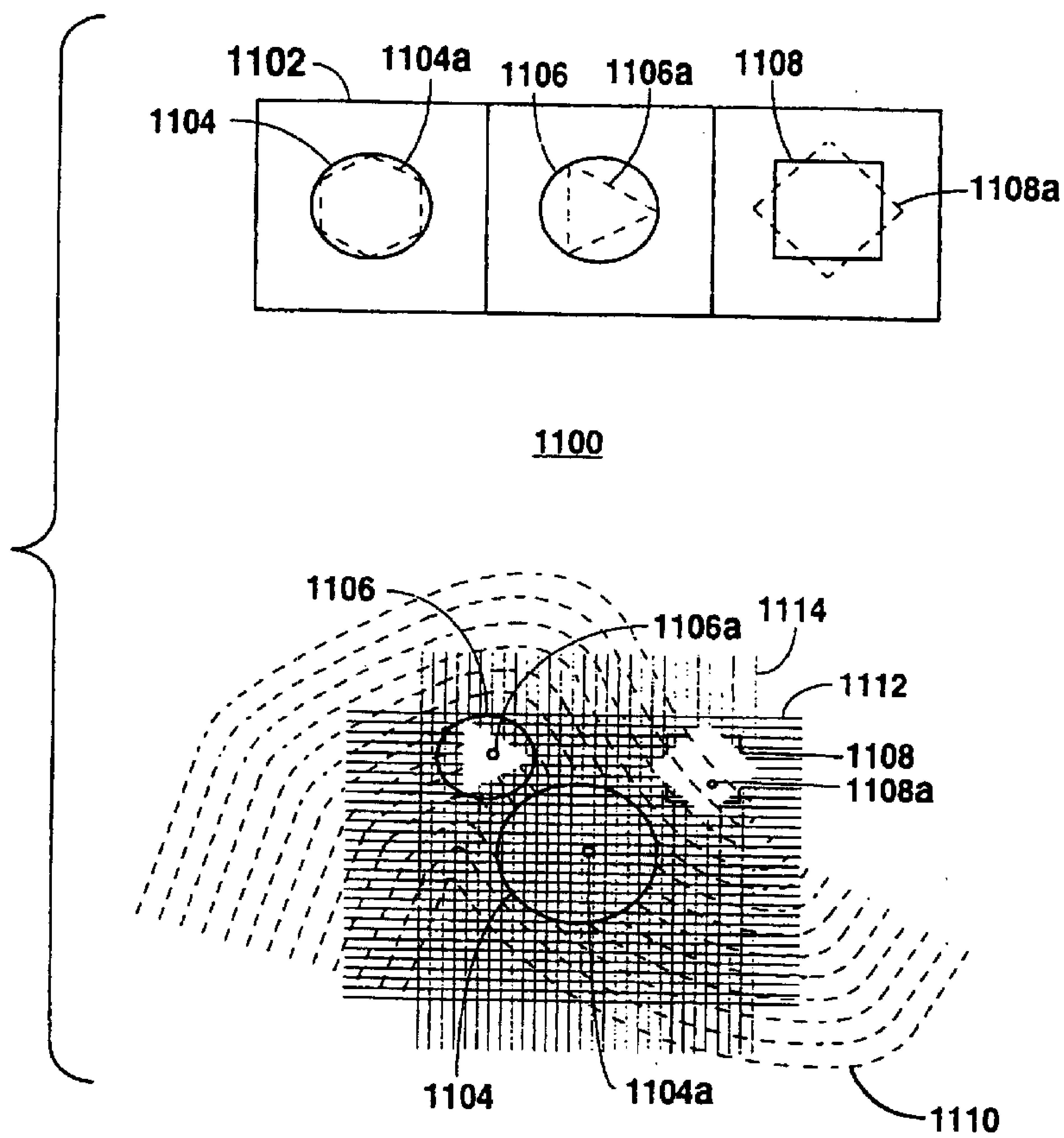

Fig. 11

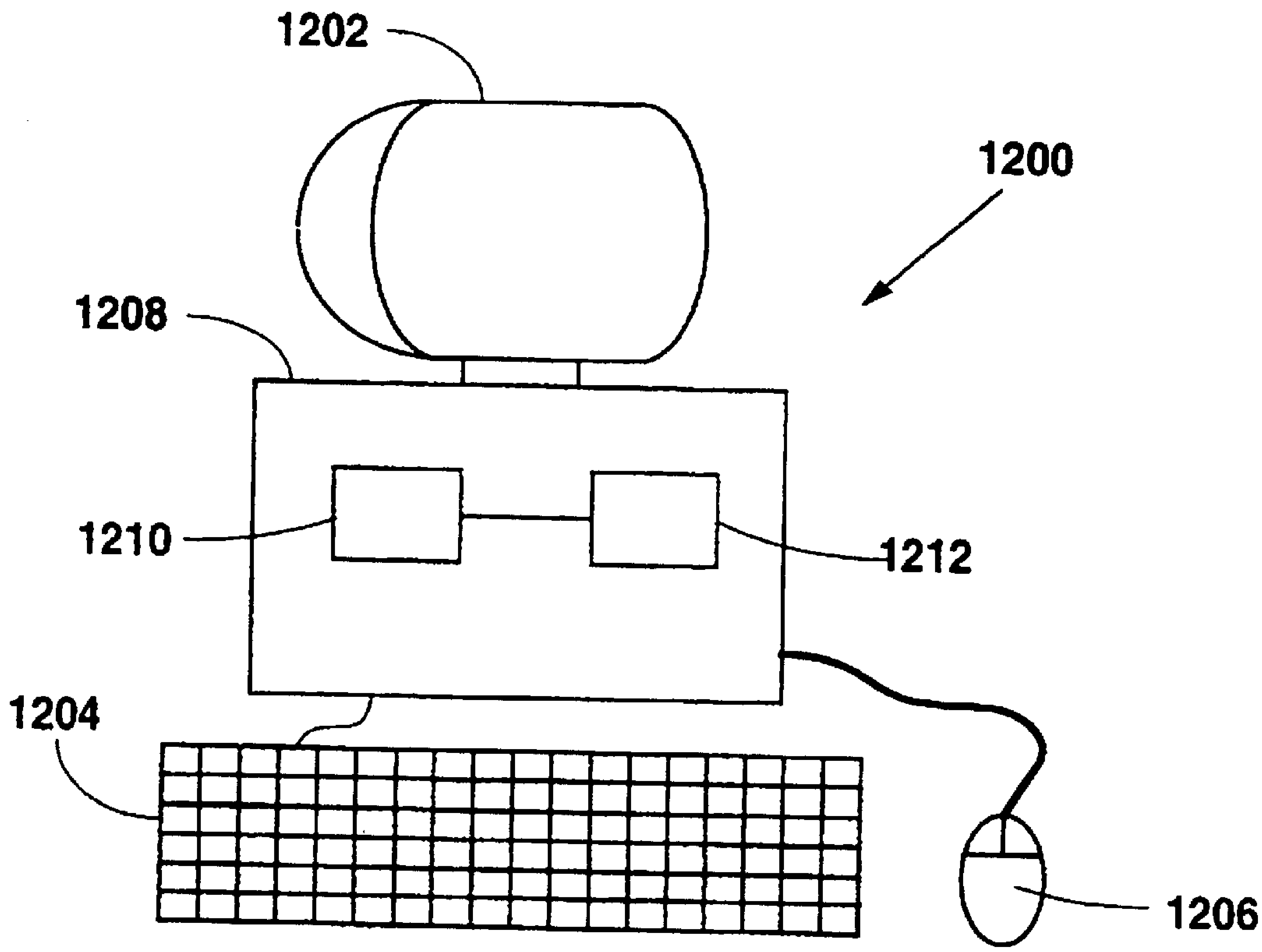

Fig. 12

METHOD AND APPARATUS FOR INTERACTIVELY MANIPULATING AND DISPLAYING PRESUMPTIVE RELATIONSHIPS BETWEEN GRAPHIC OBJECTS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

The present invention relates to computer aided design and drafting systems, and more particularly to interactively manipulating and displaying presumptive relationships between graphic objects.

DESCRIPTION OF THE RELATED ART

At the present time, the layout of drafted documents is based upon predefined geometric constraints for the graphic representation of engineering designs, utility systems, chemical processes, etc. Traditional computer aided methods for producing these types of digital drawings require the computer operator to indicate where and how a graphic object is to be drawn by the computer. The operator indicates an origin, orientation and connection point for the graphical objects and the computer subsequently produces the digital representation suggested by operator input. If the resulting representation is not correct, the operator either deletes the incorrect graphics from the drawing file or manually adjusts the graphics and attempts to create a new representation that meets defined criteria.

It is presently known that an operator may press a button on a mouse to provide a "tentative point" to the computer to suggest where an object might be placed. The computer responds by placing a graphic "crosshair" at a precise location nearby the point suggested by the operator. If the point suggested by the operator is close to a key coordinate value from an underlying object in the digital file representing the design, the computer places the tentative point at that location and redisplays the graphic object in a specified color. If the resulting location is desired by the operator, a key is depressed on an input device to accept the tentative point and the specific coordinate values are used one time in the immediately following data input operation. If the coordinate location and associated graphic object determined by the computer is not desired by the operator, the mouse button is pressed again to request another tentative point.

Such tentative point mode of operation requires multiple point and click inputs by the operator resulting in rather tedious interaction with a computer aided design and drafting (CAD) system. The locations and geometric selections generated by a CAD system of prior art are often incorrect and must otherwise be adjusted. Further, the operator must be aware of the geometric rules and relationships and usually must be a sophisticated operator or even an expert.

SUMMARY OF THE INVENTION

A method and apparatus according to the present invention replaces the tentative point mode of computer graphics input with a "presumptive point" mode tied to the motion of the input device. In the presumptive mode of operation, a computer system constantly presumes points of interest, referred to as cling points, which are in proximity with an on-screen pointing symbol or cursor for the operator to accept or reject. Predefined rules are maintained to limit selection to objects of interest and to perform the geometric computations that provide other related functions such as tangent, offset, parallel, alignment, end point, major vector, divided segment, extended segment, intersection and other specific coordinate locations derived from the graphic objects that comprise a digital design.

In addition, an interface is provided to accommodate external rule-based input verification procedures, and the newly input graphic object may inherit specific characteristics of underlying object previously accepted. A system according to the present invention eliminates much of the interactive selection and confirmation of graphics components used in drafting of designs, as well as to provide more accurate results in a design.

The present invention automatically employs a rule-based database to verify the juxtaposition of graphic objects within the intended context of the design. The interactive behavior of the graphics objects is constrained by a set of geometric specifications that are constructed in advance of digital data input operations. External procedures for the verification of graphic object relationships occur during digital data input operations to avert the creation of invalid representations of designs. Geometric relationships such as parallel, orthogonal, tangent, etc. are automatically provided for performing the accurate layout of design drawings in a dynamic manner.

For example, a selected object floats with the cursor and then jumps and clings to an underlying graphic object when the cursor is moved to within a predefined minimum distance called the location tolerance of the underlying object. The selected object clings at a predefined offset, orientation, rotation, etc. relative to the cling point, which slides along the underlying object as the cursor is moved by an operator. Other operations may be performed automatically either interactively or when the selected object is accepted, such as cutting or deleting portions of the underlying objects. These presumptive relationships are automatically made and dynamically updated as the operator moves the cursor and floating object to a desired location. The operator then merely accepts or rejects the presumptive relationship with not further input.

A system according to the present invention also offers methods of creating geometric specifications to constrain drafting input operations and produce aesthetically pleasing and geometrically correct results. Techniques are provided for a design analyst to specify the behavior of a graphic object when it is combined with other graphic objects in a design drawing.

A system according to the present inventoin preferably includes access to external databases for the provision or extraction of information that is related to the design, system or model. In addition, a base of knowledge is provided which may be accessed to ascertain whether the relationships among new graphic objects being added to the file by drafting operator input operations are valid.

The present invention allows an operator to more rapidly produce accurate digital computer drawings that conform to predefined specifications for appearance, content and relationships among the graphic objects that convey cognition for the intent of designs. The computer operator is relieved of the duty of learning the correct layout of graphic objects to assemble a valid representation of a design, system or model. In effect, a system according to the present invention is an "expert" CAD system, so that the operator need not be very knowledgeable to produce correct graphic results and representations.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

FIG. **1** is a flowchart diagram illustrating operation of a system according to the present invention;

FIG. **2** is a representative computer screen that an operator interacts with using a pointing device to create digital drawings according to the present invention;

FIG. **3**A is a graphic diagram illustrating operations performed by a system according to the present invention;

FIG. **3**B illustrates an initial cling characteristic of a floating object with an existing, underlying object;

FIG. **3**C illustrates a continuing clinging characteristic according to the present invention;

FIGS. **3**D-**3**F illustrate possible behaviors that can be applied to a floating object while it is clinging to an underlying object;

FIGS. **4**A-**4**D illustrate yet further examples of the cling characteristic using a system according to the present invention;

FIG. **5** illustrates how TEXT is handled in context with other graphic objects;

FIGS. **6**A-**6**D, **7**A-**7**D, **8**A-**8**E and **9**A-**9**E illustrate various examples of objects including alignment vectors for aligning the graphic objects and modifying underlying objects;

FIGS. **10**A and **10**B illustrate alignment of two pipe objects using alignment vectors;

FIG. **11** illustrates the present invention used to implement closed clip region objects for partial deletion of graphic objects in a design; and

FIG. **12** is a diagram of a computer system implemented according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **12** illustrates a computer system **1200** implemented according to the present invention. The computer system **1200** is preferably an IBM XT, AT or IBM compatible computer system or any comparable computer system capable of operating as a computer aided design and drafting (CAD) system. The computer system **1200** includes a display device or monitor **1202** for viewing a graphic environment. A keyboard **1204** is also provided for inputting text, as well as a pointing device **1206**, such as a mouse or the like, for manipulating graphic objects on the screen of the monitor **1202**. A main system unit **1208** includes the necessary logic for running software and processing commands as known to those skilled in the art. For example, a processor **1210**, such as an **80386**, i**486**, Pentium, etc. is coupled to memory **1212** for executing software according to the present invention.

The computer system **1200** is preferably implemented as a CAD system according to the present invention by loading software into the memory **1212** for execution by the processor **1208** for receiving input and commands from the keyboard **1204** and mouse **1206** and generating a graphic output on the display **1202**. Graphic parameters and geometric relationships are defined in database files stored in memory. It is noted that alternative computer systems and interfaces are contemplated, such as three-dimensional holographic displays for improved visual representation of the graphic environment.

Referring now to FIG. **1**, a flowchart diagram is shown illustrating operation of a system according to the present invention. The flowchart illustrates that the system is designed to create representations that conform to predefined specifications for the geometric and logical relationships that exist among graphic objects in a computer based drawing representing a design, system or model.

In step **100**, the applicable specific geometric relationships such as alignment, offset, etc. are defined for each entity that is represented in one or more drawings. Additionally, any relationships that are based upon associated database attributes are tabulated and encoded. In the next step **102**, the graphic objects used as geometric constraint components are created according to specifications for the desired functional behavior. In the next step **104**, any additional generic geometric constraints that may apply are determined and tabulated.

In the next step **106**, the constraint definitions for the object are created as a collection of digital data that appears in a recognizable form such as a graphic symbol. The symbol comprises a series of components, some of which are always displayed on a computer screen as the normal graphic representation of the associated object, some components which are not normally displayed on the screen except as an aid to their definition, some logical verification components are tabulated as a digitally encoded rule-based record that is associated with the symbol, and some components are stored as textural specification data that is provided to the control software at the moment the object is activated for inclusion in the design, system or model. The textual data may be any one of several formats, such as ASCII (American Standard Code for Information Interchange) or the like.

In the next step **108**, an object is selected for input by the operator using any of several techniques including the selection of a graphic icon from a computer screen (FIG. **2**) that represents the object, typing in a keyed command that causes the object to become active, or any other means of indicating to a software program that the desired object is to be added to the drawing using the geometry processing engine.

In the next step **110**, the object is read into the geometry processing engine and graphically interacts with other objects according to the specifications provided in the symbolic definition and the constraints of any external database attribute or knowledge based verification process. Feedback is provided to the operator to indicate the integrity of the proposed relationships between the new object and existing graphic objects in the digital drawing. Such feedback includes changing the color of the affected graphic objects, providing additional on-screen motions to the affected symbol to indicate a correct or incorrect validation result, or providing unique auditory sounds to indicate a correct or incorrect validation result. In the next step **111**, the graphic representations are verified against a rule-based database.

In the next step **112**, the object is accepted by the operator as being a correct representation at which point the geometry engine inserts the symbol in context into the graphic representation of the design, system or model, taking into account all geometric control specifications provided with the symbolic definition. Once the new graphic object is added to the existing digital file, the sequence of operations returns to step **108** and drafting operations continue. In particular, steps **108**-**112** are repeatedly performed in sequential manner until the operator has added all desired objects, and operation is then completed.

Referring now to FIG. **2**, a representative computer screen **200** is shown in the context of interactive computer aided design software. Steps **100-106** have previously been performed at this point so that the operator interactively selects objects in step **108** and accepts a selected object in step **112** until the design is completed. The operator selects objects with a cursor as known for window environments, although the present invention is not limited to a windows environment. A tool palette **202** is provided containing one or more icons that indicate the graphic objects that are available for processing by the geometry engine. A series of objects **204** that have been previously placed appear on the screen **200**, which in this particular case is a series of pipes for a plumbing system. Of course, other types of objects are contemplated, such as engineering designs, electrical schematics, utility systems such as power generation and distribution grids, chemical processes, etc. The objects **204** thus are represented in the underlying design file. An optional control panel **206** is provided to specify any additional geometric function that are to apply to the symbolic object. The balance of the screen depicts a typical interactive computer aided design environment.

FIG. **3**A is a graphic diagram illustrating operations performed by a system according to the present invention. A computer screen **300** similar to screen **200** is shown including a tool palette **302** for selecting graphic objects. The operator selects a symbol from the tool palette **302** and activates an object **304** with the cursor **306**, where the geometry processing engine performs the activation as described above. The selected object **304** floats with the cursor **306** (thus called a floating object) at a particular displacement, rotation and orientation according to predetermined criterion. In the example shown, the floating object **304** maintains zero degree rotation with its origin on the cursor **306**.

Once selected, the operator moves a pointing device to move the cursor **306** and the object **304** within the computer screen **300** along any desired path **308**, and eventually within proximity of an underlying object **310**. The floating object **304** is selected and shown on the computer screen **300** but is not made part of the underlying design file until accepted at a desired location by the operator. The underlying object **310** has already been previously accepted and therefore part of the underlying design file. Throughout this disclosure, an underlying object exists in the underlying design file, but a selected object to be placed is not made part of the design file until accepted by the operator.

A predetermined and programmed location tolerance, illustrated with a dotted circle **312** but normally not displayed, identifies a minimum perpendicular distance which determines when the object **304** is close enough to the underlying object **310** to establish an association or graphic relationship. When the designated origin point of the object **304** moves to within the location tolerance **312** with respect to the underlying object **310** or with respect to any other object where a graphic relationship is allowed, the "cling" mode of interaction is invoked whereby the floating object **304** "jumps" onto the underlying graphics object **310** as though it were magnetically attracted. In FIG. **3**A, the origin and cursor **306** are positioned at a distance from the underlying object **310** greater than the location tolerance **312**, so the object **304** remains floating with or otherwise attached to the cursor **306**.

FIG. **3**B illustrates the initial cling characteristic of a floating object with an existing, underlying object. In particular, once the object **304** is within the location tolerance of the underlying object **310**, the floating object **304** jumps from the cursor **306** to cling to the underlying object **310**. In the example shown in FIG. **3**B, the jump is the shortest or perpendicular distance where the origin of the object **304** aligns and is coincident with the closest or cling point **313** of the underlying object **310**. The cling point **313** is typically displayed on the screen **300** for purposes of visual feedback to the operator, although it may alternatively be transparent or invisible if desired.

FIG. **3**C illustrates how the floating object **304** magnetically clings to the underlying object **310** as the cursor **306** is moved in proximity with the underlying object **310**. As the pointing device is moved by the operator, the object **304** follows the extend of the underlying object **310** and, if an offset distance, rotation angle, or other geometric specification has been defined, the object **304** assumes a position with respect to the geometric specifications and the active "magnetic" cling point **313** on the underlying object **310**. In the example shown in FIG. **3**C, a programmed rejection tolerance, illustrated as a dotted circle **314** about the origin of the object **304**, is defined where the object **304** remains clinging to the underlying object **310** while the cursor **306** is within the rejection tolerance. The rejection tolerance is preferably larger than the location tolerance to achieve a hysteresis effect. It is noted that the location and rejection tolerances are different parameters which are toggled so that only one is active at a time. The location tolerance determines when an object clings to an underlying object and the rejection tolerance determines when a clinging object unclings from the underlying object.

The cursor path **308** and the underlying object **310** are extended to illustrate the cling characteristic. The floating object **304** "slides" in alignment with the underlying object **310** as the cursor **306** traverses the path **308**. In particular, when the cursor **306** is at the locations **320**, **322**, **324** and **326** as shown, the floating object **310** assumes the corresponding positions **330**, **332**, **334** and **336**, respectively. It is noted that the cursor **306** remains within the rejection tolerance defined for the floating object **304** for the positions **330**, **332**, **334** and **336**.

If the operator desires to "uncling" from the underlying graphic object **310**, operator moves the cursor **306** a distance greater than the rejection tolerance away from the underlying object **310** and the floating object **304** "jumps" away from the underlying object **310** to the cursor **306** as though it were magnetically repelled. This is shown at a location **328** of the cursor **306**, where the floating object once again floats with the cursor **306** as shown at the position **328**. If there is an additional specification for the logical relationship between the floating object **304** and the underlying object **310**, and if that relationship is not valid for the particular case, the floating object **304** does not "cling" to and is prevented from floating near the underlying object by an algorithm that displaces the floating object's position with respect to the on-screen pointing device. An additional warning such as an auditory "beep" or visual cue such as a sudden red color change in the floating object **304** is issued by the computer.

FIGS. **3**D-**3**F illustrate possible behaviors that can be applied to the floating object **304** while it is clinging to an underling object **310**. These behaviors are predefined according to geometric constraints for a given object. FIG. **3**D illustrates that the object **304** may be spun about an initial cling point **313** by manipulating the cursor **306** around the cling point **313**, in contrast with FIG. **3**C showing the object **304** predefined to maintain a zero degree orientation regardless of its location. Further, the object **304** does not slide but sticks to the initial cling point and rotates according to movements of the cursor **306**. FIG. **3**E shows the object **304** positioned at a specified perpendicular offset **315** from cling point **313** in the direction of the cursor **306** and maintaining a zero degree orientation. Note that the floating object **304** jumps to the opposite side of the underlying object **310**, as shown as **304**A, when the cursor **306** traverses from one side to the other of the underlying object **310**. FIG. **3**F shows the object **304** (**304**A) at a 180 degree rotation of the underlying object **310** at a specified perpendicular offset **315** from cling point **313** in the direction of the cursor **306**, again on opposite sides of the underlying object **310**. Other variations are possible, of course, including multiple instances of the floating object, such as a mirror image of the floating object at a specified perpendicular offset from "cling" point in the direction of the cursor **306**, etc.

FIGS. **4**A-**4**D illustrate yet further examples of the cling characteristic using a system according to the present invention. In each case, a cursor **406** with a floating object **404** is moved within a screen **400** along a path **408** relative to an underlying object **410** already placed on the screen **400**. The object **404** is kept a predefined distance from the underlying object **410** relative to a sliding cling point, which slides along the underlying object **410** following the cursor **406**. The floating object **404** flops to the other side of the underlying object **410**, as indicated at **404**A, when the cursor **406** crosses over the underlying object **410** in a similar manner as described previously. It is noted that only one object is shown at any given time in the example of FIGS. **4**A-**4**D, where the designations **404** and **404**A illustrate orientation of the same object on opposite sides of the underlying graphic object **410**.

Other graphic relationships define the orientation and rotation of the floating object **404** based on the position of the cursor **406**. In FIG. **4**A, the object **404** is mirrored about the underlying object **410** when flopped to **404**A. In FIG. **4**B, the object **404** is mirrored about a perpendicular **415** when flopped to **404**A. In FIG. **4**C, the object **404** is mirrored with respect to both the perpendicular **415** and the underlying object **410** to **404**A. In FIG. **4**D, the object **404** maintains a parallel relationship to **404**A.

FIG. **5** illustrates how TEXT is handled in context with other graphic objects. Once the related symbolic object **510** has been drawn on a screen **500**, a TEXT annotation "floats" with a cursor **506** while obeying constraints for placement of the TEXT. The TEXT is made to align to the underlying graphic object **510** using specified offsets, parallels and tangencies. In the example shown, the TEXT begins with an initial location tolerance, identified by dashed circle **512** and a larger rejection tolerance as illustrated by a dashed circle **514**, both with respect to an origin of the TEXT. At first, the TEXT floats with the cursor **506** until the cursor **506** is within the location tolerance, at which time the TEXT jumps to align parallel and at a perpendicular tangent with respect to the underlying graphic object **510**, but separated by a predefined offset **515**. While the cursor **506** is moved along a path **508**, within the rejection tolerance, the TEXT aligns tangentially with the underlying object **510** at the defined offset **515**. This is illustrated at cursor positions **520**, **522**, **524** and **526**. When the cursor **506** crosses over the underlying object **510** at point **530**, the TEXT preferably jumps to the opposite side, but maintains an orientation to allow the TEXT to be read in normal upwards fashion. A dotted line **532** illustrates the path that the TEXT follows. Furthermore, a characteristic is defined where the TEXT automatically re-aligns itself at 180 degree increments, which occurs between positions **524** and **526**, to maintain upward reading orientation. When the cursor **506** is moved outside the rejection tolerance, the TEXT jumps back to float with the cursor **506** at an origin, and the location tolerance is re-established.

FIGS. **6**A-**6**D, **7**A-**7**D, **8**A-**8**D and **9**A-**9**D illustrate various examples of alignment vectors for inserting and cutting graphic objects. FIG. **6**A illustrates an object **604** with a single alignment vector **605** having two points, an origin point **605**a for geometry calculations and an alignment point **605**b for establishing orientation and direction of the alignment vector **605** and the object **604**. Although the object **604** is shown as a simple rectangle, it can be any object following particular alignment rules, such as pipes, electrical components, etc.

FIG. **6**B shows a screen **600** with an underlying object **610** and a floating object **604** floating with a cursor **606** for insertion, where the underlying object **610** is illustrated as a single line segment. The object **604** includes an alignment vector **605** where the cursor **606** preferably aligns with the origin point **605**a. A location tolerance is predefined and indicated by a circular outline **612** around the cursor **606**. The object **604** is moved with the cursor **606** along a path **608** and brought within the location tolerance of the underlying object **610**, where the object **604** snaps to and aligns with the underlying object **610**, as shown in FIG. **6**C. In particular, the origin point **605**a jumps to a cling point **613** and the object **604** and alignment vector **605** rotate to align so that the second point **605**b lies on top of the underlying object **610**. The object **604** now clings and slides along the underlying object **610** in a similar manner described previously, where a rejection tolerance is usually defined for maintaining cling with movement of the cursor **606**.

It is noted that the eventual desired result is to "connect" the object **604** to the underlying object **610** at the origin point **605**a, thereby affecting the underlying object **610** in the data base as well as graphically, if desired. In the example shown in FIG. **6**C, the underlying object **610** is preferably split into two separate line segments **610**a, **610**b at the origin point **605**a of the alignment vector **605**. The underlying object **610** is preferably immediately modified during the cling action and dynamically updated as the object **604** is moved along the underlying object **610**, where the respective lengths of the line segments **610**a, **610**b are modified accordingly. Alternatively, the underlying object **610** is not affected until the object **604** is actually accepted at a desired location.

In FIG. **6**D, the operator has accepted an appropriate location of the object **604**, where the underlying object **610** is split into two separate vectors **610**a and **610**b at the common origin point **605**a. It is appreciated that the operator had to only select the object **604**, move the cursor to within a predetermined proximity of an underlying object **610**, and the system automatically aligned the object **604** with respect to the underlying object **610** and further modified the underlying object **610** according to predefined rules. Then the operator simply moves the cursor in proximity of the underlying object **610** to select the desired location, and accept the object **604** and the object **604** is added.

FIG. **7**A illustrates an object **704** including a double alignment vector **705** in collinear mode with two spaced vectors **705**a and **705**b, each including origin points and alignment points for directional purposes in a similar manner as shown in FIG. **6**A. The separation between the respective origin points of the alignment vectors **705**a and **705**b defines a cut length for cutting an underlying object. In FIG. **7**B, a screen **700** is shown including an object **704** selected for connection to an underlying graphic object **710**, which is another line segment as shown. When the object **704** is moved into proximity with the underlying object **710** as shown in FIG. **7**C, the origin point of vector **705**a clings to a cling point **713**, the object **704** and vectors **705**a, **705**b rotate to align with the underlying object **710**, and the underlying object **710** is divided into two separate line segments **710**a, **710**b separated by the predefined cut length. Again, the underlying object **710** is either modified or cut immediately or modified after the object **704** is actually accepted. Again, the floating object **704** clings and slides along the underlying object **710** while the cursor **706** is moved within the predefined proximity or rejection tolerance, continually redefining the location of the cut.

Eventually the operator selects the location of the object **704**, and the object **704** is inserted and the underlying object **710** is appropriately divided as shown in FIG. **7**D. As a practical example, if a floating object includes specific definitions of collinear vectors, the geometry engine cuts the underlying linear graphic object and connects the resulting linear segments to the collinear vectors. This has the effect of breaking a line and inserting a device that forms part of the line, such as a fuse on a circuit schematic.

FIG. **8**A illustrates an object **804** including double alignment vectors **805**a, **805**b in collinear mode with an additional orthogonal alignment vector **805**c. The collinear vectors **805**a, **805**b are two spaced vectors, where all three vectors include an origin point and an alignment point for directional purposes as described previously. The orthogonal alignment vector **805**c is preferably placed between and orthogonally aligned with the collinear vectors **805**a, **805**b as shown. The separation between the collinear vectors **805**a, **805**b defines a cut length.

In FIG. **8**B, the object **804** with the alignment vectors **805**a, **805**b and **805**c is selected for interaction with underlying graphic objects **810** and **811**, where the primary vector **810** orthogonally intersects a secondary vector **811** at a point **820** as shown. Again, a screen **800** is shown including a cursor **806** for locating the object **804**.

When the object **804** is in proximity of the underling object **810** as shown in FIG. **8**C, the collinear vectors **805**a, **805**b cling, align and cut the underlying primary vector **810** into two separate vector objects **810**a, **810**b separated by the predefined cut length in a similar manner as described previously. The origin point of the vector **805**a has a location tolerance for jumping and clinging with the primary vector **810**. The object **804** clings and slides along the primary vector **810**.

As illustrated in FIG. **8**D, the orthogonal alignment vector **805**c also has a separate location tolerance defined for its origin for clinging to the secondary vector **811**. Thus, when the origin point of the orthogonal alignment vector **805**c is within its location tolerance with the secondary vector **811**, the object **804** and alignment vectors **805**a, **805**b and **805**c jump so that the origin and alignment points of the vector **805**c align with the underlying vector **811**. The operator may move the cursor **806** about a rejection tolerance, where the object **804** remains static and aligned with the intersection point **820**.

In FIG. **8**E, the operator accepts the result, and the underlying primary segment **810** is divided into two collinear line segments **810**a, **810**b separated by the cut length, where the cut length is divided on either side of the secondary vector **811**. In the example shown, the primary vector **810** is divided equally on either side of the secondary vector **811**, although unequal divisions and non-orthogonal intersections, e.g. isometric, etc. are just as easily achieved as desired.

FIGS. **9**A-**9**E are similar to FIGS. **8**A-**8**E, except illustrating primary **905**a, **905**b and secondary **905**c, **905**d collinear alignment vectors defining two separate cut lengths for the primary **910** and secondary **911** underlying objects, respectively. The primary and secondary vectors **910**, **911** are divided into two portions **910**a, **910**b and **911**a, **911**b, respectively, divided by respective cut lengths, and the object **904** is aligned and places as desired.

FIGS. **10**A and **10**B illustrate operation of alignment vectors for aligning an underlying T pipe object **1010** and a selected elbow pipe object **1004** using alignment vectors on a screen **1000**. The underlying T pipe object **1004** includes an alignment vector **1005** and the T pipe object **1010** includes an alignment vector **1017**, each with an origin point and an alignment point. The operator selects the elbow object **1004** having a predefined location tolerance about the origin point of the vector **1005**. The elbow object **1004** floats with the cursor **1006** it is within the location tolerance of the origin point of the alignment vector **1017** of the T pipe object **1010**, where the elbow object **1004** is automatically rotated and positioned so that the respective origin points and alignment points of each of the alignment vectors **1005**, **1017** overlap. In this manner, the two objects **1004** and **1010** are automatically aligned with each other by the system, and the operator need only accept or reject the proposed relationship. In particular, if the operator intended to connect the objects **1004**, **1010** as proposed, the relationship is accepted, and if not, the operator simply moves the elbow object **1004** beyond the rejection tolerance for connection with another object as desired.

It is noted that the particular alignment vectors described herein are for purposes of illustration. Thus, alignment vectors need not be collinear nor orthogonal but may be aligned at any desired orientation and angle.

FIG. **11** illustrates the present invention used to implement objects including clip regions for partial deletion of underlying graphic objects in a design. A palette **1102** is provided on a screen **1100**, where the palette includes three objects **1104**, **1106** and **1108**, each having corresponding clip patterns **1104**a, **1106**a, and **1108**a, respectively. Also provided on the screen **1100** is a set of underlying object symbol patterns, including a pattern of splines **1110**, a horizontal line pattern **1112** and a vertical line pattern **1114** intersecting one another as shown. The operator selects one of the objects **1104**, **1106** and **1108** from the palette **1102**, and the selected object floats with the cursor as the cursor is moved across the screen **1100** by the operator. As the selected object coincides with or covers the patterns **1110**, **1112**, or **1114**, a portion of all or certain ones of the underlying patterns **1110**, **1112** and **1114** that are coincident with the corresponding clip region of the selected object is deleted.

In particular, the clip pattern **1104**a deletes the coincident portion of the pattern of splines **1110**, but otherwise does not affect the horizontal or vertical pattern of lines **1112**, **1114**. The clip pattern **1106**a deletes the coincident portion of all of the patterns **1110**, **1112** and **1114**. The clip pattern **1108**a deletes the coincident portion of the horizontal and vertical line patterns **1112**, **1114**, but does not affect the underlying pattern of splines **1110**. This partial deletion is contrasted with simple masking capability, where the graphic portion of the object is obscured but the object "remains" in the graphic file. Although the present invention may be used for partial masking, partial deletion involves actually deleting the coincident portion of the underlying graphic objects in a selective mode.

It is noted that the partial deletion may be performed interactively as the selected and floating object is moved across the screen **1100**. However, this is computationally intensive and may cause a computer system to slow down considerably. Thus, the object is usually drawn and the underlying deletions are preferably performed upon acceptance of object at a desired location.

An example of objects including the clip patterns to partially delete any underlying graphic object elements is TEXT, where it is desired to create "white space" for TEXT annotation. The objects to be deleted are contained in a specification for that type of annotation. In FIG. **5**, for example, if the TEXT overlaps certain underlying objects, a portion of the object coincident with the TEXT is deleted. Also, if the definition of the floating object includes a closed shape drawn with specific graphic parameters, the geometry object engine causes the CAD system to partially delete all specified graphic objects that fall within the defined region. This has the effect of "cleaning up" graphic elements that would otherwise appear to be visually merged with the floating object.

It is now appreciated that a presumptive mode CAD system according to the present invention interactively manipulates and displays selected objects according to predefined geometric relationships for acceptance by an operator. The system automatically exhibits the correct graphic and geometric relationships in an interactive fashion. Thus, the present invention allows an operator to more rapidly produce accurate digital computer drawings that conform to predefined specifications for appearance, content and relationships among the graphic objects that convey cognition for the intent of designs. The computer operator is relieved of the duty of learning the correct layout of graphic objects to assemble a valid representation of a design, system or model. In effect, a system according to the present invention is an "expert" CAD system, so that the operator need not be very knowledgeable to produce correct graphic results and representations.

Although the system and method of the present invention has been described in connection with the preferred embodiment, it is not intended to be limited to the specific form set forth herein, but on the contrary, it is intended to cover such alternatives, modifications, and equivalents, as can be reasonably included within the spirit and scope of the invention as defined by the appended claims.

I claim:

[1. A method of operating a computer aided design system in presumptive mode, comprising the steps of:

moving a selected graphic object relative to a graphic pointing symbol;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules; and

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object.**]**

2. **[**The**]** *A* method of **[**claim **1**,**]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules; and

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object;

wherein the predetermined proximity is a location tolerance before said manipulating step and converts to a larger rejection tolerance during said **[**maintaining**]** *dynamically updating* step.

3. **[**The**]** *A* method of **[**claim **1]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, wherein said manipulating step comprises the step of**[**:**]** orientating the selected graphic object according to a tangential angle with respect to the underlying graphic object at a cling point*; and*

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object.

[4. The method of claim **1**, wherein said manipulating step includes the step of:

positioning the selected graphic object at a predetermined offset relative to the underlying graphic object.**]**

5. **[**The**]** *A* method of **[**claim **4]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, wherein the underlying graphic object has two sides**[**,**]***;*

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, wherein said manipulating step includes the step of positioning the selected graphic object at a predetermined offset relative to the underlying graphic object; and

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, and during said **[**maintaining**]** *dynamically updating* step, **[**further comprising the step of:**]** moving the selected graphic object to the opposite side of the underlying graphic object when the graphic pointing symbol is moved to the opposite side.

6. The method of claim **5**, wherein said **[**maintaining**]** *dynamically updating* step further comprises the step of:

mirroring the selected graphic object about the underlying graphic object when moved to the opposite side of the underlying graphic object.

7. The method of claim **6**, wherein said **[**maintaining**]** *dynamically updating* step further comprises the step of:

mirroring the selected graphic object about a perpendicular offset line when moved to the opposite side of the underlying graphic object.

8. The method of claim **5**, wherein said **[**maintaining**]** *dynamically updating* step further comprises the step of:

mirroring the selected graphic object about a perpendicular offset line when moved to the opposite side of the underlying graphic object.

9. **[**The**]** *A* method of **[**claim **1]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, *and* after said manipulating step, **[**further comprising the step of:**]** modifying the underlying graphic object according to the predetermined geometric rules*; and*

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object.

10. The method of claim **9**, wherein said modifying step comprises the step of:

dividing the underlying graphic object into two separate underlying graphic objects for inserting the selected graphic object therebetween.

11. The method of claim **10**, wherein said modifying step further comprises the step of:

deleting a portion of the original underling graphic object for inserting the selected graphic object.

12. **[**The**]** *A* method of **[**claim **1]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol, wherein the selected graphic object includes at least one alignment vector*;*

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, said manipulating step further comprising the step of**[**:**]** aligning the selected graphic object with the underlying graphic object according to the alignment vector*; and*

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object.

13. The method of claim **[1]***12*, wherein the selected graphic object and the underlying graphic object each have an alignment vector, wherein said manipulating step comprises the step of:

aligning the selected graphic object with the underlying graphic object by aligning the alignment vectors.

14. **[**The**]** *A* method of **[**claim **1]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol, wherein the selected graphic object includes a clip region;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, said manipulating step further comprising the step of**[**:**]** partially deleting the underlying graphic object according to the clip region; *and*

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object.

15. The method of claim **14**, wherein the underlying graphic object comprises a plurality of graphic objects, said partially deleting step further comprising the step of:

partially deleting only selected ones of the plurality of graphic objects corresponding to the clip region.

16. **[**The**]** *A* method of **[**claim **1]** *operating a computer aided design system in presumptive mode, comprising the steps of:*

moving a selected graphic object relative to a graphic pointing symbol;

determining when the selected graphic object is within a predetermined proximity of an underlying graphic object;

manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules; and

dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein said **[**maintaining**]** *dynamically updating* step further comprises the steps of**[**:**]** clinging the selected graphic object to an initial cling point**[**;**]** and rotating the selected graphic object about the initial cling point corresponding to movement of the graphic pointing symbol.

17. The method of claim **[1]***16*, further comprising the step of:

unclinging the selected graphic object from the underlying graphic object to move with the graphic pointing symbol when the graphic pointing symbol is moved a greater distance than the predetermined proximity from the underlying graphic object.

18. The method of claim **[1]***16*, wherein said **[**maintaining**]** *dynamically updating* step includes the step of:

moving the selected graphic object relative to a sliding cling point along the underlying graphic object where the cling point moves relative to the graphic pointing symbol as the graphic pointing symbol is moved within the predetermined proximity of the underlying graphic object.

19. The method of claim **18**, wherein said **[**maintaining**]** *dynamically updating* step further comprises the step of:

interactively modifying the underlying graphic object according to the predetermined rules and relative to the sliding cling point as the graphic pointing symbol is moved.

20. The method of claim **18**, wherein the underlying graphic object included a primary vector and a secondary vector, the selected graphic object having a first alignment vector and a second alignment vector, wherein said manipulating and **[**maintaining**]** *dynamically updating* steps further comprise the steps of:

aligning the selected graphic object with the primary vector according to the first alignment vector when the first alignment vector is within a predetermined proximity of the primary vector; and

aligning the selected graphic object with the secondary vector according to the second alignment vector when the second alignment vector is within a predetermined proximity of the secondary vector.

[**21**. A method of operating a computer aided design system, comprising the steps of:

providing at least one graphic object to be selected for insertion into a graphic design;

displaying and moving a selected graphic object with a graphic cursor moved within the graphic design;

when the selected graphic object is within a predetermined proximity with respect to one or more underlying graphic objects, automatically manipulating the object into a geometric relationship with the underlying graphic object; and

dynamically updating the geometric relationship based on movement of the graphic cursor while the graphic cursor remains within the predetermined proximity of the underlying graphic object.]

22. [The] *A* method of [claim **21**] *operating a computer aided design system, comprising the steps of:*

providing at least one graphic object to be selected for insertion into a graphic design;

displaying and moving a selected graphic object with a graphic cursor moved within the graphic design;

when the selected graphic object is within a predetermined proximity with respect to one or more underlying graphic objects, automatically manipulating the object into a geometric relationship with the underlying graphic object, wherein said manipulating step comprises the steps of[:] orienting the selected graphic object relative to a cling point along the underlying graphic object[;] and positioning the selected graphic object at a predetermined offset relative to the cling point*; and dynamically updating the geometric relationship based on movement of the graphic cursor while the graphic cursor remains within the predetermined proximity of the underlying graphic object*.

23. The method of claim **22**, further comprising the step of:

continually re-orienting and re-positioning the selected graphic object relative to a sliding cling point which moves relative to the graphic cursor as it is moved within the predetermined proximity.

[**24**. A presumptive mode computer aided design system for interactively manipulating and displaying a selected object according to predefined geometric relationships, comprising:

a display device for displaying a graphic environment;

memory for storing data, including:

a data base defining geometric relationships among graphic objects;

a plurality of graphic object files, each defining a corresponding graphic object and associated symbol for display in said graphic environment; and

a design file for incorporating a plurality of underlying graphic objects according to said geometric relationships;

a pointing device for receiving input from an operator; and

a processor coupled to said memory, said display device and said pointing device for controlling said graphic environment;

wherein the operator selects an object for insertion into said design file and manipulates a graphic cursor in proximity with one of said underlying graphic objects displayed in said geometric environment, wherein said processor moves said selected object with said graphic cursor and then manipulates said graphic object and said design file in to a geometric relationship when said selected object is within proximity with said one of said underlying graphic objects, and wherein said processor dynamically updates said geometric relationship based on movement of said graphic cursor while said graphic cursor is within proximity of said underlying graphic objects.]

25. A computer aided design system, comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein the predetermined proximity is a location tolerance before said means for manipulating and converts to a larger rejection tolerance during said means for dynamically updating.

26. A computer aided design system, comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein said means for manipulating comprises means for orienting the selected graphic object according to a tangential angle with respect to the underlying graphic object at a cling point.

27. A computer aided design system, comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, wherein the underlying graphic object has two sides, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein said means for manipulating includes means for positioning the selected graphic object at a predetermined offset relative to the underlying graphic object, and during said means for dynamically updating, further comprising means for *moving the selected graphic object to the opposite side of the underlying graphic object when the graphic pointing symbol is moved to the opposite side.*

28. The system of claim 27, wherein said means for dynamically updating further comprises:

means for mirroring the selected graphic object about the underlying graphic object when moved to the opposite side of the underlying graphic object.

29. The system of claim 28, wherein said means for dynamically updating further comprises:

means for mirroring the selected graphic object about a perpendicular offset line when moved to the opposite side of the underlying graphic object.

30. The system of claim 27, wherein said means for dynamically updating further comprises:

means for mirroring the selected graphic object about a perpendicular offset line when moved to the opposite side of the underlying graphic object.

31. A computer aided design system, comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, and after said means for manipulating, further comprising means for modifying the underlying graphic object according to the predetermined geometric rules.

32. The system of claim 31, wherein said means for modifying comprises:

means for dividing the underlying graphic object into two separate underlying graphic objects for inserting the selected graphic object therebetween.

33. The system of claim 32, wherein said means for modifying further comprises:

means for deleting a portion of the original underlying graphic object for inserting the selected graphic object.

34. A computer aided design system, comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein the selected graphic object includes at least one alignment vector, and said means for manipulating further comprises means for aligning the selected graphic object with the underlying graphic object according to the alignment vector.

35. The system of claim 34, wherein the selected graphic object and the underlying graphic object each have an alignment vector, wherein said means for manipulating comprises:

means for aligning the selected graphic object with the underlying graphic object by aligning the alignment vectors.

36. A computer aided design system comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein the selected graphic object includes a clip region, and said means for manipulating further comprises means for partially deleting the underlying graphic object according to the clip region.

37. The system of claim 36, wherein the underlying graphic object comprises a plurality of graphic objects, said means for partially deleting further comprising:

means for partially deleting only selected ones of the plurality of graphic objects corresponding to the clip region.

38. A computer aided design system, comprising:

a computer;

means, performed by the computer, for moving a selected graphic object relative to a graphic pointing symbol, for determining when the selected graphic object is within a predetermined proximity of an underlying graphic object, for manipulating the selected graphic object into a geometric relationship with the underlying graphic object according to predetermined geometric rules, and for dynamically updating the geometric relationship based on movement of the graphic pointing symbol while the graphic pointing symbol remains within the predetermined proximity of the underlying graphic object, wherein said means for dynamically updating further comprises means for clinging the selected graphic object to an initial cling point and means for rotating the selected graphic object about the initial cling point corresponding to movement of the graphic pointing symbol.

39. The system of claim 38, further comprising:

means for unclinging the selected graphic object from the underlying graphic object to move with the graphic pointing symbol when the graphic pointing symbol is moved a greater distance than the predetermined proximity from the underlying graphic object.

40. The system of claim 38, wherein said means for dynamically updating includes:

means for moving the selected graphic object relative to a sliding cling point along the underlying graphic object where the cling point moves relative to the graphic pointing symbol as the graphic pointing symbol is moved within the predetermined proximity of the underlying graphic object.

41. The system of claim 40, wherein said means for dynamically updating further comprises:

means for interactively modifying the underlying graphic object according to the predetermined rules and relative to the sliding cling point as the graphic pointing symbol is moved.

42. The system of claim 40, wherein the underlying graphic object includes a primary vector and a secondary *vector, the selected graphic object having a first alignment vector and a second alignment vector, wherein said means for manipulating and means for dynamically updating further comprises:*

means for aligning the selected graphic object with the primary vector according to the first alignment vector when the first alignment vector is within a predetermined proximity of the primary vector; and

means for aligning the selected graphic object with the secondary vector according to the second alignment vector when the second alignment vector is within a predetermined proximity of the secondary vector.

43. A computer aided design system, comprising:

a computer;

means, performed by the computer, for providing at least one graphic object to be selected for insertion into a graphic design and for displaying and moving a selected graphic object with a graphic cursor moved within the graphic design;

means, performed by the computer, for automatically manipulating the object into a geometric relationship with the underlying graphic object when the selected graphic object is within a predetermined proximity with respect to one or more underlying graphic objects; and

means, performed by the computer, for dynamically updating the geometric relationship based on movement of the graphic cursor while the graphic cursor remains within the predetermined proximity of the underlying graphic object, wherein said means for manipulating comprises means for orienting the selected graphic object relative to a cling point along the underlying graphic object and means for positioning the selected graphic object at a predetermined offset relative to the cling point.

44. The system of claim 43, further comprising:

means for continually re-orienting and re-positioning the selected graphic object relative to a sliding cling point which moves relative to the graphic cursor as it is moved within the predetermined proximity.

45. A method of operating a computer-aided design system, comprising:

(a) displaying a first graphic object on a computer; and

(b) displaying at least one point of interest on the computer when a pointing symbol is within a predetermined proximity of the first graphic object, wherein the points of interest are identified by predefined rules and the predefined rules perform one or more geometric computations selected from a group comprising tangent, offset, parallel, alignment, end point, major vector, divided segment, extended segment, and intersection computations.

46. The method of claim 45, wherein a position of the pointing symbol is controlled by an input device coupled to the computer.

47. The method of claim 45, wherein the predefined rules limit selection of the first graphic object.

48. A method of operating a computer-aided design system, comprising:

(a) displaying a first graphic object on a computer;

(b) displaying at least one point of interest on the computer when a pointing symbol is within a predetermined proximity of the first graphic object; and

(c) displaying a second graphic object and joining the first and second graphic objects when the pointing symbol is moved to within a predetermined location tolerance of the first graphic object.

49. The method of claim 48, wherein the predetermined location tolerance identifies a minimum perpendicular distance which determines when the second graphic object is close enough to the first graphic object to establish an association therebetween.

50. The method of claim 48, wherein the second graphic object is joined to the first graphic object when a designated origin point of the second graphic object moves to within the predetermined location tolerance with respect to the first graphic object.

51. The method of claim 48, further comprising separating the first and second graphic objects when the pointing symbol is moved to beyond a predetermined rejection tolerance of the first graphic object.

52. The method of claim 48, wherein the joining step comprise joining the first and second graphic objects at one or more of the points of interest.

53. The method of claim 48, wherein the first and second graphic objects are joined according to one or more characteristics selected from a group comprising a predefined offset, orientation, and rotation.

54. The method of claim 48, further comprising dynamically updating a relationship between the first and second graphic objects as the pointing symbol is moved.

55. The method of claim 54, wherein the dynamically updating step comprises repositioning the second graphic object relative to the first graphic object as the pointing symbol is moved.

56. A method of operating a computer-aided system, comprising:

(a) displaying a first graphic object on a computer; and

(b) displaying at least one point of interest on the computer when a pointing symbol is within a predetermined proximity of the first graphic object, wherein the points of interest are cling points.

57. The method of claim 56, further comprising displaying a second graphic object and clinging the second graphic object to the first graphic object according to at least one predefined cling characteristic.

58. The method of claim 57, wherein the cling characteristic comprises at least one characteristic selected from a group comprising:

joining the second graphic object to the first graphic object via a shortest distance where the origin of the second graphic object aligns and is coincident with a closest point of interest on the first graphic object,

sliding the second graphic object in alignment with the first graphic object as the pointing symbol is moved,

rotating the second graphic object about at least one of the points of interest on the first graphic object by manipulating the pointing symbol around the point,

positioning the second graphic object at an opposite side of the first graphic object when the pointing symbol traverses from one side to another of the first graphic object, and

positioning the second graphic object at a 180-degree rotation of the first graphic object at a specified perpendicular offset in a direction of the pointing symbol.

59. The method of claim 58, further comprising unclinging the second graphic object from the first graphic object at the pointing symbol is moved a distance greater than a predetermined rejection tolerance away from the first graphic object.

60. A computer-aided design system, comprising:

(a) a computer; and

(b) means, performed by the computer, for displaying a first graphic object on a computer and for displaying at

least one point of interest on the computer when a pointing symbol is within a predetermined proximity of the first graphic object, wherein the points of interest are identified by predefined rules and the predefined rules perform one or more geometric computations selected from a group comprising tangent, offset, parallel, alignment, end point, major vector, divided segment, extended segment, and intersection computations.

61. The system of claim 60, wherein a position of the pointing symbol is controlled by an input device coupled to the computer.

62. The system of claim 60, wherein the predefined rules limit selection of the first graphic object.

63. A computer-aided design system, comprising:

(a) a computer; and

(b) means, performed by the computer, for displaying a first graphic object on a computer, for displaying at least one point of interest on the computer when a pointing symbol is within a predetermined proximity of the first graphic object, and for displaying a second graphic object and joining the first and second graphic objects when the pointing symbol is moved to within a predetermined location tolerance of the first graphic object.

64. The system of claim 63, wherein the predetermined location tolerance identifies a minimum perpendicular distance which determines when the second graphic object is close enough to the first graphic object to establish an association therebetween.

65. The system of claim 63, wherein the second graphic object is joined to the first graphic object when a designated origin point of the second graphic object moves to within the predetermined location tolerance with respect to the first graphic object.

66. The system of claim 63, further comprising means for separating the first and second graphic objects when the pointing symbol is moved to beyond a predetermined rejection tolerance of the first graphic object.

67. The system of claim 63, wherein the means for joining comprises means for joining the first and second graphic objects at one or more of the points of interest.

68. The system of claim 63, wherein the first and second graphic objects are joined according to one or more characteristics selected from a group comprising a predefined offset, orientation, and rotation.

69. The system of claim 63, further comprising means for dynamically updating a relationship between the first and second graphic objects as the pointing symbol is moved.

70. The system of claim 69, wherein the means for dynamically updating comprises means for repositioning the second graphic object relative to the first graphic object as the pointing symbol is moved.

71. A computer-aided design system, comprising:

(a) a computer; and

(b) means, performed by the computer, for displaying a first graphic object on a computer and for displaying at least one point of interest on the computer when a pointing symbol is within a predetermined proximity of the first graphic object, wherein the points of interest are cling points.

72. The system of claim 71, further comprising means for displaying a second graphic object and clinging the second graphic object to the first graphic object according to at least one predefined cling characteristic.

73. The system of claim 72, wherein the cling characteristic comprises at least one characteristic selected from a group comprising:

joining the second graphic object to the first graphic object via a shortest distance where the origin of the second graphic object aligns and is coincident with a closest point of interest on the first graphic object,

sliding the second graphic object in alignment with the first graphic object as the pointing symbol is moved,

rotating the second graphic object about at least one of the points of interest on the first graphic object by manipulating the pointing symbol around the point,

positioning the second graphic object at an opposite side of the first graphic object when the pointing symbol traverses from one side to another of the first graphic object, and

positioning the second graphic object at a 180-degree rotation of the first graphic object at a specified perpendicular offset in a direction of the pointing symbol.

74. The system of claim 72, further comprising means for unclinging the second graphic object from the first graphic object as the pointing symbol is moved a distance greater than a predetermined rejection tolerance away from the first graphic object.

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