Patents

Controlled fusion in a field reversed configuration and direct energy conversion

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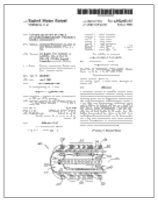

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A system and apparatus for controlled fusion in a field reversed configuration (FRC) magnetic topology and conversion of fusion product energies directly to electric power. Preferably, plasma ions are magnetically confined in the FRC while plasma electrons are electrostatically confined in a deep energy well, created by tuning an externally applied magnetic field. In this configuration, ions and electrons may have adequate density and temperature so that upon collisions they are fused together by the nuclear force, thus forming fusion products that emerge in the form of an annular beam. Energy is removed from the fusion product ions as they spiral past electrodes of an inverse cyclotron converter. Advantageously, the fusion fuel plasmas that can be used with the present confinement and energy conversion system include advanced (aneutronic) fuels.

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International Classification: B23K009/00

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Citations

Cited Patent	Filing date	Issue date	Original Assignee	Title
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US3258402	Jan 11, 1962	Jun 28, 1966		ELECTRIC DISCHARGE DEVICE FOR PRODUCING INTERACTIONS BETWEEN NUCLEI
US3386883	May 13, 1966	Jun 4, 1968		METHOD AND APPARATUS FOR PRODUCING NUCLEAR-FUSION REACTIONS
US3527977	Jun 3, 1968	Sep 8, 1970		MOLECULAR ION SOURCE
US3530036	Dec 15, 1967	Sep 22, 1970		APPARATUS FOR GENERATING FUSION REACTIONS
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US5923716	Nov 7, 1996	Jul 13, 1999		Plasma extrusion dynamo and methods related thereto
US6255648	Oct 16, 1998	Jul 3, 2001	Applied Automation, Inc.	Programmed electron flux
US6593539	Feb 26, 2001	Jul 15, 2003		Apparatus and methods for controlling charged particles

Referenced by

Citing Patent	Filing date	Issue date	Original Assignee	Title
US7459654	Nov 1, 2004	Dec 2, 2008	The Regents of the University of California University of Florida Research Foundation	Controlled fusion in a field reversed configuration and direct energy conversion
US7613271	Feb 16, 2007	Nov 3, 2009	The Regents of the University of California	Formation of a field reversed configuration for magnetic and electrostatic confinement of plasma
US8031824	Mar 7, 2006	Oct 4, 2011	Regents of the University of California	Inductive plasma source for plasma electric generation system

Claims

1. A method of converting fusion product energies into electric energy, comprising the steps of

injecting ions along a helical path within a generally cylindrical cavity formed of a plurality of semi-cylindrical electrodes in spaced relation with one another forming a plurality of elongate gaps there between,

converting substantially all of the injected ions' axial energy to rotational energy,

applying an oscillating potential to the plurality of electrodes,

forming a multi-pole electric field within the cavity, the electric field comprising three or more poles, and converting at least a portion of the ion energy into electrical energy.

2. The method of claim 1, wherein the step of forming an electric field includes creating an azimuthal electric field across the plurality of gaps.

3. The method of claim 1, further comprising the step of decelerating the ions.

4. The method of claim 1, wherein the ions are injected in the form an annular beam.

5. The method of claim 4, further comprising the step of directing the annular beam through a magnetic cusp.

6. A method of converting fusion product energies into electric energy, comprising the steps of

injecting ions along a helical path within a generally cylindrical cavity formed of a plurality of semi-cylindrical electrodes in spaced relation with one another forming a plurality of elongate gaps there between, wherein the ions are injected in the form an annular beam,

directing the annular beam through a magnetic cusp,

converting substantially all of the injected ions' axial energy to rotational energy,

collecting charge neutralizing electrons from the annular beam as the electrons follow magnetic field lines of the magnetic cusp,
forming a multi-pole electric field within the cavity, the electric field comprising three or more poles, and converting at least a portion of the ion energy into electrical energy.

7. The method of claim 6 further comprising the step of collecting the ions once a substantial portion of their energy is converted to electric energy.

8. The method of claim 1 further comprising the step of conditioning the electric energy converted from the ion energy to match existing power grids.

9. The method of claim 1 wherein the plurality of electrodes comprises at least four electrodes.

10. The method of claim 5 further comprising the step of creating the magnetic cusp.

11. A method of converting fusion product energies into electric energy, comprising the steps of

injecting ions along a helical path within a generally cylindrical cavity formed of a plurality of semi-cylindrical electrodes in spaced relation with one another forming a plurality of elongate gaps there between, wherein the ions are injected in the form an annular beam,

creating a magnetic cusp, wherein the step of creating the magnetic cusp comprises the steps of
creating first and second magnetic fields within the cavity, wherein field lines of the first and second magnetic fields extend in opposing directions, and
joining the first and second magnetic fields,
directing the annular beam through a magnetic cusp,
converting substantially all of the injected ions' axial energy to rotational energy,
forming a multi-pole electric field within the cavity, the electric field comprising three or more poles, and
converting at least a portion of the ion energy into electrical energy.

12. A method of converting fusion product energies into electric power, comprising the steps of

injecting ions along a helical path within a cylindrical cavity formed by three or more elongate electrodes in spaced relation with an elongate gap formed between adjacent electrodes of the three or more electrodes,

applying an oscillating potential to the three or more electrodes, and

converting at least a portion of the ion energy into electrical energy.

13. The method of claim 12, further comprising the step of creating an azimuthal electric field across each of the gaps.

14. The method of claim 12, further comprising the step of decelerating the ions.

15. The method of claim 12, wherein the injecting step includes converting substantially all of the ions axial energy to rotational energy.

16. The method of claim 12, wherein the ions are injected in the form an annular beam.

17. The method of claim 16, further comprising the step of directing the annular beam through a magnetic cusp.

18. A method of converting fusion product energies into electric power, comprising the steps of

injecting ions along a helical path within a cylindrical cavity formed by three or more elongate electrodes in spaced relation with an elongate gap formed between adjacent electrodes of the three or more electrodes, wherein the ions are injected in the form an annular beam,

directing the annular beam through a magnetic cusp,

collecting charge neutralizing electrons from the annular beam as the electrons follow magnetic field lines of the magnetic cusp, and

converting at least a portion of the ion energy into electrical energy.

19. The method of claim 18 further comprising the step of collecting the ions once a substantial portion of their energy is converted to electric energy.

20. The method of claim 19 further comprising the step of conditioning the electric energy converted from the ion energy to match existing power grids.

21. The method of claim 17 further comprising the step of creating the magnetic cusp.

22. A method of converting fusion product energies into electric power, comprising the steps of

injecting ions along a helical path within a cylindrical cavity formed by three or more elongate electrodes in spaced relation with an elongate gap formed between adjacent electrodes of the three or more electrodes, wherein the ions are injected in the form an annular beam,

creating a magnetic cusp, wherein the step of creating the magnetic cusp comprises the steps of
creating first and second magnetic fields within the cavity, wherein field lines of the first and second magnetic fields extend in opposing directions, and
joining the first and second magnetic fields,
directing the annular beam through the magnetic cusp, and
converting at least a portion of the ion energy into electrical energy.

23. A method of converting fusion product energies into electric power, comprising the steps of

creating first and second magnetic fields within a cavity formed in part by three or more semi-cylindrical electrodes in spaced relation with elongate gaps formed between adjacent electrodes, wherein field lines of the first and second magnetic fields extend in opposing directions,

joining the field lines of the first and second magnetic fields to form a magnetic cusp,

injecting ions in the form of an annular beam along a helical path within the cavity,

directing the annular beam through the magnetic cusp,

applying an oscillating potential to the three or more electrodes, and
converting at least a portion of the ion energy into electrical energy.

24. The method of claim 23, further comprising the step of creating azimuthal electric fields across the gaps.

25. The method of claim 24, further comprising the step of decelerating the ions.

26. The method of claim 23, wherein the injecting step includes converting substantially all of the ions' axial energy to rotational energy.

27. A method of converting fusion product energies into electric power, comprising the steps of

creating first and second magnetic fields within a cavity formed in part by three or more semi-cylindrical electrodes in spaced relation with elongate gaps formed between adjacent electrodes, wherein field lines of the first and second magnetic fields extend in opposing directions,

joining the field lines of the first and second magnetic fields to form a magnetic cusp,

injecting ions in the form of an annular beam along a helical path within the cavity,

directing the annular beam through the magnetic cusp,
collecting charge neutralizing electrons from the annular beam as the electrons follow magnetic field lines of the magnetic cusp, and
converting at least a portion of the ion energy into electrical energy.

28. The method of claim 27 further comprising the step of collecting the ions once a substantial portion of their energy is converted to electric energy.

29. The method of claim 23 further comprising the step of conditioning the electric energy converted from the ion energy to match existing power grids.

30. A method of converting fusion product energies into electric power, comprising the steps of

applying an oscillating potential to three or more elongate electrodes in spaced relation with elongate gaps formed between adjacent electrodes, the three or more elongate electrodes forming a cylindrical cavity,

creating a multi-pole elongate electric field comprising three or more poles,

injecting ions in the form of an annular beam along a helical path through the electric field, and

converting at least a portion of the ion energy into electrical energy.

31. The method of claim 30, wherein the step of creating a multi-pole elongate electric field includes creating azimuthal electric fields across the gaps.

32. The method of claim 30 further comprising the step of creating first and second magnetic fields within the cavity, wherein field lines of the first and second magnetic fields extend in opposing directions.

33. The method of claim 32 further comprising the step of joining the field lines of the first and second magnetic fields to form a magnetic cusp.

34. The method of claim 33 further comprising the step of directing the annular beam through the magnetic cusp.

35. The method of claim 30, further comprising the step of decelerating the ions.

36. The method of claim 30, wherein the injecting step includes converting substantially all of the ions' axial energy to rotational energy.

37. A method of converting fusion product energies into electric power, comprising the steps of

applying an oscillating potential to three or more elongate electrodes in spaced relation with elongate gaps formed between adjacent electrodes, the three or more elongate electrodes forming a cylindrical cavity,

creating a multi-pole elongate electric field comprising three or more poles,

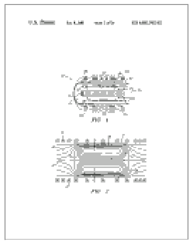
injecting ions in the form of an annular beam along a helical path through the electric field,

creating first and second magnetic fields within the cavity, wherein field lines of the first and second magnetic fields extend in opposing directions,
joining the field lines of the first and second magnetic fields to form a magnetic cusp,
collecting charge neutralizing electrons from the annular beam as the electrons follow magnetic field lines of the magnetic cusp, and
converting at least a portion of the ion energy into electrical energy.

38. The method of claim 37 further comprising the step of collecting the ions once a substantial portion of their energy is converted to electric energy.

39. The method of claim 38 further comprising the step of conditioning the electric energy converted from the ion energy to match existing power grids.

Drawings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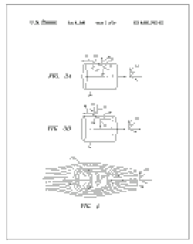
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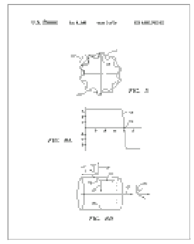
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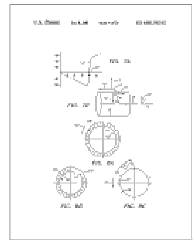
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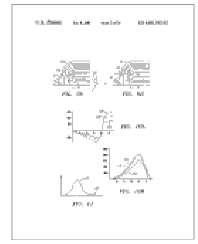
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