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(54) **TWO RAIL ELECTROMAGNETIC GUN**

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Continuation of application No. 10/710,469, filed on Jul. 13, 2004, now Pat. No. 7,077,047.

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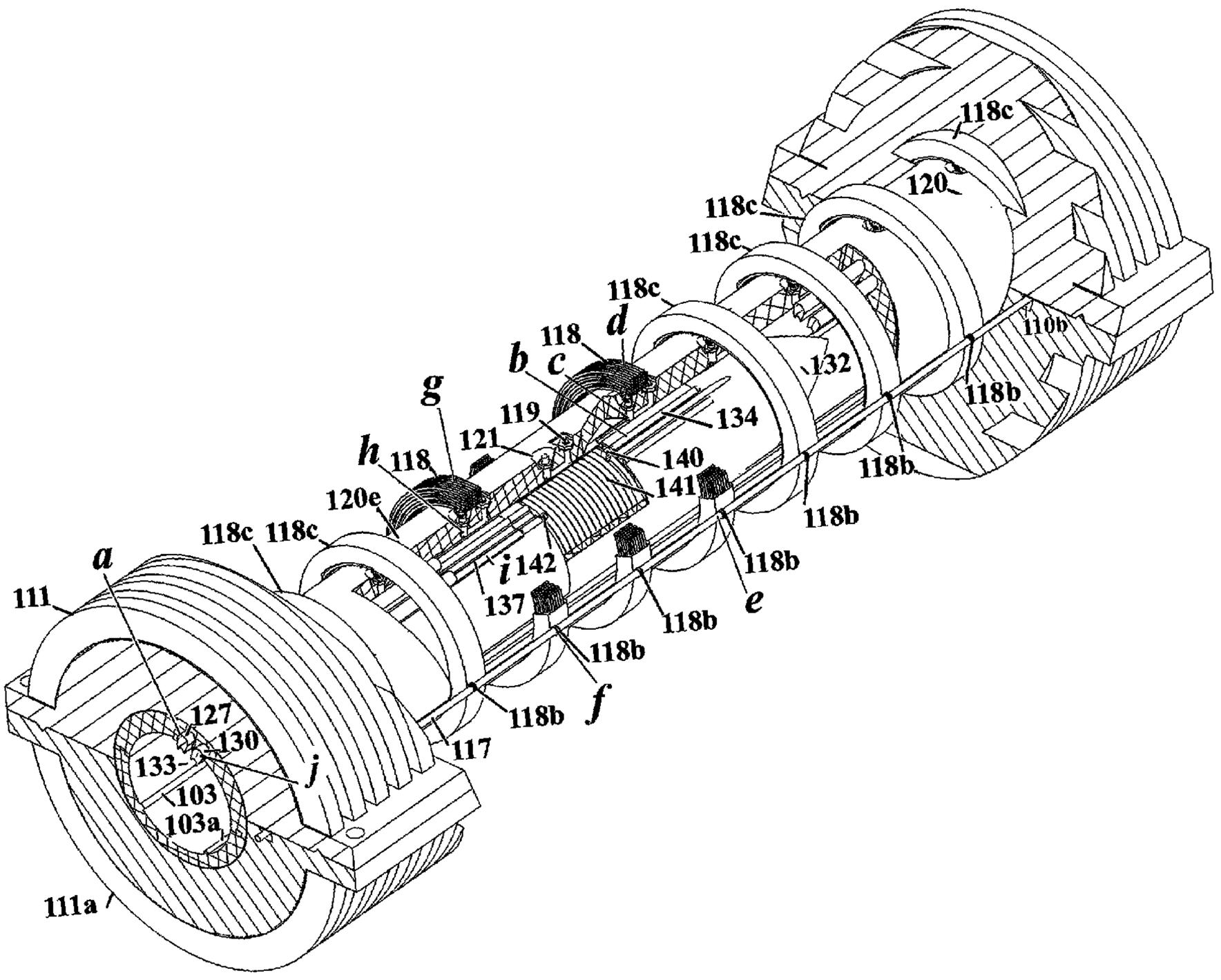
(57) **ABSTRACT**

Electromagnetic gun with a cavity extending through its barrel, two power rails with cavity surface their length, a plurality of wall (conductor) coils circumscribing and orthogonal the cavity, distributed its length with contact means at the cavity on one end a bus common to all wall coils on the other. Projectiles for traversing said cavity, having a propulsion bus coil with continuity at one end with one power rail and its other with the second power rail. A projectile forward current shunt for continuity between one power rail and forward wall coil's contact means and aft current shunt for continuity between the second power rail and aft wall coils contact means. Magnetic fields of forward and aft wall conductor coils interact with propulsion bus coil current propelling projectile in barrel towards muzzle. The above combination wherein the projectile includes propellant ignited by a bursting bridge.



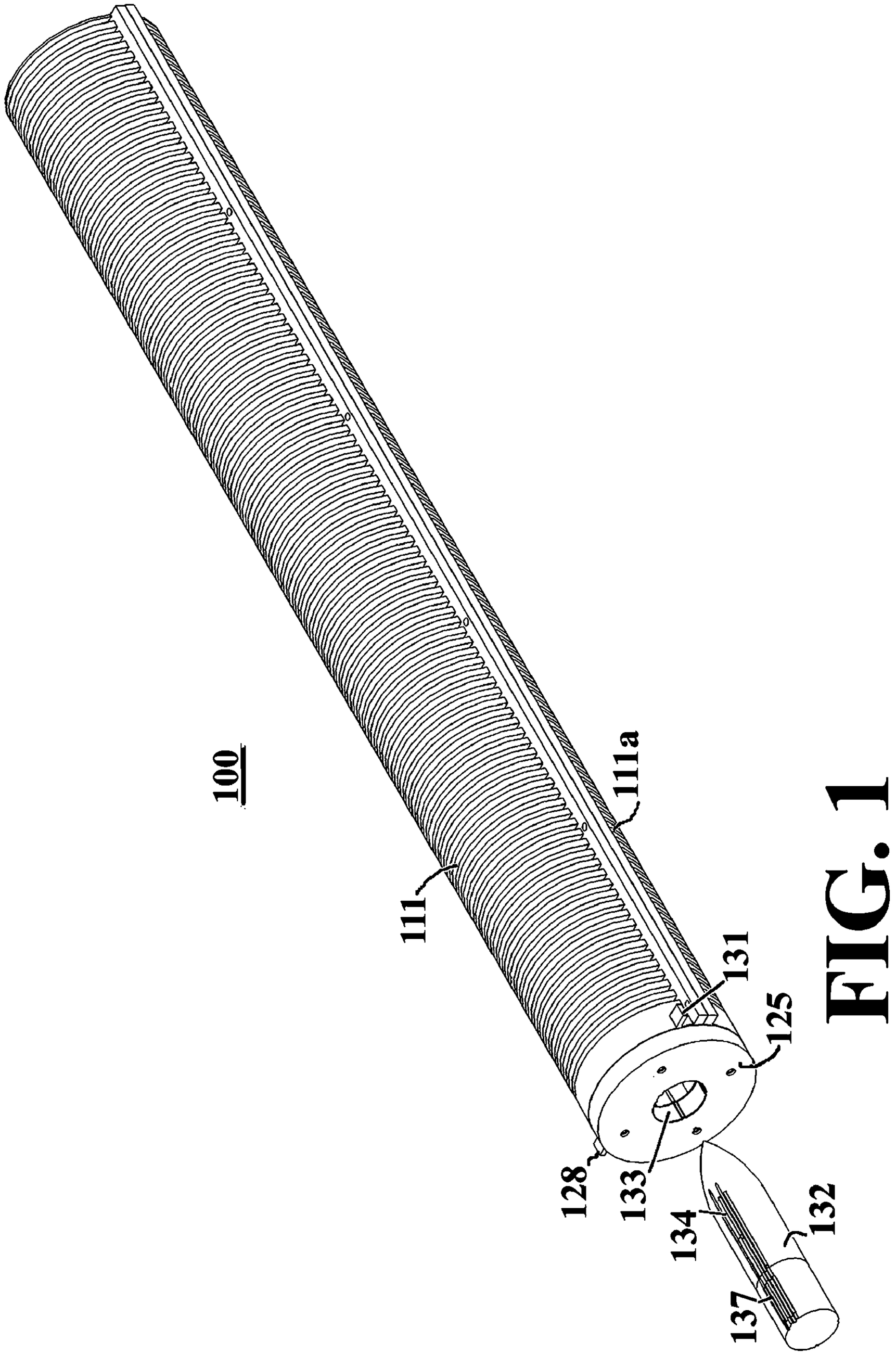


FIG. 1

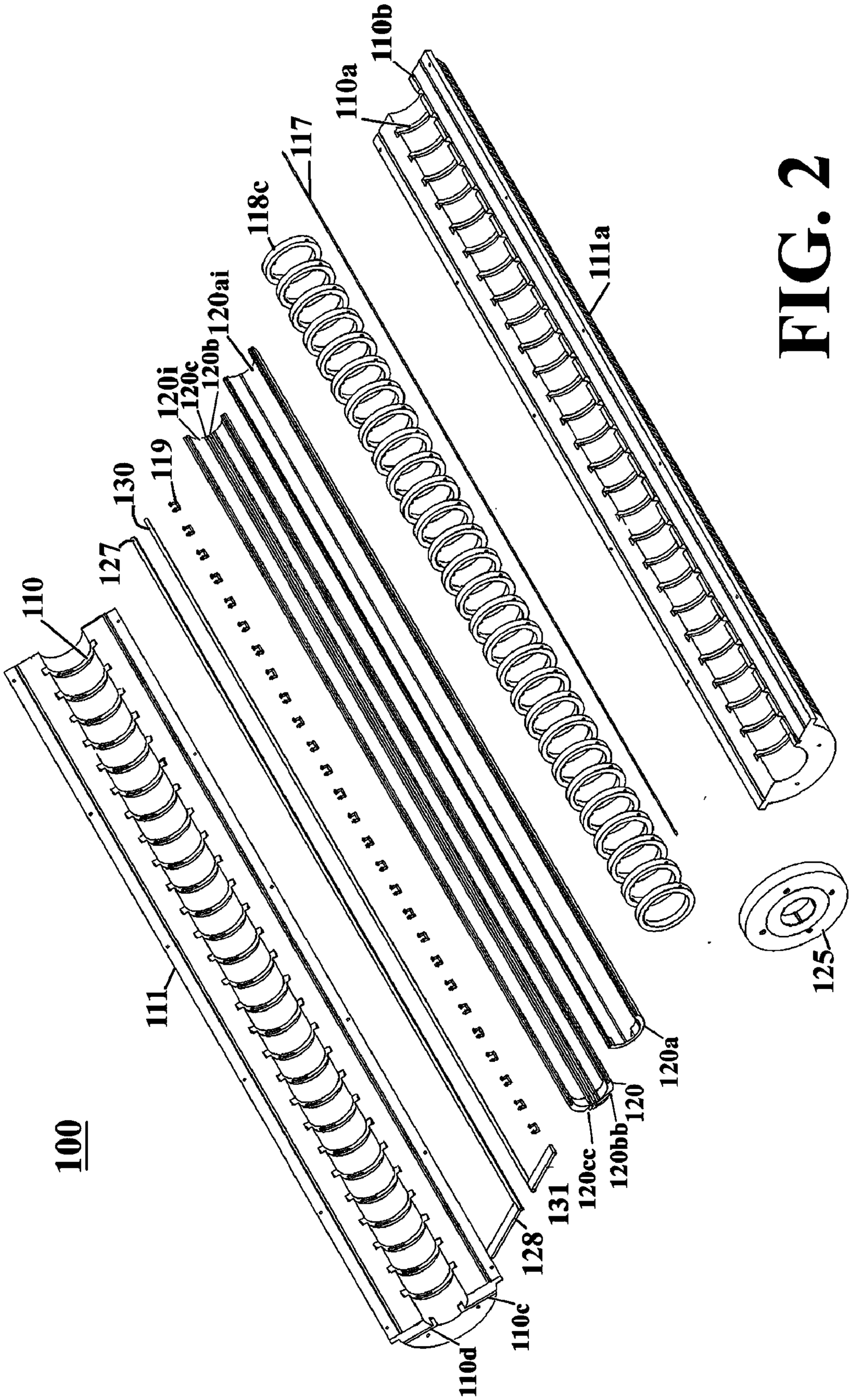

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FIG. 2

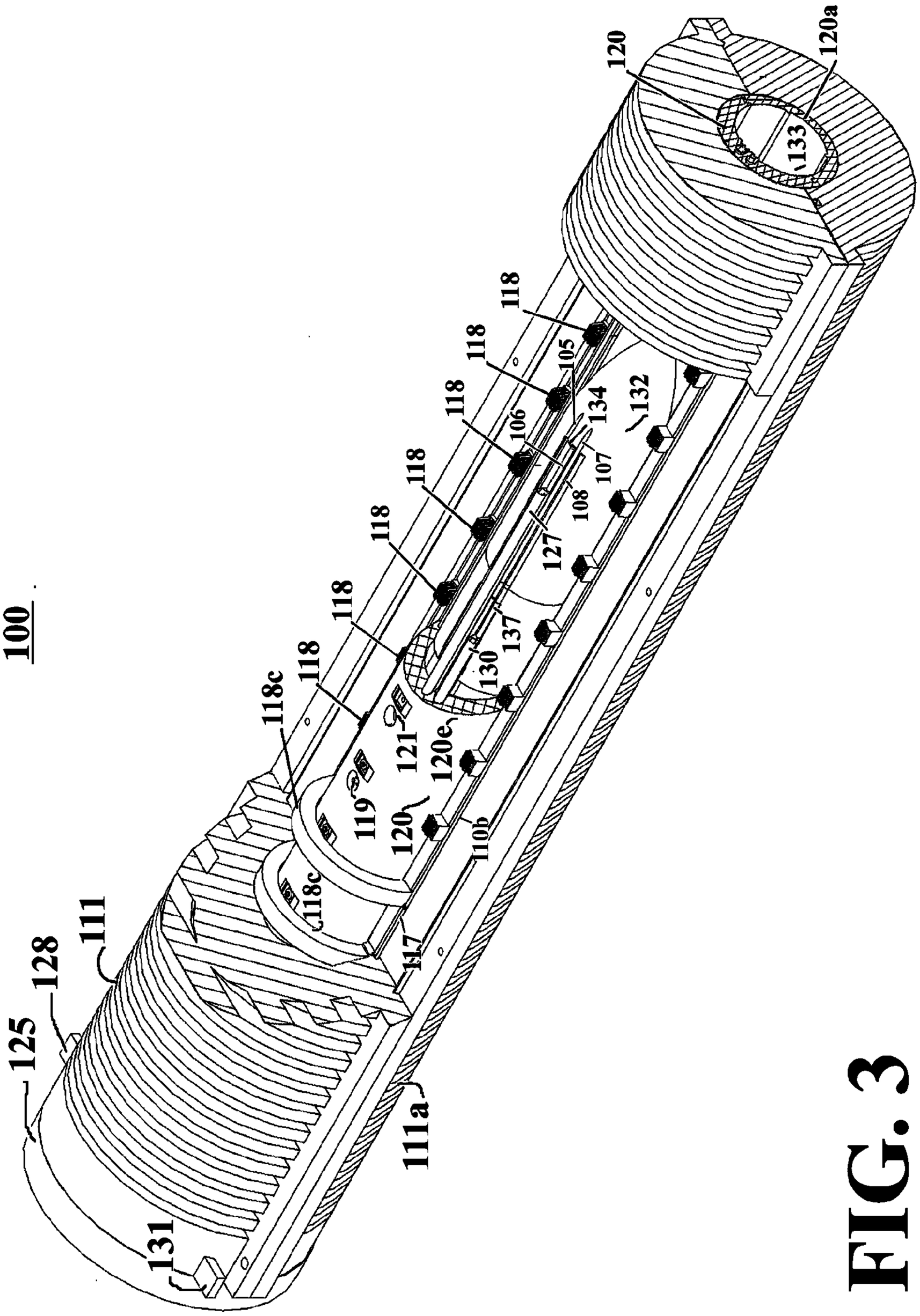
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FIG. 3

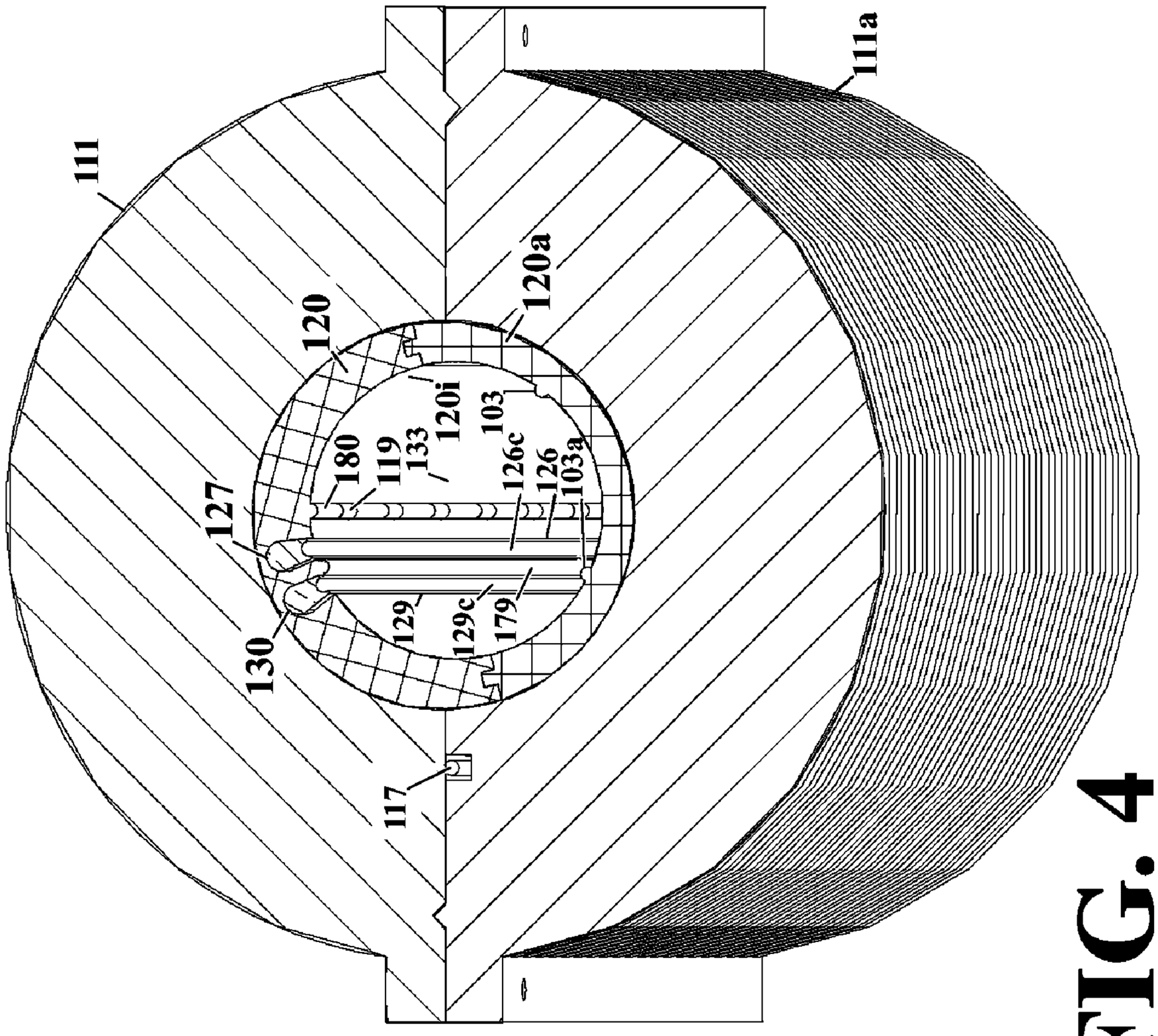
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FIG. 4

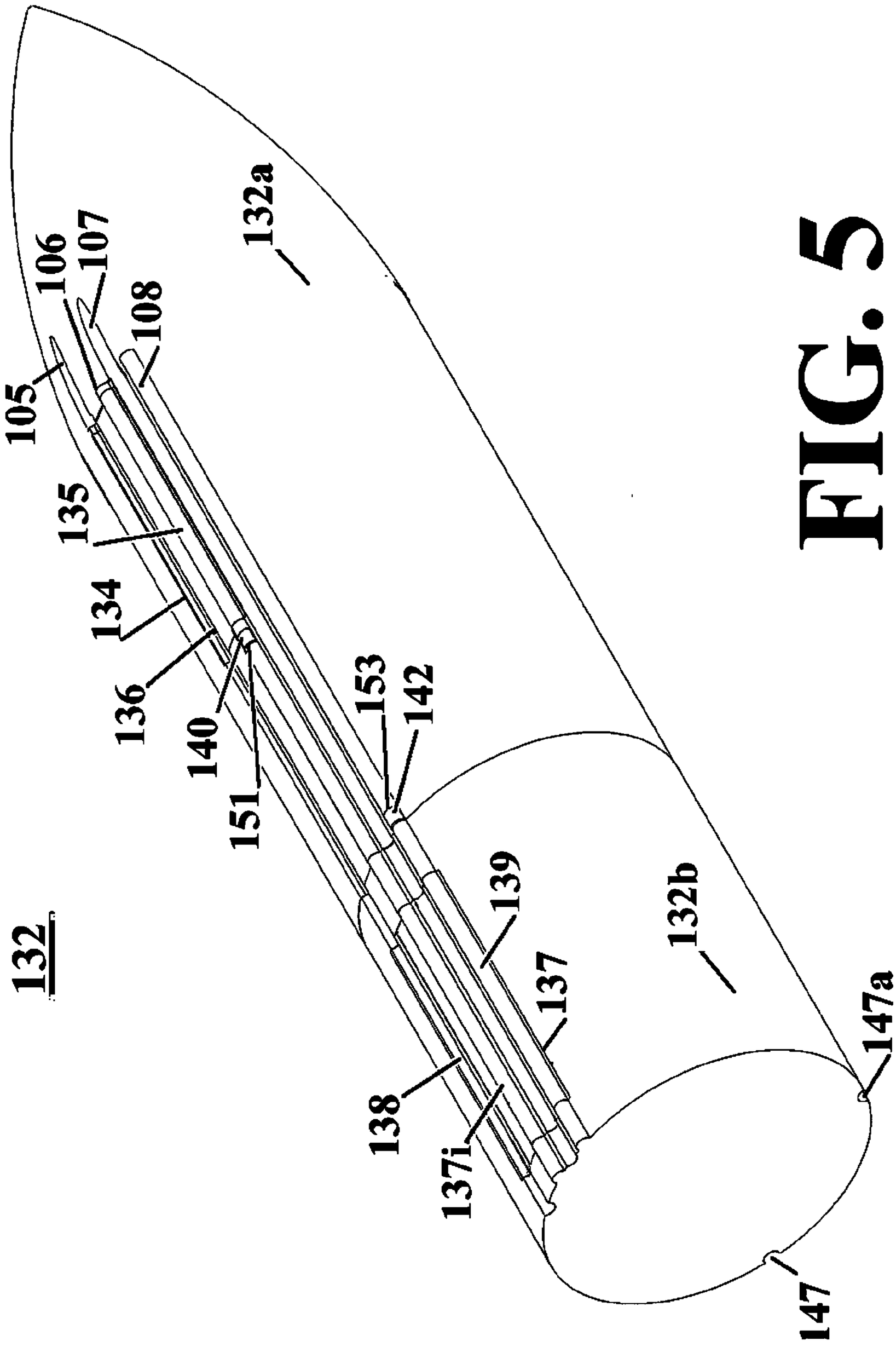
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FIG. 5

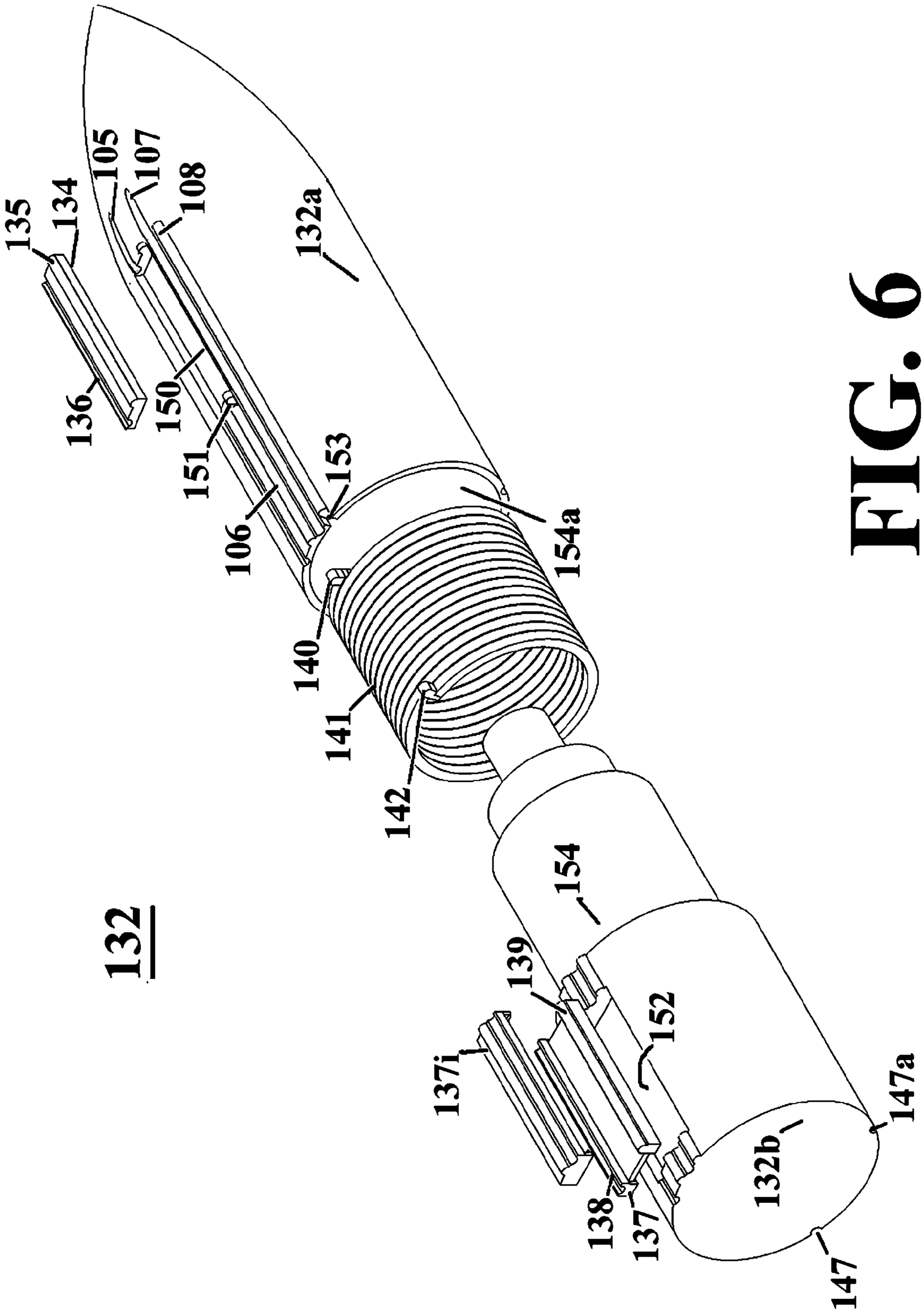
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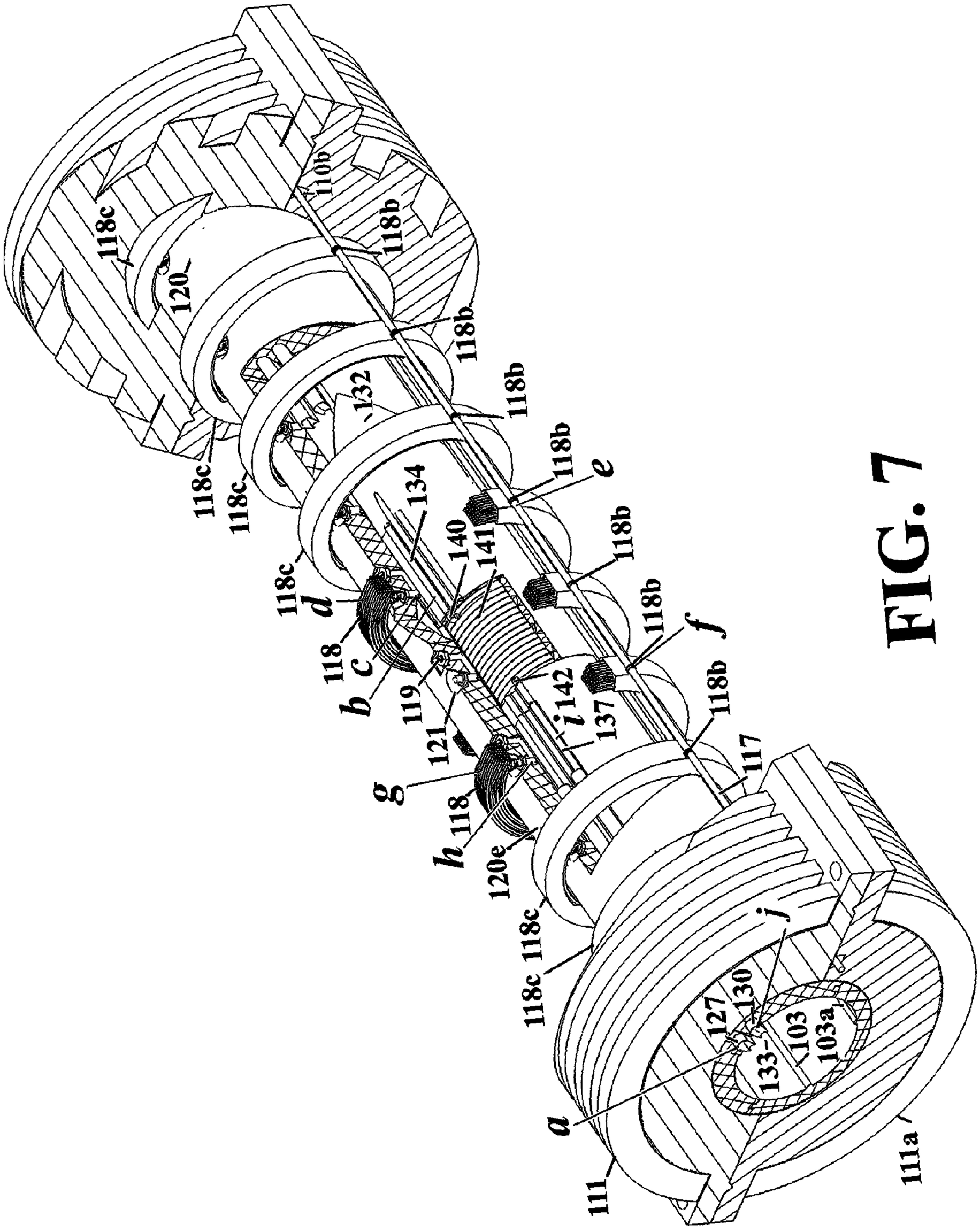
FIG. 6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118b
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i
142
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FIG. 7

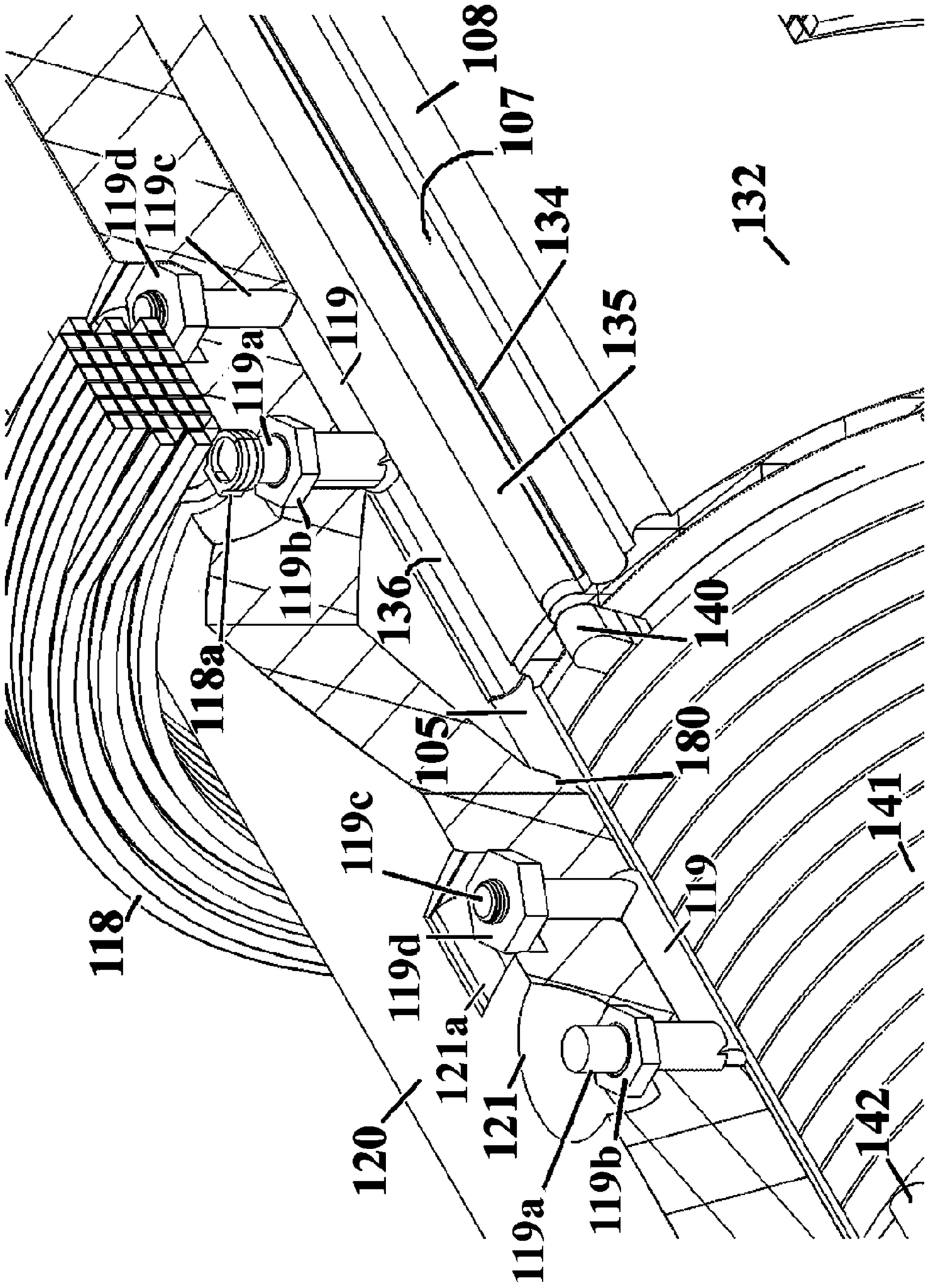
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FIG. 8

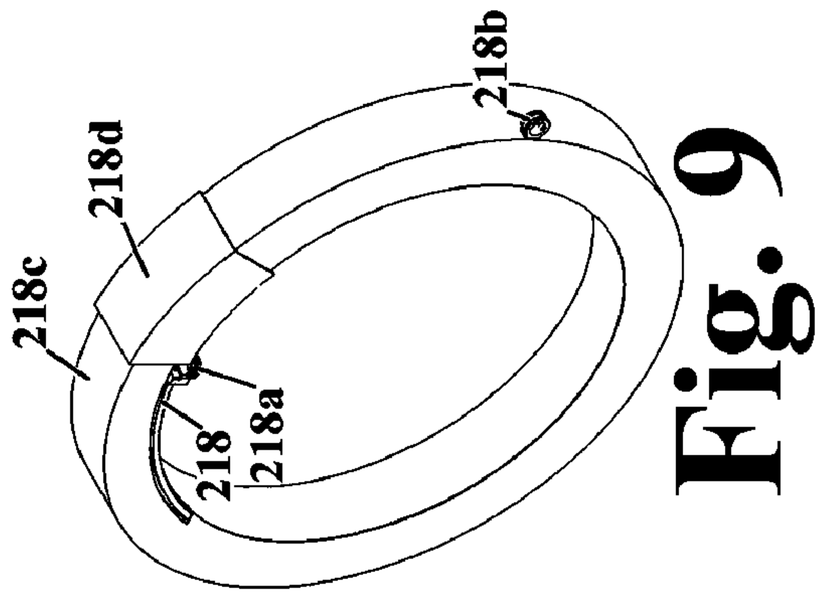
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Fig. 9

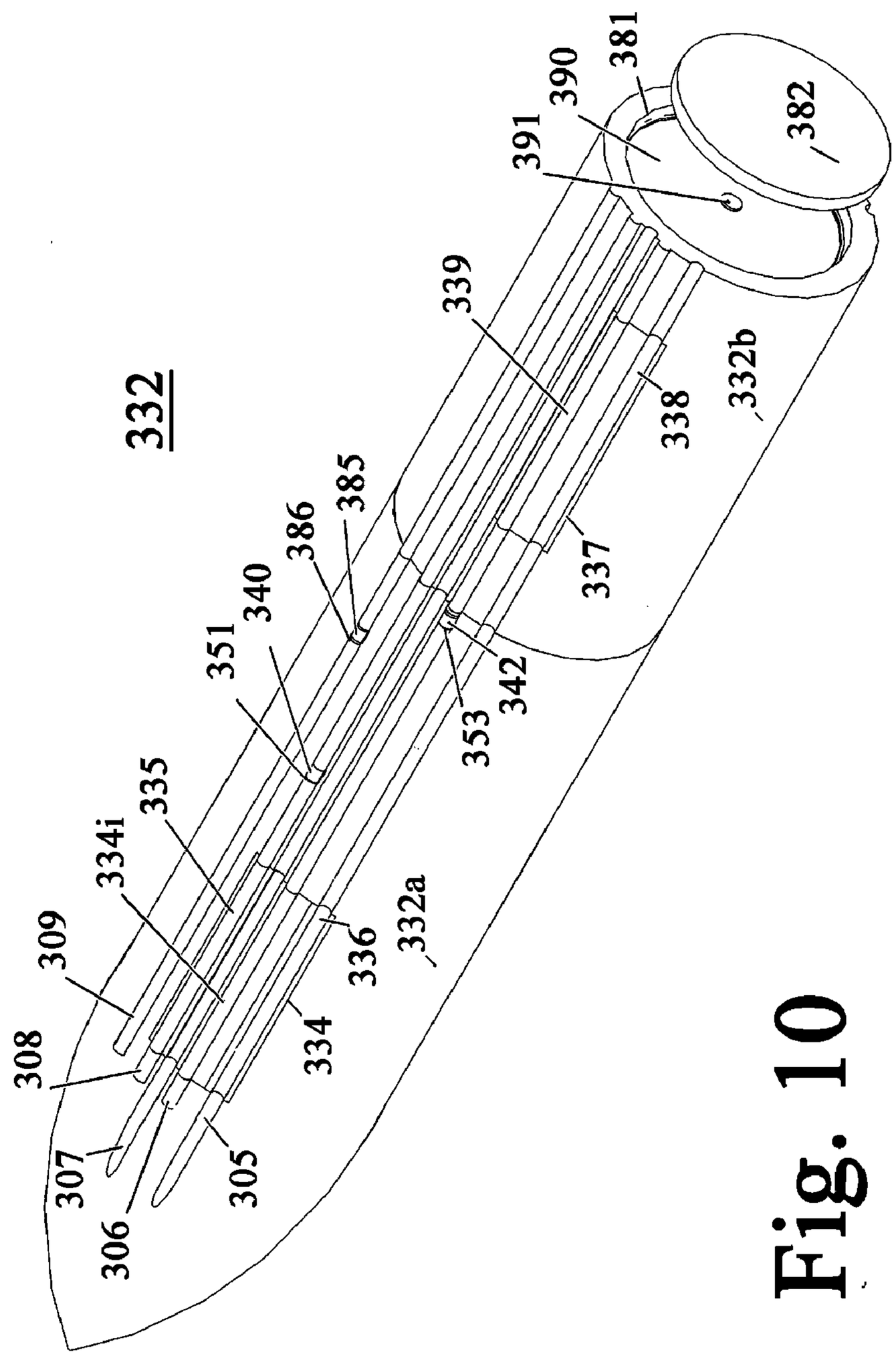
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Fig. 10

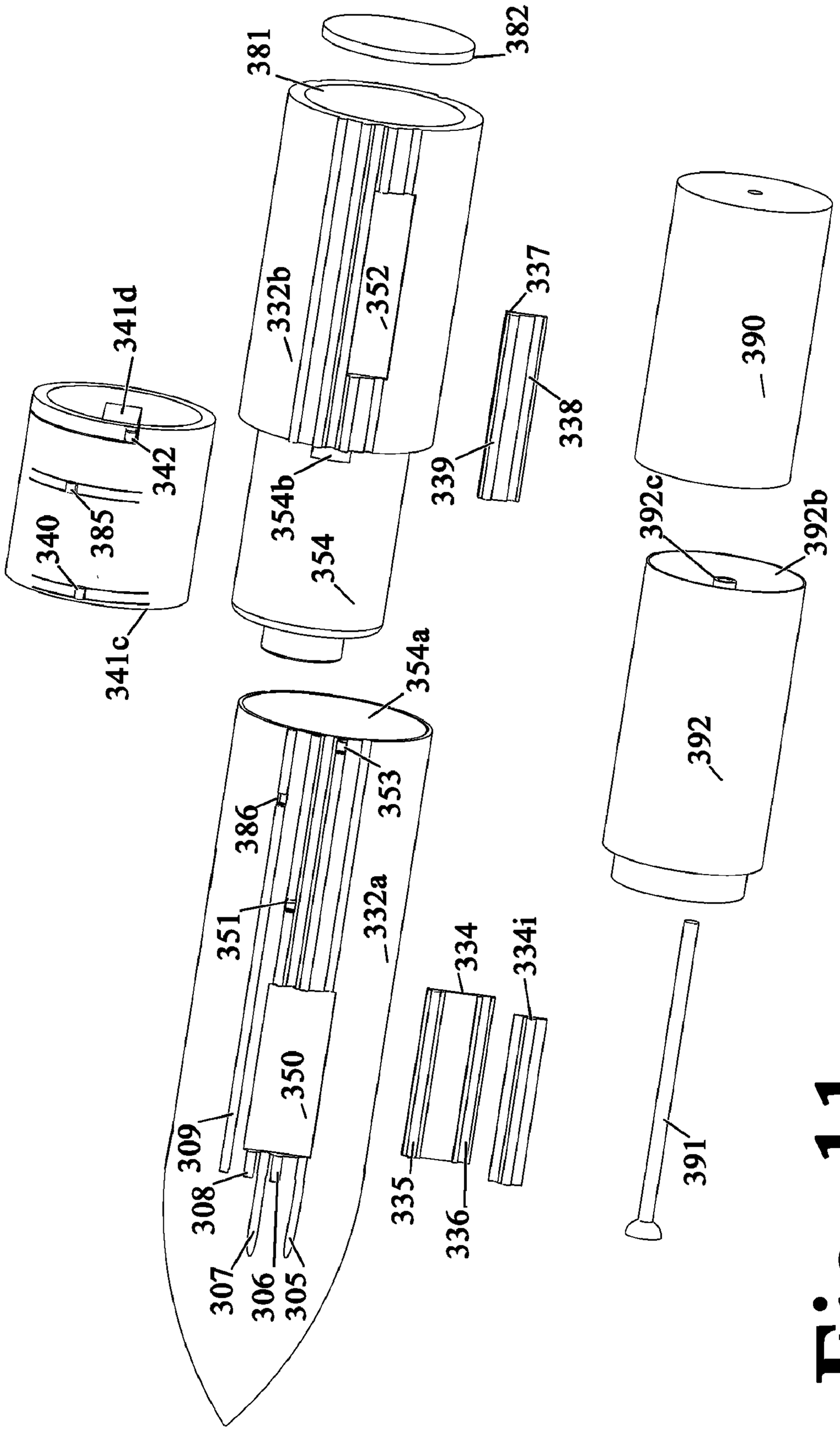
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Fig. 11

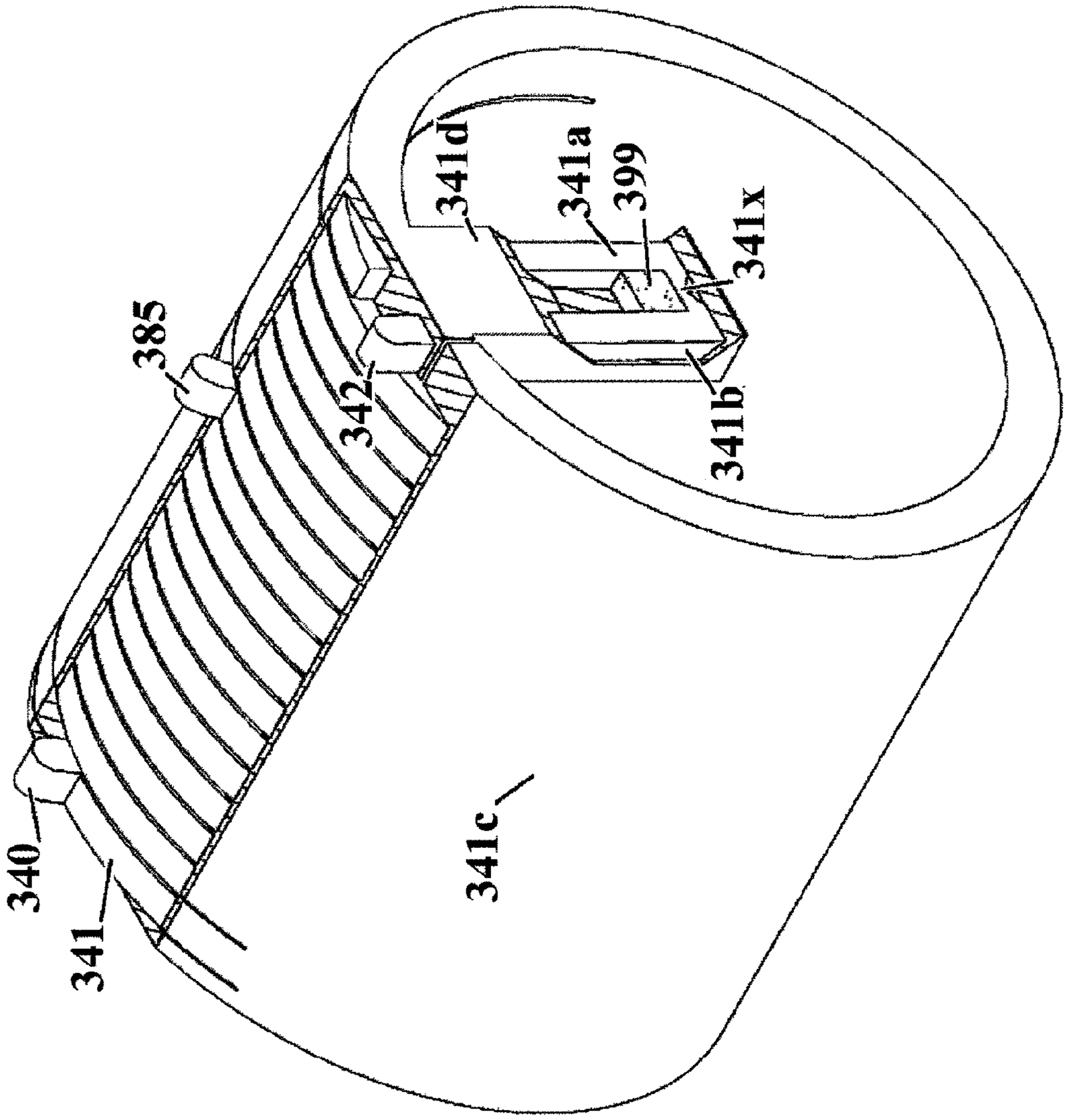

Fig. 12

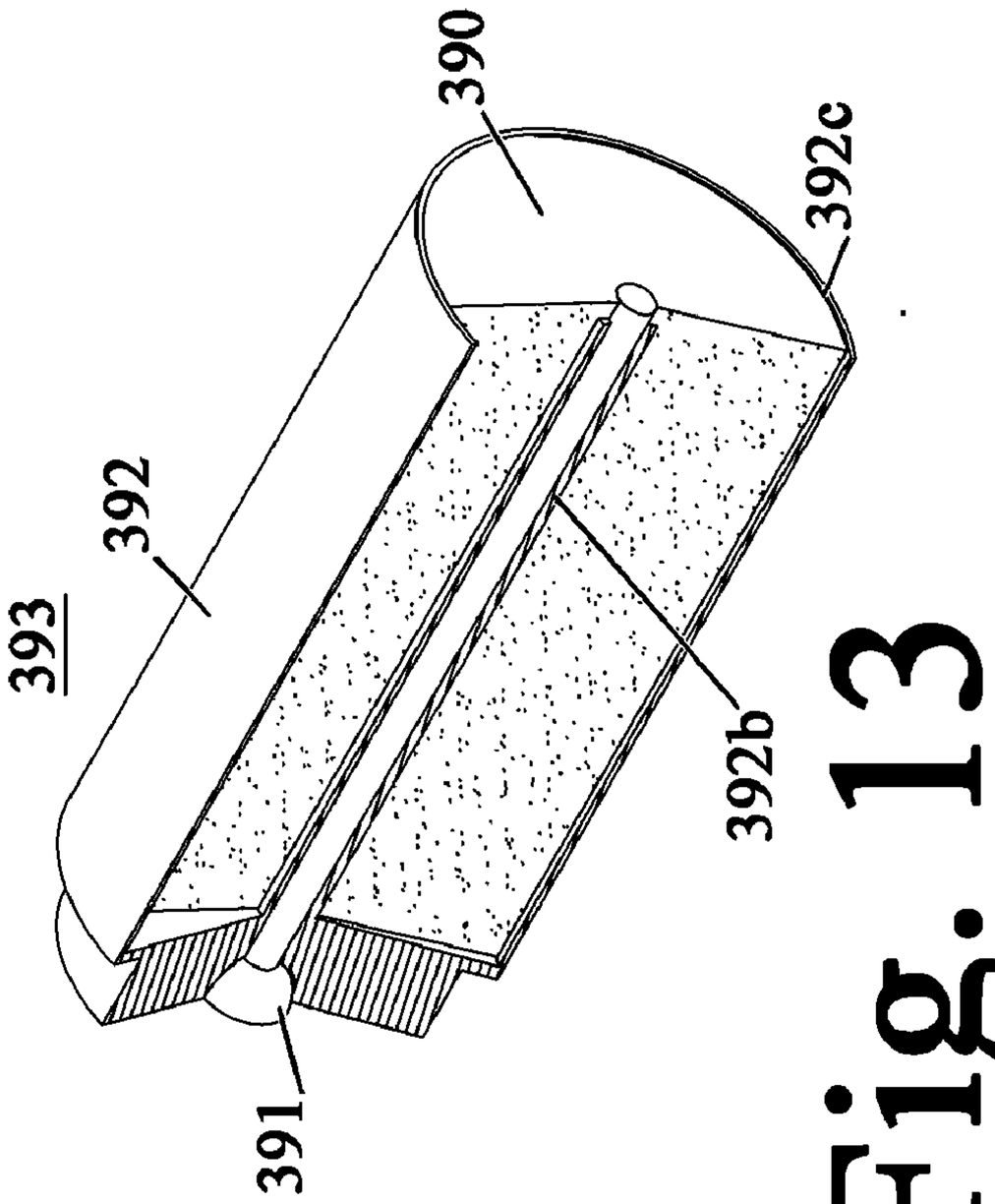

Fig. 13

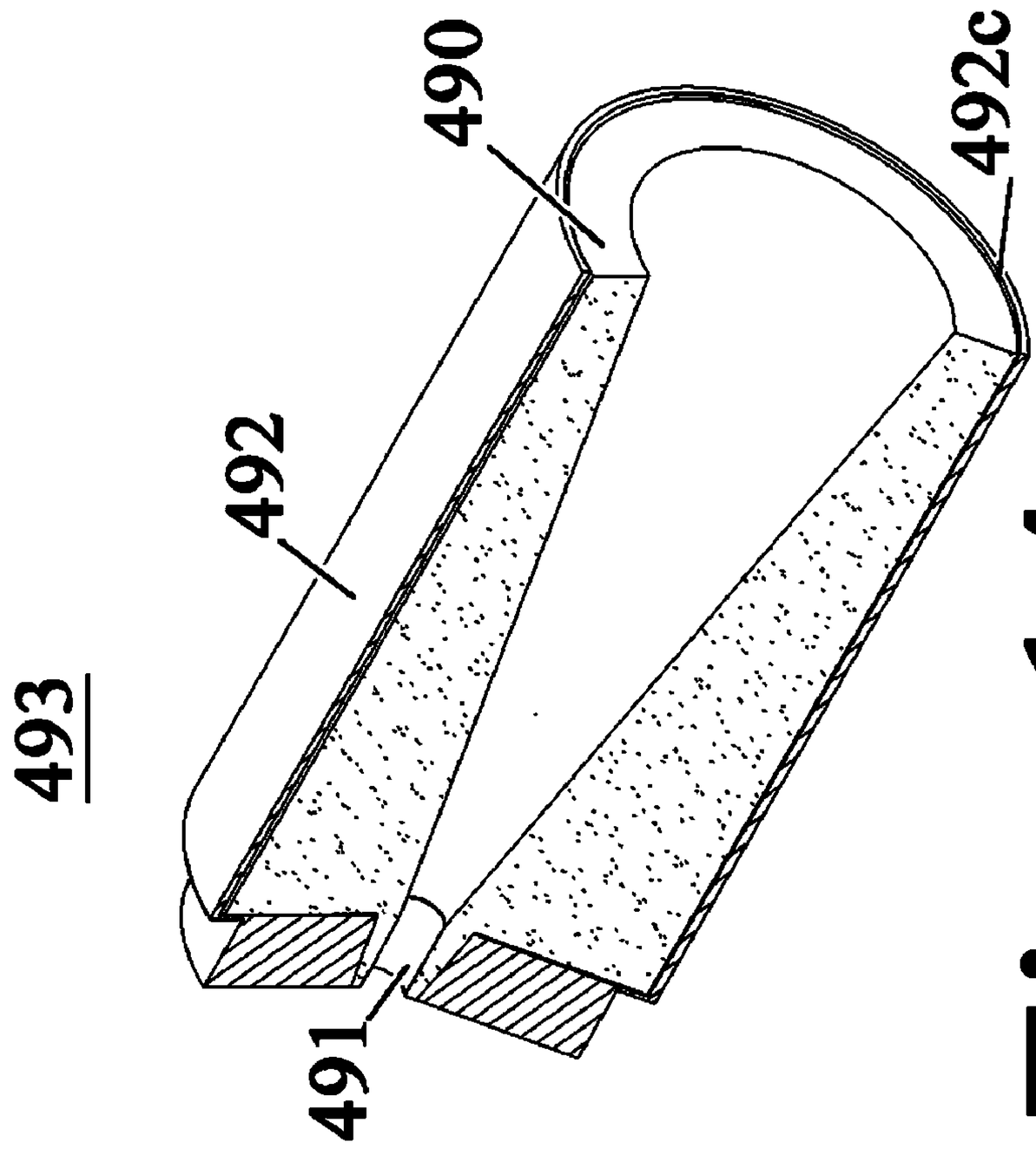

Fig. 14

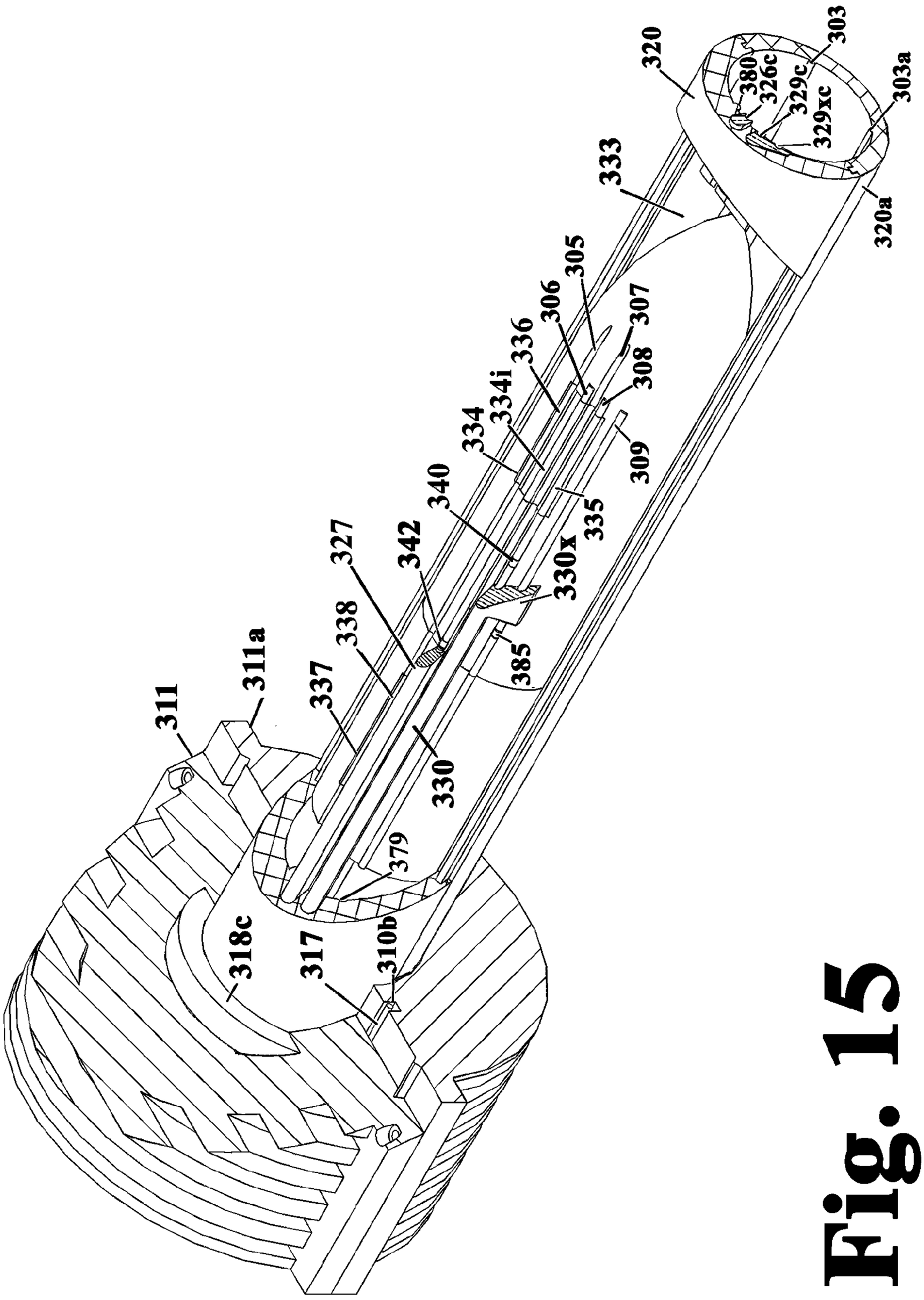
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Fig. 15

TWO RAIL ELECTROMAGNETIC GUN

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This is utility patent application Ser. No. 11/160,762 with the elected species as required by the U.S. Patent Office. Said application is directly related to utility patent application Ser. No. 10/707,607 filed Dec. 24, 2003, now abandoned and Ser. No. 10/710,469 filed Jul. 13, 2004 and issued Jul. 18, 2006 as U.S. Pat. No. 7,077,047.

BACKGROUND OF THE INVENTION

[0002] The embodiments of this invention are related to electromagnetic propulsion devices such as rail guns. In rail guns, an armature is positioned for movement between two parallel power rails. An armature in the rail gun has electrical continuity with both power rails and supplies the current path there between. The magnetic fields of the current in the power rails are perpendicular to the armature and the current therein. The magnet fields of the current in the power rails interact with the current through the armature creating forces on the armature with large power rail parallel components which accelerate the armature in the rail gun from breech to muzzle.

DESCRIPTION OF RELATED ART

[0003] Devices in application Ser. No. 10/707,607 include a barrel with a cavity whose profiles in right sections to its axis are alike. The cavity extends from its opening at the breech end of the barrel to its opening at the muzzle end of the barrel. In addition to the power rails typical rail guns the barrel has one or two wall conductor assembles in its walls.

[0004] A wall conductor assembly is comprised of an array of conductors which, in the rail gun, are oriented orthogonal to the barrel cavity axis and located in the barrel cavity wall at the barrel cavity surface or closely proximal thereto. The wall conductors have a spaced distribution in the barrel from breech to muzzle and all have electrical continuity at one end with a barrel bus which extends the length of the wall conductor distribution in the barrel wall. The other ends of the wall conductors have contact means at the barrel cavity.

[0005] Each projectile for the topic guns include a propulsion bus which carries the projectile current in a direction perpendicular the current in the power rails. On the muzzle side of the propulsion bus the projectile has a forward current shunt and on the breech side an aft current shunt. The forward and aft current shunts have continuous electrical continuity with the contact means of the wall conductors at their instant location during the projectile's traverse of the barrel cavity. The current through the projectile has a path through forward and aft wall conductors, barrel bus and additional barrel rails when extant which encircle the propulsion bus current during the traverse of the barrel. The magnetic-field of the current in each current path link located in the barrel of the propulsion bus encircling current path interacts with the current in the propulsion bus creating muzzle directed forces on the projectile. Thus the force per ampere current propelling an projectile in the barrel is increased.

[0006] In some combinations of U.S. Pat. No. 7,077,047 the wall conductors of the wall conductor assembly, between their contact means at the barrel cavity at one end and their barrel bus continuity at their other end, include multiple turn coils in the barrel wall which circumscribe the barrel cavity. When in the barrel cavity, the propulsion bus of a projectile in some embodiments therein are also a multiple turn coil about the projectile's axis and located at or close to the projectile's surface proximal the barrel cavity surface. In these embodiments the net projectile accelerating force of the power rails and barrel bus magnetic fields is negligible compared to the forces accelerating the projectile due to the magnetic fields of the forward and aft wall conductor coils acting on the current in the projectile's propulsion bus coil. In embodiments of U.S. Pat. No. 7,077,047 the projectile's propulsion bus coil is in series with the forward and aft wall conductor coils between the power rails; i.e. the wall conductor coils and projectile coil carry the same current. In other embodiments of said patent the current supply to the projectile is independent of the current supply to the wall conductors and 3 or 4 power rails are used to accomplish said independence.

BRIEF SUMMARY OF THE INVENTION

[0007] The current invention has only two power rails and its projectile's propulsion bus includes a coil of one or more turns about and approximately orthogonal the projectile axis and located at the projectile's surface that is, with the projectile in the barrel cavity, proximal the barrel cavity surface. The propulsion bus has a contact means at each end and when the projectile is in the barrel cavity one said contact means has continuous electrical continuity with one of the two power rails and the second contact means has continuous electrical continuity with the other power rail. Each wall conductor includes between its ends a coil located in the barrel cavity wall with one or more turns about the barrel cavity axis and oriented approximately orthogonal thereto. Each wall conductor has a contact means at the barrel cavity at one end and electrical continuity with the barrel bus at its other end.

[0008] In the current invention the fore and aft wall conductors with connecting barrel bus are electrically in series across the power rails via an projectile's fore and aft current shunts and said series combination is in parallel across the power rails with the propulsion bus of projectile in the barrel. The independence of the projectile's propulsion bus current from the wall conductor current permits a great variation in the concomitant operating currents in the barrel's active wall conductors and the barrel bus of a projectile in the barrel. In addition to resistance variation due to length, cross section area and temperature for a given material, resistance of various conducting materials vary greatly; e.g. CF8M Stainless steel: 5.61×10^{-5} ohm-cm, Aluminum 356: 4.095×10^{-6} ohm-cm, and Cu 1.7×10^{-6}. All or part of these factors are used to effect said current difference.

[0009] With a high resistance projectile propulsion bus coil, the proportion of the projectile mass and volume required for said coil is reduced, as is said coil's current, and current in the wall conductors may be very large by comparison.

[0010] With single turn wall conductor coils and projectile propulsion bus coil the first approximation of force in

Newtons on the projectiles for the topic device is given by the general simplified equation with a cross product integrand:

$$\text{Force} = 2\left[.9\int_{\beta_0}^{\beta_1} I_{pb} r_{pb} \cdot d\theta \times (\mu_0 L_{\omega c}/(2\pi))(\text{Cos } \alpha / d_{\omega c \cdot pb})\right]$$

[0011] I_{pb} the projectile's propulsion bus current. I_{wc} is the forward and aft wall conductor current. The '2' before the bracketed terms accounts for both the forward and aft wall conductor currents whose magnetic fields interact with the projectile's propulsion bus current over the length of the propulsion bus creating the projectile's propelling force. The 0.9 term in the bracketed term is an attenuation term compensating for the effect of the magnetic fields of a wall conductor current element on the second propulsion bus coil current element located π radian arc distance about the projectile axis from the first. The propulsion bus's coil is at the projectile's surface and orthogonal to both the projectile and the barrel cavity axis at radius r_{pb}. The length in meters of the projectile's propulsion bus coil on which the wall conductors magnetic fields act is the integral of r_{pb} $d\theta$ through the angle $\beta_1-\beta_0$, where β_1 is the angular displacement about the barrel cavity axis of the propulsion bus's contact means with second power rail continuity and β_0 is the angular displacement to said bus's contact means with first power rail continuity and all with reference to an arbitrary radial line from said axis. Permeability of free space, ϵ_o, is $4\pi\times10^{-7}$ Henries/meter.

[0012] The distance from a current element at an axis plane's intersection with a turn of a wall conductor's coil to the current element at the plane's intersection with the projectile's propulsion bus coil is $d_{wc\text{-}pb}$ and said distance has a deflection angle of a from a line in said axis plane parallel said axis. The Cos α term is the projectile axis radial component of the magnetic field of said wall conductor current element which interacts with said propulsion bus's coil current element creating a muzzle directed barrel axis parallel force component; i.e. Said force is directed perpendicular to said coil's current element direction and said magnetic field component direction and parallel the barrel cavity axis and toward the barrel muzzle. Both the $d_{wc\text{-}pb}$ and the Cos α in the (Cos $\alpha/d_{wc\text{-}pb}$) term vary for each wall conductor as its contact means is traversed by a projectile's current shunt and a mean effective value approximation for the term may best be acquired using computer iteration. The above magnetic interactions may be enhanced by using highly permeable projectile coil core material.

[0013] As indicated in the above equation, the force on the projectile is proportional to the current product $I_{pb}\times I_{wc}$. The projectile's propulsion bus current I_{pb} can be made small, along with the projectile's propulsion bus coil's mass and volume to increase the projectile's payload, while the wall conductor coils current I_{wc} can be made very large to maximize performance. In the series configurations of previous applications the wall conductors' currents where effectively limited to the maximum current possible in the projectile's propulsion bus coil.

[0014] The equations and examples herein are intended as aides to practitioners of the arts relevant the topic invention and are not part of the claimed devices, and the degree of their veracity is not intended to reflect adversely on the veracity, spirit, intent, merit or scope of this application for letters of patent.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is an oblique view of the breech end of a shortened assembled embodiment of the invention with a projectile.

[0016] FIG. **2** is an oblique view of the barrel section in figure one disassembled.

[0017] FIG. **3** is an oblique cutaway view of a section of barrel with a projectile in the barrel cavity.

[0018] FIG. **4** is a view into the muzzle end of a section of the barrel in FIG. **1** taken at an angle to the cavity axis.

[0019] FIG. **5** is an oblique view of a projectile for the invention embodiment in FIG. **1**.

[0020] FIG. **6** is an oblique view of the projectile in FIG. **5** disassembled.

[0021] FIG. **7** is an oblique cutaway view of a barrel section to illustrate the current path.

[0022] FIG. **8** is an enlarged view of the central region of FIG. **7**.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The embodiments herein disclosed increase the force on a projectile per ampere current there through by permitting independence of the current through the coil of projectile's propulsion bus with its practical limitations from the current in the coils of the forward and aft wall conductors used to propel the projectile in the barrel cavity.

[0024] The electromagnetic propulsion devices herein, as in the reference patent applications, have a barrel and a cavity through the barrel with a breech end and a muzzle end. Disregarding the minor irregularities at the wall conductors' contact means and their mating openings in the barrel cavity's wall, the barrel cavity's profiles in right section planes throughout the barrel's length are uniform. With power supplied to the gun's power rails, projectiles in or inserted into the breech end of the barrel cavity are propelled through the cavity toward and out of its muzzle end. The central axis of a projectile in the barrel cavity is approximately parallel to and close or coincident with the barrel cavity axis. All projectile profiles in right section planes taken to the projectile axis are smaller then the barrel cavity right section plane profile and a portion of said projectile right section plane profiles are similar and slightly undersize the barrel cavity right section profile.

[0025] Guns of the invention have two power rails. The power rails are of like or similar length, located in the barrel cavity wall along the same length of barrel, and proximal and insulated from each other. Each power rail has a continuous surface its length that is part of the barrel cavity surface and each power rail has a connection means for the attachment of circuitry to an outside power source.

[0026] In the figures herein the power rails are parallel to the cavity central axis; however, generally, the power rails are shaped and oriented so that their profiles along with other

gun element profiles in diametric planes throughout the length of the barrel cavity retain fixed angular relationships to each other about the cavity axis and in said figures also have a fixed angle to an axial reference plane. In guns with a twist, the power rails along with other elements of barrel and projectiles retain a fixed angular relationship to each other about the cavity axis; however, as a collection, their angle to said axial reference plane, taken at equal increments from breech to muzzle increases (or decreases) at a constant rate with reference to distance along the barrel cavity axis.

[0027] The barrel cavity walls also contain a wall conductor assembly; i.e. the wall assembly. The wall assembly includes a barrel bus (electrical conductor) which is completely outside the barrel cavity, is insulated from the power rails, and, in the embodiments herein, is within the barrel wall, is parallel to and of similar length as the power rails and proximal their barrel cavity location.

[0028] The wall assembly includes a plurality (i.e. array) of wall conductors, which are separate from each other in a distribution along the length of the barrel cavity and each wall conductor includes a barrel cavity encircling coil between its ends. Each wall conductor's coil is a continuous insulated conductor and has at least one turn between its ends circumscribing the barrel cavity at or near the cavity surface and can have segments at its ends that diverge from the winding paths. Disregarding slight skewing of individual turns to a diametric plane, each wall conductor's coil is perpendicular (orthogonal) to the cavity and its axis. All wall conductor coils are wound in the same direction about the barrel cavity.

[0029] At one end, each wall conductor has a contact means through the barrel cavity surface and at other end, each wall conductor is physically and electrically continuous with the barrel bus. Beyond the barrel bus each wall conductor is electrically insulated from its surroundings except at its electrical contact means through the cavity surface when a projectile's current shunt surface is thereat.

[0030] Midway between its ends, each projectile for the device has a propulsion bus with a coil about the projectile's axis which is a continuous insulated conductor. When a projectile is in the barrel cavity the coil of its propulsion bus is oriented therein to travel in close proximity to the cavity wall and the wall conductor coils therein. Disregarding slight skewing of individual turns to a diametric plane, the coil of the propulsion bus carries current in a direction perpendicular to the barrel cavity axis and the direction of the projectile's barrel cavity traverse and parallel to the direction of current in the coils of the wall conductors. With the projectile in the barrel cavity, the projectile's propulsion bus's coil extends from one end of the propulsion bus, with contact means having electrical continuity with one of the power rails, to the other end, with contact means having electrical continuity with the second power rail. With a projectile's movement in the barrel cavity said continuities are continuous sliding continuities.

[0031] A projectile for the device has a forward current shunt. With the projectile in the barrel cavity, its forward current shunt is located on the muzzle side of the propulsion bus's coil and has surface which has continuous electrical continuity with one of the power rails. The forward current shunt also has surface on the projectile which has continuous electrical continuity with the wall conductor assembly via the contact means of wall conductors at the barrel cavity surface location of said shunt surface. During projectile movement in the barrel cavity said continuous electrical continuities are continuous sliding electrical continuities. During an projectile's barrel cavity traverse, surface of its forward current shunt has continuous sliding electrical continuity with the wall conductor assembly from breech to muzzle and said continuity is resultant the continuous sliding electrical continuity said surface has sequentially with successive wall conductors from breech to muzzle via said wall conductors' contact means at the barrel cavity. Wall conductors during the time they have electrical continuity with the forward current shunt via their contact means at the barrel cavity are the forward wall conductors.

[0032] A projectile for the device also has an aft current shunt. With the projectile in the barrel cavity, it's the aft current shunt is located on the breech side of the propulsion bus coil and has surface which has continuous electrical continuity with the second power rail; i.e. the power rail without direct continuity with the forward current shunt. The aft current shunt also has surface on the projectile which has continuous electrical continuity with the wall conductor assembly via the contact means of the wall conductors at the barrel cavity location of the projectile's aft current shunt surface. During projectile movement in the barrel cavity said continuous electrical continuities are continuous sliding electrical continuities. During a projectile's barrel cavity traverse, surface of its aft current shunt has continuous sliding electrical continuity with the wall conductor assembly from breech to muzzle and said continuity is resultant the continuous sliding electrical continuity said surface has sequentially with successive wall conductors from breech to muzzle via said conductor's contact means at the cavity. Wall conductors, during the time they have electrical continuity with the aft current shunt via their contact means at the barrel cavity are the aft wall conductors.

[0033] When outside the barrel cavity, the various elements of the projectile; i.e. the forward current shunt, the aft current shunt and the propulsion bus are all electrically insulated from each other. The windings of the propulsion bus's coil and wall conductors' coils are the same direction in the devices herein; i.e. both are clockwise (CW) or both counter clockwise (CCW) when looking in the muzzle to breech direction for ease of presentation. The wall conductors' coils direction whether CW or CCW is determined by of their windings about the cavity axis from the contact means at the cavity. The propulsion bus's coil direction whether CW or CCW is determined by the current direction about the projectile's axis from the propulsion bus's end contact means at its current input. Regardless the direction of the projectile's propulsion bus's coil winding, the propulsion bus's contact means power rail continuities permit current circulation about the projectile's axis (cw or ccw) only in the same direction as the current circulation about the barrel cavity axis in forward wall conductors' coils (cw or ccw) and only in direction opposite the current circulation about the barrel cavity axis in aft wall conductors' coils (ccw or cw).

[0034] With an outside power source connected to the power rail terminals to outside the barrel and a projectile in or inserted into the barrel cavity of the device where the barrel rails and wall conductor assembly of the invention are extant, the electric current paths in the device, one between

the power rails through the projectile's propulsion bus and a second between the power rails via the projectile's current shunts through the forward wall conductors, the barrel bus, and the aft wall conductors of the wall conductor assembly, are extant.

[0035] A current element at the intersection of an axial plane of the cavity with each turn of the projectile's propulsion bus's coil interacts with the magnetic fields of the current elements at said plane's intersection with each windings of a forward wall coil creating forces in the propulsion bus's coil with muzzle directed cavity axis parallel components. Also, the magnetic fields of the current element at the intersection said plane with each turn of aft wall conductor's coil interact with the current element at said plane's intersection of each turn of the propulsion bus's coil creating forces in the projectile's propulsion bus's coil with muzzle directed cavity, axis parallel direction. Said cavity axis parallel, muzzle directed forces propel the projectile towards the muzzle in the barrel cavity.

[0036] When viewed with respect to the polarity of the magnetic fields generated by the wall conductor coils and projectile's propulsion bus coil, the forward wall conductor coils and the projectile's propulsion bus coil have the same field polarity and the propulsion bus coil's north pole is proximal the forward wall conductor coil's south pole and the aft wall conductor coil and said propulsion bus fields have reversed polarities and the south pole of aft wall conductor coil is proximal the propulsion bus coil's south pole, so that forward wall conductor coil's field appears to attract the projectile's propulsion bus coil field towards the barrel cavity muzzle and the aft wall conductor coil field appears to repels the projectile's propulsion bus coil field towards the barrel cavity muzzle.

[0037] Terminology

[0038] AFT WALL CONDUCTOR: With a projectile for the device in the barrel cavity, the aft wall conductors is the group of one or more consecutive wall conductors which have, at any instant, continuous electrical continuity with said projectile's aft current shunt surface via their contact means at the barrel cavity at said shunt's barrel cavity location. During a projectile movement in the barrel cavity, said continuous electrical continuity is continuous sliding electrical continuity as the projectile's aft current shunt surface passes across said contact means.

[0039] AXIS PLANE OR AXIAL PLANE: An axis plane or axial plane is any plane which is coincident with the barrel cavity's axis or projectile's axis; i.e. the axis is completely within an axis plane.

[0040] BARREL BUS AND POWER RAILS LOCATION AND LENGTH: Power rail and barrel bus lengths and locations along the barrel cavity might vary slightly from one another in a design and the barrel bus, although shown as a ridged straight conductor herein, might be a flexible conductor connecting the wall conductor coils of the wall conductor assembly with large deflections from a straight pathway through the barrel wall and completely or partially outside the barrel. Therefore, the spatial relationships between the power rails herein described use terms 'like' and 'similar' to include these minor variations. Examples follow. The power rail with forward current shunt continuity might be shortened at the breech or displace in the muzzle direction by the distance between the breech proximal edge of the propulsion bus's contact means at said power rail and the breech proximal edge of the aft current shunt. The power rail with aft current shunt continuity might be shortened at its muzzle end by the distance between the muzzle proximal edges of the projectile's propulsion bus's contact means at said rail and the forward current shunt. The barrel bus length and location along the barrel cavity length might vary by as much as the width of a wall conductor at the breech and muzzle ends of the assembly.

[0041] BARREL CAVITY: The barrel cavity profile in all right sections through the barrel where the topic invention is extant are alike and elsewhere the barrel's cavity permits unobstructed traverse by a projectile of the invention. The longer barrel and barrel cavity might contain sections before and/or after the barrel and barrel cavity of the invention. E.g. Sections in front of the breech end of the invention barrel might be a simple removable or expendable cap closing breech end of the cavity to the elements, or part of a rapid breech load mechanism, mount expendable pneumatic projectile injection cartridges or a projectile injection means using an embodiment of the invention to effect said injection, and/or may add or modify propellant or explosive payload or a guidance system of the projectile. Barrel and barrel cavity sections beyond the muzzle of the invention might include a simple frangible end cap protection of the muzzle from the elements or include other electromagnetic propulsion means and/or a safe-unsafe trigger mechanism for an explosive payload of the projectile.

[0042] BARREL CAVITY WALL: The barrel cavity wall is comprised of the barrel from the barrel cavity surface outward and in the invention contains the power rails and wall conductor assembly.

[0043] BARREL POWER RAIL: A barrel power rail is a conductor in the barrel cavity wall which is parallel the cavity central axis or has a twist of constant angle displacement about the cavity axis per unit of cavity axis length. A power rail extends the barrel length of the invention and has continuous barrel cavity surface its length. Each power rail has continuous electrical continuity via said surface with elements of a projectile in the barrel cavity and has a connection means to outside the gun's barrel for connection to an outside power source.

[0044] CAVITY CENTRAL AXIS: The cavity central axis is the line through the centroid centers of the cavity's profile area in right section planes (diametric planes) along the length of the cavity where the invention is extant.

[0045] CIRCUMSCRIBES ONE OR MORE TIME: Physical encirclement of an object completely one or more times including additional fractions of complete encirclements when extant.

[0046] CONTINUOUS ELECTRICAL CONTINUITY: Continuous electrical continuity is used to indicate the low resistance electrical conductivity between electric current conducting elements in the projectile and electric current conducting elements in the barrel whether a projectile in the barrel cavity is stationary or in motion.

[0047] DIAMETRIC PLANE: The plane through an axis which includes all possible radii extending perpendicular to said axis from the point the plane intersects the axis, is a diametric plane and is also referred to as a right section plane herein.

[0048] ELECTRICAL ISOLATION: An element that is electrically isolated from another element lacks direct low resistance electrical continuity with said element. Magnetic and electric fields couplings are ignored. Indirect electrical continuity may still be extant between said elements through intermediate conducting elements.

[0049] FORWARD WALL CONDUCTOR: With a projectile in the barrel cavity, the forward wall conductor is the group of one or more consecutive wall conductors which have continuous electrical continuity, via their contact means at the barrel cavity, with the projectile's forward current shunt surface at the barrel cavity location of said contact means. During projectile movement in the barrel cavity, said continuous electrical continuity is continuous sliding electrical continuity as the projectile's forward current shunt surface passes across said contact means

[0050] LFMTB: Looking From Muzzle Towards Breech. With reference the direction a coil is wound or the current path direction in a circuit or coil.

[0051] ORTHOGONAL OR GENERALLY ORTHOGONAL: Includes orientations perpendicular and slightly askew to true perpendicular orientation as in the case of wall conductors' coils and the propulsion bus's coil whose turns are each slightly askew true perpendiculars; e.g. a diametric plane located and abutting the beginning of a turn of a coil will be at least the distance of the thickness of the conductor and its insulation from the end of the turn. However, the encasements of the insulated coils, when extant, of the wall conductors and propulsion bus usually have boundaries that are in diametric planes.

[0052] POWER RAIL: A power rail of the device extends the length of the barrel cavity, where the invention is extant, with a continuous surface which is part of the barrel cavity surface and has connection for attachment, via outside circuit means, to a terminal of an outside power source providing the power required to operate the device:

[0053] PROJECTILE: The terms projectile and armature are interchangeable herein. The profile shape in right section planes (diametric planes) through the projectile at its propulsion bus are like but slightly undersized the invention's barrel cavity profile in right section planes (diametric plane).

[0054] PROJECTILE BREECH END AND MUZZLE END: When a projectile is properly mounted for propulsion in the barrel cavity its breech end is closest the cavity's breech end and its muzzle end is located closest the cavity's muzzle end.

[0055] PROJECTILE CENTRAL AXIS: The projectile central axis is the line through the area centroid centers of the projectile profile in right sections taken through that portion of the projectile in the barrel cavity whose profiles have shape like but slightly undersized the barrel cavity's right section profile. The projectile central axis in the barrel cavity is approximately parallel and closely proximal the barrel cavity central axis or coincident said axis.

[0056] PROPULSION BUS AND PROPULSION BUS COIL: The propulsion bus coil and propulsion bus terms are used interchangeably and includes the propulsion bus's coil and leads therefrom to and includes the contact means at the ends of the propulsion bus. The propulsion bus coil is a continuous insulated conductor wound generally orthogonal to and about the projectile's axis and at or in close proximity the projectile's surface that is proximal the barrel cavity wall surface when in the barrel cavity. Segments at the ends of said coil may diverge from the coil winding path. The propulsion bus at one end of its coil includes a contact means that, with the projectile in the barrel cavity, has continuous electrical continuity with one power rail and at the other end of its coil includes a contact means that has continuous electrical continuity with the second power rail.

[0057] RIGHT SECTION: A right section or right section plane is a plane which is perpendicular to the central axis of a body or cavity. A right section plane is a diametric plane.

[0058] SLIDING ELECTRICAL CONTINUITY: The meaning of sliding electrical continuity between elements in the invention is expanded herein to include arrangements to effect electrical continuity which use sets of conducting rollers or roller balls which are retained in and electrically continuous with one element and have low friction electricity conducting contact with a surface on the second element.

[0059] TWIST: The profiles of elements (where extant) in right sections of a barrel with a twist and projectiles for use therein have constant angular relationships to each other at fixed radiuses with reference the cavity's and projectile's axis intercept of said planes from barrel's and projectile's breech end to muzzle end and said elements with said fixed angular relationships and radiuses, have a constant increasing (or decreasing) angular displacement from an axial reference plane, in consecutive right section planes taken at fixed increments along the axis from breech end to muzzle end; i.e. where $[\alpha_i-\alpha_o]/[d_i-d_o]$=constant, where α_o and d_o are any initial angle of said profile group to said reference plane and its distance along the axis, respectively, and α_i and d_i are the group's instant angle to the reference plane angle with and distance along the axes, respectively, with reference to the starting angle and distance.

[0060] WALL CONDUCTOR AND WALL CONDUCTOR COIL: The wall conductor and wall conductor coil terms are interchangeable herein and include the lead from the coil's end with continuity with the wall conductor assembly's barrel bus and the lead from the coil's other end with continuity with a wall conductor assembly's contact means at said lead. A wall conductor is one of the array of like elements of the wall conductor assembly. The wall conductor extend between and has electrical continuity with its contact means at the barrel cavity and the wall conductor assembly's barrel bus and is generally orthogonal the barrel cavity axis. Each wall conductor between its ends includes a coil of one or more turns of a continuous insulated conductor and each coil turn completely or in part circumscribes the barrel cavity and is located in the barrel wall proximal the barrel cavity wall surface except where contoured to pass across a power rail with isolation therefrom and segments at the ends of said coil may diverge from the coil winding path.

[0061] General Design Considerations

[0062] Beyond the barrel bus of the wall conductor assembly, the wall conductors' coils, and turns thereof are isolated from one another throughout their length. Said isolation is effected by insulating barrel material, insulating encasement material and an insulating coating or sleeves on the conductor.

[0063] The parallel arrangement of power rails, guides, channels, and barrel bus in the barrel and guides and channels, etc. in the projectiles of the drawings are a special case of twist wherein profile elements, where extant, of said barrel and projectiles in diametric planes have fixed angular displacement from each other at constant radiuses to the barrel cavity axis and projectile axis, respectively; however, they as a group in diametric planes do not have the constant change in angular displacement with reference an axial reference plane per unit of axial displacement that like elements in axial plans of guns with a twist have.

[0064] Both the propulsion bus's coil and the wall conductors' coils can have more than one row of windings and any practical number of windings per row. The coils in the drawings are only representations for the actual coils.

[0065] When in the barrel cavity, each projectile current shunt at any one time has electrical continuity with one or more wall conductor coils of the wall conductor assembly except before the beginning and beyond the end of the region of the invention in the barrel.

[0066] Although the wall conductors and their coils herein illustrated are uniformly distributed along the length of the barrel and have constant cross section areas, coil winding counts, wire gage, and spacing, these wall conductor's coil characteristics might vary along the length of an assembly.

[0067] E.g. In a device where barrel mass and durability is a design constraint, to avoid wall conductor failure due to prohibitive heat and subsequent resistance buildup, the wire size and/or number of turns in the wall conductor coils at the breech end of the barrel, where the projectile spends more time in its barrel cavity traverse, will likely be larger then those of the wall conductor coils of the wall assembly at the muzzle end of the barrel.

[0068] For clarity of presentation, the invention embodiments portrayed in the included figures are chemically bonded together in assembly. In practical applications and for quick refurbishment or repair, the embodiments would be assembled using mechanical fastening means well known in the arts.

[0069] Voids and masses necessary to locate a projectile's center of mass for inflight stability are not shown in the figures.

[0070] As a safety measure, the propulsion bus coil should be designed to melt or burst open from heat after the projectile's anticipated barrel cavity traverse time has elapsed.

[0071] Molding methods also well known in the arts can be used for the barrel, projectile and coil encasement fabrication.

[0072] The projectile's current shunts whose operational life is measured in milliseconds and fractions thereof can be simple formed pieces of sheet aluminum or copper alloy or other conducting material including carbon metal composites used for motor brushes, mass restrictions permitting.

[0073] The projectiles and barrel for the devices are preferably made of electrically non-conducting materials such as SiC or high strength proprietary plastics. The wall conductor assembly and power rails are made of good conducting materials such as copper, aluminum and iron alloys.

[0074] The wall conductor coils experience rapid field reversal during barrel cavity traverse by a projectile and any proximal residual magnetic energy (polarization) stored therein and their proximal supporting structure will have attenuating effects on the wall conductor coils magnetic field.

[0075] Generally, in regards the various embodiments of the invention, surfaces of elements of the invention having sliding electrical continuity with other elements thereof might be treated and/or machined and/or formed to effect a smooth more effective sliding continuity; e.g. a surface with boundary edges could have those edges rounded and the surface treated with low friction conducting substances and/or textured to assure a correct current path when elevated voltages are extant in the invention. A projectile can have variations in its surface extruded parallel its axis; i.e. corrugated surfaces with troughs parallel the projectile axis.

[0076] A coil's current direction, and/or winding direction are herein always indicated unless otherwise noted as clockwise (cw) or counter clockwise (ccw) when looking from the muzzle end to the breech end (LFMTB) of the coil.

[0077] Although the gun barrel cavities and their projectiles illustrated herein are cylindrical with generally circular right section profiles, the cavity of a gun barrel and its mating projectile can have other right section profile shapes; e.g. rectangular, triangular, polygonal, etc. In the guns with various cavity profiles, the coils of the gun's wall conductors and the projectiles for the gun and the coil of the projectile's propulsion bus would be shaped to accommodate the different right section profiles, without leaving the intended scope of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0078] FIG. **1** is an oblique view of an assembled shortened two rail electromagnetic gun **100** of the invention with a projectile **132** for the gun located near the gun's breech end. The barrel of the gun is cylindrical with cooling ribs and has two structural sections, **111** and **111***a*. The gun barrel has extending throughout its length—from the breech end cap, **125**, through, to and opening at the muzzle, barrel cavity **133**. Barrel cavity **133** has a uniform right cross section profile throughout its length and extends within cavity shell **120**, indicated in later figures—within the barrel structure proper. Indicated are the connection lugs, **128** and **131** of power rails **127** and **130**, respectively. In the figures herein, the power rail connection means are located proximal the guns' breeches; however, a power rail's connection means can be located anywhere along its length without effecting the gun's operation. Power rails' connection means are lugs **128** and **131** which connect to an outside power supply. The forward and aft current shunts, **134** and **137**, respectively, of projectile **132** are also indicated.

[0079] FIG. **2** is an oblique illustration of the gun in FIG. **1** disassembled. Indicated are barrel sections **111** and **111***a*. Barrel section **111** has an array of open channels **110** and barrel section **111***a* has a like array of open channels **110***a*. The arrays of channels **110** and **110***a* align when the gun is assembled and in the assembly retain the array of mating wall conductor coils **118** in their casings **118***c*. Barrel bus **117** is indicated and in the assembly has electrical continuity with each of the wall conductor coils **118** in their respective casings **118***c*. Barrel bus **117** is retained in open channel

110*b* in the barrel section **111***a* which, in the assembly, is closed off by barrel section **111**. Barrel bus **117** and the array of wall conductors **118** and their contact means **119** assembled are wall conductor assembly **116**. The barrel cavity **133** is within the assembled barrel cavity shell which is comprised halves **120** and **120***a* and extends through the opening in the barrel breech cap **125**. Indicated are the interior surfaces **120***i* and **120***ai* of the cavity shell sections **120** and **120***a*, respectively, and along with the inner surface of the opening in end cap **125** and the power rails' and wall conductors' contact means cavity surfaces in the assembled barrel comprise the barrel cavity's surface. Cavity shell section **120** has open channels **120***b* and **120***c* in which power rails **127** and **130**, respectively, are mounted in the assembly. In the assembled barrel, the coil of each wall conductor **118** of the wall conductor assembly **116** mounts on and circumscribes the cavity shell and barrel cavity **133** therein.

[**0080**] In the assembly, power rail lug **131** and **128** of power rails **130** and **127**, respectively, extend through channels **120***cc* and **120***bb*, respectively, in the end of cavity shell section **120**. In the assembled gun, lug **131** of power rail **130** extends to outside the barrel through the channel **120***cc* in cavity shell section **120** and channel **110***d* of barrel section **111** and lug **128** of power rail **127** extends to outside the barrel through the channel **120***bb* in the shell section **120** and channel **110***c* of barrel section **111**. The surface of barrel breech cap **125** abutting casing sections **111** and **111***a* in the assembled gun closes the breech side of the channels retaining with the power rail lugs.

[**0081**] Also shown are the array of 'U' shaped contact means **119**, which in the assembled gun are mounted in cavity section **120** at spaced intervals from breech to muzzle. In the assembled gun each contact means **119** has barrel cavity surface at its barrel cavity location and is electrically continuous with one end of the coil of the proximal wall conductor **118** of the wall conductor assembly **116**.

[**0082**] FIG. **3** is a section of the barrel near the breech end of the gun cutaway to illustrate the arrangement of parts in the assembled gun. Shown are the barrel's sections **111** and **111***a* and power connection lug **131** of power rail **130** and power connection lug **128** of power rail **127** projecting from barrel section **111**. Also indicated is breech end cap **125**. Indicated are the array of coils of the wall conductors **118** in their casings **118***c* which mount on the cavity shell's exterior surfaces **120***e* and **120***ae* and circumscribe the barrel cavity shell comprised of sections **120** and **120***a*, and the barrel cavity **133** therein. Shell section **120** has an array of opening sets **121** and **121***a* from its exterior surface **120***e* into the barrel cavity **133**. In each set of openings **121** and **121***a* is mounted a wall conductor contact means **119**, which in turn has electrical continuity with the proximal wall conductor's coil. Indicated is barrel bus **117** in channel **110***b*. Barrel bus **117** has continuous electrical continuity with each of the coils of the wall conductors in the gun. Indicated in the barrel cavity **133** is a projectile **132** with its channels **105** and **107** and guides **106** and **108** and its forward current shunt **134** and aft current shunt **137**. Power rails **127** and **130** are also indicated and have electrical continuity with surface of forward and aft current shunt, respectively.

[**0083**] FIG. **4** is a look into a section of the barrel cavity at an angle and towards the gun's breech. Along with the barrel cavity section **111** and **111***a* and cavity shell sections **120** and **102***a* is indicated projectile guide **180** projecting into barrel cavity **133** from cavity surface **1201** which is used along with guides **179**, **103** and **103***a*, to maintain orientation of a projectile during its traverse of the barrel cavity **133**. Note the array of contact means **119** in guide **180**, whereat they supplant and continue the guide.

[**0084**] With reference also to FIGS. **5** and **6**, the channel **105** of a projectile **132** when in the barrel cavity has guide **180** and contact means **119** therein and one or more contact means **119** maintain electrical continuity with the forward current shunt **134** surface **136** where said shunt supplants and continues channel **105** in the projectile and the wall conductor coils attached to said contact means are forward wall conductor coil. One or more contact means **119** also maintain electrical continuity with surface **138** of aft current shunt **137** where said shunt supplants and continues projectile channel **105**. The wall conductor coils attached to said contact means are aft wall conductor.

[**0085**] Power rail **127** has barrel cavity surface **126** and surface **126** has open channel **126***c*, and both extend the length of the rail. When in the barrel cavity, the projectile's guide **106** along with surface **135** of its forward current shunt **134** where said shunt supplants and continues guide **106** and the contact means **140** of the projectile's propulsion bus coil **141** where it supplants and continues guide **106** are in channel **126***c* and while therein said shunt surface and coil contact means maintain continuous electrical continuity with the power rail **127**. To permit unobstructed traverse of the barrel cavity by a projectile, channel **126***c* has extension **126***a* in the barrel cap and **126***b* in the barrel cavity shell beyond the power rail proximal the muzzle.

[**0086**] Power rail **130** has barrel cavity surface **129** and surface **129** has open channel **129***c*, and both extend the length of the rail. When in the barrel cavity, the projectile's guide **108** along with surface **139** of the aft current shunt **137** where said shunt supplants and continues guide **108** and the contact means **142** of propulsion bus coil **141** where it also supplants and continues guide **108** are in channel **129***c* and while therein said shunt surface and coil contact means maintain continuous electrical continuity with the power rail **130**. Channel **129***c* has extension **129***a* in the barrel cap and extension **129***b* in the barrel cavity shell beyond the power rail proximal the muzzle. Optional guide **179**, between the power rails **127** and **130** is to reduce sparking between the rails when higher voltages are used. When a projectile is in the barrel cavity guide **179** is in the projectile's open channel **107**.

[**0087**] FIG. **5** is a projectile **132** for the gun and is comprised of major sections **132***a* and **132***b*. In profile are channels **147** and **147***a* which travel on guides **103** and **103***a*, respectively, of cavity shell section **120***a* during the projectile's traverse of the barrel cavity. Forward current shunt **134** is indicated in the projectile surface whereat it supplants and continues, along with the cylindrical surface of the projectile, the channel **105** and guide **106** of said surface. Forward current shunt **134** has surface **136** in channel **105** and surface **135** in guide **106**.

[**0088**] The contact means **140** of the projectile's propulsion bus coil **141** in its extension through opening **151** is indicated in the surface of guide **106** where it supplants and continues said guide. The contact means **142** of the projec-

tile's propulsion bus coil in its extension through opening **153** is indicated in the surface of guide **108** where it supplants and continues said guide.

[**0089**] Aft current shunt **137** and its insulating element **1371** are indicated in the projectile's surface whereat they supplant and continue, along with the cylindrical surface of the projectile, the channels **105** and **107** and guides **106** and **108** of said surface. Aft current shunt **137** has surface **138** in channel **105** and surface **139** in guide **108**. The aft shunt insulating element **137***i* electrically isolates the shunt **137** from power rail **127** when in the barrel cavity.

[**0090**] When the projectile **132** is in the barrel cavity **133**, guide **108** travels in cavity surface channel **129***c* of power rail **130** and propulsion bus coil contact means **142** and aft current shunt surface **139** in guide **108** maintain continuous electrical continuity thereby with power rail **130**. Guide **106** travels in cavity surface channel **126***c* of power rail **127** and propulsion bus coil contact means **140** and surface **135** of forward current shunt **134** in guide **106** maintain continuous electrical continuity thereby with power rail **127**.

[**0091**] Cavity guide **179** is in channel **107** of a projectile in the barrel. Cavity guide **180** and the wall conductor contact means **119** spaced therein from breech to muzzle whereat they supplant and continue said guide are in channel **105** of a projectile in the barrel cavity.

[**0092**] With a projectile **132** in the cavity, surface **136** of forward current shunt **134** in channel **105** maintains continuous electrical continuity with the one or more wall conductor's contact means **119** located in cavity guide **180** at said surface's location in the barrel cavity and the wall conductor coil of each said contact means is a forward wall conductor; i.e. when a wall conductor's contact means has electrical continuity with the forward current shunt of a projectile, it is a forward wall conductor.

[**0093**] In said projectile, surface **138** of aft current shunt **137** in channel **105** maintains continuous electrical continuity with the one or more wall conductor's contact means **119** in cavity guide **180** at said shunt surface's location in the barrel cavity and the wall conductor of each said contact means is an aft wall conductor; i.e. when a wall conductor's contact means has electrical continuity with the aft current shunt of a projectile it is an aft wall conductor.

[**0094**] FIG. **6** is the projectile **132** in FIG. **5** disassembled. Indicated in front section **132***a* is relief **150** in the projectile's surface in which forward current shunt **134** is retained. Also indicated are openings **151** and **153** in guides **106** and **108** respectively, into which, in the assembled projectile, the contact means **140** and **142** of the propulsion bus extend respectively. Propulsion bus coil **141** mounts in cavity **154***a* of the projectile's front section **132***a* on shank extension **154** of projectile section **132***b* which fits therein; i.e. in the assembled projectile, propulsion coil **141** is mounted on aft projectile section shank **154** and both are retained in cavity **154***a* in the forward projectile section **132***a*. In the aft section **132***b* is relief **152** in the projectile's surface which retains aft current shunt **137** with its insulating insert **1371**.

[**0095**] FIG. **7** is a cutaway portion of the gun with a projectile **132** in the casing cavity **133** used to illustrate the current paths in the gun. In addition to the elements already discussed, note the end fixture **118***b* on each wall conductor coil **118**. Each end fixture **118***b* is attached with good electrical continuity to its respective coil's end at the barrel bus **117** and barrel bus **117** of the wall conductor assembly **116** fits through fixture **118***b* of each of the wall conductor coil **118** with good electrical continuity.

[**0096**] The current path in the barrel circuit is indicated by italic letters 'a' through 'j' and the propulsion bus coil **141** is electrically in parallel with the wall conductor assembly circuit across power rails **127** and **130**.

[**0097**] The current through the propulsion bus is limited by the inherent resistance of its conductor material, the cross section area of its conductor and the length of the windings

[**0098**] The wall conductor circuit has sliding contact resistance due to the continuity of contact means **119** with a projectile's current shunts in addition to the sliding contact resistance with the power rails also experienced by the propulsion bus coil circuit. The wall conductor coils and the propulsion bus coil of projectiles for the topic gun are herein wound in a clockwise direction LFMTB. Looking to the projectiles propulsion bus circuit with power rail **127** connected to the positive terminal of an outside power supply and power rail **130** connected to the return terminal, current in power rail **127** is muzzle directed. Current passes from power rail **127** to the propulsion bus coil **141** via the propulsion bus's contact means **140** and circulates in a clockwise direction therein and exits therefrom via the propulsion bus's contact means **142** to power rail **130** wherein it continues in the breech direction to the return terminal of said power supply.

[**0099**] The wall conductor circuit current path is muzzle directed in power rail **127** from 'a' to 'b'. Where 'b' is at the continuous electrical continuity of forward current shunt **134** surface **135** with power rail **127**. Current in the forward current shunt **134** is clockwise from 'b' to 'c' where 'c' is at the continuous electrical continuity of forward wall conductor's contact means **119** with the projectile's forward current shunt surface **136**. Current continues from 'c' at contact means **119** in forward wall conductor coil **118**, indicated as 'd', circulating therein in a clockwise direction and exiting said coil at 'e', which is at the electrical continuity of said coil's end fixture **118***b* with the barrel bus **117**.

[**0100**] Current is breech directed in barrel bus **117** from 'e' to 'f' whereat the aft wall conductor's coil end **118***b* has electrical continuity with barrel bus **117**. Current continues from 'f', the end of the aft wall conductor coil at the barrel bus, in aft wall conductor coil, **118**'g', circulating therein with counterclockwise direction; to 'h' at the aft wall conductor coil's contact means **119** in the barrel cavity and said contact means electrical continuity with surface **138** of the projectile's aft current shunt **137**, current in the aft current shunt is counter clockwise 'h' to 'i' whereat the aft current shunt surface **139** has continuous electrical continuity with power rail **130**. Current is breech directed in power rail **130**; i.e. from 'i' to 'j'. Current in power rail **130** continues to the return terminal of said power supply.

[**0101**] With current supplied to the gun via the power rails' lugs, the magnetic fields of the clockwise current circulation in a forward wall conductor coil interact with the clockwise current circulation in the propulsion bus coil of a projectile in the barrel cavity creating forces therein with muzzle directed, cavity axis parallel, components; i.e. apparent forces of attraction are created between forward wall

conductor coils and the projectile's propulsion bus coil. The magnetic fields of the counter clockwise current circulation in an aft wall conductor coil interact with the propulsion bus coil current creating therein forces with muzzle directed, cavity axis parallel, components; i.e. apparent forces of repulsion are created between an aft wall conductor coils and the projectile's propulsion bus. The collection of muzzle directed, cavity axis parallel, force components acting on the projectile's propulsion bus coil propels the projectile in the barrel cavity from breech towards muzzle.

[**0102**] When the polarity of the power rails is reversed, current in power rail **130** is muzzle directed and in power rail **127** breech directed. Current circulation in the projectile's propulsion bus coil **141** is counter clockwise from contact means **142** at power rail **130** to contact means **140** at power rail **127**. In the wall conductor assembly circuit, current is muzzle directed in power rail **130** from 'j' to 'i' at surface **139** of aft current shunt **137** and in the shunt has a clockwise direction from 'i' to 'h' at aft current shunt surface **138** and its continuous continuity with contact means **119** of aft wall conductor at its barrel cavity location and therefrom with clockwise circulation in the aft wall conductor's coil, 'g', and exiting therefrom at 'f', the aft wall conductor coil's connection means **118***b* with the barrel bus **117**. Barrel bus **117** current is muzzle directed and exits at 'e' at the connection means **118***b* of forward wall conductor coil **118**, 'd', wherein it circulates in a counterclockwise direction and exits to 'c' at the electrical continuity of the forward wall conductor's contact means **119** with the forward current shunt **134**. Current in the forward current shunt is counter clockwise to power rail **127**; i.e. from current circulation in the coil of a forward wall conductor interacts with the counter clockwise current circulation in the projectile's propulsion bus coil creating forces therein with muzzle directed, cavity axis parallel, components; i.e. apparent forces of attraction are created between the coil of a forward wall conductor and the projectile's propulsion bus coil.

[**0103**] The magnetic fields of the clockwise current circulation in the coil of an aft wall conductor coil interact with the counter clockwise current circulation of the projectile's propulsion bus coil creating therein forces with muzzle directed, cavity axis parallel, components; i.e. apparent forces of repulsion are created between the coil of an aft wall conductor and the projectile's propulsion bus coil. The collection of muzzle directed, cavity axis parallel, force components acting on the projectile's propulsion bus coil propels the projectile in the barrel cavity from breech towards muzzle.

[**0104**] FIG. **8** is an enlargement of the central portion of FIG. **7** to more closely illustrate contact means **119** in their mountings through cavity shell section **120**. The contact means **119** of each wall conductor coil **118** has a leg extending radially out from each end of its body. At its barrel cavity location the body of contact means **119** supplants and continues cavity guide **180**. Said legs, **119***a* and **119***c*, extend through openings **121** and **121***a*, respectively, in cavity shell **120** and are retained therein by nuts **119***b* and **119***d*, respectively. Leg **119***a* extends beyond its retaining nut as a shank on which connector **118***a* of wall conductor coil **118** mounts for low resistance electrical continuity therewith.

[**0105**] In the portrayed gun, the current directions in the projectile's current shunts are the same as in their proximal conducting wall conductor coil, and the resulting radially outward acting forces on the shunts maintain the electrical continuity between said shunts and contact means **119** and the power rails; i.e. The current in forward current shunt **134** and the coil of forward wall conductor coil **118** are like directed creating forces of attraction there between which maintains continuous electrical continuity between surface **135** of shunt **134** and power rail **127** and surface **136** of said shunt and contact means **119** of said forward wall conductor coil.

[**0106**] The current in aft current shunt **137** and the coil of the aft wall conductor coil **118** are like directed creating forces of attraction there between which maintains continuous electrical continuity between surface **139** of shunt **137** and power rail **130** and surface **138** of said shunt and contact means **119** of aft wall conductor coil.

[**0107**] Although the invention has been described herein with reference to the presently preferred embodiments, a great number of modifications, changes and alterations including alternative configurations of said embodiments are possible without departing from the spirit, and scope of the invention as defined in the appended claim and equivalents thereof.

What is claimed is:

1. An electromagnetic gun comprising:

a barrel with

a cavity therein that extends the length of said barrel and having:

a breech end opening at one end, and

a muzzle end opening at the other end, and

a central axis which extends from said breech end opening to said muzzle end opening, and

a uniform right section profile to said central axis throughout said cavity; and

two power rails which:

are located in the barrel cavity wall, and

have fixed angular displacement to each other at fixed radiuses about said barrel cavity axis throughout their length, and

are electrically insulated from direct electrical continuity with one another and other electrically conductive elements in said barrel cavity wall, and

each said power rail has:

connection means to outside said barrel for attachment of circuitry from an outside power source, and

continuous surface its length that is part of the barrel cavity's surface; and

a wall conductor assembly

located in the barrel cavity wall, and

comprising:

a barrel bus which is located:

outside the barrel cavity, and

along the same barrel length as said power rails and

electrically insulated therefrom, and

a plurality of wall conductor coils that:

are located outside said barrel cavity, and

have like directed windings about said cavity, and

are oriented orthogonal said barrel cavity's axis, and

are separated from one another in distribution along the length of said cavity, and

each said wall conductor coil:

is a continuous insulated conductor between its ends, and

circumscribes said barrel cavity one or more times in the barrel cavity wall, and

is at or very near the barrel cavity surface except where shaped to avoid physical and electrical continuity with the power rails, and

has, at one end, electrical and physical continuity with said barrel bus, and

has, at its other end, an electrical contact means at said barrel cavity through a mating opening in said cavity's surface, and

is electrically insulated from its surroundings beyond said barrel bus except at said contact means; and

projectiles for:

insertion into the breech end of said barrel cavity, and

propulsion through said cavity towards its muzzle end, and

in the barrel cavity each said projectile has:

its central axes very close or coincident said barrel cavity's central axis, and

right section profiles smaller then said barrel cavity's right section profile, and

a portion of the said projectile's profiles similar to the barrel cavity's right section profile in shape and slightly undersized thereof, and

each said projectile has:

a forward current shunt in its surface near its muzzle end, and

said shunt is electrically insulated from all other electrically conducting elements in said projectile, and

with said projectile in said barrel cavity,

said forward current shunt has:

surface with continuous electrical continuity with said cavity surface of one power rail, and

surface with continuous electrical continuity with the contact means of the wall conductor coils at its barrel cavity location; and

forward wall conductor coils which are:

extant when a projectile is in said barrel's cavity, and

comprised of the group of one or more consecutive wall conductors coils that at any instant have electrical continuity via their contact means with said projectile's forward current shunt; and

said forward current shunt maintains continuous electrical continuity between the wall conductor coils comprising at any instant said forward wall conductor coils of said wall conductor assembly and said power rail; and

each said projectile also has:

an aft current shunt in its surface near its breech end, and

said shunt is electrically insulated from all other electrically conducting elements in said projectile, and

with said projectile in the barrel cavity,

said projectile's aft current shunt has:

surface with continuous electrical continuity with said cavity surface of the power rail without said forward current shunt's electrical continuity, and

surface with continuous electrical continuity with the contact means of the wall conductor coils at its barrel cavity location; and

aft wall conductor coils which are:

extant when a projectile is in said barrel's cavity, and

comprised of the group of one or more consecutive wall conductors coils that at any instant have electrical continuity via their contact means with said projectile's aft current shunt; and

said aft current shunt maintains continuous electrical continuity between said wall conductor coils comprising at any instant said aft wall conductor coils of said wall conductor assembly and said power rail; and

each said projectile also has

a propulsion bus coil which is located:

forward said aft current shunt, and

aft said forward current shunt, and

orthogonal to the axis of the projectile and

said coil is a continuous insulated conductor

with one or more turns which circumscribe said projectile's axis, and

located at or close to the projectile's surface proximal the barrel cavity's surface, and

said propulsion bus coil has:

a contact means at both ends in the surface of the projectile, and

with said projectile in the barrel cavity,

one said contact means has continuous electrical continuity with one said power rail and

the second said contact means has continuous electrical continuity with the second said power rail,

so that in the energized gun,

the current circulation about the cavity axis in the propulsion bus coil has the same direction as the current circulation about said axis in said forward wall conductor coils and counter the direction of the current circulation in said aft wall conductor coils; and

with a projectile in said barrel cavity,

there are two circuits extant between the two power rails, and one said circuit includes:

said forward current shunt of said projectile, and

said forward wall conductor coils of said wall conductor assembly, and

said barrel bus, and

said aft wall conductor coils of said wall conductor assembly, and

said aft current shunt of said projectile, and

said second circuit includes said projectile's propulsion bus coil; and

with power supplied to the power rails via their said connection means,

the magnetic fields of the current in said forward wall conductors, and

the magnetic fields of the current is said aft wall conductor coils interact with

the current in said propulsion bus coil of said projectile to propel said projectile from breech to muzzle in said barrel cavity.

2-12. (canceled)

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