Claims

1. A nucleic acid purification device comprising

a support structure having a head-assembly-support portion; and

a head assembly supported by the head-assembly-support portion of the support structure, the head assembly comprising

a frame member,

an elongated magnetizable member supported by the frame member, the elongated magnetizable member having a central axis extending longitudinally through the elongated magnetizable member, wherein the elongated magnetizable member is rotatable about the central axis relative to the frame member, wherein the elongated magnetizable member is longitudinally translatable along the central axis with respect to the head-assembly-support portion of the support structure so as to be moveable towards and away from the head-assembly-support portion, and

a permanent magnet moveable towards and away from the elongated magnetizable member so as to engage with or disengage from the elongated magnetizable member,

wherein the head assembly is operable to engage the permanent magnet with the elongated magnetizable member to induce magnetism in the elongated magnetizable member and move the elongated magnetizable member with induced magnetism to translate along the central axis with respect to the head-assembly-support portion, and

wherein the head assembly is operable to disengage the permanent magnet from the elongated magnetizable member to lose its induced magnetism and rotate the elongated magnetizable member without induced magnetism about the central axis relative to the frame member,

wherein the elongated magnetizable member comprises a flat side surface and the permanent magnet comprises a flat contact surface, wherein the permanent magnet is moveable towards and away from the flat side surface of the elongated magnetizable member so as to engage the flat contact surface of the permanent magnet with the flat side surface of the elongated magnetizable member or disengage the flat contact surface of the permanent magnet from the flat side surface of the elongated magnetizable member,

wherein an engagement between the flat side surface of the elongated magnetizable member and the flat contact surface of the permanent magnet optimises the induced

magnetism in the elongated magnetizable member to maximise localized magnetic gradient at a tip of the elongated magnetizable member.

2. The device as claimed in claim 1, wherein the permanent magnet is moveable along a trajectory intersecting the central axis of the elongated magnetizable member.

~~3. The device as claimed in claim 1, wherein the elongated magnetizable member comprises a flat side surface and the permanent magnet comprises a flat contact surface, wherein the permanent magnet is moveable towards and away from the flat side surface of the elongated magnetizable member so as to engage the flat contact surface of the permanent magnet with the flat side surface of the elongated magnetizable member or disengage the flat contact surface of the permanent magnet from the flat side surface of the elongated magnetizable member.~~

~~4~~3. The device as claimed in claim ~~3~~1, wherein the head assembly further comprises a sensor arrangement to determine relative positions between the flat contact surface of the permanent magnet and the flat side surface of the elongated magnetizable member for controlling the permanent magnet to engage with the elongated magnetizable member such that the flat contact surface of the permanent magnet and the flat side surface of the elongated magnetizable member are flatly engaged to each other.

~~5~~4. The device as claimed in claim 1, wherein the head assembly further comprises a rotary actuator coupled to the elongated magnetizable member for rotating the elongated magnetizable member about the central axis relative to the frame member and a linear actuator for translating the elongated magnetizable member longitudinally along the central axis.

5~~6~~. The device as claimed in claim ~~5~~4, wherein the linear actuator is coupled between the head-assembly-support portion of the support structure and the frame member of the head assembly to move the frame member of the head assembly with respect to the head-assembly-support portion of the support structure in a direction parallel to the central axis of the elongated magnetizable member so as to translate the elongated magnetizable

member longitudinally along the central axis towards and away from the head-assembly-support portion.

~~7~~6. The device as claimed in claim ~~6~~5,

wherein the head assembly further comprises an actuation unit coupled to the permanent magnet for moving the permanent magnet towards and away from the elongated magnetizable member,

wherein the actuation unit comprises

an extendable mechanism with the permanent magnet mounted to an end of the extendable mechanism, and

an actuating mechanism coupled to the extendable mechanism to control an extension or a retraction of the extendable mechanism for moving the permanent magnet towards and away from the elongated magnetizable member.

~~8~~7. The device as claimed in claim 1, wherein the head assembly is rotatable about a rotational axis with respect to the support structure, wherein the rotational axis is parallel to the central axis of the elongated magnetizable member of the head assembly such that rotating the head assembly about the rotational axis with respect to the support structure moves the elongated magnetizable member laterally along a circular arc path.

~~9~~8. The device as claimed in claim ~~8~~7, wherein the head assembly is rotatable about the rotational axis with respect to the head-assembly-support portion of the support structure for moving the elongated magnetizable member laterally along the circular arc path with respect to the head-assembly-support portion of the support structure.

~~10~~9. The device as claimed in claim ~~9~~8, further comprising

a further rotary actuator coupled between the head assembly and the head-assembly-support portion of the support structure in a manner so as to rotate the head assembly about the rotational axis with respect to the head-assembly-support portion of the support structure.

~~11~~10. The device as claimed in claim 1, wherein the support structure have a stage portion for supporting a microfluidic chip, the stage portion being spaced apart and

opposing the head-assembly-support portion such that the elongated magnetizable member moves away from the stage portion as the elongated magnetizable member of the head assembly translates longitudinally along the central axis to move towards the head-assembly-support portion and the elongated magnetizable member moves towards the stage portion as the elongated magnetizable member of the head assembly translates longitudinally along the central axis to move away from the head-assembly-support portion.

~~12~~11. The device as claimed in claim ~~11~~10, further comprising a sonication component having a acoustic energy output surface, wherein the sonication component is coupled to the stage portion in a manner such that the acoustic energy output surface contacts the microfluidic chip when the microfluidic chip is supported on the stage portion.

~~13~~12. A nucleic acid purification system comprising,

a nucleic acid purification device comprising

a support structure having a head-assembly-support portion and a stage portion spaced apart and opposing the head-assembly-support portion, and

a head assembly supported by the head-assembly-support portion of the support structure, the head assembly comprising

a frame member,

an elongated magnetizable member supported by the frame member, the elongated magnetizable member having a central axis extending longitudinal through the elongated magnetizable member, wherein the elongated magnetizable member is rotatable about the central axis relative to the frame member, the elongated magnetizable member having a flat side surface, wherein the elongated magnetizable member is longitudinally translatable along the central axis with respect to the head-assembly-support portion of the support structure so as to be moveable towards and away from the head-assembly-support portion, and

a permanent magnet moveable relative to the frame member towards and away from the elongated magnetizable member so as to engage with or disengage from the elongated magnetizable member, the permanent magnet having a flat contact surface; and

a microfluidic chip for placing on the stage portion of the support structure of the nucleic acid purification device, the microfluidic chip comprising a plurality of wells, wherein at least one well of the microfluidic chip contains a plurality of magnetic particles,

wherein the head assembly of the nucleic acid purification device is operable to engage the permanent magnet with the elongated magnetizable member such that the flat contact surface of the permanent magnet is engaged to the flat side surface of the elongated magnetizable member to induce magnetism in the elongated magnetizable member and move the elongated magnetizable member with induced magnetism to translate along the central axis so as to move a tip of the elongated magnetizable member towards the stage portion for inserting into the at least one well of the microfluidic chip placed on the stage portion to capture the plurality of magnetic particles in the at least one well and subsequently move the tip of the elongated magnetizable member away from the stage portion for removing the plurality of magnetic particles magnetically attached to the tip of the elongated magnetizable member from the at least one well, wherein an engagement between the flat side surface of the elongated magnetizable member and the flat contact surface of the permanent magnet optimises the induced magnetism in the elongated magnetizable member to maximise localized magnetic gradient at the tip of the elongated magnetizable member and

wherein, when the tip of the elongated magetisable member and the plurality of magnetic particles magnetically attached thereto are inserted into one other well of the microfluidic chip, the head assembly of the nucleic acid purification device is operable to disengage the permanent magnet from the elongated magnetizable member to lose its induced magnetism and rotate the elongated magnetizable member without induced magnetism about the central axis relative to the frame member in a manner so as to disperse the plurality of magnetic particles from the tip of the elongated magetisable member into the one other well.

~~14~~13. The system as claimed in claim ~~13~~12,

wherein the microfluidic chip comprises a removable cap held in the microfluidic chip,

wherein the head assembly of the nucleic acid purification device is operable to move the elongated magnetizable member to translate along the central axis so as to move

the tip of the elongated magnetizable member towards the stage portion for inserting into the cap of the microfluidic chip placed on the stage portion to fit the cap over the tip of the elongated magnetizable member and subsequently move the tip of the elongated magnetizable member away from the stage portion for removing the cap from the microfluidic chip.

~~15~~14. The system as claimed in claim ~~14~~13, wherein the cap is shaped and dimensioned for interference fit with the tip of the elongated magnetizable member.

~~16~~15. The system as claimed in claim ~~13~~12,

wherein the head assembly of the nucleic acid purification device is rotatable about a rotational axis with respect to the head-assembly-support portion of the support structure, the rotational axis being parallel to the central axis of the elongated magnetizable member of the head assembly such that rotating the head assembly about the rotational axis with respect to the head-assembly-support portion of the support structure moves the elongated magnetizable member laterally along a circular arc path,

wherein the plurality of wells of the microfluidic chip is arranged in a circular arc corresponding to the circular arc path of the elongated magnetizable member in a manner such that the head assembly of the nucleic acid purification device is operable to rotate the head assembly for moving the elongated magnetizable member along the circular arc path to transfer the plurality of magnetic particles magnetically attached to the tip of the elongated magnetizable member from the at least one well to the one other well.

~~17~~16. The system as claimed in claim ~~16~~15,

wherein the microfluidic chip comprises an arcuate opening, wherein a width of a first end of the arcuate opening is wider than a width at a second end of the arcuate opening,

wherein the head assembly of the nucleic acid purification device is operable to move the elongated magnetizable member to translate along the central axis so as to move the tip of the elongated magnetizable member with a cap fitted thereto towards the stage portion for inserting into the arcuate opening of the microfluidic chip placed on the stage portion via the first end thereof, rotate the head assembly about the rotational axis with respect to the head-assembly-support portion of the support structure to move the

elongated magnetizable member laterally along the circular arc path to the second end of the arcuate opening, and subsequently move the tip of the elongated magnetizable member away from the stage portion for removing the cap from the tip of the elongated magnetizable member as the cap is held by the narrower width at the second end of the arcuate opening.

~~18~~17. The system as claimed in claim ~~13~~12,

wherein the microfluidic chip comprises an enclosed lysis chamber with an inlet port,

wherein the nucleic acid purification device further comprises a sonication component having a acoustic energy output surface, wherein the sonication component is coupled to the stage portion in a manner so as to contact the microfluidic chip for transmitting the acoustic energy to the enclosed lysis chamber when the microfluidic chip is supported on the stage portion.

~~19~~18. The system as claimed in claim ~~18~~17, wherein the enclosed lysis chamber of the microfluidic chip comprises

a filter partitioning the enclosed lysis chamber into an upper sub-chamber and a lower sub-chamber, and

a discharge tube extending from the lower sub-chamber to an exterior surface of the microfluidic chip, wherein a first end opening of the discharge tube is within the lower sub-chamber and a second end opening of the discharge tube is exposed from the exterior surface of the microfluidic chip.

~~20~~19. The system as claimed in claim ~~19~~18,

wherein the microfluidic chip comprises a sliding plate having an embedded channel with a first end opening of the embedded channel and a second end opening of the embedded channel exposed from a surface of the sliding plate,

wherein the sliding plate is in sliding engagement with the exterior surface of the microfluidic chip in a manner so as to be slidable into an aligned position to align the first end opening of the embedded channel of the sliding plate with the second end opening of the discharge tube and to align the second end opening of the embedded channel of the

sliding plate with the at least one well of the microfluidic chip for transferring fluid from the enclosed lysis chamber into the at least one well.