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DESCRIPTION

BACKGROUND

[0001] The present invention relates generally to circulation of vehicles along a guideway conveying goods or passengers with transportation or amusement ride enjoyment purposes. More particularly, the present invention relates to a rail switching unit, respectively to a track switching unit and to a track switching system to allow selective changes of paths to be followed by vehicles conveyed along a guideway, achieved by means of switching segments of track at diverge-points (divergence of one single path into many), at merge-points (convergence of many paths into a single one) or at cross-points (combination of diverge-points and merge-points).

[0002] Transport systems based on guideways, such as conventional trains, monorail trains or many automated people movers, need means to choose between alternate directions of movement. Changing of directions can be done through vehicle-activated (on board) steering mechanisms or through central-activated (wayside) guideway modification mechanisms, being the latter option the most preferred when a high level of stable and continuous centralized control is needed.

[0003] Switching of the guideways is commonly achieved using methods and systems that imply mechanical movement of multiple rails or whole sections of the guideway. These methods and systems are often slow, complex, difficult to operate, costly to maintain, restricted in practice to only two positions, requiring too much installation space, and considerably vulnerable to critical failure, which makes them objectively perceived as costly, inefficient, inconvenient or of insufficient utility value unless performance and reliability requirements are relaxed, or unless their use is limited to very specific applications.

[0004] In the specific case of widespread railways and other mass-transit systems with large and heavy vehicles, track-switching systems (also called track points) are especially critical because of the potential significantly large damage associated to the risk of derailment. In these applications, a fast, compact and reliable switch device offering more than the two standard states (straight route and turnout route) could imply miscellaneous improvements in the form of reduced costs, abated risks, increased capacities and improved operation speeds.

[0005] In the specific case of some modern or nascent applications such as Personal Rapid Transit (PRT) or other Automated Guideway Transit (AGT) systems, a fast and reliable track-switching technology could not only overcome many disadvantages and drawbacks, but also significantly increase their capacity and, hence, make these new and disruptive transit systems definitively feasible under a medium or high scale of transport demand. The same line of thought applies to some track-based materials/products handling systems used in factories or other industrial installations.

[0006] In the specific case of amusement rides in attraction/theme parks or the like, fast and reliable guideway switching systems that are also compatible with wheels-assemblies presenting rail-wrapping profiles, could not only overcome many drawbacks, but could also lead the industry into a new generation of roller coasters or similar attractions with a substantial improvement of their capacity, customer enjoyment value and consequent business profitability

[0007] Some attempted solutions have tried to overcome the mentioned drawbacks and disadvantages and/or to cover the mentioned potential opportunities, but only partially, insufficiently or, in practice, inconveniently. Following there are some examples:

- Patents US 1,112,965 or US 4,015,805 relate to switch track sliding devices, and present systems that allow switching between two tracks by pushing and sliding a pair of switch-rails into engagement position with stock rails.
- Patents US 2010/0,147,183 and US 6,273,000 relate to transversal-axis rotary-guided devices, and present systems that allow switching between two tracks on a horizontal plane through the rotation or pivoting of whole-track segments about a vertical axis placed transversally to the main track path.
- Patents US 8,020,49 and US 7,997,540 relate to longitudinal-axis rotary-guided devices, and present systems that allow switching between two tracks by means of a one single mechanism per track (instead of mechanically independent track-switching units for each rail of the track) based on a barrel or tubular member that, having whole-track segments attached, rotates about an axis placed longitudinally and parallel to the main track path.
- Patent US 3,313,243 also relates to longitudinal-axis rotary-guided devices in which a whole track segment is attached to a barrel, but specifically presenting a two switch-rails system designed for diverge-points track-switching applications of 'suspension rails and monorails' laid out on a horizontal plane.
- Patent GB 2,516,706 relates to special junctions and vertical-transversal movement and presents a system to switch between two tracks on a horizontal plane by means of a vertical and transversal movement of a pair of switch-rails so as to engage them with corresponding stock rails using a novel junction profile configuration.
- Patent US 4,030,422 relates to switching of guideway with vertical layout and presents a system for the switching of guided vehicles between two tracks that are placed vertically, one above the other.
- Patent GB 1,404,648 discloses a monorail track assembly, where a monorail track with a rail that has a rectangular cross-section or a near-vertical flanks section is used by vehicles with a lateral guidance. It is specifically devised for transport systems that use tracks of only one rail (thus not needing pairs of synchronized rail-switching units), for transport systems that convey vehicles requiring guiding contact with only one of the laterals of the rails (as in traditional railways). The disclosed device is also concretely devised to address switch-points in a horizontal layout where divergence from the main track can only be horizontal and not possibly also vertical (in which the main rail path and moving vertical vehicle-weight bearing forces are not placed right above the rotation axis but horizontally offset from it, circumstance that, in turn, also implies not only different vehicle-passing clearance requirements, but also quite different physical

dynamics to rotate switch-rails and to maintain them stably in their engagement positions).

- Patent DE 9,302,337 discloses a switch specifically devised for a cargo distribution system of parcels conveyed over a one-rail (monorail) system. The disclosed model presents two rail-sections, one straight and one curved, mounted on planes on a crossing disposition angularly separated 90° from each other. Hence, it is devised for use with only very basic one-rail switching applications.

[0008] In sum, by means of the present invention, it should be possible to overcome many of the general drawbacks and disadvantages of the known guideway switching systems and methods. Furthermore, this invention may imply a significant technological contribution to improve common railways switching, to boost passengers-capacity in amusement rides, and to facilitate the definitive implementation of revolutionary rapid mass transit systems.

[0009] In view of the foregoing prior art, an object of the present invention is to provide improved methods and apparatus to allow selective changing of paths followed by goods or passengers conveyed along guideways.

[0010] A more particular object of the invention is to provide such methods and apparatus as are applicable to switching of guideways using vehicles.

[0011] A further object of the invention is to provide such methods and apparatus as can be used, by way of non-limiting example, with vehicles (understood as any physical entity containing or grouping goods or passengers to facilitate their movement along a guideway), such as trains, trolleys, personal rapid transit vehicles (pods), wagons, carriage vehicles, etc.

[0012] A further object of the invention is to provide such methods and apparatus as work with a variety of vehicle suspension and guidance mechanisms.

[0013] A further object of the invention is to provide such methods and apparatus as can be used in applications requiring mechanisms with reduced footprint, lower weight and lower complexity in terms of fewer moveable mechanical guidance components.

[0014] A further object of the invention is to provide such methods and apparatus as can be used in applications requiring fast operation, minimal headway and minimal distance between successive diverge-points or merge-points.

[0015] A further object of the invention is to provide such methods and apparatus in applications requiring switching into diverging track paths that come out of the switch placed on vertical or inclined planes, paths that can be more than two in number, and paths that may have different curvature profiles.

[0016] A further object of the invention is to provide such methods and apparatus in applications with rolling, sliding or gliding mechanisms that require wrapping of a significant part of the perimeter of the rails.

[0017] A still further object of the invention is to provide such methods and apparatus in applications that could require vehicle switching not only at guideway points where one single track splits into many tracks (or diverge-points), but also at merge-points (guideway points where several tracks converge into a single one), or at cross-points (configured as combination of diverge-points and merge-points).

SUMMARY OF THE INVENTION

[0018] The solution involves - in a first embodiment - a rail-switching unit, for use to switch only one rail segment at a time, functioning either singly such as in a mono-rail track-switching unit or combined with other same units such as in a multi-rail track-switching unit, wherein the rail-switching unit is part of a track-switching unit, and the track-switching unit is part of a track-switching system, and the track-switching system is part of a vehicle-guiding system comprising vehicles and guideways, standard stationary rails or "common-rails", special stationary rail segments or "fixed-rails", and special moveable rail segments or "switch-rails", the rail-switching unit comprises:

- a rotatable set of components or "rotatable ensemble",
- and a stationary set of components or "stationary set";

the rotatable ensemble further comprising:

- a "rotatable hub",
- a set of two, three or more switch-rails,
- a set of auxiliary components to facilitate attachment of the switch-rails to the rotatable hub and/or to optimize the physical attributes of the rotatable ensemble and/or to facilitate precise control of the rotational movement of the rotatable ensemble;

the stationary set further comprising:

- one main fixed-rail,
- a set of two, three or more branch fixed-rails,
- a supporting structure;

wherein the main fixed-rail is solidly fixed to a common-rail at the "external end" of the main fixed-rail or end of the main fixed-rail that is furthest in distance from the rotatable ensemble and opposite to the "internal end" of the main fixed-rail;

wherein the branch fixed-rails are solidly fixed to common-rails at their "external ends" of the branch fixed-rails or ends of the branch fixed-rails that are furthest in distance from the rotatable ensemble and that are opposite to the "internal ends" of the fixed-rails, wherein, in a normal operating mode, the number of switch-rails is equal to the number of branch fixed-rails,

wherein each of the switch-rails is designed to allow its "activation" or engagement into a stationary operative position called "active position" of alignment and/or connection with a corresponding branch fixed-rail, wherein each of the switch-rails is fixedly attached at a distance from an axis of rotation of the rotatable hub so that rotational movement of the rotatable hub about the axis of rotation allows selective activation of each of the switch-rails with a corresponding fixed-rail, wherein activation of any one of the switch-rails involves aligning and/or connecting a so called "main end" with the internal end of the main fixed-rail and aligning and/or connecting a so called "branch end" with the corresponding internal end of a corresponding branch fixed-rail with the purpose of bi-directionally conveying or guiding vehicles through the rail-switching unit, this is, either from the main fixed-rail into any of the branch fixed-rails, or from any of the branch fixed-rails into the main fixed-rail, or simultaneously allowing both directions of movement, wherein the rail-switching unit is configured so that the internal branch ends of the branch fixed-rails are separated at fixed distances between each other providing the necessary clearance spaces for the vehicles to be directed adequately and avoiding inadequate interferences through the rail-switching unit, wherein the rail-switching unit is configured so that the internal branch ends of the branch fixed-rails do not necessarily have to form a plane and, if so, the plane they form does not necessarily have to be of horizontal nature,

wherein the rotatable ensemble is in principle configured in a compact way to optimize its moment of inertia about the axis of rotation, and wherein the supporting structure solidly supports, consolidates and protects elements comprised within the rail-switching unit and, if appropriate, also firmly attaches them to the ground and/or to the common guideway structures.

[0019] The invention can be used with mono-railed, bi-railed and multi-railed tracks, being also applicable to transport solutions with vehicles that fundamentally circulate above the rails (running on the rails) or to transport solutions with vehicles that circulate below the rails (being suspended from the rails).

[0020] Since the invention is not limited to horizontal planes (or any plane) and allows two, three or more switch-rails, a more flexible switching of vehicles is possible. The invention is neither limited to any particular (or identical) curvature of the switching rails further allowing freedom of switch point design.

[0021] The invention, when applied to track-switching problems on diverge-points, provides a solution where the support means and drive means may be disposed at any side of the fixed rails. The invention provides a solution where the axis of rotation might be at any side of the fixed rails.

[0022] The invention may include a shaft-arrangement that might engage either a live-shaft, a stationary dead-shaft, or a combination of both.

[0023] The invention is applicable to multi-railed track diverge-points and merge-points, as well as to cross-road points when considering them as a combination of diverge-points and merge-

points.

[0024] The invention is applicable not only to diverge-points (vehicle moving from trunk rails into branch rails), but also to merge-points (vehicle moving from branch rails into trunk rails).

[0025] In a second embodiment, the main fixed-rail and the switch-rails are shaped and/or may be configured to allow engagement between the internal end of the main fixed-rail and any of the main ends of the switch-rails by means of mating profiles at main ends or "main mating profiles", and/or wherein the branch fixed-rails and the switch-rails are shaped and/or configured to allow engagement between the internal ends of the branch fixed-rails and the corresponding branch ends of switch-rails by means of mating profiles at branch ends or "branch mating profiles", wherein a main mating profile comprises

- a main mating surface referred as "female" that is present on the internal end of the main fixed-rail,
- and a main mating surface referred as "male" that matches the "female" surface and that can be present on any of the main ends of the switch-rails;

wherein a branch mating profile comprises:

- a branch mating surface referred as "female", present on any of the internal ends of the branch fixed-rails;
- and a branch mating surface referred as "male" that matches a corresponding "female" surface, and that can be present on any of the branch ends of the switch-rails,

wherein a branch or main mating surface that is referred as female does not necessarily have to be mainly concave and a branch or main mating surface that is referred as male does not necessarily have to be mainly convex, and wherein the mating profiles are configured to allow firm connection between switch-rails and fixed-rails and configured to facilitate smooth movement of the switch-rails into and out of their positions of engagement with corresponding fixed-rails.

[0026] In a third embodiment, at least one of the mating profiles may be designed and configured to facilitate halting the continuity of the rotational movement of the rotatable ensemble when a certain active position of a switch-rail has been reached, to facilitate maintaining the reached active position of the switch-rail, and to facilitate the reversal of the direction of the rotational movement of the rotatable ensemble in order to come out of the reached active position of the switch-rail, and/or wherein at least one of the mating profiles is configured to facilitate smooth and controlled movement of the switch-rails into and out of their active positions of engagement with the corresponding branch fixed-rails preferably by means of specific shapes of the male and female mating surfaces and/or by means of using one or more sets of mating profile bearings, these preferably being sets of bearings and/or other auxiliary mechanisms to reduce friction and/or control relative movement between surfaces which are integrated with one or both of the mating surfaces.

[0027] In a fourth embodiment, the set of switch-rails may comprise:

- a switch-rail with a basically straight shape and referred as "straight switch-rail",
- a first switch-rail with a basically curved shape and referred as "first curved switch-rail",
- and a second switch-rail with a basically curved shape and referred as "second curved switch-rail";

wherein the set of branch fixed-rails may comprise:

- a fixed-rail shaped and/or configured to be connected with the straight switch-rail and referred as "straight-path branch fixed-rail",
- a fixed-rail shaped and/or configured to be connected with the first curved switch-rail and referred as "first curved-path branch fixed-rail",
- and a fixed-rail shaped and/or configured to be connected with the second curved switch-rail and referred as "second curved-path branch fixed-rail";

wherein when the straight switch-rail is rotated into active position, it engages simultaneously on a main end with the main fixed-rail and on a branch end with a corresponding straight-path branch fixed-rail, wherein when the first curved switch-rail is rotated into active position, it engages simultaneously on a main end with the main fixed-rail and on a branch end with a corresponding first curved-path branch fixed-rail, wherein when the second curved switch-rail is rotated into active position, it engages simultaneously on a main end with the main fixed-rail and on a branch end with a corresponding second curved-path branch fixed-rail, wherein all engagements between switch-rails (straight switch-rail, first curved switch-rail and second curved switch-rail) and corresponding fixed-rails (straight-path branch fixed-rail, first curved-path branch fixed-rail and second curved-path branch fixed-rail respectively) have the purpose of providing a continuous running surface and/or a continuous connection between the switch-rail and the corresponding fixed-rail in a bi-directional way (in one direction, in the other direction, or in both directions), wherein, in order to optimize the solidity and compactness of the ensemble of the rotatable hub and the switch-rails, the first and second curved switch-rails are preferably configured forming approximate parallel planes, and wherein, in order to facilitate a simplified engagement of the switch-rails with the main fixed-rail, the main ends of the switch-rails are configured within a same plane and at a same perpendicular distance from the axis of rotation, and the main ends of the curved switch-rails are configured in approximate diametrically opposite positions from each other and in relation to the axis of rotation.

[0028] In a fifth embodiment, the first curved switch-rail and the second curved switch-rail may have different curvature profiles.

[0029] In another embodiment, the rail-switching unit may further comprise a shaft arrangement to facilitate the rotational movement of the rotatable ensemble wherein the rotating hub is solidly supporting the switch-rails in order to accurately place them into their active positions by means of selective rotational movements about a fixed axis longitudinally traversing the shaft arrangement.

[0030] In a sixth embodiment, the rail-switching unit may further comprise an actuator arrangement to provide and transmit the necessary drive for the rotational movement of the rotatable ensemble, wherein the actuator arrangement may be able to actuate on only one rotatable ensemble or simultaneously on two or more rotatable ensembles of different rail-switching units.

[0031] In a seventh embodiment, the rail-switching unit may further comprise a mechanism to block angular positions of the rotatable ensemble, named "position-blocking mechanism", to assure and/or reaffirm precision and solidness of the engagement between switch-rails and fixed-rails by allowing firm, fast and timely blocking and unblocking of the rotatable ensemble by means of a multi-point latch mechanism operated by a control system and/or mechanically linked with the angular movement of the rotatable hub, wherein the position-blocking mechanism may be able to operate on only one rotatable ensemble or on two or more rotatable ensembles of different rail-switching units.

[0032] In an eighth embodiment, the rail-switching unit may further comprise an engagement-guiding system with the purpose of providing controlled rotational movement of the rotatable hub and the switch-rails during transitional phases, and/or of accurately guiding the ends of the switch-rails into precise and/or smooth engagement with their corresponding ends of the fixed-rails

[0033] In a ninth embodiment, the engagement-guiding system may comprise:

- a set of one or more stationary engagement guides,
- a set of one or more engagement-guiding bearings;
- and a set of one or more rotatable engagement components;

wherein the engagement-guiding bearings, which are preferably cylindrical roller bearings or needle roller bearings and/or any other auxiliary mechanisms to reduce friction and/or control relative movement between surfaces, are configured to facilitate the interaction between stationary surfaces of the stationary engagement guides and moving surfaces of the rotatable engagement components to accurately control their relative motion and/or to reduce the potential friction and constrain between them, with the ultimate objective of achieving a fast, smooth and precise engagement between switch-rails and corresponding fixed-rails, and wherein the rotatable engagement components provide surfaces to interact with the stationary engagement guides directly or by means of engagement-guiding bearings, are solidly fixed to the rotatable ensemble, integrate with the rotatable hub and/or the switch-rails and/or the auxiliary components, and may integrate with mating profile surfaces at the ends of the switch-rails.

[0034] In a tenth embodiment, the set of stationary engagement guides may comprise:

- one or more stationary engagement guides placed in outermost rings and presenting guiding surfaces with inward curving - referred as "concave guiding surfaces",
- and/or one or more stationary engagement guides placed in innermost rings and

presenting guiding surfaces with outward curving - referred as "convex guiding surfaces";

wherein the concave or convex guiding surfaces do not necessarily have to be continuous, and if so, they have the general shape of an arch covering up to approximately 180 degrees, wherein the concave or convex guiding surfaces are fundamentally concentric and share the same axis of rotation of the rotatable hub, and wherein the concave or convex guiding surfaces that are adjacent to an internal end of a branch fixed-rail are solidly fixed to it and configured to allow smooth and precise engagement of the end of the switch-rail (and its mating profile if present) with the corresponding end of the fixed-rail (and its mating profile if present).

[0035] In an eleventh embodiment, with the purpose of minimizing slacks, facilitating deceleration of the rotational movement of the rotational ensemble, and thus improving the final speed and accuracy of the connections between fixed-rails and switch-rails when reaching active positions, at least one of the concave guiding surfaces may have a curvature profile with a curvature radius that is slightly and progressively reduced at one or both end sections of the stationary engagement guide and/or at the mid-section of the stationary engagement guide, and/or at least one of the convex guiding surfaces has a curvature profile with a curvature radius that is slightly and progressively increased at one or both end sections of the stationary engagement guide and/or at the mid-section of the stationary engagement guide.

[0036] In a twelfth embodiment at least one rotatable engagement component may be shaped integrating the matching profiles of different branch ends of switch-rails and providing surfaces that allow simultaneous interaction with a concave guiding surface and with a convex guiding surface.

[0037] In a thirteen embodiment, a track-switching unit used to allow controlled and selective switching of a segment of a track or guideway, the track-switching unit comprises:

- one or more rail-switching units of the previous claims,
- a set of components linked to or part of an electronic operating control system,
- a supporting structure;

wherein the number of rail-switching units is equal to the number of rails that compose the track segment affected by the track-switching unit, wherein the track-switching unit is configured so that the internal branch ends of the branch fixed-rails of the rail-switching units do not necessarily have to form a plane and, if so, the plane they form is not necessarily of horizontal nature, wherein when comprising more than one rail-switching unit and in their normal operating mode, the rail-switching units are meant to be operated in a simultaneous way, but not necessarily by means of mechanical links between them, and not necessarily in a precise synchronous manner, wherein when comprising more than one rail-switching unit and in their normal operating mode, the rail-switching units are meant to be operated congruently so as to create viable paths of continuity for the vehicles to move along the track, and wherein the supporting structure solidly supports, consolidates and protects elements comprised within the track-switching unit and, if appropriate, also firmly attaches them to the ground and/or to

the common guideway structures or integrates them with the supporting structures of the rail-switching units.

[0038] In a fourteenth embodiment, the guideway rails may be supported from the outside of the track, and/or the sets of wheels of the wheels-assemblies are wrapped around the rails from the inside of the track; and/or the width of the track and/or the maximal width of the vehicle body is adapted without considering the wheels-assemblies or a vehicle body width, so that the vehicle, when directed through a track-switching unit, is able to fit within the horizontal gap between two rails of a same track and pass through the track-switching unit without any inadequate interferences; and/or clearance gaps above and below the rails are minimized fundamentally at the internal ends of the branch fixed-rails; and/or the top height of the wheels-assembly is minimized to the height of its top wheels; and/or the bottom height of the wheels-assembly is minimized to the height of its bottom wheels, whilst always allowing the wheels-assemblies to pass through the track-switching unit without any inadequate interferences; and/or the tracks in diverging/merging points is progressive vertical distanced /approximated avoiding any lateral turns of the tracks in a portion of the guideway referred as "straight-guideways segment" that is linked to the branch fixed-rails and thus is adjacent to the track-switching unit; and/or the longitudinal length of straight-guideways segments is reduced by means of minimizing the top height of the vehicle body and/or minimizing the bottom height of the vehicle body; and/or the segments of guideway adjacent to the track-switching unit and/or the general common guideway and/or vehicles running through the track-switching unit are adapted as a consequence of directly or indirectly applying some or all of the above limitations.

[0039] The fourteenth embodiment may correspond to a track-switching unit further comprising:

- a set of design guidelines,
- adaptations made to segments of guideway adjacent to the track-switching unit that are consequence of directly or indirectly applying some or all of the design guidelines,
- adaptations made to the general common guideway that are consequence of directly or indirectly applying some or all of the design guidelines,
- adaptations made to vehicles running through the track-switching unit that are consequence of directly or indirectly applying some or all of the design-guidelines;

wherein the track-switching unit has been adapted by directly or indirectly applying some or all of the design guidelines, wherein a first design guideline comprises:

- supporting of the guideway rails from the outside of the track and wrapping of the sets of wheels of the wheels-assemblies around the rails from the inside of the track;

wherein a second design guideline comprises:

- adapting the width of the track and/or adapting the maximal width of the vehicle body without considering the wheels-assemblies or "vehicle body width" so the vehicle, when directed through a track-switching unit, is able to fit within the horizontal gap between two rails of a same track and pass through the track-switching unit without any

inadequate interferences;

wherein a third design guideline comprises:

- minimizing clearance gaps above and below the rails fundamentally at the internal ends of the branch fixed-rails,
- and/or minimizing the top height of the wheels-assembly to the height of its top wheels,
- and/or minimizing the bottom height of the wheels-assembly to the height of its bottom wheels,

whilst always allowing the wheels-assemblies to pass through the track-switching unit without any inadequate interferences, wherein a fourth design guideline comprises:

- progressive vertical distancing/approximating of the tracks in diverging/merging points, avoiding any lateral turns of the tracks in a portion of the guideway referred as "straight-guideways segment" that is linked to the branch fixed-rails and thus is adjacent to the track-switching unit;

and wherein a fifth design guideline comprises

- reducing the longitudinal length of the straight-guideways segments derived from the fourth design-guideline by means of minimizing the top height of the vehicle body and/or minimizing the bottom height of the vehicle body.

[0040] In a fifteenth embodiment, a track-switching system, for use to allow coordinated and controlled selective switching of multiple track segments of a vehicle-guiding system comprises:

- one or more track-switching units of claims 13 or 14,
- an electronic operating control system,
- and a supporting structure;

wherein the electronic operating control system manages the one or more track-switching units, including activating, coupling, verifying, maintaining and controlling the functioning of the track-switching units and their rail-switching units, and wherein the supporting structure solidly supports, consolidates and protects elements comprised within the track-switching system and, if appropriate, also firmly attaches them to the ground and/or to the common guideway structures or integrates them with the supporting structures of the track-switching units.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041]

FIG. 1A (PRIOR ART) is a schematic top view of the case of a three-diverging-ways track-

switching problem solved with two conventional two-ways track-switching devices disposed sequentially;

FIG. 1B is the same view of the same problem as in FIG. 1A, but solved with only one track-switching unit in accordance with embodiments of the invention;

FIG. 2A (PRIOR ART) is a schematic top view of the case of a five-diverging-ways track-switching problem solved with four conventional two-ways track-switching devices disposed sequentially;

FIG. 2B is the same view of the same problem as in FIG. 2A, but solved with only two track-switching units in accordance with embodiments of the invention;

FIG. 3 is a basic schematic perspective view of the case of a vertical-layout three-diverging-ways track-switching problem, solved with a track-switching unit in accordance with a preferred embodiment of the invention;

FIG. 4 is another (enlarged) basic schematic perspective view of the same shown in FIG. 3.

FIG. 5 is a basic schematic perspective view of the case of a horizontal-layout three-diverging ways track-switching problem, solved with a track-switching unit in accordance with a possible embodiment of the invention, possibly appropriate with certain slow and/or heavy-load applications;

FIG. 6A (PRIOR ART) is a schematic front cross-sectional view of the rail and wheel simple contact in the case of a common railway, which can be handled by conventional switching devices as well as by ones according with embodiments of the present invention;

FIG. 6B (PRIOR ART) is a schematic cross-sectional view of the rail and wheels-assembly wrapping contact in the case of a modern roller coaster, which can be handled by conventional switching devices as well as by ones according with embodiments of the present invention;

FIG. 7A (PRIOR ART) is a schematic front cross-sectional view presenting the example of a bi-railed track - and wrapping wheels-assemblies - where the rails are supported from the inside of the track and the wheels-assemblies wrap the rails from the outside of the track, application for which rail-switching units of the present invention can be used but not according with a preferred embodiment;

FIG. 7B (PRIOR ART) is a schematic front cross-sectional view presenting the example of a bi-railed track - and wrapping wheels-assemblies - where the rails are supported from the outside of the track and the wheels-assemblies wrap the rails from the inside of the track, application for which a track-switching unit of the present invention can be used in accordance with a preferred embodiment;

FIG. 8 (PRIOR ART) is a schematic cross-sectional view presenting the example of a bi-railed track - and a corresponding track-vehicle - where the design-guidelines proposed in the invention are not followed, application for which a track-switching unit of the present invention can be used but not according with a preferred embodiment;

FIG. 9 is a schematic cross-sectional view presenting the example of a diverge-point of a bi-railed track in which the track-switching unit - and the track-vehicle - follow design-guidelines according with a preferred embodiment of the invention;

FIG. 10A is a schematic side view of a rail-switching unit configured for a left rail (of a bi-railed track) at a vertical-layout diverge-point where a 'straight' position is activated, in a preferred embodiment of the present invention;

FIG. 10B is a schematic back view of a section plane (SP) of the same presented in 10A;

FIG. 11A is a schematic side view of the same rail-switching unit of FIGS. 10A/B, but with an 'up' position activated;

FIG. 11B is a schematic back view of a section plane (SP) of the same presented in 11A;

FIG. 12A is a schematic side view of the same rail-switching unit of FIGS. 10-11A/B, but with a 'down' position activated;

FIG. 12B is a schematic back view of a section plane (SP) of the same presented in FIG. 12A;

FIG. 13 is a schematic side view of a rail-switching unit configured for a left rail (of a bi-railed track) at a vertical-layout of not a diverge-point but a merge-point, where a 'down' position is activated, in a preferred embodiment of the present invention;

FIG. 14 is a schematic sectional view of an improved engagement-guiding system with two stationary engagement guides (one with a concave engagement surface and another one with a convex engagement surface) where the engagement surfaces present progressive changes of curvature, in a preferred embodiment of the present invention;

FIG. 15A is a perspective view (from the left of the front/main side) of a vertical-layout rail-switching unit at a diverge-point configured for a right rail (not a left rail as in FIGS. 10-12A/B), where a 'down' position has been activated, in a preferred embodiment of the present invention, where only the rotatable ensemble (comprising rotatable hub, switch-rails, sets of bearings, engagement-guiding bearings, moveable guiding components and auxiliary components) is presented;

FIG. 15B is a perspective view (from the right of the back/branches side) of the same presented in FIG. 15A;

FIG. 16A is a perspective view (from the same point of view of FIG. 15A) of the same rail-switching unit of FIGS. 15A/B, where only the stationary elements are presented: common-rails, fixed-rails, engagement guides and stationary shaft (not supporting structures);

FIG. 16B is a perspective view (from the same point of view of FIG. 15B) of the same presented in FIG. 16A;

FIG. 17A is a perspective view (from the same point of view of FIGS. 15A and 16A) of the same rail-switching unit of FIGS. 15A/B and 16A/B, where all the rotatable elements of FIGS.

15A/B and all the stationary elements of FIGS. 16A/B are jointly presented;

FIG. 17B is a perspective view (from the same point of view of FIGS. 15B and 16B) of the same presented in FIG. 17A, but further including the location of a possible actuator arrangement;

FIG. 18 is a perspective view (from the same point of view of FIGS. 15B, 16B and 17B) of the same presented in FIG. 17B, but further including a possible supporting structure;

FIG. 19 is a perspective view of a possible actuator arrangement including a motor, a drive-transmission mechanism, and a partial gear integrated with the rotatable hub (and not including supporting structure elements).

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0042] Hereafter, an embodiment of a system to switch tracks is described in detail with reference to the accompanying drawings.

Rail-Switching Unit

[0043] The herein disclosed device referred as "rail-switching unit" (RSU) allows selective switching of one rail segment of a guideway operating either singly (as in a mono-rail track-switching device) or combined with other same units (in a multi-rail track-switching device).

[0044] A rail-switching unit (RSU) is part of an ampler system that allows controlled selective switching of a track segment and is referred as a "track-switching unit" (TSU). A track-switching unit (TSU) is part of an ampler system that allows coordinated and controlled selective switching of multiple track segments and is referred as a "track-switching system" (TSS). A track-switching system (TSS) is part of an ampler system that allows guiding of vehicles along a guideway and is referred as a "vehicle-guiding system" (VGS). A vehicle-guiding system (VGS) comprises "guideways" and "vehicles".

[0045] The guideways include standard stationary rails or "common-rails" (CR) and special rail segments that are essential parts of the guideway points. These rail segments may be divided into movable ones, or "switch-rails" (SWR0/1/2/..), and stationary ones, or "fixed-rails". Fixed-rails may in turn be divided in primary rail segments, or "main fixed-rails" (MFR), and secondary branching rail segments, or "branch fixed-rails" (BFR0/1/2/..).

[0046] The vehicles, which might be trains, trolleys, pods, wagons, carriage vehicles or the like (or any physical entity containing or grouping goods or passengers to facilitate their movement along a guideway), may include different mechanisms to move along the guideways (such as

those based on wheels) referred as "wheels-assemblies" (WA). These may comprise different sets of "wheels" (or similar mechanisms to facilitate minimized-friction movement of a solid movable element relative to a stationary surface). Wheels may be divided into "top wheels" (tW) or "support-wheels" (wheels that support the weight of the vehicle and normally run on top of the rails), "side wheels" (sW) or "guide wheels" (wheels that support the lateral guiding of the vehicle and normally run at one side of the rails), and "bottom wheels" (bW) or "up-stop wheels" (wheels that prevent vehicles from coming up off the track and run hugging the bottom of the rails). FIG. 6A presents a simple wheel-rail contact of a typical railway, where a top wheel (tW) supports the weight of the vehicle and moves along and on top of a common-rail (CR). In contrast, FIG. 6B presents the more complex example of a wheels-rail contact of a typical roller-coaster, where a wheels-assembly (WA) comprising three sets of wheels (tW, sW and bW) wraps around a common-rail (CR).

[0047] The rail-switching unit (RSU) comprises a rotatable set of components or "rotatable ensemble" (RE) and a stationary set of components or "stationary set" (SS). The rotatable ensemble (RE) further comprises a "rotatable hub" (RH), a set of two, three or more switch-rails (SWR0/1/2/..), a set of auxiliary components (AC1/2/3/..) to facilitate attachment of the switch-rails to the rotatable hub and/or to optimize the physical attributes of the rotatable ensemble (volume, mass, solidness, moment of inertia, etc.) and/or to facilitate precise control of the rotational movement of the rotatable ensemble. The stationary set (SS) further comprises one main fixed-rail (MFR), a set of two, three or more branch fixed-rails (BFR0/1/2/..) and a supporting structure (ST).

[0048] Referring to FIGS. 10-12A/B and 13, the rail-switching unit (RSU) comprises a barrel that can rotate or "rotatable hub" (RH), a set of switch-rails (SWR0/1/2), a main fixed rail (MFR), a set of branch fixed-rails (BFR0/1/2) and a shaft arrangement (SA). In FIGS. 10-12A/B, 13, 14 and 16-17A/B, a system to facilitate engagement of the switch-rails with the fixed-rail, or "engagement-guiding system" (EGS) can also be appreciated. In FIGS. 17 and 19, a possible actuator arrangement (AA) without structural elements can also be appreciated.

[0049] FIGS. 15A/B present three-dimensional perspective views of only the movable elements that are part of a rotatable ensemble (RE), whereas FIGS. 16A/B show only the fundamental "fixed" elements that are part of a stationary set (SS) - excluding a structure (ST) -. FIGS. 17A/B present jointly rotatable and stationary elements all together. FIG. 18 presents the same as in 17A/B but including a possible structure (ST).

Main Fixed-Rail

[0050] Referring to FIGS. 10-12A/B and 13, the main fixed-rail (MFR) is represented as a simple solid straight rail segment (though it may also be hollow or with a non-straight profile). The main fixed-rail (MFR) is attached at its external end (eMFR) to a common-rail (CR) by means of a standard guideway connection, and it is installed to facilitate a precise and solid engagement of its internal end (iMFR) with a main end of the switch-rails (mSWR0/1/2) by

means of mating profiles.

[0051] In FIGS. 10-12A/B, which represents a diverge-point, the main fixed-rail (MFR) is placed at the inbound side of the rail-switching unit (RSU) guiding the translational motion (TraM) of a wheels-assembly (WA) into an active switch-rail (SWR0/1/2) of the rail-switching unit (RSU). In FIG. 13, which represents not a diverge-point but a merge-point, the main fixed-rail (MFR) is placed at the outbound side of the rail-switching unit (RSU) guiding the translational motion (TraM) of a wheels-assembly (WA) out of the rail-switching unit (RSU) into a common-rail (CR).

Branch Fixed-Rails

[0052] Referring to FIGS. 10-12A/B and 13, the branch fixed-rails (BFR0/1/2) are represented as simple solid rail segments, either straight (BFRO) or curved (BFR1 and BFR2) (though they may also be hollow or have other profiles). The branch fixed-rails (BFR0/1/2) are attached to a common-rail (CR) at their external ends (eBFR0/1/2) by means of a standard guideway connection, and they are installed to facilitate precise and solid engagement of their internal ends (iBFR0/1/2) with the corresponding branch ends of the switch-rails (bSWR0/1/2) by means of mating profiles (BMP0/1/2).

[0053] In FIGS. 10-12A/B, which represent a diverge-point, the branch fixed-rails (BFR0/1/2) are placed at the outbound side of the rail-switching unit guiding the translational motion (TraM) of a wheels-assembly (WA) out of the rail-switching unit (RSU). In FIG. 13, which represents not a diverge-point but a merge-point, the branch fixed-rails (BFR0/1/2) are placed at the inbound side of the rail-switching unit guiding the translational motion (TraM) of a wheels-assembly (WA) into the rail-switching unit (TSU).

[0054] The set of branch fixed-rails preferably includes a combination of two or three of the following: one fixed-rail shaped and/or configured to be connected with the straight switch-rail and referred as "straight-path branch fixed-rail" (BFR0), one fixed-rail shaped and/or configured to be connected with the first curved switch-rail and referred as "first curved-path branch fixed-rail" (BFR1), one fixed-rail shaped and/or configured to be connected with the second curved switch-rail and referred as "second curved-path branch fixed-rail" (BFR2).

[0055] The straight-path branch fixed-rail (BFR0) is preferably fixed to a common-rail (CR) at its external end (eBFR0) and installed to facilitate engagement of its internal end (iBFR0) with the branch end of a corresponding straight switch-rail (bSWR0) by means of a pair of a female and male mating surfaces (fMMS0 and mMMS0).

[0056] The first curved-path branch fixed-rail (BFR1) is preferably fixed to a common-rail (CR) at its external end (eBFR1) and installed to facilitate engagement of its internal end (iBFR1) with the branch end of a corresponding first curved switch-rail (bSWR1) by means of a pair of a female and male mating surfaces (MMSf1 and MMSm1).

[0057] The second curved-path branch fixed-rail (BFR1) is preferably fixed to a common-rail (CR) at its external end (eBFR2) and installed to facilitate engagement of its internal end (iBFR2) with the branch end of a corresponding second curved switch-rail (bSWR2) by means of a pair of a female and male mating surfaces (MMSf2 and MMSm2).

Switch-Rails

[0058] Referring to FIGS. 10-12A/B and 13, the switch-rails (SWR0/1/2) provide different alternatives for establishing connections between the main fixed-rail (MFR) and the branch fixed-rails (BFR0/1/2).

[0059] The set of switch-rails preferably includes the following switch-rails:

- one switch-rail with a basically straight shape and referred as "straight switch-rail" (SWR0),
- one first switch-rail with a basically curved shape and referred as "first curved switch-rail" (SWR1),
- and one second switch-rail with a basically curved shape and referred as "second curved switch-rail" (SWR2).

Straight Switch-Rail

[0060] Referring to FIGS. 10A/B, when the straight switch-rail (SWR0) is rotated into its active position, it engages simultaneously on a main end (mSWR0) with the main fixed-rail (MFR) and on a branch end (bSWR0) with a corresponding straight-path branch fixed-rail (BFR0), providing enough continuous running surface (or connection level) between the fixed-rails and the switch-rail so as to guide the translational motion (TraM) of the wheels-sets (tW, sW and bW) of a wheels-assembly (WA) from a main path-line (ML) through the rail-switching unit and into a path of an approximately-straight branch-line (BL0).

[0061] Referring to FIGS. 15A/B and 17A/B, the straight switch-rail (SWR0) is preferably configured fixed to the external face of the rotatable hub (RH) parallel to the axis of rotation (Ax) so it can be rotated into its active position to engage simultaneously on one end with the main fixed-rail (MFR) and on the other end with its corresponding branch fixed-rail (BFR0), and with a main end (mSWR0) placed in relation to the axis of rotation (Ax) at the same perpendicular distance as the main ends of the other switch-rails (mSWR1/2).

[0062] In FIG. 13, which represents not a diverge-point but a merge-point, the rail-switching unit (TSU) shows a selected 'down' position by which a first curved switch-rail (SWR1) is in its

active position of engagement by connecting on one end (bSWR1) with an internal end (iBFR1) of a first curved-path branch fixed-rail (BFR1) and on the other end (mSWR1) with an internal end (iMFR) of a main fixed-rail (MFR) in order to allow directing the translational motion (TraM) of a wheels-assembly (WA) through the track-switching unit (TSU) from a first curved-path line (BL1) into a main line (ML).

First Curved Switch-Rail

[0063] Referring to FIGS. 10A/B, when the first curved switch-rail (SWR1) is rotated into its active position, it engages simultaneously on a main end (mSWR1) with the main fixed-rail (MFR) and on a branch end (bSWR1) with a corresponding first curved-path branch fixed-rail (BFR1), providing enough continuous running surface (or connection level) between the fixed-rails and the switch-rail so as to guide the translational motion (TraM) of a wheels-set (tW, sW and bW), from a main path-line (ML), through the rail-switching unit, into a path of a first approximately-curved branch-line (BL1).

[0064] Referring to FIGS. 15-17A/B, the first curved switch-rail (SWR1) is preferably configured fixed to the external face of the rotatable hub (RH), curving outwardly away from the axis of rotation (Ax) at its branch end, with a curved profile different from the one of the second curved switch-rail (SWR2), contained in a plane approximately parallel to the one containing the second curved switch-rail (SWR2), and with a main end (mSWR1) placed in relation to the axis of rotation (Ax) at the same perpendicular distance as the main ends of the other switch-rails and in an approximate diametrically opposite position from the main end of the second curved switch-rail (bSWR2).

Second Curved Switch-Rail

[0065] Referring to FIGS. 10A/B, when the second curved switch-rail (SWR2) is rotated into its active position, it engages simultaneously on a main end (mSWR2) with the main fixed-rail (MFR) and on a branch end (bSWR2) with a corresponding second curved-path branch fixed-rail (BFR2), providing enough continuous running surface (or connection level) between the fixed-rails and the switch-rail so as to guide the translational motion (TraM) of a wheels-set (tW, sW and bW), from a main path-line (ML), through the rail-switching unit, into a path of a second approximately-curved branch-line (BL2).

[0066] Referring to FIGS. 15-17A/B, the second curved switch-rail (SWR2) is preferably configured fixed to the external face of the rotatable hub (RH), curving outwardly away from the axis of rotation (Ax) at its branch end, with a curved profile different from the one of the first curved switch-rail (SWR1), contained in a plane approximately parallel to the one containing the first curved switch-rail (SWR1), and with a main end (mSWR2) placed in relation to the axis of rotation (Ax) at the same perpendicular distance as the main ends of the other switch-rails

and in an approximate diametrically opposite position from the main end of the first curved switch-rail (bSWR1).

Rotatable Hub

[0067] Referring to FIGS. 10-12A/B, 13 and 15A/B, the rotatable hub (RH) solidly and compactly supports and holds together the set of switch-rails (SWR0/1/2) as part of the rotatable ensemble (RE) in order to accurately rotate them and place them into their active positions of engagement by means of selective bi-directional rotational movements (Rot) about a rotation axis (Ax) that longitudinally traverses a shaft arrangement (SA).

[0068] As shown in FIGS. 15-17A/B and 19, the rotatable hub (RH) is preferably configured with a cylindrical hole (CH) along its axis of rotation (Ax) that integrates with an arrangement comprising a stationary shaft or "dead shaft" (DS). It is also preferably configured to receive the necessary drive force for its rotational movement (Rot) interacting with the motor (Mot) of an actuator arrangement either directly or by means of gear and pinion mechanism or "drive transmission" (DT) that may link with a gear or part of a gear is attached or carved at the external surface of the rotatable hub or "hub gear" (HG). The rotatable hub (RH) is also preferably mounted for bi-directional rotation (Rot) about a stationary axis (Ax) along the dead shaft (DS) that is placed parallel to the direction of the internal end of the main fixed-rail (MFR) and located at approximately the same height (case of vertical-layout track-switching applications, as shown in FIGS. 15A/B) or beneath it (case of horizontal-layout track-switching applications such as that of FIG. 5).

Supporting Structure

[0069] The supporting structure (ST) solidly supports, consolidates and protects elements comprised within the rail-switching unit (RSU) and, if appropriate, also firmly attaches them to the ground and/or to the common guideway structures. An example of the supporting structure (ST) for a rail-switching unit (RSU) is shown in FIG. 18.

Shaft Arrangement

[0070] The shaft arrangement (SA) supports the rotatable hub (RH) and facilitates its bi-directional rotational movement (Rot) about the axis of rotation (Ax). The shaft arrangement includes either a rotating live-shaft solidly attached to the rotatable hub (RH) and supported through bearings by at least two fixed stationary housings, or - preferably - (as shown in FIGS. 16-17A/B) it includes a fixed stationary dead shaft (DS), supported and locked at its ends by at least two fixed housings (SH1, SH2) and having bearings supporting the rotation of the shaft or "shaft-rotation bearings" (SRB1/2/..) between the inside surface of the hollow rotatable hub

(RH) and the outside surface of the dead shaft (DS), or any combination of the two. The dead shaft (DS) is preferably placed traversing the rotatable hub (RH) through its longitudinal cylindrical hole (CH).

Actuator Arrangement

[0071] Referring to FIGS. 17B and 18, an actuator arrangement (AA) provides and transmits the necessary drive to directly or indirectly rotate the rotatable hub (RH) and provides the necessary speed and accuracy of rotational driving force to assure rapid and precise rotational movement (Rot) of the switch-rails (SWR0/1/2) into their active positions of engagement. The actuator or motor (Mot) is preferably a servo-motor type or the like, with the capacity of driving bi-directional movement (Rot) with enough speed, with the capacity of controlling angular positions with precision, and with the capacity of holding still in stationary positions. The motor (Mot) is preferably complemented with a gear and pinion mechanism or the like referred as "drive transmission" (DT) for transmitting forces from the actuator to the rotatable hub (RH). The motor (Mot) is preferably located as proximate as possible to the rotatable hub (RH) and in a place of no interference with the movement of the vehicles along the guideway.

[0072] The motor (Mot) may actuate on only one rotatable hub (RH) at a time, or simultaneously on two or more rotatable hubs of different rail-switching units (RSU1/2) of a same track-switching unit (TSU).

Engagement-Guiding System

[0073] A rail-switching unit (RSU) may preferably be complemented with a system referred as "engagement-guiding system" (EGS) which has the purpose of providing precise and controlled rotational movement of the rotatable hub and the switch-rails (SWR0/1/2/..) during transitional phases to accurately guide the ends of the switch-rails (mSWR0/1/2/ and bSWR0/1/2/..) into precise and/or smooth engagement with their corresponding ends of the fixed-rails (iMFR and iBFR0/1/2/..).

[0074] Figures 10-12A/B and 15-17A/B present different views and partial sets of components of a three-ways rail-switching unit (RSU) in a preferred embodiment of the invention, wherein the engagement-guiding system (EGS) comprises two stationary engagement guides (SEG1 and SEG2), a set of multiple engagement-guiding bearings (EGB1/2/..), and one rotatable engagement component (REC) that binds the two branch ends of the curved switch-rails (bSWR1 and bSWR2) into one single piece and is configured to interact simultaneously with the two stationary engagement guides (SEG1 and SEG2).

[0075] In this preferred embodiment, a first stationary engagement guide (SEG1) provides one continuous concave guiding surface (CNC) placed in an outermost ring and a second

stationary engagement guide (SEG2) provides one continuous convex guiding surface (CNV) placed in an innermost ring, wherein both surfaces (CNC and CNV) are concentric - sharing a same centre in the axis of rotation (Ax) of the rotatable hub (RH) - and have the general shape of an arch approximately covering 180 degrees or somewhat less.

[0076] In this embodiment, both stationary engagement guides (SEG1 and SEG2) are solidly fixed to the internal ends of the branch fixed-rails (iBFR1 and iBFR2), wherein the convex guiding surface (CNV) integrates with a female mating surface (fBMS1) located at the internal end of a first curved-path branch fixed-rail (iBFR1) facilitating precise and controlled movement of a first curved switch-rail (SWR1) into an active position of engagement with a corresponding first curved-path branch fixed-rail (BFR1), and wherein the concave guiding surface (CNC) integrates with a female mating surface (fBMS2) located at the internal end of a second curved-path branch fixed-rail (iBFR2) facilitating precise and controlled movement of the second curved switch-rail (SWR2) into an active position of engagement with a corresponding second curved-path branch fixed-rail (BFR2). The rotatable engagement component (REC) of this embodiment is configured to solidly bind the two branch ends of the curved switch-rails (bSWR1 and bSWR2) and to interact simultaneously with the two stationary engagement guides (SEG1 and SEG2). By having convex and concave curved surfaces designed to perfectly interact with the outer concave guiding surface (CNC) and the inner convex guiding surface (CNV) with the aid of engagement-guiding bearings (EGB1/2/..), the rotatable engagement component (REC) is able to smoothly rotate between the guiding surfaces (CNC and CNV) and to ultimately achieve accurate and controlled engagement of a switch-rail into an active position.

[0077] The engagement-guiding bearings (EGB1/2/..) of this embodiment are configured to reduce friction and constrain (and control relative motion) between the rotational engagement component (REC) and the guiding surfaces (CNC and CNV). They are preferably cylindrical roller bearings or needle roller bearings and they are preferably placed attached to the branch ends of the curved switch-rails (bSWR1 and bSWR2).

[0078] Referring to FIG. 14, which represents an extended preferred embodiment of the present invention, the stationary engagement guides (SEG1 and SEG2) do not include guiding surfaces with perfectly circular longitudinal-section shapes but instead present modifications with the purpose of further minimizing slacks, facilitating deceleration of the rotational movement (Rot) of the rotational ensemble about an axis (Ax), and ultimately improving the final speed and accuracy of the connections between fixed-rails and switch-rails when reaching active positions. These modifications, which may further increase the general accuracy and effectiveness of the engagement-guiding system (EGS), consist in that at least one of the concave guiding surfaces (CNC) has a curvature profile with a curvature radius that is slightly and progressively reduced at one or both end sections of the stationary engagement guide (bCNC and bCNC') and/or at the mid-section of the stationary engagement guide (mCNC), and/or at least one of the convex guiding surfaces (CNV) has a curvature profile with a curvature radius that is slightly and progressively increased at one or both end sections of the stationary engagement guide (bCNV and bCNV') and/or at the mid-section of the stationary

engagement guide (mCNV).

Track-Switching Unit

[0079] The herein disclosed device referred as "track-switching unit" (TSU) allows selective switching of a track segment of a guideway.

[0080] A track-switching unit (TSU) comprises one or more rail-switching units (RSU1/2/..) as the previously described rail-switching unit (RSU), as well as a set of components linked to or part of an electronic operating control system (OCS) and a structure (ST) to support, consolidate and protect the elements of the track-switching unit.

[0081] The number of rail-switching units (RSU1/2/..) in a track-switching unit (TSU) is equal to the number of rails that compose the track segment affected by the track-switching unit.

[0082] Congruently with the flexibility of its rail-switching units (RSU1/2/..), a track-switching unit (TSU) is not limited to "horizontal-layout" track-switching applications (as in FIG. 5), but can alternatively be used in many other cases, such as for example those of "vertical-layout" track-switching applications (as in FIG. 3 or FIG. 4).

[0083] When a track-switching unit (TSU) includes more than one rail-switching unit and is operating in a regular mode, its rail-switching units (RSU1/2/..) are meant to operate in a simultaneous way, but not necessarily by means of mechanical links between them, and not necessarily in a precise synchronous manner.

[0084] In their regular mode of operation, rail-switching units (RSU1/2/..) of a same track-switching unit (TSU) are meant to operate congruently, this is, creating viable track paths of continuity for the vehicles to move along the track-switching unit (TSU).

[0085] Congruent operation of rail-switching units is illustrated in FIG. 4 (and in FIG. 3), where a track-switching unit (TSU) in a preferred embodiment of the invention is used in a vertical-layout diverge-point of a bi-railed track. In this example, the two rail-switching units (RSU1 and RSU2) of the track-switching unit (TSU) have been congruently switched - both - into their 'up' active positions by placing their switch-rails (SWR1 and SWR1') in their active positions of engagement. If focusing on the rail-switching unit on the right side of the track (RSU1), a first curved switch-rail (SWR1) is placed in its active position of engagement with a main fixed-rail (MFR) and a corresponding first curved-path branch fixed-rail (BFR1), wherein both fixed-rails are attached to common-rails (CR). If focusing on the rail-switching unit on the left side of the track (RSU1'), a first curved switch-rail (SWR1') is placed in its active position of engagement with a main fixed-rail (MFR', not shown) and a corresponding first curved-path branch fixed-rail (BFR1'). The congruent switching of both rail-switching units (RSU1 and RS2) allows vehicles entering the track-switching unit (TSU) to have their vehicle translational motion (TraM) directed from a main track path (MTP) into a viable track path of continuity, in this case the

diverging branch track path that curves upwards (BTP1) and not the one that maintains a straight direction (BTP0) or the one that curves downwards (BTP2).

[0086] Congruent operation of rail-switching units is also illustrated In FIG. 5, where a track-switching unit (TSU) for a horizontal-layout diverge-point of a bi-railed track is presented in a possible embodiment of the invention. In this example, the two rail-switching units (RSU1 and RSU2) of the track-switching unit (TSU) have been congruently both switched into their 'left' active position by placing their switch-rails (SWR1 and SWR1') in their active positions of engagement. This congruent switching of both rail-switching units (RSU1 and RS2) allows vehicles entering the track-switching unit (TSU) to have their vehicle translational motion (TraM) directed from a main track path (MTP) into, in this case, the diverging branch track path that curves leftwards (BTP1) and not the one that maintains a straight direction (BTP0) or the one that curves rightwards (BTP2).

[0087] Track-switching units of the present invention (TSU, TSU1/2/3/..), when configured to allow selection of more than two directions, are especially useful to simplify, improve performance and reduce general costs of track-switching systems (TSS) and thus vehicle-guiding systems (VGS). This is illustrated in example of FIG. 1B (as compared with FIG. 1A) as well as in example of FIG. 2B (as compared with FIG. 2A):

FIG. 1A presents a track-switching problem of one main track-path (MTP) diverging into three track-paths (BTP0, BTP1 and BTP2) which is inefficiently solved using two conventional two-ways track-switching devices (TSD1 and TSD2) disposed sequentially; in contrast, FIG. 1B presents the same problem solved with only one track-switching unit (TSU) according to embodiments of the present invention.

[0088] FIG. 2A presents a track-switching problem of one main track-path (MTP) diverging into five track-paths (BTP0, BTP1, BTP2, BTP3 and BTP4) which is inefficiently solved using four conventional two-ways track-switching devices (TSD1, TSD2, TSD3 and TSD4) disposed sequentially; in contrast, FIG. 2B presents the same problem solved with only two track-switching units (TSU1 and TSU2) according to embodiments of the present invention.

[0089] The supporting structure (TSU-ST) solidly supports, consolidates and protects elements comprised within the track-switching unit (TSU) and, if appropriate, also firmly attaches them to the ground and/or to the common guideway structures or integrates them with the supporting structures (ST) of the rail-switching units (RSU1/2/..).

Design-Guidelines

[0090] In the case of vertical track-switching applications where vehicles run along bi-railed tracks and have wheels-assemblies (WA) with sets of wheels (tW, sW or bW) that wrap in more or less extent around a rail (CR) (as shown in FIG. 6B, in contrast with FIG. 6A), certain configuration and design guidelines, referred as "design-guidelines" (DG1-5), are preferable. These design-guidelines apply directly to the design/configuration of segments of guideway

that are adjacent to the track-switching units (TSU1/2/3/..) and consequently they also affect the general design of the whole guideway as well as the design of the vehicle-body (VB) and wheels-assemblies (WA) of the vehicles that move along the guideways.

[0091] The ultimate purpose of these design-guidelines is to potentially improve the performance and costs (of fabrication, installation, operation, maintenance...) of the track-switching units (TSU1/2/3/..), the track-switching system (TSS) and the vehicle-guiding system (VGS). This is achieved by means of an overall simplification and size-reduction of the rail-switching units (RSU1/2/..), the track-switching units (TSU1/2/3/..) and their supporting structures (TSU-ST), as well as of the associated guideways and vehicles, but always under the condition of providing minimal guideway clearance for the passing of the vehicles through the track-switching units (TSU1/2/3/..) whilst avoiding any possible inadequate interference of the vehicles with other elements of the vehicle-guiding system (VGS) such as unused branch fixed-rails (BFR0/1/2/..) or proximate track segments that diverge from the track-switching unit (TSU1/2/3/..) or merge into it.

Design Guideline 1

[0092] Referring to FIG. 7B (in contrast with FIG. 7A), a first design guideline (DG1) includes supporting of the guideway rails (CR) from the outside of the track and wrapping of the sets of wheels (tW, sW and bW) of the wheels-assemblies (WA) around the rails (CR) from the inside of the track. FIG. 7A shows the opposite: guideway rails supported from the inside and wheels-assemblies wrapping around rails from the outside.

[0093] This first design guideline implies significant potential reduction and simplification of the rail-switching units (RSU1/2/..), the track-switching units (TSU1/2/3/..), the track-switching systems (TSS) and the vehicle-guiding system (VGS), mainly if the design guideline is applied in conjunction with following design-guidelines 2, 3, 4 and 5 (DG2-5).

Design Guideline 2

[0094] Referring to FIG. 9 (in contrast with FIG. 8), a second design guideline (DG2) includes adapting the width of the track (HGAP) - and/or adapting the maximal width of the vehicle body (VB) without considering the wheels-assemblies (WA) or "width of vehicle body" (wVB) - so the vehicle, when directed through a track-switching unit (TSU), is able to fit - avoiding any inadequate interferences - within the horizontal gap between a pair of rails of a same track (HGAP). This is, the track horizontal gap (HGAP) is greater than the vehicle body width (wVB).

Design Guideline 3

[0095] Referring to FIG. 9 (in contrast with FIG. 8), a third design guideline (DG3) includes minimizing vertical clearance gaps above and below the rails (tvGAP and bvGAP) - and/or minimizing the top height of the wheels-assembly (thWA) to the height of its top wheels (tW) and/or minimizing the bottom height of the wheels-assembly (bhWA) to the height of its bottom wheels (bW) - so the wheels-assemblies can pass without interferences through minimal vertical gaps (tvGAP and bvGAP). Following this design guideline implies that a top vertical gap (tvGAP) is greater than the top height of the wheels-assembly (thWA) and/or that a bottom vertical gap (bvGAP) is greater than the bottom height of the wheels-assembly (bhWA). FIG. 9 illustrates gap clearances above and below a certain longitudinal point of a central-path branch fixed-rail (BFR0) that would be engaged with a corresponding central switch-rail (SWRO, not shown in FIG. 9), but these gap clearances should be assured also for the other rails (BFR1, BFR2) and along the whole track-switching unit (TSU) irrespective of its selected active position and taking into account that a bottom vertical gap (bvGAP) of one rail can also be the top vertical gap (tvGAP) of another rail (or vice versa) and that the internal ends of the branch fixed-rails (iBFR0/1/2, not shown in FIG. 9) do not necessarily have to be aligned or in a same plane.

Design Guideline 4

[0096] Referring to FIG. 3, a fourth design guideline (DG4) includes progressive vertical distancing/approximating of the tracks in diverge/merge-points, avoiding any lateral turns of the tracks in a portion of the guideways referred as "straight-guideways segment" (SGS) that is linked to the branch fixed-rails and thus is adjacent to the track-switching unit (TSU).

[0097] FIG. 3 represents the specific the case of a diverge-point with one main track-path (MTP) possibly diverging into three track-paths (BTP0, BTP1 and BTP2) in which the vehicle translational motion (TraM) follows a selected 'upwards' track path (BTP1). In this case, the purpose of the fourth design-guideline (DG4) is to direct vehicles coming out of the track-switching unit (TSU) in a horizontally-straight direction (without turns left or right) through a straight-guideways segment (SGS) until reaching vertical gaps above or below diverging tracks (e.g. vGAP1 and vGAP2) that are sufficient for the vehicles to be directed along branch tracks paths that turn outwardly (BTP1 and BTP2) whilst avoiding any possible inadequate interferences with other diverging tracks from the same track-switching unit (TSU).

[0098] In the case of merge-points, the purpose of the fourth design-guideline (DG4) is to direct vehicles approximating to a track-switching unit in a horizontally-straight direction after having reached vertical gaps above or below converging tracks that are not sufficient for the vehicles to be directed along turning tracks whilst avoiding any possible inadequate interference with other converging tracks into the same track-switching unit.

Design Guideline 5

[0099] Referring to FIG. 9 (in contrast with FIG. 8) and specifically shown in FIG. 4, a fifth design-guideline (DG5) includes reducing the longitudinal length of the straight-guideways segment (ISGS) derived from the fourth design-guideline (DG4) by means of reducing as possible the top height of the vehicle body (thVB) and/or reducing as possible the bottom height of the vehicle body (bhVB). This fifth design guideline (DG5) minimizes the design restrictions from the fourth design-guideline (DG4) whilst seeking multiple other potential benefits to the vehicle-guiding system (VGS) such as those derived from minimizing the moment of inertia of the vehicle.

Track-Switching System

[0100] The herein disclosed system referred as "track-switching system" (TSS) allows coordinated and controlled selective switching of multiple track segments of a guideway.

[0101] A track-switching system (TSS) comprises one or more track-switching units (TSU1/2/3..) as the previously described track-switching unit (TSU), an electronic operating control system (OCS), and a supporting structure (TSS-ST).

[0102] The track-switching units (TSU1/2/3..) are as the previously described track-switching unit (TSU).

[0103] The electronic operating control system (OCS) manages the one or more track-switching units (TSU1/2/3..), including activating, coupling, verifying, maintaining and controlling the functioning of the track-switching units (TSU1/2/3..) and their rail-switching units (RSU1/2/..).

[0104] The supporting structure (TSS-ST) solidly supports, consolidates and protects elements comprised within the track-switching system (TSS) and, if appropriate, also firmly attaches them to the ground and/or to the common guideway structures or integrates them with the supporting structures (ST) of the track-switching units (TSU1/2/..).

Variations to the Invention

[0105] Modifications and variations may be originated in specific requirements such as the following:

- adaptation to a two-ways track-switching application (among other possible changes, by removing one or more of the switch-rails and/or one or more of the branch fixed-rails and associated elements, or by simplifying, reducing, modifying or suppressing structure elements as well as blocking, halting, or movement guiding mechanisms);
- adaptation to a more-than-three-ways track-switching application (among other possible

changes, by installing additional switch-rails and branch fixed-rails or by installing a consecutive set of three-ways track-switching systems);

- adaptation to merge-point application applications (among other possible changes, by modifying the positioning and orientation of the track-switching units);
- adaptation to a horizontal-layout track-switching application such as that of a common railway (among other possible changes, by positioning the rail-switching units below the rails and orienting them facing upwards, and/or by modifying the structural and supporting components, and/or by reinforcing the rotation blocking mechanisms);
- adaptation to applications where the track plane is inclined (among other possible changes, by adequately positioning and orienting the rail-switching units);
- adaptation to applications where the curved switch-rails have the same curvature profile, or where all switch-rails have the same longitudinal length (among other possible changes, by adapting and simplifying the rotatable hub, rotating guides and the structures);
- adaptation to applications where the internal ends of the branch fixed-rails do not form a plane (among other possible changes by varying the range of angular movements of the rotatable hub);
- adaptation to applications where the curved switch-rails have different longitudinal lengths (among other possible changes, by adapting the rotatable hub, rotating guides and the structures);
- adaptation to applications where the straight switch-rails may not be perfectly straight, or the curved-rails may not be uniformly curved (among other possible changes, by adapting accordingly the shapes of the switch-rails and corresponding fixed-rails);
- adaptation to applications where one actuator is shared by several rail-switching units (among other possible changes, by providing a direct or indirect mechanical link between the rail-switching units upon which a same actuator would, directly or indirectly, transmit the rotational force);
- adaptation to vertical-layout track-switching applications where the track rails are not supported from the outside lateral sides of the track, but from the internal lateral sides of the rails (among other possible changes, by positioning the rail-switching units inside the track and orienting them facing outwards);
- adaptation to applications where the track rails are supported from above (among other possible changes, by modifying the positioning the rail-switching units above the rails and orienting them downwards);
- adaptation to applications with stricter safety, reliability and/or performance requirements (among other possible changes, by providing additional blocking, halting, or movement guiding mechanisms, or reinforcing the described ones, and/or by using additional mechanical or magnetic methods to improve the engagement of switch-rails with fixed-rails at their active positions, and/or by adapting the covers and structures so as to maximize the solidness and precision of the system and minimize the probability of interferences with the mechanisms);
- adaptation to applications with laxer safety and/or performance requirements (among other possible changes, by adapting, simplifying or discarding the described blocking, halting, and movement/engagement guiding mechanisms);

- adaptation to applications requiring a wheels-assembly covering only two sides or only one side of the rail (among other possible changes, by modifying and simplifying the switch-rail and fixed-rail profiles);
- adaptation to applications requiring different shapes, profiles and contacts between wheels and rail surfaces (among other possible changes, by modifying the switch-rail and fixed-rail profiles);
- adaptation to mono-rail applications (among other possible changes, by reducing to one the number of rail-switching units per track-switching unit, or by simplifying the control system);
- adaptation to applications where the vehicle moves along more than two rails (among other possible changes, by increasing to more than two the number of rail-switching units per track-switching unit);
- adaptation to applications where the vehicles are suspended from and below the rails (among other possible changes, by modifying the positioning and orientation of the rail-switching units);
- adaptation to applications with restricted g-forces (among other possible changes, by modifying the longitudinal length and shape of the switch-rails, and/or by adapting the rotating guides and the structures);
- adaptation to applications where the movement of the vehicles along the guideway is not provided by means of rolling wheels, but by means of alternative technologies (or a mix of them), such as, for example, electromagnetic levitation, direct contact sliding, air-cushioning, or continuous rolling tracks (among other possible changes, by adapting the shape profiles of switch-rails and fixed-rails, and/or by modifying the positioning and orientation of the rail-switching units);
- adaptation to crossing-points or applications where switching is needed to establish right connections between several inbound and outbound rails (among other possible changes, by combining rail-switching units for diverge-points and merge-points, by adapting the shape profiles of switch-rails and fixed-rails to allow minimal physical discontinuities at the rail crossings, by modifying the general shape, positioning and orientation of the rail-switching units, or by modifying the tracks layout so as to minimize possible crossing conflicts);
- adaptation to other guideway-switching applications where the vehicles may move along the inside of guideways with tubular forms (among other possible changes, by modifying the mating profiles);
- adaptation to other guideway-switching applications where vehicles move along the guideways not with a primary purpose of conveying goods or transporting passengers, but with secondary purposes such as those of maintenance or supervision of the guideways.

REFERENCES CITED IN THE DESCRIPTION

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KRAV

1. Skinne-skifte enhed (RSU),

bruges til at skifte et skinne segment ad gangen, som enten fungerer
5 enkeltvis i en spor-skifte enhed af et mono-skinnet spor eller kombineret
med de samme enheder i en spor-skifte enhed af et multi-skinnet spor;

skinne-skifte enheden (RSU) består af:

- et roterende set af komponenter kaldet roterbar ensemble (RE),
- 10 - og et stationært set af komponenter kaldet stationært sæt (SS);

det roterbare ensemble (RE) består ydermere af:

- en roterbar nav (RH),
- et sæt af to, tre eller flere skifte-skinner (SWR0, SWR1, SWR2, etc.)
- 15 mindst to af dem (SWR1, SWR2) har en kurvet form,
- et sæt af hjælpe komponenter (AC1, AC2, AC3, etc.) for at facilitere
påhæng af skifte-skinnerne til den roterbare nav og/eller for at
optimere de fysiske egenskaber af den roterbare ensemble og/eller
for at facilitere præcis kontrol af den roterende bevægelse af den
- 20 roterbare ensemble;

det stationære set (SS) består ydermer af:

- en hoved monterede-skinne (MFR),
- et sæt af to, tre eller flere gren monterede-skinner (BFR0, BFR1,
- 25 BFR2, etc.),
- en støtte struktur (ST) som støtter, konsolidere og beskytter
elementer der er inde i skinne-skifte enheden (RSU) og på hænger
den nævnte hoved og/eller gren monterede-skinner til jorden
og/eller til standard føringsveje strukturer;

30

hvor de hoved monterede-skinner er fastmonteret til en standard
stationær skinne, kaldet standard-skinne (CR), i den eksterne enden af

den hoved monterede-skinne (eMFR) eller i enden af den hoved monterede-skinne, som er længst væk fra den roterbare ensemble og modsat af den interne ende af den hoved monterede-skinne (iMFR);

- 5 hvori de gren monterede-skinner er monteret til standard-skinne (CR) i den eksterne ende af branch fixed-rails (eBFR0, eBFR1, eBFR2, etc.) eller enderne af branch fixed-rails der har længst afstand fra den roterbare ensemble, og som er modsat af den interne af de gren monterede-skinner (iBFR0, iBFR1, iBFR2, etc.);

10

hvori antallet af skifte-skinner er lig med antallet af gren monterede-skinner;

- hvori hver af skifte-skinnerne (SWR0, SWR1, SWR2, etc.) er konfigureret
15 til aktivering, det vil sige, aktivering af koblingen i en stationær position kaldet aktiv ensrettet position og/ellers i forbindelse med korresponderende gren monterede-skinne (BFR0, BFR1, BFR2, etc.);

- hvori hver af skifte-skinnerne er vedhæftet, med sådan en afstand fra en
20 rotationsakse (Ax), til den roterbare nav (RH), således at rotationsbevægelse (Rot) fra den roterbare nav om rotationsaksen tillader selektiv aktivering af hver af skifte-skinnerne med en korresponderende monteret-skinne;

- 25 hvori aktiveringen af enhver af skifte-skinnerne (SWR0, SWR1, SWR2, etc.) involvere ensretning, og/eller forbinder en såkaldt hoved ende (mSWR0, mSWR1, mSWR2, etc. henholdsvis) med den interne ende af hoved monterede-skinnen (iMFR) og ligger på linje med og/eller forbinder en ende af en såkaldt gren ende(bSWR0, bSWR1, bSWR2, etc.
30 henholdsvis) med den korresponderende interne ende (iBFR0, iBFR1, iBFR2, etc. henholdsvis) med korresponderende gren monterede-skinne (BFR0, BFR1, BFR2, etc. henholdsvis) med det formål at tovejs føre, eller

lede køretøjer gennem den skinne-skiftende enhed, det vil sige, enten fra det hoved monterede-skinne (MFR) til enhver af de gren monterede-skinner (BFR0, BFR1, BFR2, etc.) eller fra en af de gren monterede-skinner (BFR0, BFR1, BFR2, etc.) ind i den hoved monterede-skinne (MFR) eller samtidig tillader bevægelse i begge retninger;

hvor de interne ender af de gren monterede-skinner (iBFR0, iBFR1, iBFR2, etc.) er adskilt med bestemte længder mellem hinanden, som giver det nødvendige frirum således at køretøjs skinne-omslutnings samlingerne (WA) kan tilstrækkeligt ledes uden interferens gennem den skinne-skiftende enhed;

hvor de interne ender af de gren monterede-skinner (iBFR0, iBFR1, iBFR2, etc.) ikke nødvendigvis skal være plane, men hvis de er, så behøves planen ikke nødvendigvis at være horisontal;

hvor det roterbare ensemble er konfigureret til at være kompakt, for at optimere dets fysiske egenskaber som volumen, masse, soliditet og/eller inertia bevægelse om rotationsaksen, som karakteriseret af:

- fladerne der rummer de skinne kurvede-baner af mindst to kurvede skifte-skinner (SWR1, SWR2) er parallelle med hinanden og med rotationsaksen (Ax) og ækvidistant fra nævnte akse;
- en lige skifte-skinne (SWR0) har en skinne bane der er lige og parallelt med rotationsaksen (Ax) og gren enden (bSWR0) af nævnte lige skifte-skinne er på siden, i forhold til rotationsaksen (Ax), som er modsat siden, hvor gren enderne af de to kurvede skifte-skinner (bSWR1, bSWR2) befinder sig;
- den kurvede skifte-skinne hoved-ender af den mindst to kurvede skifte-skinne (mSWR1, mSWR2) er diametrisk modsat fra rotationsakens (Ax); og i det

- skifte-skinne hoved-enderne (mSWR0, mSWR1, mSWR2, etc.) er konfigureret på samme plane og med samme perpendikulære afstand fra rotationsaksen (Ax).

5 2. Skinne-skifte enheden i henhold af krav 1,
 hvori den hoved monterede-skinne (MFR) og den skifte-skinnerne (SWR0, SWR1, SWR2, etc) er formet, og/eller er konfigureret til at koble mellem den interne ende af den hoved monterede-skinne (iMFR) og enhver af hoved enderne af skifte-skinnerne (mSWR0, mSWR1, mSWR2, etc) ved
 10 hjælp af parringsprofiler ved hoved enderne, som kaldes hoved parringsprofiler (MMP0, MMP1, MMP2, etc.);

og/eller hvori de gren monterede-skinner og skifte-skinnerne er formet og/eller konfigurerede til at koble mellem de interne ender af de gren
 15 monterede-skinner (iBFR0, iBFR1, iBFR2, etc.), og de korresponderende gren ender af skifte-skinnerne (bSWR0, bSWR1, bSWR2, etc. henholdsvis) ved hjælp af parrings profiler ved gren enderne, som kaldes gren parrings profiler (BMP1, BMP2, BMP3, etc.);

20 hvori en hoved parringsprofil (MMP0, MMP1, MMP2, etc.) består af:

- en hoved parrings flade som kaldes hun (fMMS) som er på den interne ende af den hoved monterede-skinne (iMFR),
- og en hoved parring flade kaldet han (mMMS0, mMMS1, mMMS2, etc.) som passer sammen med hun parrings fladen (fMMS), og kan
 25 være på være på en af hoved enderne af skifte-skinnerne (mSWR0, mSWR1, mSWR2, etc. henholdsvis);

hvor en gren parringsflade (BMP0, BMP1, BMP2, etc.) består af

- en gren parringsflade kaldet hun (fBMS0, fBMS1, fBMS2, etc.) som
 30 kan være på en af de interne ender af de gren monterede-skinner (iBFR0, iBFR1, iBFR2, etc.),

- og en gren parrings flade kaldet han (mBMS) som passer sammen den korresponderende hun flade (fBMS0, fBMS1, fBMS2, etc.), og som kan være på en af gren enderne af skifte-skinne (fSWR0, fSWR1, fSWR2, etc. henholdsvis);

5

hvor en gren eller en parrings flade som kaldes hun (fMMS, eller fBMS) ikke nødvendigvis behøves at være hovedsagelig konkav og en gren eller hoved parrings flade der kaldes han (mMMS eller mBMS) ikke nødvendigvis behøves at være hovedsagelig konveks;

10

og hvor parrings profilerne er konfigureret til at tillade fast forbindelse mellem skifte-skinne og monterede-skinne og er konfigureret til at facilitere jævn bevægelse af skifte-skinne ind i og ud af deres koblings positioner med de korresponderende monterede-skinne.

15

3. Skifte-skinne enheden i henhold af krav 2,

hvor mindst en af parrings profilerne er designet og konfigureret til at facilitere standsning af rotations bevægelsen fra den roterbare ensemble, når skifte-skinne er i en bestemt aktiv position, for at facilitere vedligeholdelse af skifte-skinne's aktive position, og for at facilitere tilbagevending af rotation bevægelsens retning fra den roterbare ensemble for at komme ud af skifte-skinne's aktive position;

20

og/eller hvor mindst en af parrings profilerne er konfigureret til at facilitere at skifte skinne har jævn og kontrolleret bevægelse ind i, og ud af deres aktive koblings positioner med de korresponderende gren monterede-skinne helst ved brug af de specifikke former fra han og hun parrings fladen, og/eller ved at bruge et eller flere sæt af parring profilers lejer (MPB1, MPB2, MPB3, etc.) fortrinsvis er disse sæt af lejere og/eller andre hjælpe mekanismer, som reducere friktion og/eller kontrol relativ bevægelse mellem flader og nævnte sæt integreres med en eller begge parringsflader.

25

30

4. Skinne-skifte enheden i henhold til ethvert forrige krav,
hvor i sættet af skifte-skiner består af
- en skifte-skinne med en grundlæggende lige form som kaldes lige skifte-skinne(SWR0),
- 5
- en første skifte-skinne med en grundlæggende kurvet form som kaldes første kurvede skifte-skinne (SWR1),
 - og en anden skifte-skinne med en grundlæggende kurvet form som kaldes anden kurvede skifte-skinne (SWR2);
- 10
- hvor i sættene af de gren monterede-skiner består af
- en monteret-skinne formet og/eller konfigureret til at være i forbindelse med lige skifte-skinnen og kaldes lige-bane gren monteret-skinne (BFR0),
 - en monteret-skinne formet og/eller konfigureret til at være i
- 15
- forbindelse med den første kurvede skifte-skinne og kaldes første kurvede-skinne (BFR1),
 - og en monteret-skinne formet og/eller konfigureret til at være i forbindelse med den kurvede skifte-skinne og kaldes anden kurvede-bane gren monteret-skinne (BFR2);
- 20
- hvor i når lige skifte-skinnen roteres til aktiv position, kobler den, samtidig på en hoved ende, med den hoved monterede-skinne og på en gren ende med en korresponde lige-bane gren monterede-skinne;
- 25
- hvor i når den første kurvede skifte-skinne er roteret hen i aktiv position, kobler den samtidig på en hoved ende med den hoved monterede-skinne og på en gren ende med en korresponderende første kurvede-bane gren monterede-skinne;
- 30
- hvor i den anden kurvede skifte-skinne er roteret hen i aktiv, kobler den samtidig på en hoved ene med en med den hoved monterede-skinne og

på en gren ende med en korresponderende anden kurvede-bane gren monterede-skinne;

5 hvori alle koblinger mellem skifte-skinnerne og de korresponderende monterede-skinner giver en kontinuerlig løbeflade og/eller en kontinuerlig forbindelse mellem skifte-skinnerne og den korresponderende monterede-skinne på en tovejs måde, som er ensrettet en retning, i den anden retning eller i begge retninger.

10 5. Skifte-skinne enheden i henhold til ethvert af forrige krav, hvori den første kurvede skifte-skinne og den anden kurvede skifte-skinne har forskellige krumningsprofiler.

15 6. Skinne-skifte enheden i henhold til ethvert af forrige krav, består ydermere af

- et aktuator arrangement for at give fremdrift, og transmittere den nødvendige rotationelle bevægelse til det roterbare ensemble;

20 hvori aktuator arrangementet kan være i stand til at aktivere på kun en roterbar ensemble, eller samtidig på to eller flere roterbare ensembler fra forskellige skinne-skifte enheder.

7. Skinne-skifte enheden i henhold til ethvert af forrige krav, består ydermere af

- 25 - en mekanisme der blokere vinklede positioner i den roterbare ensemble, navngivet positions-blokerende mechanisms (PBM), for at sikre og/eller bekræfte præcision og en solid kobling mellem skifte-skinner og monterede-skinner ved at give fast, stabil og rettidig blokering og fjernelse af blokering af den roterbare ensemble ved nytte af et multi-point hængsels mekanisme styret af
- 30 et kontrolsystem og/eller mekanisk sammenkædet med den vinklede bevægelse af den roterbare nav;

hvor de positions blokerende mekanismer (PBM) kan virke med kun en roterbar ensemble eller med to eller flere roterbare ensembler fra forskellige skinne-skifte enheder.

5

8. Skinne-skifte enheden i henhold til ethvert af forrige krav, består ydermere af

- et koblings-ledende system (EGS) med formål at give den roterbare nav og skifte-skinnerne kontrolleret rotationel bevægelse i overgangsfaser, og/eller lede enderne af skifte-skinnerne nøjagtigt til præcis og/eller jævn kobling med deres korresponderende ender af de monterede-skinner.

10

9. Skinne-skifte enheden i henhold af krav 8,

15 hvor det koblings-ledende system består af:

- et sæt af et eller flere stationære koblings ledere (SEG1, SEG2, etc.),
- et sæt af en eller flere koblings-ledende lejere (EGB1, EGB2, etc.),
- og et sæt af en eller flere roterbare koblings komponenter (REC1, REC2, etc.);

20

hvor de koblings-ledende lejere, som er fortrinsvis cylindriske rullelejer eller nålelejer og/eller enhver anden støtte mekanisme, reducerer friktion og/eller kontrol relativt bevægelse mellem flader, er konfigureret til at facilitere interaktionen mellem stationære flader af den stationære koblings leder og bevægende flader af de roterbare koblings komponenter for at nøjagtigt kontrollere deres relative bevægelse, og/eller for at reducere den potentielle friktion, og begrænse dem, med det ultimative mål at opnå en fast, jævn og præcis kobling mellem skifte-skinneren og korresponderende monterede-skinner;

25

30

og hvori de roterbare koblings komponenter giver overfladerne, som kan interagere med de stationære ledere direkte eller ved brug koblings-ledende lejere, er monteret til den roterbare ensemble, integrere med den roterbare nav, og/eller skifte-skinne og/eller støtte komponenterne og
5 kan integreres med parrings profil fladerne i enderne af skifte-skinne.

10. Skinne-skifte enheden i henhold af krav 9,
hvori sættet af stationære koblings ledere består af:

- en eller flere stationære koblings ledere placeret i de yderste ringe,
10 og præsentere ledende flader til en indadgående krumning kaldes konkav ledende flader (CNC),
- og/eller en eller flere stationære koblings ledere placeret i de inderste ringe, og præsentere ledende flader med udadgående krumning kaldes konveks ledende flade (CNV);

15

hvori de konkave eller konveks ledende flader ikke nødvendigvis behøver at være kontinuerte, og hvis de er, så har de en generel form som en ark, der dækker omkring 180 grader;

20 hvori de konkave eller konvekse ledende flader er fundamentalt koncentrisk og deler samme rotationsakse som den roterbare nav;

og hvor de konkave eller konveks ledende flader som er nærliggende til en intern ende af en gren monteret-skinne, er monteret til den og
25 konfigureret til at tillade jævn og præcis kobling i enderne af skifte-skinne og dets parrings profiler, hvis den korresponderende ende af de monterede-skinne er til stede og hvis dens parrings profiler er til stede.

11. Skinne-skifte enheden i henhold af krav 10,
30 hvori, med det formål at minimere slæk, facilitere deceleration af rotations ensembles rotationelle bevægelse, og dermed forbedre den endelige

hastighed og nøjagtighed mellem skifte-skinners forbindelser, når de er i deres aktive position,
 mindst en af de konkav ledende flader (CNC)
 har en krumningsprofiler med en krumningsradius som er en anelse og
 5 reduceret, og bliver progressivt reduceret en anelse ved en eller begge
 ende sektioner af den stationære koblings leder (bCNC og bCNC') og/eller
 ved midter sektionen af den stationære koblings leder (mCNC),
 og/eller mindst af de konveks ledende flader (CNV) har en krumningsprofil
 med en radius der er en anelse øget, og bliver progressivt øget en anelse
 10 ved en eller begge sektionerne af den stationære koblings leder (bCNV og
 bCNV') og/eller i midtersektionen af den stationære koblings leder
 (mCNV).

12. Skinne-skifte enheden i henhold af krav 10 eller 11,
 15 hvori mindst et af de roterbar koblings komponenter er tilpasset
 matchende profiler fra forskellige af forskellige gren ender af skifte-skinners
 og giver en flade der giver samtidig interaktion med et konkav ledende
 flade og med en konveks ledende flade.

20 13. Spor-skifte enhed,
 bruges til at give kontrolleret og selektiv skiftning af et segment på en spor
 eller en føringsvej;

Spor-skiftende enheden består af:

- 25 - en eller flere spor-skifte enheder (RSU1, RSU2, etc.) som nævnt i
 forrige krav,
- et sæt af komponenter der er sammenkædet til eller med et
 elektronisk operativ kontrolsystem (OCS),
- en støtte struktur (TSU-ST);

30

hvori antallet af skinne-skifte enheder er tilsvarende antallet af skinner,
 der udgør spor segmentet som påvirkes af spor-skifte enheden;

hvor i spor-skifte enheden er konfigureret således, at de interne ender af de gren monterede-skiner (iBFR0, iBRFR1, iBFR2, etc.) fra skinne-skifte enhederne (RSU1, RSU2, RSU3, etc.) ikke nødvendigvis behøver at være
5 en jævn flade, men hvis de er, så er fladen ikke nødvendigvis horisontal;

hvor i når den består af mere end en skinne-skifte enhed, og de er i deres normale operative tilstand, er det meningen, at skinne-skifte enhederne betjenes samtidigt, men ikke nødvendigvis ved brug af mekaniske
10 forbindelser mellem dem, og ikke nødvendigvis på en præcis og synkron måde;

hvor i når bestående af mere end en skifte-skinne enhed og under normale driftstilstand, så er formålet at skinne-skifte enhederne drives kongruent,
15 for at skabe holdbare kontinuitets baner således at køretøjerne kan køre langs sporet;

og hvor i støtte strukturen (TSU-ST) støtter, konsolidere og beskytter elementer som er del af den spor-skiftende enhed (TSU) og, hvis
20 hensigtsmæssigt, så vedhæfter de også til jorden og/eller til de almindelige føringsveje strukturere eller integrere dem med skinne-skifte enhedens støtte struktur.

14. Spor-skifte enheden i henhold af krav 13,
25 hvor i føringsvej skinnerne (CR) støttes udefra sporene, og/eller hjulsættene (tW, sW, bW) fra hjul-samlingen (WA) omslutter skinnerne (CR) fra indersiden af sporet; og/eller

hvor i bredden af sporet (HGAP) og/eller den maximale bredde af
30 køretøjets karosseriet uden at tage hjul-samlingerne eller køretøjs karosseriets bredde (wVB), er tilpasset således at køretøjet, når ført gennem en spor-skiftende enhed (TSU1/2/3/..), er i stand til at passe ind i

det horisontale mellemrum mellem skinner på det samme spor (HGAP) og
og komme igennem spor-skifte enheden nogen utilstrækkelig interference;
og/eller

- 5 hvori fri hullerne over og under skinnerne (tvGAP og bvGAP) er
fundamentalt minimeret ved de interne ender af de gren monterede-
skinner; og/eller
top højden af hjul-samlingen (thWA) er minimeret minimeret til højden af
dens top hjul (tW); og/eller bund højden af hjul-samlingen (bhWA) er
10 minimeret til højden af dens bund hjul (bW), mens den samtidig altid lader
hjul-samlingerne (WA) at komme igennem spor-skifte enheden uden
utilstrækkelig interferens; og/eller

- hvor sporene divergens/sammenlægnings punkter er progressivt vertikalt
15 distanceret /tilnærmelsesvist undgår enhver lateral vinding af sporet i en
del af føringsvejen, der kaldes lige-føringsvejs segment (SGS), som er
forbundet med de gren monterede-skiner og dermed også nærliggende
til spor-skifte enheden (TSU1/2/3/..); og/eller

- 20 hvori den langsgående længde af lige-føringsvejs segmentet (ISGS) er
reduceret ved at minimere toppen af køretøjs karrosseriets højde (thVB),
og/eller minimere bund højden af køretøjets karrosseriet (bhVB); og/eller

- hvor føringsveje segmenterne nærliggende spor-skifte enheden (TSU
25 og/eller den generelle almindelige føringsvej og/eller køretøjerne der køre
gennem spor-skifte enheden (TSU) er tilpasset som en konsekvens af
direkte eller indirekte anvendelse af nogle eller alle de ovenstående
begrænsninger.

- 30 15. Spor-skifte systemet (TSS),
bruges til at muliggøre koordineret og kontrolleret selektive skift mellem
flere spor segmenter af et køretøjs-ledet system (VGS),

består af:

- en eller flere spor-skifte ender (TSU1, TSU2, TSU3, etc..) i henhold af krav 13 eller 14,
- 5 - et elektronisk operativ kontrollsystem (OCS),
- og en støttende struktur (TSS-ST);

hvor det elektroniske operativ kontrollsystem styrer den ene eller flere spor-skifte ender, inklusiv aktivering, kobling, verificering, vedligeholdelse
10 og styring af spor-skifte enhederne, og deres skinne-skifte enheders funktioner;

og hvor den støttende struktur (TSS-ST) støtter, konsolidere og beskytter elementerne der er inde i spor-skifte systemet (TSS) og, hvis
15 hensigtsmæssigt, også vedhæfter dem til jorden og/eller til den almindelige føringsvej struktur eller integrere dem med støtte strukturen i spor-skifte enhederne.

DRAWINGS

FIG. 1A
PRIOR ART

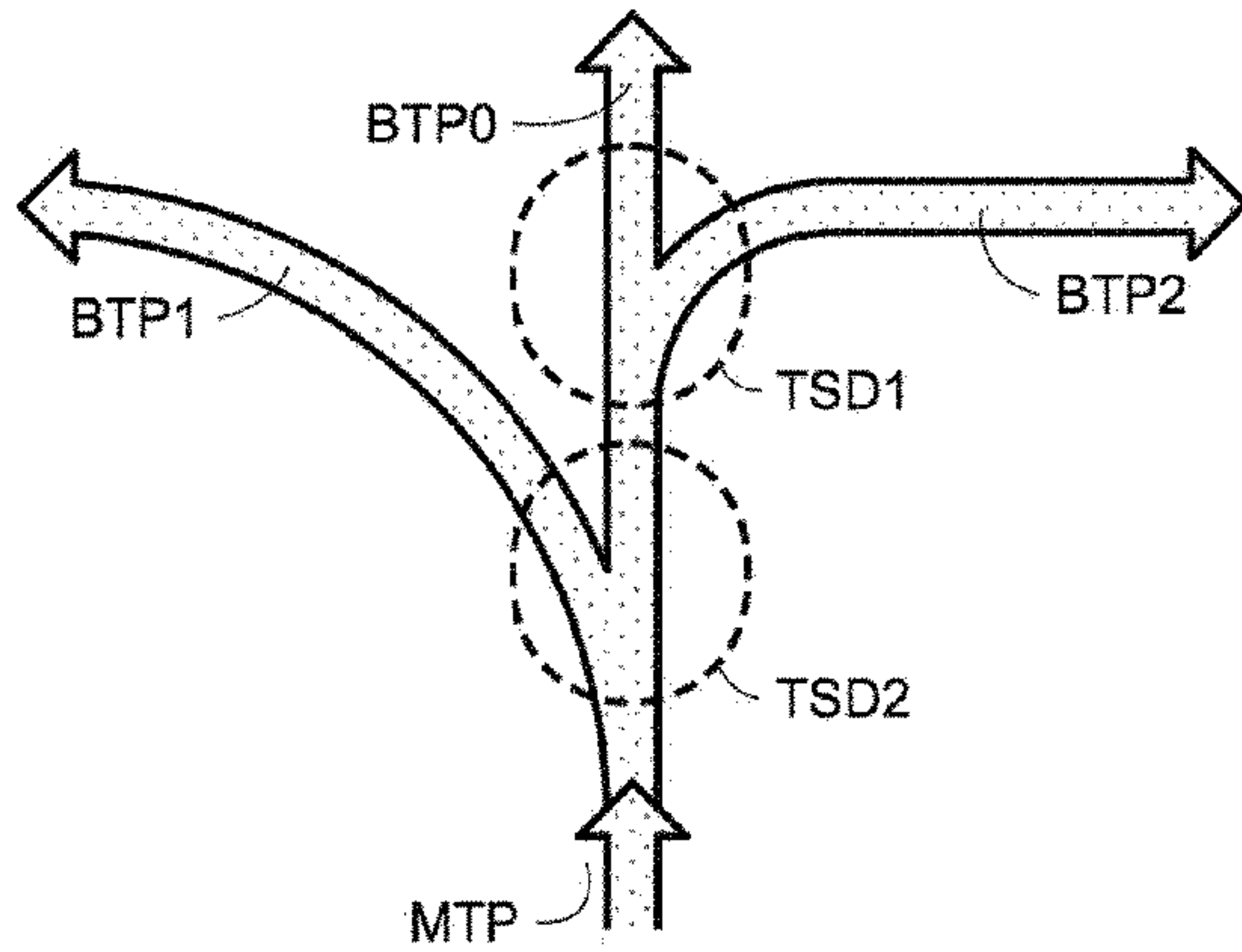


FIG. 1B

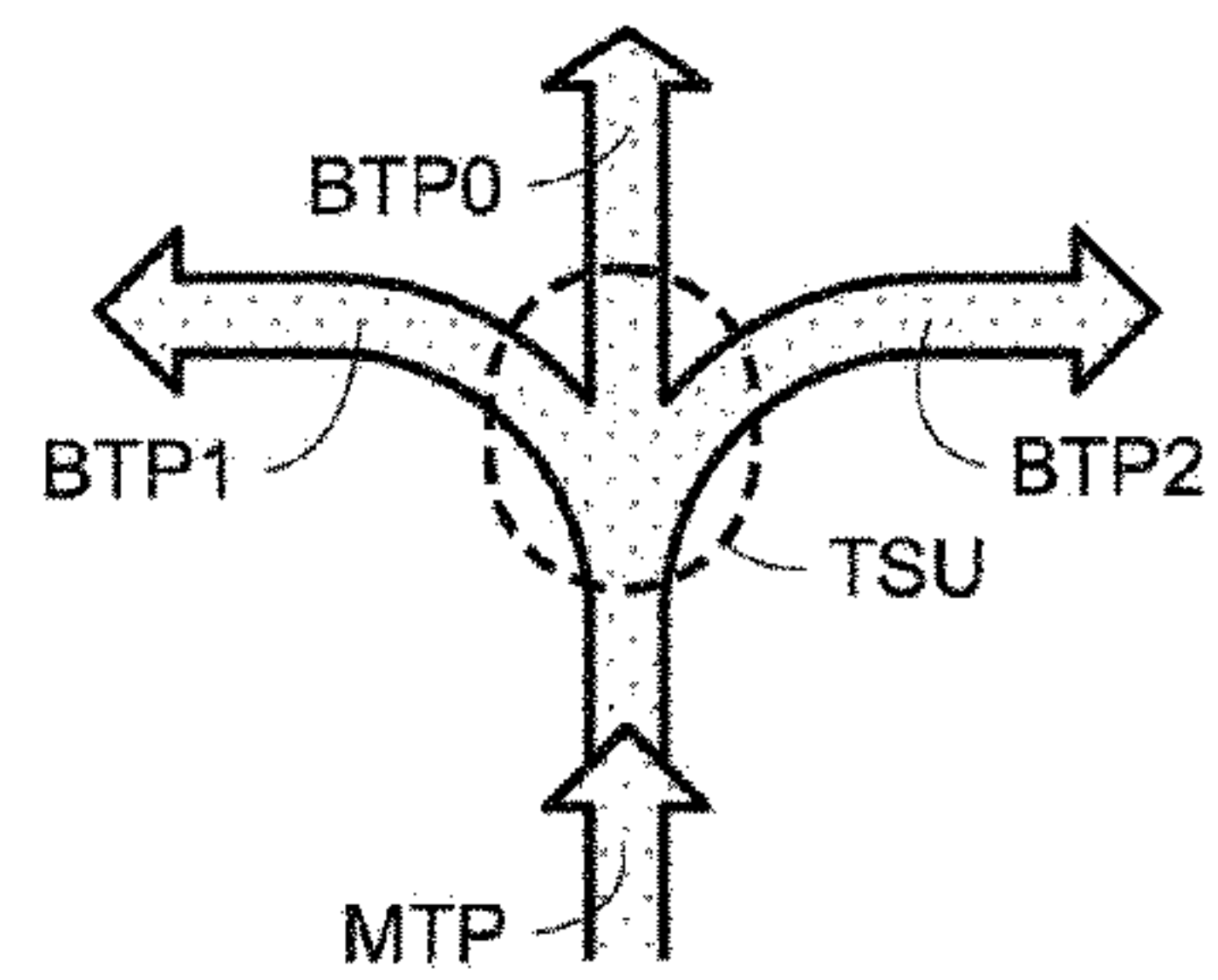


FIG. 2A
PRIOR ART

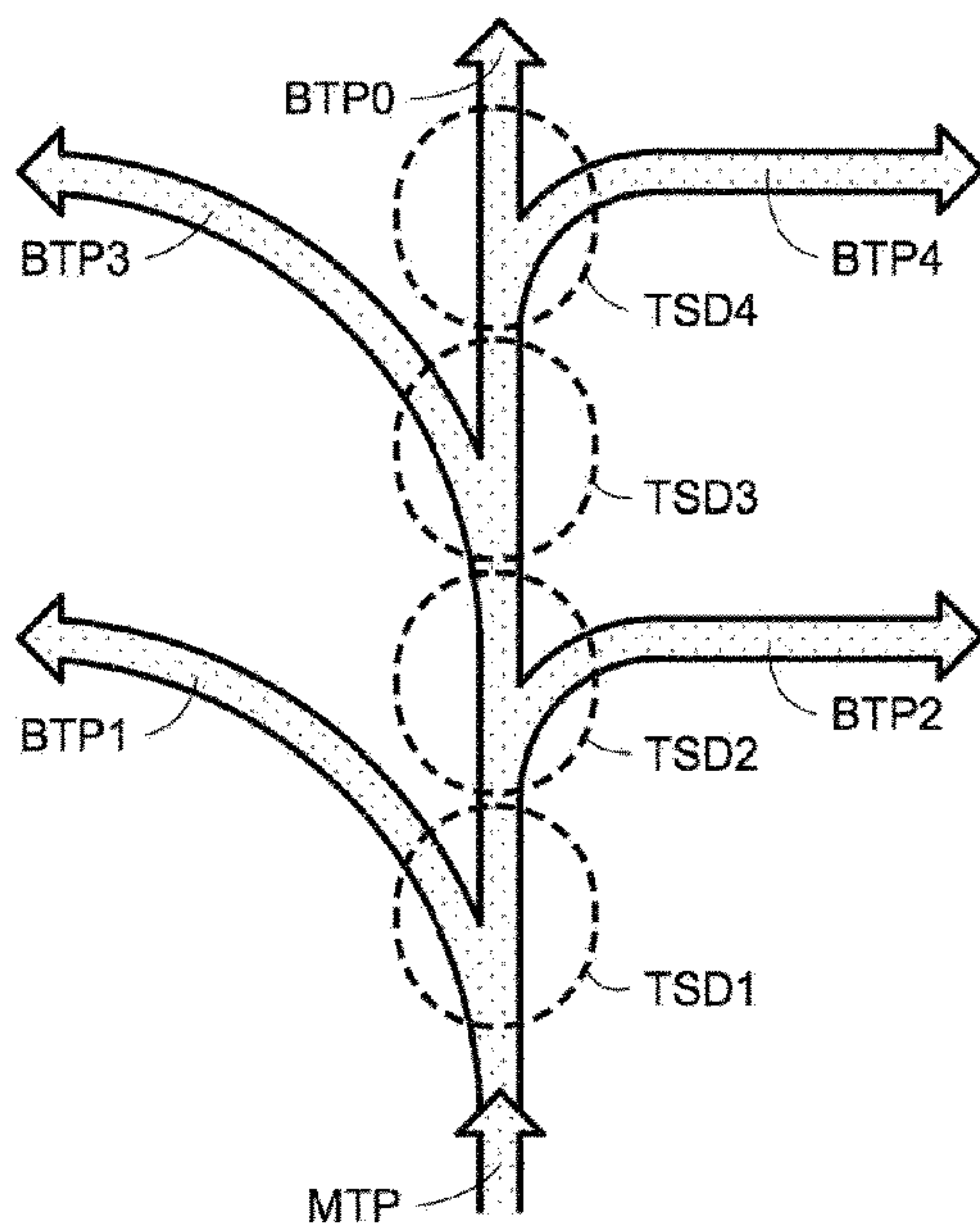


FIG. 2B

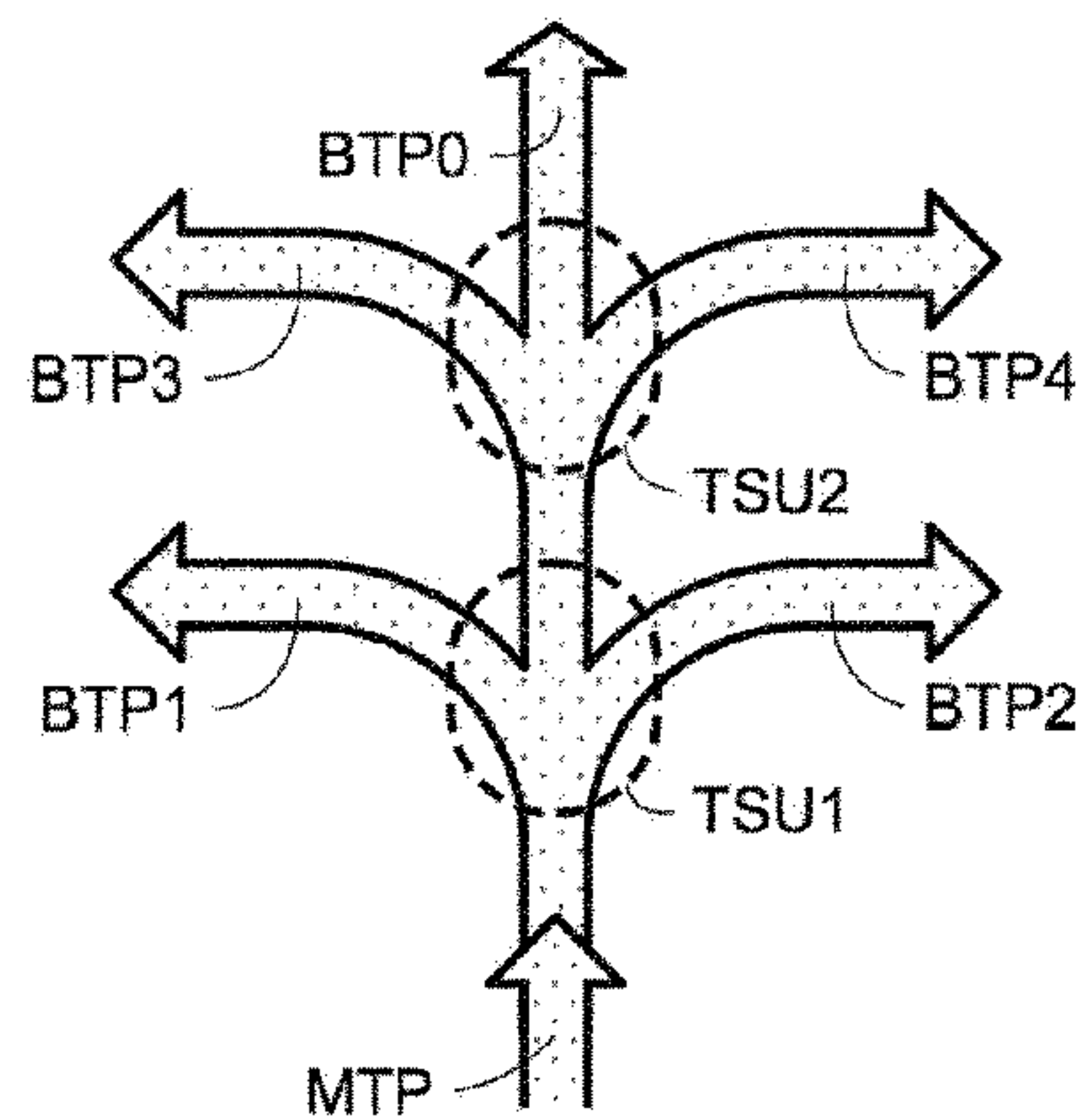


FIG. 3

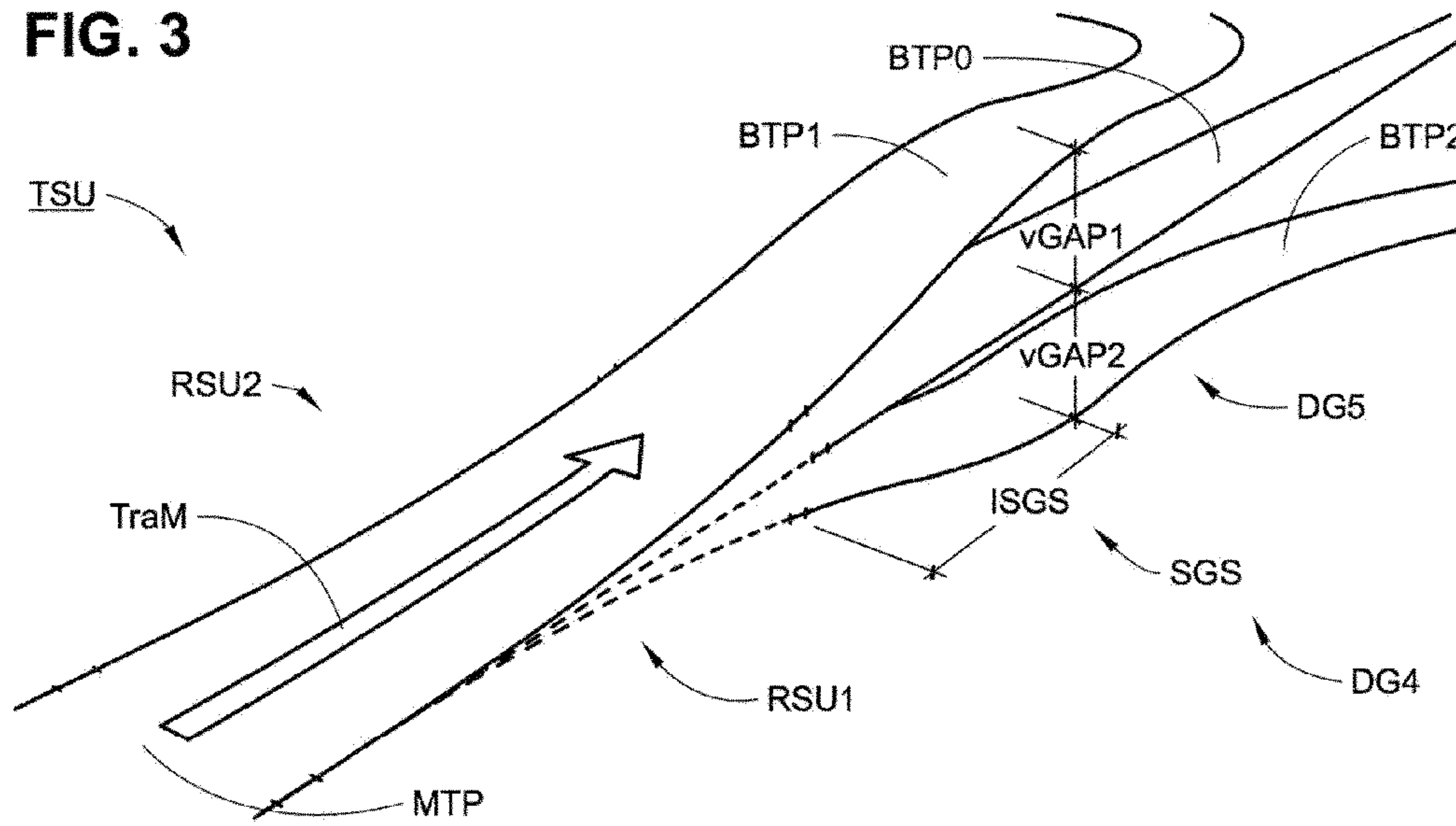


FIG. 4

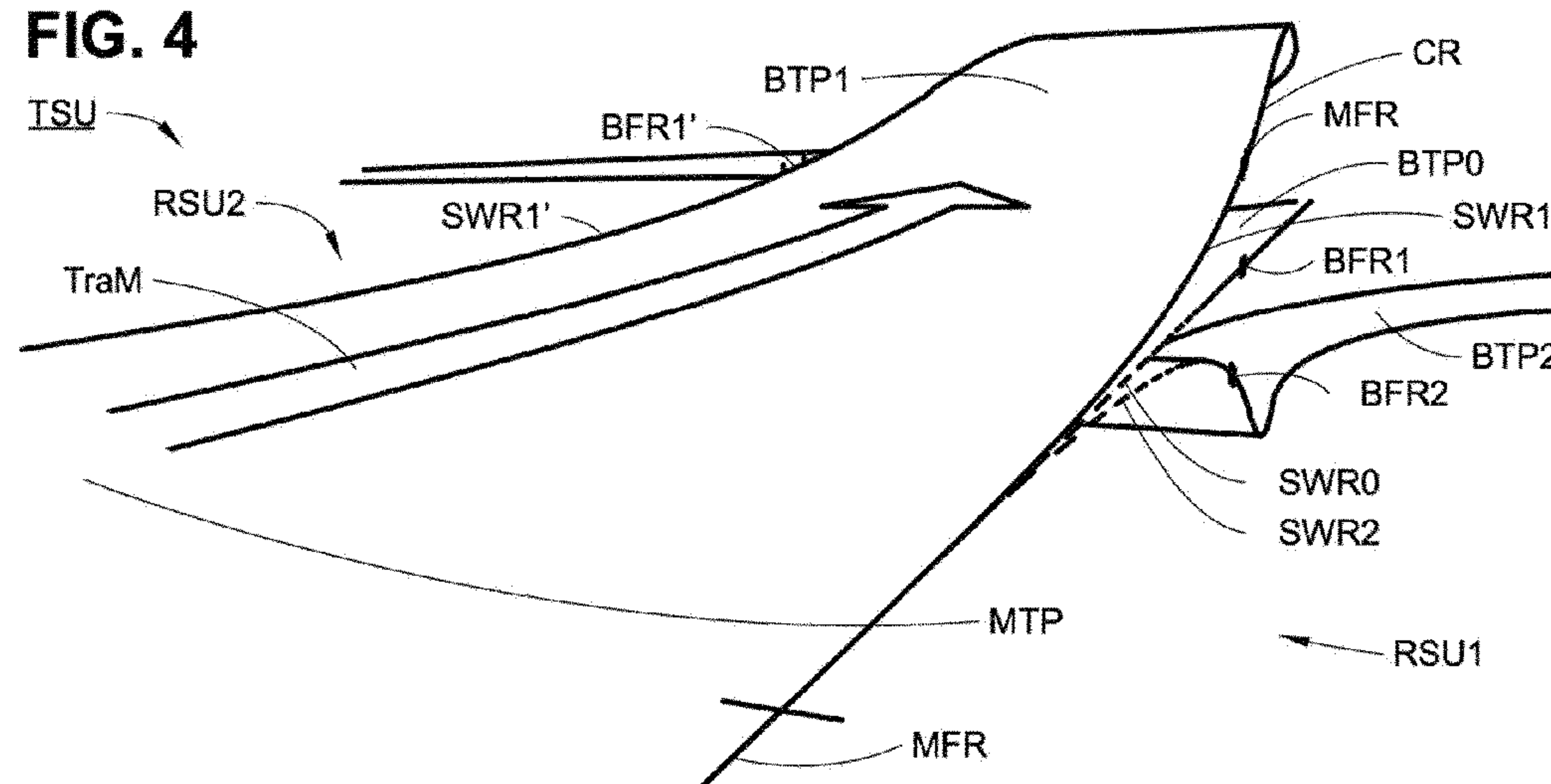


FIG. 5

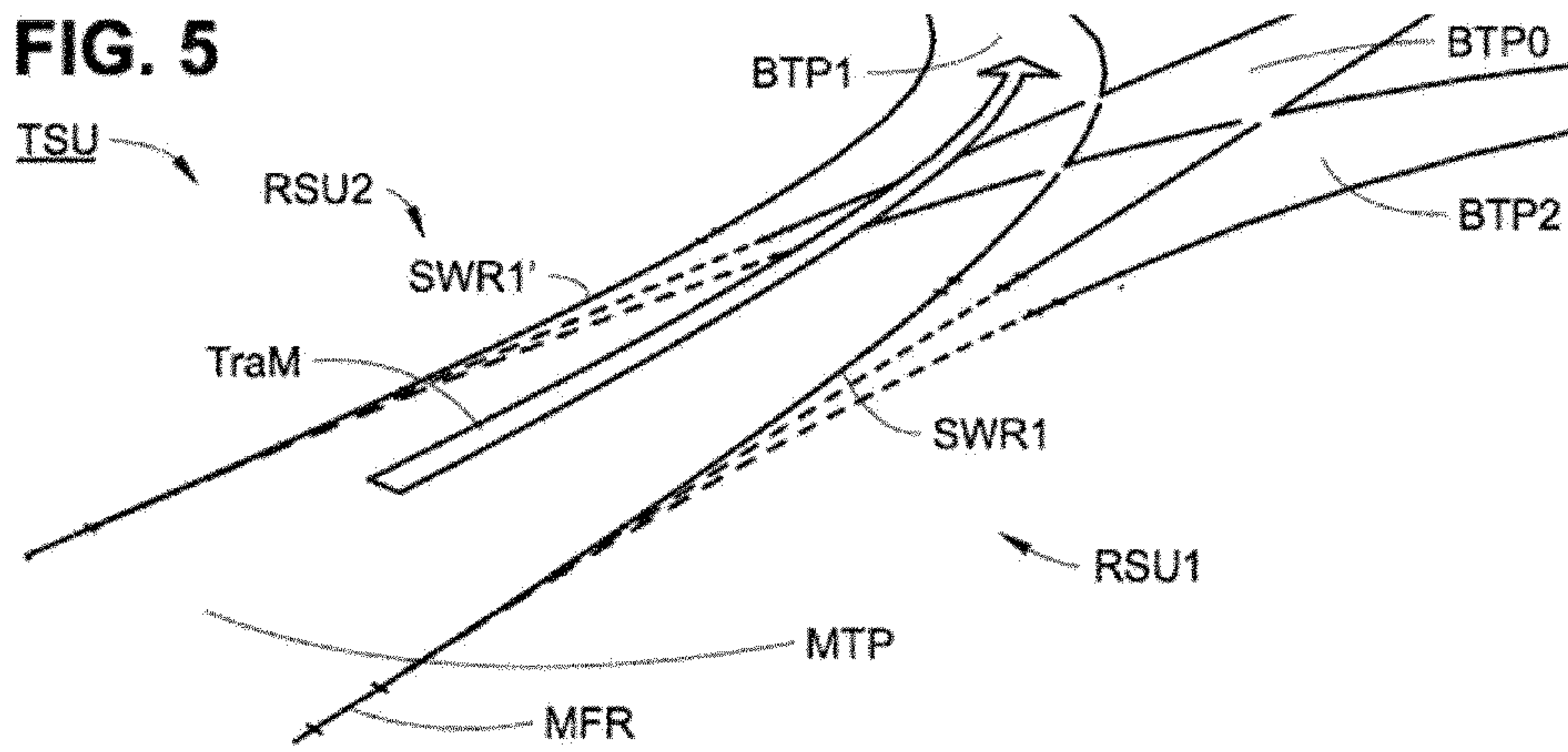


FIG. 6A
PRIOR ART

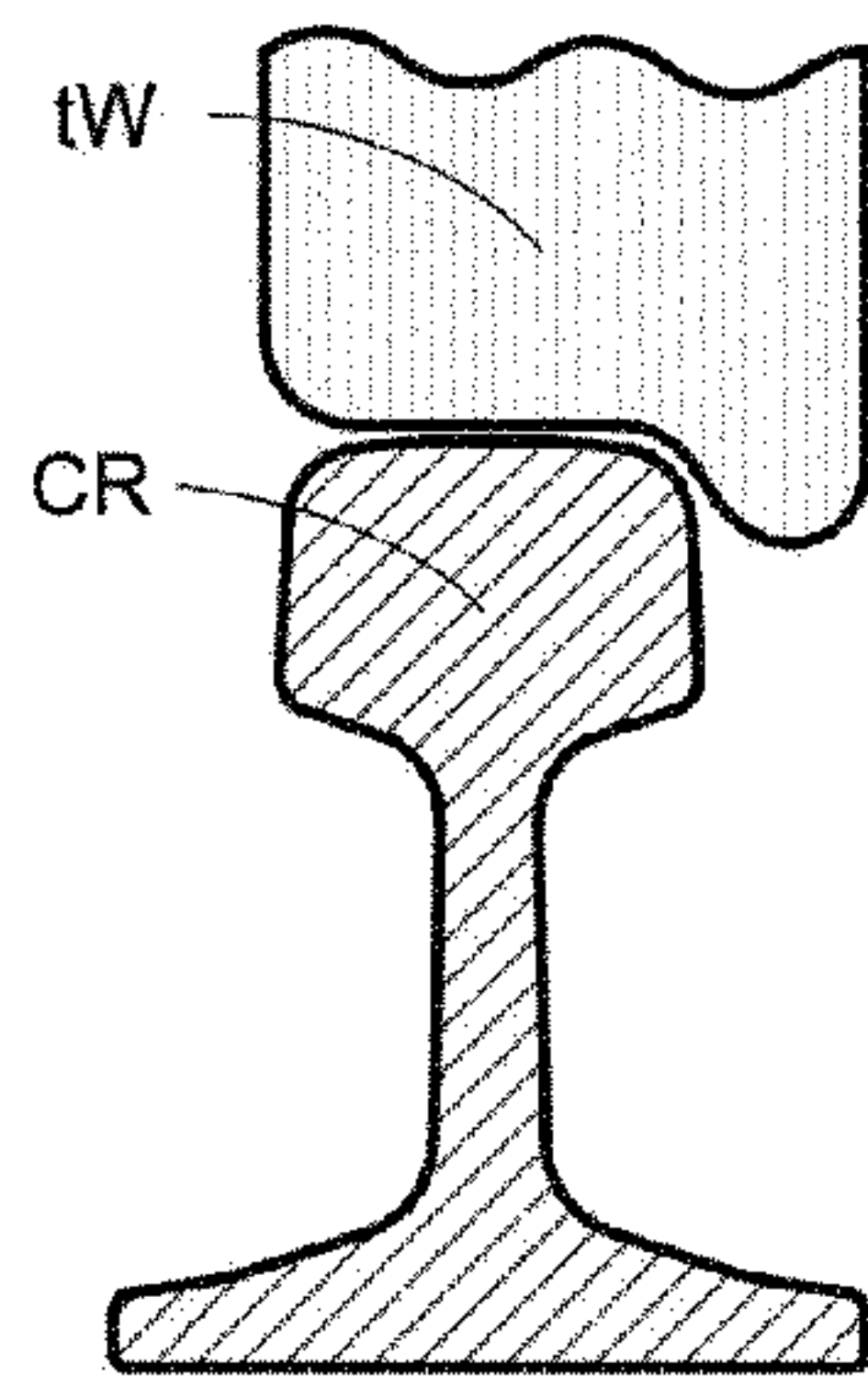


FIG. 6B
PRIOR ART

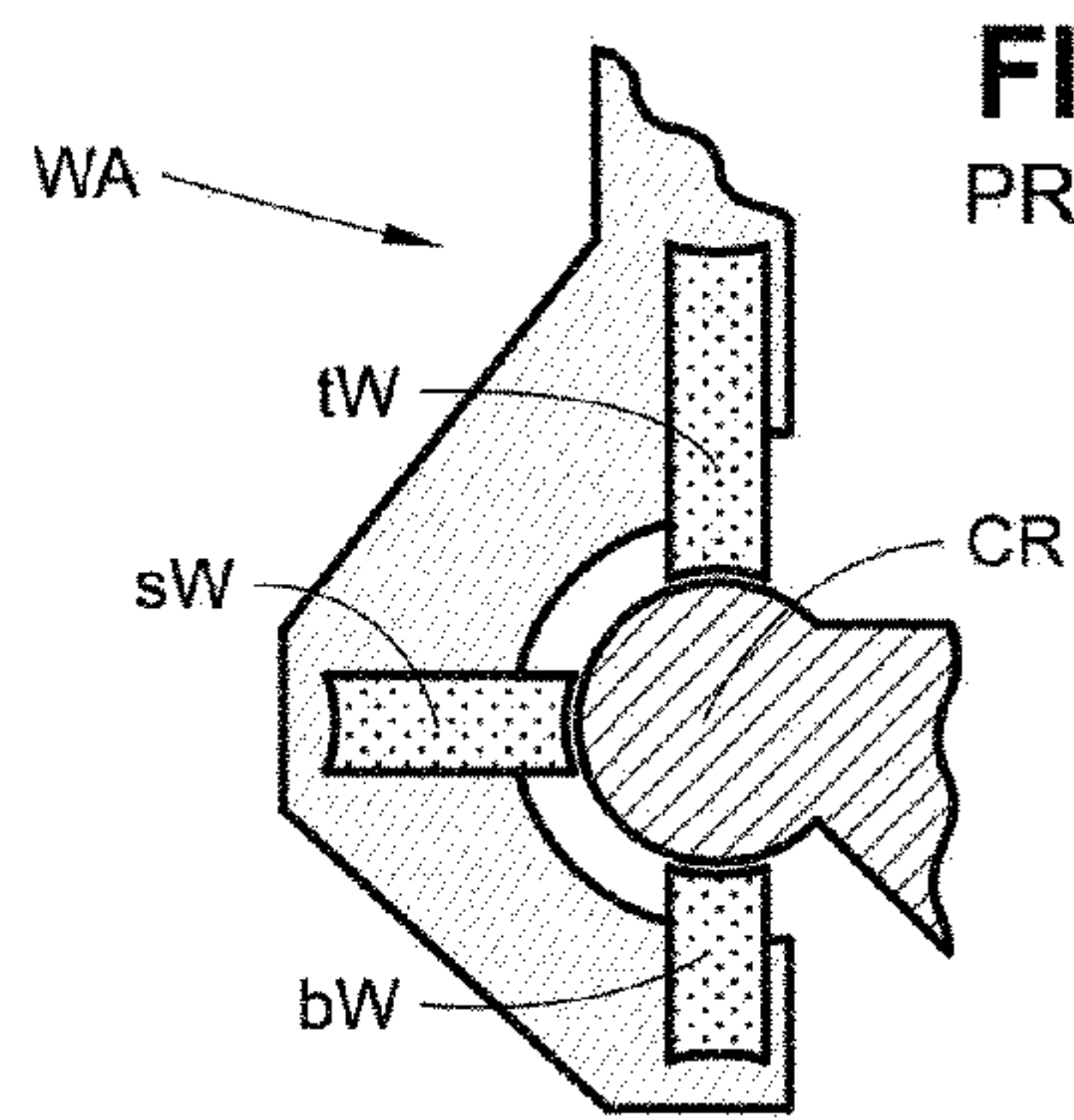


FIG. 7A

PRIOR ART

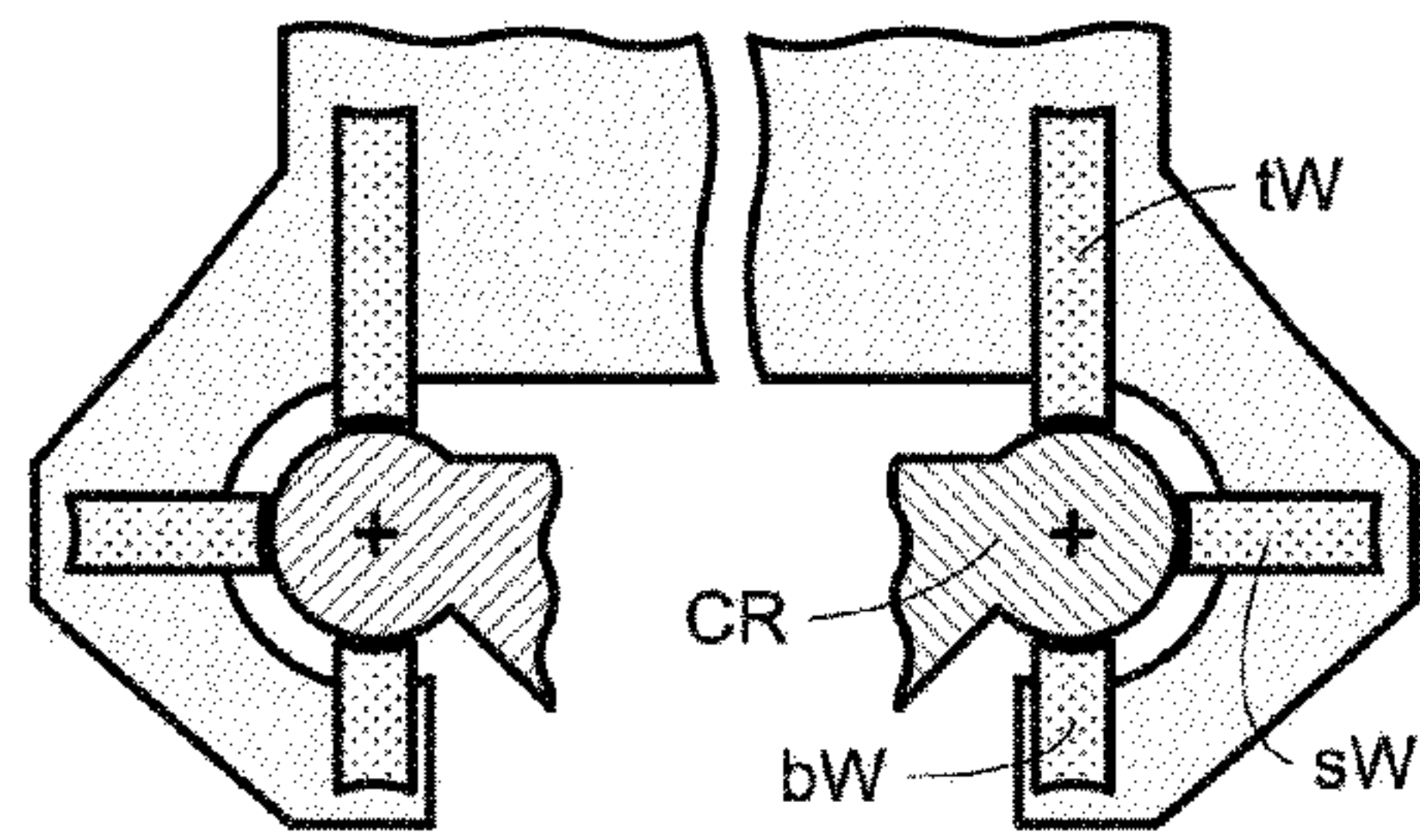


FIG. 7B

PRIOR ART

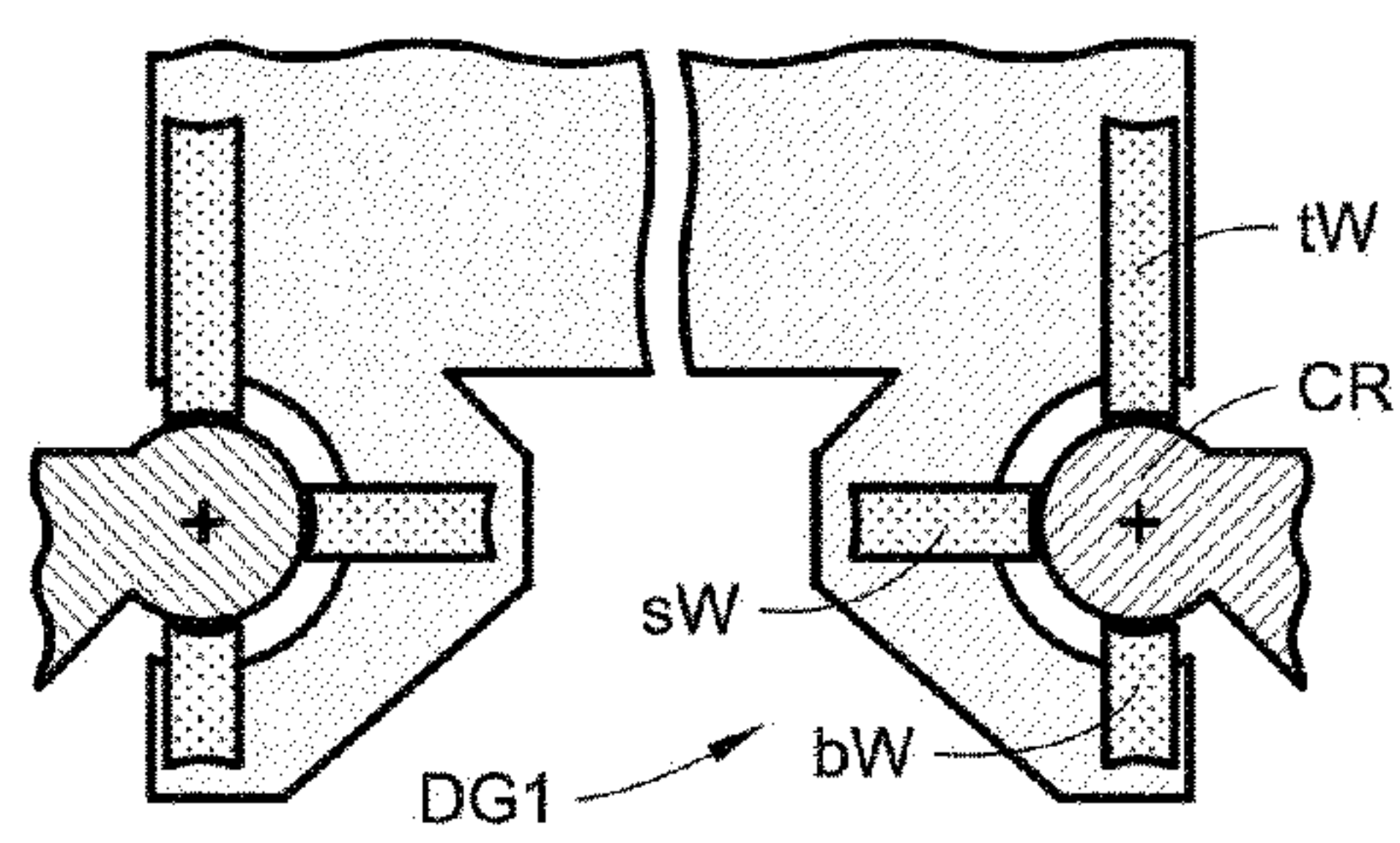


FIG. 8

PRIOR ART

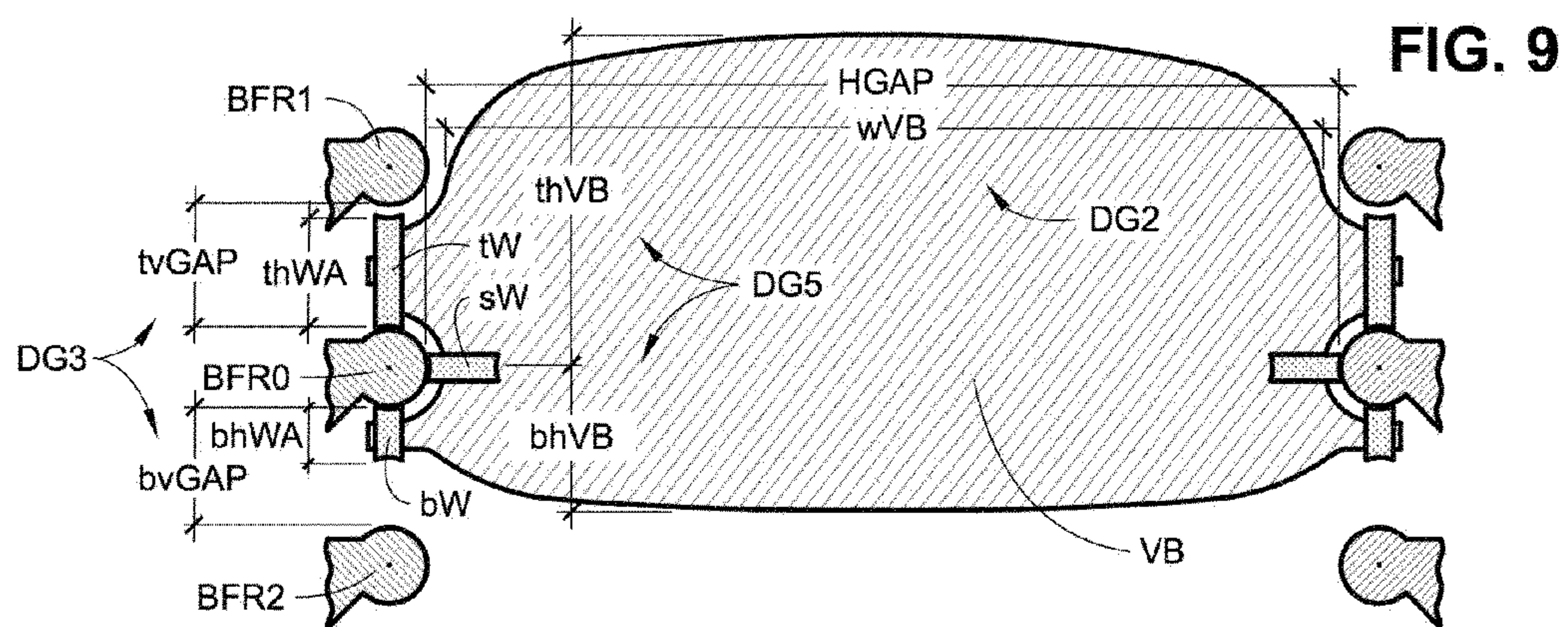
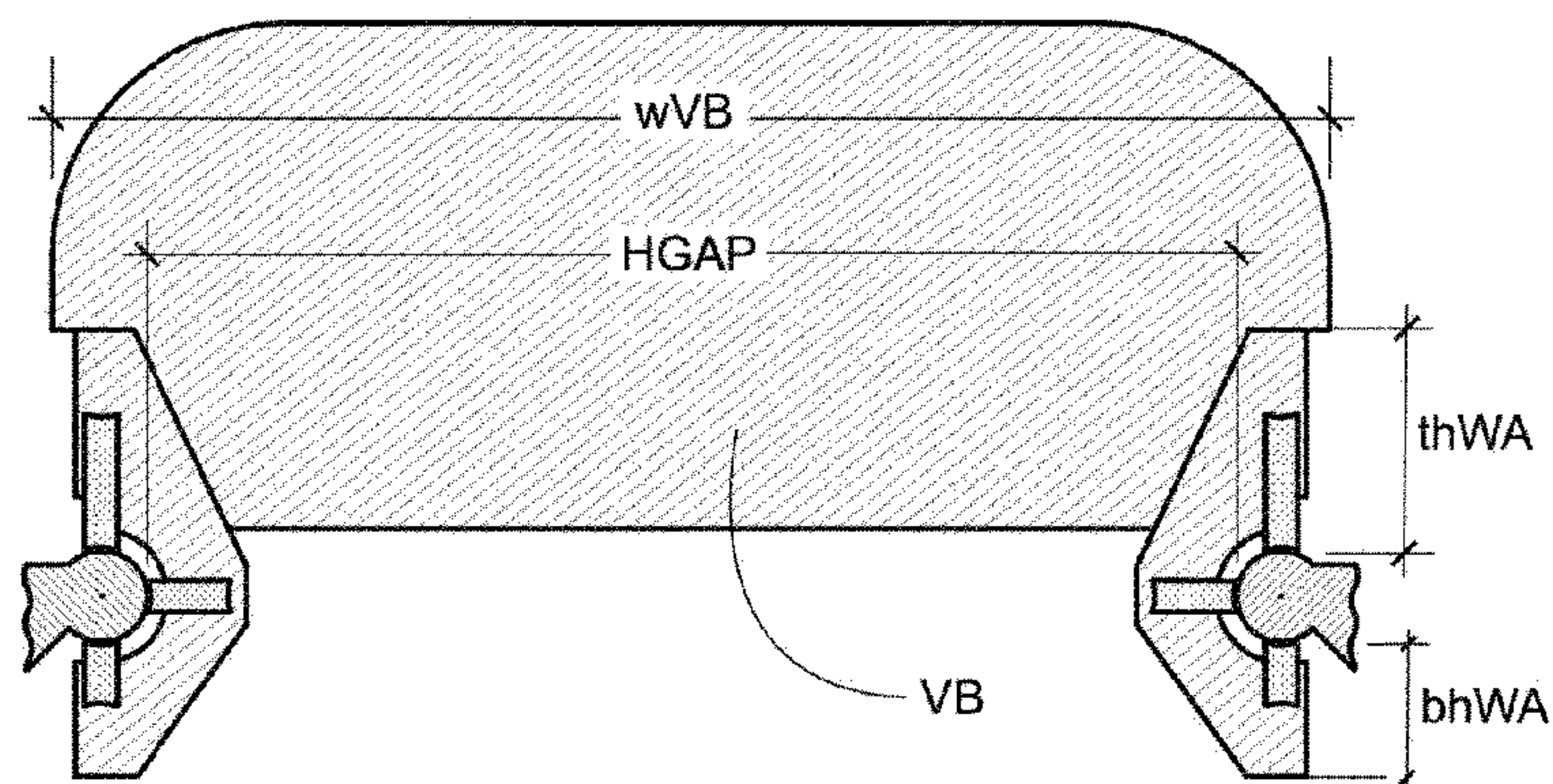


FIG. 10A

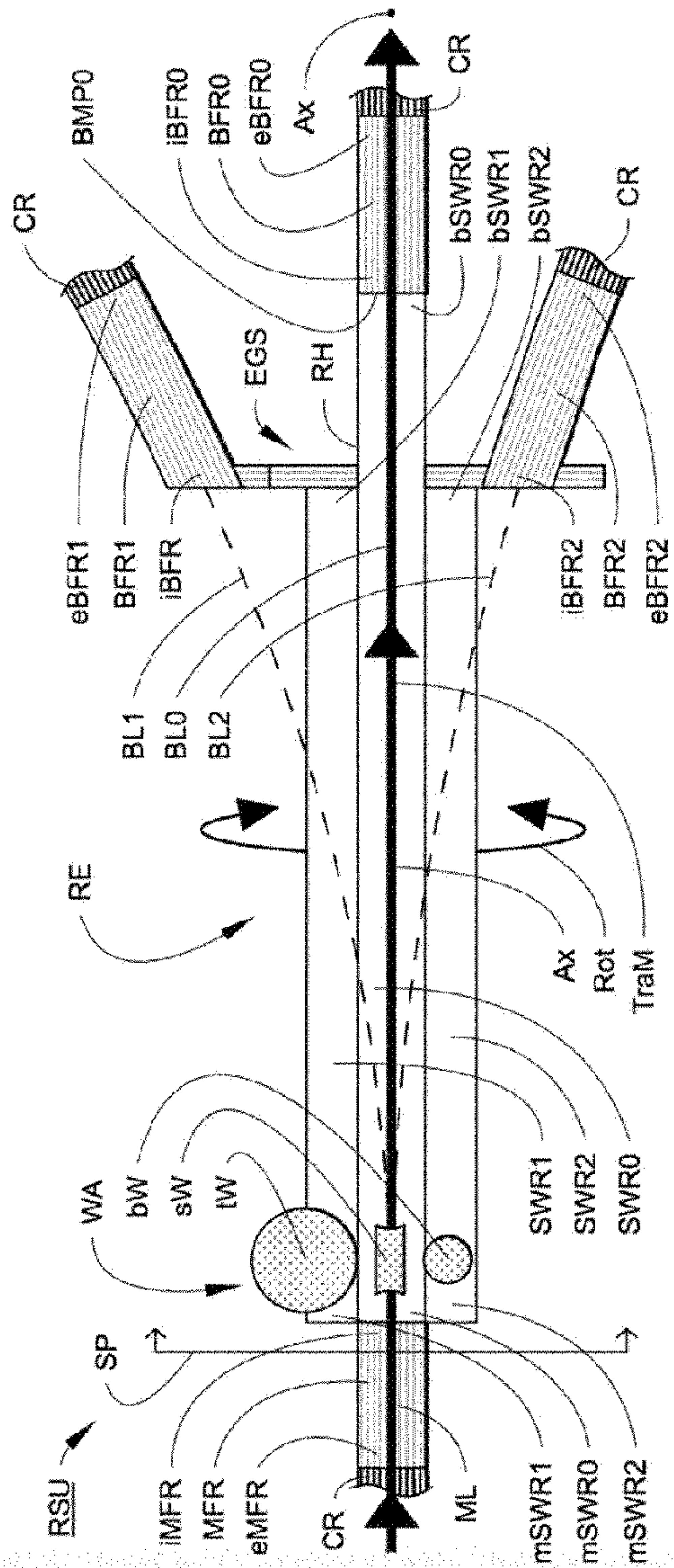


FIG. 10B

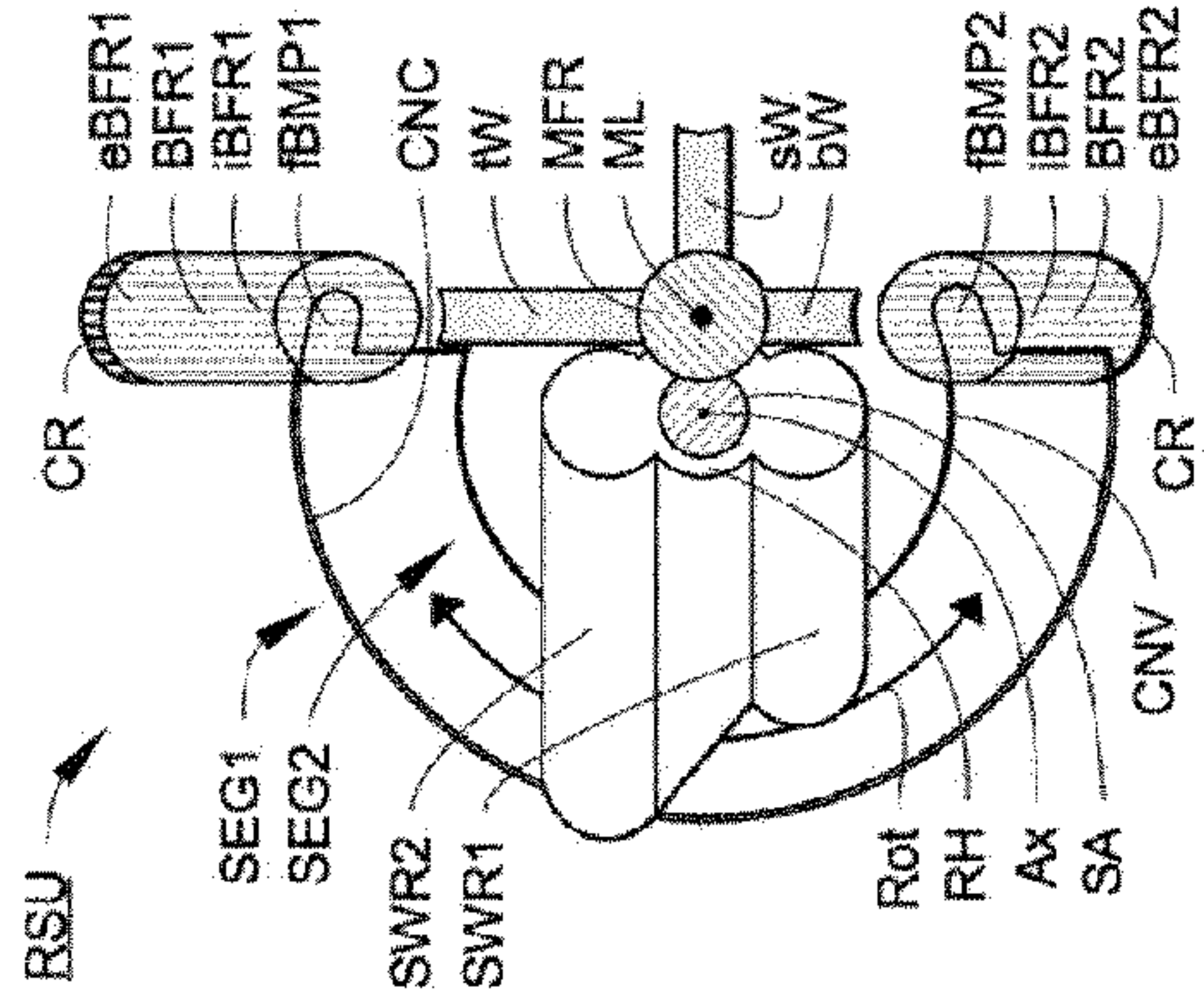


FIG. 12A

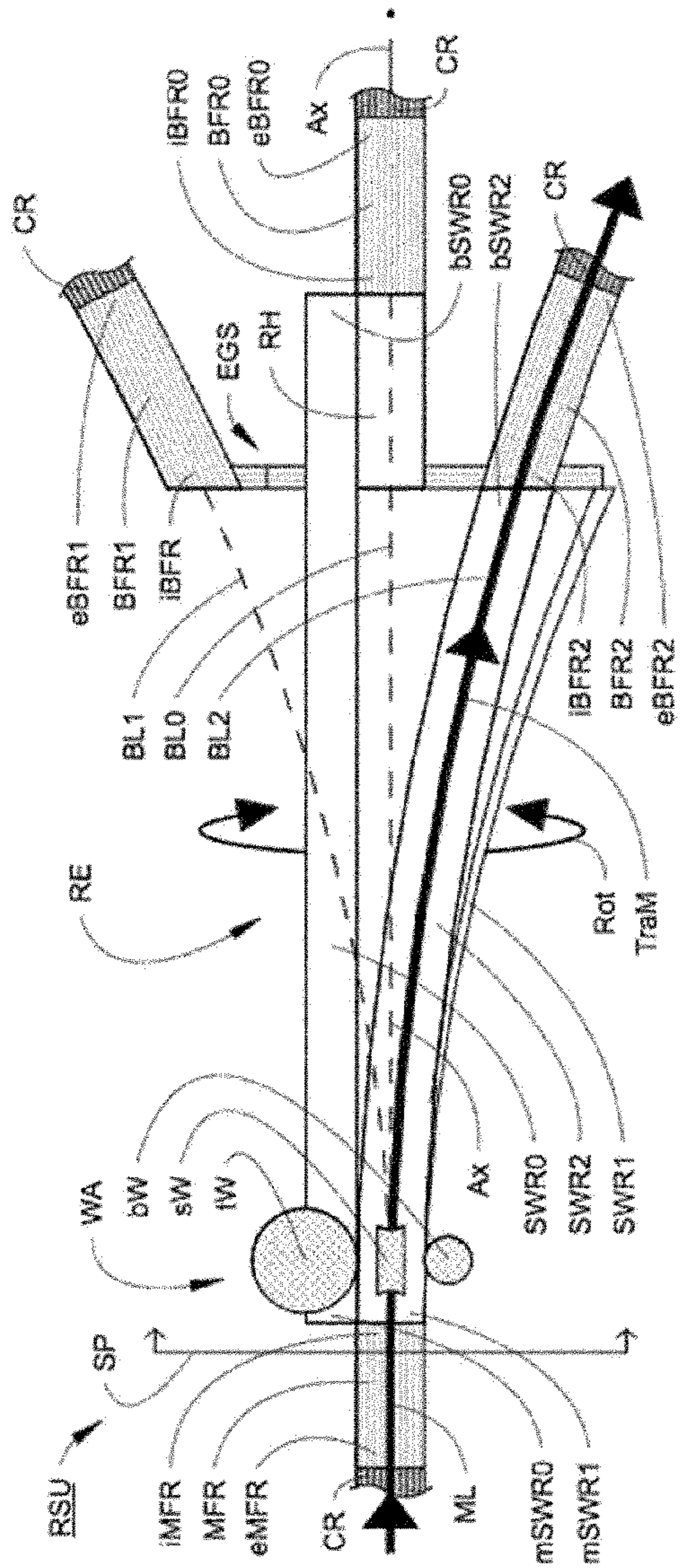


FIG. 12B

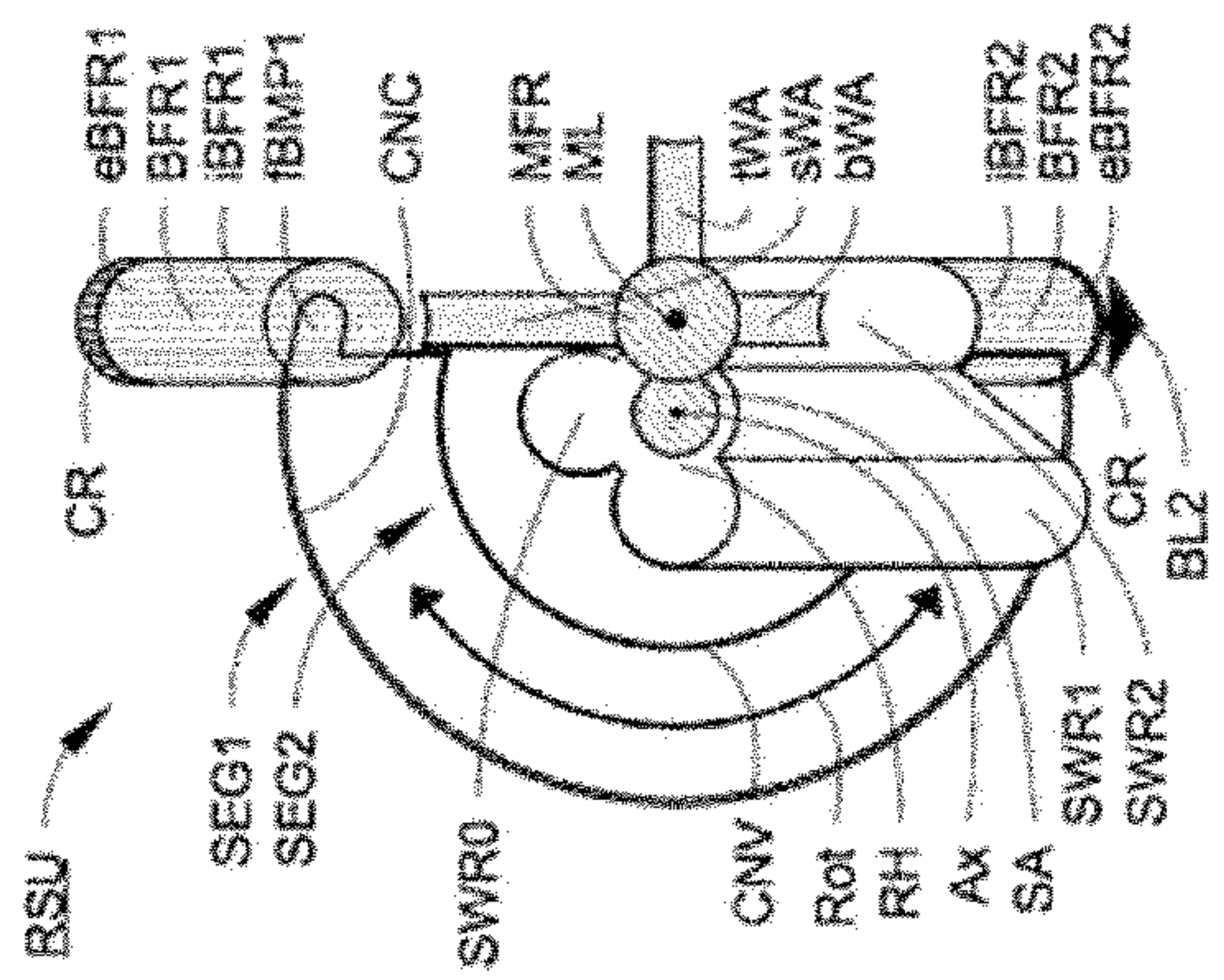


FIG. 13

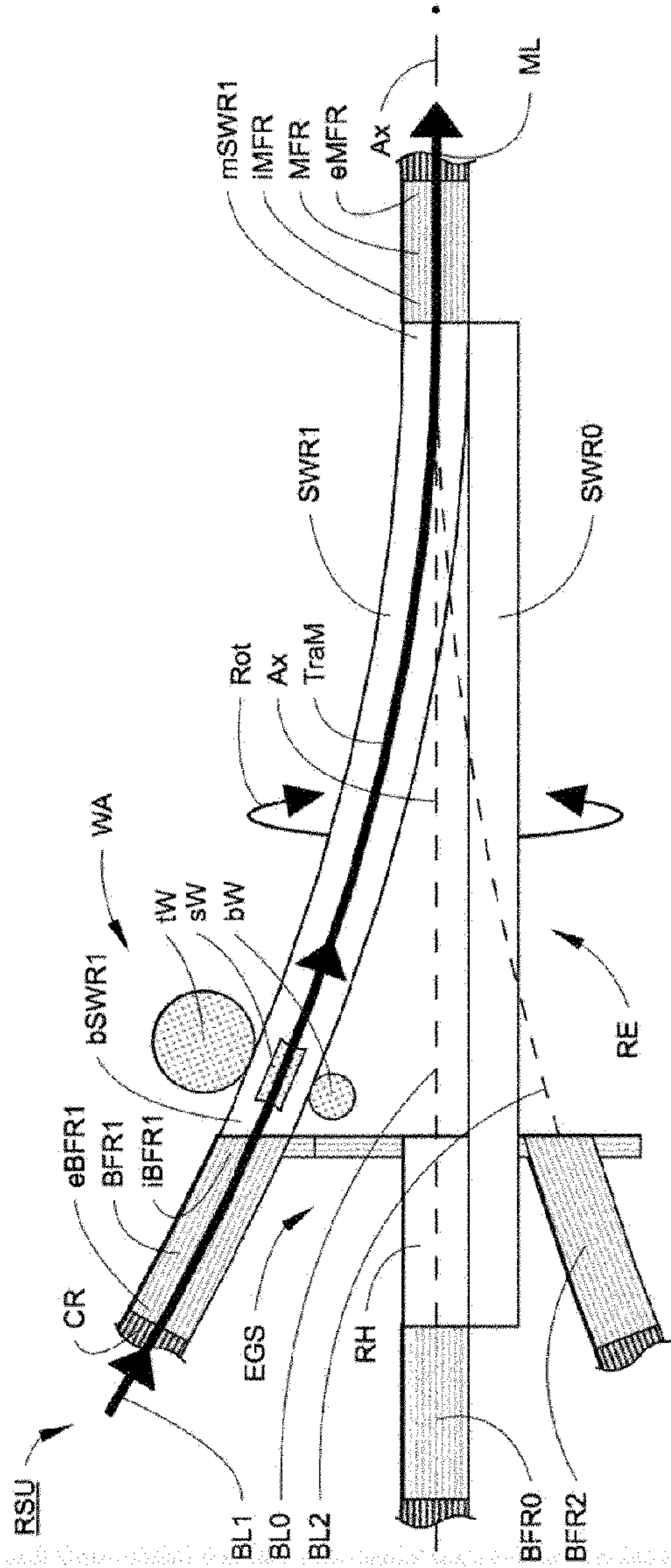


FIG. 14

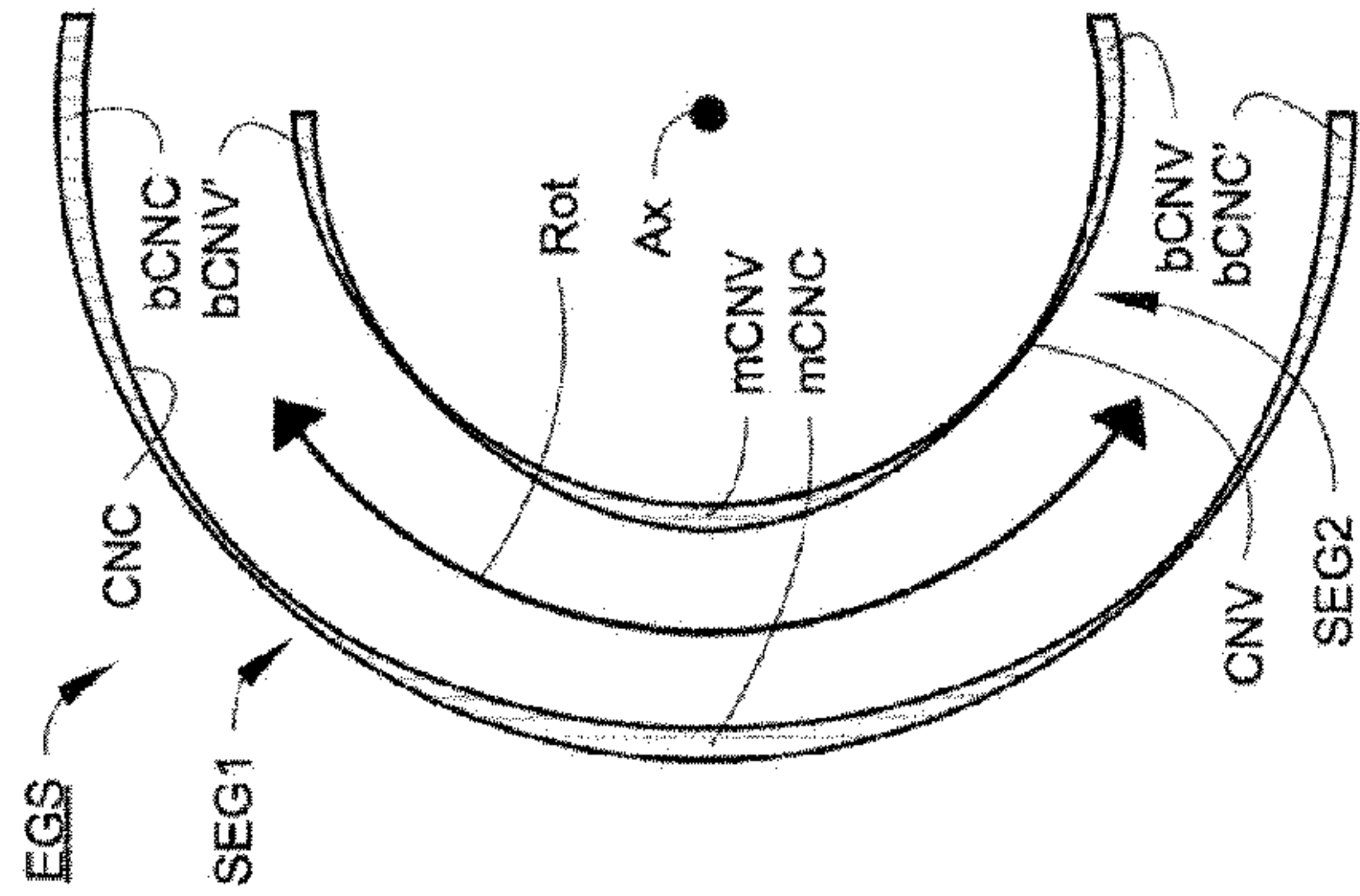


FIG. 15A

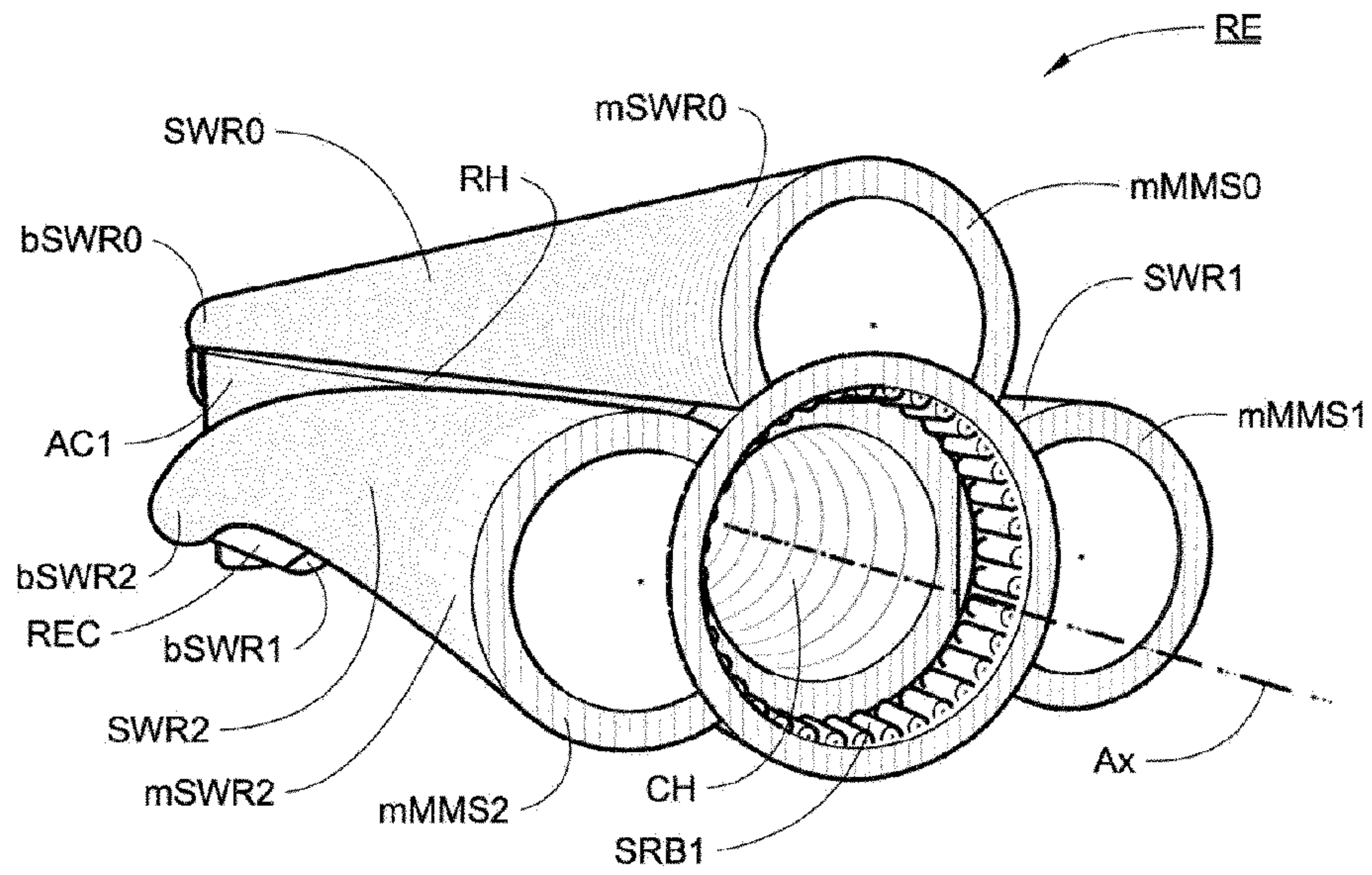


FIG. 15B

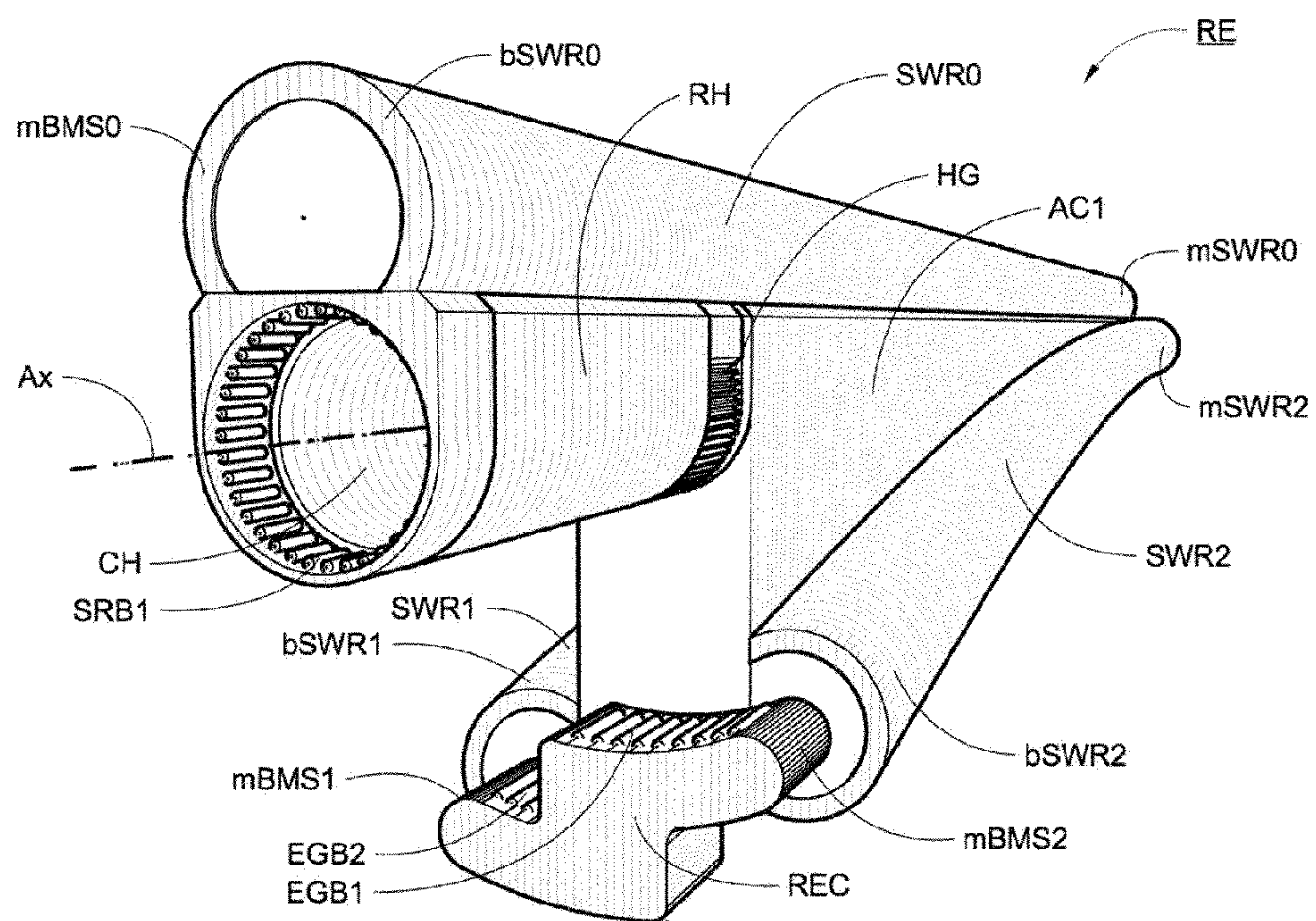


FIG. 16A

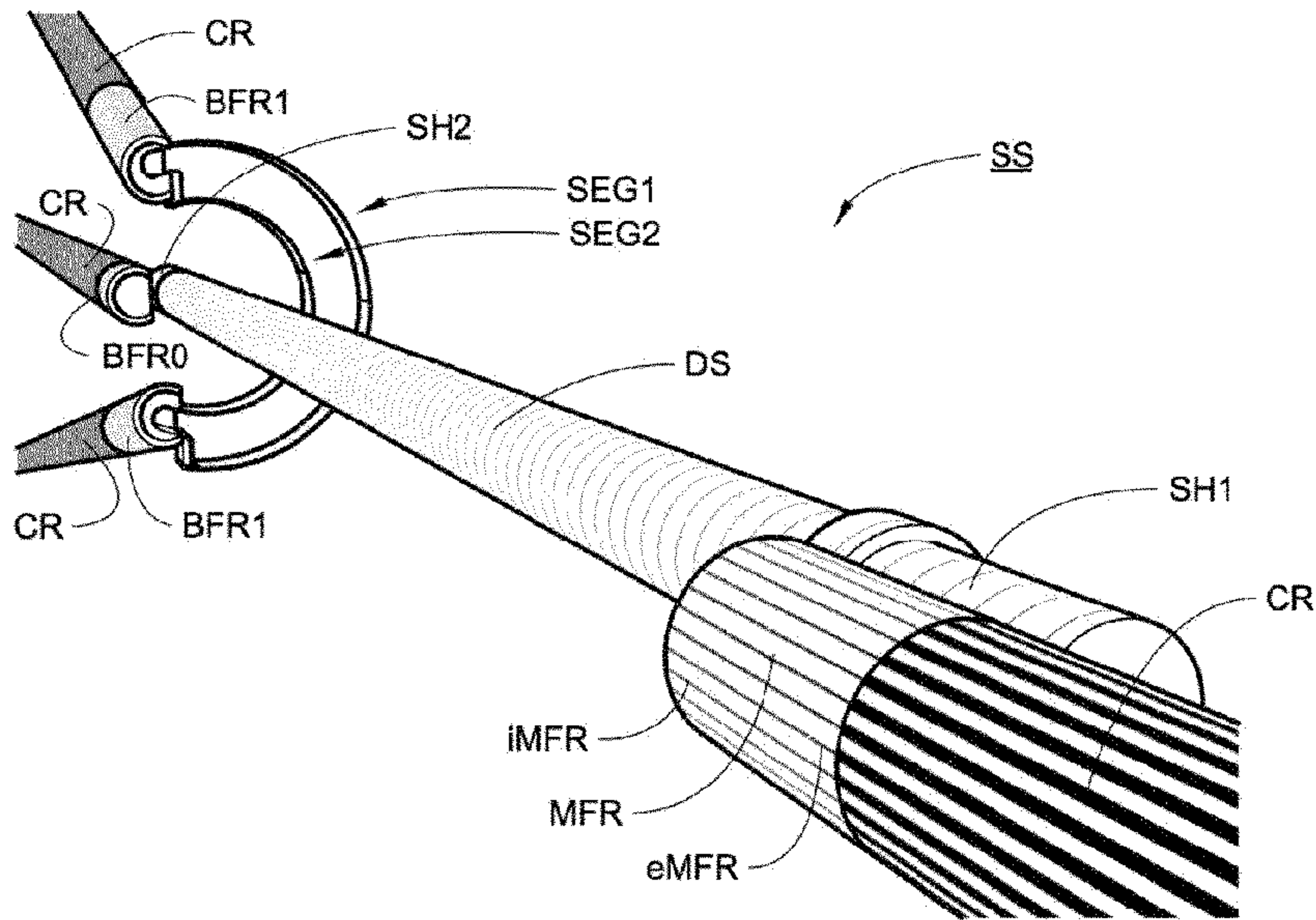


FIG. 16B

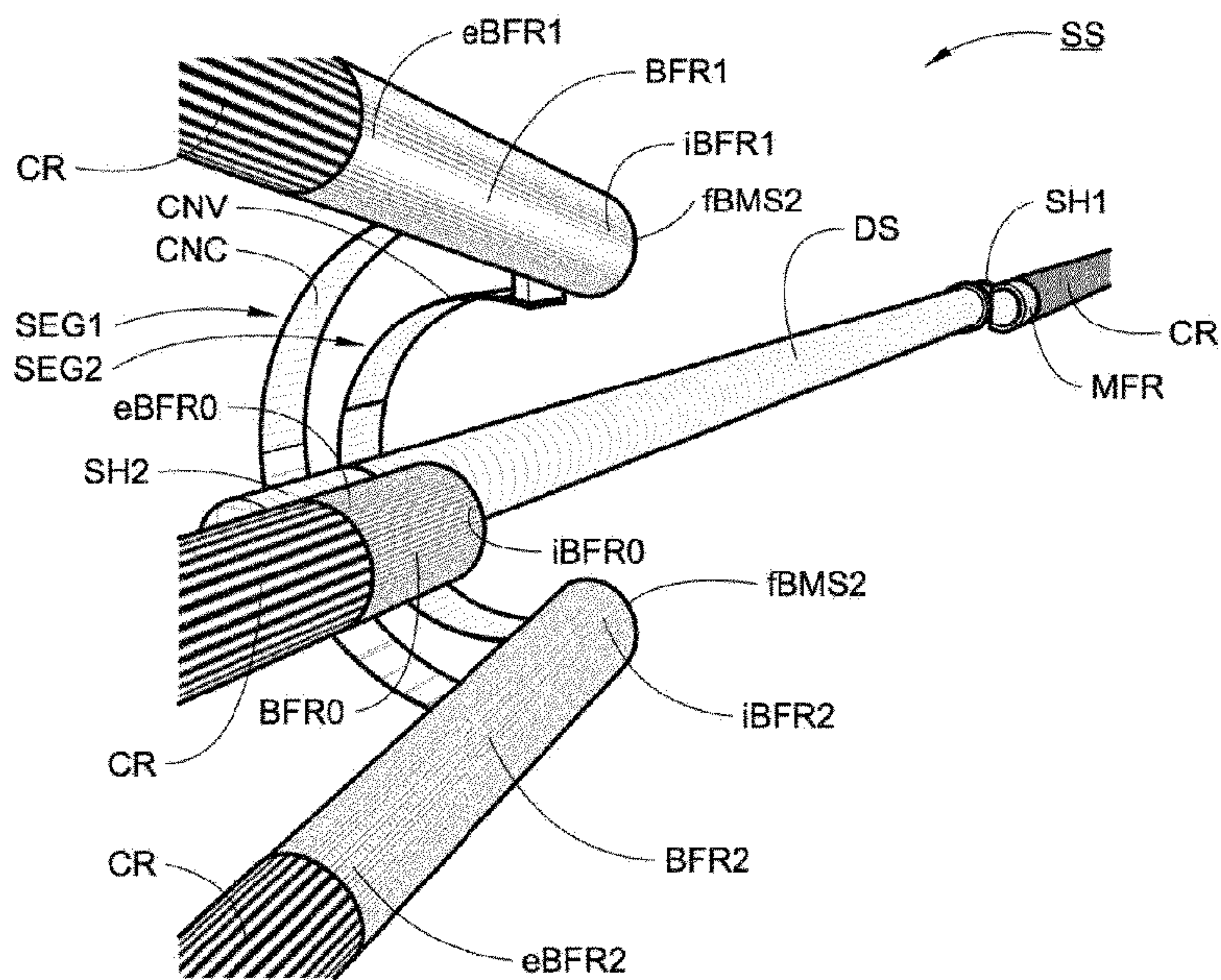


FIG. 17A

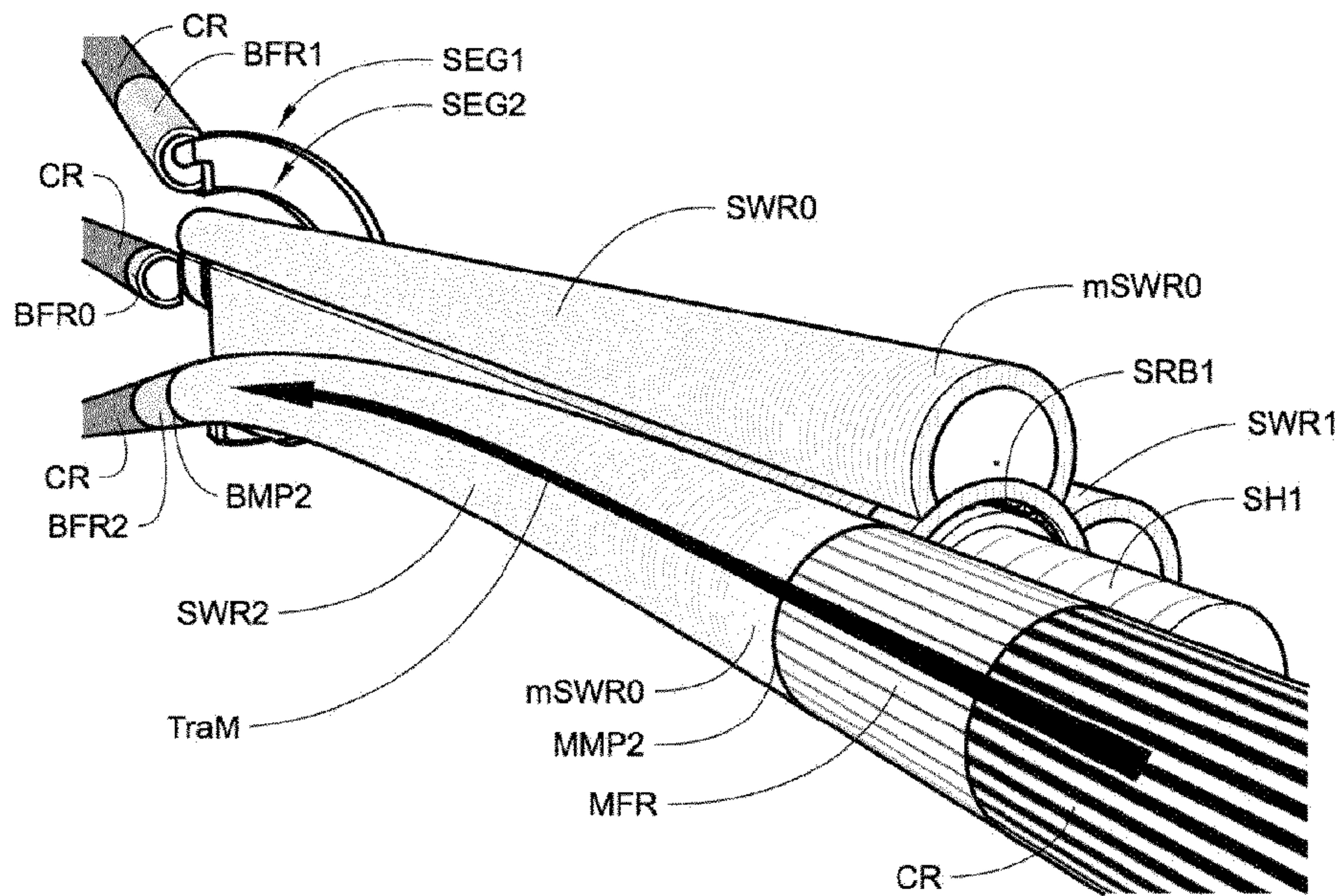


FIG. 17B

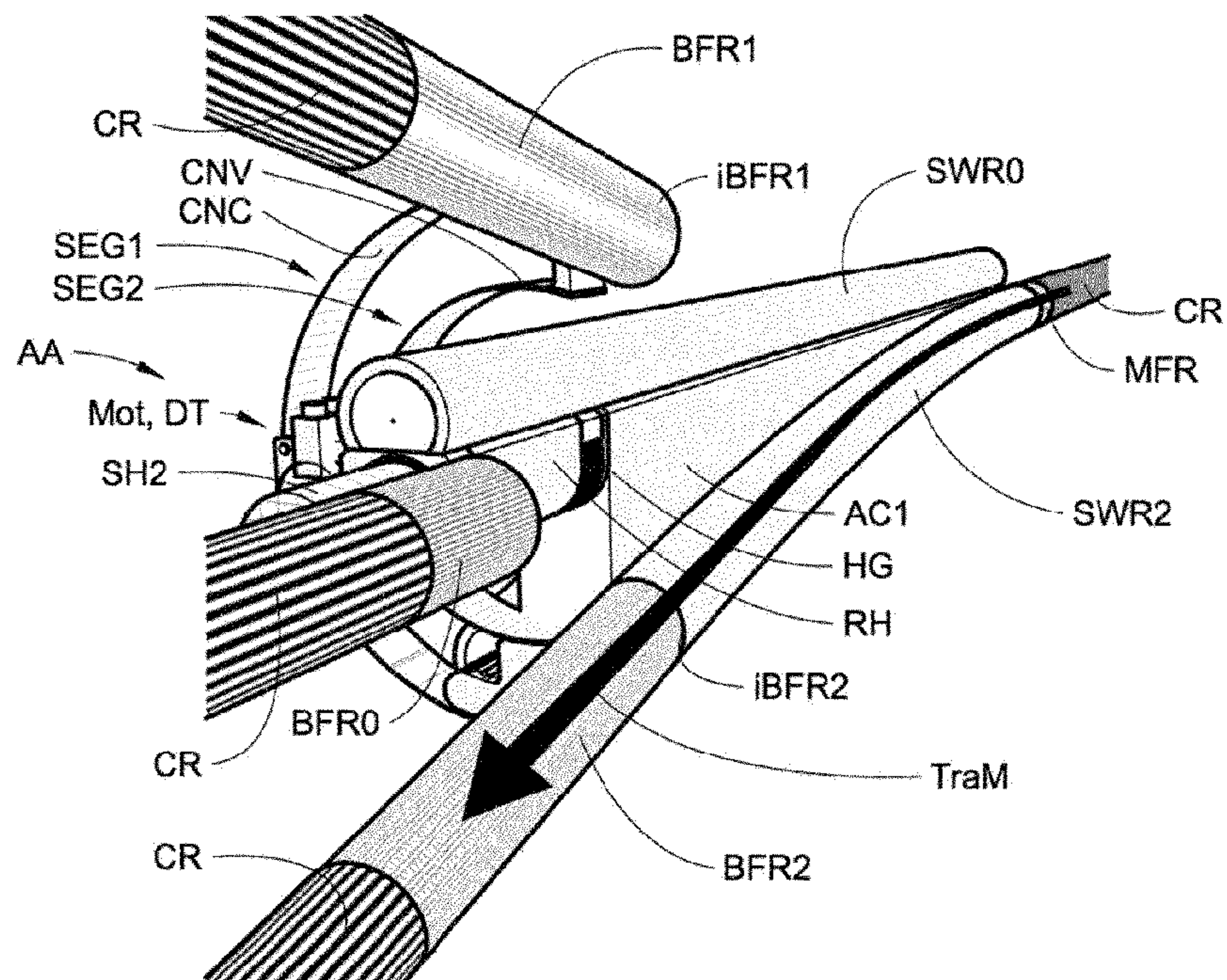


FIG. 18

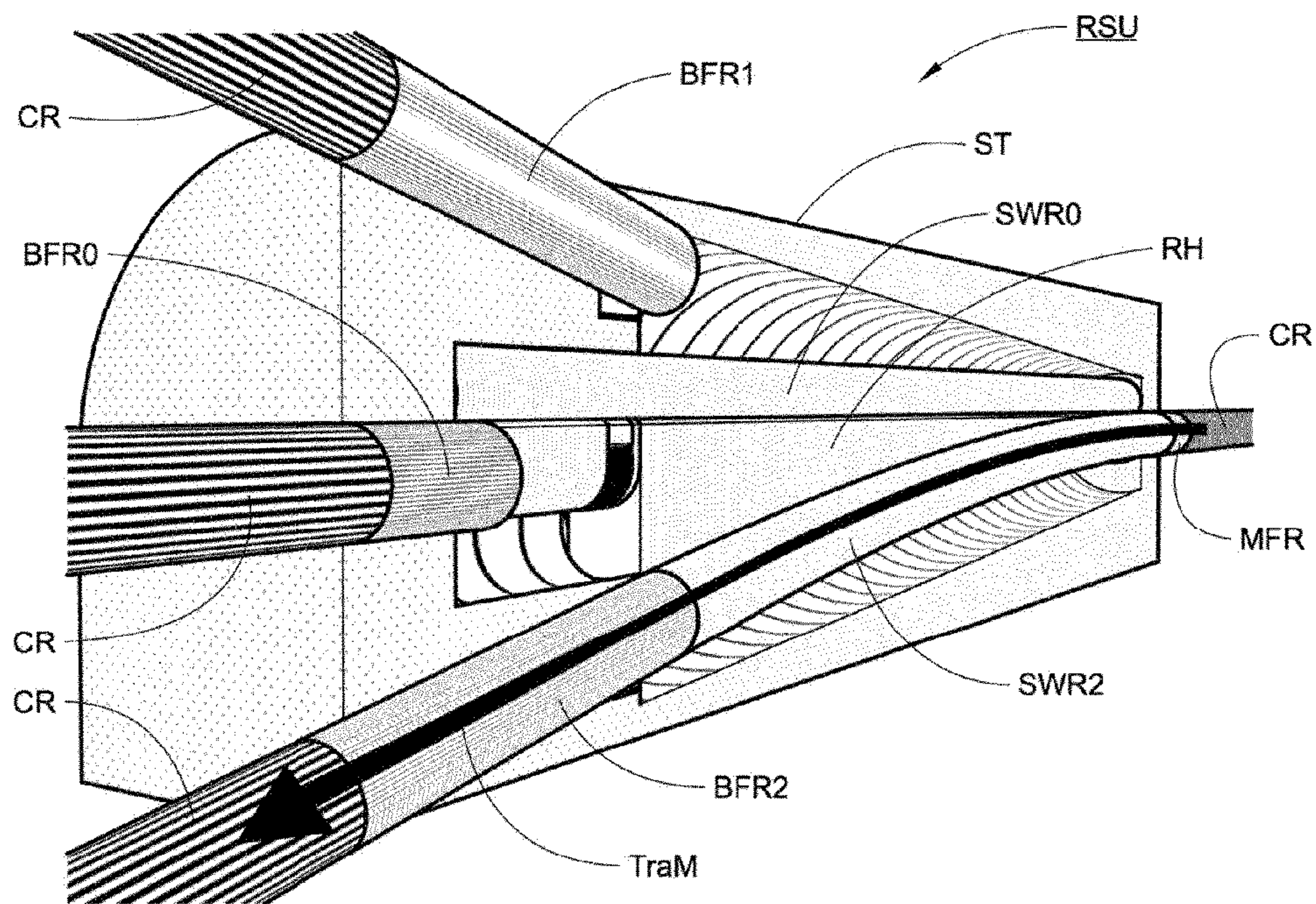


FIG. 19

