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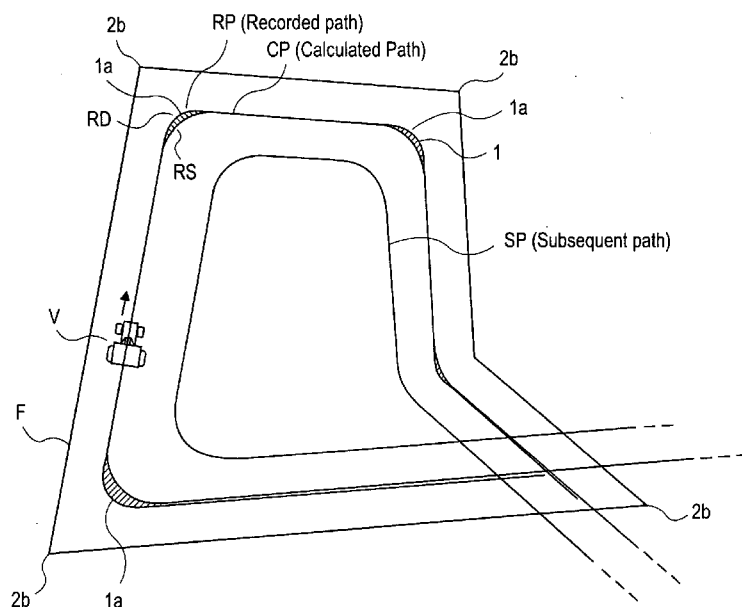
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(54) Title: AUTOMATED MACHINE GUIDANCE IN HEADLAND MANEUVERING

FIG. 1



(57) Abstract: A method for defining a contoured path for an automatic guidance system comprises defining a plurality of reference path segments; for each segment, determining one or more intersection points respectively with other segments; and subsequently defining a contoured path as a sequence of intersecting segments. An automatic guidance system based on the method is also provided.



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AUTOMATED MACHINE GUIDANCE IN HEADLAND MANEUVERING

FIELD

[0001] The present invention relates to methods for defining paths to be followed by a vehicle, in particular an agricultural vehicle working a field, and to automatic guidance systems implementing those methods.

BACKGROUND

[0002] In general when using an automatic guidance/steering (AG) system, the operator defines a path which is used as a reference or guide when travelling the work area (field). The path may be stored in the system such that it can be restored manually by the operator or automatically where, for example, the system identifies the field using a global navigation satellite system(GNSS) position of the vehicle and the GPS position of the field with the predefined path. Once a path is stored, it can then subsequently be used for different machines or applications whereby settings (e.g., working width and overlap) may be adapted for each vehicle or application type (e.g., a tractor with a tillage implement or a combine). The reference path may initially be defined manually using, for example, the A/B mode, the A+ mode, the pivot mode and/or the contour mode.

[0003] In the A/B mode, the path is defined by driving from a point A to a point B defining a straight path reference line. The initial reference line is then offset according to one or more geometry settings of the machine (e.g., a width of the machine and overlapping). At the end of the field, the operator deactivates AG by manually steering, turns the vehicle, and activates AG again, wherein the AG system steers the machine along the next line.

[0004] In the A+ mode, the path is defined by driving to a point A and adjusting an angle (e.g., with reference to the cardinal directions: NORTH is 0°, SOUTH is 180°, etcetera) to define a straight reference line intersecting the point A and running at the defined angle. Headland turning in the A+ mode is similar to headland turning in the A/B mode.

[0005] In the pivot mode, the vehicle is driven around a circular arc thereby defining a circular reference path with a center and a radius. Once the vehicle completes

a circle, the AG system guides the vehicle to the next (inner) circular path. There is no headland turning in this mode.

[0006] The contour mode is used in fields with curved or complex field boundaries. The vehicle is driven along a path surrounding the work area, wherein the driven path is recorded as the reference path. There is no headland turning in this mode.

[0007] With reference to Figure 1 of the accompanying drawings, use of the contour mode to define a path is described in more detail. A major requirement for the recording of reference path line 1 is that it can be used for various applications. A reference path line RP can then be taken to define the calculated path CP and subsequent path lines SP for the respective operations. By changing application settings like working width (width of the implement or combine header) and overlap (area which is passed twice) the subsequent path lines SP can be calculated very easily. Due to the irregular field boundary especially in small structured regions (e.g. in Mid Europe), the contour mode is used more frequently.

[0008] An agricultural vehicle V is driving in the contour recording mode along the boundary 1 of a field F which is to be worked whereby a driven path 1 is recorded. At the edges 2b of field F and depending on the agricultural application (during which the path definition is recorded), the vehicle passes a curve 1a with a respective driven radius RD which may vary during recording or may be too small for other vehicle combinations (e.g., when the reference line is recorded with a small saddled broadcast seeder and the next operation is with a very long plough needing much greater turn radius).

[0009] To meet the requirement that the reference path line 1 can be used for additional, different operations, the radius RD is corrected by overriding with a standard radius RS (e.g., 10 meters) shown by the inner curved line. So a calculated path line CP (driven path 1 with amended radiuses RS) is then recorded. As a consequence, the difference between the two radiuses RD and RS results in areas which may not be worked when using the calculated path CP or subsequent path SP line. Due to liability issues this standard radius RS cannot be changed by the operator to avoid damage during automated steering.

[0010] A further disadvantage of the contour mode relates to the fact that in some applications, a corner cannot be passed by driving a curve. A combine harvester with a

wide header, for example, may not be able to pass a curve as the loading of the header would be unbalanced, impacting the function of the feeder system. Furthermore, tractors with large ploughs also may not be able to pass the corners with a curve when the plough is engaged with the soil. In both of these scenarios the vehicles are forced to pass the corners with headland maneuvers.

[0011] To overcome this problem operators must abort contour mode at every corner and on subsequent path lines SP. This results in substantial manual intervention, introducing the risk of human error and compromising operational comfort and ease of use.

[0012] The above section provides background information related to the present disclosure which is not necessarily prior art.

SUMMARY

[0013] It is an object of the present invention to mitigate the above-mentioned problems by providing an improved system and method for defining a contoured reference path line for an automatic guidance system.

[0014] In accordance with a first aspect of the present invention there is provided a method for defining a contoured path for an automatic guidance system, the method comprising defining a plurality of reference path segments; for each segment, determining one or more intersection points respectively with other segments; and defining a contoured path as a sequence of intersecting segments. Suitably, the defined reference path segments exclude the turns into corners (that is, rounded corners) and instead are extended based on the path of the segment.

[0015] Other features and aspects of the present invention are defined in the attached claims to which reference should now be made.

DRAWINGS

[0016] Embodiments of the present invention are described in detail below with reference to the attached drawing figures, wherein:

[0017] Fig. 1 illustrates the generation of a contoured path for an automatic guidance system using a known method as described above.

[0018] Figs. 2–11 illustrate the generation of a contoured path and the integration of headland maneuver's in methods embodying aspects of the present invention.

[0019] The drawing figures do not limit the present invention to the specific embodiments disclosed and described herein. The drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the invention.

DESCRIPTION

[0020] The following detailed description of embodiments of the invention references the accompanying drawings. The embodiments are intended to describe aspects of the invention in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments can be utilized and changes can be made without departing from the scope of the claims. The following description is, therefore, not to be taken in a limiting sense.

[0021] In this description, references to “one embodiment”, “an embodiment”, or “embodiments” mean that the feature or features being referred to are included in at least one embodiment of the technology. Separate references to “one embodiment”, “an embodiment”, or “embodiments” in this description do not necessarily refer to the same embodiment and are also not mutually exclusive unless so stated and/or except as will be readily apparent to those skilled in the art from the description. For example, a feature, structure, act, etc. described in one embodiment may also be included in other embodiments, but is not necessarily included. Thus, the present technology can include a variety of combinations and/or integrations of the embodiments described herein.

[0022] The basic concept of embodiments of the present invention is to split the overall contoured reference path line RP into segments with sharp corners or edges, as shown in Fig. 2. In Fig. 2 the contoured reference path line RP is split into reference path line segments RPS1–RPS4. Various exemplary methods for splitting the contour reference path into segments are described below with reference to Figs. 3a, 3b, 4a and 4b. The ends of each single section are extended in a straight line such that the reference path line segments intersect at sharp corners or edges.

[0023] A method of manually defining an intersection point IP is depicted in Fig. 3a. According to this method the vehicle V approaches the corner or edge 2b driving in

the direction shown by arrow DD. Due to an implement attached to the vehicle (which prohibits using the standard contour mode), the vehicle V is performing a headland maneuver. During this headland maneuver, the driver activates the segmentation function by pressing a button (e.g., a Start/Pause button) which results in the AG system setting point IP3□. After the headland maneuver the recording of the points is resumed by pressing a button (e.g., an End/Pause button) and a point IP3□□ is set. Based on these two points (IP3□ and IP3□□) the system calculates the intersection point IP3. Once the point IP3 is determined, it will be recorded while points IP3□ and IP3□□ are discarded. Based on IP3 the system calculates the sections RPS2 and RPS3.

[0024] Alternatively, the system may automatically recognize a headland maneuver or an intersection of two path lines even if the path lines are curved. So the intersection point IP is automatically determined.

[0025] A method of automatically defining an intersection point IP by detecting a minimum turn radius is depicted in Fig. 3b. The automatic determination of an

intersection point IP may also be applicable when using the normal contour mode for recording a reference line by driving a curve on the edges 2b as shown in Figure 3b. Similar to what was described in Fig. 1, the vehicle V (with no implement or a small implement allowing sharp curves) approaches on segment RPS2 to corner 2b and drives a curve with radius RD into a direction aligned with next segment RPS3. The system detects that radius RD is smaller than the minimum radius RS and automatically sets an intersection point IP3. The system may determine intersection point IP3 by geometrically extending the driven path lines RPS2 and RPS3 until they intersect, wherein the intersection is defined as IP3. The driver is then informed that the system detected an intersection point and the driver can accept it or not. The system may also include a procedure to inform the driver if the automatic segmentation procedure does not work. The driver could then be asked for manual input based on system suggestions on the displayed map provided on a screen in the vehicle cab.

[0026] Furthermore, a minimum radius RM could be defined (which could be the standard radius RS or a larger value according the driver's setting chosen for an application) so that when a curve with sufficient radius is driven along a path segment or between two path segments, the intersection point IP determination, and thereby the

segmentation, is aborted. Thus, individual path segments may be straight or may include one or more arcuate sections, wherein each of the arcuate sections presents a radius of curvature greater than the minimum radius RM. Alternatively, in this case the driver could be provided with a pop-up asking whether the reference path at this edge should be segmented or not.

[0027] A method of automatically defining an intersection point IP by detecting a crossing point is depicted in Figs. 4a and 4b. The automatic determination of an intersection point IP may also be applicable when using the normal contour mode for recording a reference line by detecting a crossing point as shown in Figures 4a and 4b.

Similar to what was described in Figure 1, the vehicle V approaches on segment RPS2 to corner 2b and drives a headland maneuver. The system can determine intersection point IP3 at the crossing point. The driver is then informed that the system detected an intersection point and the driver can accept it or not. The system may also include a procedure to inform the driver if the automatic segmentation procedure does not work.

The driver could then be asked for manual input based on system suggestions on the displayed map.

[0028] As will be appreciated, it is not necessary that the reference path segments be driven as part of the process. For example, the reference path may be created by adding offsets to known field boundary positions within the system, then handling segmentation and the generation of intersection points.

[0029] As shown in Fig. 5, at the end of the reference path record process, a final reference path line RPF consisting of various segments RPS1 to RPS4 and intersection points IP1 to IP4 can be stored in the system whereby the segments can include radiuses as described above. Final reference path line RPF can then be taken to calculate subsequent path lines SPA to SPA±X.

[0030] The process of segmentation can also be applied during the generation of subsequent path lines according to various methods. With particular reference to Fig. 11, a reference path line RP may include a path segment with a curved section of radius R1 in the initial definition. If the subsequent path lines P2, P3, P4, etcetera are generated by offsetting said reference path line towards the inner side of the curve, as illustrated, a subsequent path line may have a corresponding curve with a smaller radius of curvature.

If the curve has a smaller radius compared to the minimum radius RS the system may split said path segment into two and replace the curved section with an intersection point according to, for example, the method described above and illustrated in Figure 3b.

[0031] Conversely, a reference path line may include two path segments

5 intersecting at a point while a subsequent path may merge the two path segments and replace the intersection point with a curve. The intersection point on the reference path may result from the minimum radius requirement or by any methods described in Figures 3a, 3b, 4a, 4b. If subsequent path lines SPA are generated by offsetting said reference path line or reference path line segments, the system may replace two adjacent path segments
10 by one segment with a respective curve with a radius greater than a predetermined minimum radius. This may be advantageous as the path with reduced segments can be travelled more efficiently without leaving unworked field areas.

[0032] If the system is adapting the segment definition during subsequent path line generation, the path segments being different from the strict offset of the reference
15 path may be highlighted in the display so that the operator can accept or overwrite the amendments.

[0033] In some embodiments of the invention, only the current active path of the active segment (SPA of RPS2 in figure 5) $\pm X$ path is shown on an operator's display.

[0034] During operation, the system may automatically select a next path
20 segment to be driven using one or more methods. According to a first method, the system calculates angles to adjacent path lines. In a first step, the two closest path sections are chosen by calculating the perpendicular distances of each point of each adjacent or proximate path segment and the vehicle's position. As each point on the path or path segment is defined by coordinates and an angle (with respect to next or previous
25 points on the path) the basis for considering perpendicularity to the orientation at this point on a section is provided. This is especially needed for path lines/segments with a curvature. So for each point, the distance perpendicular to the orientation/angle of the point to the position of the vehicle can be determined so that the two adjacent sections can be selected. Alternatively, other methods may be used to identify two adjacent
30 sections. The system may generate an imaginary circle around the vehicle position, for example, and increase the diameter until two different sections are cut by that circle.

[0035] In a next step, the system determines an angle between the driving direction or orientation of the vehicle and each of the two closest path sections and determines which of the two angles is the smallest. As illustrated in Fig. 6a, if the vehicle is in the position represented by point P1 the system calculates the two angles β_1 and β_2 to the sections RPS2 and RPS3. The angle β_1 is smaller than the angle β_2 , therefore the path segment RPS3 is selected as guidance target. If, for example, the vehicle were at point P2 the system may choose the other segment RPS2.

[0036] Any of various methods may be used to define angles between the vehicle's driving direction/orientation and path sections. By way of example, the angle between the orientation of a point on the section and the orientation of the vehicle can be determined directly or by assigning each angle to the cardinal system used in guidance systems (described above with A+ mode) wherein NORTH is 0° and SOUTH is 180° , and then calculating the difference between these cardinal angles.

[0037] According to another method of selecting the next path segment to be driven, the system calculates distances between the vehicle's current position and all intersection points (IP1 . . . IPx) and uses the smallest distance to select a guidance target, as illustrated in Fig. 6b. By way of example, if the vehicle is in the position shown as point P3, the system virtually connects the point P3 with next intersection points IP3 and IP4 resulting two distances r_1 and r_2 . The connecting line of P3 to intersection point IP3 has the smaller distance r_1 with the respective path segment RPS2 and is selected as guidance target. If, for example, the vehicle would be at point P4 the system may choose the other segment RPS4.

[0038] According to another method of selecting the next path segment to be driven, the system calculates the perpendicular distances between the vehicle's position and all contour segments and considers the one with the smallest distance to be taken. As illustrated in Fig. 6c, if the vehicle is in the position shown as point P3 the system virtually connects the point P3 with contour segments RPS1 through RPS4 which results in the distances r_1 through r_4 . The connecting line of P3 to contour segment RPS2 has the smallest distance r_2 and therefore the subsequent segment RPS2 is selected as guidance target. If, for example, the vehicle would be at point P4 the system may

choose the other segment RPS4□. Alternatively, the perpendicular distance may be determined relative to subsequent path segments RPS1□ through RPS4□.

[0039] According to another method of selecting the next path segment to be driven, the system determines the perpendicular distance to a calculated path (Cross track; XTRK). As illustrated in Fig. 6d, if the vehicle is in the position shown as point P5, the system virtually connects perpendicularly the point P5 with next calculated paths RPS2□ and RPS2□□ resulting in two distances $d□$ and $d□□$. The connecting line P5 to path RPS2□ has the smaller distance $d□$ and is selected as the guidance target. If, for example, the vehicle would be at point P6 the system may choose the other segment RPS2□□.

[0040] After determining the next path line segment the system can automatically activate automatic guidance mode such as, for example, when the vehicle exits a predefined area A1 around an intersection point IP defined by a radius, as shown in Figure 7.

[0041] Furthermore, the system may also be provided with provisions if the vehicle leaves an initial segment when the driver manually adjusts steering before reaching an intersection point IP. If this happens within a predetermined area around an intersection point IP, the system may activate automatic guidance again according to the procedures described above. If it happens outside of the predetermined area around the intersection point IP, the system does not reactivate automatic guidance. This function is provided, for example, for scenarios in which the driver starts a headland maneuver before reaching an intersection point IP. The predetermined area around the intersection point IP is defined to prevent the automatic reactivation of the guidance system if the driver wants to leave the field or something unanticipated/undesired happens. In these cases the automatic return to guidance mode must be avoided. In addition, a visual and/or audible warning etc. may be generated.

[0042] The system may additionally be configured to recognize a change in the driver's strategy and switch to a parallel "SEGMENT" mode based on the above described advanced CONTOUR mode. This new strategy would be that the vehicle has to work on the parallel segments SP2S2, SP3S3, SP4S4 and so forth To ensure that all the field is worked, the system geometrically extends SP2S2 on both segment ends to create

new intersection points IP3□, IP3□□ and so forth with SP1S3 of the contour path line SP1 representing the end of the area to be worked in a parallel “SEGMENT” mode. The newly created intersection points IP3□, IP3□□ and so forth are then used to automatically abort and resume automatic guidance. This switch in strategy enables the driver to drive the CONTOUR path around until reaching the mid of the field OR follow the CONTOUR path partly and then switch to the SEGMENT mode.

[0043] Looking now at a display related to this new path line determination, the segmentation offers the possibility of reducing the volume of information shown in the terminal. Only the current segment and the next segments (left and right) are shown in full detail, the rest of the path is faded-out. If the vehicle advances to a next intersection point the system may fade-in or highlight this segment. Thereby, the maps shown can be reduced and improve clarity.

[0044] There are two different working modes: 1) The field is worked from all sides of the field (Figure 8). 2) The field is separated into a headland portion and an inner field (Figure 9). The user may have to define the number of orbits (that is, the number of times the vehicle travels around the field when working the headland portion) and the contour section (field side) the inner part of the field should be worked.

[0045] To summarize, the system offers an automatic guidance operation for complex contour lines based on segmented path lines whereby there is no need to manually change the wayline, and whereby manual headland turns are possible without requiring manually aborting and resuming the guidance mode. This reduces the actions required by the driver. Furthermore, the path line definition is more flexible so that the driver can change between CONTOUR mode into a “SEGMENT” mode similar to A/B mode.

[0046] The segmented path line method can also be used to improve headland management. An automated headland management system may be configured to perform one of two different functions: A) Automated headland sequences: Reaching a headland boundary or a defined distance from it, an automatic sequence can be started to, for example, lift a plough or stop a seeder and vice versa—engage the plough or start the seeder when entering from a headland area to a work area. B) Automated headland driving: In addition to starting sequences, a system may also control steering and

propulsion to drive the tractor in the headland. The operator can select different headland path strategies including, for example, circular headland paths (HP1), reversing headland paths (HP2) or key-hole headland paths (HP3).

[0047] Currently available headland management systems require the definition of a distance to a predefined boundary to start the automated headland function. Due to the requirement of a defined boundary, the systems are mainly used for parallel line driving as one boundary line can be taken to define headland exit and entry. Furthermore, as a distance to the boundary is defined once, a quite even boundary is required so that the settings for the headland path line can be defined once. Systems using the CONTOUR mode and automated headland system are not available yet.

[0048] Referring to Figure 10, the automated headland system is controlled by using the segmented path line SP1S2 and SP1S3 and intersection point IP3. When the vehicle approaches intersection point IP3 the automatic headland system including configured to perform functions A) and B), described above, is automatically started. In case of option A) the automatic steering would be aborted, the driver would manually drive the headland similar to HP2 until returning to the next segment to restart automatic guidance mode. Due to the segmentation the headland system can cope with non-parallel path lines.

[0049] In case of option B) with automated driving and complex field geometry, the system can additionally select different headland path strategies depending on non-traversable areas. For example, the first headland H1 can only be passed using a reversing headland path HP2 to avoid collision with obstacle 10. The next headland H2 may also be a reversing headland path HP2. Looking now at headland H3 the distance to the obstacle is now enlarged so that a circular headland path HP1 or key-hole headland path HP3 may be chosen to save fuel and time (as braking and reversing is not necessary).

[0050] To summarize, contoured path segmentation offers the advantage of integrating headland management for non-parallel path lines and additionally may help to select the appropriate headland path depending on obstacles, defined contour lines and so forth.

[0051] Although the invention has been described with reference to the preferred embodiment illustrated in the attached drawing figures, it is noted that equivalents may

be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

[0052] Having thus described the preferred embodiment of the invention, what is claimed as new and desired to be protected by Letters Patent includes the following:

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CLAIMS

1. An automatic guidance system for an agricultural vehicle or an agricultural vehicle associated with an agricultural implement, the system comprising:
- 5 a position determining mechanism;
a data storage device; and
a data processing device in communication with the position determining mechanism and the data storage device, the data processing device configured to –
- 10 guide the vehicle along a contoured path defined by a series of path segments interconnected at sharp corners such that each path segment begins and ends at a sharp corner,
determine when the vehicle approaches the end of a first path segment,
execute a first sequence of actions associated with completion of the first path
15 segment,
determine when the vehicle approaches a second path segment, and
execute a second sequence of actions associated with beginning the second path segment.
- 20 2. The automatic guidance system of claim 1, the sharp corners defined by calculating an intersection point between two adjacent path segments.
3. The automatic guidance system as set forth in claim 1, the data processing device configured to generate the contoured path based on a reference contour path.
- 25 4. The automatic guidance system as set forth in claim 1, the data processing device configured to execute the first sequence of actions when the vehicle reaches the end of the first path segment.

5. The automatic guidance system as set forth in claim 1, the data processing device configured to execute the first sequence of actions when the vehicle is a predetermined distance from the end of the first path segment.

5 6. The automatic guidance system as set forth in claim 1, the data processing device configured to execute the second sequence of actions when the vehicle reaches the beginning of the second path segment.

7. The automatic guidance system as set forth in claim 1, the data processing device
10 configured to execute the second sequence of actions when the vehicle is a predetermined distance from the beginning of the second path segment.

8. The automatic guidance system as set forth in claim 1, the first sequence of actions and the second sequence of actions including actions performed on or by the
15 agricultural implement.

9. The automatic guidance system as set forth in claim 1, first sequence of actions including lifting a plough and the second sequence of actions including engaging the plough.
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10. The automatic guidance system as set forth in claim 1, first sequence of actions including stopping a seeder and the second sequence of actions including starting the seeder.

25 11. The automatic guidance system as set forth in claim 1, the first sequence of actions and the second sequence of actions including actions performed by the vehicle to control the agricultural implement.

12. The automatic guidance system as set forth in claim 1, the first sequence of
30 actions and the second sequence of actions including actions performed by a harvesting machine.

13. The automatic guidance system as set forth in claim 1, the first sequence of actions and the second sequence of actions including actions performed by a header attached to a harvesting machine.

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14. An automatic guidance system for an agricultural vehicle associated with an agricultural implement, the system comprising:

a position determining mechanism;

a data storage device; and

5 a data processing device in communication with the position determining mechanism and the data storage device, the data processing device configured to –

guide the vehicle along a contoured path defined by a series of path segments interconnected at sharp corners,

10 determine when the vehicle completes a first path segment, and

when the vehicle completes the first path segment, automatically guide the vehicle through a headland maneuver to position the vehicle to begin a second path segment.

15 15. The automatic guidance system as set forth in claim 14, the sharp corners defined by calculating an intersection point between two adjacent path segments.

16. The automatic guidance system as set forth in claim 14, the data processing device configured to automatically guide the vehicle along the first path segment and
20 along the second path segment such that no manual intervention is required as the vehicle drives along the first path segment, through the headland maneuver and along the second path segment.

17. The automatic guidance system as set forth in claim 14, the data processing
25 device configured to automatically guide the vehicle along a circular path in the headland.

18. The automatic guidance system as set forth in claim 14, the data processing
30 device configured to automatically guide the vehicle along a key-hole path in the headland.

19. The automatic guidance system as set forth in claim 14, the data processing device configured to automatically guide the vehicle along a reversing path in the headland.

5 20. The automatic guidance system as set forth in claim 14, the data processing device configured to enable an operator to select a headland path selected from the group consisting of a circular path, a key-hole path and a reversing path.

10 21. The automatic guidance system as set forth in claim 14, the data processing device configured to automatically guide the vehicle in the headland by controlling the vehicle's steering and propulsion.

FIG. 1

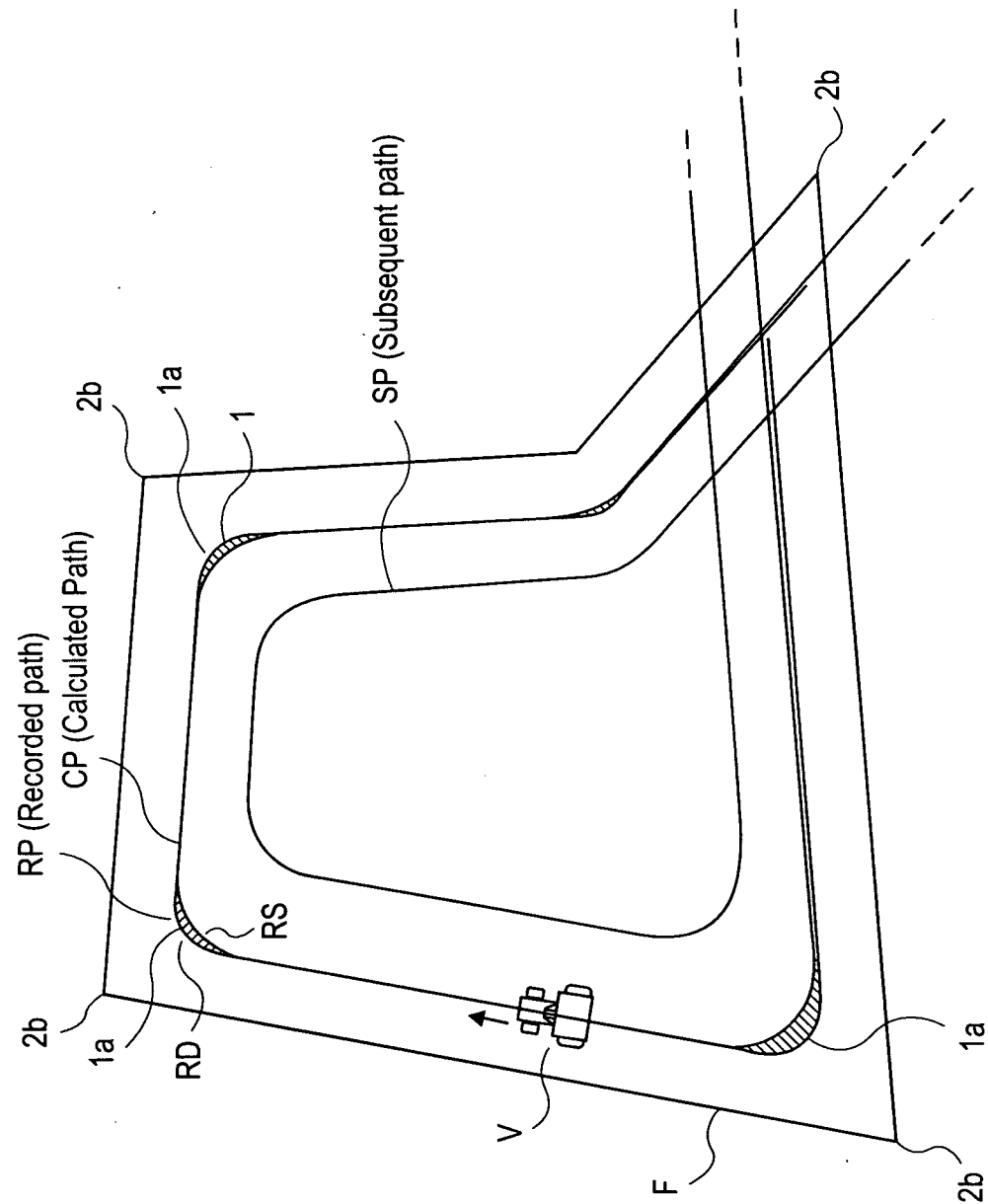


FIG. 2

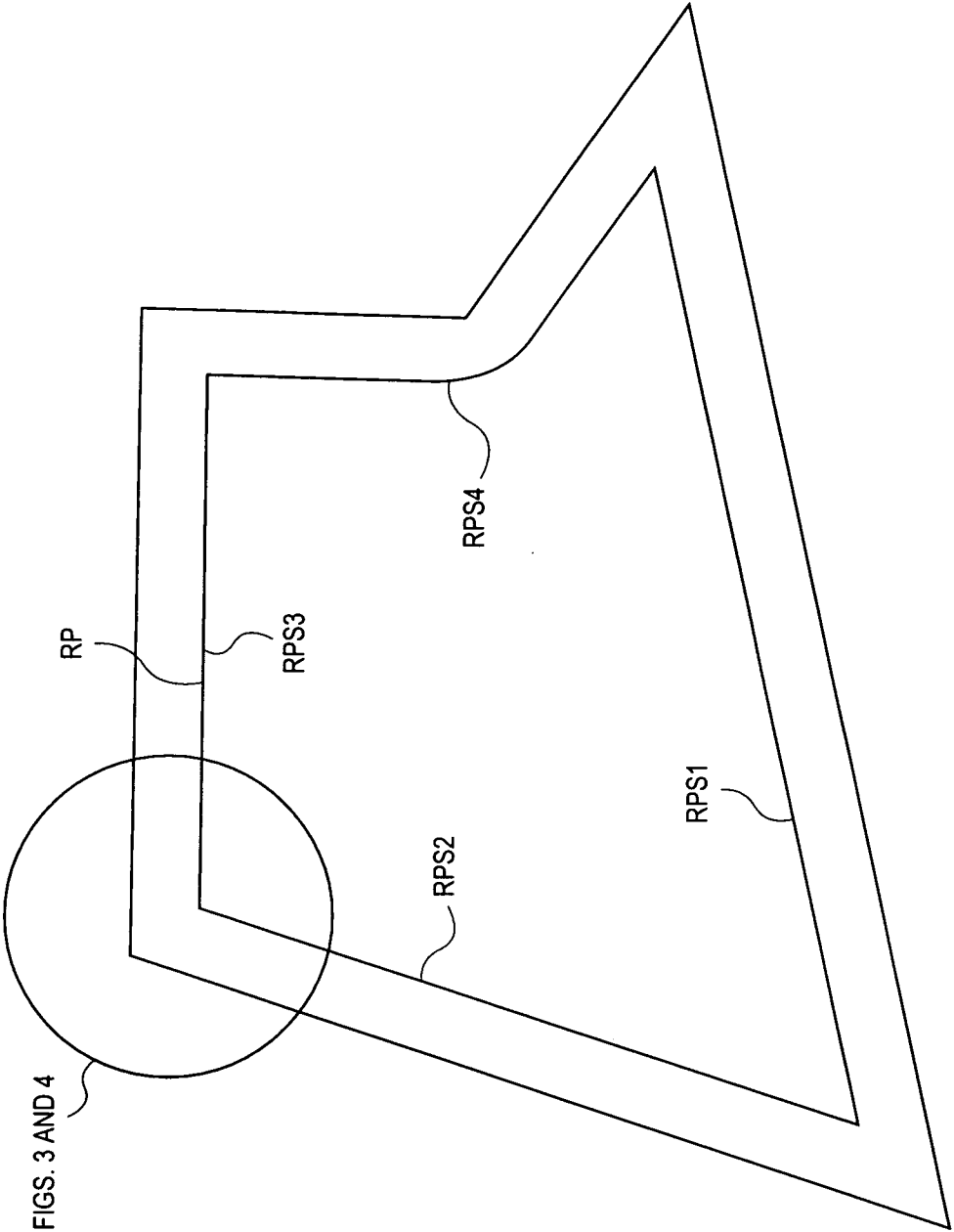


FIG. 3A

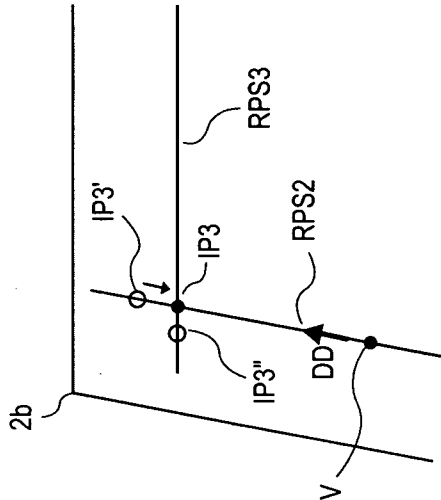


FIG. 3B

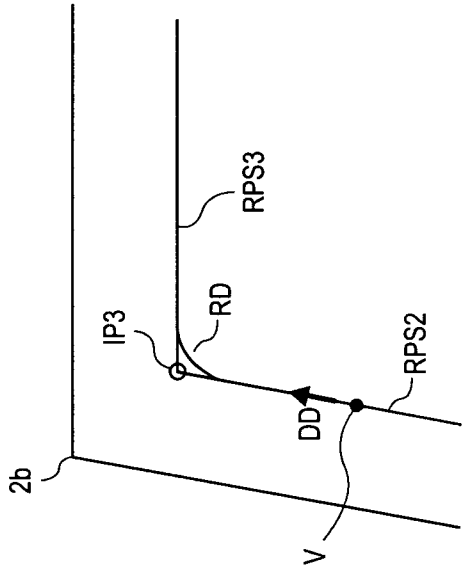


FIG. 4A

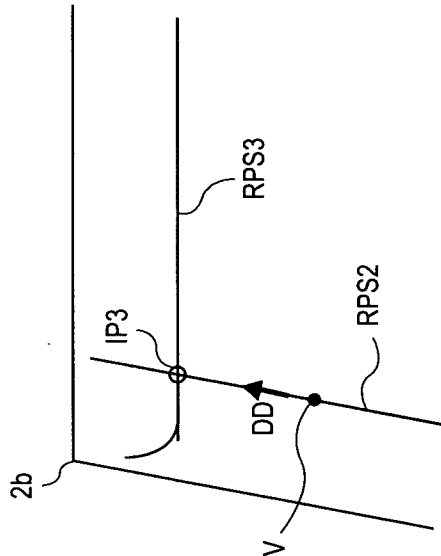
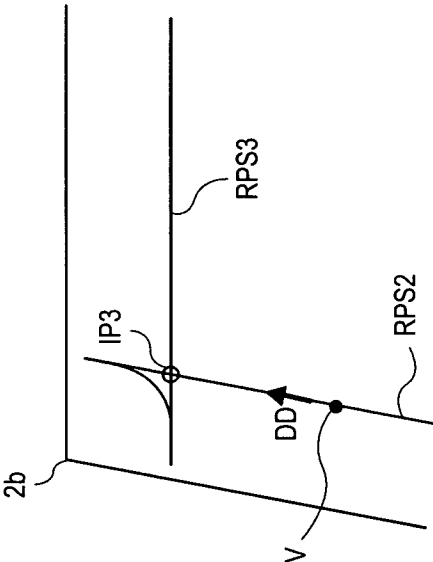
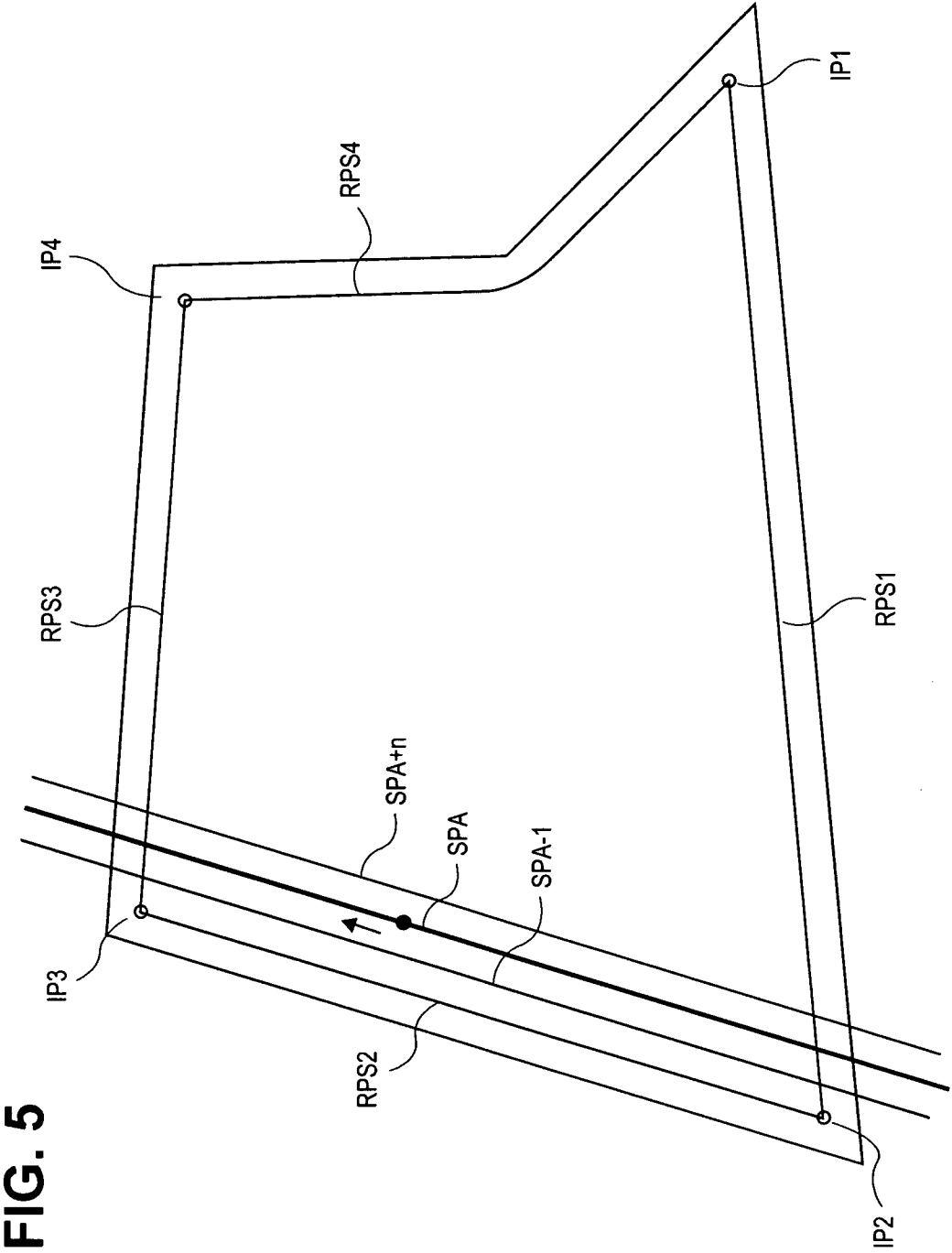
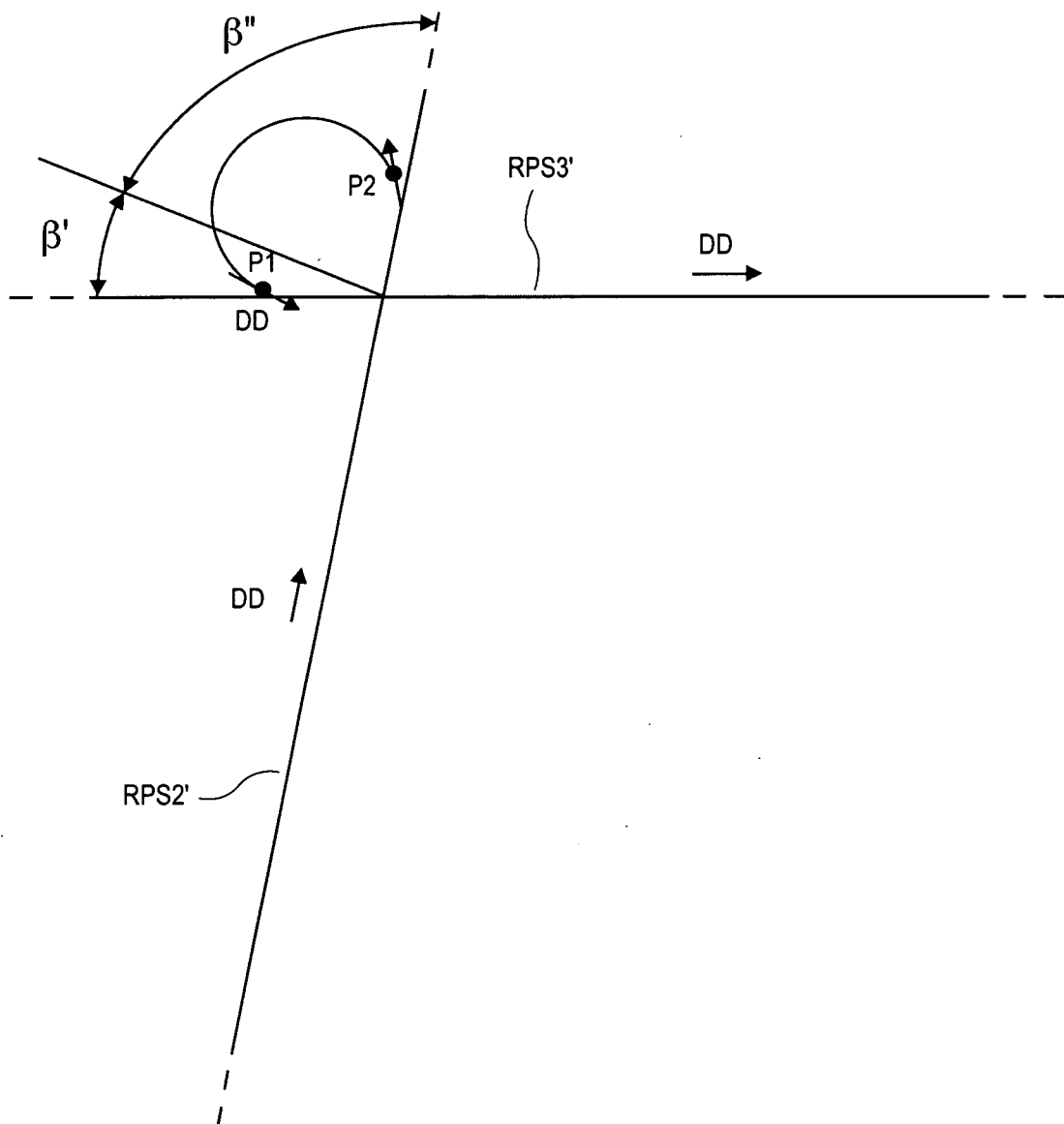


FIG. 4B





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FIG. 6A

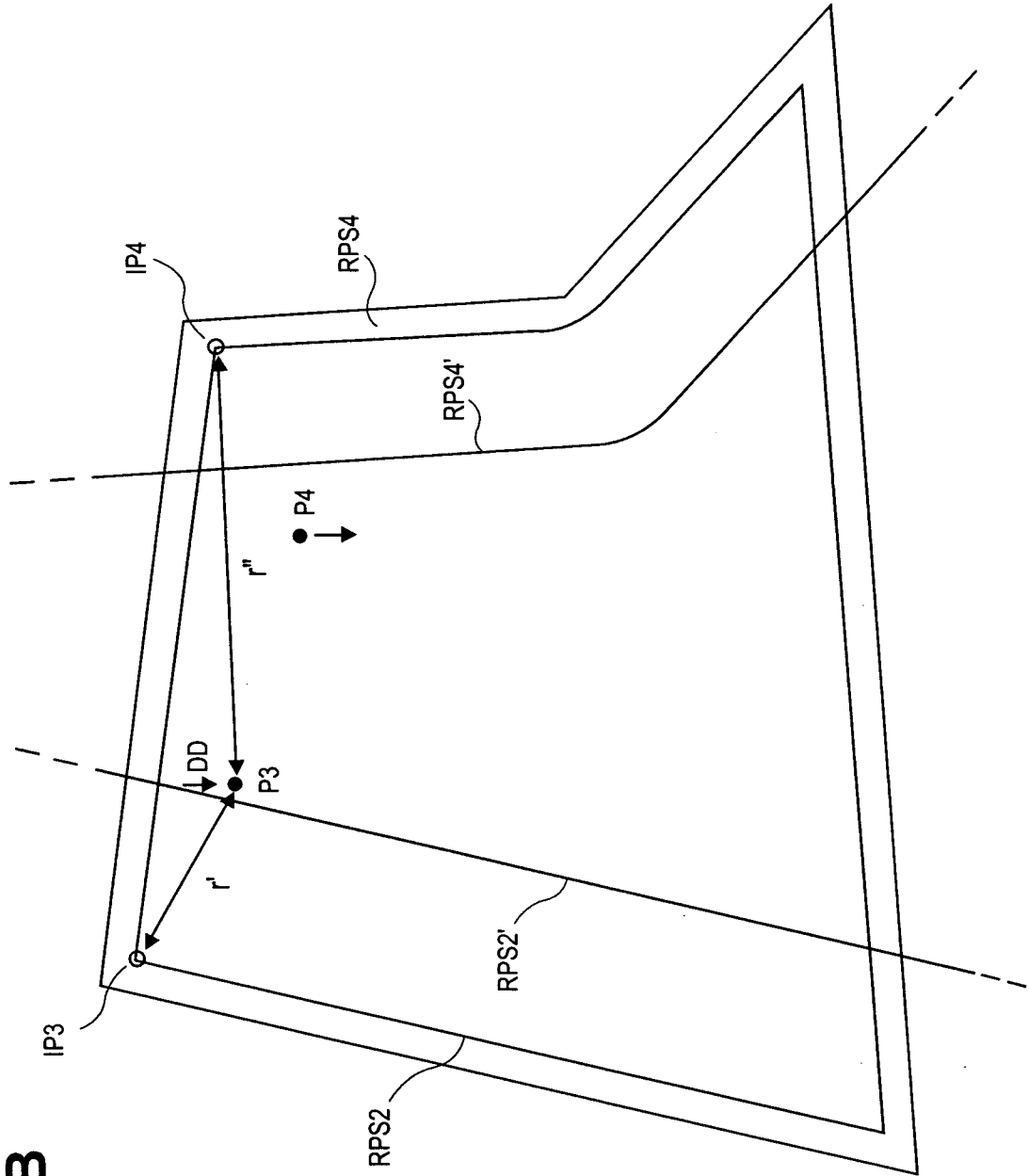
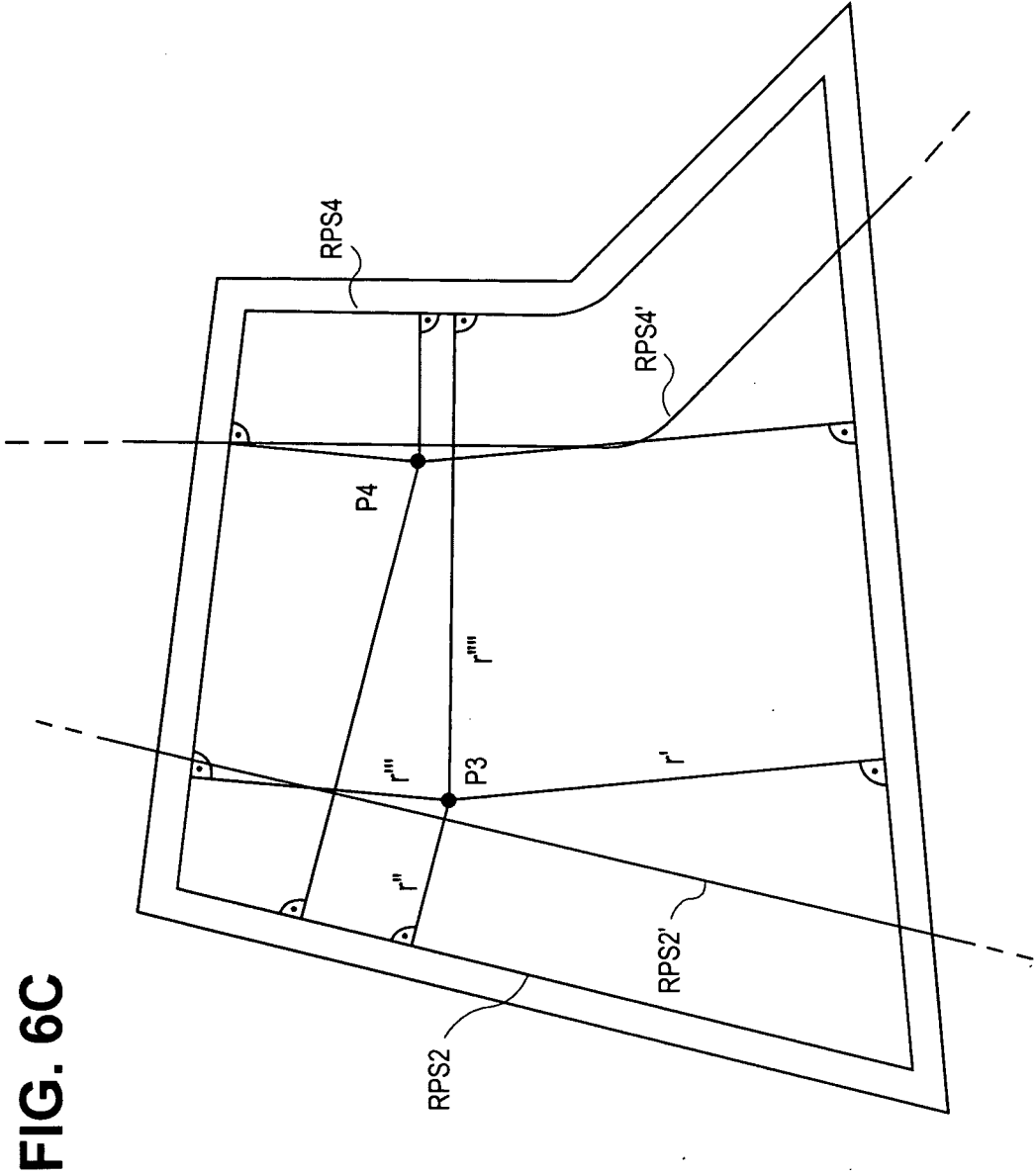


FIG. 6B



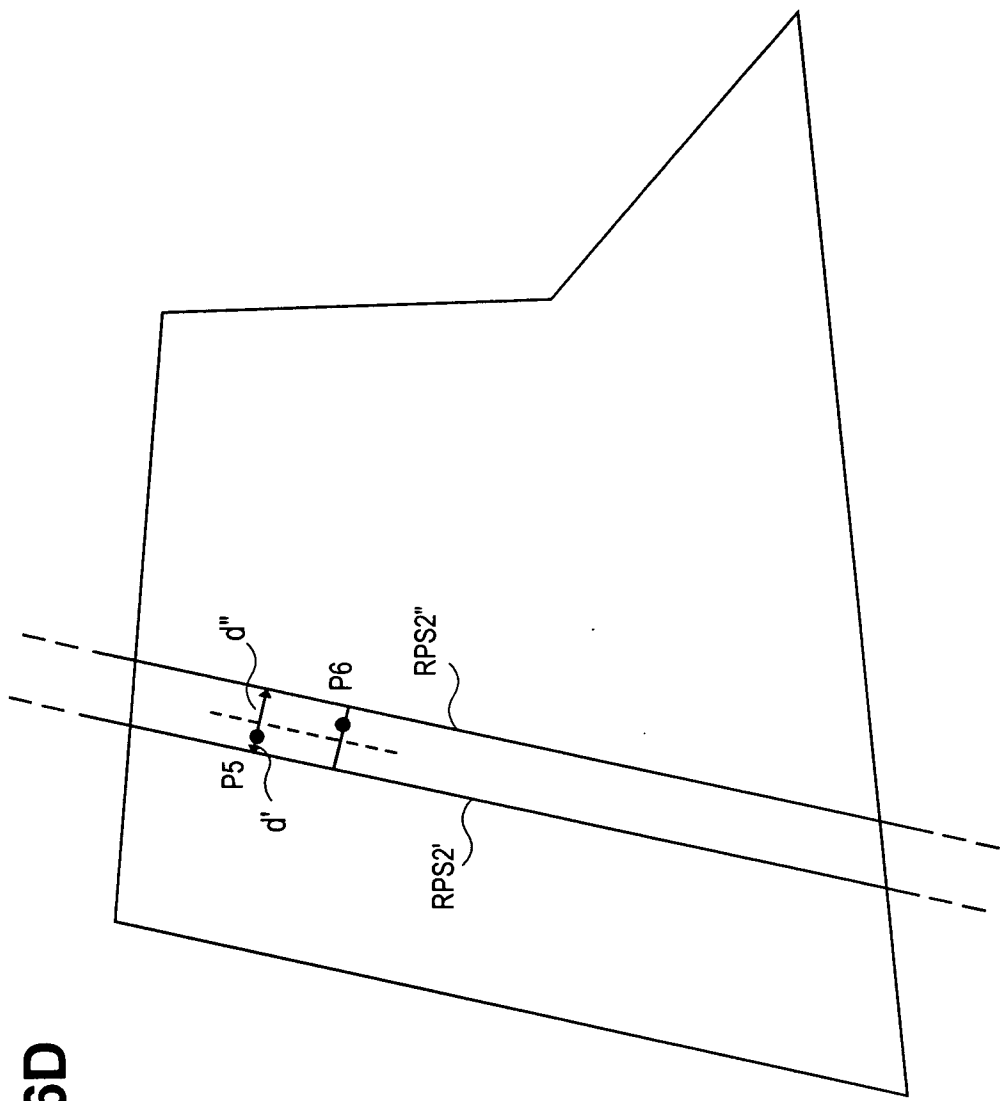


FIG. 6D

FIG. 7

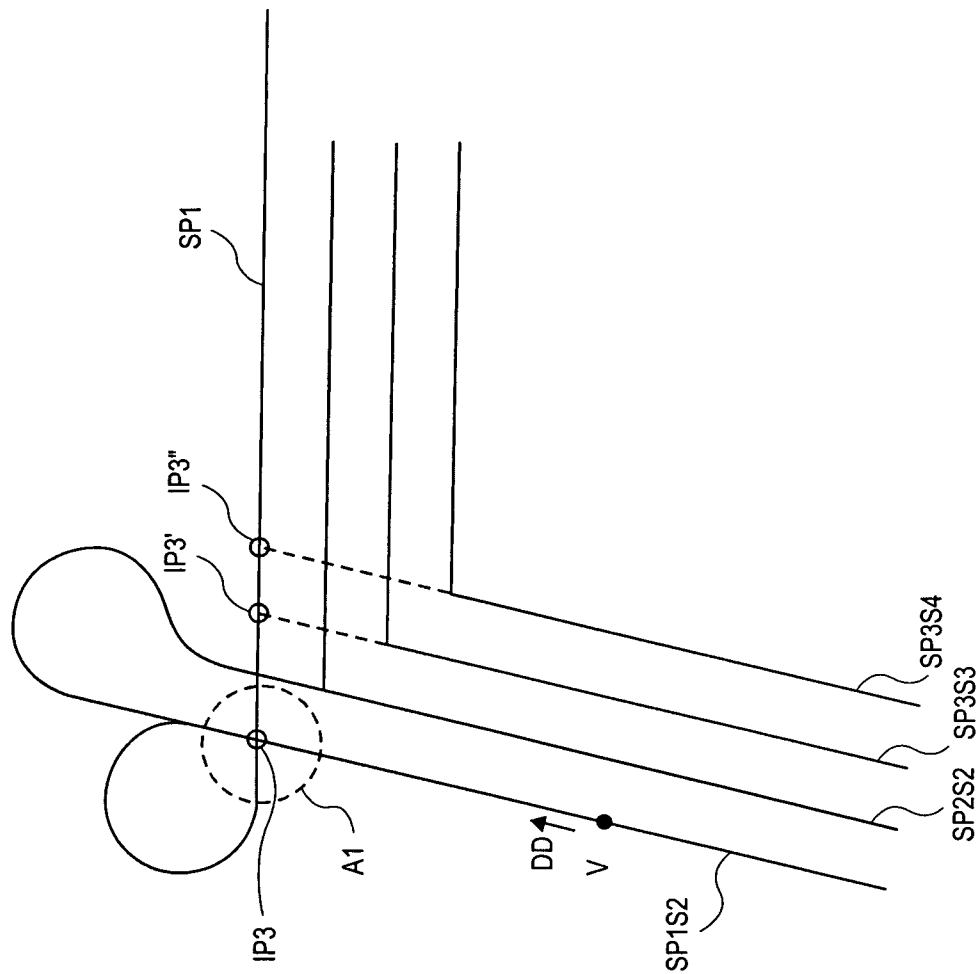


FIG. 8

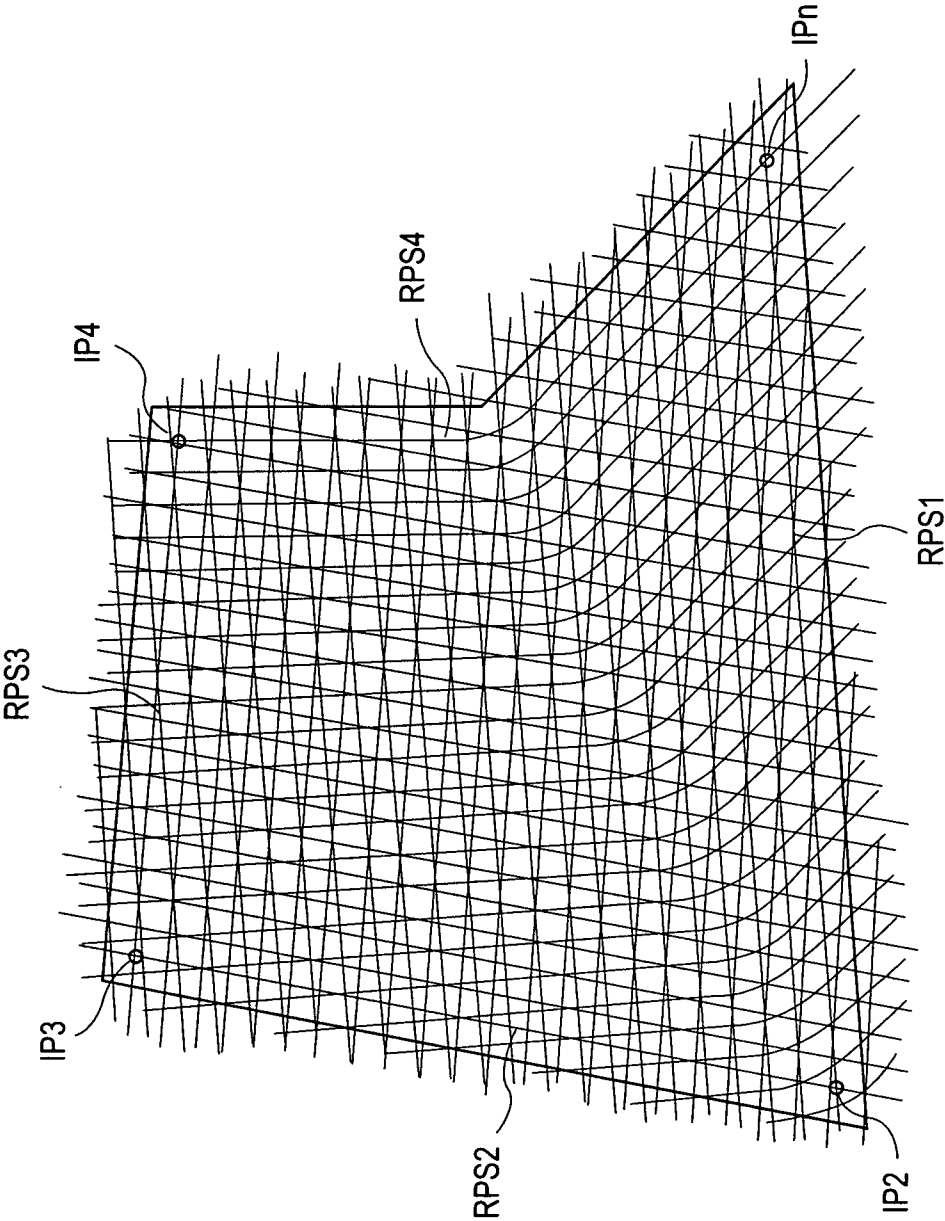


FIG. 9

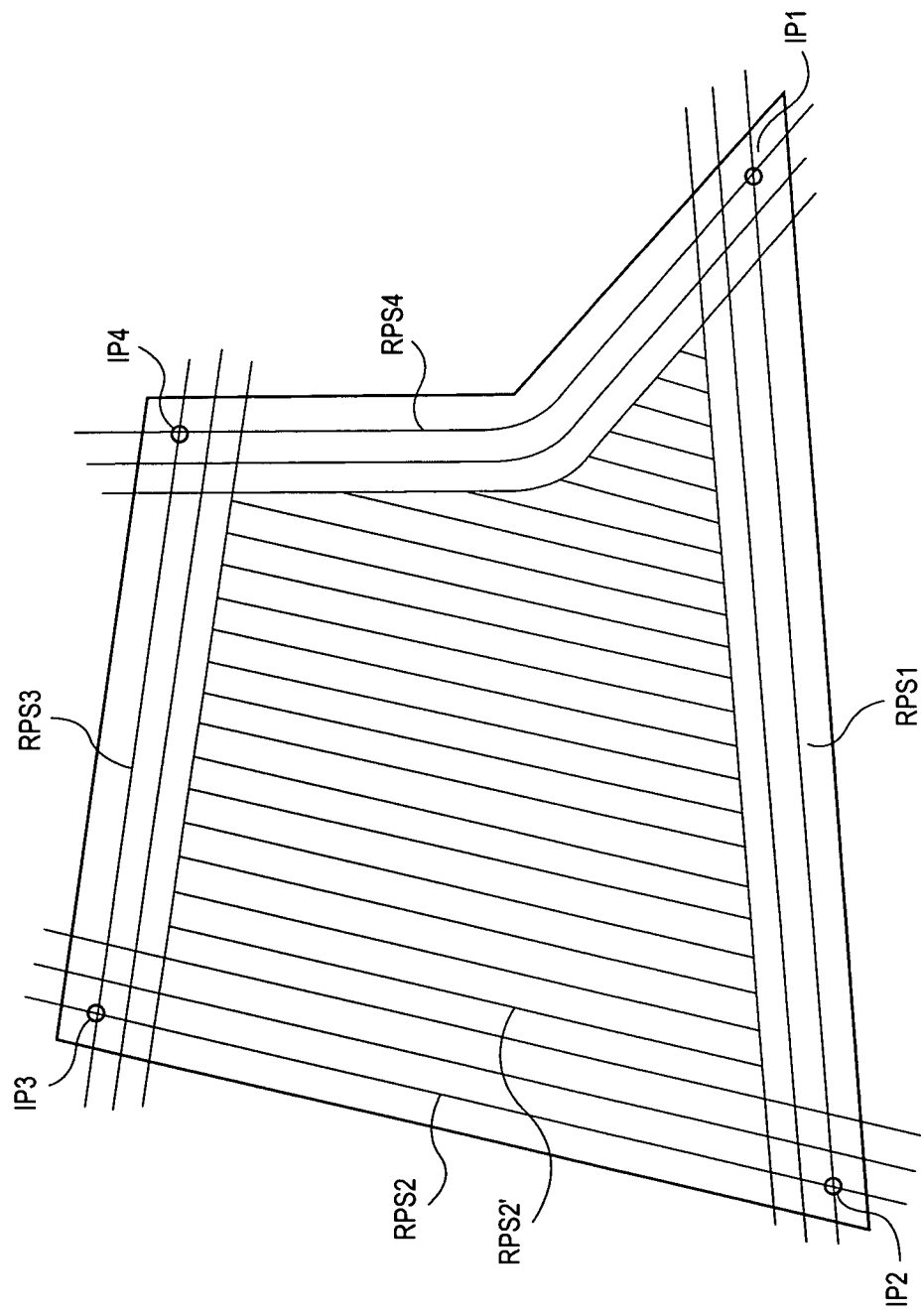


FIG. 10

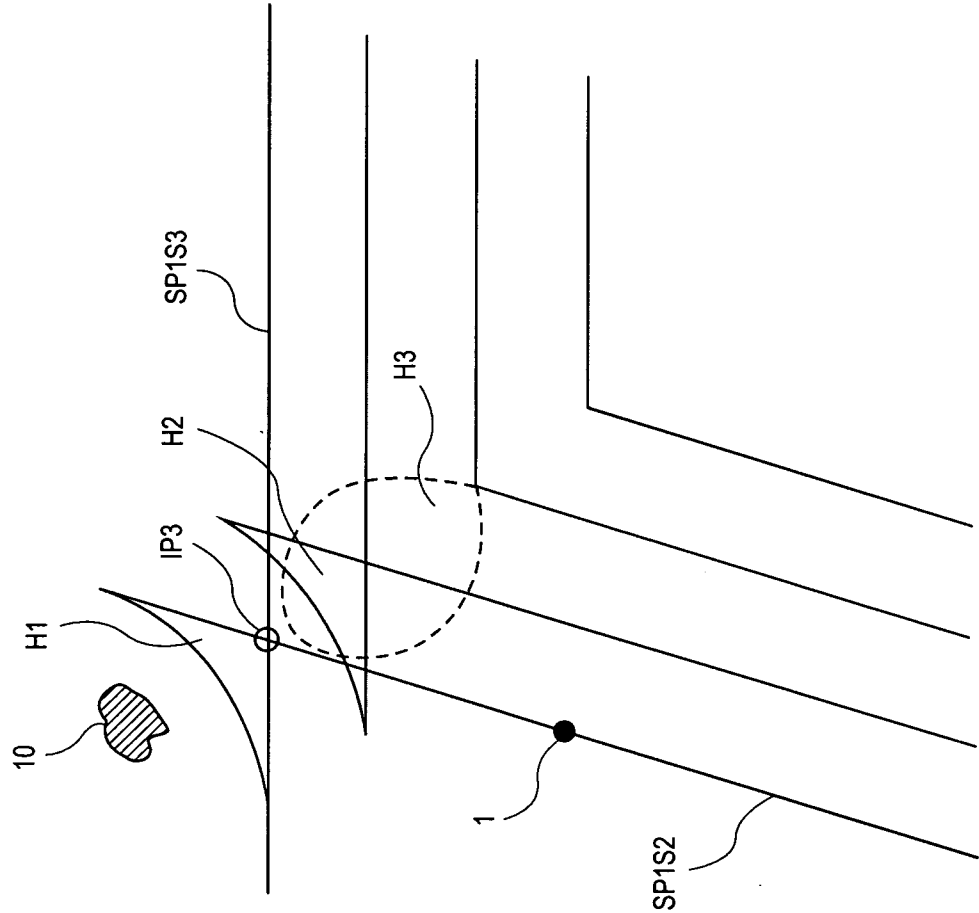
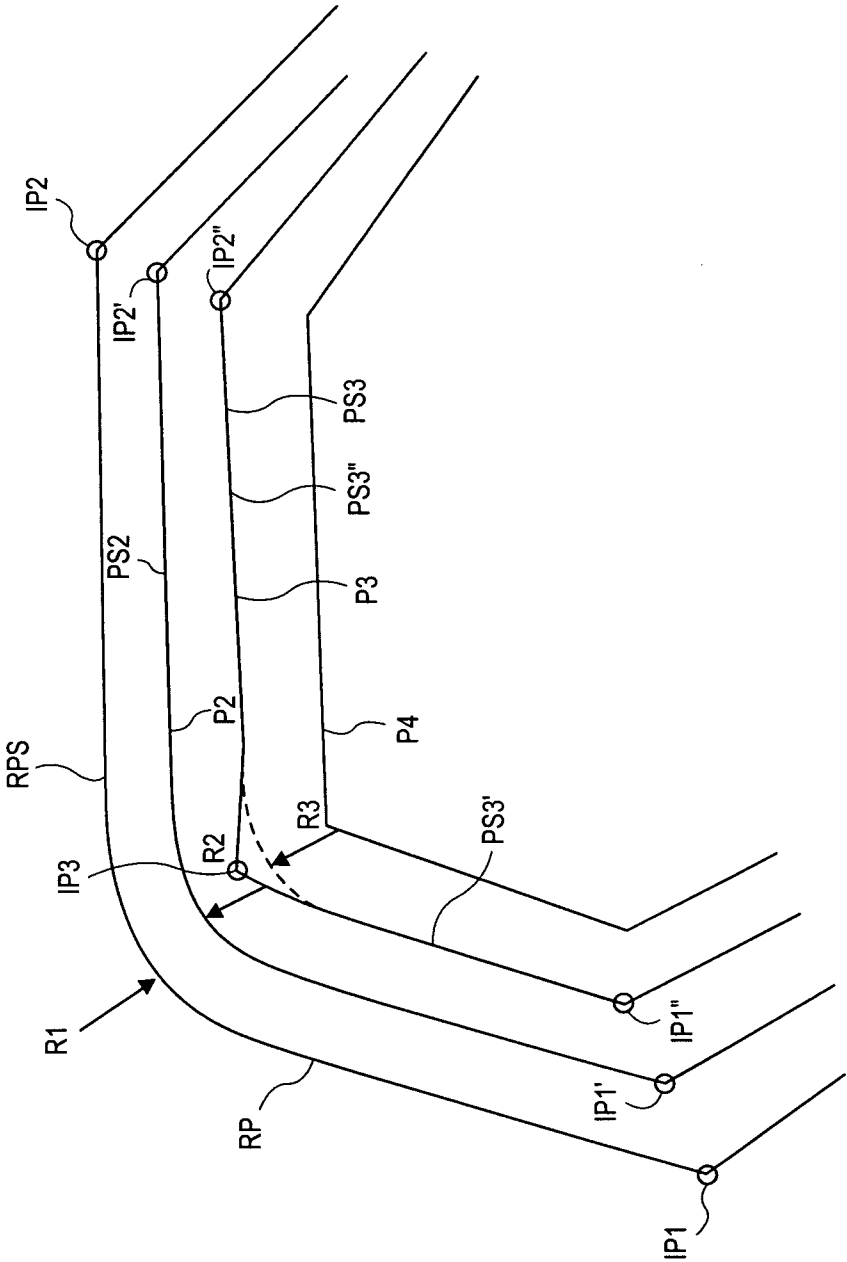


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/069681

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A01B 69/00 (2014.01)

USPC - 701/23

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A01B 69/00, 79/00, 79/02; B60T 7/12; B62D 6/00; G06F 7/70, 7/78 (2014.01)

USPC - 342/357.22; 701/23, 24, 25, 41, 50, 89, 469

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CPC - A01B 69/007, 69/008; G05D 1/0276, 1/0278, 2201/0201; G06F 17/30241 (2014.02)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/0233374 A1 (DIEKHANS et al) 04 October 2007 (04.10.2007) entire document	1-21
Y	US 6,085,130 A (BRANDT et al) 04 July 2000 (04.07.2000) entire document	1-21
Y	US 2012/0241178 A1 (GISLER) 27 September 2012 (27.09.2012) entire document	1-13
Y	US 4,515,221 A (VAN DER LELY) 07 May 7 1985 (07.05.1985) entire document	5, 7
Y	US 2007/0021913 A1 (HEINIGER et al) 25 January 2007 (25.01.2007) entire document	18

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 April 2014

Date of mailing of the international search report

02 MAY 2014

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