Magnetic recorder head and method for high coercivity media employing concentrated stray magnetic fields

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РЕФЕРАТ

In methods and arrangements for concentrating stray magnetic fields, a pair of permanent magnets is employed in combination with a magnetic flux circuit, the permanent magnets in the pair having respective magnetizations that are oriented oppositely to each other. The permanent magnets produce a stray magnetic field that adds to a magnetic field produced by the magnetic flux circuit.

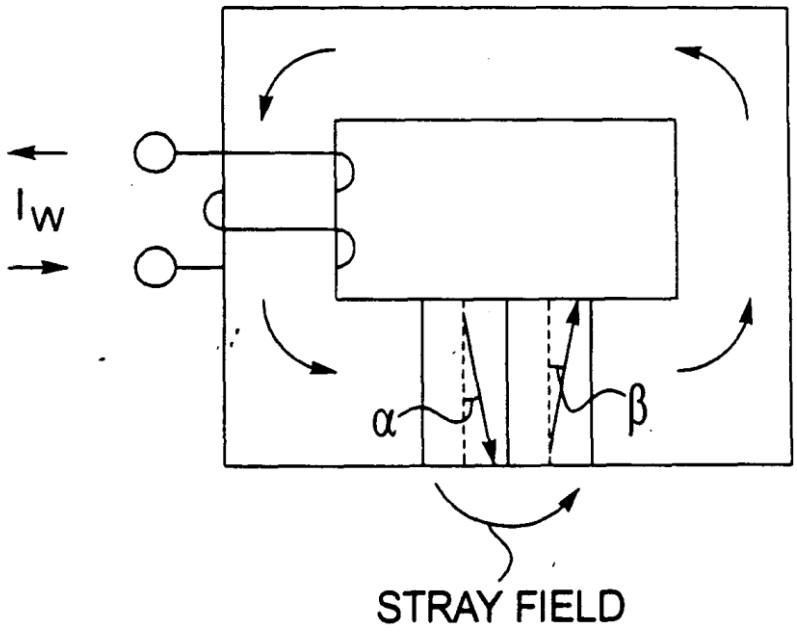
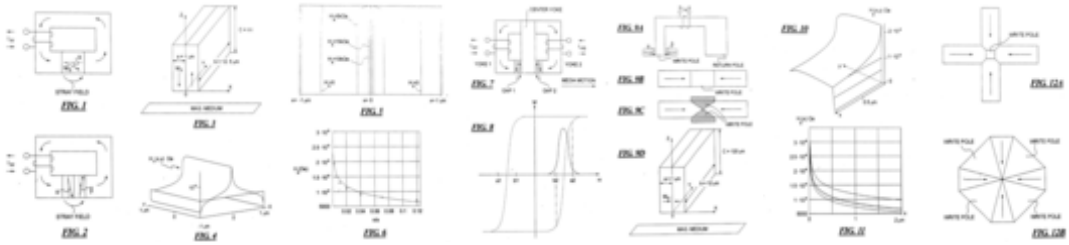


FIG. 2

ЧЕРТЕЖИ(7)



ПАТЕНТНАЯ ФОРМУЛА

1. A high gradient stray field magnetic field generator comprising:

   a magnetic flux circuit with a yoke and a gap in said yoke that produces a magnetic field; and

a permanent magnet disposed in said gap, said permanent magnet producing a stray field that adds to said magnetic field.

2. A high gradient stray field magnetic field generator comprising:

   a magnetic flux circuit with a yoke and a gap in said yoke that produces a magnetic field; and

   an even number of permanent magnets disposed in said gap, forming at least one magnet pair, with the respective magnetizations of the permanent magnets in each magnet pair oriented oppositely to each other, with substantially no open space between the permanent magnets in each pair, said permanent magnets producing a stray field that adds to said magnetic field.

3. A stray magnetic field generator as claimed in claim 2 wherein the permanent magnets are adjacent to each other with no open space between the permanent magnets.
4. A stray magnetic field generator as claimed in claim 2 wherein said even number of permanent magnets disposed in said gap is two.

5. A magnetic write element for longitudinal recording on a recording medium having a surface, comprising:

   an inductive write element supplied with current to produce a basic magnetic field, said inductive write element having a gap therein; and

   an even number of permanent magnets disposed in said gap, forming at least one magnet pair with the respective components perpendicular to the surface of the recording medium of the magnetization vectors of the permanent magnets in each magnet pair oriented oppositely to each other, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for recording on said recording medium.

6. A magnetic write element for perpendicular recording on a recording medium moving in a medium movement direction, comprising:

   a single pole write element having a write pole, said write element being comprised of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole; and

   a multitude of permanent magnets respectively disposed surrounding said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium.

7. A write head for writing on a pre-magnetized, moving, longitudinal medium, said medium having a surface and a recording layer that is pre-magnetized with a longitudinal pre-magnetization vector in a direction aligned with a direction of movement of said medium, said write head comprising:

a single inductive write element supplied with current to produce a basic magnetic field, said inductive write element having a gap therein; and

two permanent magnets disposed in said gap, with the respective components perpendicular to the surface of the recording medium of the magnetization vectors of said two permanent magnets oriented oppositely to each other, said permanent magnets producing a stray magnetic field within the recording layer of said medium in a direction opposite to the direction of said longitudinal pre-magnetization vector, with a sum of said basic magnetic field and said stray magnetic field forming a write field for recording on said medium.

8. A write head as claimed in claim 7 comprising a spacer disposed between said permanent magnets, said spacer being comprised of spacer material and having a thickness, and wherein each of the permanent magnets is comprised of permanent magnet material, and wherein, the spacer thickness and material and the permanent magnet material are selected to produce the opposite orientation of the respective magnetizations of the permanent magnets by an anti-ferromagnetic exchange coupling between the permanent magnets.

9. A write head for writing on a pre-magnetized, moving medium, said medium having a medium movement direction, a surface and a recording layer that is pre-magnetized with a perpendicular pre-magnetization vector in a direction perpendicular to the surface of said medium, said write head comprising:

a single pole write element having a write pole, said write element being comprised of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole; and

two permanent magnets, disposed on opposite sides, along said medium movement direction, of said write pole with the respective components parallel to said medium movement direction of the magnetization vectors of the permanent magnets oriented oppositely to each other to produce a stray field in a direction opposite to the direction of said perpendicular pre-magnetization vector, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium.

10. A write head for unidirectional overwriting on a medium magnetizable in a longitudinal direction, said medium having a surface and moving in a single medium movement direction, said write head comprising:

an inductive write element supplied with current to produce a basic magnetic field, said inductive write element having a gap therein;

a first magnet pair of two permanent magnets disposed in said gap with respective magnetization components perpendicular to the surface of the recording medium of said two permanent magnets in said first pair oriented oppositely to each other, said first magnet pair producing a first stray magnetic field and the two permanent magnets thereof being composed of permanent magnetic material selected so that a sum of said first stray magnetic field and said basic magnetic field is sufficient to longitudinally magnetize said recording medium only when said

inductive write element is supplied with a predetermined current, and to produce substantially no erasure in said recording medium when said write element is supplied with no current or a current that is negative compared to said predetermined current; and

a second magnet pair of two permanent magnets disposed upstream of said inductive write element relative to said direction of medium movement, with respective magnetizations of said two permanent magnets in said second magnet pair being oriented oppositely to each other in a direction perpendicular to the surface of the recording medium, with respective magnetizations of said two permanent magnets in said second magnet pair being oriented oppositely to the respective magnetizations of said two permanent magnets in said first magnet pair, said second magnet pair producing a second stray magnetic field having a strength sufficient to longitudinally magnetize said recording medium for recording on said recording medium.

11. A write head as claimed in claim 10 comprising a spacer disposed between said permanent magnets in each magnet pair, each spacer being comprised of spacer material and having a thickness, and wherein each of the permanent magnets is comprised of permanent magnet material, and wherein, in each magnet pair, the spacer thickness and material and the permanent magnet material are selected to produce the opposite orientation of the respective magnetizations of the permanent magnets in that magnet pair by an anti-ferromagnetic exchange coupling between the permanent magnets in that magnet pair.

12. A write head for unidirectional overwriting on a pre-magnetized moving medium, said medium having a surface and a recording layer, said medium moving in a single medium movement direction, said write head comprising:

a single pole write element having a write pole, said write element being composed of soft magnet material, and being supplied with current to produce a basic magnetic field;

a first magnet pair of two permanent magnets respectively disposed one on each side, along said medium movement direction, of said write pole with the respective components parallel to said medium movement direction of the magnetization vectors of said two permanent magnets in said first magnet pair oriented oppositely to each other, said first magnet pair of two permanent magnets producing a first stray magnetic field and the two permanent magnets thereof being composed of permanent magnetic material selected so that a combination of said basic magnetic field and said first stray magnetic field perpendicularly magnetizes said recording layer with a strength sufficient for recording on said recording medium only for a predetermined current supplied to said write element, and so that substantially no erasure in said recording layer occurs when said write element is supplied with no current or a current that is negative relative to said predetermined current; and

a second magnet pair of two permanent magnets disposed preceding said write element relative to said medium movement direction, the two permanent magnets in said second magnet pair having respective magnetizations oriented oppositely to each other in a direction parallel to said medium movement direction, and the respective magnetizations of the two permanent magnets in said second magnet pair being oriented oppositely to the respective magnetizations of the two permanent magnets in said first magnet pair, said second magnet pair producing a second stray

magnetic field and the two permanent magnets thereof being composed of permanent magnetic material selected so that said second stray field has a strength sufficient to perpendicularly magnetize said recording layer in said recording medium for recording on said recording medium.

13. A write head for bi-directional overwriting in a longitudinally magnetized recording layer of a recording medium having a surface, comprising:

    a first inductive write element supplied with current to produce a first basic magnetic field, said first inductive write element having a gap therein, and a first magnet pair of two permanent magnets disposed in said gap of said first inductive write element with respective components perpendicular to the surface of the recording medium of the magnetization vectors of vectors of said two permanent magnets in said first magnet pair oriented oppositely to each other, said two permanent magnets in said first pair producing a first stray magnetic field, with a sum of said first basic magnetic field and said first stray magnetic field forming a first write field for recording on said recording medium;

    a second inductive write element, disposed next to said first inductive write element, supplied with current to produce a second basic magnetic field, said second inductive write element having a gap therein, and a second magnet pair of two permanent magnets disposed in said gap of said second write element with respective components perpendicular to the surface of the recording medium of the magnetization vectors of said two permanent magnets in said second magnet pair oriented oppositely to each other, said second magnet pair producing a second stray magnetic field, with a sum of said second basic magnetic field and said second stray magnetic field forming a second write field for recording on said recording medium; and

    the respective magnetizations of the two permanent magnets of the first magnet pair being oriented oppositely to the respective magnetizations of the two permanent magnets of the second magnet pair.

    14. A write head as claimed in claim 13 comprising a spacer disposed between said permanent magnets in each magnet pair, each spacer being comprised of spacer material and having a thickness, and wherein each of the permanent magnets is comprised of permanent magnet material, and wherein, in each magnet pair, the spacer thickness and material and the permanent magnet material are selected to produce the opposite orientation of the respective magnetizations of the permanent magnets in that magnet pair by an anti-ferromagnetic exchange coupling between the permanent magnets in that magnet pair.

15. A write head for bi-directional overwriting of a perpendicularly magnetized recording layer of a recording medium moving in a medium movement direction, comprising:

    a first single pole write element having a write pole, said first single pole write element being composed of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole, and a first magnet pair of two permanent magnets respectively disposed on opposite sides, along said medium movement direction, of said write pole with respective components parallel to said medium movement direction of the magnetization vectors of the two permanent magnets in said first magnet pair oriented oppositely

to each other, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium;

a second single pole write element having a write pole disposed next to said first single pole write element, said second single pole write element being comprised of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole, and a second magnet pair of two permanent magnets respectively disposed on opposite sides along said medium movement direction, of said write pole of said second single pole write element, with respective components parallel to said medium movement direction of the magnetization vectors of the two permanent magnets in said second magnet pair oriented oppositely to each other, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium; and

the respective magnetizations of the two permanent magnets in said first magnet pair being oriented oppositely to the respective magnetizations of the two permanent magnets in said second magnet pair.

16. A write head for point recording on a pre-magnetized, moving medium, said medium having a medium movement direction, a surface and a recording layer that is pre-magnetized with a perpendicular pre-magnetization vector in a direction perpendicular to the surface of said medium, said write head comprising:

    a single pole write element having a write pole with a center, said write element being comprised of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole; and

    a multitude of permanent magnets surrounding the write pole, with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal tb zero to produce a stray field in a direction opposite to the direction of said perpendicular pre-magnetization vector, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium.

17. A write head for point recording on a pre-magnetized, moving medium, said medium having a medium movement direction, a surface and a recording layer that is pre-magnetized with a perpendicular pre-magnetization vector in a direction perpendicular to the surface of said medium, said write head comprising:

    a single pole write element having a write pole with a center, said write element being comprised of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole; and

    a multitude of wedge shaped permanent magnets sectioned into the soft magnetic material, converging at the center of said write pole, with respective magnetization vectors of said

permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero to produce a stray field in a direction opposite to the direction of said perpendicular pre-magnetization vector, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium.

18. A write head for unidirectional point overwriting on a moving medium, said medium having a surface and a recording layer, said medium moving in a single medium movement direction, said write head comprising:

    a single pole write element having a write pole, said write element being composed of soft magnet material, and being supplied with current to produce a basic magnetic field;

    a first multitude of permanent magnets respectively disposed surrounding said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero, said first multitude of permanent magnets producing a first stray magnetic field and the permanent magnets thereof being composed of permanent magnetic material selected so that a combination of said basic magnetic field and said first stray magnetic field perpendicularly magnetizes said recording layer with a strength sufficient for recording on said recording medium only for a predetermined current supplied to said write element, and so that substantially no erasure in said recording layer occurs when said write element is supplied with no current or a current that is negative relative to said predetermined current; and

    a second multitude of permanent magnets disposed preceding said write element relative to said medium movement direction, the permanent magnets in said second multitude of permanent magnets having respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said second multitude of permanent magnets and in sum essentially equal to zero, and the respective magnetizations of the permanent magnets in said second multitude being oriented oppositely to the respective magnetizations of the permanent magnets in said first multitude, said second multitude producing a second stray magnetic field and the permanent magnets thereof being composed of permanent magnetic material selected so that said second stray field has a strength sufficient to perpendicularly magnetize said recording layer in said recording medium for recording on said recording medium.

19. A write head for unidirectional point overwriting on a moving medium, said medium having a surface and a recording layer, said medium moving in a single medium movement direction, said write head comprising:

    a single pole write element having a write pole, said write element being composed of soft magnet material, and being supplied with current to produce a basic magnetic field;

    a first multitude of wedge shaped permanent magnets sectioned into the soft magnetic material, converging at the center of said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that

are essentially radial to the center of said write pole and in sum essentially equal to zero, said first multitude of permanent magnets producing a first stray magnetic field and the permanent magnets thereof being composed of permanent magnetic material selected so that a combination of said basic magnetic field and said first stray magnetic field perpendicularly magnetizes said recording layer with a strength sufficient for recording on said recording medium only for a predetermined current supplied to said write element, and so that substantially no erasure in said recording layer occurs when said write element is supplied with no current or a current that is negative relative to said predetermined current; and

a second multitude of permanent magnets disposed preceding said write element relative to said medium movement direction, the permanent magnets in said second multitude of permanent magnets having respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said second multitude of permanent magnets and in sum essentially equal to zero, and the respective magnetizations of the permanent magnets in said second multitude being oriented oppositely to the respective magnetizations of the permanent magnets in said first multitude, said second multitude producing a second stray magnetic field and the permanent magnets thereof being composed of permanent magnetic material selected so that said second stray field has a strength sufficient to perpendicularly magnetize said recording layer in said recording medium for recording on said recording medium.

20. A write head for bi-directional point overwriting of a perpendicularly magnetized recording layer of a recording medium moving in a medium movement direction, comprising:

a first single pole write element having a write pole, said first single pole write element being composed of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole, and a first multitude of permanent magnets respectively disposed surrounding said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium;

a second single pole write element having a write pole, said second single pole write element being composed of soft magnetic material, and a second multitude of permanent magnets respectively disposed surrounding said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium; and

the respective magnetizations of the permanent magnets in said first multitude of permanent magnets being oriented oppositely to the respective magnetizations of the permanent magnets in said second multitude of permanent magnets.

21. A write head for bi-directional point overwriting of a perpendicularly magnetized recording layer of a recording medium moving in a medium movement direction, comprising:

    a first single pole write element having a write pole, said first single pole write element being composed of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole, and a first multitude of wedge shaped permanent magnets sectioned into the soft magnetic material, converging at the center of said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium;

    a second single pole write element having a write pole, said second single pole write element being composed of soft magnetic material and being supplied with current to produce a basic magnetic field diverging from the tip of said write pole, and a second multitude of wedge shaped permanent magnets sectioned into the soft magnetic material, converging at the center of said write pole with respective magnetization vectors of said permanent magnets having components in a plane parallel with the surface of said medium that are essentially radial to the center of said write pole and in sum essentially equal to zero, said permanent magnets producing a stray magnetic field, with a sum of said basic magnetic field and said stray magnetic field forming a write field for perpendicular recording on said recording medium; and

    the respective magnetizations of the permanent magnets in said first multitude of permanent magnets being oriented oppositely to the respective magnetizations of the permanent magnets in said second multitude of permanent magnets.

22. A method for longitudinal recording on a recording medium having a surface, comprising the steps of:

    supplying an inductive,write element with current to produce a basic magnetic field, said inductive write element having a gap therein; and

    disposing a number of permanent magnets in said gap, producing a stray magnetic field, with a sum of the basic magnetic field and the stray magnetic field forming a write field; and

    longitudinally recording on said recording medium using said write field.

23. A method for perpendicular recording on a recording medium moving in a medium movement direction, comprising the steps of:

    providing a single pole write element having a write pole, said write element being comprised of soft magnetic material;

    supplying current to said single pole write element to produce a basic field diverging from the tip of said write pole;

providing a number of permanent magnets;

disposing the permanent magnets adjacent said write pole and thereby producing a stray magnetic field, with a sum of the basic magnetic field and the stray magnetic field forming a write field; and

perpendicularly recording on said recording medium using said write field.

24. A method for recording on a recording medium moving in a medium movement direction comprising the steps of:

providing a first write element comprising a soft magnetic circuit producing a basic magnetic field and a set of permanent magnets producing a stray magnetic field, with a sum of the basic magnetic field and the stray magnetic field forming a write field;

providing a second write element comprising a soft magnetic circuit producing a basic magnetic field and a set of permanent magnets producing a stray magnetic field in the opposite direction of the stray field from the permanent magnets in said first write element, with a sum of the basic magnetic field and the stray magnetic field forming a write field;

successively moving said recording medium past said first and second write elements in said medium movement direction; and

operating one of said first and second write elements that is first passed by any point of said recording medium with a constant current to pre-magnetize said recording medium, and operating the other of said first and second write elements, that is passed second by said point of said recording medium with a switched current to write data bits with magnetization opposite to the pre-magnetization on said recording medium; and

switching the roles of the two said write elements when the medium movement direction is reversed.

25. A method as claimed in claim 24 comprising switching said current to operate the other of said first and second write elements that is passed second by said point of said recording medium by applying a positive current to write a data bit and applying a negative current when no data bit is to be written, and limiting an absolute value of said negative current to an absolute value of the positive current thereby partially canceling respective magnetic fields from said respective first and second sets of permanent magnets to limit erasure of previously written data on said recording medium.