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Inventor: Gendron et al.
Serial No.

PATENT APPLICATION
Navy Case No. 76,358

MOVING MAP COMPOSER (MMC)

A CD-ROM appendix containing the computer listing of algorithm resident in this invention is attached as APPENDIX I

BACKGROUND OF THE INVENTION

Field of the Invention

This invention pertains generally to a method and apparatus for displaying a selected geographic area on a video display and more specifically to the providing of a user-friendly graphical interface that defines a template and builds an aircraft optical disk image (AODI) from the data available within the given template's boundaries.

Description of the Related Art

The current techniques for defining and building an aircraft optical disk image (AODI) utilizes a specialized computer system to define and build map coverages. An AODI is an image file consisting of several groups, or subdirectories, of map tiles, or segments, that are arranged in hash tables. Each subdirectory is identified in an AODI superdirectory by its map scale and zone, and its starting address.

Rectangles are used to define the bounds of an area of

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desired coverage. If a nonrectangular area of coverage is desired, the current technique can only approximate the coverage. This is accomplished by using multiple rectangles of varying size. This technique does not provide an accuracy check to verify the exact latitude/longitude or row/column extent of the coverage. The extent of the AODI coverage is estimated by interpolating between the edges of the AODI coverage and the latitude/longitude markings on a base map. Although an approximated outline of the coverage bounds is available utilizing the current techniques, this outline reflects neither missing segments in the data nor does it show individual segments. Further, current techniques are capable of only defining map coverage in non-polar regions (below 51°N and above 51°S).

Present technology is capable of calculating the size of an individual subdirectory of an AODI. However, there is no current capability to determine the complete AODI size before writing the individual subdirectories to the aircraft optical disk (AOD). This reduces the ability to fully utilize all of the AOD space when a margin of error is included in the computations. Neither can polar data be defined, viewed, or created with the current mapstation technology. Although areas of coverage can be deleted or modified using the previously discussed rectangular method, there is no method of precisely adding or deleting individual

segments within a coverage.

If two data sources overlap and one of the sources is more current than the other, the current technology does not provide a means for controlling the order in which the data sources are selected for an AODI build. Once entered into a database, the data sources are stagnant and cannot be changed or replaced unless all data sources are relogged into the database. Utilizing current technology, each subdirectory is built, the subdirectory is written to the AOD, and then the subdirectory is erased from a computer hard disk and a new one built. The multiple subdirectories cannot be merged into a single AODI or saved to a computer hard disk.

SUMMARY OF THE INVENTION

The object of this invention is to provide an apparatus that can manipulate geographic data sets without directly handling the data itself.

Another objective of this invention is to provide a map display capable of being used in the polar regions above 51°N and below 51°S).

This and other objectives are accomplished by the moving map composer (MMC)which allows a user to manipulate different sources of map data into a single map for presentation on a display. The

MMC has an ability to extract a predetermined area of map coverage defined by sets of latitude and longitude points, rows and columns, or non-orthogonal areas of map coverage, the smallest of which is a segment. A bitmap is a representation of an available map coverage for a given area selected by a user by having a "set", or "1" bit to indicate a segment is present, and a "clear", or "0" bit to indicate a segment is missing. The size of the bitmap is determined dynamically to assure a two-bit buffer zone of clear bits around a polygon's maximum extent. If the user selected polygon crosses one or more map zones, the polygon is subdivided into several new polygons. Once the total map coverage desired has been defined, the available map sources are determined and the resulting subset is displayed, if the resulting coverage is acceptable, the user may transfer the data to the display.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a functional block diagram of the moving map composer system.

Figure 2 shows a flow chart of the construction of a bitmap.

Figure 3 shows a general operational flow chart of the moving map composer.

Figure 4 shows how to create a bitmap of the polygon.

Figure 5 is a flow chart showing how a vertex is input into a link-list.

Figure 6 is a flow chart showing how to create a bitmap of a polygon.

Figure 7 shows a polygon with the selected bitmap coverage.

Figure 8 is a flow chart showing how each bit in the bitmap corresponding to an available tile is turned on.

Figure 9 shows a depiction of the edge bits of the polygon turned ON.

Figure 10 shows a depiction of the edge bits of the bitmap turned ON.

Figure 11 shows a depiction of the seed bit for the flood-fill (set=1) of all bits between the outer edge and polygon edge.

Figure 12 shows the results of the flood-fill (set=1) of all bits between the outer edges and polygon edge.

Figure 13 shows the results of reversing all 0's to 1's and vice versa and re-setting the polygon edge bits to 1's.

Figure 14 is a flow chart of the `and' user-defined bitmap and available coverage bitmaps.

Figure 15 is a flow chart of the get data for each tile in the bitmap and construction of the final product.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A moving map composer (MMC) **10**, as shown in **Figure 1**, wherein the user is allowed to manipulate different sources of map data into a single aircraft optical disk interface (AODI) **24**. The algorithm contained within MMC **10** stores terrestrial mapping representations of available tiled data at pre-selected scales of worldwide coverage. By extracting only desired tiles (represented by user defined bitmaps), MMC **10** constructs a data image for specific areas of interest. MMC **10** uses its own specially designed bitmaps to represent the smallest indivisible unit (often referred to as a "segment" or "tile") of digitally scanned, geo-referenced map data and to depict the relationship between the units in a given data set. Arranged and grouped by the user, these units or segments graphically create an image by allowing the user to design polygons representing relatively large areas or to add or subtract individual tiles from a bitmap in memory.

Although MMC **10** was originally developed to build AODI's for a moving-map display in a specific aircraft, it can readily be applied to any system that requires raster or gridded map data. Available predetermined area representations of map coverages via bitmaps stored in a first storage means **12**, such as a CD-ROM,

magneto-optical device, computer hard disk, or a magnetic tape, in a digital format, are read by a reader **14**. The areas read by the reader **14** are defined by sets of latitude and longitude points, rows and columns, or non-orthogonal areas of map coverage manually selected, and consist of many map data files. The smallest element of map coverage is a single map data file, known as a segment, which consists of 256 x 256 picture elements, or pixels. A bitmap is used to represent an available map coverage for a given area having a "set", or "1" bit indicates a segment is present and a "clear", or "0" bit indicating a segment is missing. This may be accomplished utilizing a computer language such as "C"-based X-Windows/MOTIF. In such a program, the bitmaps are "C" bit structures, allocated contiguously. The size of the bitmap is determined dynamically to assure a two-bit buffer zone of clear bits around a maximum extent of a polygon. The two-bit buffer zone allows the MMC **10** to traverse through the true interior of the bitmap without encountering an "edge" bit (a set bit indicating a segment on the extreme of the bitmap). Therefore, each bitmap can be equated to a row/column or latitude/longitude pair.

Each digital bitmap, also called a template, stored in the storage means **12**, is identified by a source identification for the data retrieval. The first sixteen bytes in each bitmap

identifies the four bounding vertices of a bitmap. The minimum and maximum row/column are listed as long words of four bytes each. If the minimum column is greater than the maximum column, this indicates that the data crosses 180 degrees longitude. Following the first sixteen bytes in a bitmap is an array of "C" bit structures identifying the status (either present or missing) of all of the segments within the bounding vertices.

The preferred polygon selection means **16** for setting forth the bounds of a desired map coverage is a computer "mouse" input device, however, other forms of input devices such as a computer keyboard may be used. The preferred method of polygon selection is known as the "draw polygon" feature. The preferred base map database for the "draw polygon" feature is the World Vector Shoreline (WVS) which allows a display as either the polar or Mercator projections, however, any form of mapping technique may be utilized. The WVS base map is subdivided into map zones and zone bounds to be used are defined by the map database being used (in this case, Compressed Aeronautical Chart developed by the Map Data Formatting Facility (MDFF) at the Naval Research Laboratory (NRL), Washington, DC.; SEE, Lohrenz et al., THE NAVY TESSELLATED SPHEROID MAP PROJECTION SYSTEM: A COMPREHENSIVE DEFINITION, N.L./FR/7741--92--9408, Aug, 11, 1993). However, these map zones are transparent to the user. If the user inputs a polygon that crosses one or more map zones, the MMC **10** automatically

subdivides the polygon into several new polygons -- one per map zone. When the MMC **10** has subdivided a polygon, a list of polygon vertices for each applicable map zone is built. A computer **18** then uses each list of polygon vertices to set bits for an AODI **24** build, according to the scale of the map data selected, using a recursive flood-fill algorithm.

Once the total map coverage desired by the user has been defined, the MMC **10** determines what available map data sources fall within the desired map coverage area. The resulting subset of available coverage is displayed on a display means **22**, such as a video monitor. If the resulting coverage is acceptable to the user, the user can transfer the data to an AODI **24**.

This invention allows a user to specify orthogonal or non-orthogonal coverages using latitude/longitude pairs entered via the keyboard or by utilizing a "mouse" **16**. Coverages defined via the mouse are created by clicking the vertices of any desired polygon or by an orthogonal stretch box. With strict size limitations of the AODI **24**, design time is minimized and AODI **24** space limitations can be minimized. Once the vertices of the desired coverage have been input, the MMC **10** can determine the exact latitude/longitude or row/column extent of the coverage and any missing segments within the coverage bounds are reflected.

The exact size of the AODI **24** can be calculated at any time. Therefore, any adjustments due to size limitations can be corrected before proceeding with the task of the MMC **10** build. Polar data can be defined, viewed, and created using all of the available methods employed by MMC **10** and at any time during the design phase, segments in the desired map coverage may be added or deleted.

MMC **10** allows the user to select the order of map sources utilized in the building of the AODI **24**. In this way, updated map segments may be used in place of older map segments of the same coverage. However, the invention is flexible enough to allow the user to select the older map segments if desired. The MMC **10** allows for the creation of hard copies through the use of a recordation means **26**, such as a printer. The printout may include such items as the creation date, AODI **24** name, aircraft optical display (AOD) identification, map scale, and AOD side. Also the latitude/longitude grid interval may be provided on the printout. However, the final AODI **24** is plotted with individual segments against a world map (WVS) background. Multiple AODIs **24** may be merged into a single AODI **24** (prior to final build) within the MMC **10**.

MMC **10** uses two fundamental types of bitmaps: actual-data bitmaps and user defined bitmaps. Actual-data bitmaps are exact representations of existing digital map data, (e.g. all available coverage of Digital Terrain Elevation Data in a specific geographic region). Segments in an actual-data bitmap are stored as geo-referenced map data on a CD-ROM, or other data-storage device **12**. User-defined bitmaps are desired areas of coverage, which MMC **10** converts to bitmaps when ANDing them with actual-data bitmaps. The algorithm keeps track of the data sets that comprise each bitmap and allows the user to add new data sets or delete existing ones. The algorithm provides continuous file-size information while the user is custom-building areas of digital map data, as well as a complete summary of the final image.

Zoom functions and overlays, such as World Vector Shoreline (WVS) and political boundaries from the National Imagery and Mapping Agency (NIMA) support the image design process. MMC **10** uses these products to display a world map over which the user can specify the area(s) of interest by either entering precise latitude and longitude coordinates, boxing in a rectangular area, or drawing a polygon area. MMC **10** allows the user to define these areas independent of any geographical zones that might be inherent in the source data (e.g., Polar, Temperate, and

Equatorial zones in various scanned map data sets). These zones are transparent to the user, so areas of interest do not need to be defined on a zone-by-zone basis.

The MMC **10** graphical user interface (GUI) efficiently and accurately represents both available and requested map data coverages. An important step towards building a final image is prompting the user to extract predetermined areas of interest from a global data set and then incorporating these areas into the final image. The area of interest may not always be a subset of the map data available. For this reason, MMC **10** maintains bitmaps of all available data in order to decide which desired map data segments exist and which do not. The area may contain data from one or more map data sources. MMC **10** keeps track of which map segments came from which data source and allows the user to add, subtract, and priortize data sources for the final image builds.

An integral part of the MMC **10** is the use of a dynamic one-dimensional structure of bits, indexed as a two-dimensional map, which is referred to as a bitmap. One bit location in the bitmap represents one map tile. Simply, if the bit is ON (set=1), then the map data tile is present, I.E., available on CD-ROM or some storage device. If the bitmap is OFF (set=0), then the tile is not available. The advantages of using bitmaps are that actual

map data does not have to be manipulated or read until the final image is built, so the computer **18** memory and data storage requirements are extremely small during the design phase of an image build. Each bitmap has a total number of bits associated with it, defined by a total number of rows and a total number of columns. MMC **10** indexes the bitmap by each bit's row and column values, which are easily determined by a simple index formula. Before building a new bitmap, MMC **10** determines the range of map data to be represented as a minimum bounding rectangle (MBR). MMC **10** then creates an initial bitmap just large enough to hold this MBR plus a 2-bit buffer zone on all sides.

The bits within the 2-bit buffer zone will never represent actual map data, but they are present for two reasons: first, when all the bits in the buffer zone are OFF, the buffer zone prevents any algorithms from erroneously crossing the bounds of a bitmap, thereby eliminating the need for time-consuming bounds checking. Secondly, the buffer zone aids in the filling of polygons within the bitmap itself.

MMC **10** facilitates the building of polygons consisting of row and column tiles to create any shaped area of coverage. N-1 vertices of a given polygon are entered by either clicking on the desired point corresponding to a vertex, or entering the vertex's coordinate pairs [latitude, longitude]. Each vertex is processed

by the algorithm and stored in a record that is added to a link-list containing all the vertices. The first vertex in the list corresponds to the first vertex entered by the user. The last vertex in the list, which is the same as the first, is not entered by the user. Instead, MMC **10** automatically places the last vertex in the list to close the polygon with a total of N vertices via a double mouse click at N-1. The vertex record contains the [latitude, longitude] values of the vertex and a crossing flag.

The crossing flag denotes whether any polygon lines cross 180 degree longitude. When the user selects the first vertex (V1) of a new polygon, that vertex's crossing flag (F1) is assigned a value of 0. When the user selects the second vertex V2), MMC **10** determines whether the vector V1 -- V2 crosses 180 degree longitude. If it does not, the F2 (the crossing flag for V2) is given the same value as F1 (in this case 0). If the vector does not cross 180 degrees, then F2 is "toggled" and given a value that is the binary opposite of the preceding vertex's flag (in this case, F2 is toggled from 0 to 1). This process is repeated for each vertex in the polygon (V1 through Vn), such that for any vertex Vx, if the vector V*-1 -- Vx does not cross 180 degrees longitude, then Fx = F *-1; otherwise, Fx = **toggle** (F*-1), where **toggle** (0) = 1 and **toggle** (1)=0. Later, when

traversing the list of vertices, if MMC **10** finds a difference between the crossing flags of two adjacent vertices, then a crossing has occurred; if not, then no crossing has occurred.

Once all n vertices of the desired polygon have been placed in the link-list with the correct crossing flags, a routine is called to fill in the polygon. The polygon is filled by first "setting" the edge bits of the user-defined shape, where "setting" a bit means assigning it a value of 1 (the default pre-set value is 0). Next, all the outermost bits of the buffer zone surrounding the polygons MBR are set. Every other bit in the bitmap should be 0.

Next a recursive flood-fill algorithm is used to set all the bits between the shape's edge bits and the outermost edge bits. The bit in location [1,1], which is one bit up from the first row and one bit from the first column, is used as the seed for the fill. This bit always lies within the buffer zone and is therefore never set prior to the flood-fill operation. All bits of the entire bitmap are then toggled. Finally, the polygon's edge bits are set again. This procedure produces a completely filled polygon every time, and the polygon can now be viewed on the display **22**.

The CAC is derived from Defense Mapping Agency (DMA) ARC (Equal Arc-second Raster Chart) Digitized Raster Graphics (ADRG),

which consists of full-color charts that have been scanned into 100-μm pixels. Each pixel consists of a red, green, and blue (RBG) component. The MDFF "downsamples" ADRG data from 100-μm (which provide an image resolution of 254 ppi (pixels per inch) to approximately 200-μm pixels (exactly 128 ppi), which results in a 4:1 reduction in data storage requirements. The lower resolution data are then color-compressed by a factor of 3:1 and, finally, spatially compressed by a factor of 4:1. (SEE, Lohrenz et al., COMPRESSION OF SCANNED AERONAUTICAL CHART DATA IN SUPPORT OF NAVAL AIRCRAFT DIGITAL MOVING MAP SYSTEMS, IEEE Data Compression Conference, Snowbird, UT, April 1991.) The final CAC product represents a data storage compression of 48:1 over the original ADRG.

CAC is stored in a seamless, global database; for example, a CD-ROM, such that the transition from one source chart to another is transparent to the pilot. The data are stored in discrete 51 mm^2 (2 $in.^2$) sections of chart, called tessellations or segments, which cover the entire globe; the model is known as a Tessellated Sphere. Approximately four chart segments may be projected onto one digital moving map display at one time. SEE, Lohrenz et al., THE NAVY TESSELLATED SPHEROID MAP PROJECTION SYSTEM: A COMPREHENSIVE DEFINITION, N.L./FR/7741--92--9408, Aug, 11, 1993) which is hereby incorporated , in total, by reference, into this document.

Construction of the bitmaps is accomplished by retrieving the CAC information from the seamless, global database utilizing the Log Available Coverage program **30**, as shown in **Figure 2**. Upon starting the program **32**, the FIND_FILE **34** operation finds the available map data files from the seamless, global database stored in an off-line source. The LL_MAXMIN_RET **36** operation determines the latitude and longitude of the data by determining the minimum bounding rectangle (MBR) of the available map data sources. A bitmap large enough to hold the data is then created in the [DATA]_BITMAP CREATE function **38** wherein the map data specific bitmap parameters (e.g., cell size): [Data] = any gridded or raster data set (e.g., CADRG, DTED, etc.) are defined. From this information, the DETERMINE_NUM_ROWS_COLS function **42** is used to determine the number of rows and columns (including the 2-bit buffer) for the entire bitmap. The bitmap is then created inside the BITMAP_CREATE FUNCTION **44** by allocating memory. All of the bits in the bitmap that correspond to the available tile data (data is any raster or gridded product) are turned on (Set=1) by the BUILD[DATA]_BITMAP function **46**. The bitmap is then saved to a storage device by the BITMAP_IO_SAVE FUNCTION **48**. Once the bitmap has been saved, the operation is stopped **52** until it is required by the user.

A general operation of the algorithm within the MMC **10**, as shown in **Figure 3**, begins with the user starting the program **54** by defining the desired polygon in the DEFINE POLYGON function **50** by "pointing and clicking" on a base map screen the points forming the exact coverage desired. This may be a random point-to-point section, a rectangle, latitude and longitude, or any multiple points. A CREATE BITMAP OF POLYGON function **70** sets (Set=1) all the tiles within the defined polygon thereby creating the selected bitmap. The tiles actually available are entered into memory, tiles that are not available may be those not defined in the storage medium by a bitmap, such as ocean areas or land masses where no map data is available in a usable format (those areas where no data in a raster data base are available). The calling of the tiles from on-line or off-line memory allows for minimum storage for bitmaps within the operational system forming the MMC **10** system. The `AND' USER-DEFINED BITMAP WITH AVAILABLE COVERAGE BITMAP(S) function **90** looks at each bit representation of a tile. If the tile is present the bit will be kept (set to "1"). If not available, the bit will be cleared, or set to"0". The algorithm only keeps the polygon bits for which data is available. If more coverage or importation of additional bitmaps is desired, the "YES" function of FINISHED DESIGNING COVERAGE **64** returns the program to the DEFINE POLYGON function

56. The information obtained by this operation is data independent. The additional coverage desired may be of a different scale, area, etc. If no additional coverage is desired, each bit forming the polygon obtained from the storage medium (tiles or raster data cells) are obtained and made resident in the GET DATA FOR EACH TILE IN EACH BITMAP function **100**. The tiles are combined as a final product by the COMBINE DATA TILES INTO FINAL PRODUCT function **110** in the aircraft optical disk, a mission planning data base, or displayed on a display device **22**. The algorithm then ceases operation with the STOP function **72**.

The size of the area described within the polygon is not important, neither is the scale of the retrieved information, it may be multiple layers of tiles of different scales of data pertaining to the same location.

Upon starting the program **54**, the DEFINE POLYGON function **50** (as shown in **Figure 4**) initializes a link-list to store user defined polygon vertices which links tile structures (nodes) together. The beginning of the list points to the first node which points to a second node, etc. As you add node you are dynamically adding memory. The number of nodes that may be linked together is only limited by the random access memory

(RAM). The position of a vertex of a polygon is defined in the HANDLE_BUTTON_PRESSES function **62** by its latitude/longitude position. The user identifies a vertex of a polygon by "pointing" and "clicking" or by entering the desired latitude/longitude of the vertex. Once the coverage of the polygon has been defined by the user, the vertex is inserted into the link-list in the POLYGON_SEND function **90**.

Each vertex is inserted into the link-list within the POLYGON_SEND function **90.** The X-Y pixel, or latitude/longitude values are input to the POLYGON_SEND function **68** (as shown in **Figure 4**) and then processed in a CALL DETERMINE_SIDE_OF_180 function **72** to determine if the line from the previous vertex to the current vertex crosses 180° longitude. If the user has selected one side of 180° (the left) the algorithm arbitrarily assigns a "0" value to the bit, if the user has selected the other side of 180° (right) the bit is toggled to a "1". The algorithm then knows which side of the 180° longitude the reference point refers to by the appearance of a "0" or "1" bit. If there is no crossing of the 180°, the bit retains its original value. The pixel is then converted to latitude/longitude by the PIXEL_TO_LL function **74** converting the screen X-Y pixel location to a reference point that relates to the bitmap. Nodes are then

allocated in the link-list and the values of the DETERMINE_SIDE_OF_180° function **72** and PIXEL_TO_LL function **74** are inserted into the algorithm in a POLYGON_GET_VERTEX function **76**. The vertex comprising the last element in the link-list is then inserted in a INSERT_VERTEX_LAST function **78** and the computation sequence of the POLYGON_SEND function **90** is completed. If more vertices are desired to expand or contract the size of the previously selected polygon **66** the program is referred back to the HANDLE_BUTTON_PRESSES function **62** for redefinition of the polygon and thereby making the wants of the user more definitive.

If no more vertices are desired, the sequence is passed to the CREATE BITMAP OF POLYGON function **70** where a bitmap is created that is large enough to accommodate the polygon in a [DATA]-BITMAP_CREATE function **82** (as shown in Figure 6). This is done by determining the number of rows and columns based on the difference in latitude (ΔLat) and the change in longitude (ΔLong) within the selected polygon in a DETERMINE_NUM_ROWS_COLS function **84**. The bitmap is then created from the numerical input of rows and columns in a BITMAP_CREATE function **86**, as shown in **Figure 7**.

The bitmap corresponding to an available tile (data is any raster or gridded product) is then turned on (set=1) in a

POLYGON_SIDES function **92**, (as shown in **Figure 8**) where the edge bits of the bitmap (as shown on **Figure 9**) and the edge bits of the polygon (as shown in **Figure 10**) are turned ON that correspond to the edge of the polygon in a POLYGON_DRAW_SIDES function **92**. The two outermost bits (with the outermost bit set to 1) are drawn so as to create a space for the outer edge of the polygon. Then in the POLYGON_FLOOD_FILL function **94** the flood-fill is set at 1 for all bits between the outer edge (as shown in **Figure 11**), this provided a fast and easy way to fill in the polygon without knowing any point inside of the polygon. Also, all bits are toggled in the bitmap (reverse all 0's and 1's) so as to reverse the polygon. Then the edge bits are redrawn in the CALL POLYGON_DRAW_SIDES function **96** and all edge bits of the polygon are set to 1. This results in a user-defined polygon bitmap with all required bits set to 1. When this operation is completed, the process is passed to the FIND_FILE function **88**. The FIND_FILE function **88** finds all the available coverage bitmaps previously logged in MMC **10**(See **Figure 2**). The BITMAP_COPY FUNCTION **92** makes an exact copy of the user-defined polygon bitmap. The BITMAP_AND function **94** logically "AND's the copy of the user-defined polygon bitmaps with all the available coverage

bitmaps found by the FIND_FILE function **88** (See **Figure 14**). A logical "AND" 5turns off (OFF≈0) all bits that are not common between user defined and available bitmaps. Once the "AND"ing process is complete, the resulting bitmap may be input to a [DATA] BITMAP_RC_INIT function **98** which actually goes and gets the data for each file input to the bitmap of available coverage. The algorithm returns the next set (=1) bit in the bitmap that are set, one at a time, in a [DATA]BITMAP_RC_RET function **102**. In a [DATA]_GET_SEGMENT_FROM_RC function **104**, the program goes to storage medium having the actual data and gets the tile (data) from the medium that corresponds to a particular bit in the final bitmap. Each bit in the final bitmap is processed via the [DATA]BITMAP_RC_RET function **102**. After all bits of a bitmap are processed and another bitmap exists (**108**) then the sequence is returned to the [DATA]BITMAP_RC_INIT function **98**. If no other bitmap exists, the data tiles are combined into a final product **70** and sent to a display means **22** for utilization by the user.

By storing only a representation of the available data and extracting only the required tiles, a means is provided for defining a coverage based upon a user selection. This allows large amounts of data to be represented in a very compact manner.

The advantages of this invention are that exact orthogonal

or non-orthogonal coverage may be specified using latitude/longitude pairs entered via the keyboard or by utilizing the `mouse'. With the strict size limitations on the airborne AOD, design time is minimized and the AOD space limitations may be minimized. Further, the exact size of a subdirectory, can be calculated at any time, therefore, any adjustments due to size limitations may be corrected before proceeding with the time-consuming task of the AOD image build. Polar data may be defined, viewed, and created using all of the available methods employed by the MMC **10**. At any time during the design phase, segments in the desired map coverage may be added or deleted. MMC **10** allows the user to select the order of map sources used in the building of the AODI **24**. In this way, updated map segments may be used in place of older map segments of the same coverage. However, the algorithm is flexible enough to allow the user to select the older map segments if desired. Any latitude/longitude grid interval may be chosen for a hard copy and plotted with individual segments against a world map (WVS) background.

This invention has been described in terms of an aeronautical environment, however, the principles set forth are applicable to such processes as inventory control or chemical processes to determine occurrences at certain points in the

process, or any other application where raster information can be developed or is available. Those skilled in the art that still other variations.

Although the invention has been described in relation to an exemplary embodiment thereof, it will understood by those skilled in the art that still other variations and modifications can be affected in the preferred embodiment without detracting from the scope and spirit of the invention.

ABSTRACT

The moving map composer (MMC) is a device that allows a user to manipulate different sources of map data into a single map for presentation on a display. The MMC has an ability to extract a predetermined area of map coverage defined by sets of latitude and longitude points, or non-orthogonal areas of map coverage, the smallest of which is a segment. A bitmap is a representation of an available map coverage for a given area selected by a user by having a "set", or "1" bit to indicate a segment is present, and a "clear", or "0" bit to indicate a segment is missing. The size of the bitmap is determined dynamically to assure a two-bit buffer zone of clear bits around a polygon's maximum extent. If the user selected polygon crosses one or more maps, the polygon is subdivided into several new polygons. Once the total map coverage desired has been defined, what available map sources are determined and the resulting subset id displayed, if the resulting coverage is acceptable, the user may transfer the data to the display.

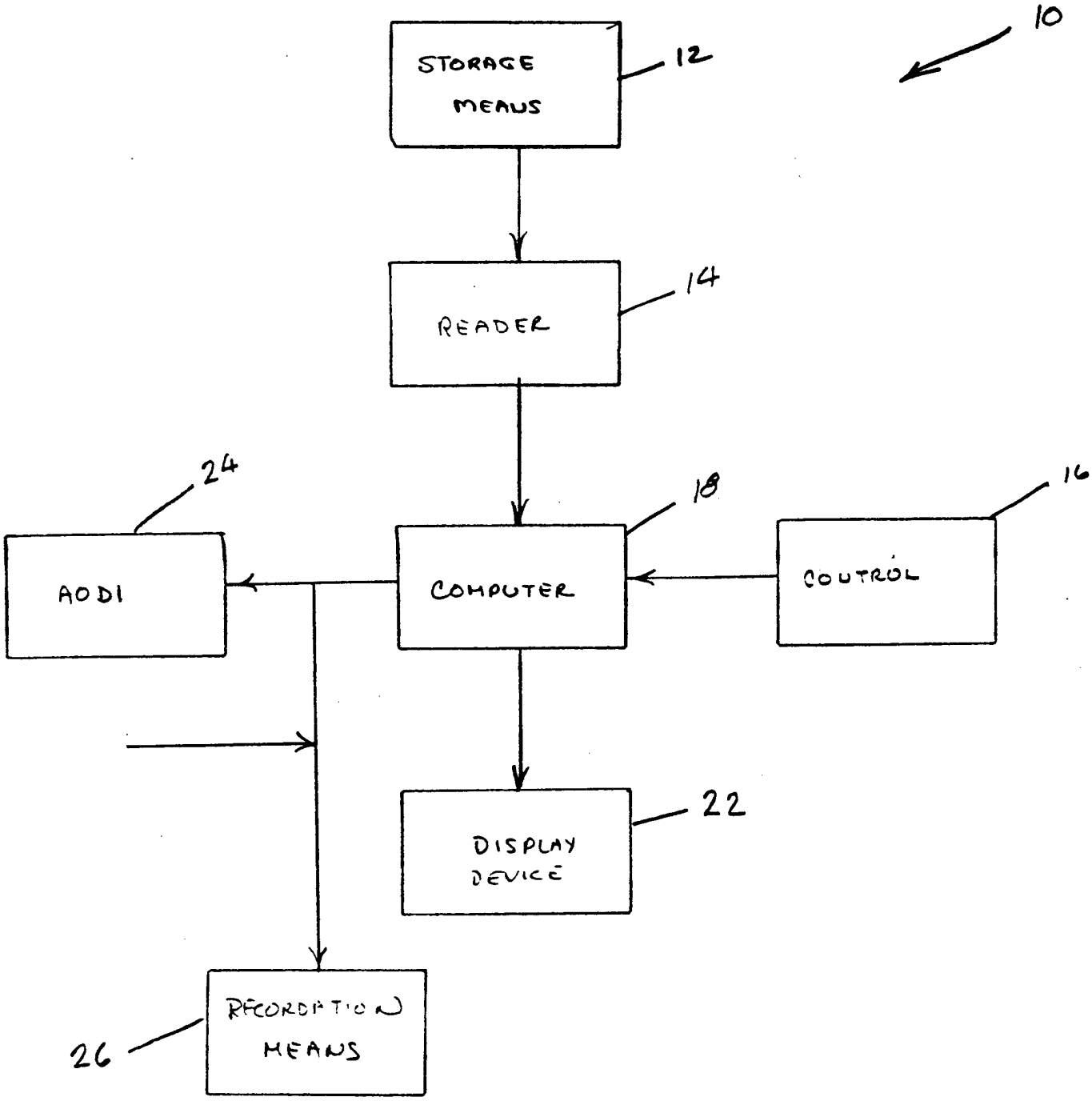

10
STORAGE MEANS
12
READER
14
24
18
16
AODI
COMPUTER
CONTROL
DISPLAY DEVICE
22
RECORDATION MEANS
26

FIGURE 1

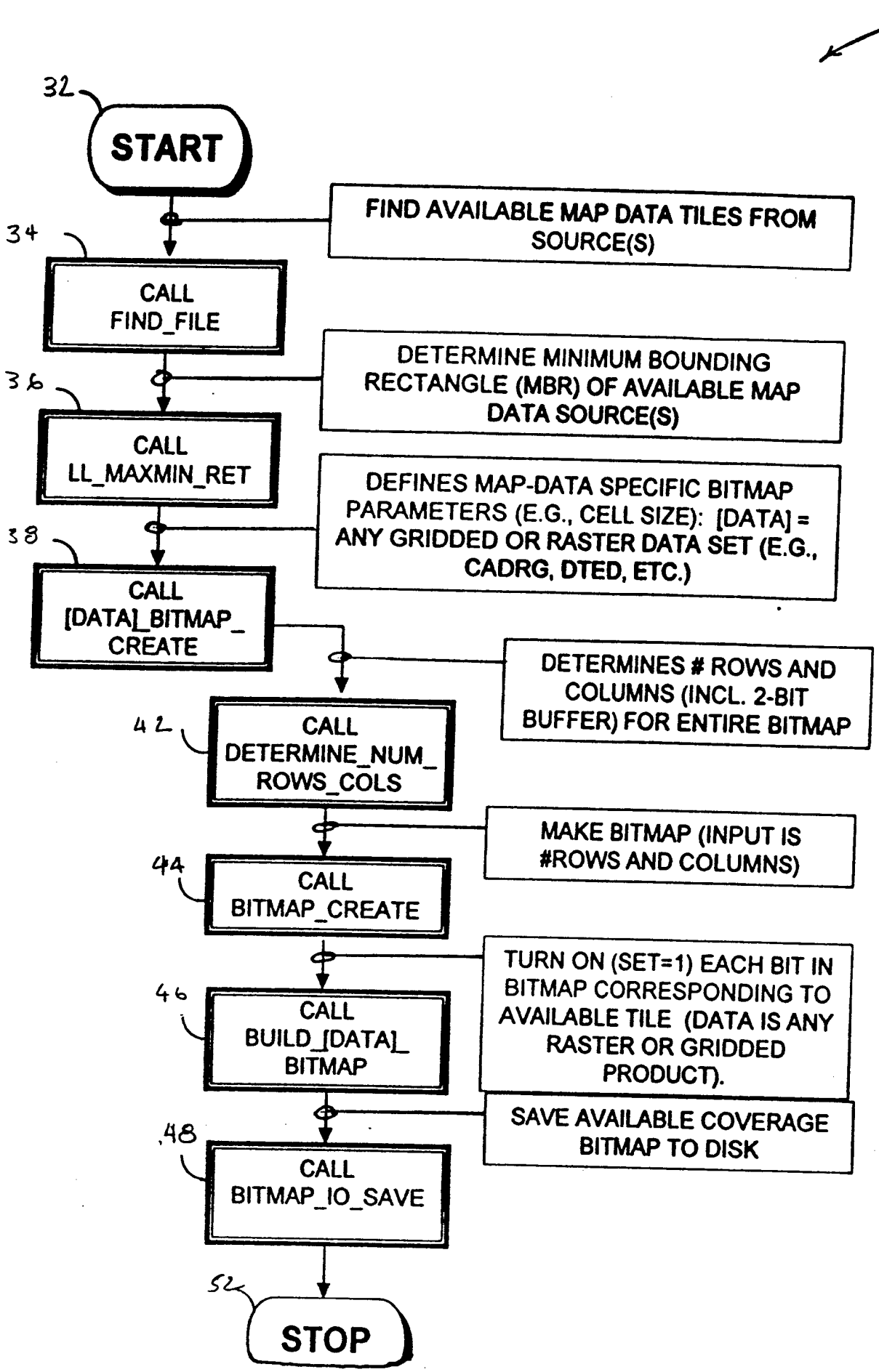

3C
32
START
FIND AVAILABLE MAP DATA TILES FROM SOURCE(S)
34
CALL FIND_FILE
DETERMINE MINIMUM BOUNDING RECTANGLE (MBR) OF AVAILABLE MAP DATA SOURCE(S)
36
CALL LL_MAXMIN_RET
DEFINES MAP-DATA SPECIFIC BITMAP PARAMETERS (E.G., CELL SIZE): [DATA] = ANY GRIDDED OR RASTER DATA SET (E.G., CADRG, DTED, ETC.)
38
CALL [DATA]_BITMAP_ CREATE
DETERMINES # ROWS AND COLUMNS (INCL. 2-BIT BUFFER) FOR ENTIRE BITMAP
42
CALL DETERMINE_NUM_ ROWS_COLS
MAKE BITMAP (INPUT IS #ROWS AND COLUMNS)
44
CALL BITMAP_CREATE
TURN ON (SET=1) EACH BIT IN BITMAP CORRESPONDING TO AVAILABLE TILE (DATA IS ANY RASTER OR GRIDDED PRODUCT).
46
CALL BUILD_[DATA]_ BITMAP
SAVE AVAILABLE COVERAGE BITMAP TO DISK
48
CALL BITMAP_IO_SAVE
52
STOP

FIGURE 2

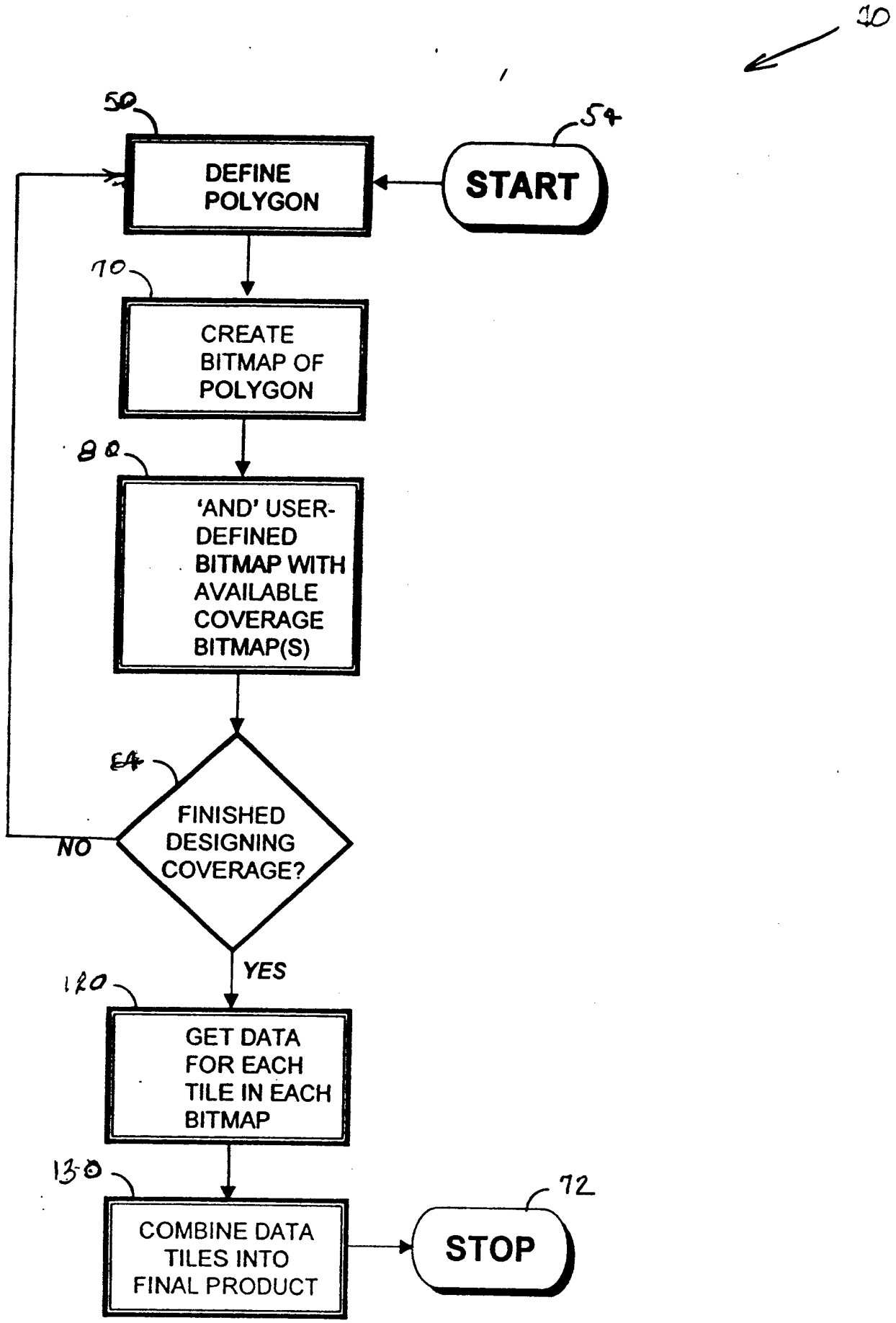

30
50
54
DEFINE POLYGON
START
70
CREATE BITMAP OF POLYGON
80
'AND' USER-DEFINED BITMAP WITH AVAILABLE COVERAGE BITMAP(S)
84
FINISHED DESIGNING COVERAGE?
NO
YES
120
GET DATA FOR EACH TILE IN EACH BITMAP
130
COMBINE DATA TILES INTO FINAL PRODUCT
72
STOP

FIGURE 3

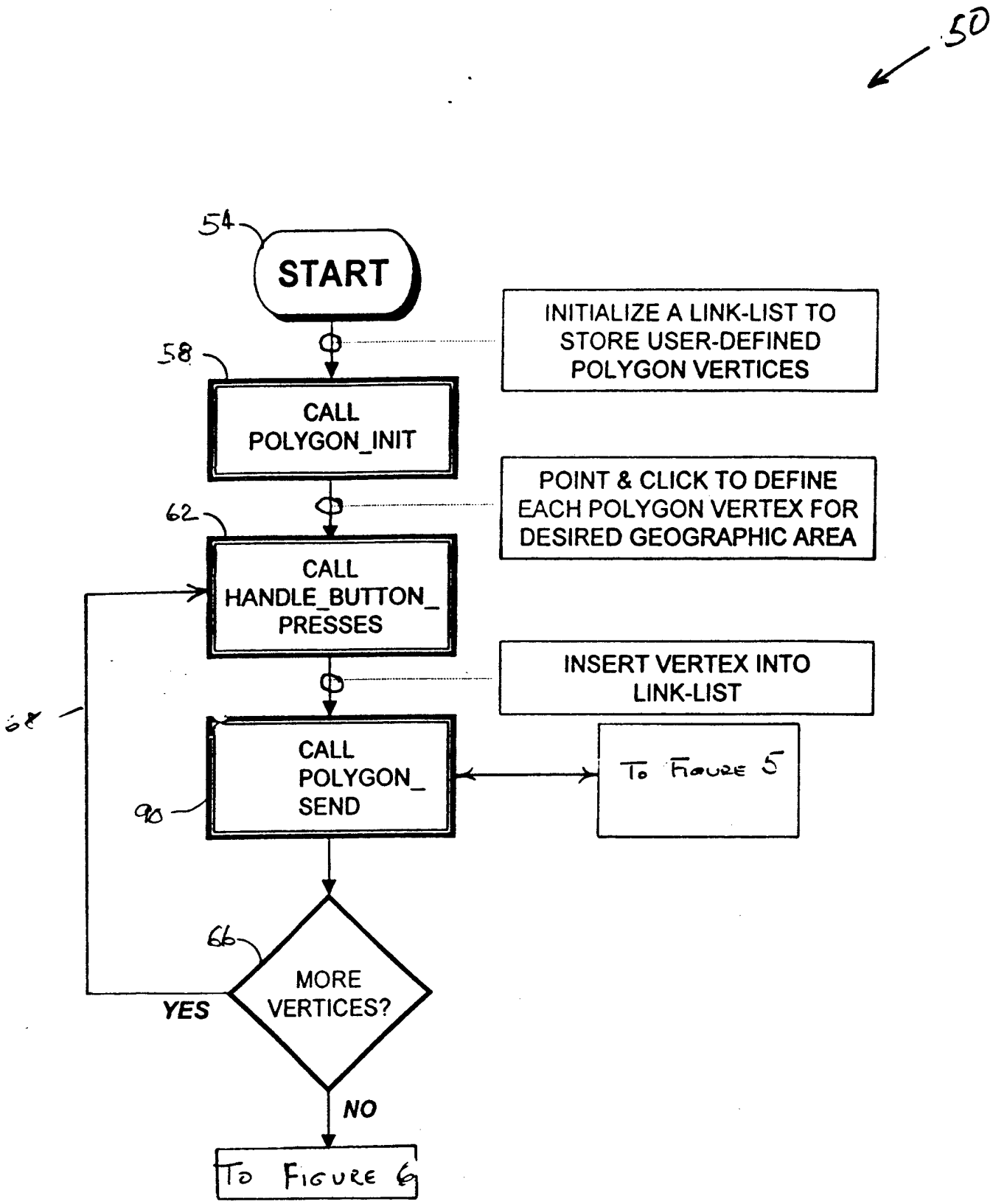

50
54
START
INITIALIZE A LINK-LIST TO STORE USER-DEFINED POLYGON VERTICES
58
CALL POLYGON_INIT
POINT & CLICK TO DEFINE EACH POLYGON VERTEX FOR DESIRED GEOGRAPHIC AREA
62
CALL HANDLE_BUTTON_ PRESSES
INSERT VERTEX INTO LINK-LIST
68
CALL POLYGON_ SEND
90
To Figure 5
66
MORE VERTICES?
YES
NO
To Figure 6

Figure 4

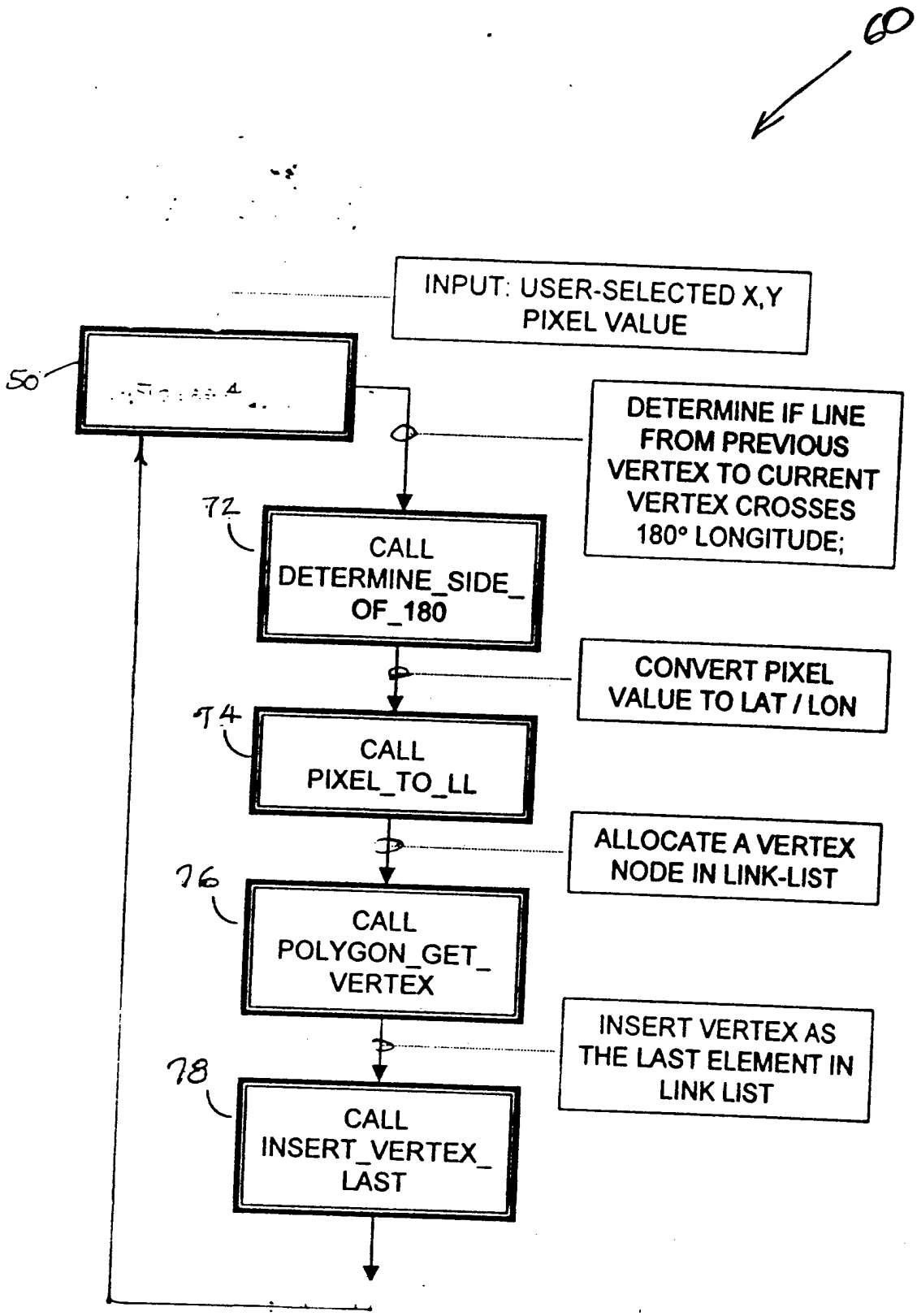

60
INPUT: USER-SELECTED X,Y PIXEL VALUE
50
DETERMINE IF LINE FROM PREVIOUS VERTEX TO CURRENT VERTEX CROSSES 180° LONGITUDE;
72
CALL DETERMINE_SIDE_OF_180
CONVERT PIXEL VALUE TO LAT / LON
74
CALL PIXEL_TO_LL
ALLOCATE A VERTEX NODE IN LINK-LIST
76
CALL POLYGON_GET_VERTEX
INSERT VERTEX AS THE LAST ELEMENT IN LINK LIST
78
CALL INSERT_VERTEX_LAST

FIGURE 5

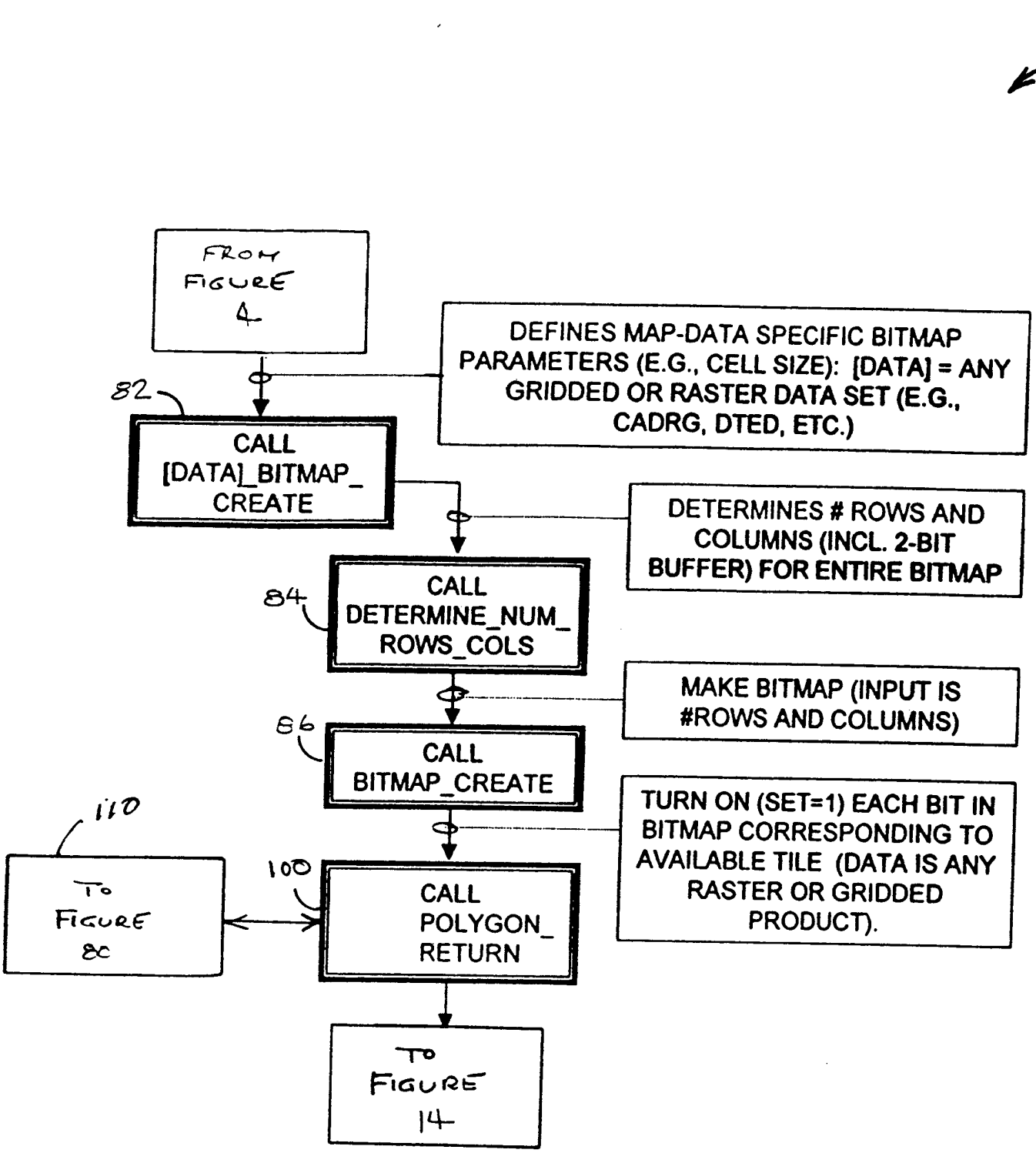

70
FROM FIGURE 4
DEFINES MAP-DATA SPECIFIC BITMAP PARAMETERS (E.G., CELL SIZE): [DATA] = ANY GRIDDED OR RASTER DATA SET (E.G., CADRG, DTED, ETC.)
82
CALL [DATA]_BITMAP_ CREATE
DETERMINES # ROWS AND COLUMNS (INCL. 2-BIT BUFFER) FOR ENTIRE BITMAP
84
CALL DETERMINE_NUM_ ROWS_COLS
MAKE BITMAP (INPUT IS #ROWS AND COLUMNS)
86
CALL BITMAP_CREATE
TURN ON (SET=1) EACH BIT IN BITMAP CORRESPONDING TO AVAILABLE TILE (DATA IS ANY RASTER OR GRIDDED PRODUCT).
110
TO FIGURE 8C
100
CALL POLYGON_ RETURN
TO FIGURE 14

FIGURE 6

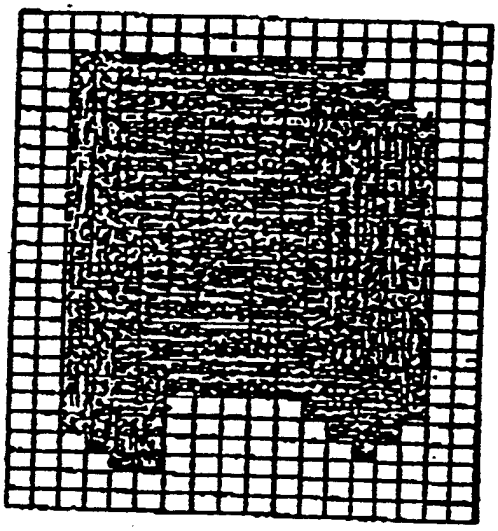


FIGURE 7

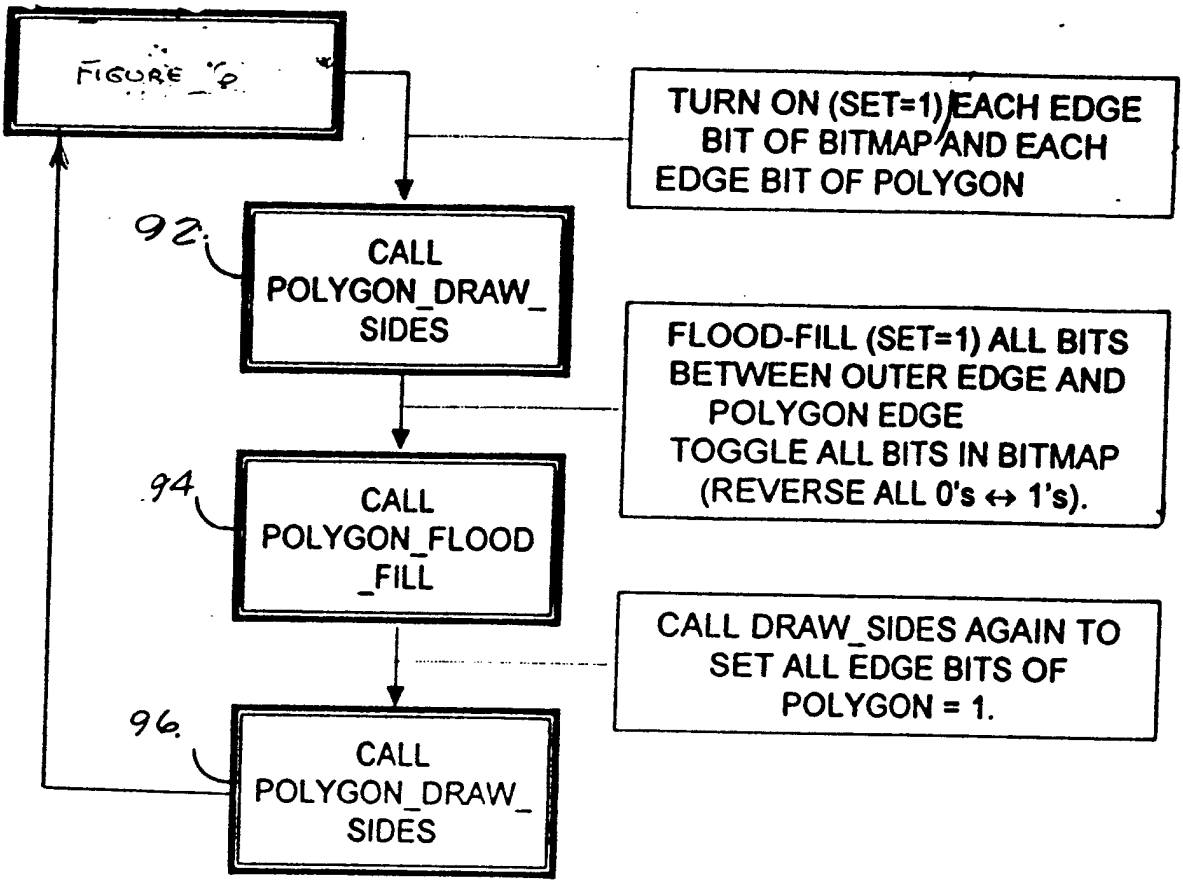


FIGURE 8
TURN ON (SET=1) EACH EDGE BIT OF BITMAP AND EACH EDGE BIT OF POLYGON
92
CALL POLYGON_DRAW_SIDES
FLOOD-FILL (SET=1) ALL BITS BETWEEN OUTER EDGE AND POLYGON EDGE
TOGGLE ALL BITS IN BITMAP (REVERSE ALL 0's ↔ 1's).
94
CALL POLYGON_FLOOD_FILL
CALL DRAW_SIDES AGAIN TO SET ALL EDGE BITS OF POLYGON = 1.
96
CALL POLYGON_DRAW_SIDES

FIGURE 8

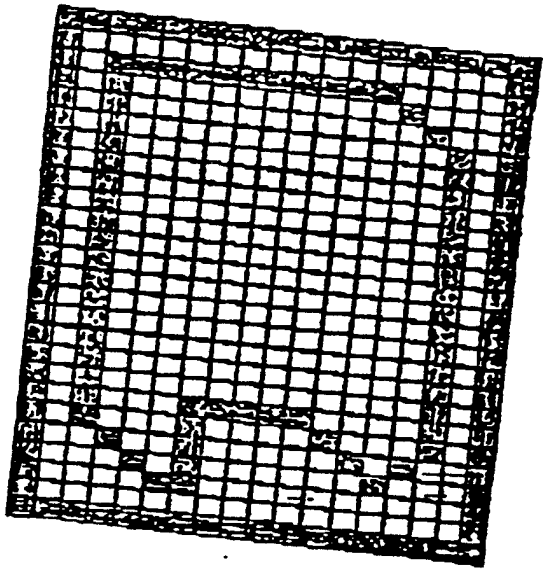


FIGURE 9

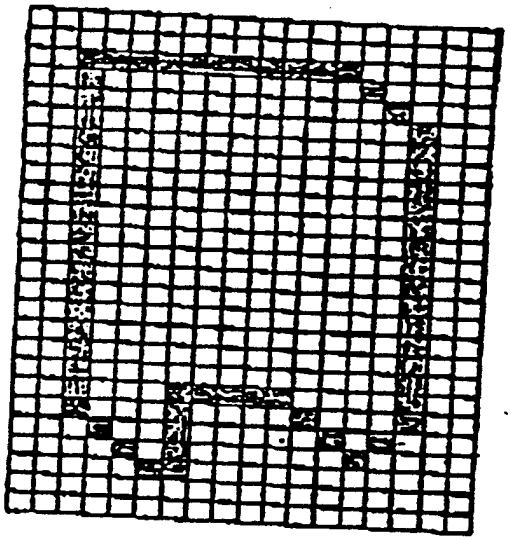
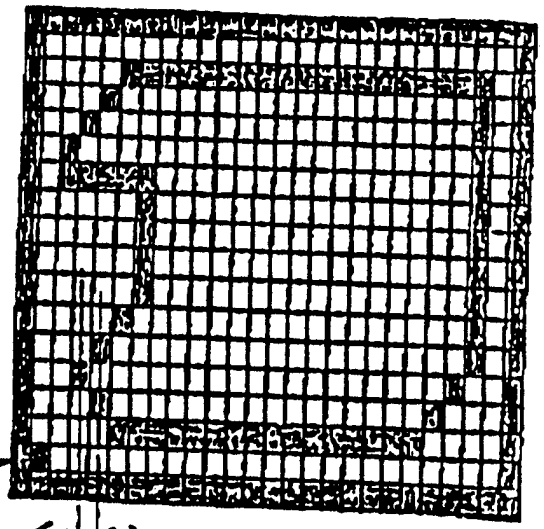


FIGURE 10



bit (1,1)
SEED FOR FLOOD-FILL ROUTINE

FIGURE 11

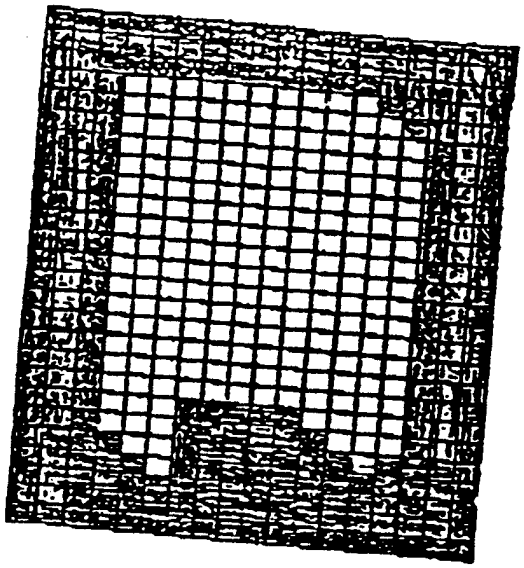


FIGURE 12

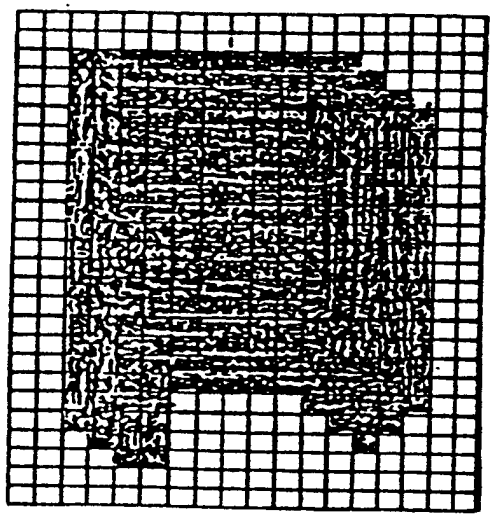


FIGURE 13

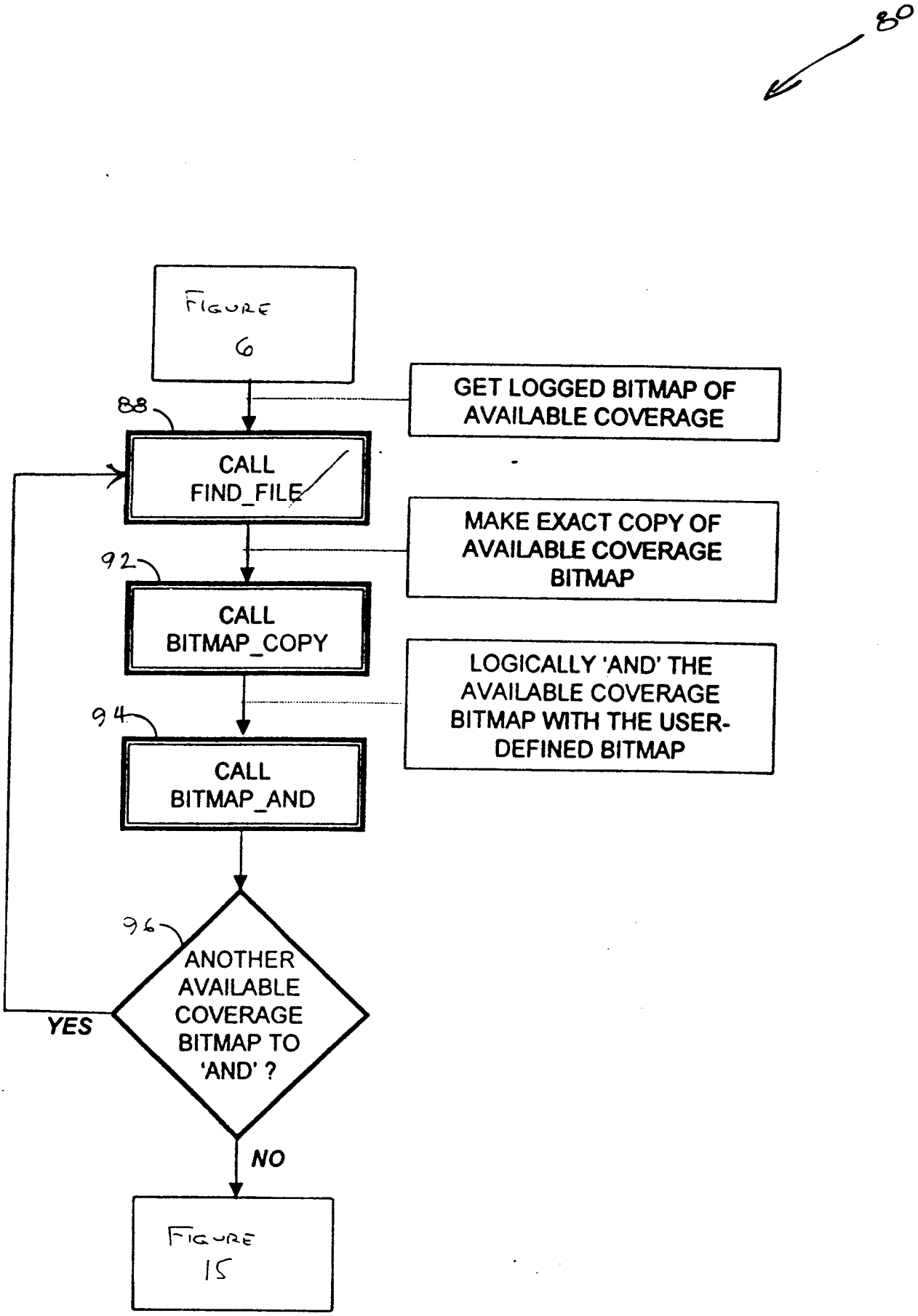

80
FIGURE 6
88
CALL FIND_FILE
GET LOGGED BITMAP OF AVAILABLE COVERAGE
92
CALL BITMAP_COPY
MAKE EXACT COPY OF AVAILABLE COVERAGE BITMAP
94
CALL BITMAP_AND
LOGICALLY 'AND' THE AVAILABLE COVERAGE BITMAP WITH THE USER-DEFINED BITMAP
96
ANOTHER AVAILABLE COVERAGE BITMAP TO 'AND' ?
YES
NO
FIGURE 15

FIGURE 14

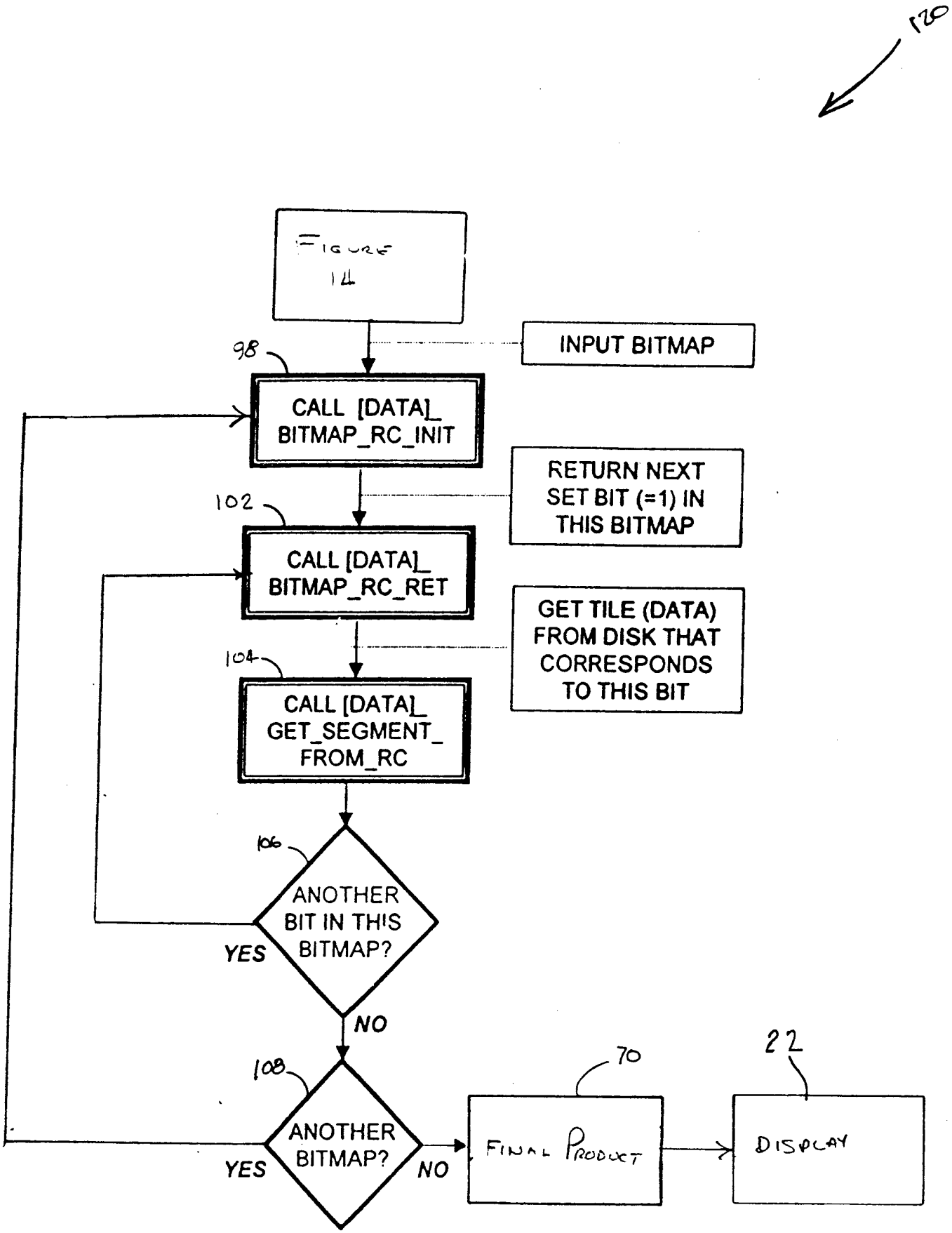

120
FIGURE 14
INPUT BITMAP
98
CALL [DATA]_ BITMAP_RC_INIT
RETURN NEXT SET BIT (=1) IN THIS BITMAP
102
CALL [DATA]_ BITMAP_RC_RET
GET TILE (DATA) FROM DISK THAT CORRESPONDS TO THIS BIT
104
CALL [DATA]_ GET_SEGMENT_ FROM_RC
106
ANOTHER BIT IN THIS BITMAP?
YES
NO
108
ANOTHER BITMAP?
YES
NO
70
FINAL PRODUCT
22
DISPLAY

FIGURE 15