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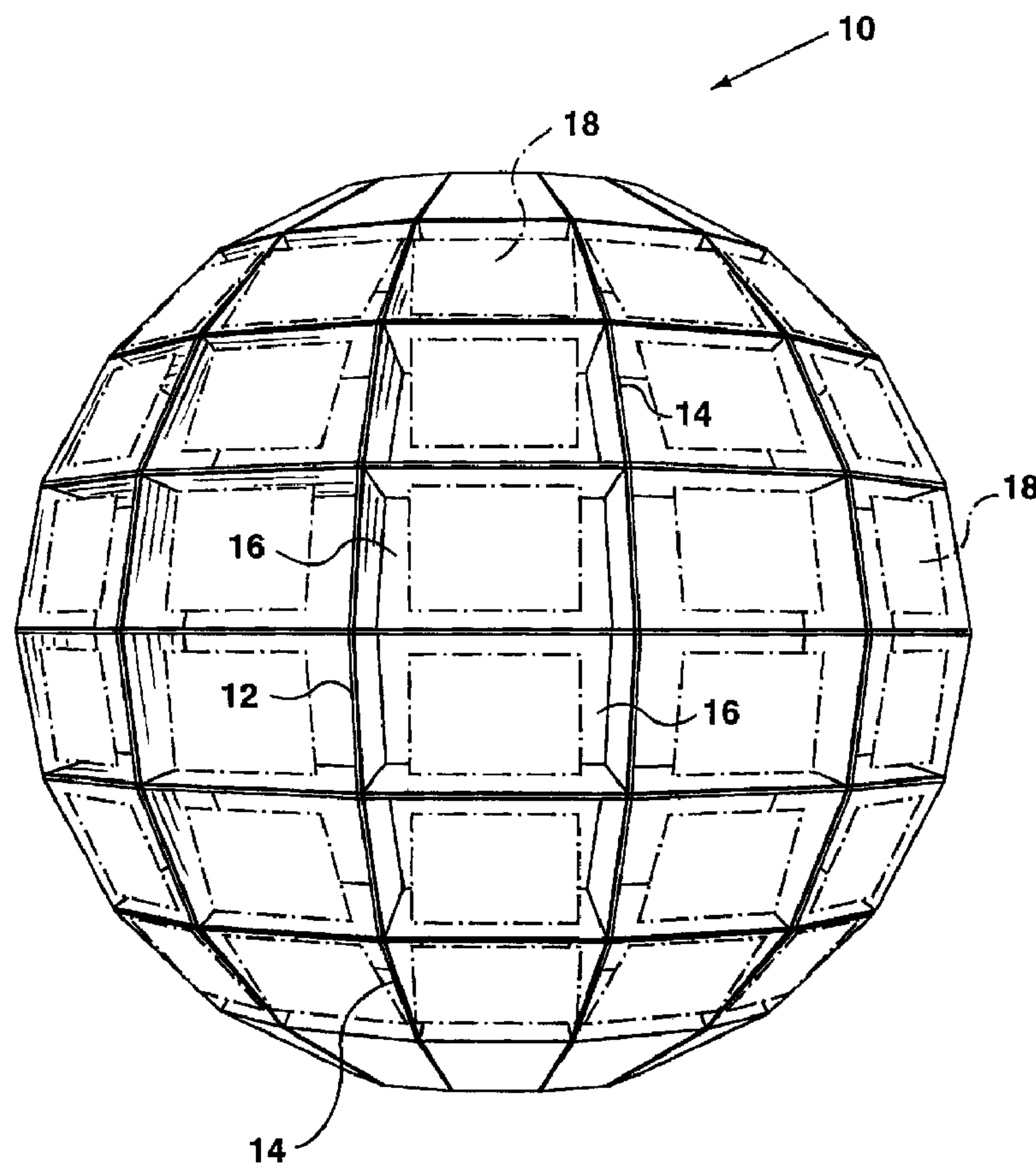
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(54) Titre : INTERFACE D'UTILISATEUR SPATIALE TRIDIMENSIONNELLE

(54) Title: A THREE DIMENSIONAL SPATIAL USER INTERFACE



(57) Abrégé/Abstract:

A method and system of providing a three dimensional spatial user interface (SUI) to a user of a computing device. The SUI may be manipulated in three dimensions and contains a plurality of portals. A portal may contain a sensory cue that provides a reminder as

(57) **Abrégé(suite)/Abstract(continued):**

to the content of the portal. Upon selection of a portal, an application program associated with the cue in the portal is invoked. Portals may also contain further instances of the SUI of the present invention, thus providing hierarchical depth. In the preferred embodiment, the SUI is implemented as a sphere and may be viewed from an external or internal perspective.

REPLACEMENT PAGE
- 52 -**ABSTRACT**

5 A method and system of providing a three dimensional spatial
user interface (SUI) to a user of a computing device. The SUI may be
manipulated in three dimensions and contains a plurality of portals. A portal
may contain a sensory cue that provides a reminder as to the content of the
portal. Upon selection of a portal, an application program associated with
the cue in the portal is invoked. Portals may also contain further instances
10 of the SUI of the present invention, thus providing hierarchical depth. In the
preferred embodiment, the SUI is implemented as a sphere and may be
viewed from an external or internal perspective.

TITLE: A THREE DIMENSIONAL SPATIAL USER INTERFACE**FIELD OF THE INVENTION**

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The invention relates to a user interface to a computing device. In particular, the invention relates to a user interface that is displayed in three dimensions to display a plurality of sensory cues.

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BACKGROUND OF THE INVENTION

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As late as the early 1990's, a user interacted with most computers through text-based interfaces, such as Microsoft's MS-DOS™ operating system or any of the many variations of UNIX. Text based interfaces in order to provide complete functionality often contained cryptic commands and options that were far from intuitive to the non-experienced user. In addition, opening several applications simultaneously was often not possible, not only due to poor memory management by the underlying operating system, but also because each application generally monopolized the entire screen, making the navigation from application to application difficult.

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Most current computer systems use two-dimensional graphical user interfaces to allow the user to manipulate the information stored on the system. These graphical user interfaces (GUIs) usually create graphical entities called "windows" to view individual documents. These windows can be placed around the screen and sized according to the user's preferences. They also enable the user to scroll through a document when the document is too large to be seen all at once. The main advantage of these GUIs over previous generation interfaces (as described above) was that one may have several documents opened within an application, and several applications running at once. In addition, it became possible to associate an application with an icon, thus providing visual recognition. The user no longer had to remember arcane keywords and commands. The user could manipulate graphical abstractions of files

- 2 -

and tools within windows on a screen. This new paradigm along with the introduction of the mouse, revolutionized how people used computers.

5 However, the complexity of the tasks performed by even casual computer users, as well as the number and types of tasks, is continually rising. It is not unusual for a user to be simultaneously running applications that allow them to: connect to the Internet, edit a document (text or multi-media), read electronic mail, access a calendar, receive or send a FAX, utilize a spreadsheet, etc. A complex task often requires the use of multiple applications to complete a task; it also requires that within an application, multiple documents may need to be accessed simultaneously. Thus, the modern user often has a large number of windows opened on the screen at once. The existing paradigm has trouble supporting a large number of windows opened simultaneously. It becomes difficult for the user to navigate through a stack of windows piled up on top of each other. Attempts have been made to alleviate the problem by providing navigational aids.

20 One such tool is the "taskbar". The taskbar is used to navigate between applications. The taskbar displays the name of each open window on separate buttons, sometimes accompanied by an icon representing the application that controls the window. The icons help in finding the right application. However, if there are multiple instances of the same application running, they will each have the same icon. Furthermore, the task bar quickly fills up, at which point the names become illegible.

30 Another navigational aid currently in use is the "window list" (typically used to navigate through the windows within a single application). This list shows the names of all the windows opened within an application; the user can bring a window to the top of the stack by clicking on its name. This is inconvenient as the user has to read all the names, and the length of the list that can be displayed is also limited.

- 3 -

When the list is too long, the window list requires the user to select "More windows..." if a window that is not on the list needs to be activated. By selecting "More windows...", another window list is displayed.

5 It is clear that the use of a taskbar and a window list improve the current two dimensional interface, but with limited success. More recently, attempts have been made to utilize a three dimensional (3D) graphical user interface. Most people are comfortable interacting with three dimensional views on a computer screen. For example, modern
10 computer games have a 3D interface to provide the illusion that the player is part of the environment. Examples of 3D interfaces are discussed below.

 U.S. patent number 5,148,154 discloses a GUI that permits
15 the production and creation of multi-media presentations. The GUI is implemented as a three dimensional "venue" (best shown in Figure 4). Viewing of the venue through different walls, provides different views of the resources available (e.g. sound or video). For example, a top view may represent the resources in time, such as the time required for a sound or
20 video track in a movie. Thus each view represents a different attribute view of the resources available. There is no single view that allows the user to comprehend all the information contained within the interface.

 U.S. patent number 5,303,388 discloses a three dimensional
25 icon associated with an object in the computer system. The example best shown in Figure 7 is that of a data or program file where the attributes of that file are indicated on faces of the icon. The attributes including: size, date created, date last modified and type of content. The disadvantage of this approach is that each object within the system must have its own
30 three dimensional icon. A user would thus be faced with hundreds of icons, with no conceptual framework in which to place them.

 U.S. patent number 5,339,390 discloses a central window

- 4 -

with two peripheral extensions, one extension on each side of the central window. The extensions serve as additional windows with content displayed to the user. The user may contract the central window to better view objects on the extensions. Similarly, the central window may be stretched to better view the objects on the central window. This stretching is dependant upon which portion of the three windows the user wishes to view. As a point or object is selected for viewing the windows are appropriately modified in size to centre the object in the central window. This is best shown in Figure 6. This patent discloses a variation on the common solution to the problem of too much data appearing in a window. The solution is simply to make the window larger than that which can be displayed on a single screen. As with other such solutions, this does not scale very well as a large amount of data requires scrolling across many panels.

U.S. patent number 5,485,197 discloses an interactive television system having means for displaying a "carousel" to allow the user to make a menu selection. As disclosed, the carousel displays a plurality of menu items on each face of the carousel. The items are displayed in text only and adjacent sides of the carousel are only marginally visible. The carousel rotates only about a single central vertical axis, hence the name "carousel". The carousel concept is wasteful of space, for example no data is available on the top or bottom of the carousel. Further, the carousel may be only rotated around one axis, requiring repeated user interaction to rotate the carousel to reveal the rear face. Finally, each menu provides at best a minimal visual cue as to the content accessible by each menu selection.

U.S. patent number 5,515,486 discloses a GUI in the form of a polyhedron display container. Each face of the polyhedron contains icons associated with an application and "workspace switches" which allow the user to switch between active applications. A central front panel is the active panel and the user may select a new face of the polyhedron to

- 5 -

be the active panel. In doing so, the polyhedron rotates a band of faces about a vertical, horizontal or diagonal axis to provide a new central active panel. As can be seen in Figures 3 or 4, the faces of the polyhedron are trapezoids, which are mapped to a rectangle when they become the central active panel. Due to the nature of the rotational interface, the inventors have in essence disclosed a three dimensional structure with a two dimensional user interface. The invention does not consider the rotation of the polyhedron as a whole about an axis of choice. In other words, a user may only rotate faces along specific axes.

U.S. patent number 5,678,015 discloses a "four-dimensional" GUI. The GUI consists of a cube, having a window containing icons displayed on each of the six faces. The fourth dimensional aspect is the ability to rotate the cube in real time. The object of the invention being to allow the user to see far more windows simultaneously than would be available with a tiled screen or more conventional interface. Practically, the invention is flawed, as in order to view multiple faces, the walls must be transparent, thus creating a very confusing view for the user. In addition, unless a face is viewed obliquely, i.e. having an edge in the centre of the screen (see Figure 5), the image will be nearly illegible given the clutter of multiple icons and the necessity to always provide a three dimensional view of a cube.

U.S. patent number 5,838,326 discloses a three dimensional workspace for interacting with large numbers of documents. Three types of spaces are described: a focus space for the current document, an immediate space for placing documents close at hand, and a tertiary space where documents are stored. The immediate space is represented by placing documents on a desk or hanging them in the air. The tertiary space is shown as a bookshelf. This invention is an example of an attempt to organize data in a format that may be friendly to a specific type of user, in this case one who deals with large numbers of documents. It does not lend itself well to the storage of objects other than documents

- 6 -

and it is not intuitive as to where documents may be stored.

U.S. patent number 6,005,579 discloses a GUI that appears as a rectangular parallelepiped (i.e. a room). The user can simultaneously view and select items from a left wall, a central wall, a right wall and the floor or ceiling. This invention provides an interface where the user views his surroundings as if he were in a room. It has the disadvantage that only five surfaces are presented, and there is no capability provided to view a rear wall.

U.S. patent number 6,016,145 discloses a GUI that displays multiple windows within a plurality of planes. The planes in the preferred embodiment represent the walls, floor and ceiling of a room. Windows may be moved between planes and are resized and reshaped accordingly. For example, a window on the back wall will appear smaller than a window on the front wall. Windows are tiled or stacked over other windows that may occupy the same plane. Thus the windows are "hung " upon a plane that is a wall of the room. The inventors also provide for a plurality of "isometric spaces" (Figure 13) arranged about a "bonding surface", in this case a central hub. Each isometric space is selectable by the user and each space contains a plurality of windows. This invention again makes use of the user interface as a "room" and permits the tiling of windows on each surface. Multiple rooms are considered, but there is no logical association between the rooms.

European patent publication number 483,777A3 (claiming priority from U.S. application 606,227 dated October 31, 1990) discloses imaging techniques to display an icon in a three dimensional manner. This is achieved by highlighting features and edges of the icon with shading and different colours. This invention has slightly enhanced the concept of layered two dimensional windows by providing each window with three dimensional attributes to aid in recognition of the window. However, the windows are still layered, in that they overlay each other. The

- 7 -

concept of a scaled down version of the contents of a window is also suggested to allow the user to sort and classify items on a visual basis. The traditional concepts of utilizing a three dimensional illustration of a filing cabinet or other storage device such as bookshelves or slide trays is also disclosed. Finally, the concept of having the image of a program icon change as the status of the application associated with the icon changes, is also discussed. This invention merely highlights the attributes of an icon or window to make them appear three dimensional and provide a sense of depth, it is a slight enhancement over the standard two dimensional interface.

As discussed above, there have been many attempts to apply a three dimensional or spatial aspect to the traditional two dimensional GUI. There have also been attempts to create a three dimensional GUI. However, none of these inventions have provided a practical and visually intuitive interface to allow users to efficiently and intuitively access the resources of a computing device via a three dimensional user interface. There is a need for a three dimensional user interface that is more intuitive and more easily utilized than the solutions provided to date.

SUMMARY OF THE INVENTION

The present invention provides a three dimensional interface that allows a user to intuitively locate and access resources from a computing device. The invention allows a user to interact with the interface in a three dimensional space. Accordingly, the user interface is referred to herein as a Spatial User Interface (SUI).

In accordance with one aspect of the present invention there is provided a user interface for a computing device, said interface comprising a graphic representation of a plurality of portals arranged in a three-dimensional space; and a sensory cue displayed in at least one of said portals to facilitate recognition by a user of an application associated

- 8 -

with said sensory cue.

5 In accordance with another aspect of the present invention there is provided a method for creating a populated three dimensional user interface, said method comprising the steps of: a) graphically representing a plurality of portals in a three dimensional space; b) mapping sensory cues on a one to one basis to at least some of said portals; and c) associating an application with each of said sensory cues.

10 In accordance with another aspect of the present invention there is provided a computer device for displaying a three dimensional user interface, said device comprising means for displaying said interface, said interface comprising: a graphic representation of a plurality of portals arranged in a three dimensional space; and a sensory cue displayed in at
15 least one of said portals to facilitate recognition by a user of an application associated with said sensory cue.

In accordance with another aspect of the present invention there is provided a method for populating portals in a three dimensional user interface, said user interface having an exterior and an interior, comprising the steps of:

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- a) establishing a connection with a first web page;
 - b) creating a sensory cue based on the first web page;
 - c) mapping said sensory cue to an exterior portal; and
 - 25 d) creating sensory cues for each additional web page accessible from said first web page and mapping said sensory cues to portals located on the interior of said user interface.

30 In accordance with another aspect of the present invention there is provided a computer readable medium containing instructions for controlling one or more three dimensional user interfaces in a computing device, by:

- a) permitting a user to select a user interface, said selected

- 9 -

interface containing a plurality of portals;

b) monitoring for first user input, said input indicating a portal of interest to said user;

5 c) upon receiving said first user input, moving said selected interface to centrally display said portal of interest;

d) monitoring for second user input to make said portal of interest an active portal, if input other than said second user input is received, returning to step b);

10 e) upon receiving said second user input, invoking an application program, until said user provides third user input to move to another portal; and

f) repeating steps b) to e) until said user provides third user input, thereby returning to step a)

15 **BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention will now be described, by way of example only, with reference to the following drawings, in which like reference numerals refer to like parts, and in which:

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FIG. 1 is an elevational view of the SUI of the present invention;

25 FIG. 2 is an elevational view of a portion of the SUI of the present invention;

FIG. 3 is an elevational view of an active portal;

30 FIG. 4 is an elevational view of a glass pane overlaying a portal;

FIG. 5 is a plan view of a polar cap of the present invention;

FIG. 6 is a schematic diagram illustrating the logical structure of the present invention;

5 FIGS. 7-10 are screenshots illustrating an embodiment of the SUI in which the direction of rotation is controlled;

FIG. 11 is a flowchart illustrating user interaction with the SUI of the present invention;

10 FIG. 12 is a scene graph illustrating the implementation of the preferred embodiment of the present invention;

15 FIG. 13 is an elevational view of an alternative embodiment of the SUI of the present invention;

FIG. 14 is an elevational view of an alternative embodiment of the SUI of the present invention;

20 FIG. 15 is an elevational view of an alternative embodiment of the SUI of the present invention;

FIG. 16 is a screenshot illustrating a SUI in a rectangular window in an alternative embodiment of the present invention; and

25 FIG. 17 is a screenshot illustrating a SUI running in "window-less" mode in an alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

30 The present invention provides a novel means to organize and present information using three-dimensional graphics (3D graphics) to create a spatial user interface (SUI). 3D graphics involve mathematical

- 11 -

representation of 3D objects in a three dimensional space, and the projection (for example, onto a two-dimensional display) of the 3D representation for viewing by a user. This present invention is general enough that it can entirely replace current windows based environments.

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The SUI of the present invention makes no assumption about the underlying operating system. As a 2D window environment can be used to hide the underlying specifics of a platform, so can the 3D SUI of the present invention.

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Referring first to FIG. 1, an elevational view of the SUI of the present invention, the SUI is shown generally as 10. SUI 10 preferably includes an armature 12 having a plurality of ribs 14. Ribs 14 define a plurality of portals 16. Portals 16 may be empty or may contain sensory cues 18. Sensory cues 18 serve to provide a cue as to the content contained within the portal 16 in which they are located. Most preferably the sensory cue 18 is a visual cue, however, cues associated with other senses are contemplated when advancements in technology will permit such cues to be utilized (e.g. smell, sound, touch or even taste).

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Sensory cues 18 are associated with an application. Sensory cues 18 may correspond to any type of content such as static or dynamic documents, three dimensional holograms or another SUI. For example, a sensory cue 18 displaying an image of a movie may be associated with an MPEG movie player to play the movie. A sensory cue 18 showing a page of a spread sheet will be associated with a spreadsheet application and a sensory cue 18 showing a web page would have web browser associated with it. One form of sensory cue 18 is a snapshot of a window used by the associated application (e.g. a web page, or a page of a text document), when the application was last active. A snapshot is a way to automatically generate a relevant icon for a sensory cue 18, as it simply takes a picture or snapshot of a screen to be used as a visual cue.

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- 12 -

The process of creating the snapshot involves accessing the underlying graphics resource of a window and making a copy of the individual pixels. When the snapshot and the original window are aligned properly, the snapshot becomes indistinguishable from the real window, except that the snapshot doesn't support user interaction. Displaying the snapshot is very efficient; it can be applied as a texture in the form of a sensory cue 18 on a portal 16. This is much quicker than having the application associated with sensory cue 18 display sensory cue 18 each time the display needs to be refreshed. It is this snapshot concept that allows the SUI 10 to handle a large number of sensory cues 18 at once. If snapshots are not used, each application associated with a sensory cue 18 would have to keep recreating the information in a sensory cue 18 as the portal 16 in which it is displayed comes within the view of the user.

The concept of providing portals 16 containing unique sensory cues 18 is radically different from the concept of "icons" used today. With icons, users are shown a visual mnemonic of the application that is associated with the sensory cue 18. Users still have to read the document name when shown a list of document icons created with the same application. Sensory cues 18 let people exploit their natural ability to easily memorize the appearance of a portal 16 without having to remember any other details (such as the text of a document, or even the filename of the document). Together with the spatial organization of sensory cues 18 in SUI 10 as discussed further below, portals 16 populated with unique sensory cues 18 let a user remember the arrangement of content more easily than current interfaces. Portals 16 do not have to contain 2D windows. When doing 3D modelling, for example, a portal 16 could contain a snapshot of the 3D object being modeled.

The optimal shape for displaying multiple portals 16 is on the surface of a sphere. In addition to providing the user with a maximal number of visible portals 16, a sphere lends itself particularly well to rotation upon any axis. The inventors recognize that an armature 12 for

- 13 -

aiding in the visual definition of portals 16 may be formed in any shape. Thus ribs 14 may be substituted with any structure capable of forming an armature 12, such as the frame for a geodesic dome, cylinder, cube, combination of known shapes or an irregular shape such as a building. The inventors do not intend to exclude shapes other than a sphere from the ambit of the present invention. The armature 12 is used to provide clues to the user as to the 3D structure of the SUI 10 as well as providing a visual aid by framing sensory cues 18. There is no requirement that the present invention have an armature 12, for example, sensory cues 18 may simply be displayed about the surface of the SUI 10 with no additional “supporting” structure.

Returning now to the shape of the SUI 10, a sphere allows the user to rotate the sphere about any axis to quickly glance over the sensory cues 18 contained in portals 16. The geometry used for a SUI 10, may suggest different manipulation clues to the user. For example, using a cylinder geometry would suggest that the SUI 10 could only be rotated about the central longitudinal axis of the cylinder. Similarly, portals 16 may take any geometric shape, however, in the preferred embodiment they are rectangular to best display a typical rectangular window. Also a user may adjust the geometry of SUI 10 by stretching or distending SUI 10, or individual portals 16.

Referring now to FIG. 2, an elevational view of a portion of SUI 10, the portion is shown generally as 30. The armature 12 geometry surrounding a portal 16 is a portal frame 32. A portal frame 32 can be used to support additional functionality such as buttons. As shown in FIG. 2 the portal frames 32 for each portal 16 display no functionality characteristics and are in fact transparent behind the sensory cue 18 allowing the user to view into the SUI 10.

Referring now to FIG. 3, an elevational view of an active portal is shown generally as 40. Portal 16 is active, i.e. it has been

- 14 -

selected by the user. When a portal 16 becomes active SUI 10 is rotated to have the now active portal 16 face the user. The sensory cue 18 within the portal 16 is enlarged for better viewing and the portal frame 32 is altered to highlight the portal. In this example the perspective views of the ribs 14 of the armature 12 form the portal frame 32 and frame the sensory cue 18. The colour of the portal frame 32 is also changed as a visual cue indicating that the portal 16 is active. An active portal may contain a conventional 2D window with the accompanying scrollbars and taskbars.

Referring now to FIG. 4, an elevational view of a glass pane overlaying a sensory cue 18 is shown generally as 50. Glass pane 52 is a transparent surface, which is positioned over sensory cue 18 and within the boundary of a portal 16. Glass pane 52 is an active surface, which allows for various functions such as highlighting, sketching, and copying from other documents. As will be understood by those skilled in the art, the glass pane 52 may be implemented as a transparent texture upon which the user can paint. This function provides recognizable landmarking, which assists in identification of the sensory cue 18. The sensory cue 18 remains unaffected by the contents of the glass pane 52. Glass pane 52 can be cleared, at the user's option.

Referring now to FIG. 5, a plan view of a polar cap of the present invention is shown generally as 60. SUI 10 has two polar caps 62, which can be used for easily identifying a SUI 10 when it is minimized. When a user has multiple SUI's 10 on their desktop, any SUI's 10 not in use are minimized and are displayed as shown in FIG. 5. A user may name or otherwise customize the look of SUI 10 by changing the bitmap image applied to the polar caps 62. Businesses can place their logo or other advertising information on the polar caps 62 of a SUI 10 that they intend to distribute. For example a movie rental outlet may choose to create a SUI 10 for use by their customers in locating movies of interest. This custom SUI 10 may be available in a retail rental outlet or via the Internet or other electronic distribution means. In the case of a custom SUI

- 15 -

10, the creator of the SUI 10 can restrict what content the user may change. For example the images on polar caps 62 may be fixed such that a user may not update them.

5 Labels 66 reside between portals 16 and polar cap 62. Labels 66 serve to identify each of the vertical groups of portals 16 on the SUI 10. Returning to our movie example, different labels could be used to classify types of movies. For example: horror, science fiction, romance or western. As with portals 16 and polar caps 62, the user may be able to
10 change the content of labels 66 to best aid them in identifying the vertical groups of portals 16. The ability to change the content of a SUI 10 is dependant upon the wishes of the creator of the SUI 10. A supplier of a catalogue embodied in a SUI 10 may choose not to permit modifications to the SUI 10. Conversely, a user wishing to populate a SUI 10 with sensory
15 cues 18 and associated applications will need to change the content of SUI 10.

 The appearance and geometry of the polar caps 62 of a SUI 10 can be modified in a variety of ways in different embodiments of the
20 present invention. For example, the geometry of the polar caps 62 can be subdivided in order to create a modified polar cap 62 composed of a pattern of individual polygons (e.g., tiling the polar cap 62 with square tiles). This allows different functions to be assigned to individual parts of a modified polar cap 62. These functions can include, for example, from
25 simple toggles for changing data displayed by the SUI 10 to more complex interactions with very large data sets.

 By using square polygons and aligning each polygon's normal vector with the vector starting at the centre of the SUI 10 (in the
30 case of a spherical SUI 10) and going through the centre of the polygon, the shape of the polar caps 62 is effectively approximated using squares. It is preferable to maintain the original curved shape of the polar cap 62 after it is subdivided so that when the SUI 10 is rotated to reveal portals 16 in

- 16 -

the top or bottom hemispheres of the SUI 10, the majority of the polar cap 62 is visible and functional. This allows the user to easily access any functionality available on the polar caps 62.

5 According to an alternative embodiment of the present invention, an example of where a modified polar cap 62 can be used to access a very large data set represented in a SUI 10 would be to subdivide the polar cap 62 geometry to create a grid of polygons (e.g. square polygons) that would be coloured in a way to create a visual map to the
10 large data set. The user could click on one of the coloured polygons which would cause data in the SUI 10 related to the selected polygon to be opened on the SUI 10.

15 More specifically, when a polar cap 62 contains a large number of polygons or tiles, it may be difficult to display numerous large textures well. In this alternative embodiment, the textures are removed and the tiles are coloured using a pre-determined colour scheme (e.g. the average colour of the visual sensory cue displayed in a given tile). Colouring the geometry generally does not place an onerous demand on
20 current video cards, thus permitting a large number of tiles to be supported. When the user wants to view the contents of a tile, he can select the corresponding colour-coded tile which causes the content (as a texture map) to be mapped onto the geometry for that specific tile.

25 In other variant embodiments, a similar colour-coding scheme may be applied to portals, particularly where an SUI 10 comprises a very large number of portals. Textures may be removed from portals, which are coloured using a pre-determined colour scheme (e.g. the average colour of the visual sensory cue displayed in a given tile). When
30 the user wants to view the contents of a portal, he can select the corresponding colour-coded portal which causes the content corresponding to that portal (as a texture map) to be mapped onto that specific portal.

- 17 -

The polar caps 62 can also be used to activate different methods of viewing the SUI 10. For example, the user can select to view the SUI 10 in a square window or in a circular window.

5 Further, in a manner analogous to traversing the contents of file folders which contain sub-folders in which one can view data in the folder at a higher level up to the root folder or at a lower level down to a child folder, by selecting the top polar cap 62 the user can move to higher levels in a data hierarchy. Similarly, by selecting the bottom polar cap 62,
10 the user can move to lower levels in a data hierarchy.

The polar caps can also act as repositories for control information for the entire SUI 10. For example, the user may select a polar cap 62 to bring up a window for managing passwords for all the portals 16
15 of the SUI 10.

Referring now to FIG. 6, a schematic diagram illustrating the logical structure of the present invention is shown generally as 70. User interaction with SUI 10 is supported at three levels: a global level 72, a
20 SUI level 74, and a portal level 76. Global level 72 includes the handling of multiple SUIs 10 resident on the user desktop, as well as the ability to create and delete SUIs 10. SUI level 74 includes functionality to manipulate a SUI 10 as a whole, such as navigation between portals 16 by rotating SUI 10. Portal level 76 includes the functionality invoked when an
25 individual portal 16 is activated.

The proposed system supports multiple SUIs 10 accessible at once. For example, a user could have a SUI 10 associated with each project she is working on. At global level 72 the functionality required to
30 deal with one or more SUIs 10 is provided by script library 78. Script library 78 comprises scripts 80, which allow a user to create or delete a SUI 10, define the layout of multiple SUIs 10 and recognize user input to activate and deactivate a SUI 10. User input would typically be provided by a

- 18 -

keyboard, mouse or other pointing device, but may also be provided by any other less conventional means such as a touch screen or voice activation. By way of example, there are shown at global level 72 a single active SUI 82 and two inactive SUIs 84.

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User interaction at the SUI level 74 can be handled in different ways to best exploit the geometry of a particular SUI 10. In the spherical SUI 10 of the present invention, the user is free to spin or rotate the SUI 10 about any axis by way of any pre-determined action, for example, a sudden mouse movement or dragging (that is, moving the mouse while keeping the left mouse button depressed). The spinning motion can be subsequently stopped by way of some other pre-determined action, such as the clicking of a left mouse button, for example. The user can align a portal 16 with the screen (to make it easier to read) with a single-click on the portal 16 (that is, pressing and releasing the left mouse button once). More specifically, if the mouse button is clicked when a cursor is on top of the portal 16, then the SUI 10 stops spinning and that portal 16 is selected. The selection causes the SUI 10 to automatically change its position so that the selected portal 16 is positioned, preferably, in the middle of the screen and upright. The portal 16 aligned with the centre of the screen preferably zooms in towards the user. If there is a music script associated with the portal, the music starts playing. The music may then stop playing when the user clicks anywhere outside the portal, or double-clicks on the portal.

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If the cursor is not directly on top of a portal when the mouse cursor is clicked, the SUI 10 stops spinning immediately and remains in that position. However, if a "gravity" feature has been activated, instead of remaining in the position where the SUI 10 stops spinning, the portal 16 closest to a pre-determined reference point on the screen such as the middle of the screen can be selected and made active. The selection of the portal 16 causes the SUI 10 to automatically change its position so that the selected portal 16 is positioned in the middle of the screen and

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- 19 -

upright, so that a portal 16 is always visible in the middle of the screen when the SUI 10 is not spinning. The inventors have chosen the middle of the screen as an example. The utilization of the gravity feature in the present invention does not restrict the positioning of the selected portal 16 to the middle of the screen nor the orientation of the selected portal 16 to upright. The portal 16 to be selected can be determined, for example, by selecting the portal 16 whose normal vector is closest to the normal vector of the computer screen pointing in the direction of the user. The requisite comparisons can be made by iterating through all the portals 16 or by trying to reduce the number of portals 16 that have to be examined using appropriate algorithms or data structures (e.g. sorting the portals 16 by their normals). The gravity feature which relates to the selection of a portal 16 so that the SUI 10 is re-positioned to display the selected portal 16 in a pre-defined manner on a screen according to a specified algorithm or set of rules or criteria can be similarly implemented utilizing input devices other than a mouse.

The user activates a portal 16 with a double-click (that is, pressing and releasing the left mouse button twice). Activating a portal 16 will bring the SUI 10 closer to the user so that the active portal 16 is large enough for user interaction. In the preferred embodiment, the active portal measures 640 x 480 pixels, but any practical size for the display device on which the sensory cue 18 within portal 16 is being displayed must be considered.

Now that the portal 16 is active, any application associated with the portal 16 is activated. If the user wishes to resize the window displayed by the portal, the user may do so and the SUI 10 will adjust itself accordingly, i.e. by moving in or out in synchronization with the window size.

Clicking anywhere outside the active portal 16 takes a snapshot of the window of the application in use, which is used to replace

- 20 -

the sensory cue 18 on the now inactive portal 16, and zooms out of the SUI 10 to let the user quickly navigate to another portal 16. Dragging the mouse while holding down the control key results in zooming in or out of the current view. The user may also be drawn within the SUI 10 by a script invoked when the user makes a portal 16 active.

As indicated above, SUI 10 can be spun or rotated about a selected axis. Rotational constraints to be imposed on a SUI 10 can be implemented to keep the SUI 10 from being rotated in an undesirable manner. Rotations of the SUI 10 that may be considered undesirable in certain contexts include, for example, rotations which cause the SUI 10 to be positioned upside-down, rotations which cause the SUI 10 to spin about multiple axes, and rotations which cause the SUI 10 to spin too quickly.

To prevent the SUI 10 from being rotated to an upside-down position, which makes it difficult for a user to read the information on the portals 16, it is possible to limit the rotation of the SUI 10. For example, rotation can be constrained so that the normal vector of a polar cap 62 is never oriented greater than 90 degrees (or some other pre-determined limit) relative to the direction of the polar cap 62 normal vector prior to rotation. As the user begins to rotate the SUI 10 toward either polar cap 62, the angle between the normal vector of the polar cap 62 prior to rotation and the normal vector of the polar cap 62 at any particular instant during rotation is calculated. When the calculated angle reaches 90 degrees, the SUI 10 is constrained from further rotation. In this example, the normal vector of a top polar cap 62 would typically point straight up, and the normal vector of a bottom polar cap 62 would typically point straight down prior to a rotation. In variant embodiments of the invention, where a SUI 10 may comprise one polar cap 62 or no polar caps, the vector along the vertical axis of the SUI 10 can be used as a reference to limit the rotation of the SUI 10. For a SUI 10 that does not have a vertical axis, the rotation limit value may be a function of another defined axis of the SUI 10.

- 21 -

If the SUI 10 is rotating about multiple axes (e.g. there is rotation about a horizontal axis and rotation about a vertical axis), it is also possible to implement another rotational constraint, such as “slippery collision”. The slippery collision feature permits rotation of the SUI 10 about one axis to be stopped, while the rotation about other axes would continue. If a user were to manually spin the SUI 10, causing the SUI 10 to rotate about multiple axes, the SUI 10 could determine the major axis of rotation, and then implement the slippery collision feature to eliminate rotation about a second axis while maintaining rotation about the major axis.

Preferably, the rate at which the SUI 10 can be rotated is constrained to permit a user to maintain visual interaction with the content presented on the SUI 10. By associating a maximum rate of rotation with a SUI 10 through an internal setting, it is possible to compare this setting with the rate at which a user has attempted to rotate the SUI 10. If the user attempts to rotate the SUI 10 at a rate of rotation which exceeds the set maximum, the rotation of the SUI 10 is constrained to the rate of maximum rotation. If the user attempts to rotate the SUI 10 at a rate of rotation less than the set maximum, the SUI 10 is rotated at the rate desired by the user.

A “bouncing back” feature can also be implemented whereby a rotation in one direction about an axis can be reversed so that the SUI 10 subsequently rotates in the opposite direction about the same axis (i.e. negate the specified rotation vector). The “bouncing back” feature can be initiated by any pre-specified input, including for example, upon a user-specified keystroke, mouse movement, automatically when a pre-determined rotation limit is reached (i.e. when the polar caps 62 are inclined at an angle greater than 90 degrees, for example), some other input or a combination of the above.

Although the above functionality is described in the context of

- 22 -

using a two button mouse, one skilled in the art will recognize that it is possible to utilize any input device including but not restricted to mice having single or multiple buttons.

5 At SUI level 74 functionality is provided by a SUI script library 86 which contains a plurality of scripts 88 which permit the user to interact with the SUI 10. For example one script 88 may implement the zooming in and out of a portal 16 upon activation and deactivation. Another script 88 may handle the rotation of the SUI 10. Also within SUI level 74 are the data
10 structures and functions that implement the display of the SUI 10. SUI polar caps 90 contain the content of polar caps 62. Inert geometry 92 contains the armature 12 of the SUI 10. SUI labels 94 contain the content of labels 66 displayed at each pole of the SUI 10. Thus, it will be understood by those skilled in the art that functions performed by the SUI
15 10 including those described in this specification will be, in most instances, performed by modules or scripts 88 associated with an instance of a SUI 10.

 At the portal level 76, each portal 16 can have different
20 functionality associated with it. For example, a portal 16 containing a web-browser could be implemented such that every time a Uniform Resource Locator (URL) link is clicked in the browser the SUI 10 is rotated so that an empty portal 16 is activated with an image of the newly selected web page as the sensory cue 18. This could be used to interactively build a SUI 10
25 showing the browsing history of the user. The functionality associated with each portal 16 is determined at the portal level 76. Thus, the same SUI 10 could have portals 16 that display movie clips when they are activated, others that play sound clips when they are active, and others that start a word processor when they become active. Within portal level 76 is visual
30 appearance data 96 which defines the geometry 98 and texture 100 of the contents of a portal 16. Within portal level 76 is a portal script library 102, which contains a plurality of portal programs or scripts 104 to react to user input at the portal level 76. For example, one script 104 may provide a

- 23 -

glass pane 52 on a portal 16. Glass pane dataset 106 contains all the information provided by a user when creating a glass pane 52. If a glass pane dataset 106 exists for a portal 16, the images contained within dataset 106 will be overlaid on a portal 16. Each non empty portal 16 has associated with it a sensory cue 18, and an associated application. Sensory cue 18 is a cue to remind the user of the function of the associated application. Associated node 108 contains information on the content of portal frame 32, which is displayed once a portal 16 has been made active.

With respect to rotation capabilities of the SUI 10, the user can optionally enable a feature that gives finer control of the speed of rotation of a SUI 10. The speed of rotation can be controlled by how far the cursor is from the centre of the SUI 10 (or the screen). For example, the farther the cursor is from the centre of the SUI 10, the quicker the SUI 10 can be made to rotate, while the closer the cursor is to the centre of the SUI 10, the slower the SUI 10 can be made to rotate.

Furthermore, the user can also optionally enable a feature that gives finer control of the direction of rotation of a SUI 10. The direction of rotation can be controlled by the position of the cursor relative to the centre of the SUI 10. For example, the direction of a mouse movement can determine the initial direction of rotation. The movement of the cursor in a specific direction while the SUI 10 is rotating can cause the direction of rotation to change so that the SUI 10 is rotating towards the position of the cursor.

Referring to FIGS. 7 through 10, screenshots illustrating one embodiment of the present invention in which the direction of rotation of a SUI 10 is controlled are shown with reference to the following example.

Consider a situation in which the user wishes to swap the contents of a portal to another portal. Referring to FIG. 7, the portal to be

- 24 -

swapped is selected by placing the mouse cursor 109a over that portal and pressing the <control> key while depressing the left mouse button. The sequence of keystrokes and mouse keys as described is provided merely as an example. Other combinations of keystrokes and mouse keys may be used to facilitate the swapping of portal contents. The surrounding frame 32 of the selected portal 109b is highlighted in yellow, for example.

Referring to FIG. 8, as the mouse cursor 109a is dragged to the right (while still pressing the <control> key and depressing the left mouse button), the frame 32 surrounding a second portal 109c with which the selected portal 109b may be swapped is also highlighted in yellow. As long as the mouse cursor 109a is positioned sufficiently far away from the edge of the SUI 10, the SUI 10 does not rotate. The distance from the edge of the SUI 10 at which the mouse cursor 109a can be placed without causing the SUI 10 to rotate can be determined through internal setting (pre-defined for the system, user-defined, or otherwise).

Referring to FIG. 9, as the mouse cursor 109a is dragged further to the right so that it approaches the edge of the SUI 10 (while still pressing the <control> key and depressing the left mouse button), the SUI 10 starts rotating so that the next portal becomes visible. In this embodiment, the further to the right the mouse cursor 109a moves, the faster the SUI 10 is made to spin.

Referring to FIG. 10, if the mouse cursor 109a is moved in a different direction, the rotation angle changes accordingly. For example, if the mouse cursor 109a is moved up rather than horizontally as shown in the previous figures, the SUI 10 spins vertically. In FIG. 10, the movement of the mouse cursor 109a upwards permits the top polar cap 62 of the SUI 10 to come into view.

Referring now to FIG. 11, a flowchart illustrating user interaction with the SUI 10 of the present invention is shown generally as

- 25 -

110. Beginning at step 112 the user activates a portal 16 through some stimulus, in the preferred embodiment this is a double click of the left mouse button. At step 114 the associated application corresponding to the portal 16 is started and positioned over the portal 16. At step 116 the sensory cue 18 displayed in the portal 16 is opened by the associated application. At step 118 the user views and possibly modifies the sensory cue. At step 120 the portal 16 is made inactive by some action taken by the user. In the preferred embodiment this action is achieved by single clicking the left mouse button in an area outside of the active portal. Moving now to step 122, the user is given the option to create a snapshot of the current window so that it may become the new sensory cue 18 displayed in portal 16 or to revert to the original sensory cue 18. If the user decides not to save the current window, the process moves to step 124 where the associated application is closed. Should the user wish to have the current window saved as a new sensory cue 18 then a snapshot of the sensory cue is taken at step 126 and saved to be displayed in portal 16. At step 128 the associated application is closed and the new sensory cue 18 is displayed in portal 16.

Referring now to FIG. 12, a scene graph illustrating the implementation of the preferred embodiment of the present invention is shown generally as 150. Most modern high-level 3D graphics libraries support a data structure concept known as a scene graph. A scene graph is a hierarchical method of organizing complex graphic environments in a manner that is both easy to programmatically manipulate and efficient to render. A program known as a renderer traverses the scene graph to render the scene defined within the scene graph. Note that scene graph 150 is a Directed Acyclic Graph (DAG) as it does not contain cycles.

FIG. 12 makes use of four different types of nodes in illustrating scene graph 150. The types of nodes are:

a) a branch group, indicated by a lozenge,

- 26 -

- b) a transform group, indicated by a triangle,
- c) a shape node, indicated by a rectangle; and
- d) a script, indicated by an oval.

5 A branch group, such as node 152, serves to branch off logical components of the objects that comprise a scene. Node 152 serves as the root of the scene graph 150 and has three logical branch groups, inactive SUIs 154, active SUI 156 and global level scripts 158, each of which have additional sub nodes, which define their attributes.

10 A transform group such as icon position 160 serves to provide the information required to manipulate and position an object relative to the parent branch group. A shape node such as node 162 contains the data necessary to display an object, such as geometry and texture. In this case node 162 contains data requiring that an inactive SUI 154 be displayed showing one of its polar caps 62.

15 Finally, a script node such as script node 164 will contain a library of scripts that react to user input. In the case of script node 164 the library will consist of scripts that recognize that an inactive SUI 154 has been selected, reposition it accordingly and make it an active SUI 156.

20 Active SUI node 156 has a single child, scale/orientation node 166, which is the parent node for all functionality to display, and interact with an active SUI 10. The children of node 166 comprise a shape node for the armature 168, and branch groups 170, 172 and 174 for the portals, labels and polar caps respectively. As the preferred embodiment of the SUI 10 is a spherical shape, there are two polar caps 62 and two sets of corresponding labels 66. This structure is illustrated by the binary sub trees below nodes 172 and 174.

25 Portals node 170 will have a plurality of portal nodes 176 (although only one is shown), one for each portal 16 in the SUI 10. As one

- 27 -

skilled in the art will understand, in the preferred embodiment the address of the subtree for each portal node is obtained via a hash table utilizing the name of the portal 16 of interest. Although the inventors have chosen a hash table, any other data structure providing rapid access to data for any of the plurality of portals 16 may be utilized as are well known in the art, for example a b-tree. Similarly, each SUI 10 will have a transform group node 166 which is also accessed via a hash table.

As shown, portal node 176 has a transform group subnode 178 to display the contents of the portal, i.e. a sensory cue 18. The information on what to display is contained in shape node 180. Node 176 also has as a sub node a portal scripts branch group 182 which has a plurality of sub nodes 184, 186 and 188 each of which provide specific functionality based upon input provided by the user. Although three scripts are shown, any number of scripts may be provided to act on user input.

Referring now to Figure 13, an elevation view of an alternative embodiment of SUI 10, shows SUI 10 generally as 200. In this embodiment of SUI 10 curves around the user, providing the impression that the user is within a composition of portals 16 which can be rotated around the viewpoint of the user. This embodiment is simply an alternative view where the alternative embodiment 200 appears to wrap around the user. In practice, rendering software displays a front face or a back face of an object based upon the direction of the normal vectors associated with that object. Thus, by reversing the direction of the normal vectors for portals 16 and the associated armature, the back faces of portals 16 are displayed, providing a view that wraps around the user. Sensory cues 18 may be located in the back faces of portals 16 that are different from the sensory cues 18 located on the front faces of portals 16.

Referring now to Figure 14, an elevation view of an alternative embodiment of SUI 10, shown generally as 210. In this embodiment the armature 12 does not have portal frames 32. Thus ribs 14 appear as a

- 28 -

wireframe structure with no underlying armature structure.

Referring now to Figure 15, an elevation view of an alternative embodiment of SUI 10, is shown generally as 220. In this embodiment, no armature 12 is present. Sensory cues 18 themselves define the portals 16. Empty portals 16 may be defined by "empty" sensory cues 18 (e.g. a blank image).

The interior of SUI 10 may also be used to display information, providing a simple two-level hierarchy. This functionality can be useful in many instances, for example with browsing web sites on the Internet. In such a scenario, an exterior portal 16 on SUI 10 could represent the first page of a web site. When the user activates the exterior portal 16, the view is moved to the inside of the SUI 10, and interior portals inside SUI 10 display sensory cues 18 of all the web pages that could be accessed from the web page displayed in the exterior active portal 16. Such an interior view would be similar to the view shown in FIG. 9. The user can activate the portals on the interior of the SUI 10 (which become regular web browsers), or can back out of the SUI 10 to browse the first level of the hierarchy. This is useful for shallow but wide hierarchies as each exterior portal 16 creates a different group of interior portals.

Another way to represent a hierarchy is to place a SUI 10 within a SUI 10. For example, when utilizing a SUI 10 as a web browser, each time a portal 16 is activated, the viewpoint is moved to the inside of the SUI 10 where another SUI 10 displays sensory cues 18 of all the web pages that could be accessed from the active portal. Unlike the previous scenario where the hierarchy can only be two levels deep, this hierarchical scheme is not limited and can continue forever.

A SUI 10 is a self contained object that can be shared with other computer users. Thus a SUI 10 could be used by businesses to distribute information about their services and products. A movie theatre

- 29 -

company, for example, could make available on its web site a MovieWorld, i.e. a SUI 10 that shows all available movies playing in a particular city. Screen captures of the movies would be displayed as sensory cues 18 on SUI 10. When the user selects a movie, the viewpoint moves to the inside of the SUI 10, where the portals 16 contain sensory cues 18 of the locations where a particular movie is playing.

Although third parties may provide populated SUIs 10, users may create their own SUIs 10. In this situation, the user is provided with an empty SUI 10 (e.g. just the armature 12). The user may then populate the portals 16 with applications (and sensory cues 18) that are of interest to the user. As with any software program dealing with the editing of content, the user is free to let an application populate the SUI 10 or select individual sensory cues 18 as they wish. In one such scenario, a user may have access to a device that stores and plays music. A custom SUI 10 may be constructed by the user to index all of the music available on the device. In this case the sensory cues 18 could be an illustration of the musicians (i.e. the cover label of a disc or a promotional poster) or could perhaps include lyrics or musical notes or even an audio sample of the music. Upon selecting a sensory cue 18 (in this case a compilation or perhaps a single track), the associated software application would be invoked to locate and play the music identified by the sensory cue 18.

Functionality may be added to the present invention by users and programmers alike through scripting. A script is a program that can be associated with one or more portals and is activated through user interaction or other stimuli. Referring back to the MovieWorld example, functionality could be added to a portal to enable a sound clip or a movie trailer to be played when the portal is activated.

Script authoring is provided through a visual interface for simple scripts or through a text-based interface for more sophisticated users. The visual interface will be available to a user who wishes to

- 30 -

customize a SUI 10. More sophisticated users may take advantage of third party script libraries. Scripting is supported at the global level 72, at the SUI level 74 and at the portal level 76.

5 In addition to the static model of creating a sensory cue 18 for a portal 16, sensory cues 18 may be automatically updated by their associated application. The associated application may continue to execute even if the portal 16 in which it is contained is not active. For example, a user may choose to render a complex 3D figure and rather
10 than wait for the application to complete the rendition, move on to another portal. Upon completion of the rendition, the portal will be updated with the new 3D figure.

By way of further example, sensory cues 18 may be updated
15 in real-time through a network connection. Information in a portal may be updated by either pushing or pulling information. A SUI 10 can employ both strategies simultaneously for different portals. Regardless of how the information is updated for each portal 16, SUI 10 supports dynamic rearrangement of the portals 16 and/or the attributes of a portal frame 32.
20 A user may move the information associated with a portal 16 to another portal 16. In the preferred embodiment this is implemented through a right mouse button click on the active portal which displays a drop-down menu providing the user with portal relocation, deletion or update options.

25 With regard to the pulling of information, a script associated with one or more portals 16 could periodically open a network connection, via TCP/IP socket or any other convenient means, to connect to an information server to obtain new information. The server does not need to know that a script is querying it. For example, a script could download a
30 web page containing stock quotes from a public quote server, such as finance.yahoo.com. This approach requires that the script understand how to parse the information received from the server rather than the two parties agreeing to a (presumably simpler) common communication

- 31 -

protocol. This approach is best suited for slowly updating information, as there is no established protocol for obtaining only the exact information required, significant amounts of non relevant data may be acquired. Furthermore, SUI 10 may not know when the information on the information server was last updated. Querying the information server too often will result in wasted network resources. Querying not often enough will result in outdated information being displayed by the SUI 10.

With regard to the pushing of information, a portal 16 establishes an initial connection with a SUI-aware server. The script establishing the connection will attempt to reestablish the connection in the case of a communications error. Whenever new information is available, the server automatically "pushes" it to the SUI 10. This requires a common protocol to be followed by both the server and the SUI 10. This approach is best suited for large information sources where only part of the information is updated in a frequent yet non-periodic manner. A stock portfolio is a good example. In this case, there can be a long list of stocks being monitored, yet some stocks trade with high demand and some with low demand. With the server pushing the information to the information sink (the SUI 10), only the information that has changed is transmitted. If the SUI 10 had to query the information server, a lot of (potentially non-updated) information could be downloaded each time.

Any number of schemes may be developed to make a web site "SUI-aware". One such scheme would be for the web site to be aware of which portal 16 a web page or other web site content (e.g. streaming video or audio) should be pushed to. As will be recognized by those skilled in the art, this may be accomplished through the use of an agreed upon Hypertext Markup Language (HTML) tag within the web site. Variations on this scheme may include an HTML tag which points to content to be delivered to a portal 16 as chosen by the SUI 10. Such schemes put the onus upon the web site or content provider to provide a sensory cue 18 to populate a portal 16. These schemes may also be

- 32 -

implemented by Internet search engines. Should a user wish to populate a SUI 10 with web sites of interest on a specific topic, the search engine would be aware of the HTML tags and rather than return a list of URL's, return content to populate portals 16.

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10 In variant embodiments of the invention, SUI 10 further comprises means to intercept hyperlink calls from a browser application and to compare them with web pages that are currently represented in the SUI 10. If a hyperlink in a particular document is selected and the web page corresponding to the hyperlink currently exists somewhere in the SUI 10, the SUI 10 is re-positioned or rotated to display the portal 16 associated with the web page and the web page is subsequently activated. If however, such a web page corresponding to the hyperlink does not yet exist, the hyperlinked page is then opened within the currently active browser window. For example, if the active web page has a hyperlink to a web page titled "www.vizable.com/employment.htm", when the user clicks with his mouse on the link, a module or script associated with the SUI 10 compares this with an associated database of existing links and causes the SUI 10 to rotate to display the portal 16 containing the "www.vizable.com/employment.htm" web page. Similarly, if a user manually types a web site address into a browser's address bar and requests the corresponding web page, the module or script associated with the SUI 10 compares the address with the associated database of existing links and causes the SUI 10 to rotate to display the portal 16 containing the requested web page.

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30 In variant embodiments of the present invention, the SUI 10 may comprise a means for permitting a sequence of interactions to be performed on the SUI 10 to be recorded, and optionally re-performed or re-executed at a later time, upon occurrence of a specific event, at a pre-determined time interval, or as initiated by the user.

In variant embodiments of the present invention, the SUI 10

- 33 -

can provide means to permit text-based navigation of the contents in the portals 16 of the SUI 10. For example, the name of the file which is contained within a portal 16 can be stored within an index. The index can be used to navigate the SUI 10. The user can press any letter or number
5 key to find portals 16 associated with a file name having the same first letter or number. The SUI 10 will then rotate so that the corresponding portal 16 can be viewed in a desired position, preferably in the middle of the screen and upright. If there are multiple files with the same first letter or number, the SUI 10 can rotate the corresponding portals into view in
10 alphabetical or numerical order. Other identifiers can also be navigated in this way, such as file type or application. The user may also choose to build their own index based upon arbitrary criteria to allow them to locate portals 16 by a single key stroke.

15 In variant embodiments of the present invention, the user can control one or more SUIs 10 through a network by having commands sent to remote SUIs 10. These commands can be sent, for example, by pre-recorded scripts, or through real-time interaction with one a SUI 10 on a local machine. For example, one computer can be chosen to run the
20 "master" SUI 10 which is used to control "slave" SUIs 10. Slave SUIs 10 (e.g., there could be one, several hundreds, or any number) would establish a network connection to the master SUI 10. Each slave SUI 10 must be able to reach the master SUI 10 over a network such as a LAN or the Internet. After a slave SUI 10 has connected with the master SUI 10, it
25 receives commands (e.g., selecting or activating a portal) from the master SUI 10. If the master SUI 10 is running a pre-recorded script, then those commands are transmitted to each slave SUI 10. If a user is controlling the master SUI 10 in real-time, the user's actions are "translated" into a scripting language (e.g. a click on a portal could be translated to "select
30 clicked- on portal"). These script commands can then be transmitted from the master SUI 10 to each slave SUI 10. When a slave SUI 10 receives a script command from the master SUI 10, it is interpreted by a local script interpreter and subsequently executed. This method of transmitting script

- 34 -

commands is more efficient than the method capturing each frame of the master SUI 10 and streaming this typically large amount of information to each slave SUI 10. In these variant embodiments, the slave SUI 10 can only be controlled by the master SUI 10 (i.e. a user's attempts to interact with a slave SUI 10 through the mouse or keyboard connected to the computer on which the slave SUI 10 is running will be ignored). However, in other embodiments, the slave SUI 10 can be enabled to receive commands from local users and to send these commands back to the master SUI 10. Priorities can be assigned to each slave SUI 10 and the master SUI 10, and can be used to determine which commands should be executed in the event of a conflict. Furthermore, in other embodiments, a peer-to-peer network of SUIs 10 can be implemented. For example, in one such embodiment, each slave SUI 10 can receive command "requests" from local users. These command requests are transmitted to the master SUI 10 which decides, having considered requests from all slave SUIs 10 and resolving any conflicts, which selected request(s) to execute. The selected command request(s) are then transmitted to each slave SUI 10 for execution.

Further, in variant embodiments of the invention, multiple SUIs 10 can be linked together in real-time. Portals 16 in a SUI 10 can be linked in real-time to other portals either locally or remotely through a network. An SUI 10s can comprise update means to update remote SUIs, so that when the content is changed on one portal or SUI, other linked portals or SUIs (either all of them or a subset based on a defined criteria) may be updated automatically.

In variant embodiments of the invention, SUI 10 can further comprise means for importing data in a hierarchical format from other data sources. Files which are typically stored on a storage device, for example, in a hierarchy (e.g., of folders) can be represented in various ways in a SUI 10. For instance, existing hierarchies of file names can be represented in the SUI 10 by mapping the names or the files themselves onto the SUI 10

- 35 -

using a variety of methods.

In variant embodiments of the invention, SUI 10 can further comprise means for allowing objects to be dragged from an application running in a two-dimensional interface and dropped onto the SUI 10. Similarly, SUI 10 can comprise means for allowing objects to be moved by “dragging and dropping” between portals 16 of a SUI 10, and between the exterior and interior surfaces of the SUI 10. For example, if a user was to drag and drop a folder onto a selected portal 16, this can permit the content of the folder to be expressed either on the exterior of the selected portal 16, or on the interior of the selected portal 16. If a user were to drag an image file from a folder on their hard drive and drop it onto a portal 16, the image can be mapped directly on the portal 16. If a user were to select and drag a body of text in an application running in an two-dimensional interface and drop the body of text onto a portal 16 containing a text document, the text document could be opened if it is not currently open, and the selected body of text can be appended to the opened text document. Alternatively, if a text document did not exist, a new document could be created and expressed in the selected portal 16 into which the selected body of text can be inserted.

In variant embodiments of the invention, a SUI 10 can be viewed in a “window-less” mode, rather than inside a regular, typically rectangular window. In the “window-less” mode, the SUI 10 which is a three-dimensional object, appears to be floating on the desktop represented in the screen. One method of implementing this feature is to use a window that takes the same shape as the SUI’s 10 silhouette. In this embodiment, although the term “window-less” is used to describe the feature, a window having the same shape as the SUI 10 is actually used. The screen size of the SUI 10 (i.e. the diameter in the case of a spherical SUI 10) is computed, and the size of a window is set so that it fits exactly around the SUI 10. Accordingly, for a spherical SUI 10, the SUI 10 is viewed inside a window which is circular. For example, Figure 16

- 36 -

illustrates a SUI 10 running in a rectangular window 238 in (regular) window mode, while Figure 17 illustrates the SUI 10 running in "window-less" mode. The SUI 10 appears to be floating on top of other applications. The toolbar 240 docked at the top of the window of Figure 16 is now floating by the SUI 10 in Figure 17.

As can be appreciated by those skilled in the art, the invention as described herein may be applied to any computing device capable of implementing the present invention. It is not the intent of the inventors to restrict the invention to conventional computing devices. For example the present invention would provide an excellent interface to devices such as a cellular telephone having restricted screen size or an Internet enabled television. Applications of the present invention are numerous and include a new user interface to any operating system and any computer application (including world-wide-web browsers, word processors, spreadsheets, etc.).

As will be apparent to those skilled in the art, various modifications and adaptations of the method and system described above are possible without departing from the present invention, the scope of which is defined in the appended claims.

REPLACEMENT PAGE

- 37 -

WE CLAIM:

1. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises user input means permitting said user to rotate said interface about a plurality of axes, and at least one of a rotational constraint means and a control means for controlling the rotation of said interface.

2. The apparatus of claim 1, said rotational constraint means for preventing said interface from rotating to an upside-down position.

3. The apparatus of claim 1, said rotational constraint means for preventing said interface from rotating about at least one first axis while permitting rotation of the interface about at least one second axis.

REPLACEMENT PAGE

- 38 -

4. The apparatus of claim 1, said rotational constraint means for preventing said interface from rotating at a rate greater than a pre-determined maximum rotation rate.
5. The apparatus of claim 1, said rotational constraint means for reversing the current direction of rotation of said interface when said interface is rotating.
6. The apparatus of claim 1, said control means for controlling the speed of rotation of said interface, wherein the speed of rotation of said interface depends on the position of a cursor relative to an edge of said interface.
7. The apparatus of claim 1, said control means for controlling the direction of rotation of said interface, wherein the direction of rotation of said interface depends on the position of a cursor relative to a point on said interface.
8. The apparatus of claim 7 wherein said point is located at the centre of said interface.
9. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:
 - a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and
 - b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the

REPLACEMENT PAGE

- 39 -

user interface; and wherein said user interface is projected onto a two-dimensional display.

10. A computer device for displaying a three dimensional user interface, said device comprising means for displaying the interface as claimed in claim 9.

11. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for selecting a portal to be made active from said plurality of portals, wherein the portal to be selected is closest to a pre-determined reference point.

12. The apparatus of claim 11 wherein said selected portal is positioned proximate the middle of a screen and substantially upright.

13. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

REPLACEMENT PAGE

- 40 -

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for recording a plurality of interactions and subsequently executing said recorded interactions on said interface.

14. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user

REPLACEMENT PAGE

- 41 -

interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said graphic representation is in the form of a sphere, wherein said sphere includes polar caps, and wherein said polar caps are used to view a subset of data represented in said interface.

15. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for navigating the interface using a text-based index, wherein elements of said index are associated with said plurality of portals.

16. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

REPLACEMENT PAGE

- 42 -

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for transmitting data to and receiving data from at least one other remotely-located interface through a network connection.

17. The apparatus of claim 16 wherein said interface is used to control the operation of said at least one remotely-located interface.

18. The apparatus of claim 16 wherein the operation of said interface is controlled by said at least one remotely-located interface.

19. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is

REPLACEMENT PAGE

- 43 -

changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for importing data into said interface from a data source, said data being represented in said data source in a hierarchical format.

20. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for enabling objects to be moved between portals of said interface.

21. The apparatus of claim 20 wherein objects can be dragged from one of said plurality of portals to another of said plurality of portals.

22. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

REPLACEMENT PAGE

- 44 -

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means for enabling objects to be dragged from an application to one of said plurality of portals.

23. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

REPLACEMENT PAGE

- 45 -

and wherein said interface is displayed in a window having substantially the same shape as a cross-section of said interface.

24. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises update means for updating content in at least one remotely-located portal when content in a portal of said interface is changed.

25. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

REPLACEMENT PAGE

- 46 -

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises update means for updating content in at least one remote interfaces when content in said interface is changed.

26. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise changes to at least one of the shape of the user interface, the shape of one or more portals of the user interface, and the arrangement of portals of the user interface;

and wherein said user interface further comprises means to search for a web page contained in one of said plurality of portals corresponding to a user-designated web address, and to display said web page to said user.

27. An image reproducing apparatus for presenting a user interface, said image reproducing apparatus comprising:

REPLACEMENT PAGE

- 47 -

a) means for displaying a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and

b) means for providing a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein ;

wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, one or more geometric properties thereof dynamically, so that the graphical representation displayed to said user is changed, and said changes comprise at least one of the following group of changes:

- (i) change to the shape of the user interface,
- (ii) change to the shape of one or more portals of the user interface, and
- (iii) change to the arrangement of portals of the user interface.

28. The apparatus of claim 27 further comprising user input means permitting said user to rotate said interface about a plurality of axes.

29. The apparatus of claim 27 further comprising user input means permitting said user to adjust the geometry of said interface.

30. The apparatus of claim 27 further comprising user input means, permitting said user to view the details of a portal of interest, said portal of interest increasing in size for enhanced viewing by said user.

31. The apparatus of claim 27 further comprising user input means permitting said user to select a portal to be made active, said selection resulting in the execution of the application associated with said portal.

REPLACEMENT PAGE

- 48 -

32. The apparatus of claim 27 wherein said graphical representation is in the form of a sphere, with the exterior of the sphere displayed to said user.

33. The apparatus of claim 27 wherein said graphical representation is in the form of a sphere, with the interior of the sphere displayed to said user.

34. The apparatus of claim 27 wherein at least one of said portals contains a user interface.

35. The apparatus of claim 27, further comprising user input means, said user input means accepting input to permit said user to access an interior of said graphical representation.

36. The apparatus of claim 27 wherein said graphical representation includes an armature to visually define each of said portals.

37. The apparatus of claim 27 further comprising user input means for accepting input from said user to create a transparent pane for covering a portal, said transparent pane containing content editable by said user.

38. The apparatus of claim 32, wherein said sphere includes polar caps and labels.

39. The apparatus of claim 33, wherein said sphere includes polar caps and labels.

40. A method for creating a populated three dimensional user interface, said method comprising the steps of:

a) arranging a plurality of portals containing content in a three dimensional graphical representation for display to a user;

REPLACEMENT PAGE

- 49 -

- b) for each of said plurality of portals, associating an application therewith that permits user interaction with the content contained therein;
- c) for each of said plurality of portals, displaying a sensory cue therein that facilitates recognition by a user of the application associated therewith; and
- d) dynamically changing one or more geometric properties of said user interface based on the content contained in one or more portals of the user interface, so that the graphical representation displayed to the user is changed, and at least one of the following group of changes is made; change to the shape of the user interface, change to the shape of one or more portals of the user interface, and change to the arrangement of portals of the user interface.

41. A computer device for displaying a three dimensional user interface, said device comprising means for displaying said interface, said interface comprising: a plurality of portals containing content, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to a user, and wherein for each of said plurality of portals, an application that permits user interaction with the content contained therein is associated therewith; and a plurality of sensory cues, wherein for each of said plurality of portals, a sensory cue is displayed therein that provides a cue to the content contained therein therewith; wherein said user interface is adapted to change, based on the content contained in one or more portals of the user interface, to one or more geometric properties thereof dynamically, whereby the graphical representation displayed to said user is changed, and said changes comprise at least one of the following group of changes;

- (i) change to the shape of the user interface,
- (ii) change to the shape of one or more portals of the user interface, and
- (iii) change to the arrangement of portals of the user interface.

REPLACEMENT PAGE

- 50 -

42. The device of claim 41 wherein at least one application is a further three dimensional interface.

43. The device of claim 41 wherein said graphical representation is hollow and at least one of said portals provides access to the interior of the space within said graphical representation, said interior containing a plurality of interior portals.

44. The device of claim 43 wherein the interior of said interface contains a further interface.

45. The device of claim 44 wherein said further interface contains a plurality of additional interfaces to a depth selected by a creator of said three dimensional user interface.

46. The device of claim 41 wherein said graphical representation is spherical in shape.

47. The device of claim 46 wherein said spherical representation further comprises polar caps and labels.

48. A method for populating portals in a three dimensional user interface, said user interface comprising an arrangement of a plurality of portals and having an exterior and an interior, comprising the steps of:

- a) establishing a connection with a first web page;
- b) creating a sensory cue based on the first web page;
- c) mapping said sensory cue to one of said plurality of portals located on the exterior of said user interface;
- d) creating sensory cues for each additional web page accessible from said first web page and mapping said sensory cues to at least one portal of said plurality of portals located on the interior of said user interface; and

REPLACEMENT PAGE

- 51 -

e) dynamically changing one or more geometric properties of said user interface based on the content contained in one or more portals of the user interface, so that the graphical representation displayed to said user is changed, and at least one of the following group of changes is made; change to the shape of the user interface, change to the shape of one or more portals of the user interface, and change to the arrangement of portals of the user interface.

49. A computer program product for controlling one or more three dimensional user interfaces in a computing device, said product having computer readable memory tangibly embodying computer readable code, said code comprising instructions, which when executed on the computing device, cause the computing device to perform a method comprising:

- a) permitting a user to select a user interface, said selected interface containing a plurality of portals, wherein said plurality of portals are arranged in a three dimensional graphical representation for display to said user, and wherein said selected interface is adapted to permit changes to one or more geometric properties of said selected interface dynamically based on the content contained in one or more portals of the user interface, so that the graphical representation displayed to said user is changed, and at least one of the following group of changes is made; change to the shape of the user interface, change to the shape of one or more portals of the user interface, and change to the arrangement of portals of the user interface;
- b) monitoring for first user input, said input indicating a portal of interest to said user;
- c) moving, upon receiving said first user input, said selected interface to centrally display said portal of interest;
- d) monitoring for second user input to make said portal of interest an active portal, if input other than said second user input is received, returning to step b);
- e) invoking, upon receiving said second user input, an application program, until said user provides third user input to move another portal; and
- f) repeating, until said user provides third user input, said permitting, monitoring for first user input, moving, monitoring for second user input, and invoking.

1 / 17

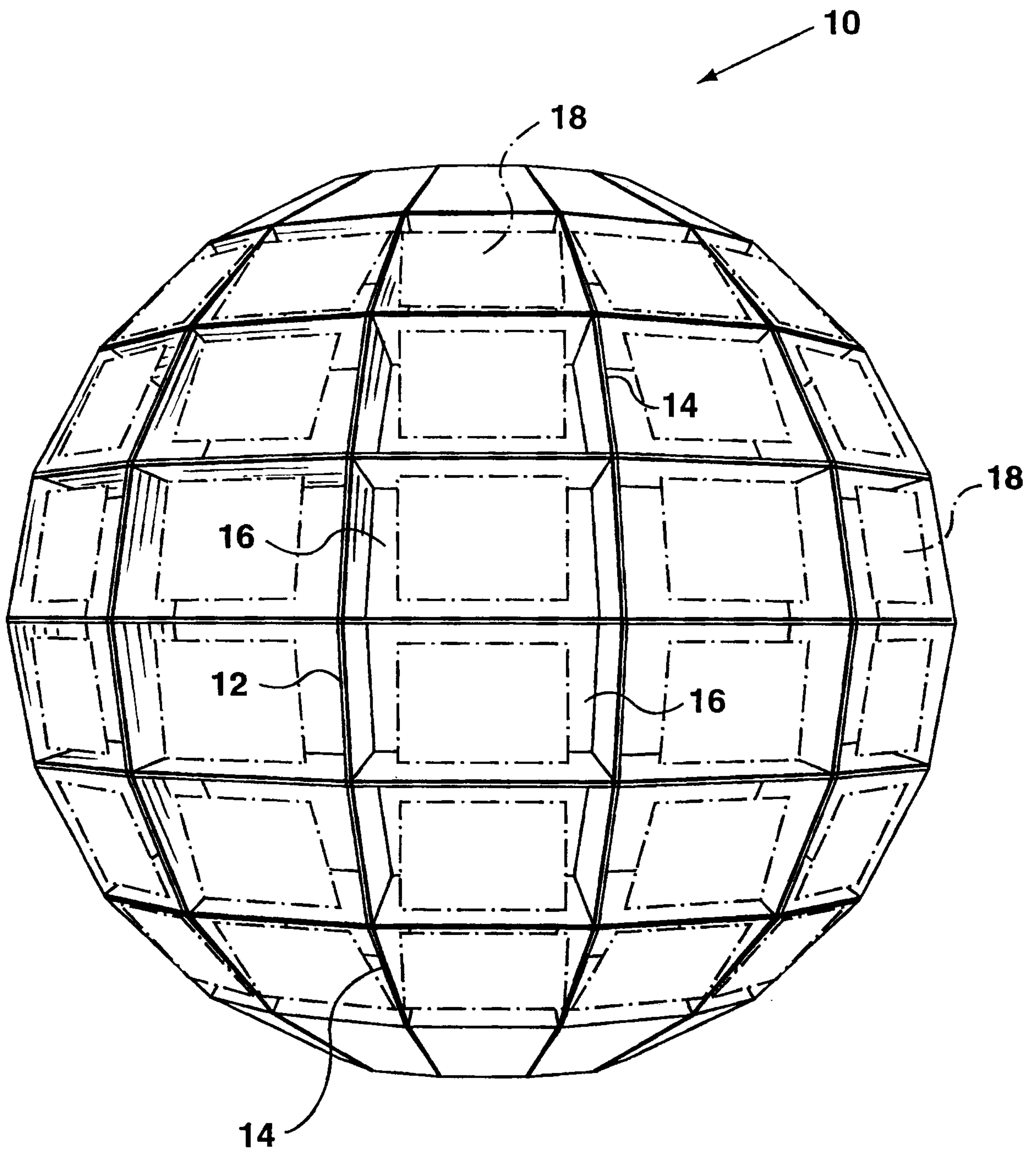


FIG. 1

2 / 17

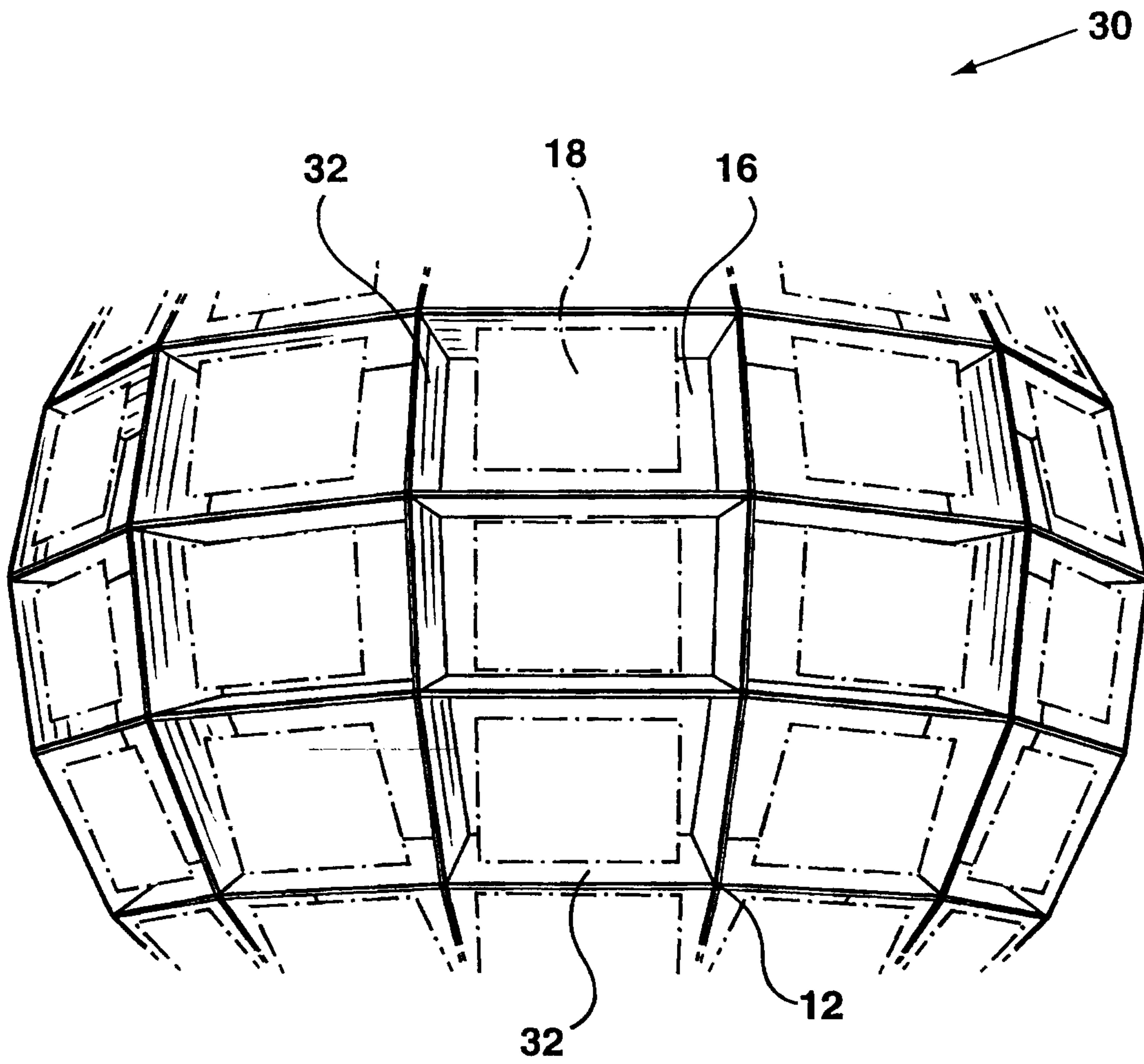


FIG. 2

3 / 17

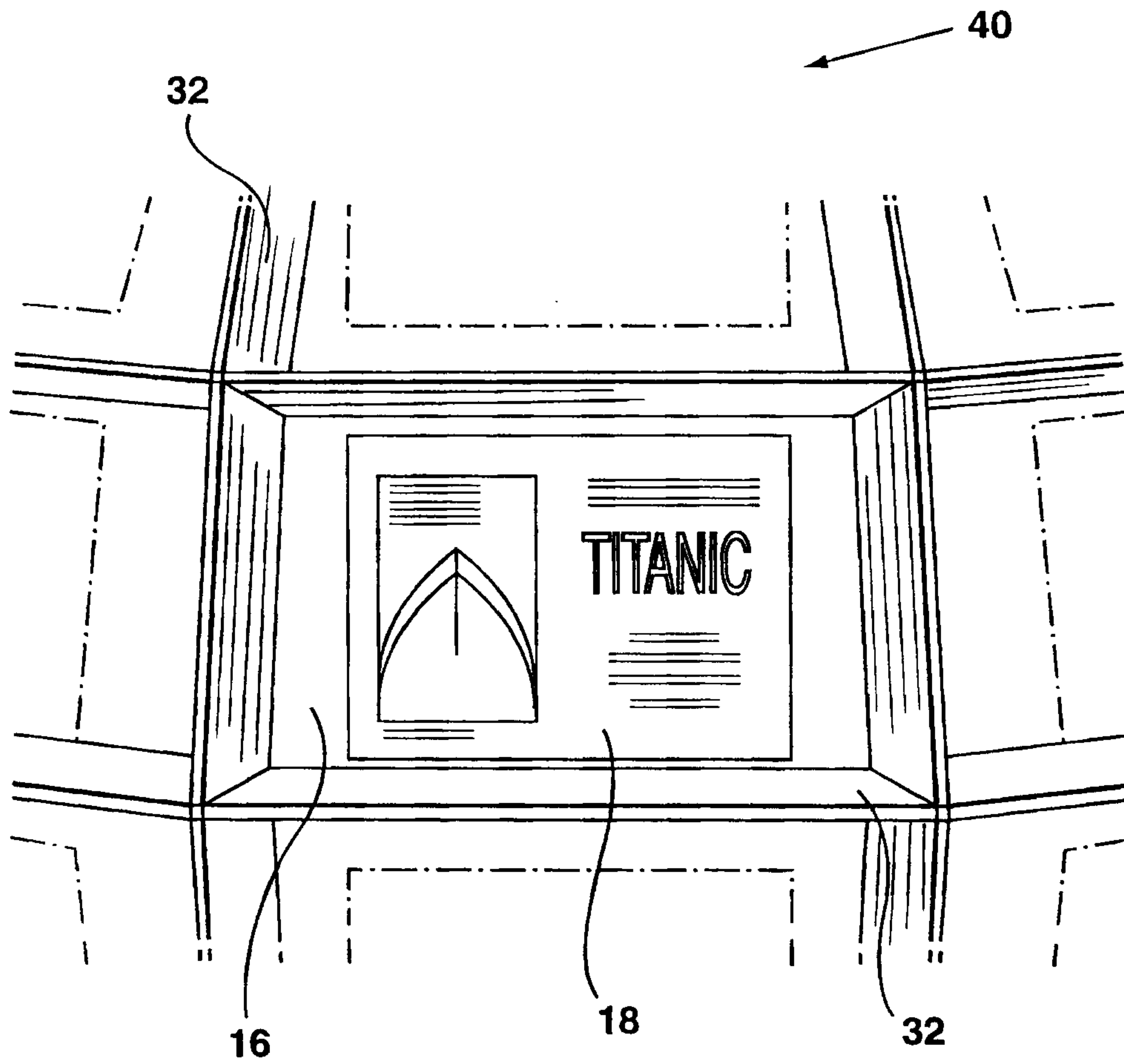


FIG. 3

4 / 17

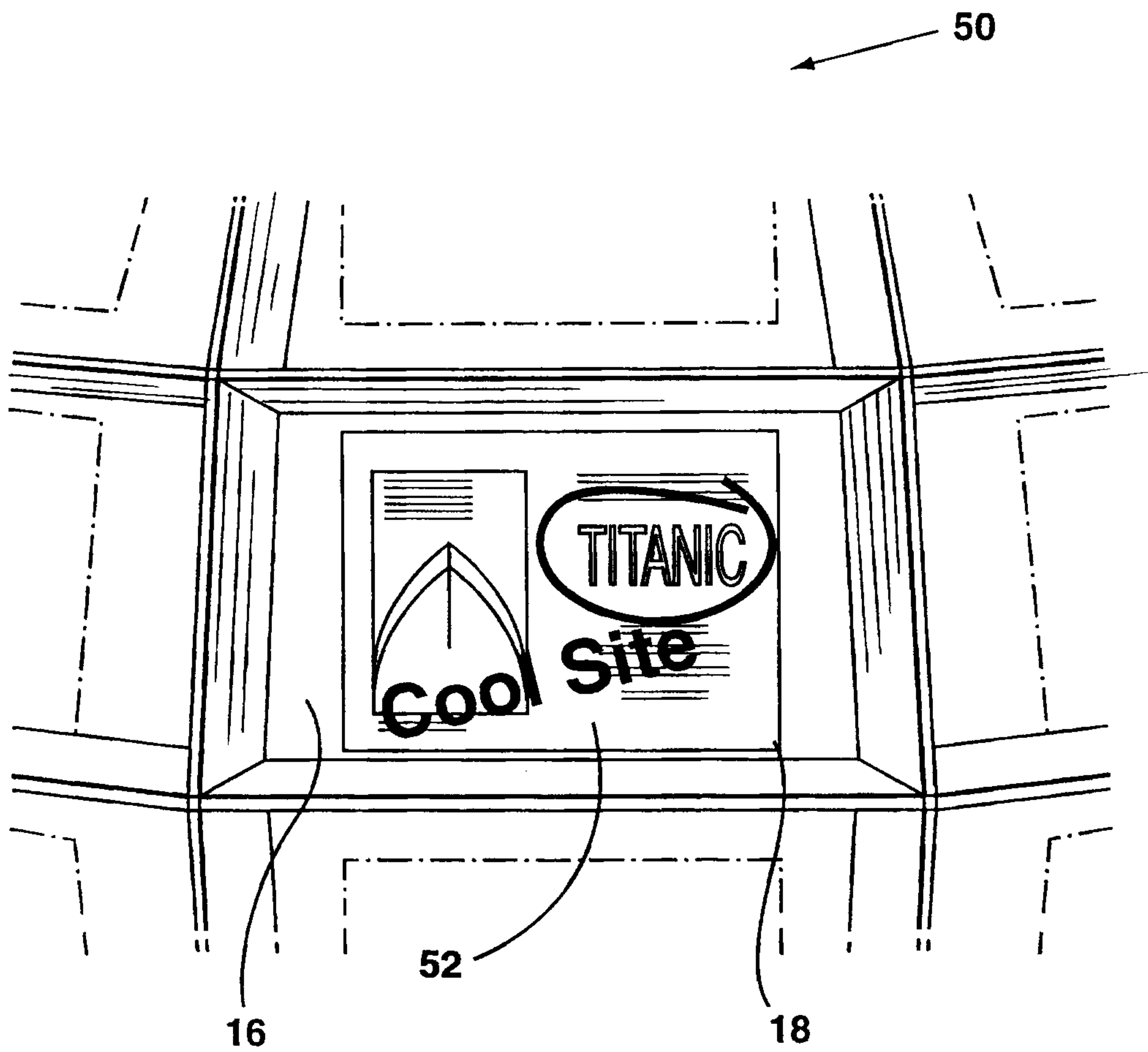


FIG. 4

5 / 17

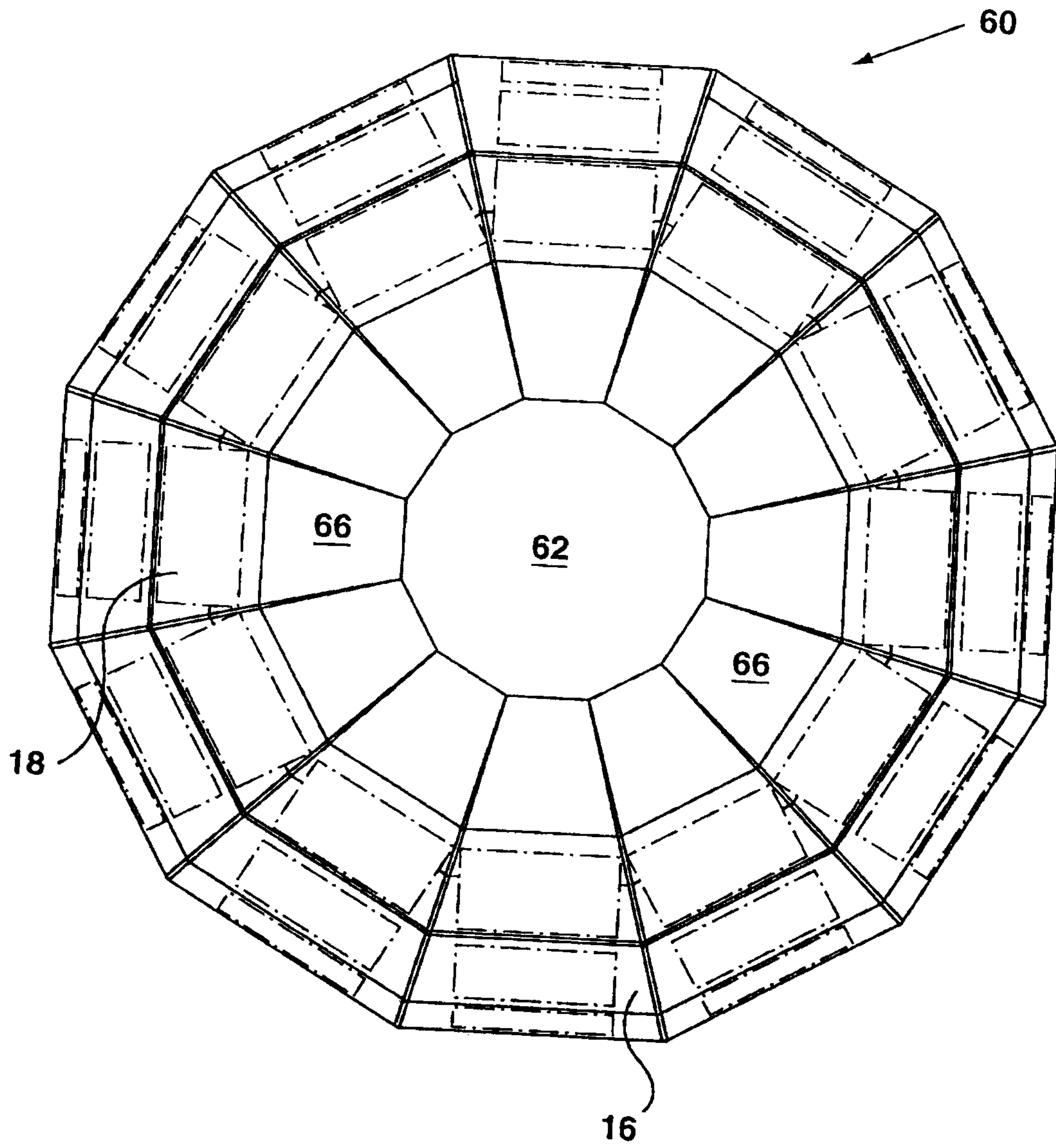


FIG. 5

6 / 17

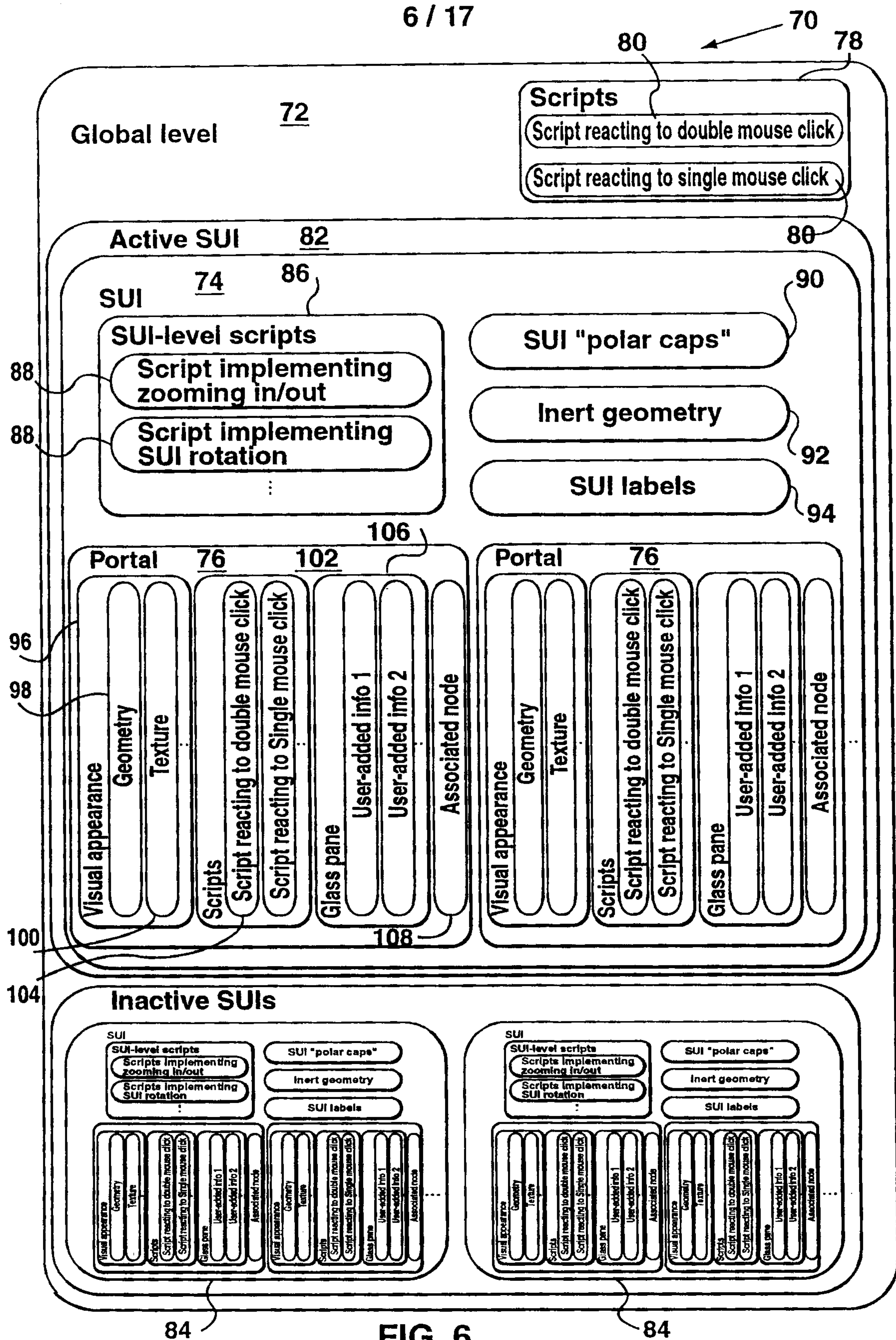


FIG. 6

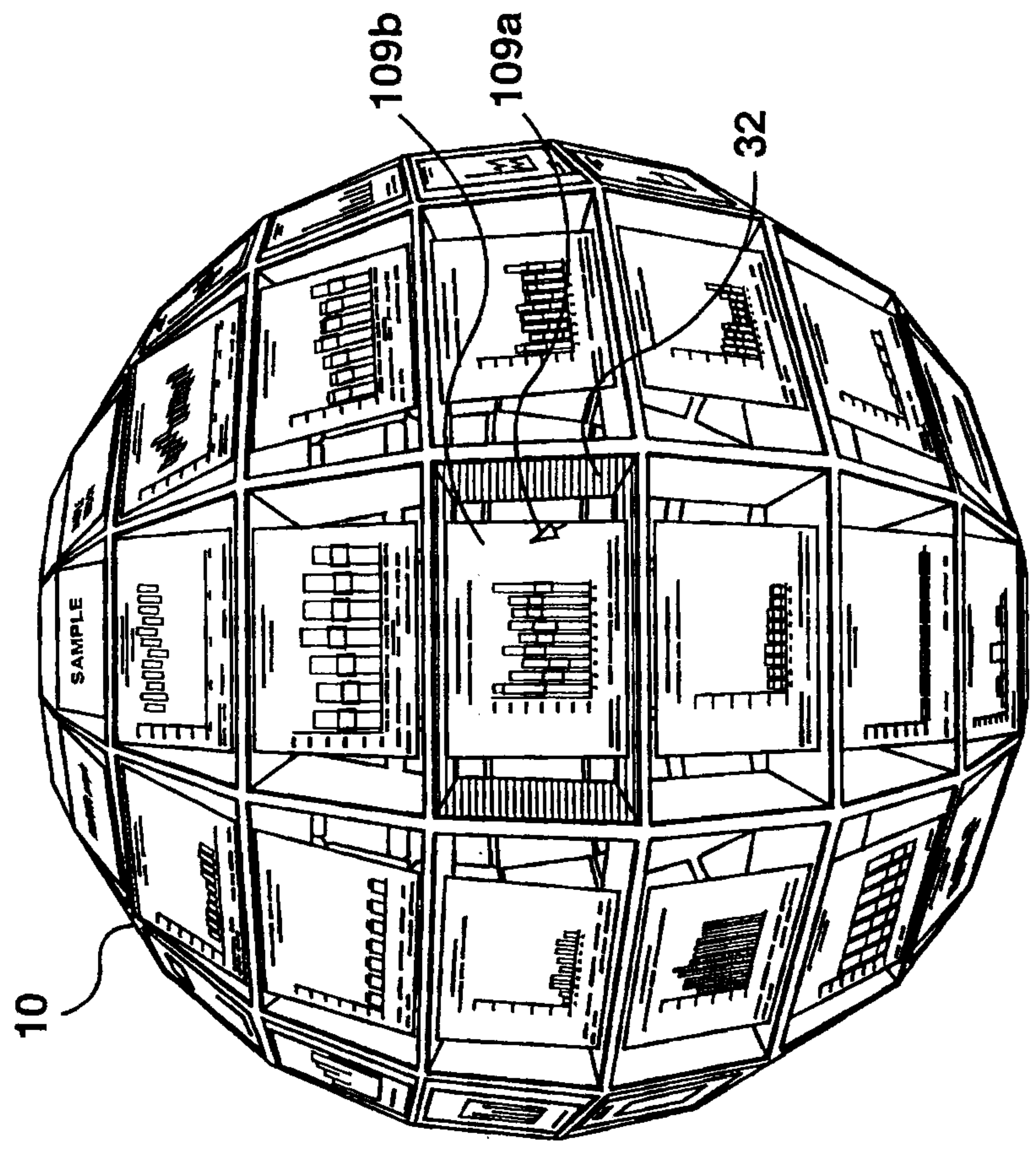


FIG. 7

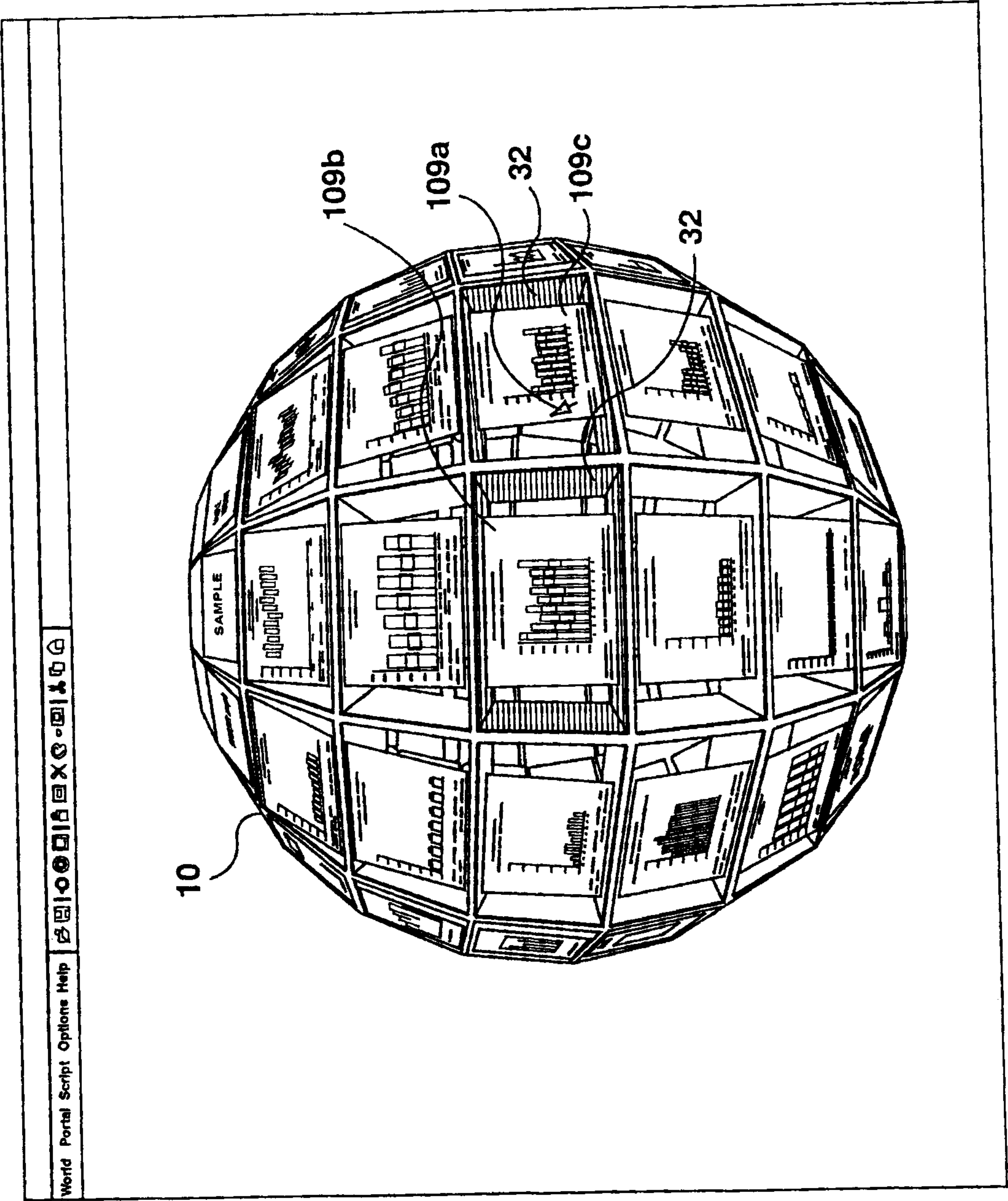


FIG. 8

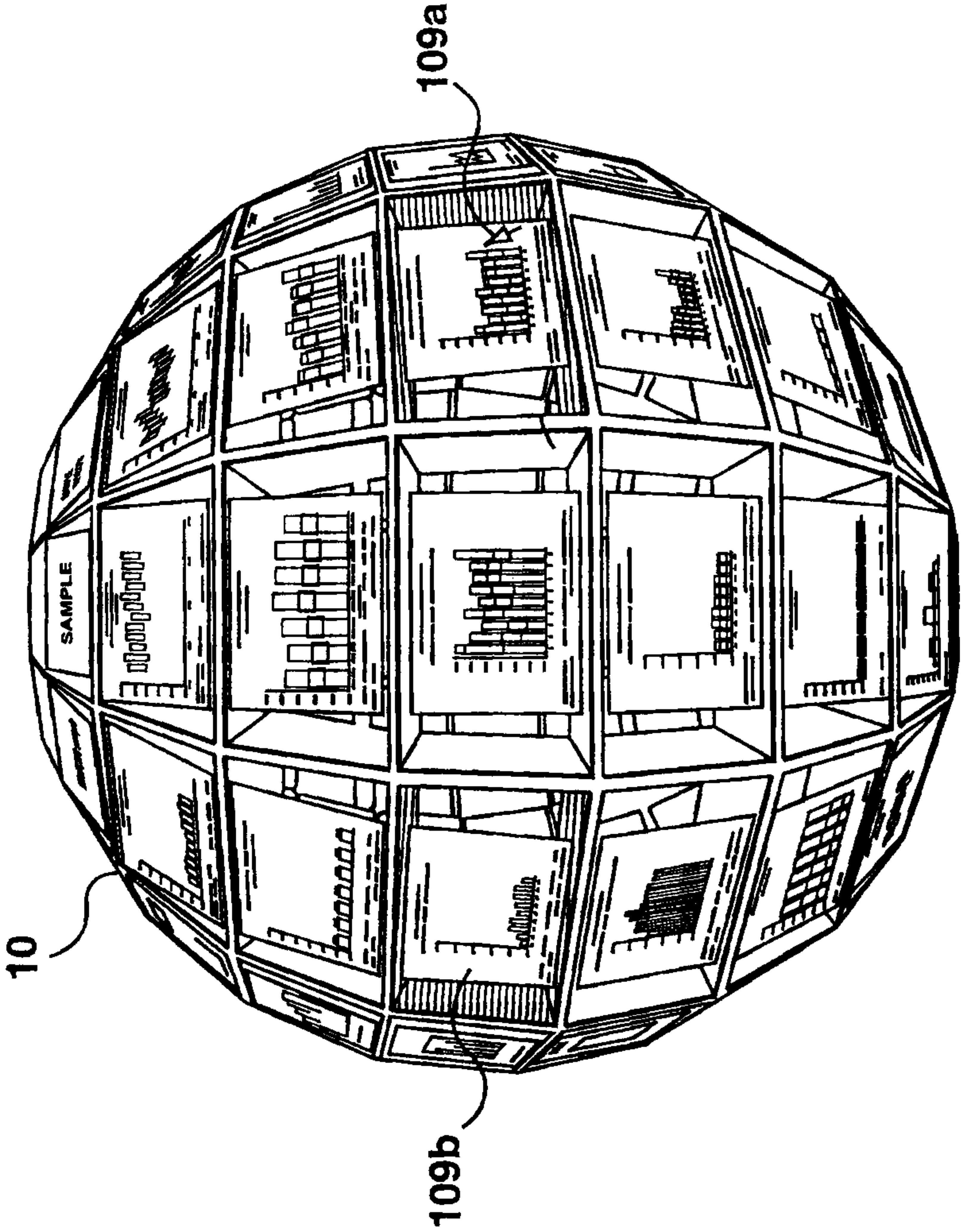


FIG. 9

10 / 17

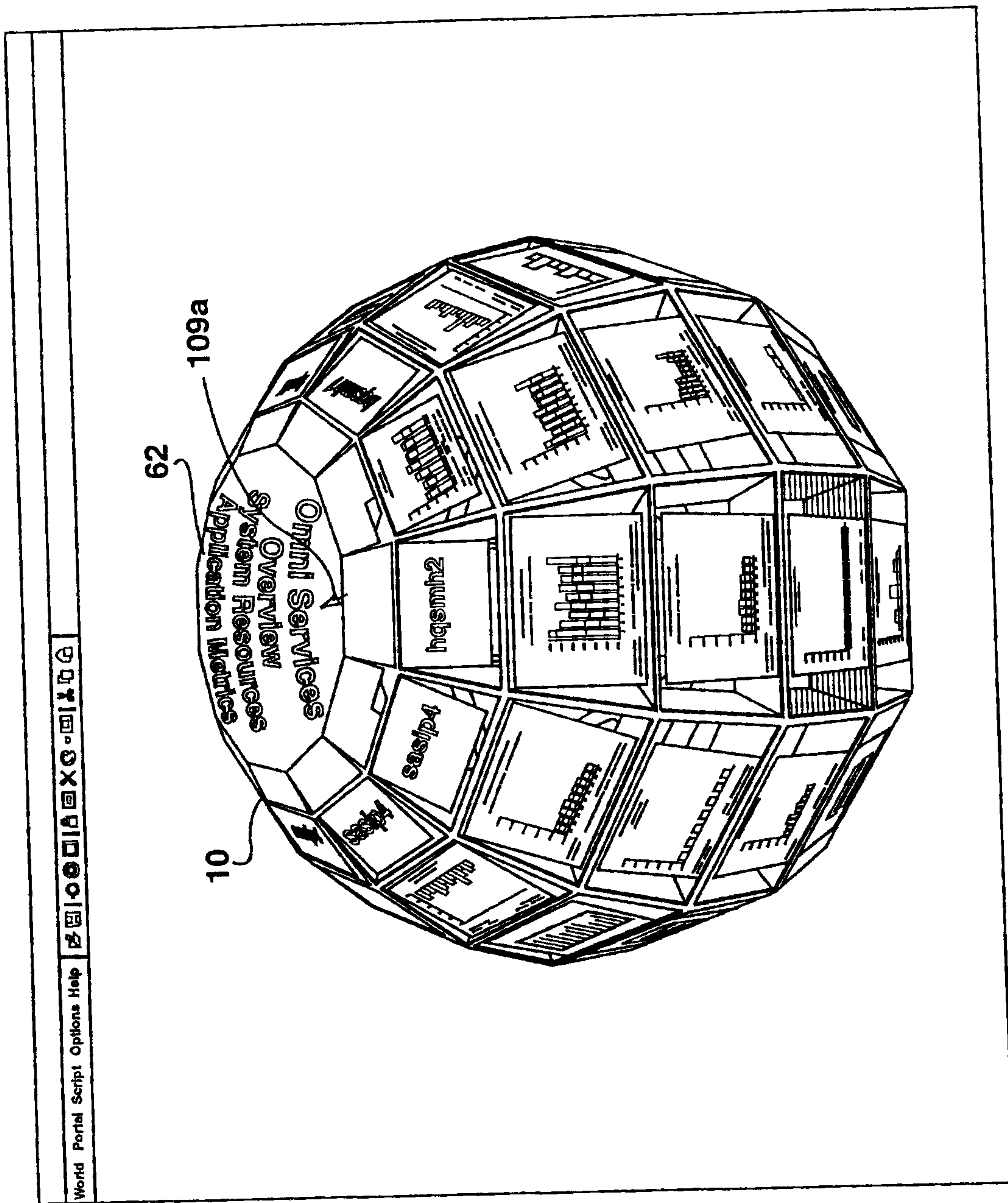
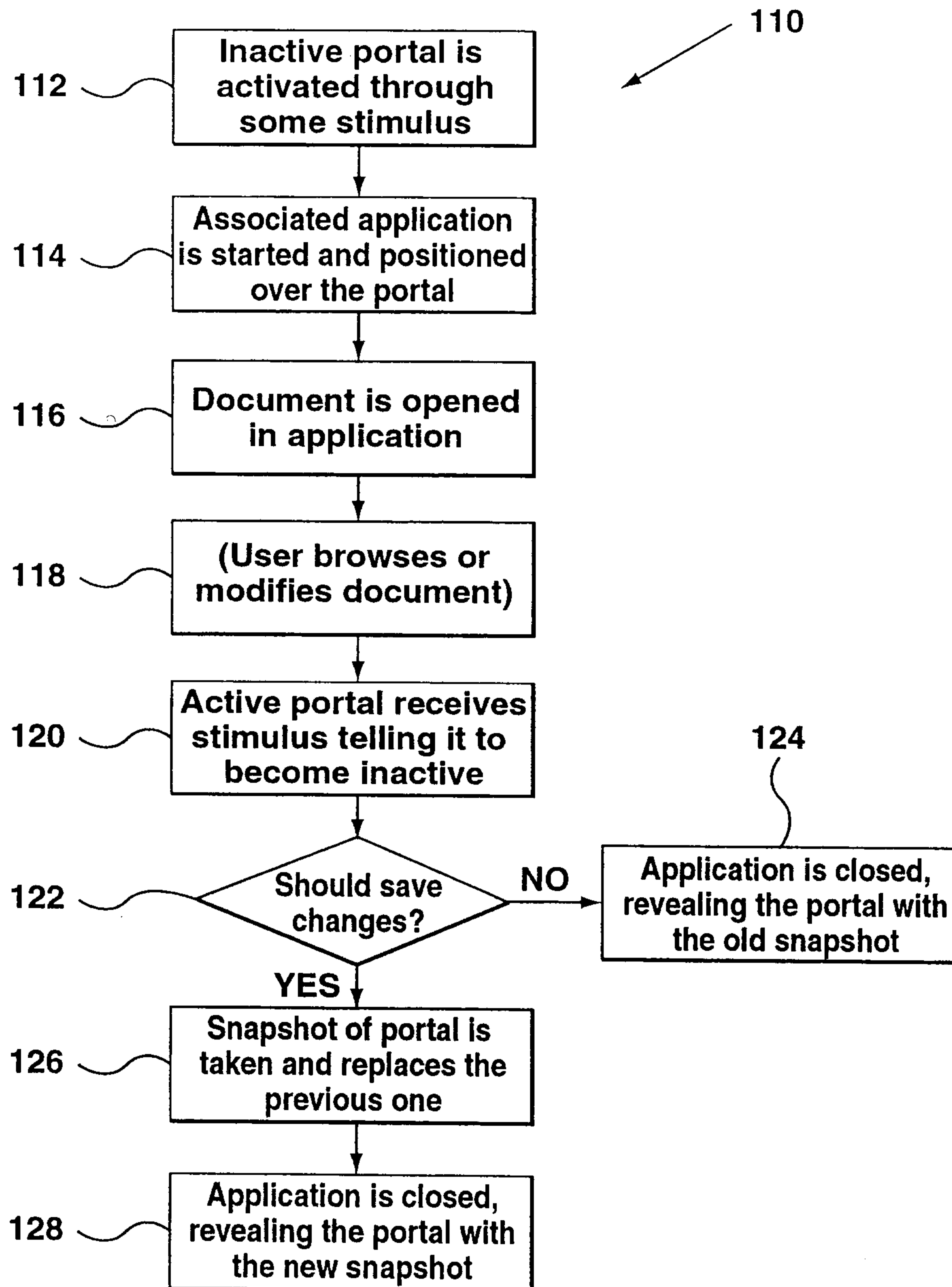
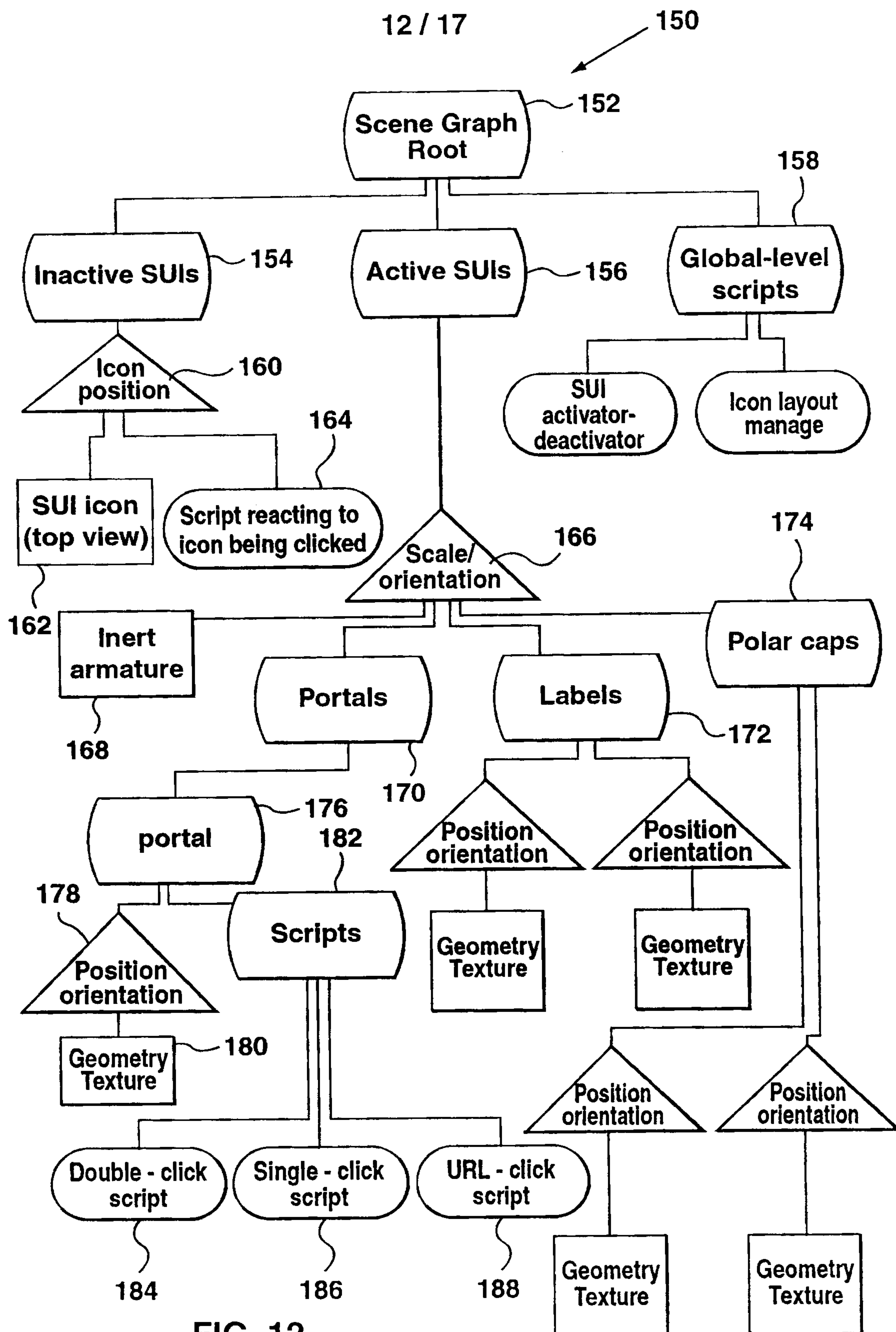


FIG. 10

11 / 17

**FIG. 11**



13 / 17

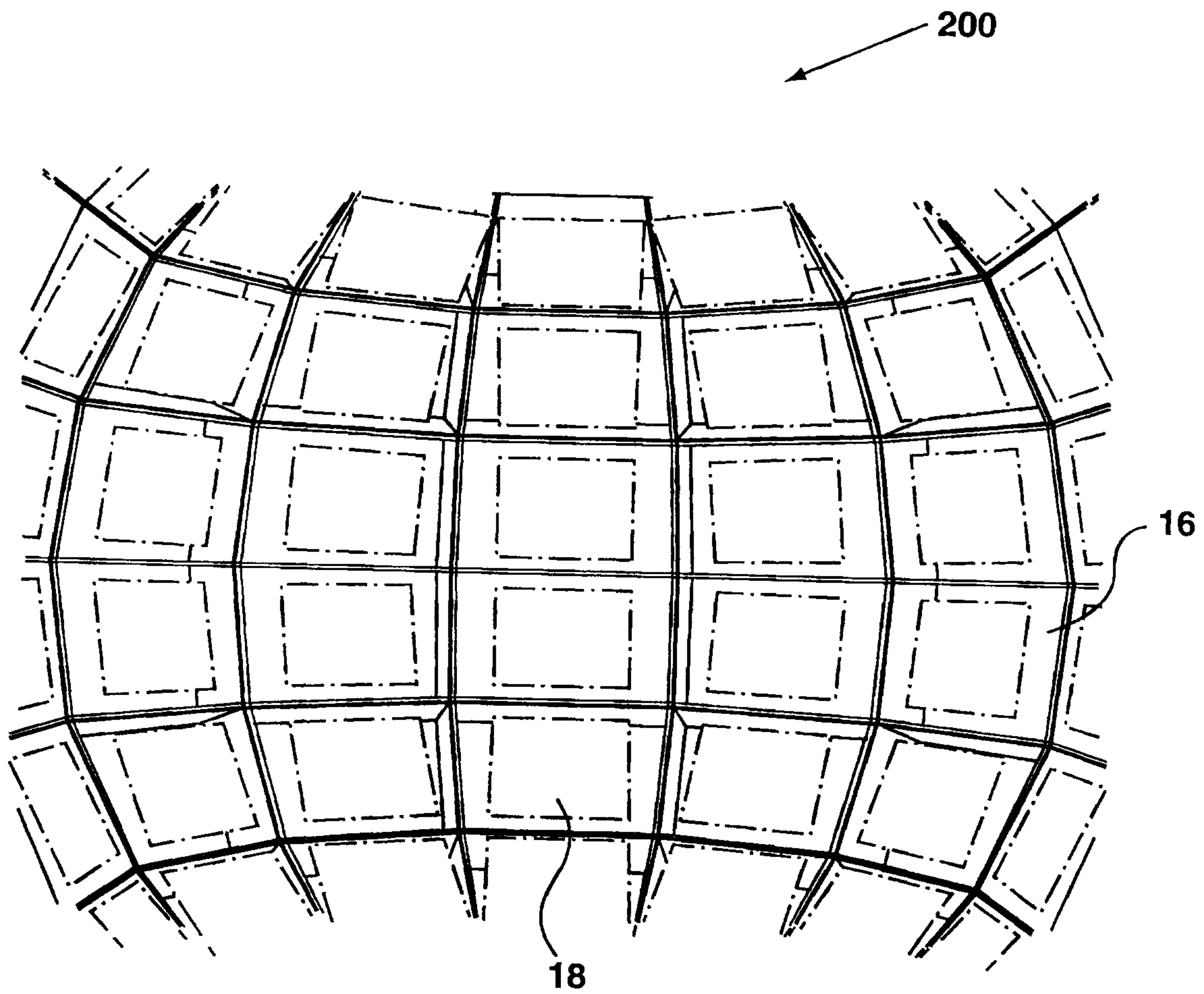


FIG. 13

14 / 17

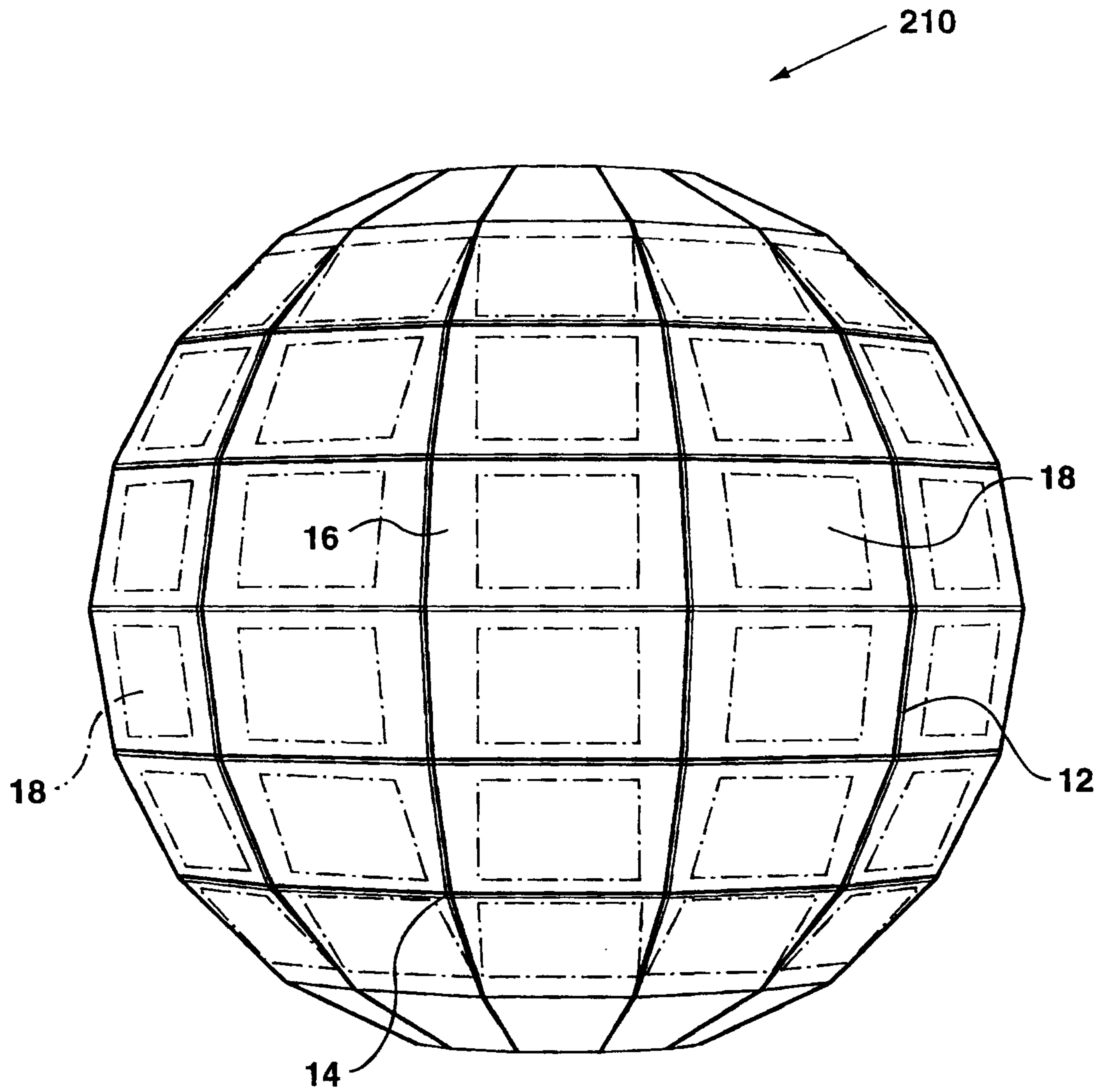


FIG. 14

15 / 17

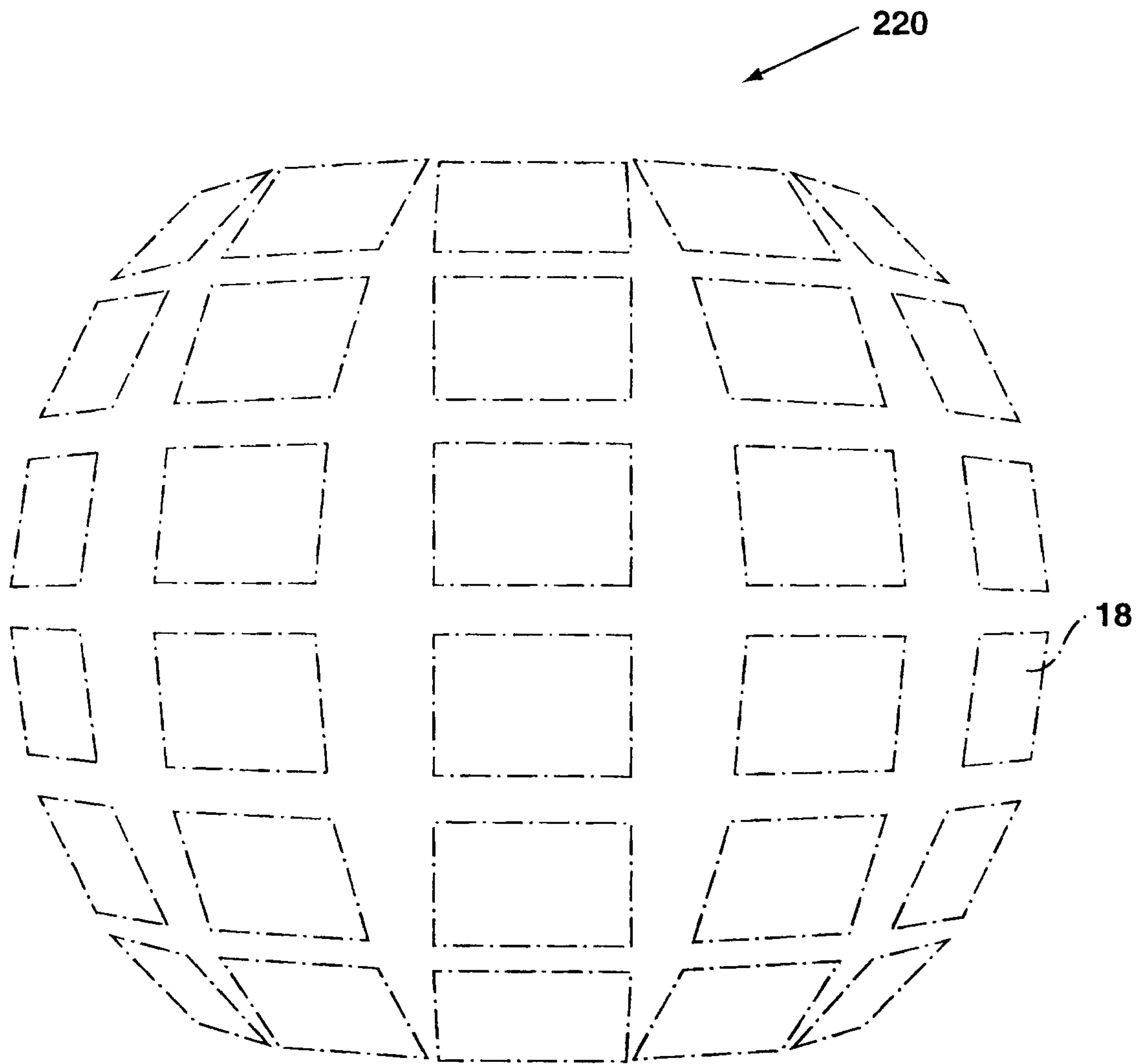


FIG. 15

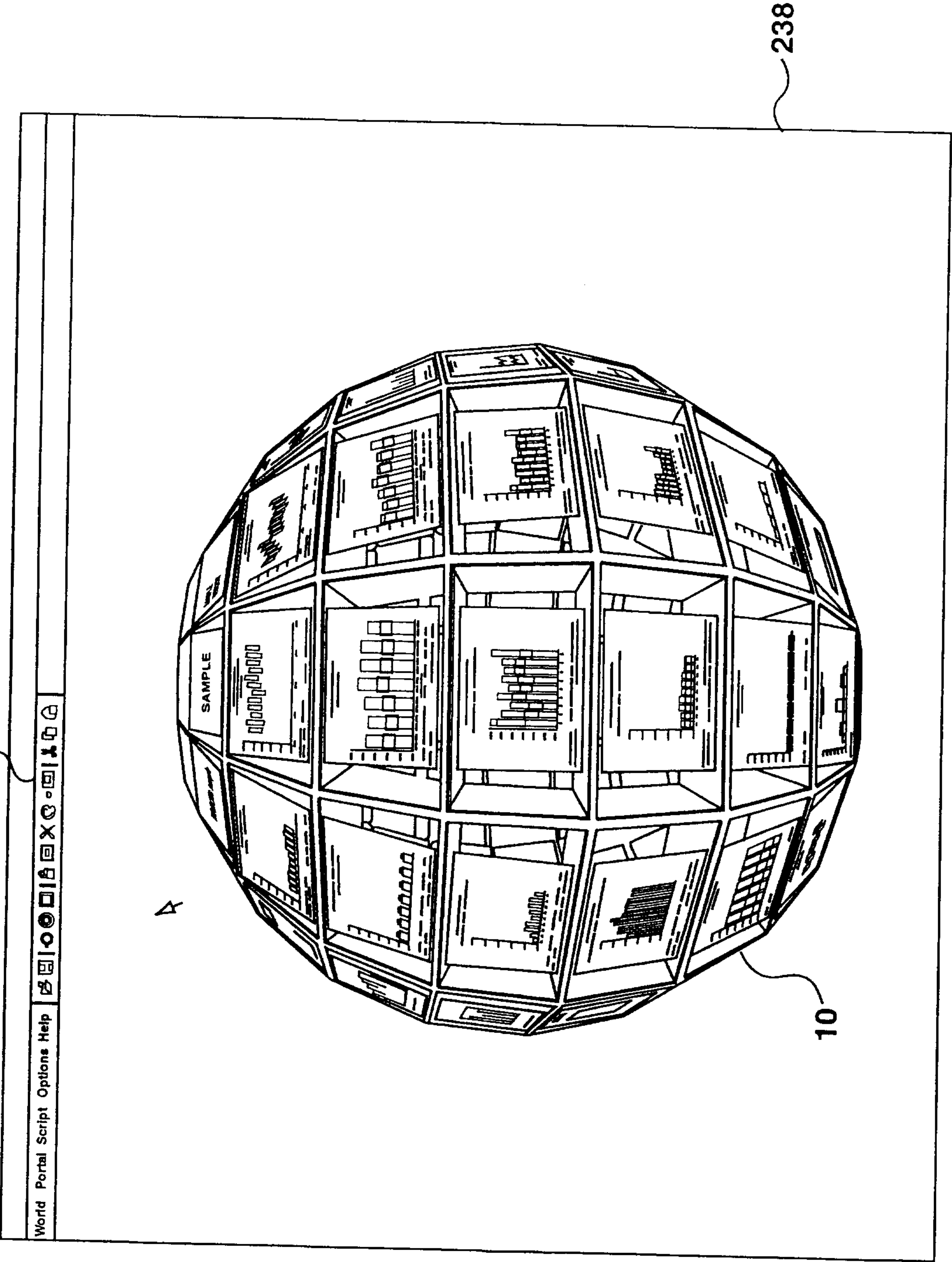
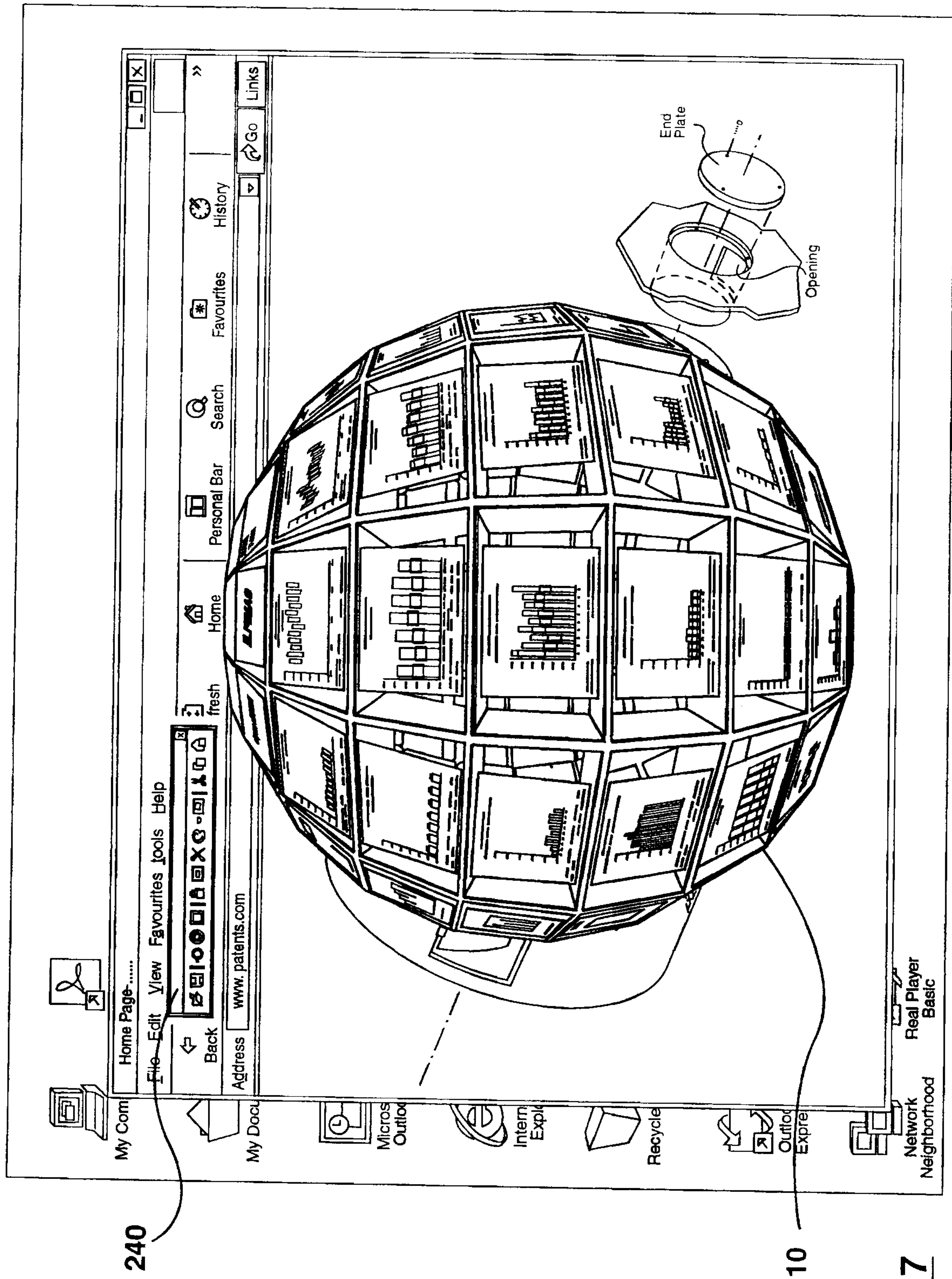


FIG. 16

17 / 17

**FIG. 17**

