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(54) Benævnelse: **Systemer og fremgangsmåder til reduktion af uønskede hvirvelstrømme**

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DESCRIPTION

FIELD

[0001] The subject matter described herein relates generally to magnetic plasma confinement systems and, more particularly, to systems and methods that facilitate cancellation of undesired eddy currents.

BACKGROUND

[0002] The Field Reversed Configuration (FRC) belongs to the class of magnetic plasma confinement topologies known as compact toroids (CT). It exhibits predominantly poloidal magnetic fields and possesses zero or small self-generated toroidal fields (*see* M. Tuszewski, Nucl. Fusion 28, 2033 (1988)). The traditional method of forming an FRC uses the field-reversed θ-pinch technology, producing hot, high-density plasmas (*see* A. L. Hoffman et al., Nucl. Fusion 33, 27 (1993)). A variation on this is the translation-trapping method in which the plasma created in a theta-pinch "source" is more-or-less immediately ejected out one end into a confinement chamber. The translating plasmoid is then trapped between two strong mirrors at the ends of the chamber (*see, for instance,* H. Himura et al., Phys. Plasmas 2, 191 (1995)).

[0003] Significant progress has been made in the last decade developing other FRC formation methods: merging spheromaks with oppositely-directed helicities (*see, e.g.* Y. Ono et al., Nucl. Fusion 39, 2001 (1999)) and by driving current with rotating magnetic fields (RMF) (*see, e.g.* I. R. Jones, Phys. Plasmas 6, 1950 (1999)) which also provides additional stability. Recently, the collision-merging technique, proposed long ago (*see, e.g.* D. R. Wells, Phys. Fluids 9, 1010 (1966)) has been significantly developed further: two separate theta-pinches at opposite ends of a confinement chamber simultaneously generate two plasmoids and accelerate the plasmoids toward each other at high speed; they then collide at the center of the confinement chamber and merge to form a compound FRC. In the construction and successful operation of one of the largest FRC experiments to date, the conventional collision-merging method was shown to produce stable, long-lived, high-flux, high temperature FRCs (*see, e.g.* M. Binderbauer et al., Phys. Rev. Lett. 105, 045003 (2010)).

[0004] When an FRC translates into the confinement section, it induces eddy currents in any conducting structure within its vicinity (e.g. the vessel wall or conducting in-vessel components). These eddy currents influence the plasma state and decay over time, thereby contributing to a continuous evolution of the plasma and preventing any steady-state until the eddy currents have decayed to negligible magnitudes. If the conducting structures are not axisymmetric (which is generally the case), the eddy currents break the axisymmetry of the FRC. Overall, such translation-induced eddy currents are undesirable. Their initial excitation imposes constraints on the plasma shape and thereby limits the ability of conducting structures

to provide passive stabilization of plasma instabilities, and their decay over time complicates plasma control by requiring continuous compensation even in the absence of plasma instabilities. Furthermore, any beneficial effects of translation-induced eddy currents can also be provided by suitable adjustments of the equilibrium magnetic field.

[0005] Translation-induced eddy currents are not the only type of eddy currents that arise during experiments. Plasma instabilities may excite eddy currents which reduce the growth rate of the instability and are thus desirable. Eddy currents will also arise in response to neutral beam current ramp-up.

[0006] Plasma lifetimes in other FRC experiments have typically been limited to values significantly lower than the resistive timescale of the conducting wall, so that time-varying eddy currents did not pose any practical problems and have not been receiving much attention.

[0007] One related technique to prevent the excitation of translation-induced eddy currents is the use of insulating axial "gaps" in the vessel to prevent the excitation of axisymmetric eddy currents. The drawback of this method is that it requires structural changes to the conducting vessel, and that eddy currents are not suppressed but axisymmetric currents are transformed into 3-D currents. This thus aggravates the detrimental effects from 3-D fields and also makes the wall unsuitable for passive stabilization of axisymmetric plasma instabilities.

[0008] Three dimensional error fields are often corrected by error field correction coils that are themselves not axisymmetric. In the best case, such coils can eliminate as many harmonics as there are coils, but they tend to introduce new errors in the remaining harmonics and need to be able to follow any time-variation of the error fields during the experiment.

[0009] Therefore, it is desirable to provide systems and methods that facilitate the reduction or elimination of undesirable eddy currents.

[0010] United States Patent Application US 5451877 discloses a method for the compensation of eddy currents caused by gradients in nuclear magnetic resonance apparatus wherein a gradient pulse is activated and a nuclear magnetic resonance signal is excited in a slice of a spatially extended phantom, the nuclear magnetic resonance signal is acquired after the end of the gradient pulse and during the decay time of the eddy currents caused by said gradient pulse and the eddy current magnetic field is identified from the phase curve of this nuclear magnetic resonance signal. A filter for the gradient system that generates the gradient pulse is calculated on the basis of the eddy current magnetic field identified in this way.

[0011] United States Patent Application US 2014/084925 discloses a prepolarizing magnetic resonance or relaxation-based measurement system, comprising a pre-polarizing coil for producing a prepolarizing field at the target zone, means for pulsing the prepolarizing field according to a first pulsing scheme, and means for measuring magnetization of a target placed in the target zone.

[0012] Publication F Gnesotto: "RFX: new tools for real-time MHD control", 2005, XP055522032, discloses a summary of principal results obtained in the past by means of active control of magnetic fields in RFX, describing recent modifications to the machine and improvements to power supplies and magnetic diagnostics. The old thick shell has been replaced by a much thinner shell, whose electromagnetic time constants are much shorter than pulse duration, and a system of 192 radial field coils has been added, covering the whole torus surface. In addition, models used to design the new real-time control system of RFX and some preliminary results are disclosed.

[0013] International PCT Application WO 2013/074666 discloses systems and methods that facilitate the formation and maintenance of new high performance Field Reversed Configurations (FRCs). An FRC system for the High Performance FRC (HPF) includes a central confinement vessel surrounded by two diametrically opposed reversed-field-theta-pinch formation sections and, beyond the formation sections, two divertor chambers to control neutral density and impurity contamination. A magnetic system includes a series of quasi-de coils axially positioned along the FRC system components, quasi-de mirror coils between the confinement chamber and the adjacent formation sections, and mirror plugs between the formation sections and the divertors. The formation sections include modular pulsed power formation systems that enable FRCs to be formed in-situ and then accelerated and injected (=static formation) or formed and accelerated simultaneously (=dynamic formation).

[0014] Publication B. E. Chapman ET AL: "Observation of tearing mode deceleration and locking due to eddy currents induced in a conducting shell", PHYSICS OF PLASMAS, vol. 11, no. 5, May 2004, pages 2156-2171, XP055522040, ISSN: 1070-664X, DOI: 10.1063/1.1689353 discloses that growth to large amplitude of a single core-resonant tearing mode in the Madison Symmetric Torus reversed-field pinch is accompanied by braking and eventual cessation of mode rotation. There is also a concurrent deceleration of bulk plasma rotation. The mode deceleration is shown to be well described by a time-dependent version of a magnetohydrodynamical model in which a braking torque originates from eddy currents induced by the rotating mode in the conducting shell surrounding the plasma. According to the model, the electromagnetic braking torque is localized to the plasma in the immediate vicinity of the mode's resonant surface, but viscosity transfers the torque to the rest of the plasma.

SUMMARY OF INVENTION

[0015] Embodiments provided herein are directed to systems and methods that facilitate the reduction in amplitude of undesirable eddy currents (wall currents), e.g., translation-induced eddy currents such as eddy currents induce by translation of FRC plasmas, while leaving beneficial eddy currents unaffected. The reduction in amplitude of undesirable eddy currents is achieved by inducing opposing currents in the same structures prior to plasma translation, for example using active coils. If both tangential and normal components of the total magnetic field on a surface separating the plasma from the conducting structures are measured, the field can be decomposed into components produced by the plasma and components produced by

exterior currents (eg. equilibrium coil currents). By subtracting the known fields from exterior coils, the field due to eddy current remains. The corresponding eddy current distribution can be reconstructed from the time evolution of this field. With the eddy current distribution known, active coils are used to induce a similar distribution with an opposite sign before the plasma translates into the chamber. Calculating the necessary coil currents requires knowledge of only the geometry of the active coils and passive structures. When the plasma translates into the confinement chamber, the two eddy current distributions superimpose and cancel. The more exact the eddy current distribution is reproduced, the more complete is the cancellation.

[0016] The systems and methods described herein advantageously:

- reduce time-varying external fields due to decaying eddy currents, which interfere with plasma control;
- reduce symmetry-breaking effects of a non-axisymmetric wall; since both pre-induced and translation-induced eddy currents have the same 3-D structure, 3-D fields are reduced without the need for non-axisymmetric coils; and
- enable the installation of close fitting, axisymmetric, in-vessel structures to increase passive stabilization of axisymmetric and non-axisymmetric instabilities.

[0017] Other systems, methods, features and advantages of the example embodiments will be or will become apparent to one with skill in the art upon examination of the following figures and detailed description.

BRIEF DESCRIPTION OF FIGURES

[0018] The details of the example embodiments, including structure and operation, may be gleaned in part by study of the accompanying figures, in which like reference numerals refer to like parts. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, all illustrations are intended to convey concepts, where relative sizes, shapes and other detailed attributes may be illustrated schematically rather than literally or precisely.

FIGURE 1 is a schematic of a chamber or vessel with formation tubes attached to opposing ends and axisymmetric coils positioned around the wall of the chamber for inducing eddy currents in the wall of the chamber (wall currents).

FIGURE 1A is a schematic showing a control system coupled to an active coil system and a formation system.

FIGURE 2 is a schematic of the chamber and formation tubes in Figure 1 with a plasma present in the formation tube.

FIGURE 3 is a schematic of the chamber and formation tubes in Figure 1 following translation

of the plasma into the chamber and showing translation-induced eddy currents formed in the wall of the chamber (translation induced wall currents).

FIGURE 4 is the chamber and formation tubes in Figure 1 prior to translation of the plasma into the chamber with pre-induced eddy currents formed in the wall of the chamber (pre-induced wall currents).

FIGURE 5 is the chamber and formation tubes in Figure 1 following translation of the plasma into the chamber and showing the pre-induced and translation-induced eddy currents in the wall of the chamber (pre-induced and translation-induced wall currents).

FIGURE 6 is the chamber and formation tubes in Figure 1 following translation of the plasma into the chamber and showing the translation-induced eddy currents in the wall of the chamber (translation induced wall currents) cancelled out by the pre-induced eddy currents in the wall of the chamber (pre-induced wall currents).

FIGURE 7 is a graph showing the simulated eddy current distribution in an axisymmetric wall of the chamber (simulated wall current distribution) for three (3) cases: (1) no pre-induced, (2) pre-induced, and (3) pre-induced and adjusted vacuum field.

[0019] It should be noted that elements of similar structures or functions are generally represented by like reference numerals for illustrative purpose throughout the figures. It should also be noted that the figures are only intended to facilitate the description of the preferred embodiments.

DETAILED DESCRIPTION

[0020] Each of the additional features and teachings disclosed below can be utilized separately or in conjunction with other features and teachings to provide systems and methods that facilitate the reduction in amplitude of undesirable eddy currents (wall currents), e.g., translation-induced eddy currents, while leaving beneficial eddy currents unaffected. Representative examples of the embodiments described herein, which examples utilize many of these additional features and teachings both separately and in combination, will now be described in further detail with reference to the attached drawings. This detailed description is merely intended to teach a person of skill in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention being defined by the appended claims. Therefore, combinations of features and steps disclosed in the following detail description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly describe representative examples of the present teachings.

[0021] Moreover, the various features of the representative examples and the dependent

claims may be combined in ways that are not specifically and explicitly enumerated in order to provide additional useful embodiments of the present teachings. It is also expressly noted that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure.

[0022] Embodiments provided herein are directed to systems and that facilitate the reduction in amplitude of undesirable eddy currents, e.g., translation-induced eddy currents such as eddy currents induced by translating FRC plasmas, while leaving beneficial eddy currents unaffected. The eddy currents induced by translating FRC plasmas do not depend on the prior field configuration or on the presence of prior currents. Therefore, if the currents induced by the plasma translation are undesirable, they can be eliminated by creating an equal and opposite current pattern before the plasma translates.

[0023] In practice, this can be achieved, as shown in Figure 1, with axisymmetric active coils 20 positioned around the inside or the outside of the vessel 10. Plasmas, such as, e.g., FRC plasmas, are formed in and translated toward the mid-plane of the vessel 10 from formation tubes 12 and 14 positioned on opposing ends of the vessel 10. A detailed discussion of systems and methods for forming and maintaining an FRC plasma is provided in published PCT Application No. WO 2015048092, which claims priority to US Provisional Patent Application No. 61/881874 and US Provisional Patent Application No. 62/001583.

[0024] As shown in Figure 1A, a control system 100 is coupled to an active coil system 200 comprising the active coils 20, power supplies and the like, and to a formation system comprising the formation tubes 12 and 14, coils or straps, power supplies and the like.

[0025] Prior to plasma translation from the formation tubes 12 and 14, the coils 20 are ramped-up and held at constant current until all eddy currents in the wall of the vessel 10 have decayed. At this point current to the coils 20 is interrupted and the plasma formation sequence is started. The interruption of current to the coils 20 will excite a specific eddy current distribution in the wall of the vessel 10 to conserve the flux through the vessel 10, until a subsequent flux injection from the translating plasma reduces the eddy currents in the wall of the vessel 10 back towards zero. Alternatively, the coils 20 may be quickly ramped-up just before the plasma translates. In this case, the quick ramp-up will produce the desired eddy current distribution in the wall of the vessel 10, and the subsequent flux injection from the translated plasma will bring the eddy currents back to zero. After translation, currents in the coils 20 are kept constant. This method may be used if the characteristic eddy current decay time of the wall 10 is sufficiently slow compared to the rate at which the coils 20 can be ramped up. Cancellation can generally be increased by optimizing the geometry of the active coils, but even with the active coil geometry prescribed, the eddy current amplitude can be reduced.

[0026] To determine the currents in the active coils that will maximize eddy current cancellation, the eddy current distribution induced by the plasma has to be measured. This can be done by measuring at least two components of the magnetic field in the region between the conducting structures and the plasma. With two components of the magnetic field known, the

magnetic field can then be separated into components due to the plasma and due to external currents. This is easily seen in a cylindrical geometry, i.e., for a given mode number m and phase, the magnetic scalar potential is determined by two amplitudes, one for the term proportional to r^m, and the other for the term proportional to r^{-m}. Having two measurements of the magnetic field at the same spatial point allows solving for both coefficients, and the field from the plasma is trivially identified with the term proportional to r^m. In more complicated geometries the mathematics are not as straightforward but the same procedure can be used. With the time evolution of both the internal and external magnetic field known, the current distribution in the conducting structures can be computed by least-squares fitting to a finite-element circuit model.

[0027] Figures 2-6 illustrate the basic idea of reducing translation-induced eddy currents. Plasma currents (white filled), plasma induced wall currents (gray filled), and pre-induced wall currents (cross-hatched filled) are shown in the figures in two stages, i.e., 1) prior to translation and 2) after translation. In Figure 2 and 3, no wall currents have been pre-induced in the wall of the vessel 10, so the net current in the wall is a non-zero value after translation of the plasma from the formation tubes 12 and 14. In Figures 4-6, some currents have been pre-induced in the wall of the vessel 10. After translation of the plasma from the formation tubes 12 and 14, the net current in the wall becomes zero.

[0028] Application of the proposed technique has been simulated using LamyRidge, a 2-fluid simulation code to evaluate its effects on plasma formation and translation. Figure 7 shows the eddy current distribution in an axisymmetric wall two hundred microseconds (200 ms) after formation for three different cases:

1. 1) In case 1 (- -), no eddy current compensation was utilized, resulting in a plasma with separatrix radius 39 cm and elongation 2.5.
2. 2) In case 2 (-), an (exactly) opposing current pattern was put on the wall prior to start of the formation. As expected, the amplitude of the eddy currents at the end of the simulation is reduced. The currents do not cancel exactly, because the presence of the pre-induced currents results in an expansion of the plasma, so that it reaches a radius of 46 cm with an elongation of 2.0.
3. 3) In Case 3 (------) in addition to pre-inducing eddy currents in the chamber wall, the currents in the confinement coils are adjusted to compensate for the suppressed eddy currents. In other words, the field produced by the confinement coils in case 3 at t=0 is now equal to the field produced by both confinement coils and eddy currents in case 1 at t=200us. This results in a plasma that is very similar to case 1 (radius 38 cm, elongation 2.5), but the eddy currents have been reduced by a factor of 10. Subsequent evolution of this plasma is therefore much less affected by wall eddy currents and thus easier to control and predict. Furthermore, by adjusting the pre-induced wall currents together with the confinement coils, the plasma separatrix radius can be directly controlled.

Other Advantages

[0029] To stabilize FRC position or shape, axisymmetric, conducting in-vessel passive structures may be used. If eddy currents are pre-induced in the in-vessel passive structures in a manner as described above, the in-vessel passive structures can be installed without affecting initial plasma shape and configuration. If, on the other hand, no currents are pre-induced, installation of the in-vessel passive structures will decrease the FRC radius and thus reduce the coupling between in-vessel passive structures and plasma to approximate the same coupling strength that was previously between the wall of the vessel and the plasma, neglecting much of the advantage of installing additional components in the vessel

[0030] A similar issue applies to control coils. Where ex-vessel coils have insufficient plasma coupling to stabilize plasma instabilities and in-vessel coils are used, the in-vessel coils need to be protected from the plasma typically with an additional internal wall. If eddy currents in this in-vessel coil wall are not eliminated, they will reduce the plasma radius and the intended increase in coil-plasma coupling will be reduced. Therefore, eliminating eddy currents increases the coupling between coils and plasma, and thus reduces both current and voltage requirements for control coils.

[0031] Due to the 3-D shape of the vessel, any induced wall currents will break axisymmetry and potentially reduce confinement, excite instabilities, or otherwise reduce performance. Error field correction coils can be used to reduce a fixed number of specific harmonics, but are non-axisymmetric themselves and thus further amplify other sideband harmonics. In contrast, elimination of the eddy currents as described above requires only axisymmetric coils, results in less sideband harmonics, and does not require any currents in the coils after the plasma has formed.

[0032] In summary, the proposed systems and methods provided herein increase the chance of stabilizing plasma instabilities; increase the efficiency of plasma control systems by improving the coupling to the wall, reduces the amplitude of symmetry breaking 3-D fields, and lowers the complexity of the real-time systems. Up to some degree, all of these advantages can also be realized with very little cost by re-using existing coil systems. Best results can be achieved by taking eddy current elimination into account for coil placement and design.

[0033] The example embodiments provided herein advantageously reduces time-varying external fields due to decaying eddy currents, which interfere with plasma control; reduces symmetry-breaking effects of a non-axisymmetric wall (since both pre-induced and translation-induced eddy currents have the same 3-D structure, 3-D fields are reduced without the need for non-axisymmetric coils) and enables the installation of close fitting, axisymmetric, in-vessel structures to increase passive stabilization of axisymmetric and non-axisymmetric instabilities.

[0034] The example embodiments provided herein, however, are merely intended as illustrative examples and not to be limiting in any way.

[0035] In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. For example, the reader is to understand that the specific ordering and combination of process actions shown in the process flow diagrams described herein is merely illustrative, unless otherwise stated, and the invention can be performed using different or additional process actions, or a different combination or ordering of process actions. As another example, each feature of one embodiment can be mixed and matched with other features shown in other embodiments. Features and processes known to those of ordinary skill may similarly be incorporated as desired.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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Patentkrav

1. Fremgangsmåde til reduktion af uønskede hvirvelstrømme induceret i en ledende struktur af en plasmaindeslutningsbeholder (10), hvilken fremgangsmåde omfatter trinnene:
at inducere et første sæt af hvirvelstrømme i den ledende struktur af plasmaindeslutningsbeholderen (10) og
at overføre et FRC (field reversed configuration)-plasma ind i den ledende struktur af plasmaindeslutningsbeholderen (10), hvilket inducerer et andet sæt af hvirvelstrømme i den ledende struktur, hvor det første sæt af hvirvelstrømme induceres før det andet sæt af hvirvelstrømme og har en fordeling, der er i det væsentlige lig med og med omvendt fortegn af fordelingen af det andet sæt af hvirvelstrømme til i det væsentlige ophævelse af det andet sæt af hvirvelstrømme ved inducering af det andet sæt af hvirvelstrømme i den ledende struktur;
kendetegnet ved, at
det at inducere det første sæt af hvirvelstrømme indbefatter en af
at øge strømmen i spoler (20) om den ledende struktur lige før overføring af plasmaet ind i den ledende struktur og holde spoler (20) om den ledende struktur ved en konstant strøm til generering af det første sæt af hvirvelstrømme i den ledende struktur eller
at øge og holde spoler (20) om den ledende struktur ved en konstant strøm, indtil alle hvirvelstrømme er blevet svækket i den ledende struktur, og
at afbryde strømmen til spolerne (20) til muliggørelse af, at det første sæt af hvirvelstrømme exciteres i de ledende strukturer og bevarer den magnetiske flux gennem strukturerne.

2. Fremgangsmåde ifølge krav 1, hvor den ledende struktur er en væg af plasmaindeslutningsbeholderen.

3. Fremgangsmåde ifølge krav 1, hvor det at overføre FRC-plasma injicerer en flux ind i den ledende struktur, som inducerer det andet sæt af hvirvelstrømme i den ledende struktur, hvilket reducerer amplituden af hvirvelstrømme i den

ledende struktur tilbage mod nul.

4. System til reduktion af uønskede hvirvelstrømme induceret i en beholder (10)-væg, hvilket system omfatter:
en ledende struktur af en plasmaindeslutningsbeholder (10), som har en væg og et indre,
et dannelsesafsnit (12,14), der er fastgjort til en ende af beholderen (10),
en flerhed af spoler (20), der er anbragt omkring beholderen, og
et styresystem (100), der er koblet til flerheden af spoler (20) og konfigureret til at udføre fremgangsmåden ifølge krav 1, hvor styresystemet (100) endvidere er konfigureret til at overføre et plasma fra dannelsesafsnittet (12,14) ind i det indre af beholderen (10), hvor overføring af plasma inducerer det andet sæt af hvirvelstrømme i væggen af beholderen (10).

5. System ifølge krav 4, hvor styresystemet (100) endvidere er konfigureret til at øge og holde flerheden af spoler (20) ved en konstant strøm, indtil alle hvirvelstrømme i væggen af beholderen (10) er blevet svækket, og derefter afbryde strømmen til flerheden af spoler (20) til muliggørelse af, at det første sæt af hvirvelstrømme exciteres (10) og bevarer fluxen gennem beholderen (10).

6. System ifølge krav 5, hvor det at overføre plasma injicerer en flux ind væggen af beholderen (10), som inducerer det andet sæt af hvirvelstrømme i væggen af beholderen (10), hvilket reducerer amplituden af hvirvelstrømme i væggen af beholderen (10) tilbage mod nul.

7. System ifølge krav 4, hvor styresystemet (100) endvidere er konfigureret til at øge og holde flerheden af spoler (20) ved en konstant strøm til generering af det første sæt af hvirvelstrømme i den ledende struktur.

8. System ifølge krav 7, hvor det at overføre plasma injicerer en flux ind væggen af beholderen (10), som inducerer det andet sæt af hvirvelstrømme i væggen af beholderen (10), hvilket reducerer amplituden af hvirvelstrømme i væggen af beholderen (10) tilbage mod nul.

9. Fremgangsmåde ifølge krav 1, hvor den ledende struktur er en væg af plasmaindeslutningsbeholderen (10), som har en væg og et indre, og hvor trinnet at inducere et første sæt af hvirvelstrømme i den ledende struktur omfatter:
at inducere et første sæt af hvirvelstrømme i væggen af beholderen (10) før inducering af det andet sæt af hvirvelstrømme i væggen af beholderen (10).

10. Fremgangsmåde ifølge krav 9, hvor det at overføre plasma injicerer en flux ind væggen af beholderen (10), som inducerer det andet sæt af hvirvelstrømme i væggen af beholderen (10), hvilket reducerer amplituden af hvirvelstrømme i væggen af beholderen (10) tilbage mod nul.

11. Fremgangsmåde ifølge krav 1 eller 9, hvor FRC-plasmaet overføres fra modsatrettede dannelsesafsnit (12, 14), der er fastgjort til modsatte ender af beholderen (10).

12. Fremgangsmåde ifølge krav 11, endvidere omfattende trinnet at danne FRC-plasmaer i de modsatrettede dannelsesafsnit (12, 14), og hvor trinnet at overføre et plasma ind i beholderen (10) omfatter at overføre FRC-plasmaerne ind i beholderen (10).

DRAWINGS

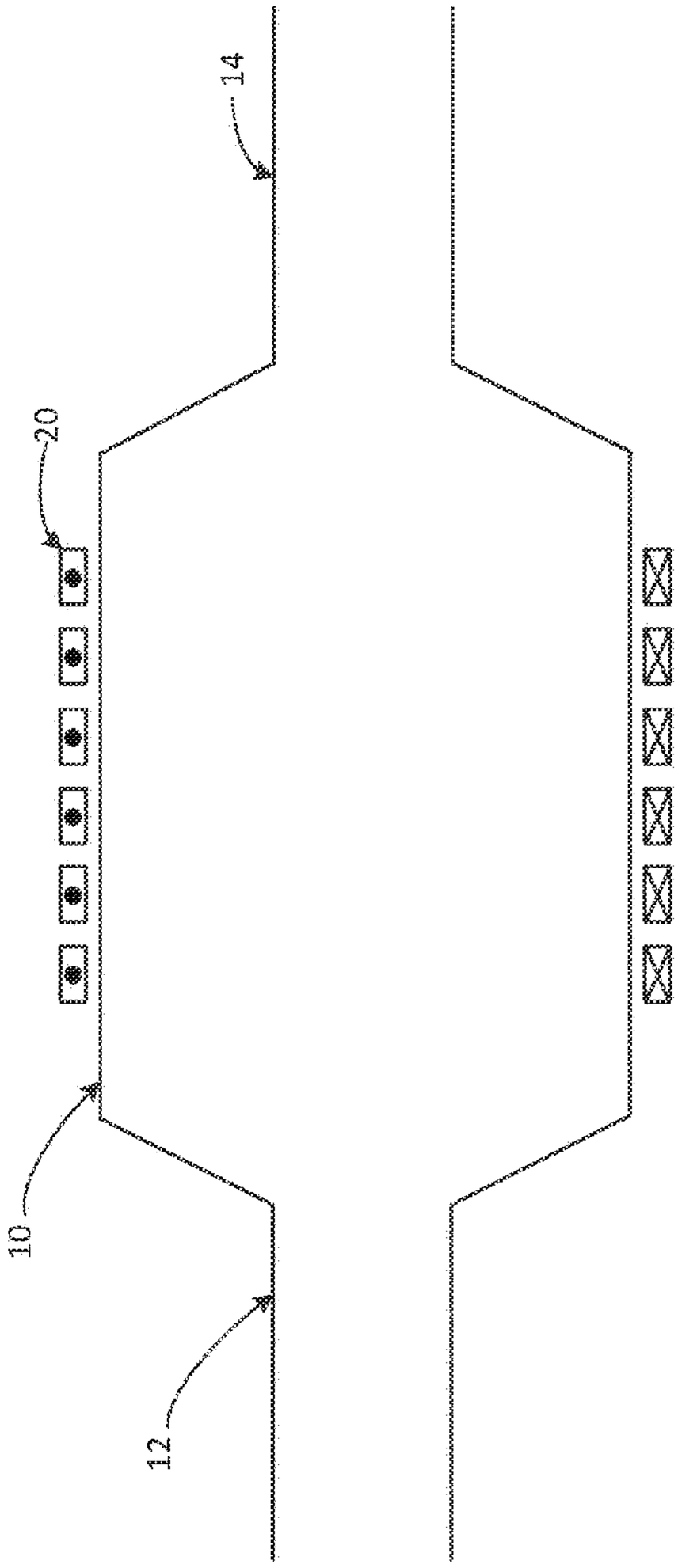


FIGURE 1

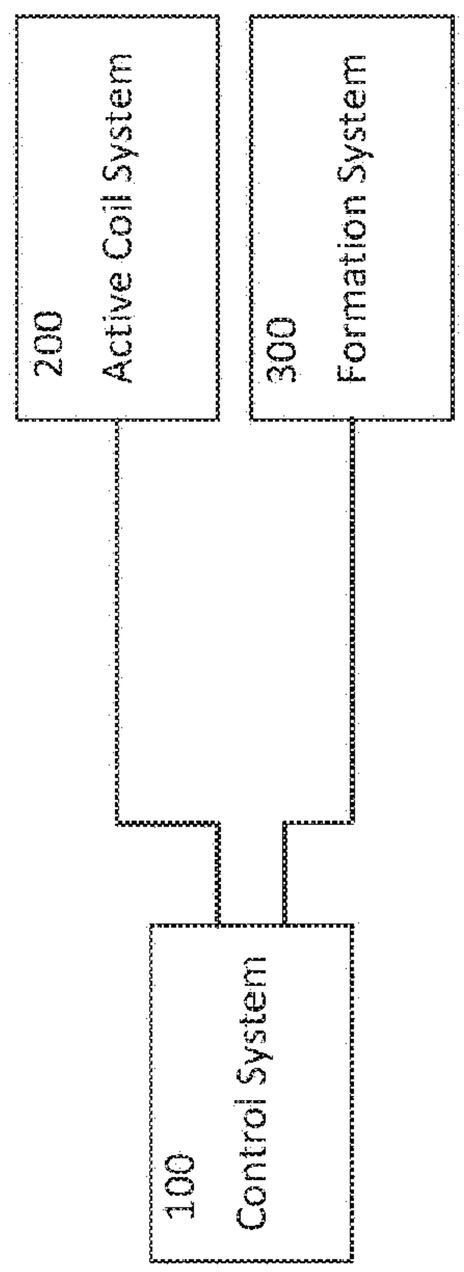


FIGURE 1A

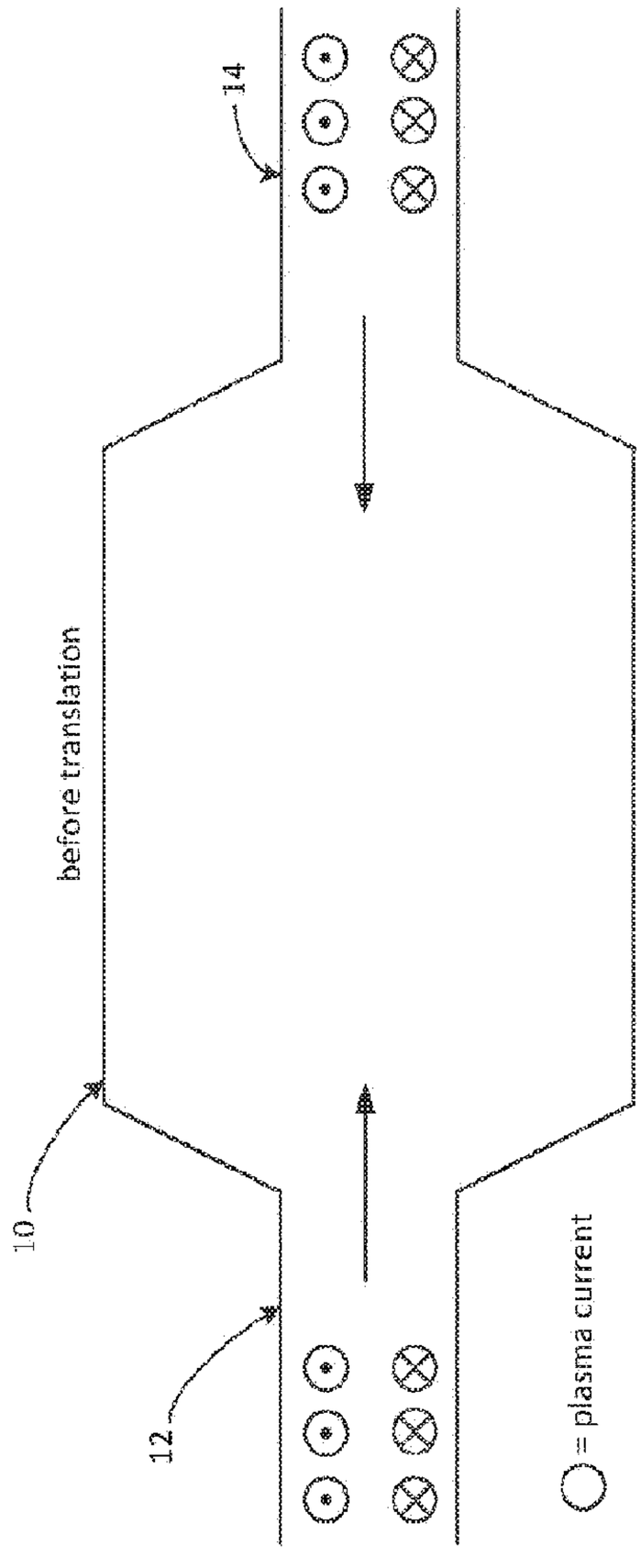


FIGURE 2

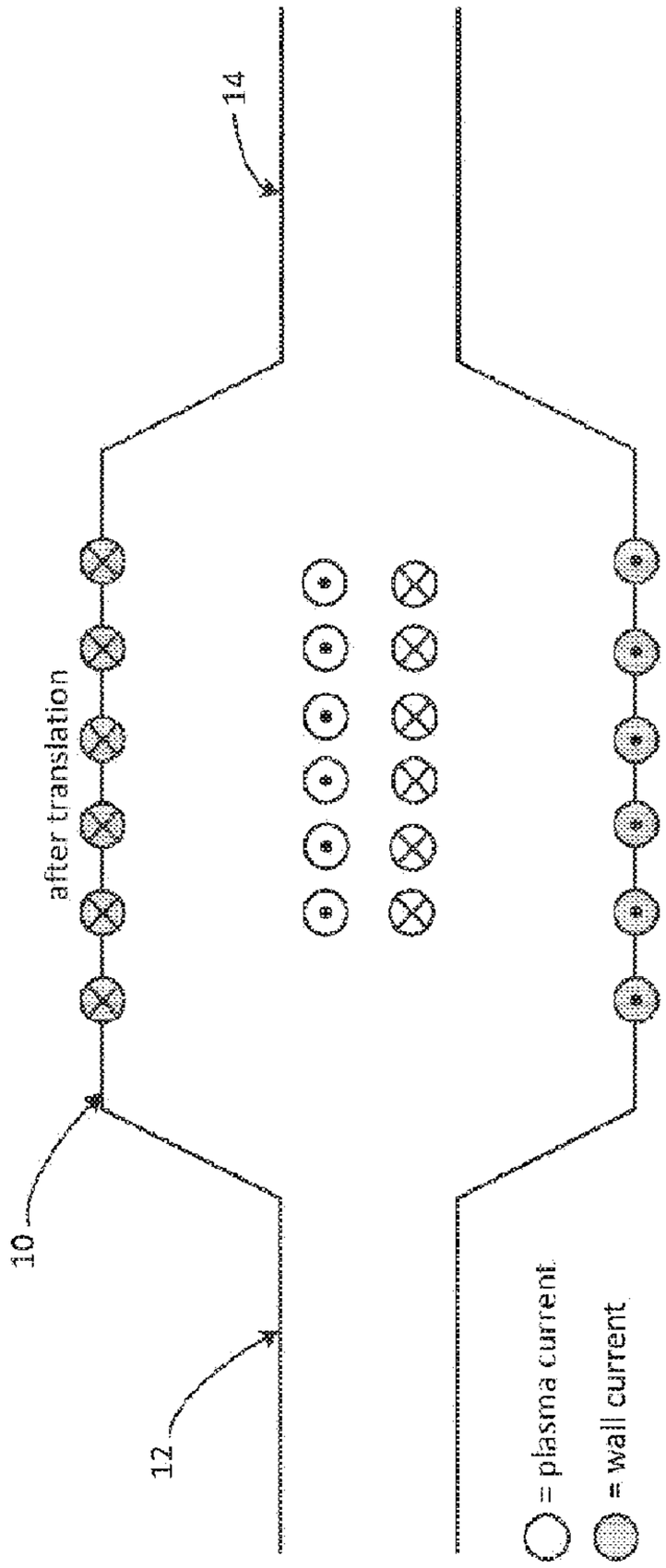


FIGURE 3

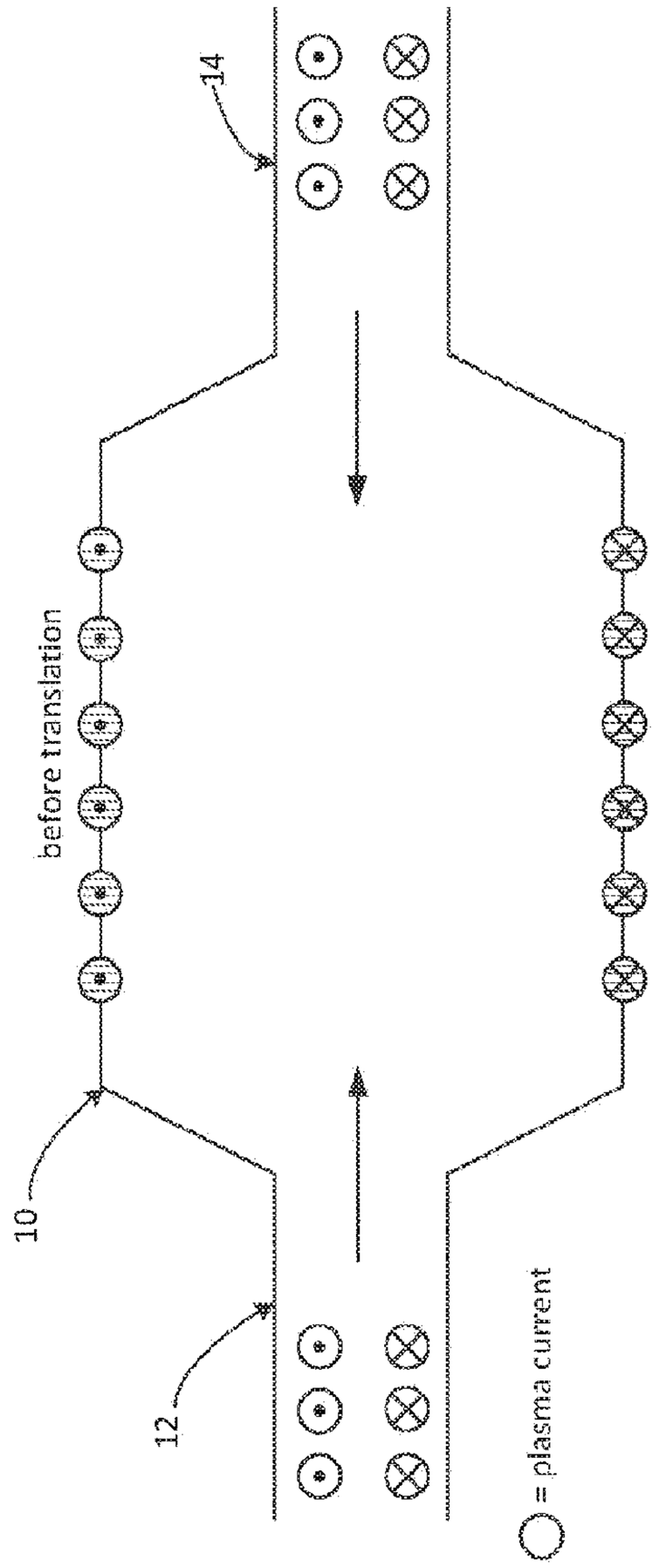


FIGURE 4

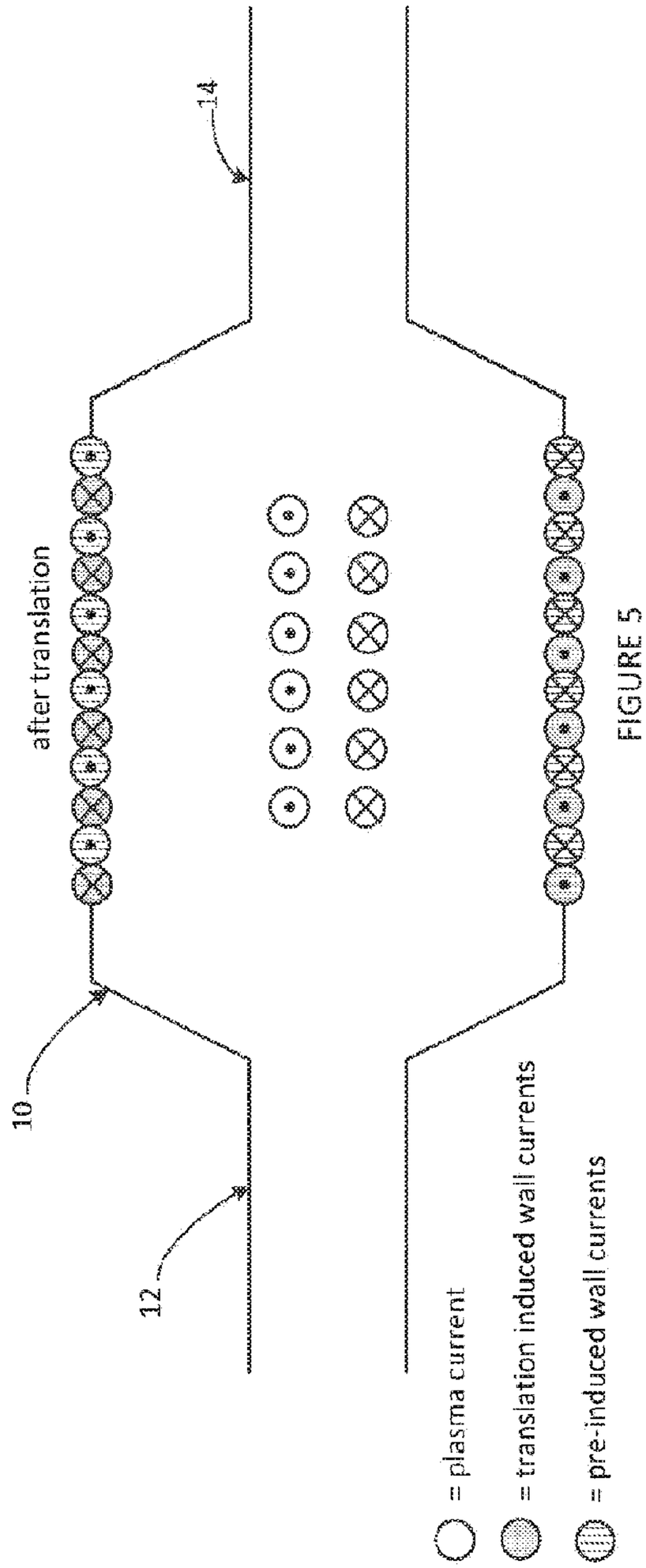


FIGURE 5

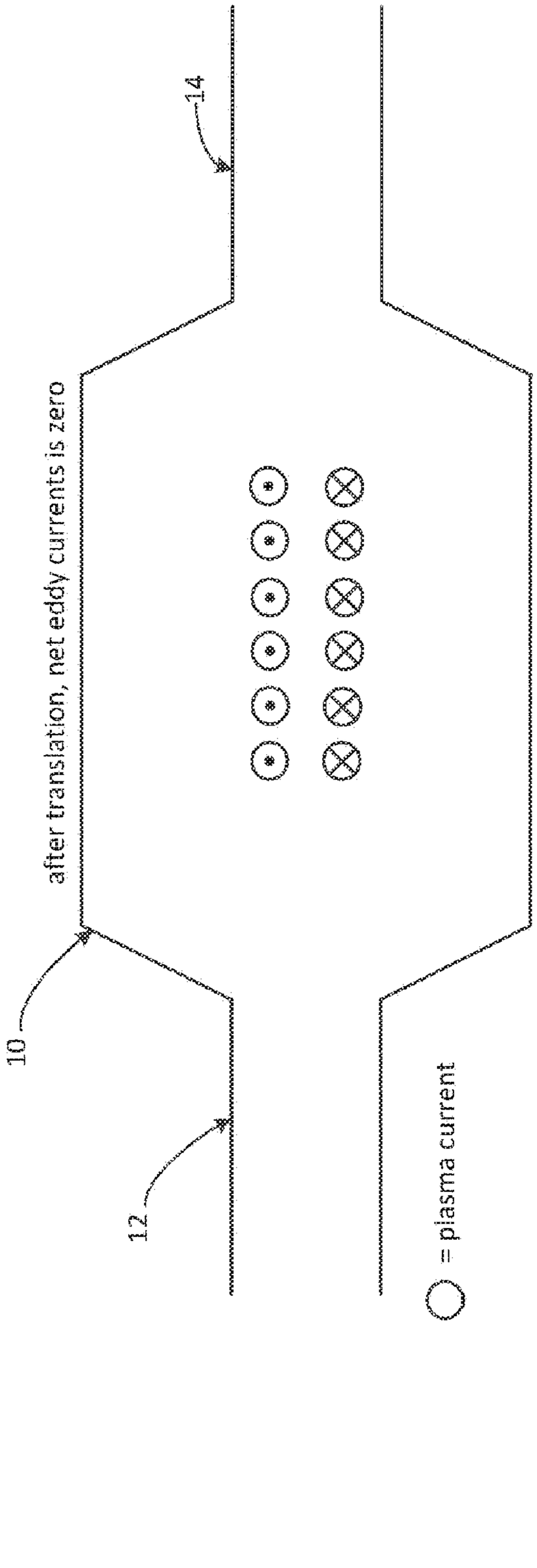

14
after translation, net eddy currents is zero
10
12
= plasma current

FIGURE 6

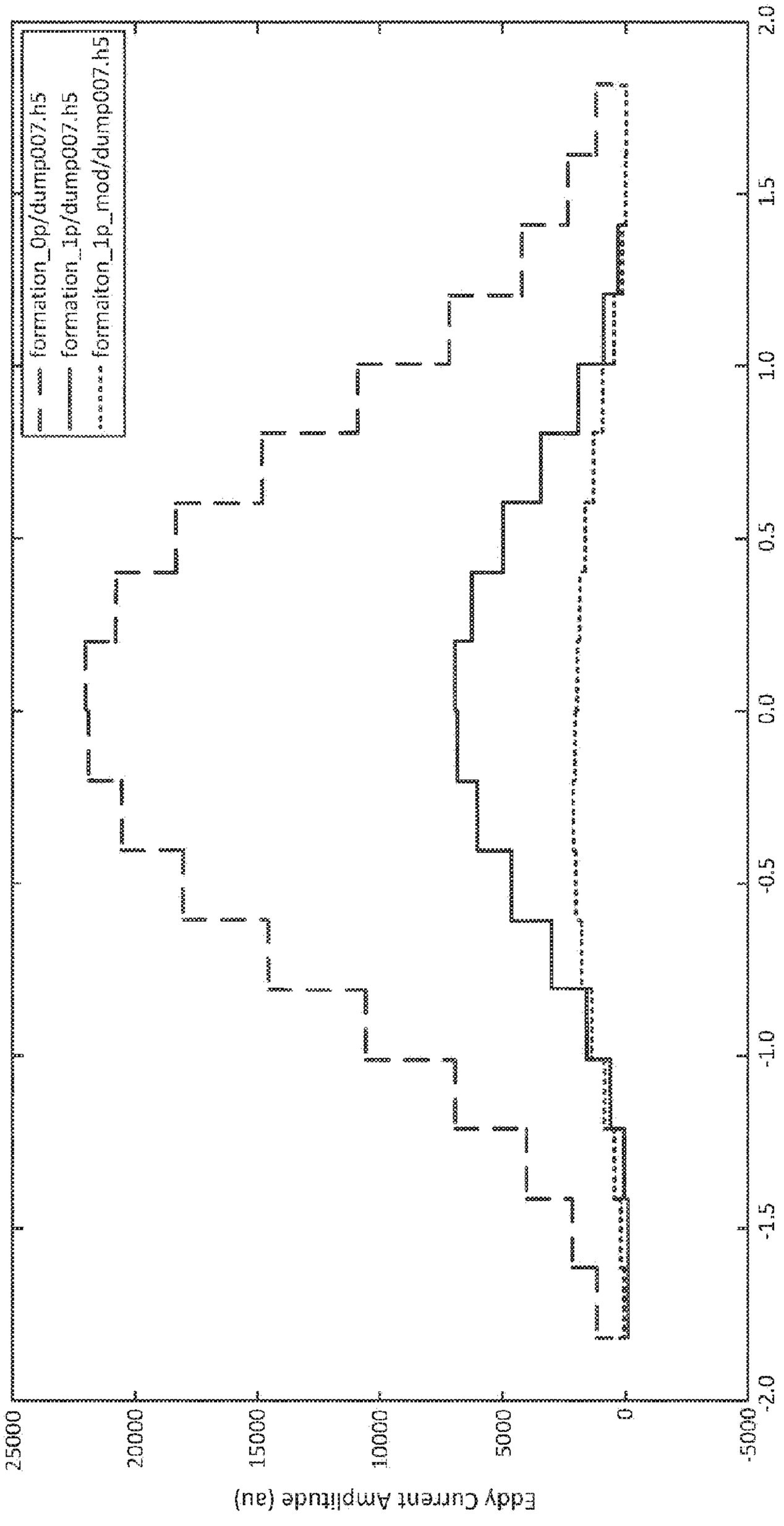

formation_0p/dump007.h5
formation_1p/dump007.h5
formaiton_1p_mod/dump007.h5
Eddy Current Amplitude (au)
Z (m)
25000
20000
15000
10000
5000
0
-5000
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0

FIGURE 7