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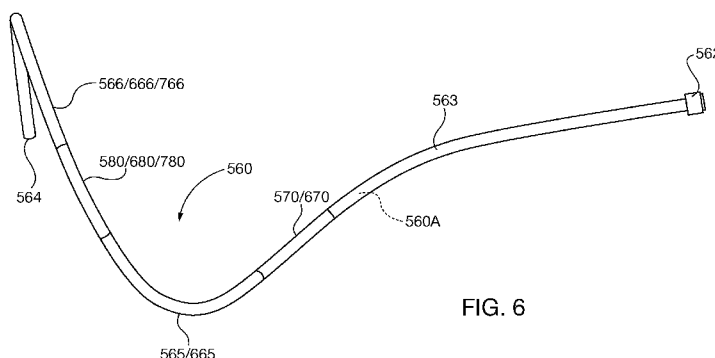
(54) Title: ROLLING MILL COIL-FORMING LAYING HEAD WITH PATH OR PIPE HAVING LATERALLY JOINED SEG-  
MENTED CONSTRUCTION

FIG. 6

(57) Abstract: A rolling mill coil-forming apparatus (30) includes a rotating quill (50) that supports an elongated path hollow structure (60), such as a laying head pipe, for receiving elongated material after it has been rolled. The elongated structure is constructed of combinations of ferrous and non-ferrous dissimilar materials. Elongated path hollow structures are formed from adjoining, abutting segments, and can be constructed in any three dimensional compound curve shape that can replicate the smooth, continuous curve elongated material transport path of known laying pipes, or any other desired path. A pathway structure segment or plurality of segments may be constructed of a homogeneous material, or alternatively, different materials may be spliced or otherwise joined to form the composite, complete elongated path hollow structure. The adjoining segment portions may be nested within or circumscribe another pathway structure layer.

**ROLLING MILL COIL-FORMING LAYING HEAD WITH PATH OR PIPE  
HAVING Laterally JOINED SEGMENTED CONSTRUCTION**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119(e) to co-pending U.S. Provisional Application Serial Nos.: 61/539,014, 61/539,062, and 61/539,069, filed 26  
5 September 2011; and U.S. Provisional Application Serial Nos.: 61/540,590; 61/540,602; 61/540,609; 61/540,617; and 61/540,798, filed 29 September 2011, all of which are entirely incorporated herein by reference as if fully set forth below.

BACKGROUND

10 [0002] 1. Field

[0003] Embodiments of the present invention relate to rolling mill coil-forming  
apparatuses, often referred to as laying heads, and more particularly to replaceable laying  
15 head pathways, such as laying head pipes, in laying heads.

[0004] 2. Description of the Prior Art

[0005] Rolling mill coil-forming laying head apparatuses form moving rolled elongated  
20 material into a series of helical continuous loop rings. Those rings may be further processed downstream by bundling them into coils of the helical turns. Known laying heads are described generally in United States Patents Nos. 5,312,065; 6,769,641; and 7,011,264, the entire contents of all of which are hereby incorporated by reference as if fully contained herein.

25 [0006] As described in these patents, rolling mill laying head systems comprise a quill, pipe support and a laying head pipe. The quill and pipe support are adapted to rotate the laying head pipe such that it can receive elongated material into its entry end. The laying

head pipe has a curved intermediate portion that is surrounded by the quill's flared section and an end portion that projects radially outwardly from and generally tangential to the quill's rotational axis. In combination, the rotating quill and the laying head conforms the rolled material into a helical curved shape. The laying head pipe may be replaced with one of a different profile and/or diameter in order to reconfigure the laying head to accommodate different dimensioned rolled material or to replace worn pipes.

[0007] Further helical profiling of the rolled material is accomplished in a rotating helical guide that includes troughs for receiving the rolled material about its outer circumference. The helical guide described in United States Patent No. 6,769,641 is of segmented, sector-shaped, modular rim construction with the circumferential troughs formed within the rim sectors.

[0008] A generally annular ring or shroud, also commonly referred to as an end ring or guide ring, has a guide surface that circumscribes the laying head pipe discharge end and helical guide, so that the elongated material is confined radially as it is discharged in now fully coiled configuration to a conveyor for subsequent bundling and other processing. A pivoting tripper mechanism, including one or more tripper paddles, may be positioned at approximately the six o'clock or bottom position of the end ring/shroud distal the quill. Varying the pivot attack angle of the tripper mechanism relative to the ring/shroud inner diameter surface is useful to control elongated material coiling, for example to compensate for varying elongated material plasticity thickness, composition, rolling speed and cross sectional structure.

#### [0009] Laying Head Pipe Design and Operational Constraints

[0010] As previously noted, the hollow laying head pipe in combination with the rotating quill and pipe support, conform the rolled material into a helical curved shape. Typically, the laying head pipe is formed from a continuous length of symmetrical steel pipe or steel tubing that is bent in a forming jig by application of external heat and mechanical force to conform to the desired generally helical profile. Steel pipe or tubing is generally chosen for construction of laying head pipes for relative ease of workability

into the desired final generally helical shape and relatively low material purchase cost. But commercial steel pipe or tubing have relatively low hardness: an undesirable limiting factor for rolling mill operation, productivity and maintenance.

5 [0011] Elongated material that is advancing at speeds up to approximately 500 feet/second (150 m/sec) is received in the laying head system intake end and discharged in a series of continuous coil loops at the discharge end. At such speeds, the hot rolled products exert a punishing effect on the laying head pipes, causing internal pipe surfaces to undergo rapid localized frictional wear and premature failure. Also, as the laying head  
10 pipes wear, their ability to deliver a stable ring pattern to the looped coil receiving conveyor at the discharge end of the laying head deteriorates. Unstable ring patterns disturb cooling uniformity and also contribute to coiling mishaps commonly referred to as “cobbling.”

15 [0012] For a number of years, it has been well accepted that laying head pipes with reduced bore sizes provide a number of significant advantages. By radially constricting the hot rolled products within a smaller space, guidance is improved and the ring pattern delivered to the cooling conveyor is more consistent, making it possible to roll at higher speeds. Unfortunately, however, these advantages have been offset to a large extent by  
20 significantly accelerated pipe wear due to the higher speed of the product. Also, the reduced bore size pipe can only be used with small diameter products, so it must be replaced by a larger bore size pipe for coiling of larger diameter products.

[0013] Frequent and costly mill shutdowns and preventive maintenance are required to  
25 replace prematurely worn laying head pipes and to address problems associated with elongated material cobbling. If a laying head pipe becomes so worn that it suffers a pipe wall rupture, the cobbling mishap can impact elongated material feed upstream of the laying head. From a wear resistance point of view it is desirable to form the laying head pipe inner wear surface from relatively hard low surface friction steel and further  
30 desirable to perform further surface hardening and heat treatment, but such wear treatment steps must be balanced with ease and cost of pipe fabrication.

[0014] Thus, in the past, those skilled in the art have deemed it necessary to compromise laying head pipe design and performance by employing larger bore laying head pipes and rolling at reduced speeds below the rated design speeds of the mills. The combination of larger than desired laying head pipe internal diameter and reduced rolling speeds have been implemented in order to schedule preventive maintenance pipe replacement during scheduled maintenance “downtime”. Conventional and current laying head pipes must be replaced after processing quantities of elongated material of approximately 3,000 tons or less, depending on diameter, speed and product composition.

[0015] Those skilled in the art have made repeated attempts at increasing the useful life of laying head pipes for larger total processing tonnage, so that more elongated material can be processed before replacement. For example, as disclosed in U.S. Patent Nos. 4,074,553 and 5,839,684, it has been proposed to line the laying head pipes with wear resistant insert rings that are inserted into an external laying head pipe casing. Adjoining rings within curved sections of the laying head pipe casing have discontinuity gaps that are not desirable for smooth advancement of elongated material that is being transported within the laying head pipe. U.S. Patent No. 6,098,909 discloses a different approach where the laying head pipe is eliminated in favor of a guide path defined by a spiral groove in the outer surface of a conical insert enclosed by a conical outer casing, with the insert being rotatable within the outer casing to gradually shift the wear pattern on the inner surface of the outer casing. It is not believed that the spiral groove conical insert approach is readily compatible with all existing quill laying heads that presently incorporate laying head pipe structures.

[0016] Attempts have also been made at carburizing the interior laying head pipe surfaces in order to increase hardness and resistance to wear. But the carburizing process requires a drastic quenching from elevated processing temperatures, which can distort the pipe curvature. The carburized layer has also been found to be relatively brittle and to temper down at elevated temperatures resulting from exposure to the hot rolled products.

[0017] The owner of this patent application has also disclosed the application of a boronized layer to the laying head pipe wear surfaces by subjecting them to a thermochemical treatment in which boron atoms are diffused into the pipe interior to increase its hardness. See Patent Cooperation Treaty Application entitled “Boronized Laying Pipe”, filed in the United States Receiving Office on September 2, 2011, Serial No. PCT/US2011/050314.

[0018] The owner of this patent application has also disclosed a laying head pipe having inner and outer friction-tight engaged concentric layers in which the inner layer advances axially relative to the outer layer during laying head operation due to centrifugal forces, differences in localized thermal expansion, and thermal cycling between the layers. Thus worn sections of the laying head pipe interior advance along the pipe interior so that a “fresh” unworn surface continually replenishes the worn section. See Patent Cooperation Treaty Application entitled “Regenerative Laying Pipe”, filed in the United States Receiving Office on September 2, 2011, Serial No. PCT/US2011/050283.

## SUMMARY

[0019] Accordingly, embodiments of the present invention include a rolling mill laying head elongated structure for retention and transport of elongated materials in a laying head, so that the elongated material can be selectively coiled. The laying head path structure may perform the functionality of a conventional laying head pipe. In aspects of the present invention, any portion of the laying head path structure or the structure in its entirety is formed from adjoining, abutting segments that form an effectively continuous inner surface for passage and transport of elongated material therethrough. An effectively continuous inner surface is one where gaps, if any, between adjoining sections are sufficiently smaller than the elongated material diameter and circumference so that any such gaps do not impede transport of the elongated material through the laying head path structure. The abutting segments may be spliced or otherwise coupled to each other by mating interlocking ends, fasteners or by permanent joining them together (e.g., by welding). Alternatively, the entire pipe may be constructed of homogeneous non-ferrous

material rather than from adjoining segments of ferrous and non-ferrous materials. The adjoining segment portion (or homogeneous non-ferrous material pipe) may be nested within or circumscribe another pipe to form a laying head path/pipe structure with two or more multiple layers.

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[0020] The laying head path structure components formed from adjoining segments can be constructed in any three dimensional compound curve shape that can replicate the smooth, continuous curve elongated material transport path of known laying pipes, or other desired path. A pipe segment or plurality of segments may be constructed of a homogeneous material or different materials may be spliced or otherwise joined to form the composite, complete laying head path structure and thereafter formed into its final three dimensional profile (e.g., by bending). Additionally or alternatively segments may be pre-formed into three dimensional profiles and then joined at their axial ends with other straight or curved segments. For example, a laying head elongated structure for transporting elongated materials can be constructed of two or more adjoining segments of pipe or tubing of the same or dissimilar metals. The fabricated adjoining segments facilitate formation of zones within the component segment, such as including by way of example wear-resistant zones or friction reducing zones in the segment that are in direct contact with the elongated material. The innermost segment layer can be a regenerative layer that advances downstream the same direction as the elongated material, so that the upstream portion within a laying path/pipe internal wear zone constitutes a fresh, unworn surface.

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[0021] Another exemplary embodiment relates to a coil-forming apparatus laying head system for coiling hot rolled elongated material, comprising a quill rotating about an axis, for discharging elongated material. A support is coaxial with the quill rotational axis. An elongated transport path hollow member, such as a laying head pipe, is coupled to the support, for passage of elongated material there through. The hollow member comprises a first end generally aligned with the quill rotational axis for receiving elongated material discharged from the quill, and a second end radially spaced from the rotational axis for discharging elongated material generally tangentially relative to the rotational axis. A

portion of the hollow member structure or the structure in its entirety is formed from adjoining, abutting segments that form a continuous inner surface for passage and transport of elongated material therethrough. The abutting segments may spliced or otherwise coupled to each other by mating interlocking ends, fasteners and permanent attachment (e.g., by welding). The adjoining segment portions may be nested within or circumscribe another structure layer. Alternatively, the entire transport path hollow member, such as a laying head pipe, may be constructed of homogeneous non-ferrous material rather than from adjoining segments of ferrous and non-ferrous materials. The adjoining segment portion (or homogeneous non-ferrous material pipe) may be nested within or circumscribe another layer to form a laying head path/pipe with two or more multiple layers.

[0022] An additional exemplary embodiment of the present is directed to an apparatus for retention and transport of elongated materials in a rolling mill coil forming laying head system comprising an elongated hollow pathway structure defining a continuous inner surface for transport of elongated materials therein. At least a portion of the pathway structure, or the structure in its entirety, is formed by the method of adjoining laterally abutting segments and then forming the structure into the desired three dimensional curved shape of a laying head path/pipe. The adjoining segment portion layer may be nested within or circumscribe another layer of the structure or pipe. Additionally or alternatively, pre-formed curved sections may be joined axially to form a portion or all of the elongated transport path/pipe composite structure. Alternatively, the entire pipe may be constructed of homogeneous non-ferrous material rather than from adjoining segments of ferrous and non-ferrous materials. The adjoining segment portion (or homogeneous non-ferrous material pipe) may be nested within or circumscribe another layer to form a laying head path/pipe with two or more multiple layers.

[0023] The features of aspects of the present invention may be applied jointly or severally in any combination or sub-combination by those skilled in the art. Further features of aspects and embodiments of the present invention, and the advantages offered thereby, are explained in greater detail hereinafter with reference to specific

embodiments illustrated in the accompanying drawings, wherein like elements are indicated by like reference designators.

#### BRIEF DESCRIPTION OF THE DRAWINGS

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[0024] The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

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[0025] FIG. 1 shows a side elevational view of a coil-forming apparatus laying head system, in accordance with an exemplary embodiment of the present invention;

[0026] FIG. 2 shows a top plan view of the laying head system of FIG. 1, in accordance with an exemplary embodiment of the present invention;

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[0027] FIG. 3 shows a sectional elevational view of the laying head system of FIG. 1, including its end ring and tripper mechanism, in accordance with an exemplary embodiment of the present invention;

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[0028] FIG. 4 shows an elevational view of the discharge end of the laying head system of FIG. 1, including its end ring and tripper mechanism, in accordance with an exemplary embodiment of the present invention;

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[0029] FIG. 5 shows a known construction laying head transport path/pipe and typical exemplary wear zones experienced during laying head operation;

[0030] FIG. 6 shows a perspective view of a laying head elongated material transport path pipe, in accordance with an exemplary embodiment of the present invention;

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[0031] FIG. 7 shows a partially cut away axial cross-sectional view of the laying head pipe of FIG. 6;

[0032] FIGs. 8-11 show, partially cut away axial or radial cross-sectional views of adjoining pipe segment coupling in laying head pipes of FIG. 6, in accordance with alternative exemplary embodiments of the present invention;

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[0033] FIG. 12 shows a perspective view of a laying head pipe, in accordance with another exemplary embodiment of the present invention;

[0034] FIG. 13 a perspective view of a laying head pipe, in accordance with yet another exemplary embodiment of the present invention;

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[0035] FIG. 14 shows a partially cut away axial cross-sectional view of the laying head pipe of FIG. 13;

[0036] FIG. 15 shows a partially cut away perspective view of the laying head pipe of FIG. 13;

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[0037] FIG. 16 shows a side elevational view of a laying head pipe, in accordance with an another exemplary embodiment of the present invention;

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[0038] FIG. 17 shows a partial cut away axial cross-sectional view of the laying head pipe of FIG. 16;

[0039] FIG. 18 shows a radial cross sectional view of the laying head pipe of FIG. 16, taken along line 18-18 thereof;

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[0040] FIG. 19 shows a partial axial cross-sectional view of the laying head pipe of FIG. 16; and

[0041] FIGs. 20A-20C are diagrammatic depictions illustrating the forces acting on a laying head pipe in accordance with embodiments of the present invention during heating

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and cooling cycles.

[0042] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

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#### DETAILED DESCRIPTION

[0043] After considering the following description, those skilled in the art will realize that the teachings of the present invention can be utilized in rolling mill coil-forming apparatus laying heads and more particularly to laying head elongated transport path pipes or other equivalent elongated structures for laying heads. Aspects of the present invention facilitate longer laying head path service life so that more tons of elongated material can be processed by the laying head before preventative maintenance replacement. For example, it is possible to increase the laying head elongated material processing speed so that more tons of elongated material can be processed in a production shift without undue risk of laying head path/pipe failure.

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#### [0044] Laying Head System Overview

[0045] Referring generally to FIGs. 1-4, the coil-forming apparatus laying head system 30 coils rolled elongated material M, such as for example hot rolled steel rebar. Elongated material M that is advancing at speed S, which may be as high as or greater than approximately 500 feet/second (150 m/sec), is received in the laying head system 30 intake end 32 and discharged in a series of continuous coil loops at the discharge end 34, whereupon the coils are deposited on a conveyor 40.

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[0046] The laying head system 30 comprises a rotatable quill 50, a path 60 and a pipe path support 70. The path 60 defines a hollow elongated cavity to enable transport of the material M. Aspects of the present invention allow the path to comprise a laying head pipe; indeed, the path 60 may occasionally be referred to as a laying head pipe herein.

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[0047] The quill 50 can have a generally horn shape that is adapted to rotate about an axis. The path 60 has a generally helical axial profile of increasing radius, with a first end 62 that is aligned with the rotational axis of quill 50 and receives elongated material M. The path 60 has a second end that is spaced radially outwardly from and generally tangential to the quill 50 rotational axis and thus discharges the elongated material generally tangentially to the periphery of the rotating quill. The path 60 is coupled to a pipe support 70 that is in turn coupled coaxially to the quill 50, so that all three components rotate synchronously about the quill rotational axis. The quill 50 rotational speed can be selected based upon, among other factors, the elongated material M structural dimensions and material properties, advancement speed S, desired coil diameter and number of tons of elongated material that can be processed by the laying head pipe without undue risk of excessive wear. FIG. 5 shows conventional laying head path/pipe 60 wear zones 66, 68 in which the pipe interior is subjected to relatively higher wear rates than other portions of the pipe. Aspects of the present invention address the higher wear rates by locally hardening the zones 66, 68 and other portions or all other desired zones. In an embodiment, the entire or equivalent elongated structure can be hardened by application of aspects of the present invention.

[0048] As illustrated, as elongated material M is discharged from the second end 64, it is directed into a ring guide 80 having guide rim segments 82 into which are formed a guide trough channel 84 having a helical pitch profile, such as that described in commonly owned U.S. Patent No. 6,769,641. As the elongated material M is advanced through the ring guide 80 it is continued to be conformed into a continuous loop helix.

[0049] As described in the '641 patent, the segmented ring guide enables relatively easy reconfiguration of the ring guide helical diameter to accommodate different elongated materials by changing the rim segments 82 without disassembling and replacing the entire ring guide 80.

[0050] As previously noted, the elongated material M is configured into a continuous looped coil as it rides within the ring guide 80 helical trough channel 84. Ring guide 80

is coupled to the pipe support 70 and rotates coaxially with the quill 50. The helical trough 84 advancement rotational speed is harmonized with the elongated material M advancement speed S, so there is little relative linear motion speed between the two abutting objects and less rubbing wear of the trough 84 surfaces that contact the coiling material.

[0051] Stationary end ring 90 has an inner diameter that is coaxial with the quill 50 rotational axis and circumscribes the laying path/pipe 60 second end 62 as well as the ring guide 80. The end ring 90 counteracts centrifugal force imparted on the elongated material M as it is discharged from the laying head pipe 60 second end 62 and advances along the ring guide 80 helical trough channel 84 by radially restraining the material within the end ring inner diameter guide surface. High relative speed between the advancing elongated material M and the stationary end ring 90 causes rubbing wear on the end ring inner diameter guide surface.

[0052] Referring to FIG. 1, elongated material M that is discharged from the coil-forming apparatus laying head system 30 falls by gravity in continuous loops on roller conveyor 40, aided by the downwardly angled quill rotational axis at the system discharge end 34. Tripper mechanism 150 pivots about an axis abutting the distal axial side of the end ring 90 guide surface. That pivotal axis is generally tangential to the end ring 90 inner diameter guide surface about a pivotal range of motion  $\Theta$ . As is known, coiled material M coiling characteristics and placement on the conveyor 40 can be controlled by varying the pivotal angle  $\Theta$ .

#### [0053] Laying Head Path Structure Fabrication

[0054] Embodiments of the present invention include a rolling mill laying head path structure, for retention and transport of elongated materials in a laying head, so that the elongated material can be selectively coiled. A portion of the path structure, or the structure in its entirety is formed from laterally adjoining, abutting segments that form a continuous inner diameter surface for passage and transport of elongated material

therethrough. The abutting segments may spliced or otherwise coupled to each other by mating interlocking ends, fasteners and permanent joinder (e.g., by welding). The laterally adjoining segment portion may be nested within or circumscribe another pipe.

5 [0055] Alternatively, in lieu of forming the laying head path/pipe structure from adjoining segments, the entire structure may be constructed of a homogeneous non-ferrous material having higher wear resistance than ferrous metals. That homogeneous non-ferrous structure may be nested within or circumscribe another pipe or other multiple layers of nested pipes to form a multi-layer pipe of two or more layers. The alternative  
10 construction nested or single layer non-ferrous material pipe is subsequently formed into any desired three dimensional profile to construct a laying head elongated path/pipe structure.

[0056] Laying head components formed from adjoining segments can be constructed in  
15 any three dimensional compound curve shape that can replicate the smooth, continuous curve elongated material transport path of known laying pipes, or any other desired path. A pipe segment or plurality of adjoining, abutting segments may be constructed of a homogeneous material or different materials, and may be spliced or otherwise joined to form the composite, complete laying path structure. The fabricated structures facilitate  
20 formation of zones within the component, such as including by way of example wear-resistant zones or friction reducing zones. The zones can be formed during the path/pipe structure fabrication process, such as by laterally joining or abutting pipe or other hollow segments that are constructed of different material next to each other in a given layer.

25 [0057] FIGs. 6-12 show a laying head path 560 that has a generally cylindrical outer profile conforming to known laying head pipes, for direct substitution in a known laying head such as the one shown in FIGs. 1-5. Laying head path 560 has a first intake end 562 and a second discharge end 264. The laying head path 560 is a composite structure that may be fabricated from spliced adjoining, abutting subcomponents including sections of  
30 steel pipe or tube 563, and depending on the embodiment shown also the subcomponents 565/665 and 566/666/766. Those steel pipes have a continuous inner

surface 560A for contact with elongated material that is transported through the laying head pipe. The inner surface 560A may be surface coated or treated to harden the surface or provide a friction reducing surface. The laying head path 560 also has zones 570/670 and 580, 680, 780 corresponding to wear zones that experience greater path inner surface 560A erosion than other portions of the path/pipe. The zones are often constructed of dissimilar metals than the steel pipe sections or have different surface properties (e.g., hardness, surface treatment or coatings, and/or friction reducing surfaces). The zones 570/670 and 580, 680, 780 engage or are spliced in abutting axial relationship with an adjoining segment so that the inner surface is effectively continuous (i.e., gaps between adjoining sections are sufficiently smaller than the elongated material diameter and circumference so that any such gaps do not impede transport of the elongated material through the laying head path structure 560).

[0058] Various alternative embodiments of axially adjoining, abutting segment coupling are practiced in accordance with the present invention, and shown in FIGs. 7-15 herein. In FIG. 7, the zone is an insert 570 having a male necked portion 572 that is inserted into a female necked portion 565A of steel pipe section 565, with the respective mating necked portions having straight profiles (as shown) or tapered profiles. Similarly, in FIG. 8 insert 670 has a tapered male frusto-conical necked portion 672 that mates with a tapered female frusto-conical portion 665A of pipe section 665. In FIG. 9, the insert 580 has a flat axial face 582 that is abutted against a corresponding axial flat face 566A of pipe 566. The abutting axial faces 566A and 582 are coupled to each other by weld bead 583. In FIGs. 10 and 11, the insert 680 has a plurality of necked male radially projecting splines 682 that mate with corresponding female splines 666A in pipe section 566. Alternatively a single spline or key can be utilized rather than a larger number of splines. In FIG. 12, the insert 780 has a circumferential flange 782 that mates with corresponding flange 766A of pipe 766. The respective flanges are fastened together with bolts and nuts 784, though other known fasteners, such as circumferential clamps or permanent weld beads can be utilized to couple the respective adjoining segments 766 and 780 to form a continuous path/pipe section having a continuous interior surface 560A.

[0059] At least one portion of a segmented, spliced laying head elongated structure can be circumscribed and retained within an outer path/pipe layer, and conversely such a segmented, spliced laying path structure can circumscribe another path/pipe laying path structure in layered fashion. Alternatively, if a laying path/pipe is formed from a homogeneous non-ferrous metal rather than from segmented adjoining layers it also may be retained within one or more outer pipe layers or can circumscribe one or more pipe layers, in which case either nested, layered path/pipe composite configuration may have a plurality of two or more layers. In FIGs.13-15, laying head path structure 860 has a first intake end 862 and a second discharge end 864 that defines a generally continuous surface 860A therein for passage of elongated material. The laying head path 860 is a composite structure fabricated from spliced adjoining subcomponents 861, 880 and 861B that form an outer concentric layer as well as a generally concentric pipe inner layer including sections 863, 870, 865 and 865A. Specifically with reference to a downstream flow direction from the intake end 862 to the discharge end 864, the outer layer of laying head path structure 860 has a steel outer pipe segment 861 that abuts against and is joined to a fabricated wear element 880, shown as a cast or sintered structure (for example, sintered tungsten carbide) by a weld bead (not shown) and in turn to downstream steel pipe 861B. The laying head path structure 860 also has an inner nested layer, which again from intake end 862 to discharge end 864, includes an inner steel pipe 863 that abuts against wear insert 870 (formed for example from stainless steel tubing) and in turn axially abuts against inner layer steel pipe 865. Referring to FIG. 15 the steel pipe 865 abuts against fabricated wear element 880. Lastly inner layer steel pipe 865 abuts against the other downstream end of fabricated wear element 880. The inner layers 863, 870, 865 and 865A do not have to be rigidly coupled to each other because they are circumscribed by and captured within the outer path/pipe layers 861, 880 and 861B.

[0060] As shown and described in commonly owned Patent Cooperation Treaty Application entitled "Regenerative Laying Pipe", filed in the United States Receiving Office on September 2, 2011, Serial No. PCT/US2011/050283, a laying head pipe having inner and outer friction-tight engaged concentric layers in which the inner layer advances axially relative to the outer layer during laying head operation due to centrifugal forces,

differences in localized thermal expansion, and thermal cycling between the layers. Thus worn sections of the laying head pipe or other elongated laying head path interior advance along the pipe interior so that a “fresh” unworn surface continually replenishes the worn section. Specifically, referring to FIGs. 16-20C, the laying head pipe 460 in accordance with the present invention, has an outer tube or pipe 461, constructed from ferrous metal, such as steel, with that pipe having an entry section 462 aligned with axis A, an intermediate section 28b curving away from axis A, and a delivery section 28c having a radius measured from axis A.

[0061] An inner tube or pipe 463 has entry, intermediate and delivery sections respectively lining the entry, intermediate and delivery sections of the outer tube 461, and is constructed of non-ferrous material such as stainless steel or tungsten carbide. The inner tube 463 can be constrained against movement relative to the outer tube 461 solely by frictional contact with the outer tube. It has been observed that in service, the internal surface of a laying head pipe 463A is prone to accelerated localized wear in zone Z, approximately at the junction of entry section 28a and intermediate section 28b, and again in zone Z<sub>2</sub> approximately at the junction between intermediate section 28b and the delivery section 28c. If left unchecked, this localized wear results in premature grooving of the interior pipe surface, followed by a breakthrough of the product through the wall of the laying head pipe.

[0062] In accordance with the present invention, this wear problem is addressed by lining the outer tube 461 with the inner tube 463, and by allowing the inner tube to be restrained against movement within the outer tube solely by frictional contact between their respective outer and inner surfaces.

[0063] When the laying head path laying head pipe 460 is in service, the inner tube 463 is heated by contact with the hot rolled product M. Typically, the hot rolled product will be at a temperature of about 900-1100 °C, which will result in a heating of the inner tube 463 to an elevated temperature of about 400 °C. The outer tube will typically have a lower temperature due to its exposure to the surrounding atmosphere.

[0064] Additionally, as shown in FIG. 17, the intermediate section 28b of the laying head pipe will be subjected to a centrifugal force  $F_{CEN}$  as a result of its rotation about axis A. This force can be resolved into a force  $F_N$  normal to the guide path of the laying head pipe, and drive force  $F_D$  exerted towards the delivery end of the laying head pipe. Driving force  $F_D$  will be supplemented by an additional driving force exerted by the hot rolled product passing through the laying head pipe.

[0065] Shown in FIG. 20A, the inner tube 463 is being heated by contact with the hot rolled product, it will undergo expansion, exerting forces in opposite directions towards the entry end (arrow  $F_{EE}$ ) and the delivery end (arrow  $F_{DE}$ ). The expansion forces  $F_{EE}$  and  $F_{DE}$  are sufficient to overcome the frictional resistance  $F_F$ . The expansion force  $F_{EE}$  is overcome by the sum of expansion force  $F_{DE}$  and the driving force  $F_D$ , resulting in the inner tube 463 being shifted incrementally within the outer tube 461 towards the delivery end of the outer tube.

[0066] As shown in FIG. 20B, when the temperature of the inner tube 463 stabilizes, there are no expansion or contraction forces. The frictional force  $F_F$  overcomes the driving force  $F_D$ , and the inner tube remains fixed within the outer tube.

[0067] As shown in FIG. 20C, when the inner tube 463 is cooled, it will undergo contraction, again exerting opposite forces towards the entry end (arrow  $C_{EE}$ ) and the delivery end (arrow  $C_{DE}$ ). The forces  $C_{EE}$  and  $C_{DE}$  are sufficient to overcome the frictional force  $F_F$ . The contraction force  $C_{EE}$  is overcome by the sum of contraction force  $C_{DE}$  and the driving force  $F_D$ , resulting in the entry end of the inner tube 463 being shifted incrementally within the outer tube 461 towards the delivery end 464 of the outer tube.

[0068] Thus, it will be seen that as the laying head path pipe 460 undergoes heating and cooling cycles, the inner tube 463 will be shifted incrementally in one direction towards the delivery end 464 of the outer tube 461. This incremental shifting will change and

thus renew the internal surfaces of the inner tube that are in frictional contact with the hot rolled product, and in so doing, will avoid prolonged frictional contact at any one given area. The axially overlapping nested configuration of the inner tube 463 and inner sleeve 470 compensates for axial advancement of the inner tube toward the delivery end 464, so that two nested pipe layers circumscribe the elongated material M.

[0069] For all laying head laying pipe elongated structures embodiments of the present invention herein, the laying path elongated structure inner diameter can be varied by varying the wall thickness of the single layer path, or in multilayer nested embodiments the inner layer path, while if desired, maintaining the same path structure outer diameter. The adjoining, abutting segments forming laying the laying head path structure or the structure in its entirety may be fabricated from various ferrous or non-ferrous materials, including ceramics, preferred examples comprising ferrous metals, nickel based alloys, cobalt based alloys and titanium based alloys, as well as deposited nano particle coatings of any of them. Different coating materials may be deposited in abutting relationship to form the laying path inner surface. More specifically the outer layer or pipe, if any, comprises any desired material or metal (steel often being a cost effective choice) or non-metallic structures, such as filament reinforced carbon fiber. The inner surface of a filament reinforced carbon fiber or other outer elongated path member/pipe may include an inner layer formed from a nano particle layer of non-ferrous material, such as stainless steel or tungsten carbide, deposited thereon, including abutting deposited layers of materials. The deposited nano layer(s) function(s) as the equivalent of a separate inner pipe pathway segmented or non-segmented structure. The segmented path/pipe layer, or other functionally equivalent inner layer path forming structure, comprises ferrous or non-ferrous materials, including ceramic, nano particle material coatings, steel, or non-ferrous alloys such as stainless steel, tungsten carbide or so-called super alloys, such as for example Inconel®, Waspaloy® or Hastelloy®. Other non-ferrous metals may be substituted for adjoining, abutting segments, whether in inner or outer (if any) layers, comprising by way of example stainless steel, tungsten carbide, and so-called super alloys, such as for example Inconel®, Waspaloy® or Hastelloy®, ceramics or nano particle layers of the above. The inner surface that is in contact with the elongated

material may be treated or coated (including nano particle coatings) to increase surface hardness, reduce friction or decrease thermal ablation. Alternatively the entire elongated structure path/pipe can be constructed from a single homogeneous one of such non-ferrous materials of any desired dimensional circumferential profile inner or outer diameter and thickness rather than in adjoining, abutting segments. That homogeneous non-ferrous material pipe can be nested inside or circumscribe one or more pipe layers to form a multilayer laying head pipe of two or more layers. The multilayer path/pipe is then formed into any desired three dimensional profile to form a laying head path elongated structure.

[0070] Although various embodiments, which incorporate the teachings of the present invention, have been shown and described in detail herein, those skilled in the art can readily devise many other varied embodiments that still incorporate these teachings.

CLAIMS

What is claimed is:

- 1        1.        An apparatus for retention and transport of elongated materials in a rolling mill  
2                coil-forming laying head system comprising:  
3                an elongated hollow pathway structure defining an inner surface for transport of  
4                elongated materials therein, the elongated hollow pathway structure comprising a  
5                segmented construction formed from laterally abutting adjoining segments.
- 1        2.        The apparatus of claim 1, all segments forming the inner surface comprising non-  
2                ferrous material.
- 1        3.        The apparatus of claim 1, at least a portion of the segments comprising non-  
2                ferrous material.
- 1        4.        The apparatus of claim 1, comprising at least two abutting segments coupled by  
2                joining structure selected from group consisting of weld, splice, spines, keys,  
3                interlocking ends, fastened ends, flanged ends and fasteners.
- 1        5.        The apparatus of claim 1, having a zone selected from the group consisting of  
2                wear resistant zone, projecting material standoff, material transport guide structures  
3                and friction reducing zone.
- 1        6.        The apparatus of claim 1, the pathway structure comprising an asymmetrical  
2                profile selected from group consisting of cross section, twist about elongate axis, and  
3                smooth inner surface continuous curve.
- 1        7.        The apparatus of claim 1, comprising adjoining segments of ferrous and non-  
2                ferrous material.

- 1        8.        The apparatus of claim 7, comprising an inner layer of adjoining segments  
2                circumscribed by an outer layer.
- 1        9.        The apparatus of claim 8, the inner layer and the outer layer are in circumferential  
2                friction contact with each other, with the inner layer advancing axially with respect to  
3                outer layer during repetitive heating and cooling cycles of the elongated pathway  
4                structure.
- 1        10.        The apparatus of claim 1, comprising an inner layer of adjoining segments  
2                circumscribed by an outer layer.
- 1        11.        The apparatus of claim 10, the inner layer and the outer layer are in  
2                circumferential friction contact with each other, with the inner layer advancing  
3                axially with respect to outer layer during repetitive heating and cooling cycles of the  
4                elongated pathway structure.
- 1        12.        The apparatus of claim 1, at least a portion of the segments comprising non-  
2                ferrous materials selected from group consisting of nickel based alloys, cobalt based  
3                alloys and titanium based alloys, stainless steel, tungsten carbide, ceramics,  
4                superalloys and nano layers of said non-ferrous materials deposited on the inner  
5                surface.
- 1        13.        An apparatus for retention and transport of elongated materials in a rolling mill  
2                coil forming laying head system comprising:  
3                an elongated hollow pathway structure defining an inner surface for transport of  
4                elongated materials therein formed by joining laterally abutting segments.
- 1        14.        The apparatus of claim 13, comprising joining at least two abutting segments by  
2                joining structure selected from group consisting of weld, splice, spines, keys,  
3                interlocking ends, fastened ends, flanged ends and fasteners.

1 15. The apparatus of claim 13, formed by inserting an inner layer of the segments into  
2 an outer layer and thereafter bending both layers into an elongated pathway structure.

1 16. A rolling mill coil-forming laying head system comprising:  
2 a driven rotating quill; and  
3 an elongated hollow pathway structure defining an inner surface for transport of  
4 elongated materials therein, the elongated hollow pathway structure comprising a  
5 segmented construction formed from laterally abutting adjoining segments.

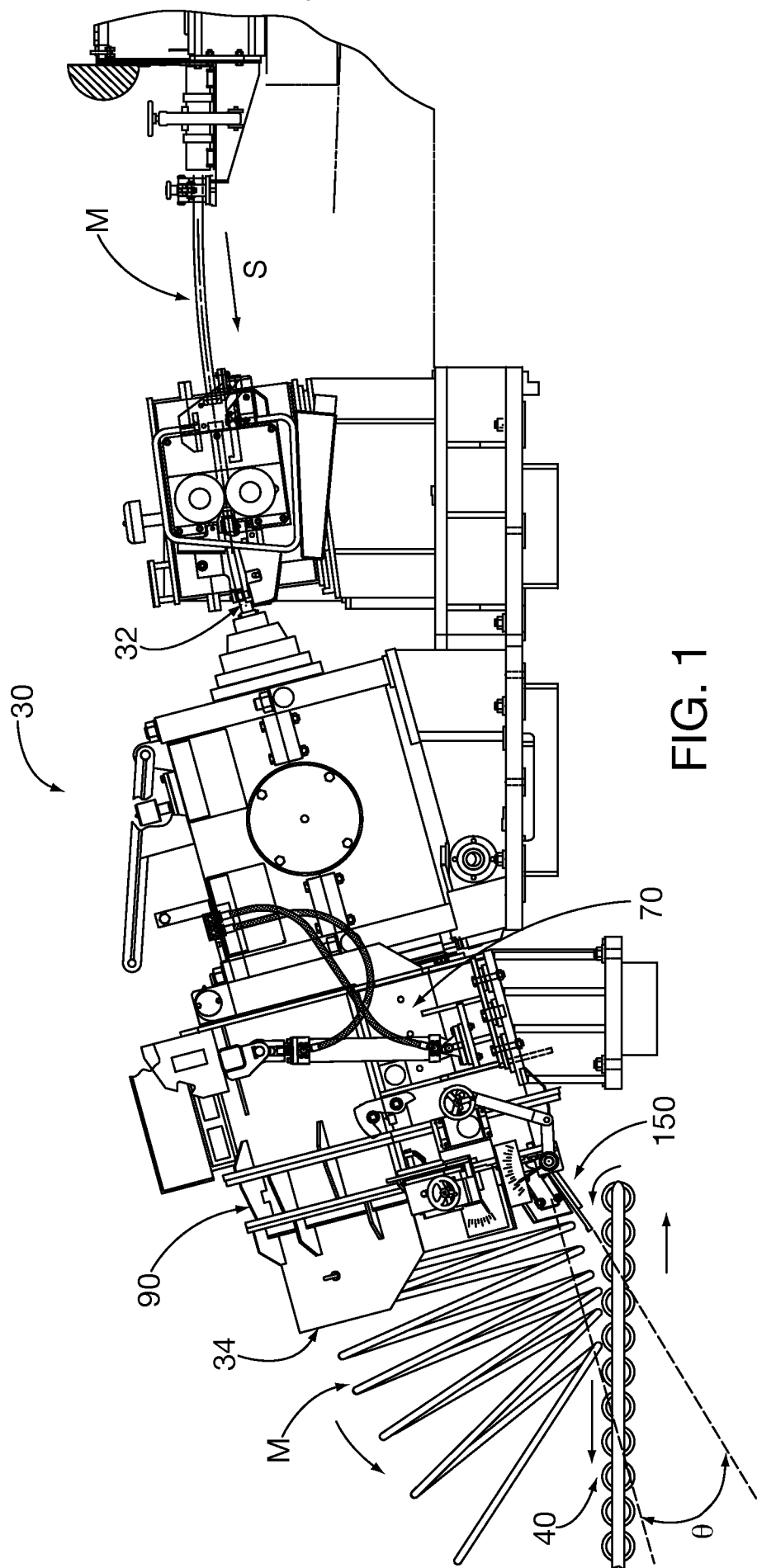
1 17. The system of claim 16, all segments forming the inner surface comprising non-  
2 ferrous material.

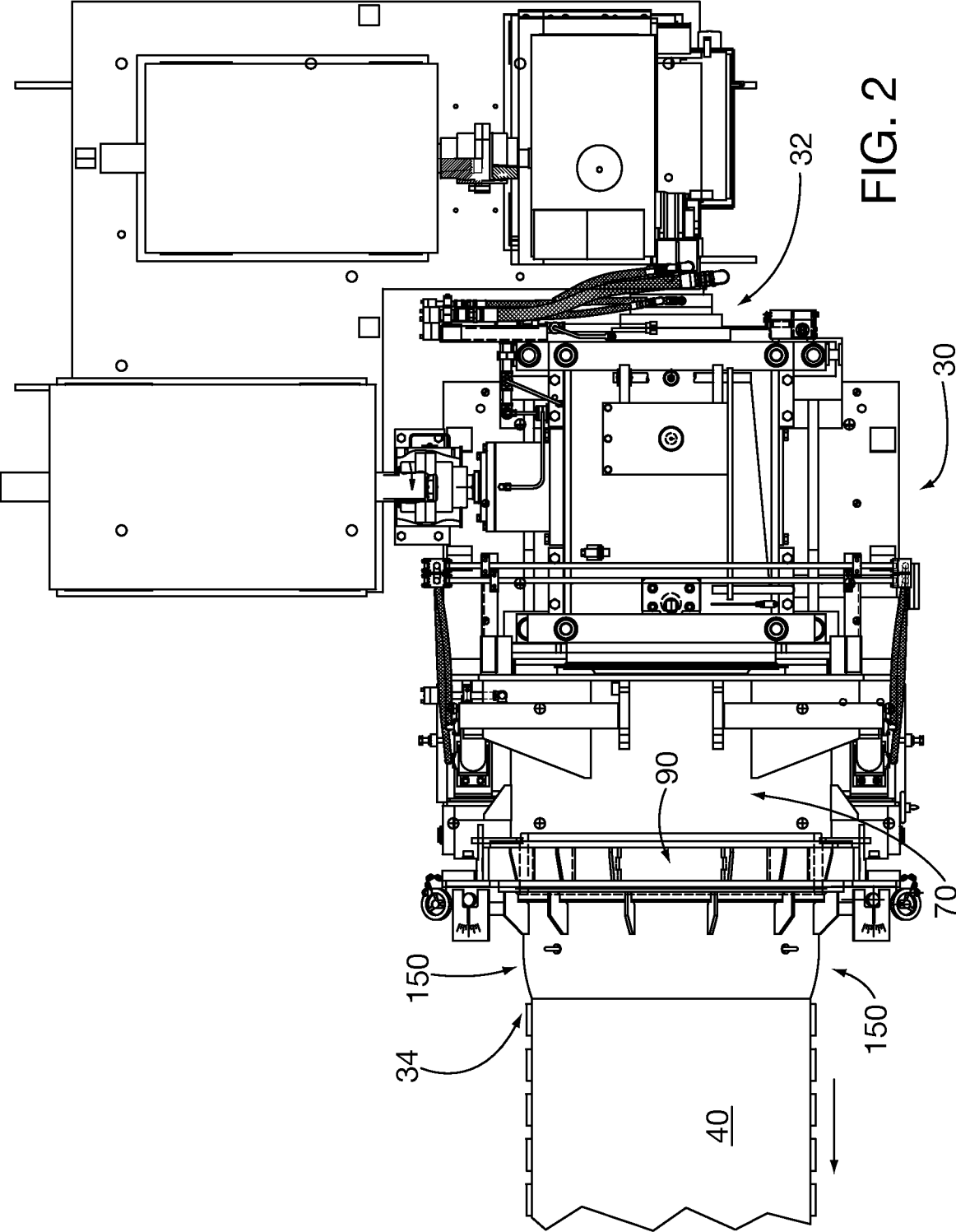
1 18. The system of claim 16, at least a portion of the segments comprising non-ferrous  
2 material.

1 19. The system of claim 16, comprising at least two abutting segments coupled by  
2 joining structure selected from group consisting of weld, splice, spines, keys,  
3 interlocking ends, fastened ends, flanged ends and fasteners.

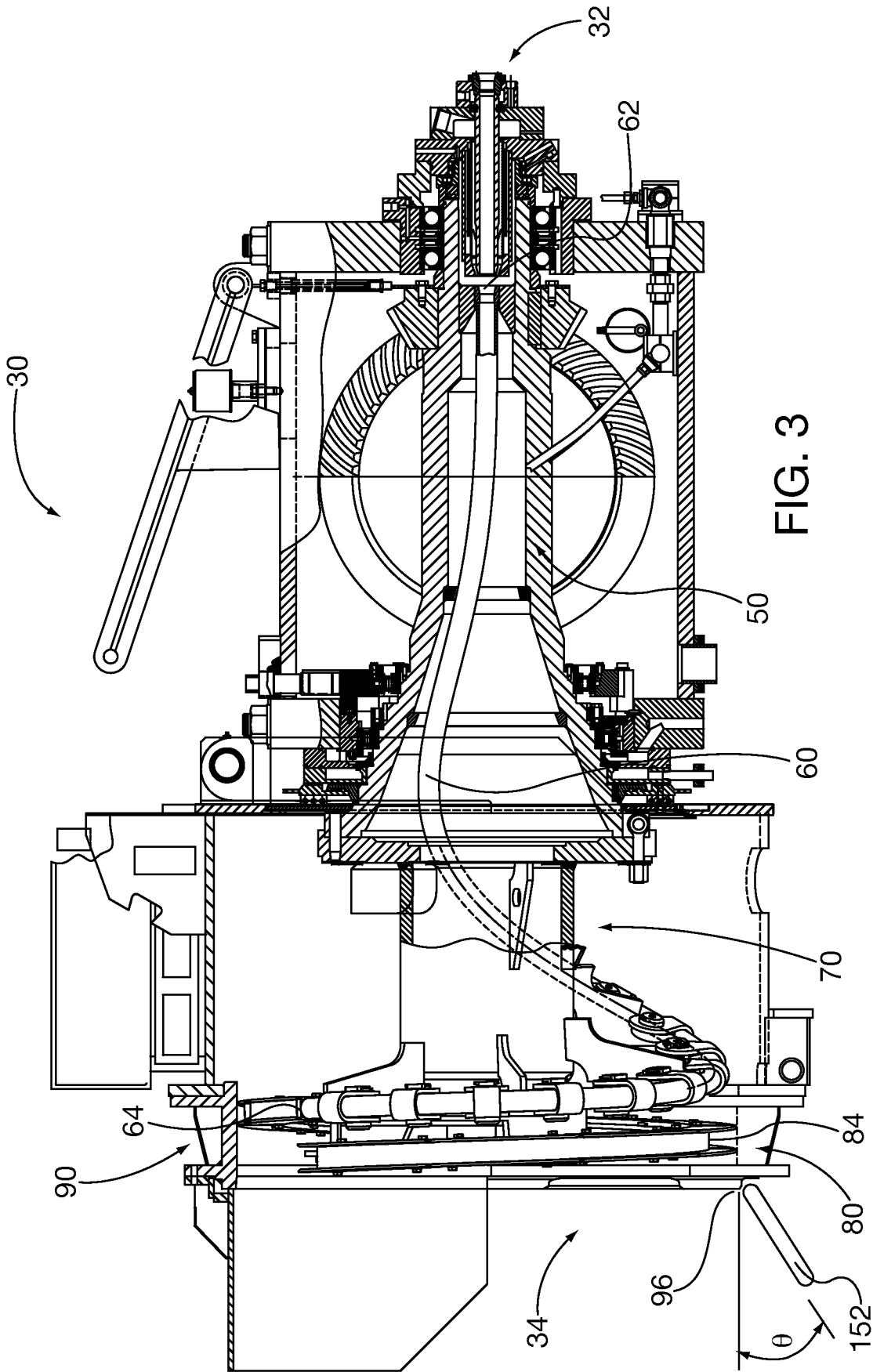
1 20. The system of claim 16, having a zone selected from the group consisting of wear  
2 resistant zone, projecting material standoff, material transport guide structures and  
3 friction reducing zone.

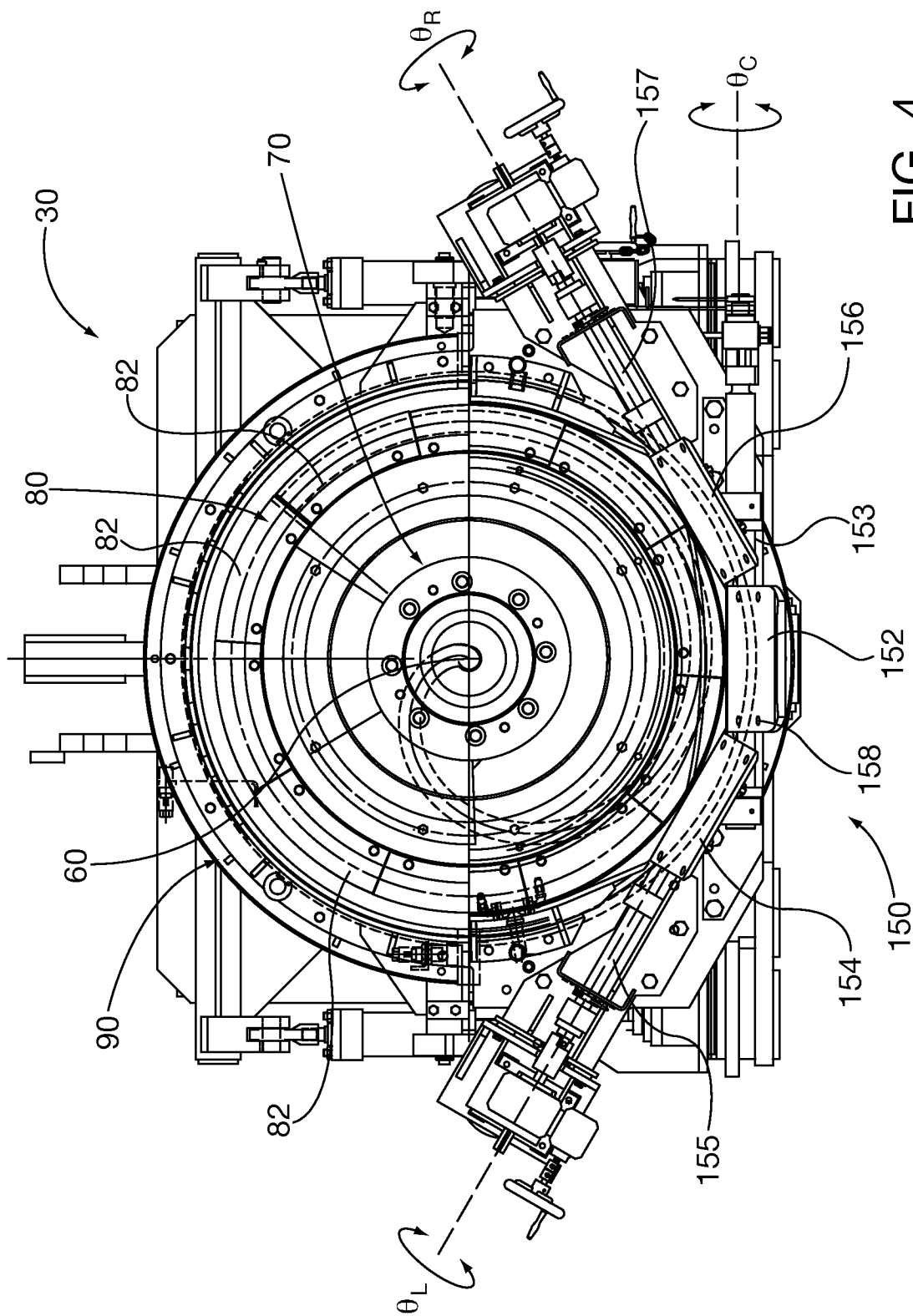
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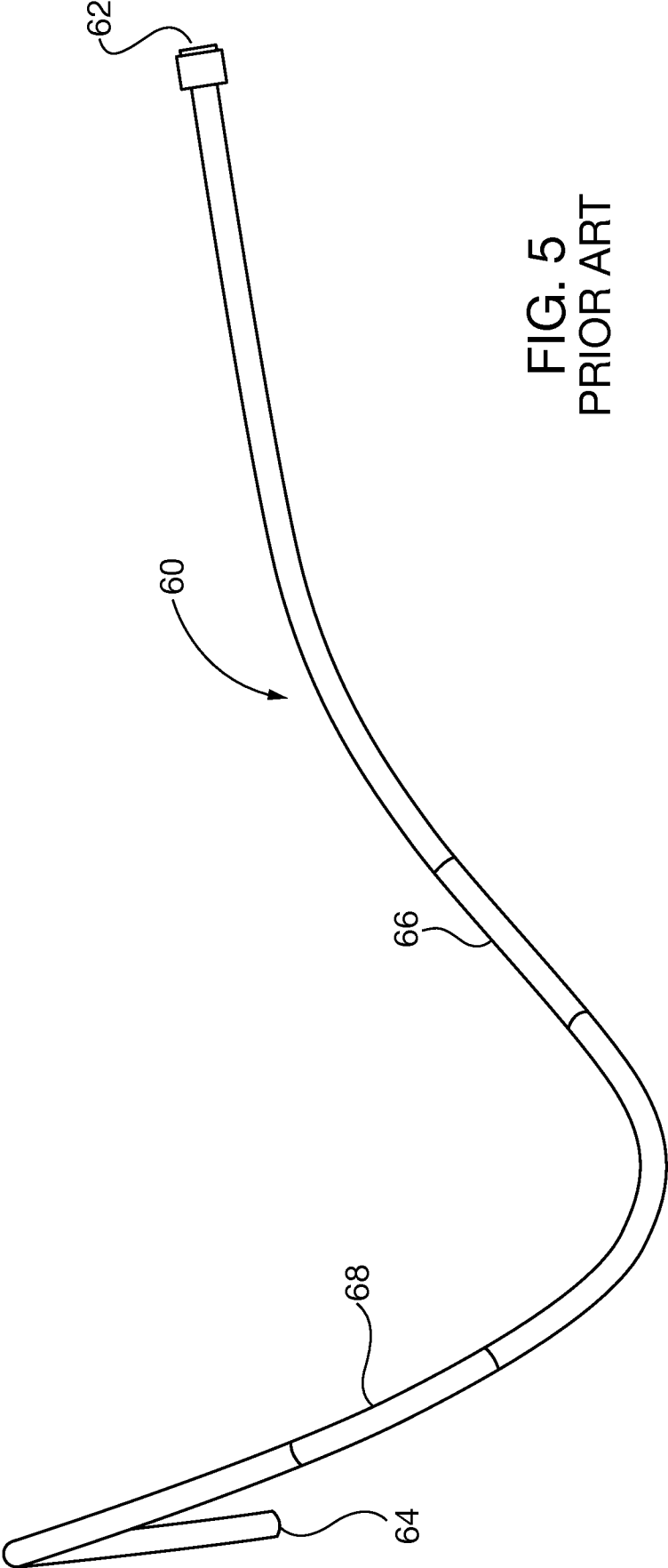


FIG. 5  
PRIOR ART

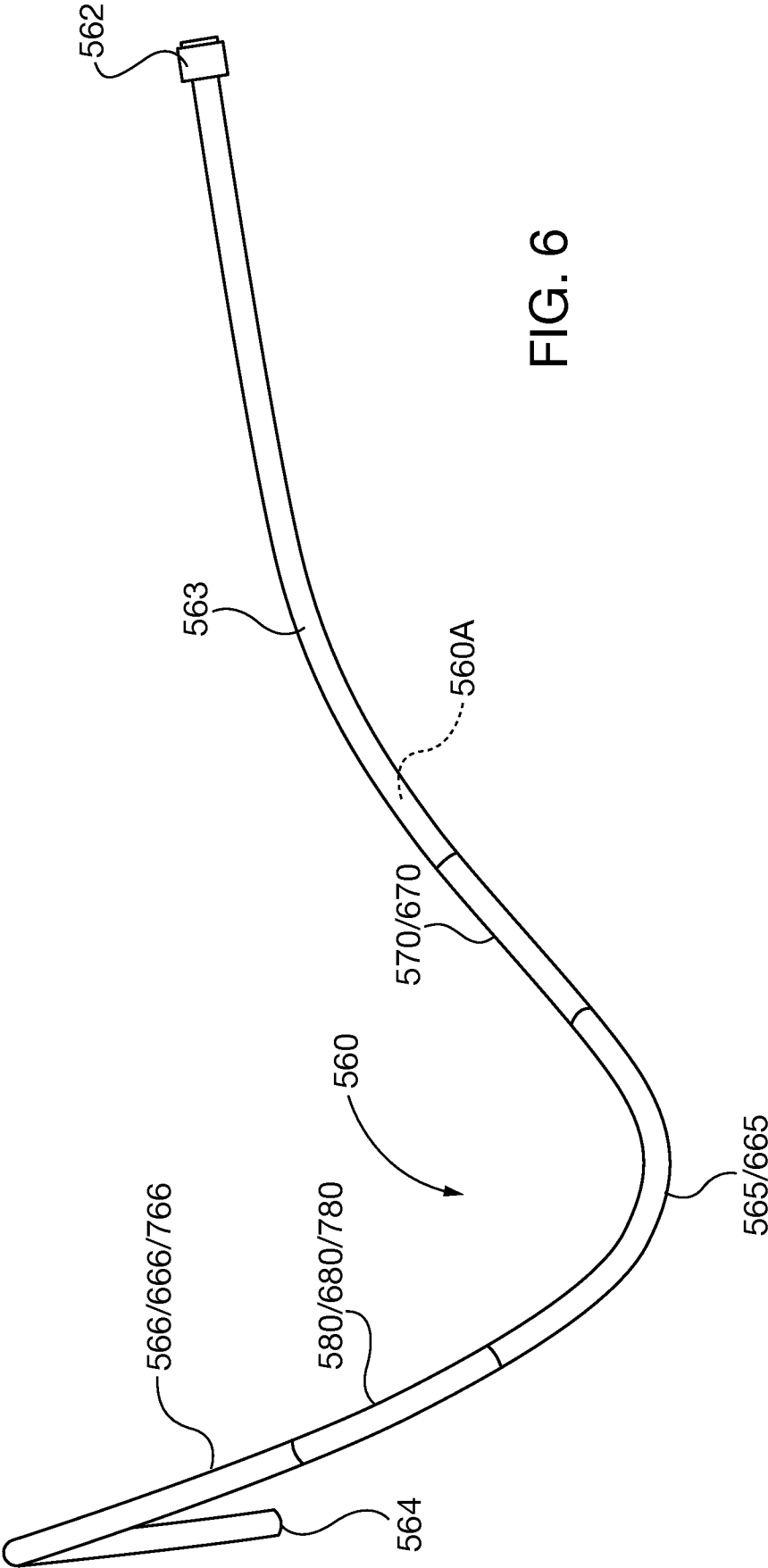
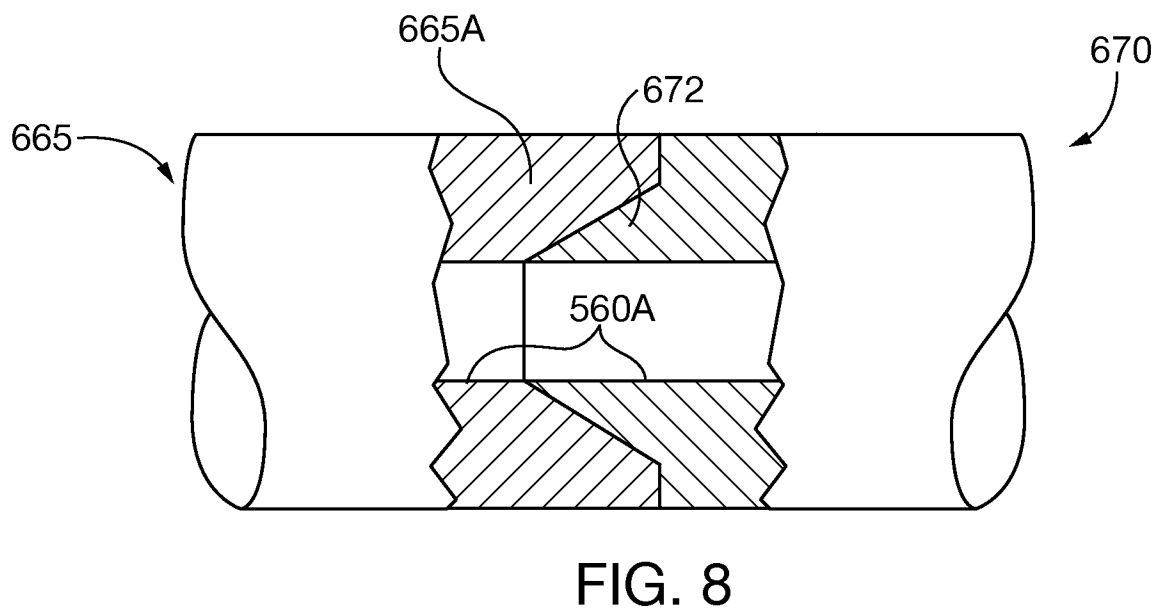
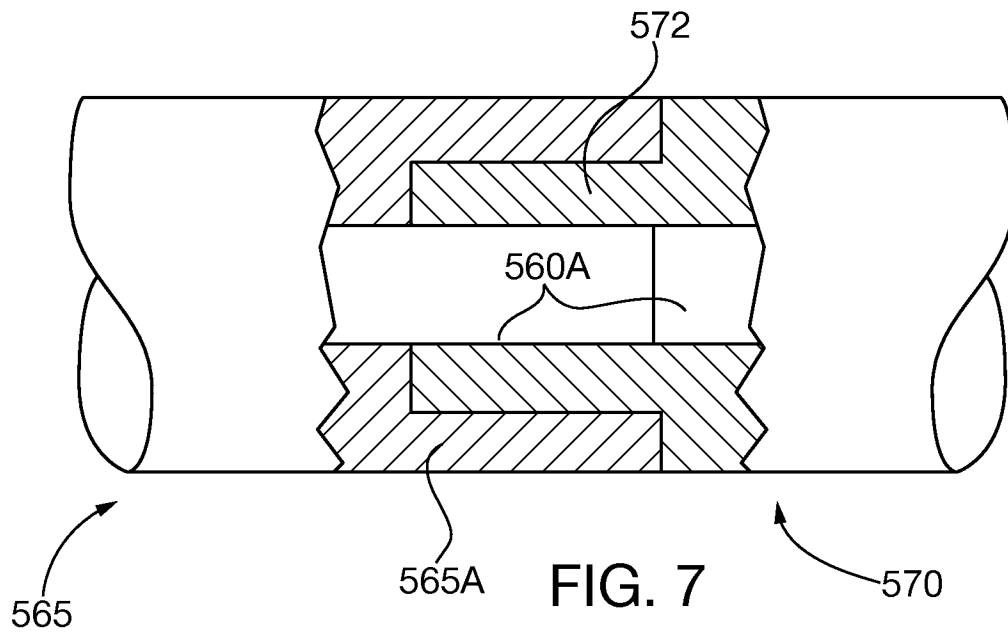


FIG. 6

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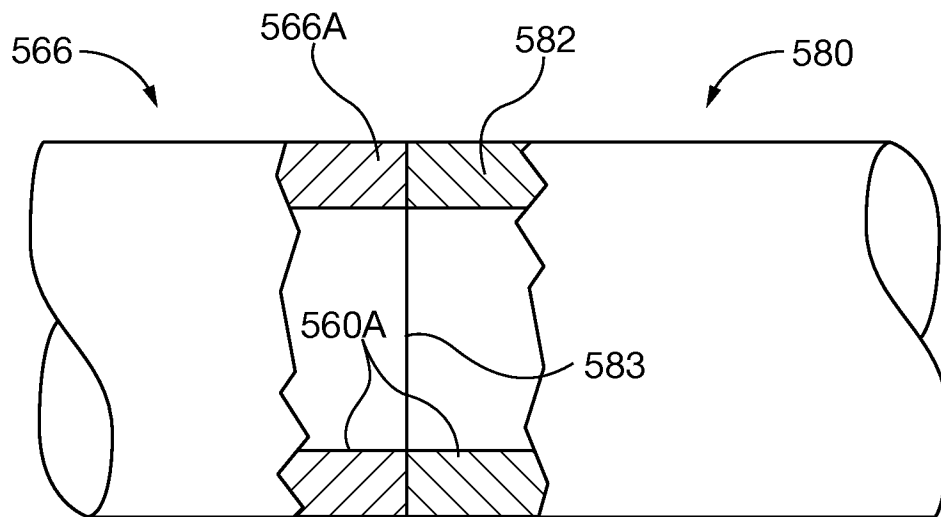


FIG. 9

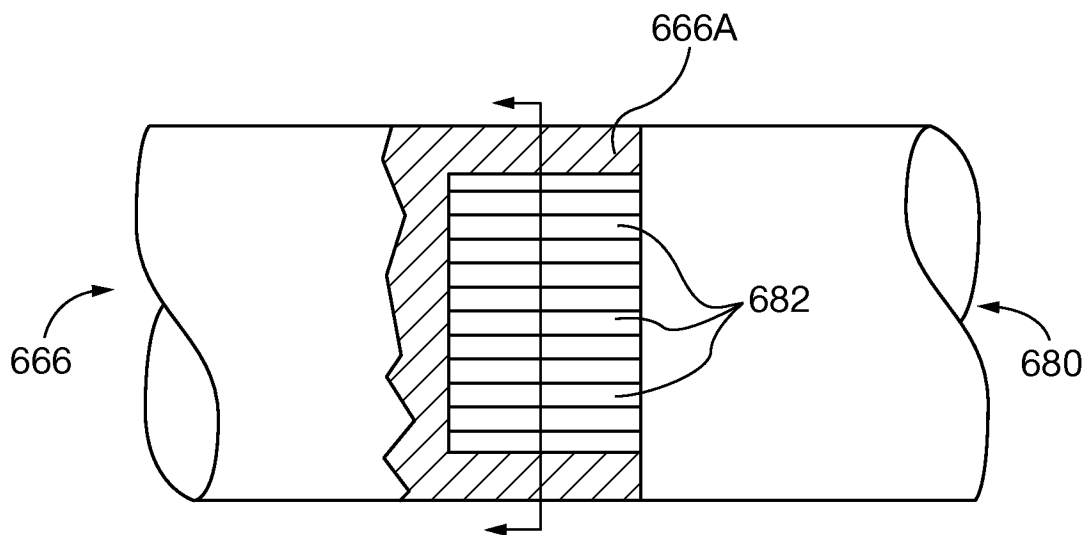


FIG. 10

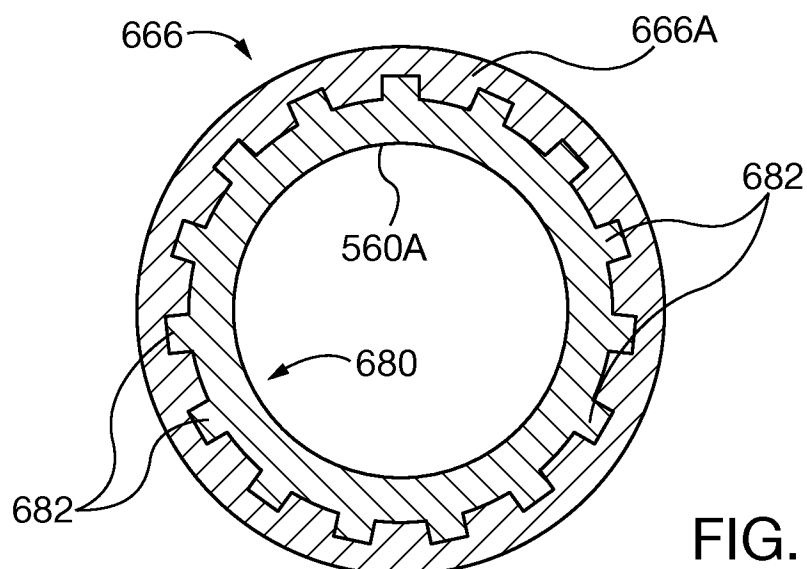


FIG. 11

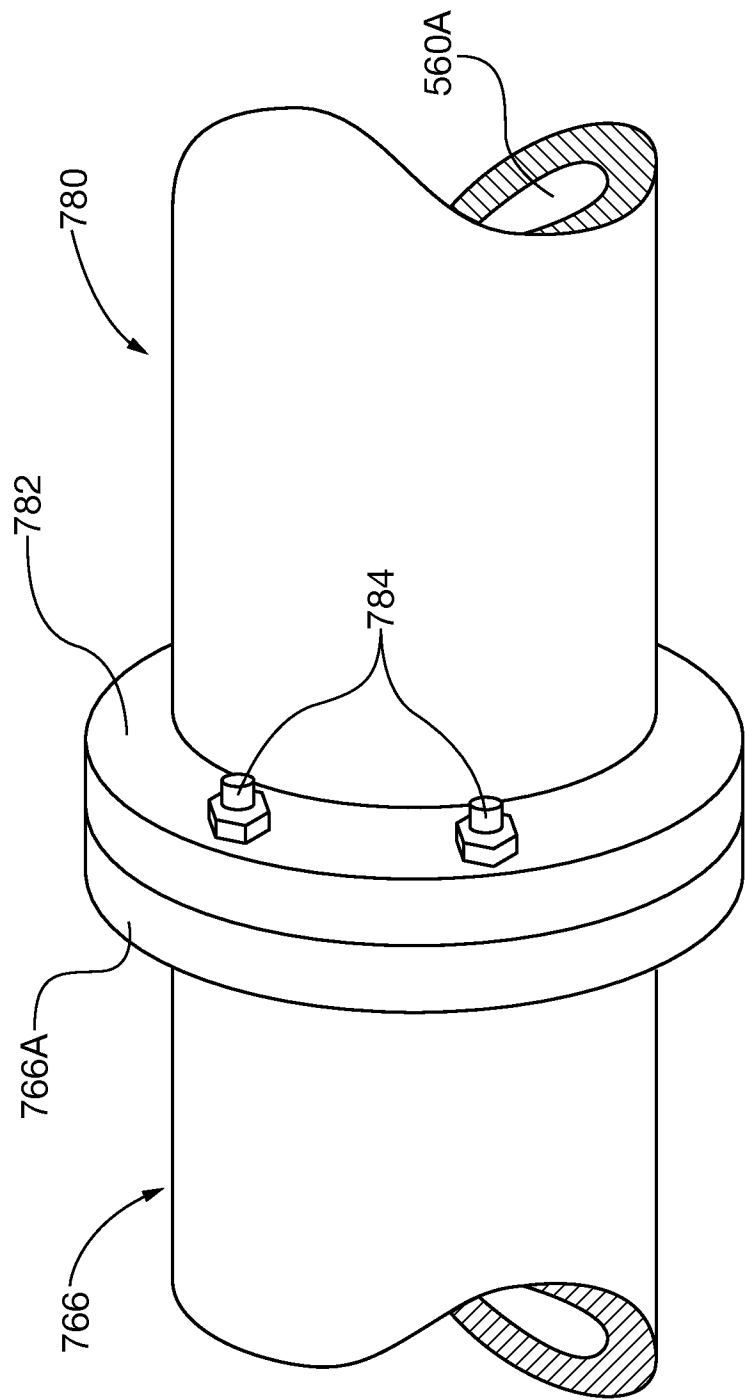


FIG. 12

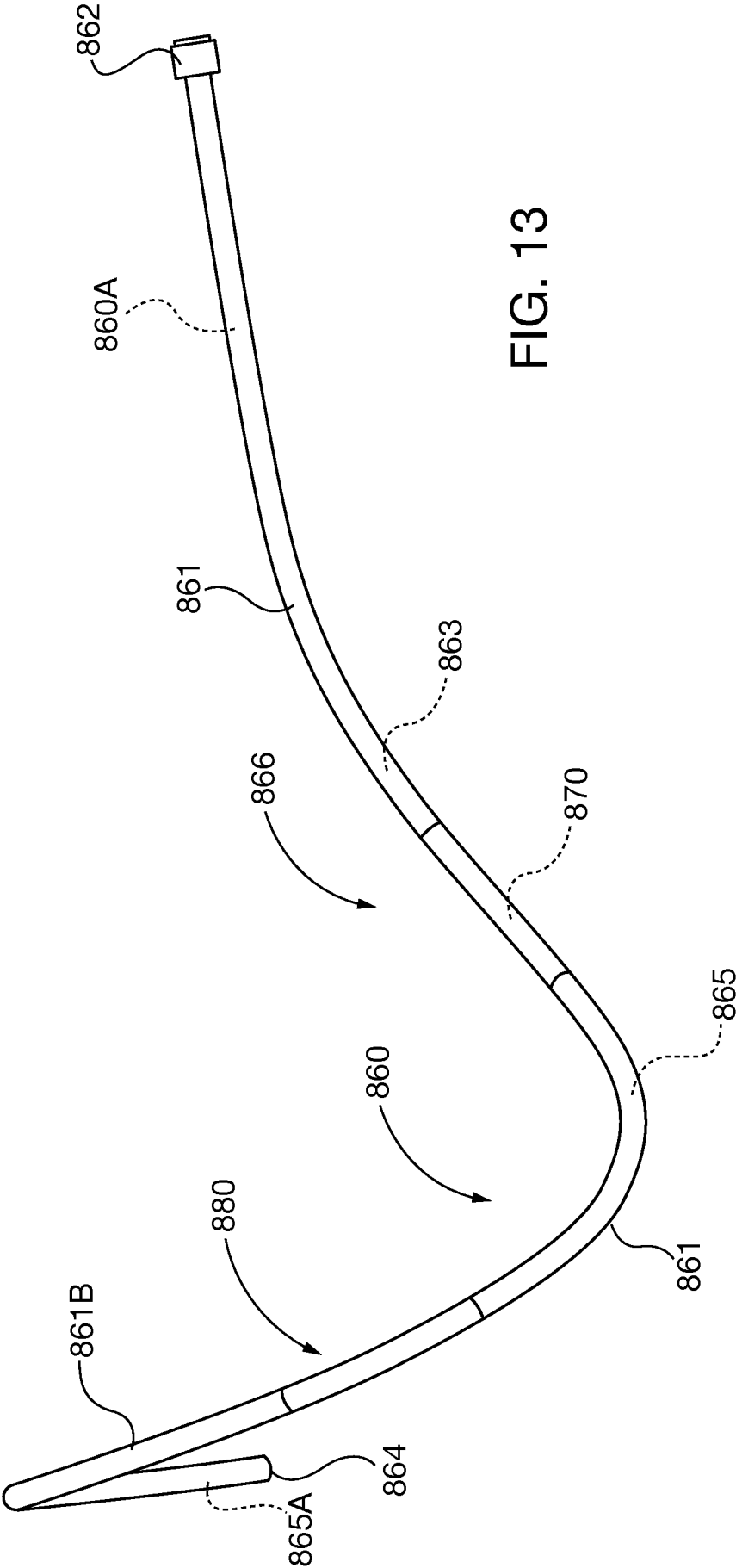
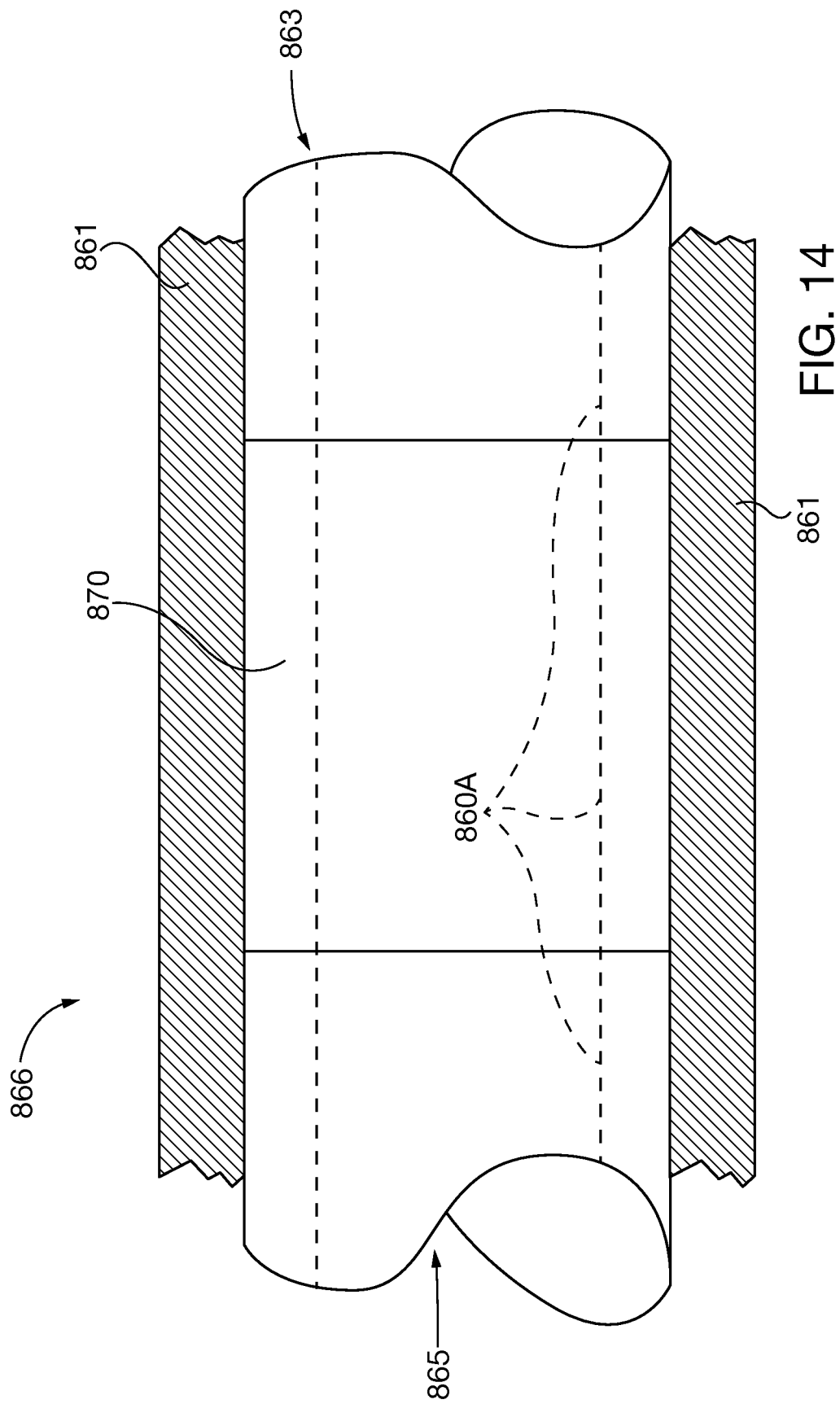
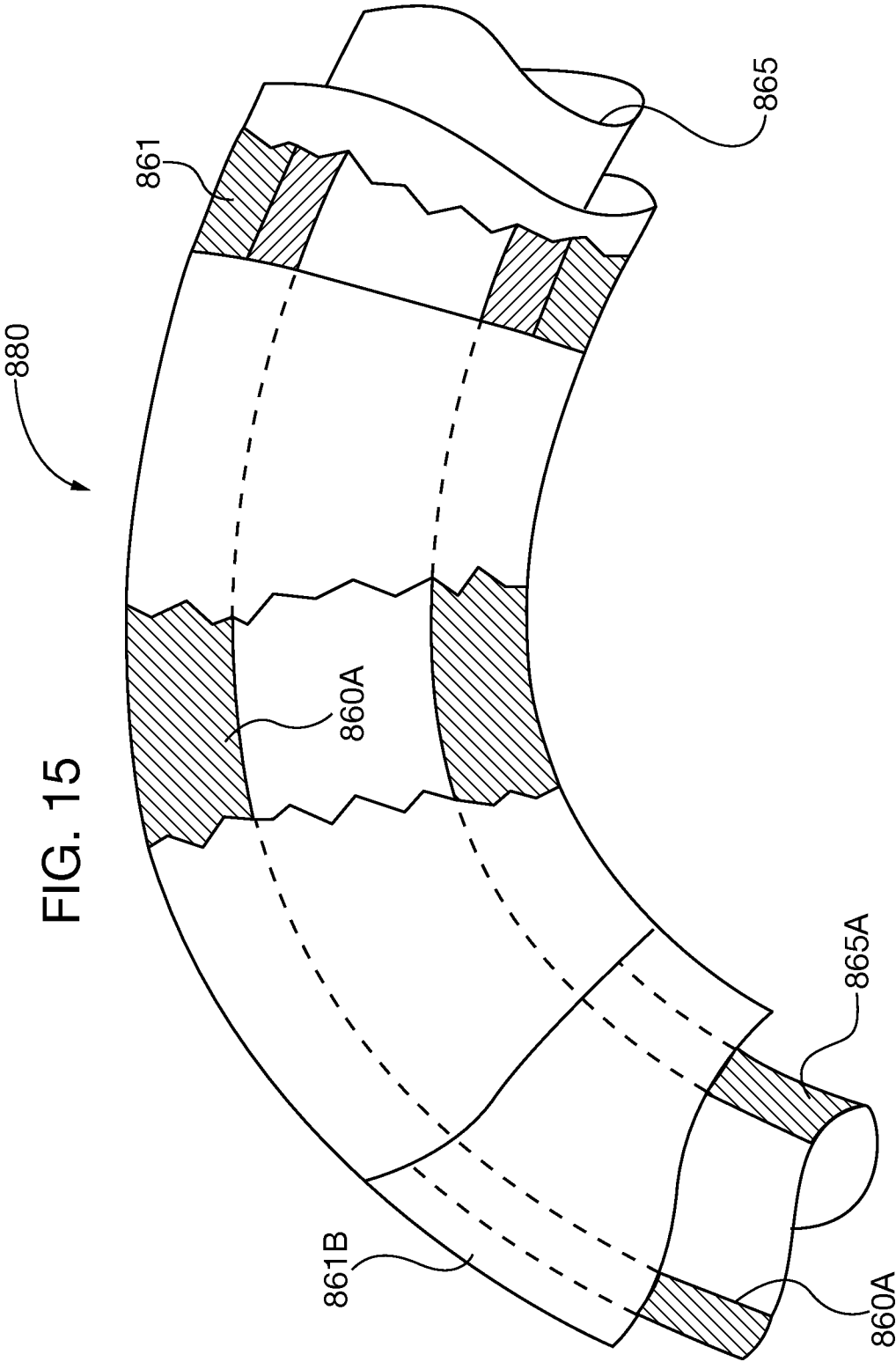
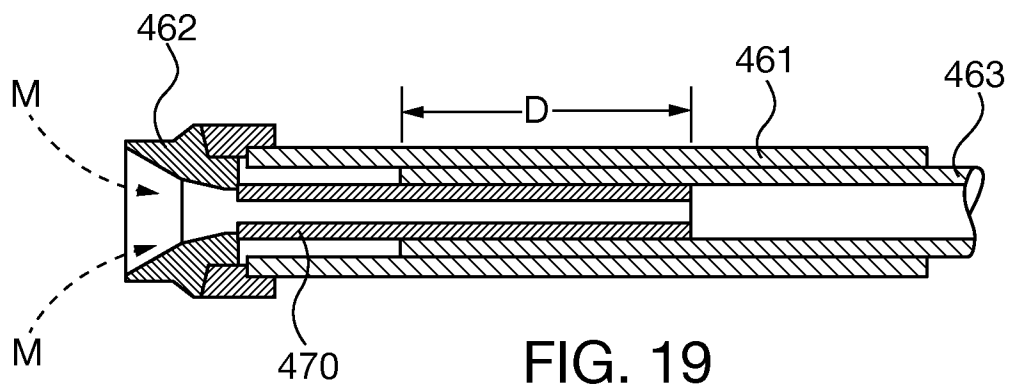
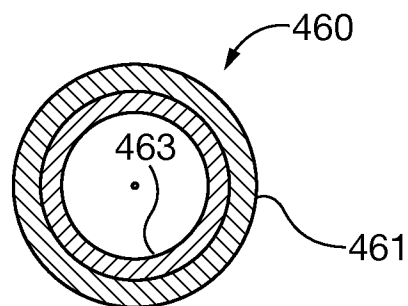
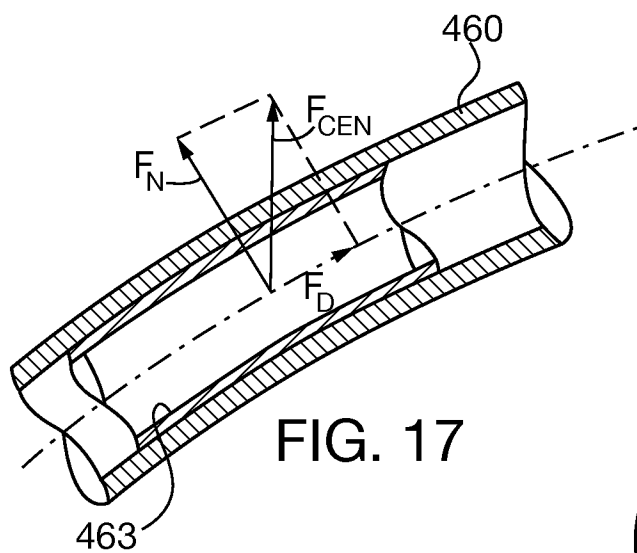
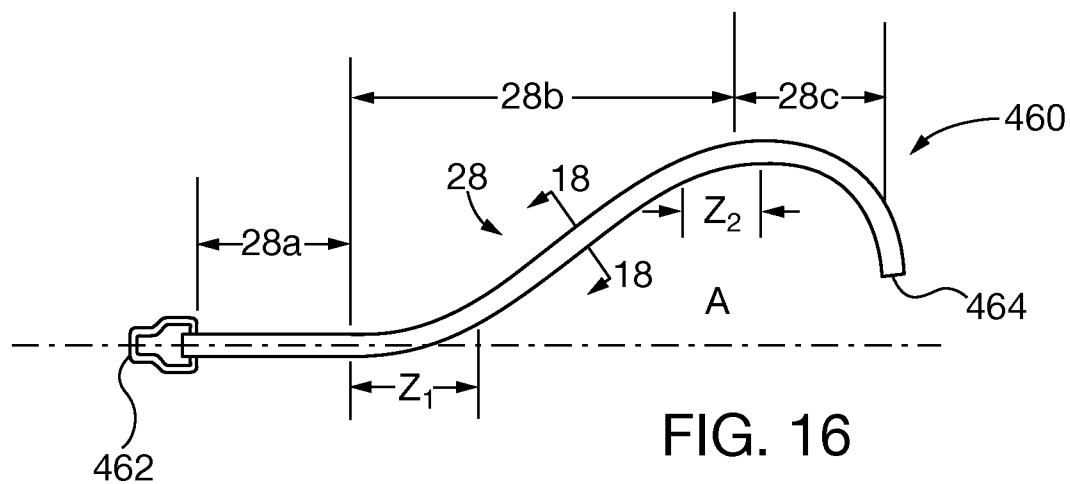


FIG. 13





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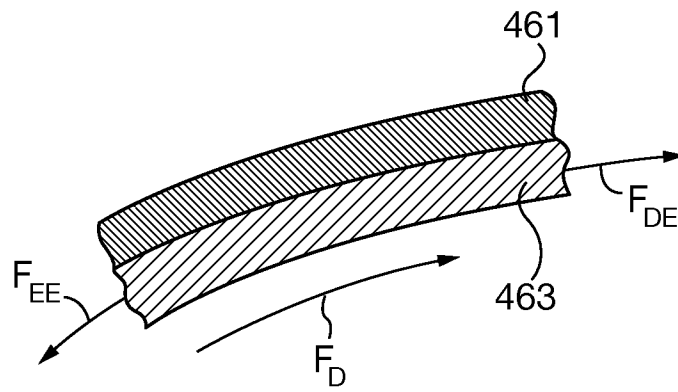


FIG. 20A

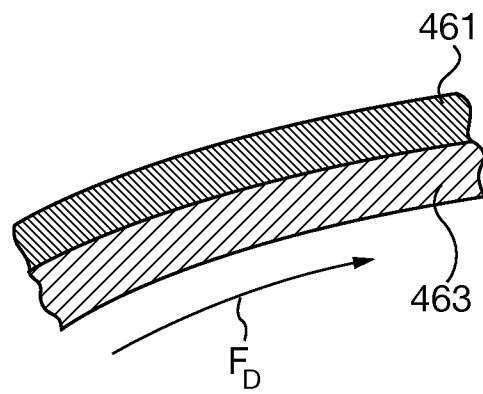


FIG. 20B

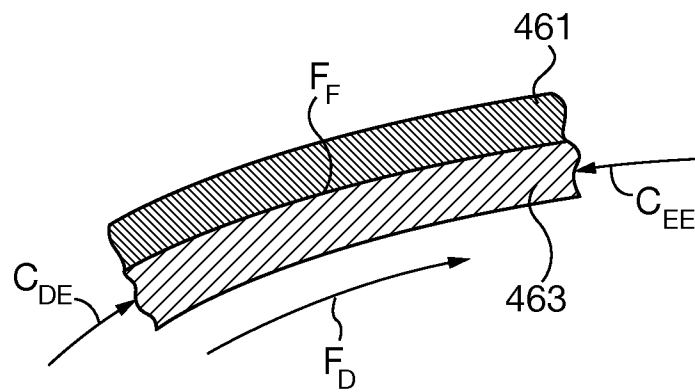


FIG. 20C

# INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/055714

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. B21C47/14  
ADD.

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21C B65H

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

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

EP0-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                               | Relevant to claim No.                 |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| X         | US 4 074 553 A (WOODROW HAROLD E)<br>21 February 1978 (1978-02-21)<br>cited in the application                                                                   | 1,4-6,<br>8-10,<br>12-14,<br>16,19,20 |
| Y         | column 2, lines 61-64; figure 3<br>-----                                                                                                                         | 15                                    |
| X         | EP 0 832 701 A1 (DANIELI OFF MECC [IT])<br>1 April 1998 (1998-04-01)<br>cited in the application<br><br>paragraphs [0048] - [0050]; figures 1-6<br>-----         | 1,4-6,<br>8-10,<br>12-14,<br>16,19,20 |
| X         | DE 197 49 446 A1 (ELSEN TOOLING IRELAND LTD [IE]) 16 July 1998 (1998-07-16)<br><br>column 3, line 43 - column 4, line 1;<br>figures 1-2<br><br>-----<br><br>-/-- | 1-10,<br>12-14,<br>16-20              |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

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Date of the actual completion of the international search

7 December 2012

Date of mailing of the international search report

18/12/2012

Name and mailing address of the ISA/

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NL - 2280 HV Rijswijk  
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Fax: (+31-70) 340-3016

Authorized officer

Augé, Marc

# INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/055714

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                            |                                       |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Category*                                            | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                         | Relevant to claim No.                 |
| X                                                    | JP 2004 042123 A (DAIDO STEEL CO LTD)<br>12 February 2004 (2004-02-12)<br><br>abstract<br>-----                                                                                                                                            | 1-6,<br>8-10,<br>12-14,<br>16-20      |
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| Y                                                    | US 2007/256752 A1 (DE LUCA ANDREA [IT] ET<br>AL) 8 November 2007 (2007-11-08)<br>paragraphs [0008], [0019] - [0023];<br>figures 1-3<br>-----                                                                                               | 15                                    |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/055714

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date                                                                                                                                                                                                                                                                                           |
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| JP 11244937                               | A                   | 14-09-1999                 | NONE                                                                                                                                                                                                                                                                                                          |
| WO 2012033710                             | A1                  | 15-03-2012                 | US 2012055218 A1 08-03-2012<br>US 2012260710 A1 18-10-2012<br>WO 2012033710 A1 15-03-2012                                                                                                                                                                                                                     |
| US 2007256752                             | A1                  | 08-11-2007                 | NONE                                                                                                                                                                                                                                                                                                          |