

Claims

1. A magnetic field gradient apparatus, especially a unidirectional magnetic field gradient apparatus, for generating a magnetic field having a magnetic field gradient in a direction
5 perpendicular to a first plane defined by a first axis and a second axis transverse to the first axis, wherein the first axis and the second axis are in the first plane, and the magnetic field is obtained by having a current distribution of a current in the first plane with a current direction of the current distribution alternating between opposite directions parallel to the second axis with a period λ along the first axis, and wherein the magnet apparatus comprises:
10 leg sections (100A, 100B) extending along the second axis and arranged besides each other along the first axis, wherein a distance (d) between adjacent leg sections is $\lambda/6$, and a width (wA) of a leg section (100A) having an adjacent leg section (100A, 100B) on either side is $\lambda/3$, as seen along the first axis, wherein the leg sections comprise a conductor for the current; and
15 a controller configured to control current through the respective leg sections,
wherein the leg sections and the controller are arranged to provide a current direction in adjacent leg sections in opposite directions to obtain the current direction of the current distribution alternating between opposite directions parallel to the second axis with the period λ along the first axis.
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2. The apparatus according to claim 1, wherein each leg section (100A, 100B) comprises a conductor comprising a material having superconducting properties at an operating temperature.
- 25 3. The apparatus according to any one of claims 1-2, wherein a width (wB) of a leg section (100B) having only an adjacent leg section on one side is smaller than $\lambda/3$, as seen along the first axis, optionally the width (wB) of the leg section (100B) having only an adjacent leg section on one side is $\lambda/6$, as seen along the first axis.

4. The apparatus according to any one of claims 1-3, wherein a current is equal in each leg section having an adjacent leg section on either side, as seen along the first axis.
5. The apparatus according to any one of claims 1-4, wherein the apparatus comprises:
 - 5 coils, optionally at least three coils (21; 22; 23), arranged besides each other, as seen along the first axis, in the first plane, wherein each coil comprises a conductor for the current, each coil further comprises a first leg (211; 221; 231), a second leg (212; 222; 232) and two bent end sections (213, 214; 223, 224; 233, 234) in the first plane, the first and the second leg of each coil are arranged parallel to each other along the second axis in the first plane, and the two bent sections are arranged opposite to each other to connect the first leg and the second leg of each coil, and wherein the first leg of a coil is adjacent the second leg of an adjacent coil and vice versa, as seen along the first axis, and the first legs and the second legs of the coils are configured and arranged to form the leg sections, wherein the controller is arranged to control current through the respective coils.
- 15 6. The apparatus according to claim 5, wherein a distance between centers of adjacent coils is $\lambda/2$, as seen along the first axis, and the controller is arranged to control a current direction in the first leg of a coil to be equal to a current direction in the second leg of an adjacent coil and vice versa.
- 20 7. The apparatus according to claim 6, wherein a width of the respective coils is $\lambda/2$, a width of the first legs is $\lambda/6$, and a width of the second legs is $\lambda/6$, as seen along the first axis.
8. The apparatus according to any one of claims 5-7, wherein the first leg of a coil and the second leg of an adjacent coil, and vice versa, together form a leg section.
- 25 9. The apparatus according to any one of claims 5-8, wherein the apparatus comprises three or five coils.

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10. The apparatus according to claim 5, wherein a distance between centers of adjacent coils is λ , as seen along the first axis, and the controller is arranged to control a current direction in the first leg of a coil to be opposite to a current direction in the second leg of an adjacent coil and vice versa.

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11. The apparatus according to claim 10, wherein a width of the respective coils is $5\lambda/6$, a width of the first legs is $\lambda/3$, and a width of the second legs is $\lambda/3$, as seen along the first axis.

12. The apparatus according to any one of claims 10-11, wherein the first legs and the second
10 legs of the respective coils separately form the leg sections.

13. The apparatus according to any one of claims 10-12, wherein the apparatus comprises three coils.

- 15 14. The apparatus according to any one of claims 5-13, wherein a current is equal in each respective coil.

15. The apparatus according to any one of claims 5-14, wherein the respective coils are racetrack-shaped coils.

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16. A magnet apparatus for generating a magnetic field, especially a unidirectional magnet field gradient apparatus for generating a magnetic field having a magnetic field gradient in a direction perpendicular to a first plane, the magnet apparatus comprising:

- at least three coils arranged besides each other along a first axis in the first plane,
25 wherein each coil comprises a conductor comprising a material having superconducting properties at an operating temperature, the coils further comprise two legs and two bent end sections in the first plane, wherein a first and a second leg are arranged parallel to each other along a second axis in the first plane transverse to the first axis, and the two bent sections are arranged opposite to each other; and

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a controller arranged to control currents through the respective coils to obtain a current distribution in the first plane, wherein a current direction of the current distribution is alternating between opposite directions parallel to the second axis, with a period λ along the first axis.

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17. The apparatus according to claim 16, wherein the magnet apparatus comprises three or five coils, wherein the distance between the centres of the respective coils equals $\lambda/2$, as seen along the first axis, and the controller is further arranged such that a current direction in the first leg of one of two adjacent coils is equal to a direction of the current direction in the adjacent second leg of the other one of the two adjacent coils.

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18. The apparatus according to claim 17, wherein the width of the respective coils is $\lambda/2$ and the width of the first and second legs is $\lambda/6$, as seen along the first axis.

19. The apparatus according to claim 16, wherein the magnet apparatus comprises three coils, wherein the distance between the centers of adjacent coils is λ , as seen along the first axis, and the controller is further arranged such that a current direction in the first leg of one of two adjacent coils is opposite to a direction of the current direction in the second adjacent leg of the other one of the two adjacent coils.

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20. The apparatus according to claim 19, wherein the width of the respective coils is $5\lambda/6$ and the width of the respective first and second legs is $\lambda/3$, as seen along the first axis.

21. The apparatus according to any one of claims 1-20, wherein λ is in the range from 30 to 150 cm, preferably between 50 to 70 cm, more preferably 60 cm.

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22. The apparatus according to any one of claims 1-21 as dependent on claim 2, wherein the material having superconducting properties comprises NbTi, Nb₃Sn or MgB₂.

23. The apparatus according to any one of claims 1-22 as dependent on claim 2, wherein the material having superconducting properties comprises Bi₂Sr₂CaCu₂O₈ or Bi₂Sr₂Ca₂Cu₃O₁₀, or a rare earth barium copper oxide, in particular one of the group YBa₂Cu₃O₇.

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24. The apparatus according to any one of claims 1-23, wherein the conductor comprises copper
Cu or copper Cu-alloys.
- 5 25. The apparatus according to any one of claims 5-24, wherein the respective coils comprise a
plurality of windings of the conductor, optionally wherein the diameter of the conductor is
1.4 mm.
26. The apparatus according to claim 25, wherein a number of windings of the coils is in a range
10 from 1000 to 3000.
27. The apparatus according to any one of claims 5-26, wherein the bent end sections of the
coils are flared.
- 15 28. An apparatus for separation, especially magnetic density separation, of materials, and
comprising an apparatus according to any one of claims 1-27.