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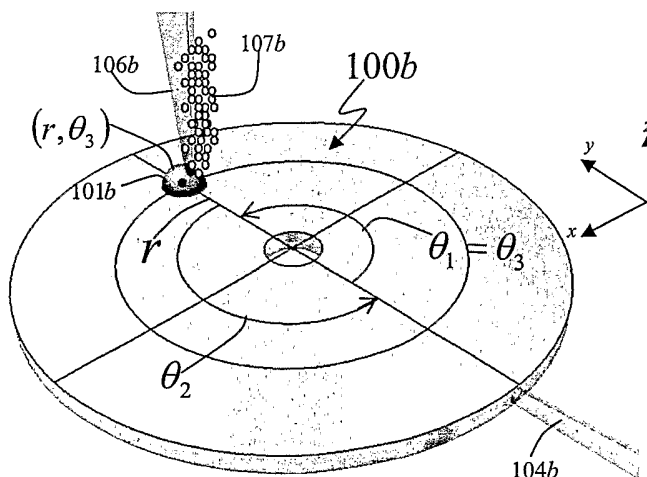
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(54) Title: ROTATABLE OBJECTS AND SYSTEMS AND METHODS FOR DETERMINING THE POSITION OF AT LEAST ONE SAMPLE ON A ROTATABLE OBJECT



(57) Abstract: A system for determining the position for at least one sample (101b) disposed on a rotatable body eg. MALDI disc (100b) comprising one or more detectable features (not shown but read by 104b) disposed on the body which may be a disc or sphere or cylinder (100b), and sampling at least a portion of the sample (106b) from the body, the sample being located at a known position on the body relative to the one or more detectable features. A processor determines the arrival time of when the sample will arrive at a sampling location after the detecting of the detectable feature using radius and angular position and velocity of the disc.

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ROTATABLE OBJECTS AND SYSTEMS AND METHODS FOR DETERMINING THE POSITION OF AT LEAST ONE SAMPLE ON A ROTATABLE OBJECT

Technical Field

5 This invention relates to rotatable objects, and systems and methods for determining the position of at least one sample on a rotatable object.

Background of the Invention

Endeavours such as the human genome project, proteomics and drug discovery are driving the development of fast high throughput chemical analysis. In such increasingly important applications, the handling of hundreds or even thousands of samples and their presentation to analytical instruments is not a trivial task. For example, in the bioanalytical context where Matrix Assisted Laser Desorption Ionisation (MALDI) is a key tool, the traditional x-y stage is currently chosen to manipulate square sample arrays. The stage brings one of typically hundreds of samples (each currently about 0.5-2mm in diameter) into the line of the laser and ion sampling optics of the spectrometer.

15 The current state of the art in the case of sample arrays currently used in MALDI applications, involves the use of x-y arrays originating from the research of Cantor *et al.* (*Anal Chem*, **69**, 2438, (1997)) and commercialised by Sequenom (San Diego California, USA, www.sequenom.com). Sequenom has developed x-y arrays of up to 384 samples which may be sequentially analysed. Between 1 and 10 of these arrays can be loaded into a mass spectrometer at a time.

However, greater sample densities, random access to samples, built-in standards and smaller spot sizes are likely to place impossible demands on x-y stage based systems, which are approaching their fundamental limits.

25 Caprioli *et al.* (*J. Am. Soc. Mass Spectrom.*, **10**, 67, (1999)) have pioneered the use of MALDI for tissue imaging. This demanding experiment is not assisted by the limitations of the x-y stage because of the inability to go back to an earlier location with accuracy, and the inefficiency of relocation to distant points on the imaging area. Such limitations can in some cases be partly overcome with complex and costly technological measures.

30 Secondary ionisation time-of-flight mass spectrometry is another area where imaging is providing key insights into chemical composition on sample arrays, e.g., imaging of inorganic and biological samples. The specifications of the x-y stage similarly impose a barrier to the evolution of these fields.

Laser ablation ICP-TOFMS is a relatively new technique that facilitates isotopic imaging across a diverse range of sample types. Once again, the x-y stage is at the core and limits the ultimate speed, resolution and accuracy of the sampling.

Summary of the Invention

5 In one aspect of the present invention there is provided a rotatable disc comprising an edge side about the perimeter of the disc, a sample side and a back side and comprising one or more detectable features disposed on the disc at at least one location selected from the group consisting of the sample side and the edge side.

10 Throughout the specification a reference to a sample side of a disc means the surface of the disc on which a sample is located or is locatable. Throughout the specification a reference to a back side of a disc means the surface of the disc at the back of the disc which is opposite to the sample side of the disc. The back side of the disc may or may not be suitable for locating one or more samples.

According to another aspect of the present invention there is provided a rotatable
15 disc comprising one or more detectable features disposed on the disc and one or more positioners to position the disc at a predetermined position on a rotator.

In another aspect of the present invention there is provided a rotatable disc comprising an edge side about the perimeter of the disc, a sample side and a back side said disc comprising:

- 20 (i) one or more detectable features disposed on the disc at at least one location selected from the group consisting of the sample side and the edge side,
(ii) a sample positioned on the sample side of the rotatable disc at a known position relative to the one or more detectable features.

In a particular embodiment there is provided a rotatable disc comprising an edge
25 side about the perimeter of the disc, a sample side and a back side said disc comprising:

- (i) one or more detectable features disposed on the disc at at least one location selected from the group consisting of the sample side and the edge side,
(ii) one or more samples positioned on the sample side wherein the angular position of each of the samples is known relative to the one or more detectable features
30 relative to the central axis position of the rotatable disc and the radius of the one or more samples is known relative to the central axis position of the rotatable disc.

The size of each of the one or more samples on the disc may be in a range selected from the group consisting of 0.2 – 7mm or more, 0.5 – 5 mm, 0.5 – 3 mm and 0.5-2mm in

diameter. Each of the one or more samples may be disposed in a compositional matrix. The matrix is one suitable for use in MALDI. The matrix may be a solid, liquid or gel matrix or other suitable matrix. Where the matrix is in the form of a liquid then for each sample from 30nl to 5 microlitres or 50nl to 2 microlitres of matrix plus sample may be placed on the disc (usually in the form of a drop or spot on the disc). The matrix may be suitable for use with laser desorption.

In another aspect of the present invention there is provided, a rotator comprising one or more detectable features, said rotator adapted to rotate a rotatable disc said disc comprising:

- (i) a positioner to position the disc on a rotator at a predetermined position, and
- (ii) one or more samples in a matrix positioned at a known radius and angular position on the rotatable disc,

wherein the angular position of each of the samples is known relative to the one or more detectable features and the radius of the one or more samples is known relative to the center of the rotatable disc.

The positioner may comprise one or more spindles protruding from the back side of the rotatable disc. Each spindle may be removable or fixed. There may be one or more complementary shaped apertures or cavities located in the rotator so as to receive the spindles when the rotatable disc is disposed on the rotator at a predetermined position.

Alternatively the positioner may comprise a mating feature disposed on or through the disc said mating feature being capable of mating to a rotator at a predetermined position on the rotator. The mating feature may be capable of mating to a spindle that comprises part of the rotator and is disposed so as to allow the rotatable disc to be disposed at a predetermined position on the rotator. The mating feature may be a cavity and/or aperture and the spindle may have a complementary shape to the cavity and/or aperture. The shapes of the cavity and/or aperture and spindle may be such that the rotatable disc may only be mounted on the rotator at a predetermined single position said predetermined single position corresponding to a position where the spindle is aligned with and is disposed in the cavity and/or passes through the aperture.

The positioner may comprise 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more cavities and/or apertures which may be the same cross-sectional shape as one another or may be different or a mixture thereof.

In one form, the rotatable disc may comprise a polygon-shaped cavity and/or aperture or other shaped cavity and/or aperture wherein the shape of the polygon or other shaped cavity and/or aperture is complementary to the shape of a spindle on the rotator such that the rotatable disc may be disposed on the rotator at a predetermined single position said predetermined single position corresponding to a position where the spindle is aligned with and is disposed in the cavity and/or passes through the aperture.

The rotatable disc may have two or more cavities and/or apertures which are disposed or shaped such that the rotatable disc may be disposed on two or more complementary shaped spindles on the rotator at a single predetermined position. The single predetermined position corresponds to the position where the at least two spindles on the rotator are aligned with and pass through the two or more cavities and/or apertures in the rotatable disc.

The rotatable disc may comprise one or more keyhole cavities or apertures such that the rotatable disc may be disposed on a complementary keyhole shaped spindle on the rotator at a single predetermined position on the rotator. The single predetermined position corresponds to the position where the keyhole shaped spindle on the rotator is aligned with and is disposed in and/or passes through the keyhole cavity and/or aperture in the rotatable disc.

The detectable feature may be a mark or an aperture or other suitable feature. Where the detectable feature is a mark it will be referred to as a registration mark throughout the specification. The size of the detectable feature is such that it permits a sample on the rotatable disc to be located from the detected position of the detectable feature. The size of the detectable feature may be about the same as or smaller than the size of the sample on the rotatable disc.

The detectable feature(s) may be at least one registration mark located on the edge side of the rotatable disc.

Alternatively, the detectable feature(s) may be at least one registration mark located on the sample side of the rotatable disc.

In another alternative the detectable features are at least one registration mark located on the edge side of the rotatable disc and at least one registration mark located on the sample side of the rotatable disc or at least one registration mark located on the edge side of the rotatable disc and at least one registration mark located on the back side of the rotatable disc or at least one registration mark located on the sample side of the rotatable disc and at least one registration mark located on the back side of the rotatable disc or at

least one registration mark located on the edge side of the rotatable disc, at least one registration mark located on the back side of the rotatable disc and at least one registration mark located on the sample side of the rotatable disc.

5 The registration mark may be present in the form of barcode data on the rotatable disc. Alternatively, the registration mark may be one or more reflective parts and/or absorption parts and/or one or more fluorescent parts on the rotatable disc. The reflective, absorption and/or absorption parts may be an area of any shape or a line, for example. The size of the registration mark is such that it permits the at least one sample on the disc to be located from the detected position of the registration mark. The size of the registration mark may be about the same as or the same as the size of the sample on the
10 rotatable disc. The size of the registration mark may be about the same as or the same as the size of the smallest sample on the rotatable disc. The size of the registration mark may be smaller than the size of the sample on the rotatable disc. The size of the registration mark may be smaller than the size of the smallest sample on the rotatable disc.

15 The rotatable disc may comprise metal, a metal coated plastic, plastic, ceramic or other conducting or non-conducting material capable of being formed into a solid disk.

The rotatable disc may contain purpose built Matrix-Assisted Laser-Desorption/Ionisation (MALDI) sample surfaces comprising wells, hydrophobic or hydrophilic coatings, raised sections to contain wells and specialised surface materials to
20 enhance MALDI signals.

The rotatable disc may feature a radio frequency tag which is capable of being detected by a radio frequency receiver used to authenticate the rotatable disc.

The rotatable disc may comprise a barcode for use with Laboratory Information Management Systems (LIMS) software.

25 Each of the samples may be portions of one or more chemical analyte(s), which are supported in a matrix and suitable for Matrix Assisted Laser Desorption Ionisation (MALDI) analysis.

Discrete samples may be arranged on the rotatable disc in a pattern lying on concentric circles where the center of each circle is the central axis point of the rotatable
30 disc.

Discrete samples may be arranged in a shape of a spiral on the rotatable disc. The spiral may emanate from the central axis point of the rotatable disc.

Discrete samples spots may be arranged in a rectangular or square array on the rotatable disc. The array may be arranged about the central axis point of the rotatable disc.

The sample may comprise an area about the size of a spot or an area larger than a spot. In the case where the area is larger than a spot the sample may be an area of tissue such as a tissue section for example.

5 The unused sample space on the rotatable disc between samples may be used for standard mass calibrants.

In a further aspect of the present invention there is provided a method of determining at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, and sampling at least a portion of the sample from the disc, said at least one sample being located at a known position on said disc
10 relative to said feature, said method comprising:

- (i) locating the rotatable disc on a rotator at a predetermined position on the rotator,
- (ii) rotating the rotatable disc;
- (iii) detecting the detectable feature on the rotatable disc;
- 15 (iv) determining an arrival time when the sample will arrive at a sampling location after the detecting,
- (v) sampling at least a portion of the sample at the arrival time.

The method may further comprise the step of:

- enabling a sampler to sample at the sampling location.

20 The enabling may comprise moving the sampler or a component of the sampler.

The method for determining the position of at least one sample on rotatable disc, and sampling the sample from the disc may further comprise analysing the sample.

In an embodiment of the method of the present invention there is provided a method for determining the position of at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, sampling at least a
25 portion of the sample from the disc, and analysing said portion, said at least one sample being located at a known position on said disc relative to said feature, said method comprising:

- (i) locating the rotatable disc on a rotator at a predetermined position on the
30 rotator,
- (ii) rotating the rotatable disc at a known rotational velocity,
- (iii) detecting the detectable feature on the rotatable disc,
- (iv) determining an arrival time when the sample will arrive at a sampling location after the detecting,

(v) desorbing or ablating at least a portion of the sample one or more times per revolution of the rotatable disc,

(vi) analysing the desorbed or ablated sample, and

(vii) optionally repeating steps (i) through (vi).

5 The step of sampling may comprise ablating or desorbing at least a portion of each of the sample from the rotatable disc with a laser beam.

The rotatable disc may be rotated at variable angular velocity and frequency. Alternatively, the rotatable disc may rotated at a constant frequency of 1 to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz 1 to 400 Hz, 1 to 300 Hz,
10 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The step of analysing may be performed with an analyser which may be an ion
15 mobility device or may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, where the sampler is a laser beam
20 it may be directed to ablate or desorb another sample from the rotatable disc.

The step of detecting may comprise detecting a detectable feature with a detector, so that the angular position of the sample is known relative to the detectable feature. The time delay taken from when the detectable feature is detected to when the sample crosses the path of a sampler, such as a laser which is capable of producing a desorbing laser
25 beam, may be calculated, so that upon the detection of the detectable feature by a detector, the laser can be fired at the arrival time.

The method may include directing a laser beam to a sampling location on the rotatable disc in order to sample at least a portion of the sample at the arrival time. A director may be used to direct the laser beam to the sampling location on the rotatable
30 disc.

The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example.

Alternatively, a linear director may be attached to the rotatable disc. The linear director may position the rotatable disc at a point in one or more planes perpendicular to

the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable disc in the x-y plane. The director only need direct the laser beam back and forth along one arbitrarily chosen radial line which extends from the centre of the rotatable disc in order to access every sample on the rotatable disc as it rotates.

The step of sampling may be performed by a sampler such as a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable disc. Suitably, the sampler may emit one or more beams onto the required sample per revolution of the sample on the rotatable disc. There may be one or more samplers(e.g. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more samplers). Where there is more than one sampler they may be arranged in an array e.g. a liner array.

The radial coordinate of the sample with respect to the central axis point of the rotatable disc may be recorded at the same time as or after its deposition onto the rotatable disc.

In a further aspect of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, and sampling at least a portion of the sample from the disc, said at least one sample being located at a known position on said disc relative to said one or more detectable features, said system comprising:

- (i) a rotator for rotating the rotatable disc;
- (ii) a detector for detecting the detectable feature on the rotatable disc;
- (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector,
- (iv) a sampler for sampling at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise an enabler for enabling the sampler to sample the sample at the sampling location. The enabler may comprise means for moving the sampler or a component of the sampler. For example, where the sampler is a laser the enabler may comprise means for moving the laser or means for moving a mirror or other reflective surface at which the laser beam is directed, so that the laser beam when activated desorbs a sample at the sampling location. By way of example only, in the case of a means for moving a mirror or other reflective surface or the end of an optical fibre

through which a laser beam passes, the means for moving may comprise a piezoelectric device.

In an embodiment of the system of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, sampling at least a portion of the sample from the disc, and analysing said portion, said at least one sample being located at a known position on said disc relative to said feature, said system comprising:

- (i) a rotator for rotating the rotatable disc at a known rotational velocity,
- 10 (ii) a positioner for positioning the rotatable disc on a rotator at a predetermined position on the rotator,
- (iii) a detector detecting the detectable feature on the rotatable disc,
- (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled to said detector, and
- 15 (v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise

- 20 (vi) an analyser for analysing the desorbed or ablated sample.

The sampler may be capable of desorbing or ablating at least a portion of the sample at the arrival time one or more times per revolution of the rotatable disc.

The systems of the invention may further comprise one or more rotatable discs of the invention.

The rotator may comprise an actuator for rotationally and optionally linearly actuating the rotatable disc. The actuator may rotationally and optionally linearly actuate the rotatable disc. The rotatable disc may be rotationally actuated at variable angular velocity and frequency.

The rotatable disc may be rotationally actuated at a constant frequency of 1 to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz, 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The actuator may be a rotational actuator. The rotational actuator may be coupled to a linear actuator. The linear actuator may actuate the rotational actuator in one or more planes perpendicular to the plane in which the sampler operates in order to position the required sample on the rotatable disc in a location amenable to the sampler. For example, if the sampler operates in the z-y-plane, then the linear actuator may actuate the rotational actuator in the x-y plane. The linear actuator may have a position repeatability which is dependent on the dimensions of the smallest sample. For example, for a circular sample of 0.01mm in diameter the linear actuator has a position repeatability of at least 0.01mm.

The processor may store the locations of the one or more samples on the rotatable disc relative to the position of the one or more detectable features. The processor may comprise a computer.

The detector may be a photodiode in combination with a light emitting diode which is able to transmit and receive signals. Alternatively, the detector may be any imaging device that is capable of detecting a registration mark such as a camera, Charged Coupled Device (CCD), or a photovoltaic device for example. As another alternative, the detector may be a proximity device based on magnetic fields or electrical capacitance. As a further alternative the detector may be a mechanical device such as a micro-switch or a phase sensitive inductance device for example.

The sampler may be a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable disc. Suitably, the sampler may emit one or more laser beams onto the required sample per revolution of the sample on the rotatable cylinder to ablate or desorb at least a portion of the sample.

The system of the invention may further comprise a director may be used to direct the sampler to the appropriate location on the rotatable disc. In one form the director may be coupled to the sampler for directing the sampler to the appropriate radial coordinate on the rotatable disc such that the sampler can sample the at least portion of the sample at the arrival time. The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example. A linear director may be attached to the rotatable disc. The linear director may position the rotatable disc at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable disc in the x-y plane. The director only need direct the laser beam back and forth along one arbitrarily chosen radial line

which extends from the centre of the rotatable disc in order to access every sample on the rotatable disc as it rotates.

The system of the invention may further comprise an analyser to analyse the sample sampled from the rotatable disc. The analyser may be an ion mobility device.
5 Alternatively, the analyser may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

In one aspect of the present invention there is provided a rotatable cylinder or cone
10 comprising one or more detectable features.

In another aspect of the present invention there is provided a rotatable cylinder or cone comprising:

- (i) one or more detectable features on the rotatable cylinder or cone,
- (ii) a sample disposed on the rotatable cylinder or cone at a known position
15 relative to the one or more detectable features.

There may be a plurality of samples disposed on the rotatable cylinder or cone each sample being at a known position relative to the one or more detectable features.

In an embodiment of the present invention there is provided a rotatable cylinder or cone comprising:

- 20 (i) one or more detectable features on the rotatable cylinder or cone,
- (ii) one or more samples disposed on the rotatable cylinder or cone, wherein the azimuth of each of the samples is known relative to the detectable feature(s) and the distances from the top or bottom of the rotatable cylinder or cone is known for each of the samples and the one or more detectable features.

25 In another aspect of the present invention there is provided a combination of (a) a rotatable cylinder or cone comprising one or more positioners to position the cylinder or cone on a rotator at a predetermined position and (b) one or more rotors for coupling the one or more positioners and a rotator wherein:

- (i) at least one detectable feature(s) is on at least one of the rotors;
- 30 (ii) the rotatable cylinder or cone, the one or more rotors and the rotator are capable of being coupled together such that the rotatable cylinder or cone is at a predetermined angular orientation relative to the rotator, and
- (iii) one or more samples disposed on the rotatable cylinder or cone, wherein the azimuth of each of the samples is known relative to the detectable feature(s) and the

distances from the top or bottom of the rotatable cylinder or cone is known for each of the samples and the one or more detectable features.

In another aspect of the present invention there is provided a rotatable cone or cylinder comprising:

- 5 (i) one or more detectable features on the rotatable cone or cylinder,
- (ii) one or more samples, each sample being disposed in a matrix, and being positioned wherein the angle subtended in a horizontal plane parallel to the end or bottom of the cylinder or cone between each sample, the central longitudinal axis of the cone or cylinder and an imaginary vertical line running from the top of the cylinder or cone to the
10 bottom of the cylinder or cone and intersecting the detectable feature(s) is known and the length coordinates of the detectable feature(s) and each of the samples on the cone or cylinder is known relative to the top or bottom of the rotatable cone or cylinder.

In a further aspect of the present invention there is provided a combination of a rotatable cylinder or cone, a support comprising one or more detectable features and a
15 linker for linking the support and the rotatable cylinder or cone.

In yet a further aspect of the present invention there is provided a combination of a rotatable cylinder or cone, a support comprising one or more detectable features and a linker for linking the support and the rotatable cylinder or cone and one or more samples on the rotatable cylinder or cone wherein the latitude and the altitude of the detectable
20 feature are known and the latitude and longitude of each of the samples is known.

The rotatable cylinder or cone may comprise a positioner to position the cylinder or cone on a rotator at a predetermined position. The positioner may comprise one or more spindles protruding from the top and/or bottom ends of the rotatable cylinder or cone. Each of the spindles may be fixed or removable. There may be one or more
25 complementary shaped apertures or cavities located in the rotator so as to receive each of the spindles when the rotatable cylinder or cone is disposed on the rotator at a predetermined position. Alternatively the positioner may comprise a mating feature disposed on or through the cylinder or cone said mating feature being capable of mating to a rotator at a predetermined position on the rotator. The mating feature(s) may be
30 capable of mating to one or more spindles that comprise part of the rotator and is/are disposed so as to allow the rotatable cylinder or cone to be disposed at a predetermined position on the rotator. The mating feature(s) may be one or more apertures in the cylinder or cone which is/are located on the cylinder or cone and shaped such that the cylinder or cone may be coupled with a rotator having one or more complementary

spindles disposed on the rotator so as to fit in the one or more apertures in the cylinder or cone when the cylinder or cone is disposed on the rotator at a predetermined position. For example, a cavity or aperture may be positioned centrally in the top of the cylinder or cone and a cavity or aperture may be located centrally in the bottom of the cylinder or cone. Two spindles may be disposed on a rotator (one to go in aperture at the top of the cylinder or cone and one to go in the aperture at the bottom of the cylinder or cone), each of which may have a complementary shape to the cavity or aperture in or through which it is intended to fit or pass. The shape of the aperture and spindle may be such that the rotatable cylinder or cone may only be mounted on the rotator at a unique predetermined position.

In one form, the rotatable cylinder or cone may have one or more polygon-shaped cavities or apertures or other shaped cavities or apertures wherein the shape of the polygon or other shaped cavity or aperture is complementary to the shape of the one or more spindle on the rotator such that the rotatable cylinder or cone may be disposed on the rotator at a unique predetermined position. The predetermined position corresponds to a position where the one or more spindles is aligned with and is disposed in the one or more cavities or passes through the one or more apertures.

The rotatable cylinder or cone may have two or more cavities or apertures which are disposed or shaped such that the rotatable cylinder or cone may be disposed on two or more complementary shaped spindles on the rotator at a single predetermined position. The single predetermined position corresponds to the position where the at least two spindles on the rotator are aligned with and are disposed in the two or more cavities or pass through the two or more apertures in the rotatable cylinder or cone.

The rotatable cylinder or cone may comprise one or more keyhole cavities or apertures so that the rotatable cylinder or cone may be disposed on one or more complementary keyhole shaped spindles on the rotator such that the cylinder or cone is at a predetermined position on the rotator. The predetermined position may be a unique position. The single predetermined position corresponds to the position where the one or more keyhole shaped spindles on the rotator is/are aligned with and is/are disposed in the one or more keyhole cavities or pass through the one or more keyhole apertures in the rotatable cylinder or cone.

The rotatable cylinder or cone may comprise a mating shape that allows the rotatable cylinder or cone to be coupled to the rotator. The rotatable cylinder or cone and the rotator may be couplable to each other such that the cylinder or cone is at a

predetermined position relative to the rotator. The predetermined position may be a unique predetermined position. At the predetermined position the cylinder or cone may be at a singular angular orientation relative to the rotator about the central axis of rotation of the cylinder or cone.

5 The rotatable cylinder or cone may have one or more mating shapes and the rotator may have one or more complementary mating shapes such that the rotatable cylinder or cone and the rotator may be coupled to each other whereby the cylinder or cone is at a predetermined position relative to the rotator. The mating shapes may be the same as each other or different or a mixture thereof. The complementary mating shapes may be the same as each other or different or a mixture thereof. The predetermined position may be a singular angular orientation of the cylinder or cone relative to the rotator about the axis of rotation of the cylinder or cone. The axis of rotation may be the longitudinal central axis of the cylinder or cone. The mating shape may be a polygon mating shape.

15 The detectable feature may be disposed on the cylindrical surface and/or the top and/or bottom surface(s) of the rotatable cylinder or the conical surface and/or the top and/or bottom surface(s) of the cone. The detectable feature may be a registration mark. The registration mark may be present in the form of - barcode data on the rotatable cylinder or cone. Alternatively, the registration mark may be one or more reflective parts and/or absorption parts and/or one or more fluorescent parts on the rotatable cylinder or cone. The reflective, absorption and/or absorption parts may be an area of any shape or a line, for example. The size of the registration mark is such that it permits the at least one sample on the cylinder or cone to be located from the detected position of the registration mark. The size of the registration mark may be about the same as or the same as the size of the sample on the rotatable cylinder or cone. The size of the registration mark may be about the same as or the same as the size of the smallest sample on the rotatable cylinder or cone. The size of the registration mark may be smaller than the size of the sample on the rotatable cylinder or cone. The size of the registration mark may be smaller than the size of the smallest sample on the rotatable cylinder or cone.

25 The rotatable cylinder or cone may comprise metal, a metal coated plastic, plastic, ceramic or other conducting or non-conducting material capable of being formed into a solid or hollow cylinder or cone.

30 The rotatable cylinder or cone may contain purpose built Matrix-Assisted Laser-Desorption/Ionisation (MALDI) sample surfaces comprising wells, hydrophobic or

hydrophilic coatings, raised sections to contain wells and specialised surface materials to enhance MALDI signals.

The rotatable cylinder or cone may feature a radio frequency tag which is capable of being detected by a radio frequency receiver used to authenticate the rotatable cylinder or
5 cone.

The rotatable cylinder or cone may comprise a barcode for use with Laboratory Information Management Systems (LIMS) software.

The sample may be disposed on the cylindrical surface of the rotatable cylinder or the conical surface of the rotatable cone. There may be a plurality of samples disposed on
10 the cylindrical surface of the cylinder or the conical surface of the cone. Each of the samples may be disposed in a matrix. The one or more detectable features may be disposed on or integral with a surface of the cylinder or cone. The sample and the one or more detectable features may be disposed on the rotatable cylinder or cone at known positions relative to each other and to the central longitudinal axis of the cylinder or cone.
15 Each of the samples may be portions of one or more chemical analyte(s), which are supported in a matrix and suitable for Matrix Assisted Laser Desorption Ionisation (MALDI) analysis.

Discrete samples may be arranged on the rotatable cylinder or cone in a pattern lying on concentric circles where the center of each circle is a point lying on the central
20 longitudinal axis of the rotatable cylinder or cone.

Discrete samples may be arranged in a shape of a spiral on the rotatable cylinder or cone. The spiral may emanate from a point on the central longitudinal axis of the rotatable cylinder or cone.

Discrete sample spots may be arranged in a rectangular or square array on the
25 rotatable cylinder or cone. The array may be arranged about the central longitudinal axis of the rotatable cylinder or cone.

The sample may comprise an area about the size of a spot or an area larger than a spot. In the case where the area is larger than a spot the sample may be an area of tissue such as a tissue section for example.

30 The unused sample space on the rotatable cylinder or cone between samples may be used for standard mass calibrants.

The size of each of the one or more samples on the cylinder or cone may be in a range selected from the group consisting of 0.2 – 7mm or more, 0.5 – 5 mm, 0.5 – 3 mm and 0.5-2mm in diameter. Each of the one or more samples may be disposed in a

compositional matrix. The matrix is one suitable for use in MALDI. The matrix may be a solid, liquid or gel matrix or other suitable matrix. Where the matrix is in the form of a liquid then for each sample from 30nl to 5microlitre or 50nl to 2 microlitres of matrix plus sample may be placed on the cylinder or cone (usually in the form of a drop or spot
5 on the cylinder or cone). The matrix may be suitable for use with laser desorption.

In another aspect of the present invention there is provided a method for determining the position of at least one sample on a rotatable cylinder or cone, and subsequently sampling the sample, said rotatable cylinder or cone comprising a detectable feature and wherein said at least one sample is located at a known position on said
10 cylinder or cone relative to said feature, said method comprising:

- (i) rotating the rotatable cylinder or cone at a constant frequency about the central longitudinal axis of the cylinder or cone,
- (ii) detecting the detectable feature,
- (iii) determining an arrival time of the sample at a sampling location after
15 the detecting,
- (iv) sampling at least a portion of the sample at the arrival time, and
- (v) optionally repeating steps (i) to (iv).

The method may further comprise the step of:

- (iii)(a) enabling a sampler to sample the sample at the sampling location.
20 Step (iii) (a) may comprise moving the sampler or a component of the sampler to sample the sample at the sampling location.

In another aspect of the present invention there is provided a method for determining the position of at least one sample on a rotatable cylinder or cone, and subsequently releasing the sample from the cylinder or cone, said rotatable cylinder or
25 cone having a registration mark and said at least one sample being located at a known position on said cylinder or cone relative to said feature, said method comprising:

- (i) storing the known locations of the samples,
- (ii) rotating the rotatable cylinder or cone at a known rotational velocity,
- (iii) registering the detected registration mark signal,
- 30 (iv) determining the time at which the particular sample will arrive at a sampling location,
- (v) directing the sampler to desorb at least a portion of the sample one more times per revolution of the rotatable cylinder or cone,
- (vi) analysing the desorbed sample, and

(vii) optionally repeating steps (i) through (vi).

The rotatable cylinder or cone may be rotated at variable angular velocity and frequency. Alternatively, the rotatable cylinder or cone may be rotated at a constant frequency of 1 to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz, 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The method for determining the position of at least one sample on rotatable cylinder or cone, and subsequently releasing the sample from the cylinder or cone may comprise an analyser for analysing the sample sampled (e.g. by desorption or ablation) from the rotatable cylinder or cone.

The step of analysing may be performed with an analyser may be an ion mobility device or may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, where the sampler is a laser beam it may be directed to ablate or desorb another sample from the rotatable cylinder or cone.

The step of detecting may comprise detecting a detectable feature with a detector, so that the angular position of sample is known relative to the detectable feature. The angular position may be the angular position of the sample and the detectable feature relative to the longitudinal axis of the cylinder or cone and, in particular relative to the center of the longitudinal axis of the cylinder or cone or some other point on the longitudinal axis of the cylinder or cone. The time delay taken from when the detectable feature is detected to when the sample crosses the path of a sampler, such as a laser which is capable of producing a desorbing laser beam, may be calculated, so that upon the detection of the registration mark by a detector, the laser can be fired at the arrival time.

The method may include directing a laser beam to a sampling location on the rotatable cylinder or cone in order to sample at least a portion of the sample at the arrival time. A director may be used to direct the laser beam to the sampling location on the rotatable cylinder or cone.

The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example.

Alternatively, a linear director may be attached to the rotatable cylinder or cone. The linear director may position the rotatable cylinder or cone at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable cylinder or cone in the x-y plane. The director only need direct the laser beam back and forth along one arbitrarily chosen line along the cylindrical surface which extends from the bottom to the top of the rotatable cylinder or along the conical surface which extends from the bottom to the top of the rotatable cone in order to access every sample on the rotatable cylinder or cone as it rotates around the central longitudinal axis of the cylinder or cone.

The step of sampling may be performed by a sampler such as a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable cylinder or cone. Suitably, the sampler may emit one or more beams onto the required sample per revolution of the sample on the rotatable cylinder or cone. There may be one or more samplers(e.g. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more samplers). Where there is more than one sampler they may be arranged in an array e.g. a linear or a non linear array.

The radial coordinate of the sample with respect to the center of the central longitudinal axis of the rotatable cylinder or cone (or some other suitable may be recorded at the same time as or after its deposition onto the rotatable cylinder or cone.

In a further aspect of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable cylinder or cone comprising one or more detectable features disposed on the cylinder or cone, and sampling at least a portion of the sample from the cylinder or cone, said at least one sample being located at a known position on said cylinder or cone relative to said one or more detectable features, said system comprising:

- (i) a rotator for rotating the rotatable cylinder or cone;
- (ii) a detector for detecting the detectable feature on the rotatable cylinder or cone;
- (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector; and
- (iv) a sampler for sampling at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise an enabler for enabling the sampler to sample a sample at the sampling location. The enabler may comprise means for moving the sampler or a component of the sampler. For example, where the sampler is a laser the enabler may comprise means for moving the laser or means for moving a mirror or other
5 reflective surface at which the laser beam is directed, so that the laser beam when activated desorbs a sample at the sampling location.

In an embodiment of the system of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable cylinder or cone comprising one or more detectable features disposed on the cylinder or cone,
10 sampling at least a portion of the sample from the cylinder or cone, and analysing said portion, said at least one sample being located at a known position on said cylinder or cone relative to said feature, said system comprising:

- (i) a rotator for rotating the rotatable cylinder or cone at a known rotational velocity,
- 15 (ii) a positioner for positioning the rotatable cylinder or cone on a rotator at a predetermined position on the rotator,
- (iii) a detector detecting the detectable feature on the rotatable cylinder or cone,
- (iv) a processor for determining an arrival time when the sample will arrive
20 at a sampling location after the detecting said processor being coupled to said detector, and
- (v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise

- 25 (vi) an analyser for analysing the desorbed or ablated sample.

The sampler may be capable of desorbing or ablating at least a portion of the sample at the arrival time one or more times per revolution of the rotatable cylinder or cone. The sampler may be capable of sampling a plurality of samples per revolution of the rotatable cylinder or cone.

30 The systems of the invention may further comprise one or more rotatable cylinder or cones of the invention.

The rotator may comprise an actuator which may rotationally and optionally linearly actuate the rotatable cylinder or cone. The rotatable cylinder or cone may be rotationally actuated at variable angular velocity and frequency. The rotatable cylinder or

cone may be rotationally actuated at a constant frequency of 1 to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz, 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The rotational actuator may be attached to a linear actuator. The linear actuator may actuate the rotational actuator in one or more planes perpendicular to the plane in which the sampler operates in order to position the required sample on the rotatable cylinder or cone in a location amenable to the sampler. For example, if the sampler operates in the z-y-plane, then the linear actuator may actuate the rotational actuator in the x-y plane. The linear actuator may have a position repeatability in the range of 0.001 to 0.05 mm. The linear actuator may have a position repeatability which is dependent on the dimensions of the smallest sample. For example, for a circular sample of 0.01mm in diameter the linear actuator has a position repeatability of at least 0.01mm.

The processor may store the locations of the one or more samples on the rotatable cylinder or cone relative to the position of the one or more detectable features.

The detector may be a photodiode in combination with a light emitting diode which is able to transmit and receive signals. Alternatively, the detector may be any imaging device that is capable of detecting a registration mark such as a camera, Charged Coupled Device (CCD), or a photovoltaic device for example. As another alternative, the detector may be a proximity device based on magnetic fields or electrical capacitance. As a further alternative the detector may be a mechanical device such as a micro-switch or a phase sensitive inductance device for example.

The radial coordinate of the sample with respect to the center of the central longitudinal axis of the rotatable cylinder or cone may be recorded upon its deposition onto the rotatable cylinder or cone.

The detectable feature may be detected by the detector, so that the angular position of sample is known relative to the detectable feature.

The time delay taken when the detectable feature is detected to when the sample crosses the path of the desorbing laser beam may be calculated, so that upon the subsequent detection of the detectable feature, the laser can be fired at the arrival time.

The sampler may be a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable cylinder or cone.

Suitably, the sampler may emit one or more laser beams onto the required sample per revolution of the sample on the rotatable cylinder or cone to ablate or desorb at least a portion of the sample.

The systems of the invention may include a director may be used to direct the
5 sampler to the appropriate location on the rotatable cylinder or cone. In one form the director may be coupled to the sampler for directing the sampler to the appropriate radial coordinate on the rotatable cylinder or cone such that the sampler can sample the at least portion of the sample at the arrival time. The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example. A linear director may be attached
10 to the rotatable cylinder or cone. The linear director may position the rotatable cylinder or cone at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable cylinder or cone in the x-y plane. The director only need direct the laser beam
15 back and forth along one arbitrarily chosen line which extends from the top to the bottom of the rotatable cylinder or cone in order to access every sample on the rotatable cylinder or cone as it rotates.

The system for determining the position of at least one sample on a cylinder or cone of a rotatable cylinder or cone, and subsequently releasing the sample from the cylinder or
20 cone may comprise an analyser to analyse the sample desorbed from the rotatable cylinder or cone. The analyser may be an ion mobility device. The analyser may be a may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS).
25 The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, the sampler may be directed to ablate or desorb another sample.

In one aspect of the present invention there is provided a rotatable sphere comprising one or more detectable features.

30 In another aspect of the present invention there is provided a rotatable sphere comprising:

- (i) one or more detectable features on the rotatable sphere,
- (ii) a sample disposed on the rotatable sphere at a known position relative to the one or more detectable features.

There may be a plurality of samples disposed on the sphere each sample being at a known position relative to the one or more detectable features.

In an embodiment of the present invention there is provided a rotatable sphere comprising:

- 5 (i) one or more detectable features on the rotatable sphere,
- (ii) one or more samples disposed on the rotatable sphere, wherein the latitude and longitude of each of the samples is known relative to the detectable feature(s).

In a further aspect of the present invention there is provided a combination of a
10 rotatable sphere, a support comprising one or more detectable features and a linker for linking the support and the rotatable sphere.

In yet a further aspect of the present invention there is provided a combination of a rotatable sphere, a support comprising one or more detectable features and a linker for linking the support and the rotatable sphere and one or more samples on the rotatable
15 sphere wherein the latitude and the altitude of the detectable feature are known and the latitude and longitude of each of the samples is known.

In another aspect of the present invention there is provided a combination of (a) a rotatable sphere comprising one or more positioners to position the sphere on a rotator at a predetermined position and (b) one or more rotors for coupling the one or more
20 positioners and a rotator wherein:

- (i) at least one detectable feature(s) on at least one of the rotors;
- (ii) the rotatable sphere, the one or more rotors and the rotator are capable of being coupled together such that the rotatable sphere is at a predetermined angular orientation relative to the rotator, and
- 25 (iii) one or more samples disposed on the rotatable sphere, wherein the latitude and longitude of each of the samples is known relative to the detectable feature(s).

In another aspect of the present invention there is provided a rotatable sphere comprising:

- 30 (i) one or more detectable features on the rotatable sphere,
- (ii) one or more samples, each sample being disposed in a matrix, and being positioned on the rotatable sphere, wherein the latitude and longitude of each of the samples is known relative to the detectable feature(s).

In another aspect of the present invention there is provided a rotatable sphere comprising:

(i) one or more registration mark(s) on the rotatable sphere wherein the latitude and longitude of the registration mark(s) is known,

5 (ii) one or more samples disposed on the rotatable sphere, wherein the latitude and longitude of each of the samples is known.

In another aspect of the present invention there is provided a rotatable sphere comprising a rotor and a registration mark disposed on the rotor, said sphere comprising:

(i) one or more positioners for positioning the rotatable sphere on a rotator
10 at a predetermined angular orientation relative to the rotator about the axis of rotation of the sphere, and

(ii) a sample disposed at known coordinates such as longitude and latitude on the rotatable sphere,

wherein the latitude of the samples is known relative to the equatorial latitude of the
15 rotatable sphere and the longitude of the sample is known relative to the registration mark on the rotor.

The rotatable sphere may comprise a positioner to position the sphere on a rotator at a predetermined position. The positioner may comprise one or more spindles protruding from the top and/or bottom ends of the rotatable sphere. Each of the spindles may be fixed
20 or removable. There may be one or more complementary shaped apertures or cavities located in the rotator so as to receive each of the spindles when the rotatable sphere is disposed on the rotator at a predetermined position. Alternatively the positioner may comprise a mating feature disposed on or through the sphere said mating feature being capable of mating to a rotator at a predetermined position on the rotator. The mating
25 feature(s) may be capable of mating to one or more spindles that comprise part of the rotator and is/are disposed so as to allow the rotatable sphere to be disposed at a predetermined position on the rotator. The mating feature(s) may be one or more apertures in the sphere which is/are located on the sphere and shaped such that the sphere may be coupled with a rotator having one or more complementary spindles disposed on
30 the rotator so as to fit in the one or more apertures in the sphere when the sphere is disposed on the rotator at a predetermined position. For example, a cavity or aperture may be positioned centrally in the top of the sphere and a cavity or aperture may be located centrally in the bottom of the sphere. Two spindles may be disposed on a rotator (one to go in aperture at the top of the sphere and one to go in the aperture at the bottom of the

sphere), each of which may have a complementary shape to the cavity or aperture in or through which it is intended to fit or pass. The shape of the aperture and spindle may be such that the rotatable sphere may only be mounted on the rotator at a unique predetermined position.

5 In one form, the rotatable sphere may have one or more polygon-shaped cavities or apertures or other shaped cavities or apertures wherein the shape of the polygon or other shaped cavity or aperture is complementary to the shape of the one or more spindle on the rotator such that the rotatable sphere may be disposed on the rotator at a unique predetermined position. The predetermined position corresponds to a position where the
10 one or more spindles is aligned with and is disposed in the one or more cavities or passes through the one or more apertures.

The rotatable sphere may have two or more cavities or apertures which are disposed or shaped such that the rotatable sphere may be disposed on two or more complementary shaped spindles on the rotator at a single predetermined position. The single
15 predetermined position corresponds to the position where the at least two spindles on the rotator are aligned with and are disposed in the two or more cavities or pass through the two or more apertures in the rotatable sphere.

The rotatable sphere may comprise one or more keyhole cavities or apertures so that the rotatable sphere may be disposed on one or more complementary keyhole shaped
20 spindles on the rotator such that the sphere is at a predetermined position on the rotator. The predetermined position may be a unique position. The single predetermined position corresponds to the position where the one or more keyhole shaped spindles on the rotator is/are aligned with and is/are disposed in the one or more keyhole cavities or pass through the one or more keyhole apertures in the rotatable sphere.

25 The rotatable sphere may comprise a mating shape that allows the rotatable sphere to be coupled to the rotator. The rotatable sphere and the rotator may be capable of being coupled to each other such that the sphere is at a predetermined position relative to the rotator. The predetermined position may be a unique predetermined position. At the predetermined position the sphere may be at a singular angular orientation relative to the
30 rotator about the central axis of rotation of the sphere.

The rotatable sphere may have one or more mating shapes and the rotator may have one or more complementary mating shapes such that the rotatable sphere and the rotator may be coupled to each other whereby the sphere is at a predetermined position relative to the rotator. The mating shapes may be the same as each other or different or a mixture

thereof. The complementary mating shapes may be the same as each other or different or a mixture thereof. The predetermined position may be a singular angular orientation of the sphere relative to the rotator about the axis of rotation of the sphere. The axis of rotation may be the longitudinal central axis of the sphere. The mating shape may be a polygon mating shape.

The detectable feature may be disposed on the spherical surface and/or the top and/or bottom surface(s) of the rotatable sphere. The detectable feature may be a registration mark. The registration mark may be present in the form of -barcode data on the rotatable sphere. Alternatively, the registration mark may be one or more reflective parts and/or absorption parts and/or one or more fluorescent parts on the rotatable sphere. The reflective, absorption and/or absorption parts may be an area of any shape or a line, for example. The size of the registration mark is such that it permits the at least one sample on the sphere to be located from the detected position of the registration mark. The size of the registration mark may be about the same as or the same as the size of the sample on the rotatable sphere. The size of the registration mark may be about the same as or the same as the size of the smallest sample on the rotatable sphere. The size of the registration mark may be smaller than the size of the sample on the rotatable sphere. The size of the registration mark may be smaller than the size of the smallest sample on the rotatable sphere.

The rotatable sphere may comprise metal, a metal coated plastic, plastic, ceramic or other conducting or non-conducting material capable of being formed into a solid or hollow sphere.

The rotatable sphere may contain purpose built Matrix-Assisted Laser-Desorption/Ionisation (MALDI) sample surfaces comprising wells, hydrophobic or hydrophilic coatings, raised sections to contain wells and specialised surface materials to enhance MALDI signals.

The rotatable sphere may feature a radio frequency tag which is capable of being detected by a radio frequency receiver used to authenticate the rotatable sphere.

The rotatable sphere may comprise a barcode for use with Laboratory Information Management Systems (LIMS) software.

The sample may be disposed on the spherical surface of the rotatable sphere. There may be a plurality of samples disposed on the spherical surface of the sphere. Each of the samples may be disposed in a matrix. The one or more detectable features may be disposed on or integral with a surface of the sphere. The sample and the one or more

detectable features may be disposed on the rotatable sphere at known positions relative to each other and to the central longitudinal axis of the sphere.

Each of the samples may be portions of one or more chemical analyte(s), which are supported in a matrix and suitable for Matrix Assisted Laser Desorption Ionisation (MALDI) analysis.

Discrete samples may be arranged on the rotatable sphere in a pattern lying on concentric circles where the centre of each circle is a point lying on the central longitudinal axis of the rotatable sphere.

Discrete samples may be arranged in a shape of a spiral on the rotatable sphere. The spiral may emanate from a point on the central longitudinal axis of the rotatable sphere.

Discrete samples spots may be arranged in a rectangular or square array on the rotatable sphere. The array may be arranged about the central longitudinal axis of the rotatable sphere.

The sample may comprise an area about the size of a spot or an area larger than a spot. In the case where the area is larger than a spot the sample may be an area of tissue such as a tissue section for example.

The unused sample space on the rotatable sphere between samples may be used for standard mass calibrants. The size of each of the one or more samples on the sphere may be in a range selected from the group consisting of 0.2 – 7mm or more, 0.5 – 5 mm, 0.5 – 3 mm and 0.5-2mm in diameter. Each of the one or more samples may be disposed in a compositional matrix. The matrix is one suitable for use in MALDI. The matrix may be a solid, liquid or gel matrix or other suitable matrix. Where the matrix is in the form of a liquid then for each sample from 30nl to 5microlitre or 50nl to 2 microlitres of matrix plus sample may be placed on the sphere (usually in the form of a drop or spot on the sphere). The matrix may be suitable for use with laser desorption.

In another aspect of the present invention there is provided a method for determining the position of at least one sample on a rotatable sphere, and subsequently sampling the sample, said rotatable sphere comprising a detectable feature and wherein said at least one sample is located at a known position on said sphere relative to said feature, said method comprising:

- (i) rotating the rotatable sphere at a constant frequency optionally about the central longitudinal axis of the sphere,
- (ii) detecting the detectable feature,

(iii) determining an arrival time of the sample at a sampling location after the detecting,

(iv) sampling at least a portion of the sample at the arrival time, and

(v) optionally repeating steps (i) to (iv).

5 The method may further comprise the step of:

(iii)(a) enabling a sampler to sample a sample at the sampling location.

The enabling may comprise moving the sampler or a component of the sampler.

In another aspect of the present invention there is provided a method for determining the position of at least one sample on a rotatable sphere, and subsequently releasing the sample from the sphere, said rotatable sphere having a registration mark and
10 said at least one sample being located at a known position on said sphere relative to said feature, said method comprising:

(i) storing the known locations of the samples,

(ii) rotating the rotatable sphere at a known rotational velocity optionally
15 about the central longitudinal axis of the sphere,

(iii) detecting the registration mark,

(iv) determining the time at which the sample will arrive at a sampling location,

(v) directing a sampler to desorb or ablate at least a portion of the sample
20 one more times per revolution of the rotatable sphere,

(vi) analysing the desorbed sample, and

(vii) optionally repeating steps (i) through (vi).

The method may further comprise the step of:

(iv)(a) enabling a sampler to sample the sample at the sampling location.

25 The enabling may comprise moving the sampler or a component of the sampler.

In another aspect of the present invention there is provided a METHOD for determining the position of at least one sample on a rotatable sphere, and subsequently releasing the sample from the sphere, said rotatable sphere having a registration mark and said at least one sample being located at a known latitude and longitude on said sphere
30 relative to said feature, said method comprising:

(i) rotating the rotatable sphere at a known rotational velocity,

(ii) detecting the registration mark,

(iii) determining an arrival time at which the sample will arrive at a sampling location,

(iv) if necessary, tilting the rotatable sphere so as to present the latitude on which the sample lies to the sampler,

(v) sampling at least a portion of the sample at the arrival time,

(vi) analysing the desorbed sample, and

5 (vii) optionally repeating steps (i) through (vi).

The rotatable sphere may be rotated at variable angular velocity and frequency. Alternatively, the rotatable sphere may be rotated at a constant frequency of 1 to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz, 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The method for determining the position of at least one sample on rotatable sphere, and subsequently releasing the sample from the sphere may comprise an analyser for analysing the sample sampled (e.g. by desorption or ablation) from the rotatable sphere.

The step of analysing may be performed with an analyser may be an ion mobility device or may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, where the sampler is a laser beam it may be directed to ablate or desorb another sample from the rotatable sphere.

The step of detecting may comprise detecting a detectable feature with a detector, so that the angular position of sample is known relative to the detectable feature. The angular position may be the angular position of the sample and the detectable feature relative to the longitudinal axis of the sphere and, in particular relative to the center of the longitudinal axis of the sphere or some other point on the longitudinal axis of the sphere. The time delay taken from when the detectable feature is detected to when the sample crosses the path of a sampler, such as a laser which is capable of producing a desorbing laser beam, may be calculated, so that upon the detection of the registration mark by a detector, the laser can be fired at the arrival time.

The method may include directing a laser beam to a sampling location on the rotatable sphere in order to sample at least a portion of the sample at the arrival time. A

director may be used to direct the laser beam to the sampling location on the rotatable sphere.

The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example.

5 Alternatively, a linear director may be attached to the rotatable sphere. The linear director may position the rotatable sphere at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable sphere in the x-y plane. The director only need
10 direct the laser beam back and forth along one arbitrarily chosen semi-spherical line parallel to the spherical surface which extends from the bottom to the top of the rotatable sphere in order to access every sample on the rotatable sphere as it rotates around the central longitudinal axis of the sphere.

The step of sampling may be performed by a sampler such as a laser or any other
15 pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable sphere. Suitably, the sampler may emit one or more beams onto the required sample per revolution of the sample on the rotatable sphere. There may be one or more samplers(e.g. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more samplers). Where there is more than one sampler they may be arranged in an array e.g. a linear or a non linear
20 array.

The latitude and longitude of the sample with respect to detectable feature on the rotatable sphere (or some other suitable position) may be recorded at the same time as or after its deposition onto the rotatable sphere.

In a further aspect of the present invention there is provided a system for
25 determining the position of at least one sample disposed on a rotatable sphere comprising one or more detectable features disposed on the sphere, and sampling at least a portion of the sample from the sphere, said at least one sample being located at a known position on said sphere relative to said one or more detectable features, said system comprising:

- (i) a rotator for rotating the rotatable sphere;
- 30 (ii) a detector for detecting the detectable feature on the rotatable sphere;
- (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector; and

(iv) a sampler for sampling at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise an enabler for enabling the sampler to sample a sample at the sampling location. The enabler may comprise means for moving the sampler or a component of the sampler. For example, where the sampler is a laser the enabler may comprise means for moving the laser or means for moving a mirror or other reflective surface at which the laser beam is directed, so that the laser beam when activated desorbs a sample at the sampling location.

In an embodiment of the system of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable sphere comprising one or more detectable features disposed on the sphere, sampling at least a portion of the sample from the sphere, and analysing said portion, said at least one sample being located at a known position on said sphere relative to said feature, said system comprising:

- (i) a rotator for rotating the rotatable sphere at a known rotational velocity,
- (ii) a positioner for positioning the rotatable sphere on a rotator at a predetermined position on the rotator,
- (iii) a detector detecting the detectable feature on the rotatable sphere,
- (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled to said detector, and

(v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise

- (vi) an analyser for analysing the desorbed or ablated sample.

The sampler may be capable of desorbing or ablating at least a portion of the sample at the arrival time one or more times per revolution of the rotatable sphere. The sampler may be capable of sampling a plurality of samples per revolution of the rotatable sphere.

The systems of the invention may further comprise one or more rotatable spheres of the invention.

The rotator may comprise an actuator which may rotationally actuate the rotatable sphere. The rotatable sphere may be rotationally actuated at variable angular velocity and frequency. The rotatable sphere may be rotationally actuated at a constant frequency of 1

to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz, 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The rotational actuator of the rotatable sphere may be coupled to a tilt actuator or mechanism. The tilt actuator or mechanism may tilt the rotational actuator to present the latitude of the rotatable sphere on which the required sample lies to the sampler.

The tilt actuator may have a position repeatability in the range of 0.001 to 0.05 mm. The tilt actuator may have a position repeatability which is dependent on the dimensions of the smallest sample. For example, for a circular sample of 0.01mm in diameter the tilt actuator has a position repeatability of at least 0.01mm.

The tilt actuator may be used to position the rotatable sphere such that upon rotation of the rotatable sphere any particular sample on the rotatable sphere may be exposed to a desorbing laser beam.

The processor may store the locations of the one or more samples on the rotatable sphere relative to the position of the one or more detectable features.

The detector may be a photodiode in combination with a light emitting diode which is able to transmit and receive signals. Alternatively, the detector may be any imaging device that is capable of detecting a registration mark such as a camera, Charged Coupled Device (CCD), or a photovoltaic device for example. As another alternative, the detector may be a proximity device based on magnetic fields or electrical capacitance. As a further alternative the detector may be a mechanical device such as a micro-switch or a phase sensitive inductance device for example.

The radial coordinate of the sample with respect to the center of the central longitudinal axis of the rotatable sphere may be recorded upon its deposition onto the rotatable sphere. The latitude (and longitude) of the sample with respect to the registration mark associated with the rotatable sphere may be recorded upon its deposition onto the rotatable sphere.

The detectable feature may be detected by the detector, so that the angular position of sample is known relative to the detectable feature.

The time delay taken when the detectable feature is detected to when the sample crosses the path of the desorbing laser beam may be calculated, so that upon the subsequent detection of the detectable feature, the laser can be fired at the arrival time.

The sampler may be a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable sphere.

Suitably, the sampler may emit one or more laser beams onto the required sample per revolution of the sample on the rotatable sphere to ablate or desorb at least a portion
5 of the sample.

The systems of the invention may include a director may be used to direct the sampler to the appropriate location on the rotatable sphere. In one form the director may be coupled to the sampler for directing the sampler to the appropriate radial coordinate on the rotatable sphere such that the sampler can sample the at least portion of the sample at
10 the arrival time. The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example. A linear director may be attached to the rotatable sphere. The linear director may position the rotatable sphere at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the
15 z-y-plane, then the linear director may direct the rotatable sphere in the x-y plane. The director only need direct the laser beam back and forth along one arbitrarily chosen line which extends from the top to the bottom of the rotatable sphere in order to access every sample on the rotatable sphere as it rotates.

The system for determining the position of at least one sample on a sphere of a rotatable sphere, and subsequently releasing the sample from the sphere may comprise an
20 analyser to analyse the sample desorbed from the rotatable sphere. The analyser may be an ion mobility device. The analyser may be a may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation
25 Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, the sampler may be directed to ablate or desorb another sample.

In one aspect of the present invention there is provided a rotatable object
30 comprising one or more detectable features.

In another aspect of the present invention there is provided a rotatable object comprising:

- (i) one or more detectable features on the rotatable object,

(ii) a sample disposed on the rotatable object at a known position relative to the one or more detectable features.

There may be a plurality of samples disposed on the rotatable object each sample being at a known position relative to the one or more detectable features.

5 In a further aspect of the present invention there is provided a combination of a rotatable object, a support comprising one or more detectable features and a linker for linking the support and the rotatable object.

In yet a further aspect of the present invention there is provided a combination of a rotatable object, a support comprising one or more detectable features and a linker for
10 linking the support and the rotatable object and one or more samples disposed on the rotatable object wherein the position of each of the samples is known relative to the position and altitude of the detectable feature.

In another aspect of the present invention there is provided a combination of (a) a rotatable object comprising one or more positioners to position the object on a rotator at a
15 predetermined position and (b) one or more rotors for coupling the one or more positioners and a rotator wherein:

(i) at least one detectable feature(s) is disposed on at least one of the rotors;
(ii) the rotatable object, the one or more rotors and the rotator are capable of
being coupled together such that the rotatable object is at a predetermined angular
20 orientation relative to the rotator, and

(iii) one or more samples disposed on the rotatable object wherein the position of each of the samples is known relative to the position and altitude of the detectable feature.

In another aspect of the present invention there is provided a rotatable object
25 comprising:

(i) one or more detectable features on the rotatable object,
(ii) one or more samples, each sample being disposed in a matrix, disposed
on the rotatable object wherein the position of each of the samples is known relative to
the position and altitude of the detectable feature.

30 The rotatable object may comprise a positioner to position the object on a rotator at a predetermined position. The positioner may comprise one or more spindles protruding from the top and/or bottom ends of the rotatable object. Each of the spindles may be fixed or removable. There may be one or more complementary shaped apertures or cavities located in the rotator so as to receive each of the spindles when the rotatable object is

disposed on the rotator at a predetermined position. Alternatively the positioner may comprise a mating feature disposed on or through the object said mating feature being capable of mating to a rotator at a predetermined position on the rotator. The mating feature(s) may be capable of mating to one or more spindles that comprise part of the rotator and is/are disposed so as to allow the rotatable object to be disposed at a predetermined position on the rotator. The mating feature(s) may be one or more apertures in the object which is/are located on the object and shaped such that the object may be coupled with a rotator having one or more complementary spindles disposed on the rotator so as to fit in the one or more apertures in the object when the object is disposed on the rotator at a predetermined position. For example, a cavity or aperture may be positioned centrally in the top of the object and a cavity or aperture may be located centrally in the bottom of the object. Two spindles may be disposed on a rotator (one to go in aperture at the top of the object and one to go in the aperture at the bottom of the object), each of which may have a complementary shape to the cavity or aperture in or through which it is intended to fit or pass. The shape of the aperture and spindle may be such that the rotatable object may only be mounted on the rotator at a unique predetermined position.

In one form, the rotatable object may have one or more polygon-shaped cavities or apertures or other shaped cavities or apertures wherein the shape of the polygon or other shaped cavity or aperture is complementary to the shape of the one or more spindle on the rotator such that the rotatable object may be disposed on the rotator at a unique predetermined position. The predetermined position corresponds to a position where the one or more spindles is aligned with and is disposed in the one or more cavities or passes through the one or more apertures.

The rotatable object may have two or more cavities or apertures which are disposed or shaped such that the rotatable object may be disposed on two or more complementary shaped spindles on the rotator at a single predetermined position. The single predetermined position corresponds to the position where the at least two spindles on the rotator are aligned with and are disposed in the two or more cavities or pass through the two or more apertures in the rotatable object.

The rotatable object may comprise one or more keyhole cavities or apertures so that the rotatable object may be disposed on one or more complementary keyhole shaped spindles on the rotator such that the object is at a predetermined position on the rotator. The predetermined position may be a unique position. The single predetermined position

corresponds to the position where the one or more keyhole shaped spindles on the rotator is/are aligned with and is/are disposed in the one or more keyhole cavities or pass through the one or more keyhole apertures in the rotatable object.

5 The rotatable object may comprise a mating shape that allows the rotatable object to be coupled to the rotator. The rotatable object and the rotator may be couplable to each other such that the object is at a predetermined position relative to the rotator. The predetermined position may be a unique predetermined position. At the predetermined position the object may be at a singular angular orientation relative to the rotator about the central axis of rotation of the object.

10 The rotatable object may have one or more mating shapes and the rotator may have one or more complementary mating shapes such that the rotatable object and the rotator may be coupled to each other whereby the object is at a predetermined position relative to the rotator. The mating shapes may be the same as each other or different or a mixture thereof. The complementary mating shapes may be the same as each other or different or
15 a mixture thereof. The predetermined position may be a singular angular orientation of the object relative to the rotator about the axis of rotation of the object. The axis of rotation may be the longitudinal central axis of the object. The mating shape may be a polygon mating shape.

The detectable feature may be disposed on the surface of the object and/or the top
20 and/or bottom surface(s) of the object. The detectable feature may be a registration mark. The registration mark may be present in the form of barcode data on the rotatable object. Alternatively, the registration mark may be one or more reflective parts and/or absorption parts and/or one or more fluorescent parts on the rotatable object. The reflective, absorption and/or absorption parts may be an area of any shape or a line, for example.
25 The size of the registration mark is such that it permits the at least one sample on the object to be located from the detected position of the registration mark. The size of the registration mark may be about the same as or the same as the size of the sample on the rotatable object. The size of the registration mark may be about the same as or the same as the size of the smallest sample on the rotatable object. The size of the registration mark
30 may be smaller than the size of the sample on the rotatable object. The size of the registration mark may be smaller than the size of the smallest sample on the rotatable object.

The rotatable object may comprise metal, a metal coated plastic, plastic, ceramic or other conducting or non-conducting material capable of being formed into a solid or hollow object.

The rotatable object may contain purpose built Matrix-Assisted Laser-
5 Desorption/Ionisation (MALDI) sample surfaces comprising wells, hydrophobic or hydrophilic coatings, raised sections to contain wells and specialised surface materials to enhance MALDI signals.

The rotatable object may comprise a radio frequency tag which is capable of being detected by a radio frequency receiver used to authenticate the rotatable object.

10 The rotatable object may comprise a barcode for use with Laboratory Information Management Systems (LIMS) software.

The sample may be disposed on the surface of the rotatable object. There may be a plurality of samples disposed on the surface of the object. Each of the samples may be disposed in a matrix. The one or more detectable features may be disposed on or integral
15 with a surface of the object. The sample and the one or more detectable features may be disposed on the rotatable object at known positions relative to each other and to the central longitudinal axis of the object.

Each of the samples may be portions of one or more chemical analyte(s), which are supported in a matrix and suitable for Matrix Assisted Laser Desorption Ionisation
20 (MALDI) analysis.

Discrete samples may be arranged on the rotatable object in a pattern lying on concentric circles where the centre of each circle is a point lying on the central longitudinal axis of the rotatable object.

Discrete samples may be arranged in a shape of a spiral on the rotatable object. The
25 spiral may emanate from a point on the central longitudinal axis of the rotatable object.

Discrete samples spots may be arranged in a rectangular or square array on the rotatable object. The array may be arranged about the central longitudinal axis of the rotatable object.

The sample may comprise an area about the size of a spot or an area larger than a
30 spot. In the case where the area is larger than a spot the sample may be an area of tissue such as a tissue section for example.

The unused sample space on the rotatable object between samples may be used for standard mass calibrants.

The size of each of the one or more samples on the object may be in a range selected from the group consisting of 0.2 – 7mm or more, 0.5 – 5 mm, 0.5 – 3 mm and 0.5-2mm in diameter. Each of the one or more samples may be disposed in a compositional matrix. The matrix is one suitable for use in MALDI. The matrix may be a solid, liquid or gel matrix or other suitable matrix. Where the matrix is in the form of a liquid then for each sample from 30nl to 5microlitre or 50nl to 2 microlitres of matrix plus sample may be placed on the object (usually in the form of a drop or spot on the object). The matrix may be suitable for use with laser desorption.

In another aspect of the present invention there is provided a method for determining the position of at least one sample on a rotatable object, and subsequently sampling the sample, said rotatable object comprising a detectable feature and wherein said at least one sample is located at a known position on said object relative to said feature, said method comprising:

- (i) rotating the rotatable object at a constant frequency optionally about the central longitudinal axis of the object,
- (ii) detecting the detectable feature,
- (iii) determining an arrival time of the sample at a sampling location after the detecting,
- (iv) sampling at least a portion of the sample at the arrival time, and
- (v) optionally repeating steps (i) to (iv).

The method may further comprise the step of:

- (iii)(a) enabling a sampler to enable sampling at the sampling location.

The enabling may comprise moving the sampler or a component of the sampler.

In another aspect of the present invention there is provided a method for determining the position of at least one sample on a rotatable object, and subsequently releasing the sample from the object, said rotatable object having a registration mark and said at least one sample being located at a known position on said object relative to said feature, said method comprising:

- (i) storing the known locations of the samples,
- (ii) rotating the rotatable object at a known rotational velocity optionally about the central longitudinal axis of the object,
- (iii) detecting the registration mark,
- (iv) determining the time at which the sample will arrive at a sampling location,

(v) directing a sampler to desorb or ablate at least a portion of the sample one more times per revolution of the rotatable object,

(vi) analysing the desorbed sample, and

(vii) optionally repeating steps (i) through (vi).

5 The method may further comprise the step of:

(iv)(a) enabling a sampler to enable sampling of the sample at the sampling location.

The enabling may comprise moving the sampler or a component of the sampler.

The rotatable object may be rotated at variable angular velocity and frequency. Alternatively, the rotatable object may be rotated at a constant frequency of 1 to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz, 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or
15 200 to 300 Hz.

The method for determining the position of at least one sample on rotatable object, and subsequently releasing the sample from the object may comprise an analyser for analysing the sample sampled (e.g. by desorption or ablation) from the rotatable object.

The step of analysing may be performed with an analyser may be an ion mobility
20 device or may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, where the sampler is a laser beam
25 it may be directed to ablate or desorb another sample from the rotatable object.

The step of detecting may comprise detecting a detectable feature with a detector, so that the angular position of sample is known relative to the detectable feature. The angular position may be the angular position of the sample and the detectable feature relative to the longitudinal axis of the object and, in particular relative to the center of the
30 longitudinal axis of the object or some other point on the longitudinal axis of the object. The time delay taken from when the detectable feature is detected to when the sample crosses the path of a sampler, such as a laser which is capable of producing a desorbing laser beam, may be calculated, so that upon the detection of the registration mark by a detector, the laser can be fired at the arrival time.

The method may include directing a laser beam to a sampling location on the rotatable object in order to sample at least a portion of the sample at the arrival time. A director may be used to direct the laser beam to the sampling location on the rotatable object.

5 The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example.

Alternatively, a linear director may be attached to the rotatable object. The linear director may position the rotatable object at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable object in the x-y plane. The director only need direct the laser beam back and forth along one arbitrarily chosen line parallel to the surface which extends from the bottom to the top of the rotatable object in order to access every sample on the rotatable object as it rotates around the central longitudinal axis of the object.

15 The step of sampling may be performed by a sampler such as a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable object. Suitably, the sampler may emit one or more beams onto the required sample per revolution of the sample on the rotatable object. There may be one or more samplers (e.g. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more samplers). Where there is more than one sampler they may be arranged in an array e.g. a linear or a non linear array.

The position of the sample with respect to detectable feature on the rotatable object (or some other suitable position) may be recorded at the same time as or after its deposition onto the rotatable object.

25 In a further aspect of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable object comprising one or more detectable features disposed on the object, and sampling at least a portion of the sample from the object, said at least one sample being located at a known position on said object relative to said one or more detectable features, said system comprising:

- 30 (i) a rotator for rotating the rotatable object;
- (ii) a detector for detecting the detectable feature on the rotatable object;
- (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector; and

(iv) a sampler for sampling at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise an enabler for enabling the sampler to sample a sample at the sampling location. The enabler may comprise means for moving the sampler or a component of the sampler. For example, where the sampler is a laser the enabler may comprise means for moving the laser or means for moving a mirror or other reflective surface at which the laser beam is directed, so that the laser beam when activated desorbs a sample at the sampling location.

In an embodiment of the system of the present invention there is provided a system for determining the position of at least one sample disposed on a rotatable object comprising one or more detectable features disposed on the object, sampling at least a portion of the sample from the object, and analysing said portion, said at least one sample being located at a known position on said object relative to said feature, said system comprising:

- (i) a rotator for rotating the rotatable object at a known rotational velocity,
- (ii) a positioner for positioning the rotatable object on a rotator at a predetermined position on the rotator,
- (iii) a detector detecting the detectable feature on the rotatable object,
- (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled to said detector, and
- (v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

The system may further comprise

- (vi) an analyser for analysing the desorbed or ablated sample.

The sampler may be capable of desorbing or ablating at least a portion of the sample at the arrival time one or more times per revolution of the rotatable object. The sampler may be capable of sampling a plurality of samples per revolution of the rotatable object.

The systems of the invention may further comprise one or more rotatable objects of the invention.

The rotator may comprise an actuator which may rotationally actuate the rotatable object. The rotatable object may be rotationally actuated at variable angular velocity and frequency. The rotatable object may be rotationally actuated at a constant frequency of 1

to 5000 Hz, 1 to 900 Hz, 1 to 800 Hz, 1 to 700 Hz, 1 to 600 Hz, 1 to 500 Hz 1 to 400 Hz, 1 to 300 Hz, 1 to 200 Hz, 1 to 100 Hz, 1 to 50 Hz, 1 to 20 Hz, 1 to 10 Hz, 50 to 3000 Hz, 50 to 1000 Hz, 50 to 750 Hz, 50 to 500 Hz, 50 to 250 Hz, 50 to 100 Hz, 100 to 1000 Hz, 100 to 750 Hz, 100 to 500 Hz, 100 to 250 Hz, 200 to 1000 Hz, 200 to 750 Hz, 200 to 500 Hz, or 200 to 300 Hz.

The rotational actuator of the rotatable object may be coupled to a tilt actuator or mechanism. The tilt actuator or mechanism may tilt the rotational actuator to present the latitude of the rotatable object on which the required sample lies to the sampler.

The tilt actuator may have a position repeatability in the range of 0.001 to 0.05 mm. The tilt actuator may have a position repeatability which is dependent on the dimensions of the smallest sample. For example, for a circular sample of 0.01mm in diameter the tilt actuator has a position repeatability of at least 0.01mm.

The tilt actuator may be used to position the rotatable object such that upon rotation of the rotatable object any particular sample on the rotatable object may be exposed to a desorbing laser beam.

The processor may store the locations of the one or more samples on the rotatable object relative to the position of the one or more detectable features.

The detector may be a photodiode in combination with a light emitting diode which is able to transmit and receive signals. Alternatively, the detector may be any imaging device that is capable of detecting a registration mark such as a camera, Charged Coupled Device (CCD), or a photovoltaic device for example. As another alternative, the detector may be a proximity device based on magnetic fields or electrical capacitance. As a further alternative the detector may be a mechanical device such as a micro-switch or a phase sensitive inductance device for example.

The radial coordinate of the sample with respect to the center of the central longitudinal axis of the rotatable object may be recorded upon its deposition onto the rotatable object.

The detectable feature may be detected by the detector, so that the angular position of sample is known relative to the detectable feature.

The time delay taken when the detectable feature is detected to when the sample crosses the path of the desorbing laser beam may be calculated, so that upon the subsequent detection of the detectable feature, the laser can be fired at the arrival time.

The sampler may be a laser or any other pulsed energy source for ablating or desorbing at least a portion of each of the samples from the rotatable object.

Suitably, the sampler may emit one or more laser beams onto the required sample per revolution of the sample on the rotatable object to ablate or desorb at least a portion of the sample.

The systems of the invention may include a director may be used to direct the
5 sampler to the appropriate location on the rotatable object. In one form the director may be coupled to the sampler for directing the sampler to the appropriate radial coordinate on the rotatable object such that the sampler can sample the at least portion of the sample at the arrival time. The director may be a movable mirror, reflector, deflector, moveable optical fibre or prism for example. A linear director may be attached to the rotatable
10 object. The linear director may position the rotatable object at a point in one or more planes perpendicular to the plane in which the sampler operates so that the appropriate sample is amenable to the path of the sampler. For example, if the sampler operates in the z-y-plane, then the linear director may direct the rotatable object in the x-y plane. The director only need direct the laser beam back and forth along one arbitrarily chosen line
15 which extends from the top to the bottom of the rotatable object in order to access every sample on the rotatable object as it rotates.

The system for determining the position of at least one sample on a object of a rotatable object, and subsequently releasing the sample from the object may comprise an analyser to analyse the sample desorbed from the rotatable object. The analyser may be an
20 ion mobility device. The analyser may be a may be a mass spectrometer such as a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI-TOF) mass spectrometer, Secondary Ionisation Mass spectrometer (SIMS), or Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS). The analyser may be a chromatograph.

Upon analysis of the ablated or desorbed sample, the sampler may be directed to
25 ablate or desorb another sample.

According to a further aspect of this invention there is provided a Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI) comprising a system for determining the position of at least one sample disposed on a rotatable object in accordance with the invention.

30 The object may be a disc, sphere, cylinder, cone or other suitable object.

The MALDI-TOF may further comprise an object loader for loading the object into the MALDI-TOF.

The MALDI-TOF may further comprise an object loader for loading the object into the MALDI-TOF and for unloading the object from the MALDI-TOF.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying figures; in which:

5

Figure 1a is a front view of a MALDISC which features discrete MALDI samples laid down in circular tracks of concentric circles;

Figure 1b is isometric perspective view of a MALDISC featuring a view of a single enlarged sample;

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Figure 1c is an isometric perspective view of a MALDISC featuring a view of the single enlarged sample being sampled;

Figure 2 is a front view of a MALDISC which features MALDI samples laid down in a spiral track;

15

Figure 3 is a front view of a MALDISC which features MALDI samples laid down in rectangular arrays;

Figure 4 is a front view of a MALDISC with a continuous sample surface which may be a tissue section for example;

20

Figure 5 is a front view of a MALDISC which features a key shaped spindle hole which is required when the MALDISC is interlocked with a rotating spindle at an angle within 360 degrees during rotation of one with respect to the other on their axes of symmetry;

Figure 6 is a front view of a MALDISC which features a polygon (star-shaped) spindle hole;

25

Figure 7 is a front view of a MALDISC which features a triangle-shaped spindle hole and two circular spindle holes;

Figure 8 is a front view of a MALDISC which features a diamond-shaped hole and a square hole;

30

Figure 9 is a rear view of a MALDISC which features a (1) bar code on the MALDISC for use with Laboratory Information Management Systems (LIMS) software in order to facilitate sample management traceability, (2) a radio frequency authentication tag, and (3) two registration marks;

Figure 10 is an oblique side view of a MALDISC which has registration marks on its side;

35

Figure 11a is an oblique side view of the MALDI sphere which has MALDI samples laid down along lines of different latitude;

Figure 11b is an oblique side view of the MALDI sphere featuring a single enlarged sample 1101b;

Figure 11c is an oblique side view of the MALDI sphere featuring a single enlarged sample 1101b being sampled;

5 Figure 12a is an oblique side view of a MALDI cylinder which features MALDI samples laid down in rings along the body of the cylinder;

Figure 12b is an oblique side view of a MALDI cylinder which features MALDI samples laid down in a spiral track along the body of the cylinder;

10 Figure 12c is an oblique side view of the MALDI cylinder featuring a single enlarged sample 1201c;

Figure 12d is an oblique perspective side view of the MALDI sphere featuring a single enlarged sample 1201c being sampled;

Figure 13a is an oblique side view of a MALDI cone which features MALDI samples laid down in a spiral track along the body of the cone;

15 Figure 13b is an oblique side view of a MALDI cone which features MALDI samples laid down in rings along the body of the cone;

Figure 14a is a perspective oblique exterior view illustrating the front, top and right hand side of apparatus 1400, an analytical apparatus introduction device used for automatically introducing and operating the aforementioned MALDISCs;

20 Figure 14b is a perspective oblique exterior view illustrating the rear, top and left hand side of the apparatus 1400;

Figure 14c is a view from the right hand side of apparatus 1400, where the right hand side of said apparatus has been made transparent in order to view the internal components;

25 Figure 14d is an oblique top view, where the top plate of the 1st compartment of apparatus 1400 has been removed in order to view the internal components;

Figure 14e is a rear perspective view (from where the back panel of apparatus 1400 should be) of the internal components of apparatus 1400;

Figures 14f is an oblique front view of the front vacuum hatch 1401a;

30 Figures 14g is an oblique rear view of the front vacuum hatch 1401a;

Figures 14h is an oblique right hand internal side view of the play and stop/eject buttons of apparatus 1400;

Figures 14i is an oblique side internal side view of the rear vacuum hatch 1401b where the left hand side of apparatus 1400 has been removed in order to view the internal components;

Figure 14j is an inside view of the right hand side plate of apparatus 1400;

5 Figure 14k is an inside view of the left hand side plate of apparatus 1400;

Figure 15a is a top down view of a system in which apparatus 1400 could be used;

Figure 15b is a restricted oblique side view of a system in which apparatus 1400 could be used;

Figure 16a is a front perspective view of the apparatus 1600a;

10 Figure 16b is an oblique perspective right hand side view (as viewed from the front) of the apparatus 1600a;

Figure 16c is an oblique perspective rear view of the apparatus 1600a;

Figure 16d and 16 e are oblique perspective front views of a registration mark finder displaced next to a MALDISC where the registration mark is read from the side rather than the back of the MALDISC;

15 Figure 16f is a top down view of a system where apparatus 1600a could be used;

Figure 17a is an oblique rendered perspective front view which illustrates the front, top and left hand side of the apparatus 1700 used to drive a MALDI cylinder or cone;

Figure 17b is another oblique rendered perspective front view which illustrates the front, top and right hand side of the apparatus 1700 used to drive a MALDI cylinder or cone;

Figure 17c is an oblique wire-frame perspective front view which illustrates the front, top and left hand side of the apparatus 1700 used to drive a MALDI cylinder or cone;

25 Figure 17d is right hand side view (as viewed from the front) of apparatus 1700 used to drive a MALDI cylinder or cone. The outer has been made transparent in this illustration;

Figure 17e zoomed restricted view of the left hand side of apparatus 1700 where the outer housing has been made transparent in order to illustrate internal components of the apparatus;

30 Figure 17f is an oblique perspective view of the rotor module used to rotationally actuate the MALDI cylinder or cone, and features a registration mark finder for a mark on the rotor of the module, a shaft for repeatable placement, and two spring loaded catches;

Figure 17g is an internal perspective view of the first compartment of apparatus 1700 facing toward the rear in order to illustrate the internal components of the apparatus;

Figure 17h is an internal perspective view of the first compartment of apparatus 1700 facing toward the front in order to illustrate the internal components of the apparatus;

Figure 17i is an oblique perspective side view of one of the sliding doors used to seal a vacuum within the 1st compartment of apparatus 1700 before its introduction into a vacuum of another vacuum chamber housing an analytical apparatus;

Figure 17j is an oblique perspective side view of the slide assembly (which may be a ball slide assembly, a cross roller slide assembly or a ball and crossed roller slide assembly) used to linearly actuate the rotor module in figure 17f;

Figure 18a is a top down perspective view of a system in which apparatus 1700 could be used;

Figure 18b is stage 1 of 4 in which a MALDI cylinder or cone is introduced to an analytical apparatus within a vacuum chamber;

Figure 18c is stage 2 of 4 in which a MALDI cylinder or cone is introduced to an analytical apparatus within a vacuum chamber;

Figure 18d is stage 3 of 4 in which a MALDI cylinder or cone is introduced to an analytical apparatus within a vacuum chamber;

Figure 18e is stage 4 of 4 in which a MALDI cylinder or cone is introduced to an analytical apparatus within a vacuum chamber;

Figure 19 is a schematic drawing of an apparatus for determining the position of a sample on a rotating sample platform, and subsequently releasing the sample from the sample platform where the registration mark is present on the side of disc;

Figure 20 is a schematic drawing of an apparatus for determining the position of a sample on a rotating sample platform, and subsequently releasing the sample from the sample platform where the registration mark is present on the shaft that is used to rotate the disc;

Figure 21a is an oblique perspective front view of an apparatus used to drive a MALDI sphere featured in figure 10;

Figure 21b is a perspective right hand side view of an apparatus used to drive a MALDI sphere featured in figure 10;

Figure 21c is an oblique perspective rear view of an apparatus used to drive a MALDI sphere featured in figure 10;

Figure 21d is a top perspective view of an apparatus used to drive a MALDI sphere featured in figure 10;

Figure 21e is an oblique side perspective close-up view of components in the apparatus used to drive a MALDI sphere featured in figure 10, namely the sphere,
5 registration cap and registration mark finder in action;

Figure 21f is an oblique side perspective close-up view of components in the apparatus used to drive a MALDI sphere (featured in figure 10) illustrating the registration cap and the corresponding holes in the MALDI sphere; and

Figure 22 is a top down perspective view of a system where the apparatus used to
10 drive the MALDI sphere as shown in Figure 10 may be integrated and used.

Detailed Description of the Preferred Embodiment(s) of the Invention

Figure 1a is a front view of a disc ("MALDISC") 100a. The MALDISC 100a features a circular axis hole 101a centrally located in the MALDISC 100a and used as an
15 insertion and engagement point for a rotor (not shown) used to rotate the MALDISC 100a. The region 102a of the MALDISC 100a is left blank with no samples placed thereon. A region 103a of discrete sample spots is located towards the outer periphery of the MALDISC 100a which, in use, is to be analysed by matrix-assisted laser-desorption/ionisation (hereinafter referred to as a "MALDI sample"). In this particular
20 figure, the discrete sample spots are spaced apart and positioned in circular tracks of concentric circles as seen in Figure 1a.

In this particular embodiment, the discrete sample spots are 1 to 2mm in diameter. However, the desorbing laser beam in this particular embodiment has a 100 μ m spot size which enables specific parts of the individual sample spot to be located and desorbed. In
25 one embodiment, there are 24 tracks with selected target wells 0.5mm in diameter with 128 wells located on each track for example, which would give a discrete sample capacity of 3072 samples. This embodiment would leave ample space between spots. In another embodiment, the capacity could be increased to double this figure. An alternative use of the space between samples is the printing of inks doped with standard mass calibrants so
30 that reference can be made at any point in an analysis to a mass standard to confirm sample mass.

The MALDISC may be made of metal, or may be a metal coated plastic, plastic, ceramic or any other conducting or non-conducting surface. It may contain purpose built MALDI sample surfaces comprising wells, hydrophobic or hydrophilic perimeter

coatings on spot locations of the target MALDISC, and raised sections to contain wells and specialised surface materials to enhance MALDI signals.

Figure 1b depicts an isometric perspective view of the MALDISC 100b. The MALDISC 100b features one sample 101b (the size of which is grossly exaggerated in Figure 1b), a distance r from the centre of MALDISC 100b which inscribes out a circumferential path 102b. When a registration mark 103b passes under the path of a registration mark finder beam 104b, the sample 101b is θ_1 from the registration mark 103b.

Once the MALDISC 100b has rotated through an angle θ_3 the MALDISC 100b will be at a position 105b as seen in Figure 1b. The sample 101b will then be under the path of a desorbing laser beam 106b which subsequently releases a plume of desorbed sample 107b as best seen in Figure 1c. It should be noted that in this particular example, the spot size of the laser beam 106b (about 100 μ m) is much smaller than the size of the sample 101b (about 0.5 to about 2mm in diameter), so that individual portions of the sample 101b can be desorbed for analysis.

The length of a circumferential path l is given by $l = r\theta$, where r is the radial distance from the centre of the MALDISC 100b to the centre of the sample, and θ is the angle in radians subtended between the radial line and the imaginary line denoted by the registration mark. The radius r is given by $r = \frac{v}{\omega}$, where v is the instantaneous (tangential) velocity of the sample, and ω is the angular (rotational) velocity of the sample. The instantaneous velocity v is given by $v = \frac{l}{t}$. Therefore, the length of circumferential path l is now given by $l = r\theta = \frac{v}{\omega}\theta = \left(\frac{l}{t}\right)\frac{1}{\omega}\theta = \frac{l}{t}\frac{\theta}{\omega}$, so that the time taken is given by $t = \frac{\theta}{\omega}$, where $\theta = \theta_{laser}$ which is the arbitrary angle in the x-y plane relative to the point at which the registration mark is read at which the desorbing beam is chosen to strike the MALDISC 100b and is given by $\theta_{laser} = \theta_2 + \theta_3 = (2\pi - \theta_1) + \theta_3$. For example, if $\theta_1 = \frac{1}{4}\pi rad (45^\circ)$, and the desorbing laser beam strikes the MALDISC at an angle of $\theta_3 = \pi rad (180^\circ)$ relative to the imaginary line denoted by the registration mark, and the MALDISC 100b rotates at a specified rate of 10 Hz (knowing that $\omega = 2\pi f$) then the time at which the laser should be fired after the registration mark has been detected is given by $t = \frac{(2\pi - \frac{1}{4}\pi) + \pi}{2\pi(10)} = 0.28 \text{ sec}$. Likewise, if $\theta_1 = \frac{7}{4}\pi rad (315^\circ)$, and the desorbing laser beam strikes the MALDISC 100b at an angle of $\theta_3 = \pi rad (180^\circ)$ relative to the imaginary line denoted by the registration mark, and the MALDISC 100b rotates at a specified rate of 10 Hz (knowing that $\omega = 2\pi f$) then the time at which the laser should be

fired after the registration mark has been detected is given by

$$t = \frac{(2\pi - \frac{7}{4}\pi) + \pi}{2\pi(10)} = 0.35 \text{ sec.}$$

In use, the registration mark 103b is detected by the registration mark finder beam 104b, so that the angular position of sample 101b is known (the radial coordinate of the sample 101b being specified at its deposition onto the MALDISC 100b). A moveable mirror moves the laser beam to a radial position along the y-axis (see Figure 1b) equal to the radial coordinate of the required sample 101b so that it can access sample 101b. Optionally, or in combination with a moveable mirror, the MALDISC 100b could be moved (accurately, using a linear encoder) so that the required sample 101b is at a position amenable to a desorbing laser beam 106b. The time delay taken when the registration mark 103b is detected to when the sample crosses the path of the desorbing laser beam 106b is calculated (see above for the method), so that upon the subsequent detection of the registration mark 103b, the laser can be fired at the appropriate time releasing a desorbed sample plume 107b. The beam 106b may consist of single or multiple bursts on the sample 101b per revolution of the MALDISC 100b.

Figure 2 is a front view of a MALDISC 200. The MALDISC 200 features a circular axis hole 201 centrally located therein and used as an insertion point for a rotor (not shown) used to rotate the MALDISC 200. A region 202 of the MALDISC 200 located towards the centre axis hole 201 is left blank with no samples placed thereon. A further region 203 of the MALDISC 200 located adjacent the region 202 and is located towards the periphery of the MALDISC 200 comprises discrete matrix assisted samples which are laid down in a spiral formation beginning from a point in the region 203 close to the region 202 and moving outwardly towards the edge or periphery of the region 203. In one embodiment, the selected target wells are 0.5mm in diameter. Samples locations are specified in spherical coordinates (r, θ) ; the origin for radial coordinates is the centre of the hole 201, the origin of the angular coordinate is the registration mark featured on the reverse side of the MALDISC 200 (see Figure 9 and 10).

Figure 3 is a front view of a MALDISC 300 which comprises a circular axis hole 301 centrally located and used as an insertion point for a rotor (not shown) used to rotate the MALDISC 300. In an outer portion of the MALDISC 300, a region 303 of the MALDISC 300 comprises discrete matrix assisted samples which are laid down in a series of rectangular arrays which are positioned around the centre of the MALDISC 300 and which extend from the periphery of the MALDISC 300 in a radial direction towards

the centre axis hole 301. In one embodiment, the selected target wells are 0.5mm in diameter. Samples locations are specified in Cartesian coordinates (x, y) . Optionally, the regions 302 & 303 on MALDISC 300 could be used for standards, such as sample calibrants.

5 Figure 4 is a front view of MALDISC 400 used for tissue imaging and protein mapping. The MALDISC 400 comprises a continuous sample surface 401 (as opposed to a discrete spot in the other embodiments). The continuous sample surface 401 is located in the outer region of the MALDISC 400 towards the periphery of the MALDISC 400. The continuous sample surface 401 may be a tissue sample such as a section of an organ,
10 for example. As a further example, proteins which are taken through a gel and then lifted off with a membrane which has digesting enzymes could form a continuous surface 401 of digested proteins (peptides) on which mass spectrometry could be performed. The continuous surface 401 is affixed to the MALDISC surface using a matrix. In an imaging experiment, the tissue sample may be surveyed in a low spatial resolution mode so that
15 areas of interest can be quickly identified. Later, these areas of interest can be revisited at a higher spatial resolution. The selection of a particular location on this continuous surface 401 requires a raster approach to be adopted. The tissue sample may be any shape and is not limited to the shape depicted in Figure 4. For example, the tissue could be in the shape of a square or rectangle or circle or it could be an irregular shape. Further there
20 may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more tissue samples on the MALDISC 400.

Figure 5 is a front view of a MALDISC 500 which features a key-hole aperture 501 used as an insertion point for a spindle or rotor (not shown) which is used to rotate the MALDISC 500. In some embodiments, at least one registration mark from which a sample location is designated may feature on the rotor on which the sample surface (e.g. a
25 disc, cylinder, or cone) is rotated rather than the sample surface itself. In such a case the MALDISC may be interlocked with the rotating spindle at one and only one angle within 360 degrees during rotation of one with respect to the other on their axes of symmetry. In order to facilitate this, the MALDISC 500 features the key-shaped axis hole 501. For the same purpose the MALDISC 600 (See Figure 6) features a polygon (star) shaped axis
30 hole 601 which has one point of the star missing so that only one alignment with respect to the axis of rotation is possible. The MALDISC 700 (figure 7) features a triangle-shaped hole 703 and two circular holes 701 and 702, and MALDISC 800 (figure 8) features a diamond-shaped hole 801 and a square hole 802.

Figure 9 is a rear view of the MALDISC 900. The region 901 of the MALDISC 900 is used for data storage of digitally encoded information. The data format could be that of a compact disc read only memory (CD-ROM) or digital versatile disc (DVD) format. However, a digital versatile disc (DVD) format is preferred in one embodiment because of its larger data storage capacity.

In use, once analysis of the sample on the MALDISC 900 has been performed and stored on a data processor, the MALDISC 900 could be removed from the driver and placed in a CD or DVD burner connected to the data processor so that the experimental results could be 'burned' and stored on the reverse side of the MALDISC 900 in the region 901, thereby conveniently storing the data on one side of the MALDISC with the sample on the other.

The MALDISC 900 as depicted in Figure 9 features a printed bar code 907 which is used by Laboratory Information Management Systems (LIMS) software in order to facilitate sample management traceability.

The MALDISC 900 as depicted in Figure 9 features registration marks 905 and 906 respectively. One or more registration mark(s) are used as the origin for the angular coordinate (θ) which specifies the angular location of a particular sample on the front side of the MALDISC 900. The registration mark is at a fixed radius corresponding to the position of the registration mark finder. More than one registration mark is not strictly necessary if the rotation of the MALDISC is smooth, however additional registration marks (such as the mark 906) can overcome eccentricity or other rotational irregularities. A short radial line is preferred to a dot so that any variance in the alignment of the reading device will not affect the reception of its signal. A registration mark may also feature on the side of the MALDISC (as opposed to the back) such as is the case with the registration mark 1001 on the MALDISC 1000 in Figure 10.

The MALDISC 900 as depicted in figure 9 also features a Radio Frequency (RF) tag 904 affixed thereon. The RF tag 904 is used to establish the authenticity of the MALDISC 900. If the RF tag reader in the MALDISC driver does not detect the RF tag 904, then the MALDISC driver will not operate.

Figure 11 is a side view of the MALDI sphere 1100. Discrete samples 1101 are laid down along lines of latitude around the sphere 1100. The MALDI sphere 1100 is penetrated through aperture 1102 along its axis by a rotor used to rotate the sphere 1100. The surface area of a sphere is equal to $SA_{sphere} = 4\pi r^2$, but the surface area of a circle is equal to $SA_{circle} = \pi r^2$, so a sphere can potentially hold four times the number of samples

as compared to a disc of the same radius. If a sphere with a radius of only half the size of a corresponding disc is used, then the sphere could still hold potentially twice as many samples.

Figure 11b depicts an isometric perspective view of the MALDI Sphere 1100b. MALDI Sphere 1100b features one sample 1101b (the size of which is greatly expanded for illustration purposes), a fixed distance R from the centre of MALDI Sphere 1100b which inscribes out a line of latitude (δ) 1106b.

A registration cap 1102b is inserted on a rotation actuating shaft (not shown in Figures 11b or 11c, see figure 21f) and is located on top of the MALDI sphere 1100b. The registration cap 1102b comprises two placement shafts; a circular placement shaft and a triangular shaft 2116b (see figures 21f). This ensures that the registration cap 1102b is always placed on the same way with respect to the MALDI sphere 1100b which has corresponding female sockets. The registration cap 1102b has around its circumference a registration mark 1103b (see figure 11b). The registration mark 1103b is the bearing position for lines of longitude on the sphere 1100b. The latitude δ of a particular sample is recorded at its deposition onto the MALDI sphere. The apex of the triangular shaft (see figure 21f) marks the prime meridian 1104b (the invisible line along which samples are laid) of sphere 2101, the 0° of longitude (equivalent to Greenwich Meridian on the Earth). The samples get their longitude bearing with reference to this location.

When the registration mark 1101b passes under the path of the registration mark finder beam 1107b, the sample 1101b is λ_1 (longitude is denoted λ , which is the azimuthal angle in the xy -plane relative to the angle at which the registration mark finder detects the registration mark) from the registration mark.

Once the MALDI SPHERE 1100b has rotated through an longitude λ_2 , the sample 1101b will on the correct longitude for desorption. The MALDI samples laid down on different points of latitude δ are positioned for desorption via a tilt mechanism demonstrated in figure 11c (for a detailed examination of the tilt mechanism see figure 21a and the accompanying description).

The desorbing laser beam 1108b is shown in figure 11c as causing the release of a plume of desorbed sample 1109b. It should be noted that in this example, the spot size of the laser beam 1108b (about $100\mu\text{m}$) is much smaller than the size of the sample 1101b (in general about 0.5 to 2 mm in diameter), so that the individual portions of a sample 1101b can be desorbed for analysis.

The length of a circumference of a circle l is given by $l = r\theta$, where r is the radial distance from the centre of the circle to point of interest, and θ is the angle in radians subtended between the radial origin and the radial line extending from the centre of a circle to the point of interest.

5 In this case, the length of a line of latitude l is given by $l = r\lambda$. Longitude is denoted by λ , which is the azimuthal angle in the xy -plane relative to the angle at which the registration mark finder detects the registration mark. The radius is equal to $r = R \sin \phi$ where R is the radius of the MALDI sphere and ϕ is the zenith angle which is equal to $\phi = \frac{\pi}{2} - \delta$. δ is the latitude measured from the equator (note that south latitudes are
10 designated negative, likewise north latitudes are designated positive). Whether one specifies the angular position of the sample(s) in latitude or zenith angle is arbitrary.

Another form of expression for the radius is $r = \frac{v}{\omega}$, where v is the instantaneous (tangential) velocity of the sample, and ω is the angular (rotational) velocity of the sample. The instantaneous velocity v is given by $v = \frac{l}{t}$. Therefore, the length of the line of
15 latitude l is now given by $l = r\lambda = \frac{v}{\omega}\lambda = \frac{(\frac{l}{t})}{\omega}\lambda = (\frac{l}{t})\frac{\lambda}{\omega}$; solving for the time taken gives $t = \frac{\lambda}{\omega}$, where $\lambda = \lambda_{laser}$ which is the arbitrary longitude in the x - y plane relative to the point at which the registration mark is read at which the desorbing beam is chosen to strike the MALDI sphere and is given by $\lambda_{laser} = \lambda_2 + \lambda_3 = (2\pi - \lambda_1) + \lambda_3$. For example, if $\lambda_1 = \pi \text{ rad } (180^\circ)$, and the desorbing laser beam strikes the MALDI sphere at an angle of
20 $\lambda_3 = \frac{3}{2}\pi \text{ rad } (270^\circ)$ relative to the imaginary line denoted by the registration mark, and the MALDI sphere rotates at a specified rate of 10 Hz (knowing that $\omega = 2\pi f$) then the time at which the laser should be fired after the registration mark has been detected is given by $t = \frac{(2\pi - \pi) + \frac{3}{2}\pi}{2\pi(10)} = 0.125 \text{ sec}$. Likewise, if $\lambda_1 = \frac{35}{18}\pi \text{ rad } (350^\circ)$, and the desorbing laser beam strikes the MALDI sphere at an angle of $\lambda_3 = \frac{3}{2}\pi \text{ rad } (270^\circ)$
25 relative to the imaginary line denoted by the registration mark, and the MALDI SPHERE rotates at a specified rate of 10 Hz (knowing that $\omega = 2\pi f$) then the time at which the laser should be fired after the registration mark has been detected is given by $t = \frac{(2\pi - \frac{35}{18}\pi) + \frac{3}{2}\pi}{2\pi(10)} = 0.08 \text{ sec}$.

In use, the registration mark 1103b is detected by the registration mark finder beam
30 1107b, so that the longitude of sample 1101b is known (the radial coordinate of the sample 101b being recorded at its deposition on the MALDI sphere 1100b). The tilt

mechanism moves the MALDI sphere to the correct angle so that so that it is amenable to a desorbing laser beam 1108b (see figure 11c). The time delay taken when the registration mark 1103b is detected to when the sample crosses the path of the desorbing laser beam 105b is calculated (see above for the method), so that upon the subsequent detection of the registration mark 1103b, the laser can be fired at the appropriate time releasing a desorbed plume of sample 1109b. The beam 1108b may consist of single or multiple bursts on the sample 1101b per revolution of the MALDI sphere 1100b.

The figures 12a and 12b are oblique side views of MALDI cylinders 1200a and 1200b. Discrete samples can be deposited in rings which are formed in a transverse direction to the longitudinal shaft of the cylinder such as in the case of cylinder 1300a (See Figure 13a), or in a spiral formation 1301b along the cylinder shaft such as with the cylinder 1300b (See Figure 13b).

There may be at least one registration mark disposed near the end of the cylinders 1300a and 1300b, for example marks 1302a and 1302b (which may be located on the sample surface side or at either end of the cylinders); samples positions are specified in cylindrical coordinates $\{(r, \theta, z)\}$ where r is constant relative to the registration mark(s). The cylinders 1300a and 1300b would be penetrated along through the holes 1303a and 1303b by a spindle used to rotate it. The cylindrical surface area of a cylinder (not including the two ends) is equal to $SA = 2\pi rh$. The surface area of one side of a circle is equal to $SA = \pi r^2$. If a disc had a radius of 5 cm, and a cylinder a radius of 2.5cm and a height of 10 cm, then the useable surface area of the cylinder would be $SA = 2\pi(2.5)(10) = 50\pi \text{ cm}^2$, and the surface area of a sphere would be $SA = \pi(5)^2 = 25\pi \text{ cm}^2$. Therefore there is the potential to store approximately twice as many samples on a cylinder compared to a disc.

Figure 12c depicts an oblique isometric view of the MALDI cylinder 1200c. The MALDI cylinder 1200c features one sample 1201c (the size of which is greatly expanded for illustration purposes), a fixed distance r from the centre of MALDI cylinder 1200c. When the registration mark 1202c passes under the path of the registration mark finder beam 1203c, the sample 1201c is θ_1 from the registration mark.

Once the MALDI cylinder 1200c has rotated through an angle θ_3 , the sample 1201c will be under the path of a desorbing laser beam 1204c (see Figure 12d) releasing a plume of desorbed sample 1205c. It should be noted that in this example the spot size of the laser beam 1204c (about 100 μm) is much smaller than the size of the sample 1201c (in

this example about 0.5 to 2mm in diameter), so that the individual portions of a sample 1201c can be desorbed for analysis.

The length of a circumferential path l of a circle is given by $l = r\theta$, where r is the radial distance from the centre of the MALDI cylinder to the centre of the sample, and θ is the angle in radians subtended between the radial line and the imaginary line denoted by the registration mark. The radius r is given by $r = \frac{v}{\omega}$, where v is the instantaneous (tangential) velocity of the sample, and ω is the angular (rotational) velocity of the sample. The instantaneous velocity v is given by $v = \frac{l}{t}$. Therefore, the length of circumferential path l is now given by $l = r\theta = \frac{v}{\omega}\theta = \left(\frac{l}{t}\right)\frac{1}{\omega}\theta = \frac{l}{t}\frac{\theta}{\omega}$, so that the time taken is given by $t = \frac{\theta}{\omega}$, where $\theta = \theta_{laser}$ which is the arbitrary angle in the x-y plane relative to the point at which the registration mark is read at which the desorbing beam is chosen to strike the MALDI cylinder and is given by $\theta_{laser} = \theta_2 + \theta_3 = (2\pi - \theta_1) + \theta_3$. For example, if $\theta_1 = \pi \text{ rad } (180^\circ)$, and the desorbing laser beam strikes the MALDI cylinder at an angle of $\theta_3 = \frac{3}{2}\pi \text{ rad } (180^\circ)$ relative to the imaginary line denoted by the registration mark, and the MALDI CYLINDER rotates at a specified rate of 10 Hz (knowing that $\omega = 2\pi f$) then the time at which the laser should be fired after the registration mark has been detected is given by $t = \frac{(2\pi - \pi) + \frac{3}{2}\pi}{2\pi(10)} = 0.125 \text{ sec}$.

In use, the registration mark 1202c (see figure 12c) is detected by the registration mark finder beam 1203c, so that the angular position of sample 1201c is known (the height coordinate z of the sample 1201c is recorded at its deposition onto the MALDI cylinder 100b). A moveable mirror moves the laser beam to a height position z along the z -axis (see figure 12d) equal to the height coordinate of the required sample 1201c so that it can access sample 1201c. Optionally, or in combination with a moveable mirror, the MALDI cylinder 1200c could be moved (accurately, using a linear encoder) along the z -axis so that the required sample 1201c is at a position amenable to a desorbing laser beam 1204c. The time delay taken when the registration mark 1202c is detected to when the sample crosses the path of the desorbing laser beam 1204c is calculated (see above for the method), so that upon the subsequent detection of the registration mark 1202c, the laser can be fired at the appropriate time releasing a desorbed sample plume 1205c. The desorbing laser beam 1204c (see figure 12d) may consist of single or multiple bursts on the sample 1201c per revolution of the MALDI cylinder 1200c.

Figure 13a is an oblique side view of the MALDI Cone 1300a. Discrete samples can be laid down in a spiral formation 1301a along the cone shaft (see the MALDI cone

1300a in figure 13a), or in rings 1301b along the cylinder shaft (see the MALDI cone 1300b in figure 13b). The MALDI cones would be penetrated along through holes 1302a and 1302b by a spindle used to actuate their rotation.

Figure 14a is a perspective oblique exterior view illustrating the front, top and right hand side of apparatus 1400, an analytical apparatus introduction device used for automatically introducing and operating the aforementioned MALDISCs described above. Similarly, figure 14b is a perspective oblique exterior view illustrating the rear, top and left hand side of the apparatus 1400.

Figures 14f and 14g are an oblique front view and an oblique reverse view respectively of the front vacuum hatch 1401. The door 1429 opens to allow insertion of a MALDISC into apparatus 1400, and closes to seal a vacuum within the first compartment of apparatus 1400. The door 1429 closes against the frame 1439; the frame 1439 features a rubber seal onto which door 1429 closes in order to ensure that a tight seal occurs between door 1429 and frame 1401. The door 1429 is actuated via a hinge assembly which is comprised of two stationary support cylinders 1432 and 1433, and one moveable cylinder 1431. Cylinder 1431 features a main body which has two male appendages which penetrate and are free rotate within female support apertures within cylinders 1432 and 1433 (to an extent of 90^0 beginning at frame 1439). The cylinder 1431 features plate 1430 which is attached to and actuates door 1429. The cylinder 1431 is rotationally actuated by the motor 1438 via a bevelled cog assembly (beveling not shown) composed of the bevelled cog 1433 which is directly attached to the cylinder 1431 and interacts at a right angle with the bevelled cog 1434 which is connected along a shaft in the same plane to the bevelled cog 1435 that is interfaced at a right angle with the bevelled cog 1436. The bevelled cog 1436 is connected along a shaft in the same plane with the motor 1438 (see figure 1438) which is itself connected to circuit board 1423a via wires 1438a and 1438b which respectively apply positive or negative voltages respectively to the motor 1438 in order for it to turn in different directions and thereby both open and close the door 1438 by means of the bevelled cog assembly mentioned above.

The user activates the opening or closing of door 1438 by pressing the buttons 1441 and 1442 which are the 'play' and 'stop/eject' buttons respectively (illustrated in figure 14h). The buttons 1441 and 1442 are connected to shafts 1441a and 1442b respectively, so that when either button 1441 or button 1442 is pressed they will make contact with the electrodes 1441b or 1442b respectively which are within apparatus 1400 and are connected to circuit board 1423a. A similar arrangement of mechanical components exists

for the hatch 1401b which can be seen in figure 14c and the bevelled gear system that actuates can be seen in figure 14i. The back hatch 1401b opens in the opposite direction to the front hatch 1401 but has the bevelled gear system located on the same side as the front hatch 1401 (which can be seen in figure 14b). The opening and closing of the back hatch 1401b are electronically automated via buttons 1441 and 1442.

The MALDISC 1408 is affixed to the platform rotor 1410 by catches 1409a and 1409b (see figure 14c) which are rectangular spring-loaded extrusions that are filleted such that with the pressure of an incoming or outgoing MALDISC they are depressed, and protrude under the restoring force of their internal springs otherwise to affix the MALDISC to the platform rotor 1410. The platform rotor 1410 has a textured rubber surface in order to increase friction and thereby maximise the torque delivered to the MALDISC by motor 1411. The motor 1411 is attached to support shaft 1411a which in turn is mounted on and electrically connected to circuit board 1413. Circuit board 1413 is suspended by shafts 1412a, 1412b, and 1412c (see figure 14e) which are attached to plate 1412.

The plate 1412 also supports the registration mark finder 1413 (best viewed in figure 14d) used to detect the one or more registration marks on the reverse side of the MALDISC. In this illustration the registration mark finder 1413 operates by optical means, emitting a beam from 1413a and receiving the reflecting beam via window 1413b; however, the registration mark finder may be any imaging device that is capable of detecting a registration mark (such as a Camera, CCD, or photovoltaic device for example), a proximity device based on magnetic fields or electrical capacitance, or a mechanical device (such as a micro-switch or a phase sensitive inductance device for example).

The registration mark finder may be stationary and positioned at a fixed radius in order to detect the registration mark on the reverse side of the MALDISC as it rotates, or alternatively it may be moveable along one radial axis as is the case with registration mark finder 1413. The advantage of having a moveable registration mark finder is that information could be encoded on a number of radii on the reverse side of the MALDISC 1408 (such as the apparatus 1400 driving software package, or Laboratory Information Management Systems Software information about the MALDI sample(s) contained on the MALDISC) could also be detected and computed using this optical registration mark finder.

The registration mark finder 1413 is supported on cylindrical rails which penetrate apertures 1413c and 1413d in finder 1413 and allow it to have a range of movements and move along a radial axis of the MALDISC 1408 equal to the radial length of the useable area (the area on which information is able to be digitally encoded or otherwise) on the reverse side of the MALDISC 1408. The finder 1413 is driven in a backward and forward direction along a radial axis of the MALDISC 1408 by the notch 1413f (see figure 14d) which protrudes from the finder 1413 body (beyond rail 1414b) and interfaces with the rotatable screw 1415a (pictured in figure 14i) driven clockwise or counter-clockwise (depending on the desired direction) by the motor 1415b which is supported by the structure 1415c and is attached to the platform 1418.

A ribbon cable 1416 connects the circuit board 1413 electrically controlling the motor 1411 (driving MALDISC 1408) to the circuit board 1417 (see Figure 14c). Likewise, ribbon cable 1413e connects the registration mark finder 1413 to the circuit board 1417 and is of sufficiently length in order to allow for the finder 1413's range of movement.

The circuit board 1417 is supported by sliding tray 1418 which contains an aperture so that the major ribbon cable 1419 can connect circuit board 1417 to the primary circuit board 1423a (see figure 14c and 14e); the ribbon cable 1419 being of sufficient length to allow for the range of movement where circuit board 1417 is fully extruded from apparatus 1400 in the event of MALDISC loading, and fully withdrawn into the second compartment of the apparatus 1400.

The sliding tray 1418 has projections 1418a and 1418b (toward the bottom of apparatus 1400) that feature teeth (in a plane parallel to the sides of apparatus 1400) which interface with the teeth on cogs 1421, 1422 and 1424.

The cog 1421 guides the sliding tray 1418 into and out of apparatus 1440 via hatch 1401a in response to a signal from the user via the play button 1441 and the stop/eject button 1442 to a suitable distance so that MALDISC 1408 can be mounted upon rotor 1410. The cog 1422 moves sliding tray 1418 from the 1st compartment (in which a vacuum is produced equal to the vacuum present inside the analytical apparatus to which the MALDISC is to be introduced) to the cog 1424 in the second compartment. Cogs 1421, 1422 are held in position by support 1423 (shown as transparent figure 14c) which contain exact female moulded counterparts of cog motors 1421 and 1422 and surround the majority of the motor bodies in order to support them even if apparatus 1400 is tilted on any angle; support 1423 contains apertures large enough for cables 1421a and 1422a to

emerge from the side (or bottom) of motors 1421 and 1422 so as to be connected to the primary circuit board 1423a. Similarly, motor 1424 is held in position by support 1425 and features an aperture so that cable 1424a (see figures 14e and 14c) is able to emerge from the side (or bottom) of motor 1424 so as to be connected to the primary circuit board
5 1423a. The cog 1424 actuated by motor 1424 interfaces with teathed-projections 1418a in sliding tray 1418 in order to actuate sliding tray 1418 (see figures 14e and 14c) into the second compartment of apparatus 1400 and a position where MALDISC 1408 is amenable to a desorbing laser beam.

The guides 1445a and 1445b in right hand side 1402 (see figure 14j) and guides
10 1450a and 1450b in left hand side 1403 (see figure 14k) together support cog support sliding tray 1418 (see figures 14c and 14d). The guides 1446 in right hand side 1402 (see figure 14j) and guide 1452 in left hand side 1403 (see figure 14k) together support cog support tray 142 (see figures 14c and 14d). The guides 1448 in right hand side 1402 (see figure 14j) and guide 1454 in left hand side 1403 (see figure 14k) together support the
15 primary circuit board 1423a of the first compartment (see figures 14c). The guides 1449 in right hand side 1402 (see figure 14j) and guide 1455 in left hand side 1403 (see figure 14k) together support the circuit board 1423b of the second compartment of apparatus 1400 (see figures 14c and 14e). The cavity 1448 in right hand side 1402 (see figure 14j) and cavity 1451 in left hand side 1403 (see figure 14k) are present to allow for the
20 rotational clearance of vacuum hatch door 1401b (see figure 14c).

Power is supplied to the apparatus 1400 via DC Input 1425 (see figure 14a, 14c and, and information is returned to processing unit 1504 (see figure 15a) via the Integrated Drive Electronics (IDE) interface 1427 (see figure 14c and 15b).

Apparatus 1400 can be installed into system 1500 for operation (see figure 15a).
25 System 1500 comprises a chamber 1501 which contains an analytical apparatus 1509 that may be an ion-mobility device, or a mass spectrometer such as an orthogonal acceleration time of flight mass spectrometer (oa-TOFMS), a Secondary Ionisation Mass spectrometer (SIMS), or a Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS)) for example. Chamber 1501 features an aperture so that
30 apparatus 1400 can be inserted either vertically or horizontally (as is depicted figure 15b), penetrating into apparatus 1501 to an extent permitted by the position of support 1507 (see figure 14a and 15b).

The analytical apparatus 1509 has a vacuum sustained within it by the vacuum generator 1506 connected to it by line 1506a (see figure 15a). This induces a vacuum

within the chamber 1501 which also contains the apparatus 1400. It should be noted however, that the apparatus 1400 can operate in a high vacuum, or at medium pressure (1 millibar, for example), or at atmospheric pressure. However, in this embodiment, the apparatus 1400 is illustrated as operating in at least a medium to hard vacuum.

5 The analytical apparatus within the chamber 1501 is powered by the power supply 1505 which is connected to the analytical apparatus by line 1505b; the power supply 1505 is connected to and directed by a central processing unit 1504 by line 1505a. The central processing unit 1504 directs via line 1507a a laser 1507 which is used to emit a pulsed laser beam 1507b through chamber window 1501b into the analytical apparatus 1509 via
10 window 1509a and out via window 1509b (see figure 15b) directed at the MALDISC 1408 being operated within apparatus 1400. The central processing unit 1504 receives the detected signal from the analytical apparatus within chamber 1501 via line 1508. A vacuum generator 1503 is connected to apparatus 1400 via line 1503a in order to establish a vacuum (or at least a pressure equal to that sustained within chamber 1501 as a result of
15 the vacuum generator 1506 connected to the analyser 1509) in the first compartment of the apparatus 1400 before the introduction of the MALDISC 1408 into the pressure subsisting within the second compartment of the apparatus 1400 produced by the vacuum generator 1506.

Power is provided to the apparatus 1400 by the power supply 1502 via line 1502a
20 which connects to DC Input 1425 on apparatus 1400 (see figures 15a and 15b). Information feedback from the apparatus 1400 [such as (1) a graphical representation on the display screen of the processing unit 1504 for the user of the disc position within the apparatus, (2) LIMS bar-code information read on the reverse side of the MALDISC, (3) RF tag reception, or (4) rate of revolution of the MALDISC as determined using the
25 registration marks] is linked to the central processing unit 1504 by the line 1504a.

The entire operation of the apparatus 1400 interacting with the system 1500 will now be described. To load the MALDISC 1408 into apparatus 1400, the user presses the stop/eject button 1442 on the apparatus 1400 located near the bottom of the front vacuum hatch 1401a (and illustrated in figures 14a and 14f). A cylindrical extrusion 1442a
30 attached to eject button 1442 makes contact with electrode 1442b and an eject signal is sent via a circuit (not shown) on circuit board 1423a to cable 1438a (see figure 14g) to make the motor 1438 rotate the shaft of cog 1436 in a clockwise direction (as seen from the right hand side to the left hand side of apparatus 1400 whilst the top is facing up as illustrated in figure 14h), thereby turning cylinder 1431 and plate 1430 attached to it and

opening door 1429; simultaneously (or within one or more seconds as is required for door 1429 to open), an eject signal is sent via a circuit on circuit board 1423a to the motorized cog 1421 via cable 1421a so that the motor begins to rotate the cog 1436 in a clockwise direction (as seen from the top of apparatus 1400 facing along the length of 1400 from front to back) thereby driving sliding tray 1418 (and all those components including rotor 1410 attached to it) out of apparatus 1400 relative to first compartment to a distance such that the MALDISC 1408 may be easily mounted upon rotor 1410 by the user and secured by catches 1409a and 1409b.

To retract the MALDISC 1408 into apparatus 1400 with the intent of initiating is ablation of the samples on it, the user presses the play button 1441 on the apparatus 1400 located near the bottom of the front vacuum hatch 1401a (and illustrated in figures 14a and 14f). A cylindrical extrusion 1441a attached to play button 1441 makes contact with electrode 1441b and a play signal is sent via a circuit (not shown) on circuit board 1423a to the motorized cog 1421 via cable 1421a so that the motor begins to rotate the cog 1436 in an anti-clockwise direction (as seen from the top of apparatus 1400 facing along the length of 1400 from front to back) thereby drawing sliding tray 1418 (and all those components including rotor 1410 attached to it) into apparatus 1400 relative to first compartment to a distance such that the sliding tray 1418 fits within the first compartment of apparatus 1400; simultaneously (or within one or more seconds as is required for sliding tray 1418 to move), a signal is sent via a circuit (not shown) on circuit board 1423a to cable 1438b (see figure 14g) to make the motor 1438 rotate the shaft of cog 1436 in an anti-clockwise direction (as seen from the right hand side to the left hand side of apparatus 1400 whilst the top is facing up as illustrated in figure 14h), thereby turning cylinder 1431 and plate 1430 attached to it and closing door 1429.

The vacuum generator 1503 then draws air from the first compartment of apparatus 1400 until a vacuum equal to the vacuum subsisting within chamber 1501 (as generated by vacuum generator 1506) is established. Once a vacuum has been established a signal is sent to hatch 1401b (see figure 14c) to open (to be automated, this will require a vacuum sensor attached to aperture 1443 whose electronics are integrated with circuit board 1423a). The motorized cog 1422 then begins to rotate in an anti-clockwise direction (as seen from the top of apparatus 1400 facing along the length of 1400 from front to back), actuating the sliding tray 1418 into the second compartment of apparatus 1400.

There are no guides for a portion of sides 1402 and 1403 as indicated by cavity 1448 in the right hand side 1402 (see figure 14j) and cavity 1451 in the left hand side

1403 (see figure 14k) due to the rotational clearance required of the door of back vacuum hatch 1401b. Once sliding tray 1418 has been moved by the motorized cog 1422 to a point beyond cavities 1448 and 1451 it slides into guides 1445b (see figure 14j) and 1450b (see figure 14k). A signal is sent from a circuit (not shown) on circuit board 1423a via cable 1426b to plug 1426a (in order not to provide a possible breach in the atmosphere of the first compartment of apparatus 1400) to cable 1426c to circuit board 1423b and along a circuit (not shown) on circuit board 1423a to the motorized cog 1424 in order to actuate the sliding tray 1418 into the guides 1445b (see figure 14j) and 1450b (see figure 14k). The motorized cog 1424 moves sliding tray 1418 at a constant rate in guides 1445b and 1450b so that every MALDI sample in the sample region of MALDISC 1408 (see MALDISC 100 in figure 1 for illustration) is accessible to the desorbing laser beam 1507b (see figure 15b). The exact distance that motorized cog 1424 must move sliding tray 1418 and thereby MALDISC 1408 depends on the position of the window 1501b in vacuum chamber 1501 and thereby the incident pulsed laser beam 1507b (see figure 15b).

At least a part of the desorbed sample is then drawn into an analytical apparatus/analyser 1509 (see figure 15a) by (1) the flow of gas from high pressure to low pressure induced by the vacuum pump 1506 connected to the analytical apparatus 1509, (2) electrostatic lenses or ion guides interposed to direct ions to the aperture (not illustrated), (3) passes through the aperture spontaneously. All of the samples on the MALDISC 1408 have been ablated if (1) the laser 1507 has been continuously emitting pulsed laser beam 1507 and (2) motorized cog 1424 has rotated a circular distance equivalent to the linear radial distance of the sample region on the MALDISC 1408 (e.g. 30 mm) and (3) no more readings are detected at the detector within the analyser within vacuum chamber 1501. The user could be aided by software (digitally encoded on the reverse side of the MALDISC) that graphically depicts on the screen of the processing unit 1504 the position of the disc within apparatus 1400 (because the internal workings of the apparatus are not visible from outside the vacuum chamber 1501 in reality) in order to ascertain an estimate how much of the MALDISC 1408 (and thereby the samples on it) have been exposed to the ablating laser beam 1507 or how long a full ablation of the MALDISC 1408 will take.

The user can then press the stop/eject button 1442 (once all samples have been ablated or at an intermediate time before that for any reason) and the above process is reversed in order to eject the MALDISC 1408. Motorized cog 1424 receives an electrical

'eject' signal as passed from electrode 1441b (see figure 14f and 14h) to a circuit on circuit board 1423a to cable 1426b to plug 1426a to cable 1426c to a circuit on circuit board 1423b to cable 1424 (see figure 14c) and begins to rotate an anti-clockwise direction (as viewed from above from the front of apparatus 1400 to the back).
5 Consequently sliding tray 1418 is moved back into the first compartment of the apparatus 1400. Once this has been accomplished, a signal is sent to back hatch 1401b to close (hatch 1401b operates in the same way as hatch 1401a does as described above). Vacuum generator 1503 then releases the vacuum within the first compartment of the apparatus 1400, allowing it to come to atmospheric pressure.

10 A signal is sent via a circuit (not shown) on circuit board 1423a to cable 1438b (see figure 14g and 14h) to drive motor rotate the shaft of cog 1436 in a clockwise direction (as seen from the right hand side to the left hand side of apparatus 1400 whilst the top is facing up as illustrated in figure 14h), thereby turning cylinder 1431 and plate 1430 attached to it and opening door 1429; simultaneously (or within one or more seconds as is
15 required for door 1429 to open), an eject signal is sent via a circuit on circuit board 1423a to the motorized cog 1421 via cable 1421a so that the motor begins to rotate the cog 1436 in a clockwise direction (as seen from the top of apparatus 1400 facing along the length of 1400 from front to back) thereby driving sliding tray 1418 (and all those components including rotor 1410 attached to it) out of apparatus 1400 relative to first compartment to
20 a distance such that the spent MALDISC 1408 may be easily removed from rotor 1410 by the user and secured by catches 1409a and 1409b.

Figures 16a, 16b, 16c, 16d, 16e and 16f depict apparatus 1600a in system 1600b for ablating the samples on the aforementioned MALDISCs (refer to figures 1 to 3). MALDISC 1601 region 1601a has MALDI samples laid down in multiple tracks of
25 concentric circles as seen in Figure 16a, but there could also be a single spiral track of samples as shown in figure 2, or rectangular sample arrays as shown in figure 3. MALDISC 1601 region 1601b is left blank and contains no samples. MALDISC 1601 region 1601c is an aperture for the spindle 1602a.

One or more registration mark(s) are located on the reverse side of MALDISC 1601
30 (the side opposite to the side on which the samples are placed) as illustrated in figure 16b; however they also be located on the side of the MALDISC 1601 as illustrated in figures 16d and 16e. The registration marks are detected by the registration mark finder 1610 (see figure 16b for reverse registration marks, and figure 16d and 16e for side registration marks) placed adjacent to MALDISC 1601 in order to read it (by transmitting, and

receiving the reflected signal). Samples positions are specified in polar coordinates (r, θ) with relative to the registration mark 1610d on the reverse side of MALDISC 1601. The registration mark finder 1610 (which may comprise an infra-red light source and a light detector, for example) is attached to the top of drive module 1602d and is positioned such that it faces the reverse side of the MALDISC 1601 in order to detect, in use, the one or more registration marks as it passes the finder 1610 during rotation of MALDISC 1601. The registration mark finder may optionally be any imaging device that is capable of detecting a registration mark (such as a Camera, CCD, or photovoltaic device for example), a proximity device based on magnetic fields or electrical capacitance, or a mechanical device (such as a micro-switch or a phase sensitive inductance device for example). The position of the samples on MALDISC 1601 may be computed on detection of the registration mark(s), provided MALDISC 1601 is rotated in a known direction and velocity as specified by a rotary encoder.

The spindle 1602a has catches 1602b which are rectangular spring-loaded extrusions that are filleted such that with the pressure of an incoming or outgoing MALDISC they are depressed, and protrude under the restoring force of their internal springs otherwise to affix the MALDISC to the rotor 1602c. The rotor 1602c has a textured rubber surface in order to increase friction and thereby maximise the torque delivered to the MALDISC by motor 1602d. The rotor 1602c is connected to the drive module 1602d which contains a rotatory actuating motor. The rotary actuating motor is interfaced with the rotary encoder 1602e which is used determine and monitor the position of the rotor 1602c and thereby rotating MALDISC 1601 to a high degree of accuracy. The drive module 1602d is attached to the x-axis drive rail assembly 1603 by means of a carriage containing wheels mounted on roller bearings and eccentric axles connected to a timing belt. The x-axis drive rail assembly 1603 is linearly actuated by the x-axis drive motor with linear encoder 1603c mounted on the drive station 1603b and located on the end of the x-axis drive rail assembly 1603a.

The x-axis drive rail assembly 1603 is attached to the z-axis drive rail 1605a and the z-axis driven rail 1604a (see figure 16c) by the carriage plates 1603d (see figure 16b) and 1603e which interface with the z-axis drive grooves and contain wheels mounted on roller bearings and eccentric axles connected to a timing belt sufficient in strength and tension to actuate the x-axis drive rail assembly 1603 along the z-axis to within a position repeatability of at least 0.05mm.

The z-axis drive rail assembly 1605a (see figure 16c) is linearly actuated by the z-axis drive motor with linear encoder 1606a mounted on the drive station 1606b situated on top of the z-axis drive rail 1605a. The drive station 1606b is linked to the driven station 1606d by means of the z-axis link shaft assembly 1606c which transfers rotation produced by the z-axis drive motor with linear encoder 1606a so that the x-axis drive rail assembly 1603a is equally actuated by both the z-axis drive rail 1605a and z-axis driven rail 1604a.

The z-axis drive rail assembly is attached to the y-axis drive rail 1608 (see figure 16c) and the y-axis driven rail 1607 by the carriage plates 1604b and 1605b which interface with y-axis drive grooves and contain wheels mounted on roller bearings and eccentric axles connected to a timing belt sufficient in strength and tension to actuate the z-axis drive rail 1605a and the driven rail 1604b along the y-axis to within a position repeatability of at least 0.05mm.

The y-axis drive rail 1608 is linearly actuated by the y-axis drive motor with linear encoder 1609a mounted on the drive station 1609b situated at the end of the y-axis drive rail 1608. The drive station 1609b is linked to the drive station 1609d by means of the y-axis link shaft assembly 1609c which transfers the rotation produced by the y-axis drive motor with linear encoder 1609a so that the z-axis drive and driven rails 1605a and 1604a are equally actuated by both the y-axis drive rail 1608 and the y-axis driven rail 1607.

The operation may be completed because the samples on MALDISC 1601 have been completely ablated by a desorbing laser beam, or the user terminates operation of Apparatus 4300 for whatever reason. MALDISC 1601 will have been completely ablated once a radial length encompassing Sample Region 1601a (the radial distance between Magnetic Region 1601b and the periphery of MALDISC 1601) has been completely presented to Aperture 4308a through which the desorbing laser beam has been fired. The signal to terminate the operation of Apparatus 4300 could be initiated by the user by pressing an open/close button for example.

Apparatus 1600a can operate with system 1600b (see figure 16f). System 1600b comprises an analytical apparatus 1613 that may be an ion-mobility device, or a mass spectrometer such as an orthogonal acceleration time of flight mass spectrometer (oa-TOFMS), a Secondary Ionisation Mass spectrometer (SIMS), or a Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS)) for example. The analytical apparatus 1613 has a vacuum sustained within it by the vacuum generator 1616 connected to analytical apparatus 1613 by line 1616a (see figure 16f). The analytical

apparatus within analytical apparatus 1613 is powered by the power supply 1617 which is connected to the analytical apparatus by line 1617a; the power supply 1617 is connected to and directed by a central processing unit 1615 by line 1617a. The central processing unit 1615 directs via line 1619a a laser 1619 which is used to emit a pulsed laser beam
5 1619b through the analytical apparatus via windows 1613a and 1613b directed at the MALDISC 1601 being operated by apparatus 1600a.

Power is supplied to the power coupler 1611 by power supply 1614 via line 1614a. Power coupler 1611 directs power to apparatus 1600a according to instructions from the central processing unit 1615 via line 1615a. Power coupler 1611 is connected to: (1) x-
10 axis drive motor with linear encoder 1603c via line 1603d (see figure 16c), (2) y-axis drive motor with linear encoder 1609a via line 1609e (see figure 16c), (3) z-axis drive motor with linear encoder 1606a via line 1606e (see figure 16c), (4) the rotary encoder 1602e and thereby the drive module 1602d which contains a rotatory actuating motor that rotates the MALDISC 1601 via line 1605 (see figure 16c), and (5) the registration mark
15 finder 1610 via line 1610b (see figure 16c).

Figure 17a is a perspective oblique exterior view illustrating the front, top and left hand side of apparatus 1700, an analytical apparatus introduction device used for automatically introducing and operating the aforementioned MALDI Cylinders (see figures 12a and 12b) or MALDI Cones (see figure 13). Similarly, figure 17b is a
20 perspective oblique exterior view illustrating the front, top and right hand side of the apparatus 1400. Figure 17c is a wire frame view of figure 17a illustrating the internal components of the apparatus 1700.

Apparatus 1700 is comprised of the rectangular housing 1704. The rectangular housing 1704 is comprised of two major compartments; the first compartment is used to
25 create a vacuum so that the MALDI Cylinder 1701 can be introduced into the second compartment which is at the medium or hard vacuum pressure within chamber 1801. The second compartment has no top face so that the MALDI Cylinder 1701 will be accessible to a desorbing laser beam 1804b. Apparatus 1700 is permitted to extend into a vacuum chamber to the extent permitted by the support 1707 containing the rubber seal 1707a.

30 The first compartment comprises a front sliding vacuum containment door 1705 and a back sliding vacuum containment door 1706. The periphery of both of these vacuum containment doors is lined with rubber seals 1704b and 1704c to ensure that a tight seal occurs upon closure in order to contain a vacuum created within the first compartment. The doors 1705 and 1706 both feature two rails: an upper driven rail 1705b, and a lower

drive rail 1705c which contains teeth that interface with motorised cogs 1711 and 1710 used to actuate them (see figure 17i for a direct view of the doors, and figures 17g and 17h for internal view of housing 1704 featuring the doors).

The user activates the opening or closing of door 1705 by pressing buttons 1708a and 1709a which are the 'play' and 'stop/eject' buttons respectively (illustrated in figure 17e). Buttons 1708a and 1709a are connected to shafts 1708b and 1709b respectively, so that when either button 1708a or 1709a is pressed they will make contact with the electrodes 1708c or 1709c respectively which are within the apparatus 1700 and are connected to the circuit board 1712. The opening and closing of the back door 1706 is electronically automated via buttons 1708a or 1709a.

Running throughout the length of the rectangular housing 1704 is the slide assembly 1703 (see figure 17c, 17d and 17j) which may be a ball slide assembly, a cross roller slide assembly or a ball and crossed roller slide assembly. The slide assembly 1703 is connected to the primary circuit board 1703d via the ribbon cable 1703d (which passes through the aperture 1703a in housing 1704 – see figures 17g and 17h) from where it receives instructions in the form of voltage directed to its internal motor. The slide assembly is composed of two major sections: the front section 1703c located in the first compartment of housing 1704 and the back section 1703a located in the second compartment of housing 1704, which are separated by gap 1703b used as a passage way for the back sliding vacuum containment door 1706 (see figure 17d). Messages are communicated between the two sections via joint 1703d which runs throughout the left hand side of housing 1704 in order not to provide a potential breach in the vacuum contained therein.

The slide assembly 1703 is used as a linear actuator for the rotary drive module 1702 (see figure 17f) which is attached to the slide assembly 1703 by means of a carriage containing wheels mounted on roller bearings and eccentric axles connected to a timing belt. Module 1702 contains a rotary actuating motor that is interfaced with a rotary encoder which is used determine and monitor the position of the rotor 1702b and thereby rotating MALDI cylinder 1701 to a high degree of accuracy. The rotary encoder is in electrical communication with the primary circuit board 1712 also using ribbon cable 1703d.

The rotor 1702b is attached to spindle 1702e; spindle 1702 features three protrusions: firstly, the guide 1702 which has a corresponding female counterpart in the MALDI cylinder 1701 and ensures that the cylinder is always placed on the rotor in the

same way, and secondly a set of two catches 1702h and 1702f which are rectangular spring-loaded extrusions that are filleted such that with the pressure of an incoming or outgoing MALDI cylinder 1701 they are depressed, and protrude under the restoring force of their internal springs otherwise to affix the MALDI cylinder 1701 to the rotor
5 1702b.

The rotor 1702b also features registration mark 1702c which is read by a registration mark finder 1702d. Samples positions are specified in cylindrical coordinates $\{(r, \theta, z)$ where r is constant $\}$ relative to the registration mark 1702c. The registration mark finder 1702d may be a photoelectric proximity switch (which could be a glass or
10 plastic optical fibre sensor for example), or a miniaturised inductive proximity switch/sensor, or a basic mechanical micro switch for example. Finder 1702d is in communication with the circuit board 1712 via a circuit within the slide assembly 1703 (not shown) and ribbon cable 1703d.

Power is supplied to the apparatus 1700 via DC Input 1713 (see figure 17a, 17c and
15 17e).

Apparatus 1700 can be installed into system 1800 for operation (see figure 18a). System 1800 comprises a chamber 1801 which contains an analytical apparatus 1806 that may be an ion mobility device or a mass spectrometer such as an orthogonal acceleration time of flight mass spectrometer (oa-TOFMS), a Secondary Ionisation Mass spectrometer
20 (SIMS), a Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS)), or a chromatograph, for example. Chamber 1801 features an aperture so that apparatus 1700 can be inserted either horizontally or vertically (as is depicted figure 18b), penetrating into apparatus 1801 to an extent permitted by the position of support 1707 (see figure 18b).

The analytical apparatus 1806 has a vacuum sustained within it by the vacuum
25 generator 1805 connected to it by line 1805a (see figure 18a). This induces a vacuum within the chamber 1801 which also contains the apparatus 1700. It should be noted however, that the apparatus 1700 can operate in a hard vacuum, or at medium pressure (1 millibar, for example), or at atmospheric pressure. However, in this embodiment, the
30 apparatus 1700 is illustrated as operating in at least a medium to hard vacuum.

The analytical apparatus within chamber 1801 is powered by the power supply 1804 which is connected to the analytical apparatus by line 1804a; the power supply 1805 is connected to and directed by a central processing unit 1803 by line 1804b.

The central processing unit 1804 directs via line 1807a a laser 1807 which is used to emit a pulsed laser beam 1807b through chamber window 1801b, analyser windows 1806a and 1806b directed at the MALDI CYLINDER 1701 being operated within apparatus 1700. The central processing unit 1803 receives the detected signal from the analytical apparatus within chamber 1801 via line 1801b. A vacuum generator 1803 is connected to apparatus 1700 via line 1803a in order to establish a vacuum in the first compartment of the apparatus 1700 before the introduction of the MALDI cylinder 1701 into the vacuum subsisting within the second compartment of the apparatus 1700 produced in chamber 1801 by the vacuum generator 1805. Power is provided to the apparatus 1700 by the power supply 1802 via line 1802a which connects to DC Input 1713 on apparatus 1700 (see figure 18b).

The entire operation of the apparatus 1700 interacting with the system 1800 will now be described (illustrated in figures 18a, 18b, 18c, 18d and 18e). To load the MALDI CYLINDER 1701 into apparatus 1700, the user presses the stop/eject button 1709 on the apparatus 1700 located near the bottom of the front of housing 1704. A circuit on circuit board 1712 is connected to cable 1710d (see figure 17h) which directs the motorised cog 1710 to turn in an anti-clockwise direction (as seen from above apparatus 1700) thereby driving the front sliding vacuum containment door 1705 out of the body of apparatus 1700 to an extent which allows the user to place the MALDI Cylinder 1701 upon the rotary drive module 1702 (see figure 18b). Simultaneously (or within one or more seconds as is required for door 1705 to open), a signal is sent via a circuit on circuit board 1712 to the slide assembly 1703 to move the rotary drive module 1702 to the front of housing 1704 so that MALDI cylinder 1701 may be mounted upon rotor 1702b by the user and secured by catches 1702f and 1702h on the spindle 1702e.

To retract the MALDI cylinder 1701 into apparatus 1700 with the intent of initiating is ablation of the samples on it, the user presses the play button 1709a on the apparatus 1700. A cylindrical extrusion 1709b (not shown, but similar to 1708b featured in figure 17e) attached to play button 1709a makes contact with electrode 1709b (not shown) and a play signal is sent via a circuit (not shown) on circuit board 1712 to the cable 1710d (see figure 17h) which directs the motorised cog 1710 to turn in an clockwise direction (as seen from above apparatus 1700) thereby driving the front sliding vacuum containment door 1705 into the body of apparatus 1700 to an extent which seals the housing 1704 (illustrated in figure 18c).

The vacuum generator 1803 then draws air from the first compartment of apparatus 1700 until a vacuum equal to the vacuum subsisting within vacuum chamber 1801 (as generated by vacuum generator 1805 connected to the analytical apparatus 1806) is established. Once a vacuum has been established a signal is sent to door 1706 (see figure 5 17c) to open (to be automated, this will require a vacuum sensor attached to aperture 1704e whose electronics are integrated with circuit board 1712). The motorized cog 1711 then begins to rotate in an clockwise direction (as seen from the top of apparatus 1700 facing along the length of 1700 from front to back), actuating the sliding door 1706 out of the housing 1704 (as depicted in figure 18d).

10 The slide assembly 1703 then moves the rotary drive module 1702 at a constant rate into the second compartment of apparatus 1700 so that every MALDI sample on the MALDI cylinder 1701 (see MALDI cylinder 1200a in figure 12a for illustration) is accessible to the desorbing laser beam 1804b (see figures 18d and 18e). At least a part of the desorbed sample is then drawn into an analytical apparatus/analyser within the 15 vacuum chamber 1801 as drawn by (1) vacuum pressure or (2) electrostatic lenses or ion guides interposed to direct ions to the aperture, or (3) passes through the aperture spontaneously, or a combination of forces (1) to (3).

The user can then press the stop/eject button 1742 (once all samples have been ablated or at an intermediate time before that for any reason) and the above process is 20 reversed in order to eject the MALDI cylinder 1709a. The rotary drive module 1702 and the MALDI cylinder 17071 attached to it then move along the slide assembly 1703 back into the first compartment. The motorized cog 1711 receives an electrical 'eject' signal as passed from electrode 1709c (see figure 17f and 17h) to a circuit on circuit board 1712 to cable 1711d and begins to rotate an anti-clockwise direction (as viewed from above 25 facing from the front of apparatus 1700 to the back). Consequently sliding door 1706 is moved back into the first compartment of the apparatus 1700 thereby sealing the first compartment of housing 1704.

Vacuum generator 1803 then releases the vacuum within the first compartment of the apparatus 1700, allowing it to come to atmospheric pressure. A circuit on circuit 30 board 1712 is connected to cable 1710d (see figure 17h) which directs the motorised cog 1710 to turn in an anti-clockwise direction (as seen from above apparatus 1700) thereby driving the front sliding vacuum containment door 1705 out of the body of apparatus 1700. The rotary drive module 1702 (see figure 18b) then raises the spent MALDI cylinder 1701 out of the body of the apparatus 1700 to be removed by the user.

Figure 19 depicts apparatus 1900 for determining the position of samples 1903a – 1903d, 1904a – 1904d, 1905a – 1905d (which are representative of a plurality of samples) on rotating MALDISC 1902, and desorbing at least a portion of at least some of samples from rotating MALDISC 1902. Apparatus 1900 includes motor 1906 which, in use, rotates shaft 1907. Rotating MALDISC 1902 has a centrally located hole 1908. In use, shaft 1907 is placed through centrally located hole 1908 to support rotating MALDISC 1902 at a position near the end of shaft 1907 as depicted in Figure 19. Samples 1903a – 1903d, 1904a – 1904d, 1905a – 1905d are arranged on side 1911 of MALDISC 1902 in a spiral track 1910 respectively. At least one registration mark 1912 is disposed on the side 113 of MALDISC 1902. Samples 1903a – 1903d, 1904a – 1904d, 1905a – 1905d are arranged on side 1911 of MALDISC 1902 at positions relative to registration mark 1912 which are known or which may be computed on detection of registration mark 1912 and specified in polar coordinates (r, θ) , provided MALDISC 1902 is rotated in a known direction and velocity and in communication with processing unit 1915 via line 1926. Optical detection device 1914 (which may comprise a light source and a light detector, for example) is disposed on the same side as reverse side 1913 in order to detect, in use, the one or more registration marks 1912 as it passes device 1914 during rotation of MALDISC 1902. Optical detection device 1914 is in communication (e.g. optical or electrical communication) with processing unit 1915 via line 1920. Processing unit 1915 which is in communication with laser light source 1925 via line 1921 controls the operation of laser light source 1925. In use, laser light source 1925 emits a pulsed laser beam 1916. Moveable mirror unit 1919 (which may be a shaft encoded rotating mirror with rapid digital angle setting or a mirror coupled to a galvanometer) which is linked to processing unit 1915 via line 1918 and is disposed in the path of beam 1916 deflects beam 1916 onto one of samples 1903a – 1903d, 1904a – 1904d, 1905a – 1905d. Beam 1916 is of sufficient intensity to desorb at least a portion of the sample 1903a – 1903d, 1904a – 1904d, 1905a – 1905d on which beam 1916 falls. At least a part of the desorbed sample 1917 is then drawn into analyser 1923 by vacuum or passes through the aperture spontaneously. Analyser 1923 includes sample port slit 1922 which is disposed to capture desorbed samples 1917 from MALDISC 1902 by laser beam 1916.

In operation, shaft 1907 is rotated by motor 1906 at constant angular velocity. MALDISC 1902 which is supported on end 1908 of shaft 1907 is thereby rotated at the same constant angular velocity as shaft 1907. As MALDISC 1902 rotates, optical detection device 1914 detects registration mark 1912 as it passes past device 1914.

Device 1914 transmits a registration mark detection signal to processing unit 1915. On receipt of the registration mark detection signal, processing unit 1915 computes the position within the area of one of samples 1903a – 1903d, 1904a – 1904d, 1905a – 1905d. Processing unit 1915 sends a signal to movable mirror unit 1919 via line 1918 to adjust
5 the position of mirror 1919 to a position which will provide reflected beam 1916 directed at the point on the spiral track on which the required sample lies (e.g. 1903a in Figure 19) on the on MALDISC 1902. At the appropriate time computed by processing unit 1915 from receipt of following registration mark detection signal from device 1914 sends a signal to laser light source 1925 to fire. A pulsed laser beam 1916 is subsequently emitted
10 from laser light source 1925, reflected off mirror 1919 and onto one of samples 1903a – 1903d, etc. Beam 1916 is of sufficient intensity to desorb at least a portion of the sample 1903a – 1903d, 1904a – 1904d, 1905a – 1905d on which beam 1916 falls. Beam 1916 may consist of single or multiple bursts on the sample (e.g. 1903a on Figure 19) per revolution of the MALDISC 1902. Space between samples 1903a – 1903d, 1904a –
15 1904d, 1905a – 1905d may be used by inks doped with standard mass calibrants so that reference can be made at any point in an analysis to a mass standard to confirm sample mass. The desorbed sample 1917 passes through sample port slit 1922 into analyser 1923 which then proceeds to analyse desorbed sample 1917.

Referring to Figure 20, apparatus 2000 for determining the position of a sample on
20 a rotating platform 2002, and subsequently releasing the sample from platform 2002 has a shaft 2018 capable of rotation and comprises a nodule 2016 which facilitates correct placement of the MALDISC 2002 on the shaft 2018 using aperture 2012. Rotating shaft 2018 comprises registration mark 2028, and the samples to be released 2003a – 2003d, 2004a – 2004d, 2005a – 2005d (which are representative of a plurality of samples) are
25 arranged on MALDISC 2002 in a series of circular tracks 2008, 2011, 2029. Optical detection device 2014 is disposed adjacent to the rotating shaft 2018 in order to detect registration mark 2028 as it passes during rotation of the shaft 2018. Optical detection device 2014 is in communication with a processing unit 2015 which controls the operation of the laser light source 2025. The resulting laser beam 2016 is incident upon
30 rotating mirror 2019 which directs laser beam 2016 to the desired position on the rotating MALDISC 2002.

In operation, shaft 2018 is rotated by motor 2006 at constant angular velocity. MALDISC 2002 which is supported on shaft 2018 is thereby rotated at the same constant angular velocity as shaft 2018. As MALDISC 2002 rotates optical detection device 2014

detects registration mark 2028 as it passes past device 2014. Device 2014 transmits a registration mark detection signal to processing unit 2015. On receipt of the registration mark detection signal, processing unit 2015 computes the position of at least one of samples 2003a – 2003d, 2004a – 2004d, 2005a – 2005d. Processing unit 2015 sends a
5 signal to movable mirror unit 2019 via line 2018 to adjust the position of mirror 2019 so that the reflected beam 2016 is directed at the appropriate radial track on which the required sample lies (e.g. 2003a in Figure 20) on the MALDISC 2002. At the appropriate time computed by processing unit 2015 from receipt of the registration mark detection signal from device 2014 sends a signal to laser light source 2025 to fire. A pulsed laser
10 beam 2016 is subsequently emitted from laser light source 2025, reflected off mirror 2019 and onto one of samples 2003a – 2003d, etc. Beam 2016 is of sufficient intensity to desorb at least a portion of the sample 2003a – 2003d, 2004a – 2004d, 2005a – 2005d on which beam 2016 falls. Beam 2016 may consist of single or multiple bursts on the sample (e.g. 2003a on Figure 20) per revolution of the MALDISC 2002. Space between samples
15 2003a – 2003d, 2004a – 2004d, 2005a – 2005d may be used by inks doped with standard mass calibrants so that reference can be made at any point in an analysis to a mass standard to confirm sample mass. The desorbed sample 2017 passes through sample port slit 2022 into analyser 2023 which then proceeds to analyse the desorbed sample 2017.

*Figure 21a, 21b, 21d, 21e, and 21f depict the apparatus 2100 for determining the
20 position of samples on the MALDI Sphere 2101, and desorbing at least a portion of at least some of MALDI samples from the rotating sphere 2101. Discrete samples are laid down along lines of latitude around the rotating sphere 2101 (See Figure 21e for a close up illustration).*

The rotating sphere 2101 is penetrated along its axis by the rotor 2102. The rotor
25 2102 is composed of the rotation actuating shaft 2102a (shown as a dotted line in figure 21a) which is connected to the rotatory actuating motor with encoder 2105. The rotation actuating shaft 2102a is encased within the cylinder 2102b which connects the rotatory actuating motor with encoder 2105 to the cylinder 2102c (see Figure 21a). A washer 2102d sits on top of the MALDI sphere 2101. The rotation actuating shaft 2102a extends
30 through the cylinder 2102c and penetrates the MALDI sphere 2101, actuating its rotation.

The registration cap 2116 is inserted on the rotation actuating shaft 2102a and sits on top of the MALDI sphere 2101 (see figure 21f). The registration cap 2116 has two placement shafts; a circular placement shaft 2116c and a triangular shaft 2116b (see figures 21f). This ensures that the registration cap 2116 is always placed on the same way

with respect to the MALDI sphere 2101 which has corresponding female sockets 2101b and 2101c. The registration cap 2116 has around its circumference a registration mark 2116a (see figures 21e and 21f). The registration mark 2116a is the bearing position for lines of longitude on the sphere 2101. The latitude of a particular sample is specified at its deposition. The apex of Triangular Shaft 2116c marks the prime meridian (invisible line
5 along which samples are laid) of sphere 2101, the 0^0 of longitude (equivalent to Greenwich Meridian on the Earth). Samples get their longitude bearing with reference to this location.

The registration cap 2116 precludes the existence of samples at $+90^0$ latitude (the
10 sphere's 'north pole') and its immediate vicinity. Likewise the washer 2102d precludes the existence of samples at -90^0 latitude (the 'south pole') and its immediate vicinity. These regions can also be used as handling points.

MALDI samples laid down on different points of latitude are accessed via a tilt mechanism. The tilt mechanism is composed of the cylinder 2102c which is attached to
15 the cog 2106a and cog 2106b (see figure 21a). The cog 2106a and the cog 2106b are not attached by a shaft that penetrates the cylinder 2102c (which would disrupt the rotation actuator shaft 2102a) but are merely attached to its surface. Hollow cylinders protrude from the cylinder 2102c (not shown). The cogs 2106a and 2106b have an inner male counterpart which fits inside the cylinder 2102c, and an outer larger female counterpart
20 which fits outside the cylinder 2102c (not shown). The outer larger female counterpart has cogs on its out surface (pictured in Figure 21a as Cogs 2106a and 2106b). This system allows the cogs to run along the tracks.

The cog 2106b (see figure 21a) is attached to the cylinder 2108 which is connected to the motor with encoder 2109. The cylinder 2108 houses the rotor 2108a which is
25 actuated by the motor with encoder 2109 and drives the cog 2106b along the track 2107b and thereby the cylinder 2102c, the cog 2106a which is attached to the cylinder 2102c along track 2107a, and thereby all of the shaft 2102 and the MALDI sphere 2101 along the track body 2107.

The teeth on the cogs 2106a and 2106b and likewise the grooves on the tracks
30 2107a and 2107b are of sufficient size to actuate movements around the great circle (a circle on the surface of the MALDI sphere 2101 which is formed as the result of the intersection of the sphere and a plane passing through the centre of the sphere 2101) at 90^0 clockwise from Prime Meridian (looking from the North) and upon which Laser

Beam 2204b is incident, to a precision of up to 0.5mm movements which could be the spacing between latitude tracks along which samples are laid.

The cylinder 2109 protrudes from the motor with encoder 2109 and sits inside the guide rail 2111a which is a feature of plate 2111 (see Figures 21b and 21c). The guide rail
5 2111a exists to ensure that cogs 2106a and 2106b maintain contact with the tracks 2107a and 2107b at all times in order that the MALDI sphere 2101 may tilt on its axis correctly.

The cog 2106a has an articulated support structure 2114 attached to it. The registration mark detector 2105 sits on top of the articulated support structure 2114 so that it is always aiming at the registration cap 2116 even when the shaft 2102 is tilted on its
10 axis.

The registration mark detector 2115 transmits a beam 2115d from its window 2115c which reflects off the registration mark 2116a and is received by the window 2115d. The registration mark 2116a a signal is sent to the relay station 2113 (see figure 21b) in apparatus 2100 via the cable 2115a and from there to central processing unit 2206 via
15 cable 2206c (see figure 22). This indicates to the central processing unit 2206 that the registration cap 2116 and therefore the MALDI sphere 2101 have rotated through 360^0 (from the prime meridian).

The processing unit 2206 is in communication with the laser light source 2207 via the line 2206b and controls the operation of the laser light source 2207 (see Figure 22).
20 The analytical apparatus 2204 may be an ion mobility device or a mass spectrometer for example, and is powered by the power source 2205 and connected via cable line 2205a (see figure 22). Detection signals of the analyser 2204 are sent to the central processing unit 2206 via cable line 2206a. A vacuum is generated in the analytical apparatus by the vacuum generator 2203 connected to the analytical apparatus via line 2203a. The
25 apparatus 2100 is powered by the power source 2202.

In use, the laser light source 2207 emits the pulsed laser beam 2207a which passes into the analytical apparatus 2204 via slit 2204a and out via the slit 2204b (see Figure 22). The pulsed beam 2207a lands on the rotating MALDI sphere 2101, and is of sufficient intensity to desorb at least a portion of the required sample on which the pulsed beam
30 2202b falls. The desorbed sample (not shown) passes into the analytical apparatus 2204 via slit 2204b (see figure 21f and 22) spontaneously drawn by the flow of gas from high pressure to low pressure (from the vacuum pump 2203 connected to connected to the analytical apparatus 2204) or under the action of electrostatic lenses or ion guides (not shown) interposed to direct ions to the slit 2204b.

In order to bring a sample on a positive (i.e. north) latitude into the path of the beam 2207a, the processing unit 2206 sends a signal sent to the motor with encoder 2109 via cable 2109a and the relay station 2113 (see figure 21a) to drive the rotor 2109 (encased within the cylinder 2108) in an anti-clockwise direction (looking along the cylinder 2102b, from the plate 2111). The rotor 2109 (see figure 21b) is attached to the cog 2106b and therefore also moves in an anti-clockwise direction along the track 2107b (in the negative y direction – see figure 21a). The cog 2106b is attached to the cylinder 2102c and therefore it follows correspondingly moving up the track 2107a, in the negative y direction. The cylinder 2102c is attached to the cog 2106a so cog 2106a moves along the track 2107a in the negative y direction. The cylinder 2102c holds the shaft 2102b which contains the rotor 2102a. The rotor 2102a penetrates the MALDI sphere 2101 (and may comprise a catch mechanism which is not shown), so the sphere 2101 is tilted in the positive y direction and the required positive latitude on which the sample lies is brought to a point accessible by the pulsed laser beam 2207a.

In order to bring a sample on a negative (i.e. south) latitude into the path of the beam 2207a, the processing unit 2206 sends a signal sent to the motor to encoder 2109 (as described above) to drive the rotor 2108a (encased within cylinder 2108 - see figure 21b) in an clockwise direction (looking along the cylinder 2108, from the plate 2111). The rotor 2108 is attached to the cog 2106b and therefore also moves in a clockwise direction along the track 2107b (in the positive y direction). The cog 2106b is attached to the cylinder 2102c and therefore it follows correspondingly moving up the track assembly 2107, in the positive y direction. The cylinder 2102c is attached to the cog 2106a so cog 2106a moves along the track 2107a in the positive y direction. The cylinder 2102c holds the shaft 2102b which contains the rotor 2102a. The rotor 2102a penetrates the MALDI sphere 2101, so the sphere 2101 is tilted in the positive y direction and the negative latitude on which the required sample lies is brought to a point accessible by the pulsed laser beam 2207a.

The tilt mechanism of apparatus 2100 ensures that the distance of the surface of the sphere from the entrance to the analytical apparatus remains the same throughout the MALDI sphere's motion.

The processing unit 2201 sends a signal containing the information to rotate in a given velocity and direction to the rotatory actuating motor with encoder 2105 via the means outlined above. The rotatory actuating motor with encoder 2105 causes the rotor 2102a to rotate and thereby causes the MALDI sphere 2101 to rotate correspondingly.

When the registration mark 2116a on the registration cap 2116 is detected by the device 2115 (see Figure 21b), the device 2115 sends a signal of its detection to the processing unit 2201 via the cable 2115a, relay station 2113 and cable 2206c. The processing unit 2206 is previously programmed with the rotational velocity and direction of the shaft 2102a and thereby the MALDI sphere 2101 and uses these parameters to calculate how long it will take the registration mark of interest (and thereby the longitude on which the required sample resides) to rotate $+90^{\circ}$ clockwise in longitude from the prime meridian (the sample's latitude being is recorded upon its deposition).

The processing unit 2206 then sends a signal to fire to the laser light source 2207 via Line 2206b (see figure 22) which emits a pulsed laser beam 2207a which passes through into analytical apparatus 2204 via slit 2204a and out via slit 2204b and onto the MALDI sphere 2101; the beam is timed to correspond with required sample's expected transit time across $+90^{\circ}$ clockwise longitude from the prime meridian (see figure 21d), and thereby facilitate its desorption by the pulsed laser beam 2207a. The beam 2207a is of sufficient intensity to desorb at least a portion of the sample on which it falls and may consist of single or multiple bursts on the sample per revolution of the MALDI Sphere 2201. The space between samples may be used by inks doped with standard mass calibrants so that reference can be made at any point in an analysis to a mass standard to confirm sample mass.

The desorbed sample passes through the slit 2204b into the analytical apparatus 2203 (spontaneously drawn by the flow from low pressure to high pressure, or otherwise by an electrostatic lens or ion guide which are not shown) which then proceeds to analyse the desorbed sample. Upon detection of the desorbed sample by the analytical apparatus 2206a, a signal is sent to the processing unit 2201 via the line 2206a to repeat the process.

Modifications and variations such as would be apparent to a skilled addressee are deemed to be within the scope of the present invention. It is to be understood that the scope of the present invention should not be restricted to the particular embodiments and examples described above.

Claims

1. A rotatable disc comprising an edge side about the perimeter of the disc, a sample side and a back side and comprising one or more detectable features disposed on the disc at at least one location selected from the group consisting of the sample side and the edge side.
2. A rotatable disc comprising one or more detectable features disposed on the disc and one or more positioners to position the disc at a predetermined position on a rotator.
3. A rotatable disc comprising an edge side about the perimeter of the disc, a sample side and a back side said disc comprising:
 - (i) one or more detectable features disposed on the disc at at least one location selected from the group consisting of the sample side and the edge side, and
 - (ii) a sample positioned on the sample side of the rotatable disc at a known position relative to the one or more detectable features.
4. A rotatable disc comprising an edge side about the perimeter of the disc, a sample side and a back side said disc comprising:
 - (i) one or more detectable features disposed on the disc at at least one location selected from the group consisting of the sample side and the edge side, and
 - (ii) one or more samples positioned on the sample side wherein the angular position of each of the samples is known relative to the one or more detectable features relative to the central axis position of the rotatable disc and the radius of the one or more samples is known relative to the central axis position of the rotatable disc.
5. A rotatable disc according to any one of the preceding claims, wherein the size of each of the one or more samples is in a range selected from the group

consisting of about 0.2 to about 7mm, about 0.5 to about 5mm, about 0.3mm to about 3mm and about 0.5 to about 2mm.

- 5 6. A rotatable disc according to any one of the preceding claims, wherein each of then one or more samples is disposed in a compositional matrix suitable for use in Matrix Assisted Laser Desorption Ionisation (MALDI).
- 10 7. A rotator comprising one or more detectable features, said rotator adapted to rotate a rotatable disc; said disc comprising:
 - (i) a positioner to position the disc on a rotator at a predetermined position, and
 - (ii) one or more samples in a matrix positioned at a known radius and angular position on the rotatable disc, wherein the angular position of each of the samples is known relative to the one or more detectable features and the radius of the one or more samples is known relative to the center of the rotatable disc.
- 20 8. The rotator according to claim 7, wherein the positioner comprises one or more spindles protruding from a back side of the rotatable disc.
9. The rotator according to claim 8, wherein each spindle is removably attached to the rotatable disc.
- 25 10. The rotator according to claim 8, wherein each spindle is fixedly attached to the rotatable disc.
- 30 11. The rotator according to claim 7, wherein the rotator comprises one or more complementary shaped apertures or cavities so as to receive the spindles when the rotatable disc is disposed on the rotator at a predetermined position.
12. The rotator according to claim 11, wherein the rotatable disc comprises a cavity or aperture which is complementary to the shape of the spindle on the rotator

such that the rotatable disc is able to be disposed on the rotator at a predetermined position.

- 5 13. The rotator according to claim 7, wherein the detectable feature is a mark or an aperture.
14. The rotator according to claim 13, wherein the mark is a registration mark.
- 10 15. A method of determining at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, and sampling at least a portion of the sample from the disc, said at least one sample being located at a known position on said disc relative to said feature, said method comprising:
- 15 (i) locating the rotatable disc on a rotator at a predetermined position on the rotator,
- (ii) rotating the rotatable disc;
- (iii) detecting the detectable feature on the rotatable disc;
- (iv) determining an arrival time when the sample will arrive at a sampling location after the detecting, and
- 20 (v) sampling at least a portion of the sample at the arrival time.
16. The method of claim 15, further comprising the step of enabling a sampler to sample at the sampling location.
- 25 17. The method of claim 16, further comprising the step of analysing the sample.
18. A method for determining the position of at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, sampling at least a portion of the sample from the disc, and analysing said portion, said at least one sample being located at a known position on said disc relative to said feature, said method comprising:
- 30 (i) locating the rotatable disc on a rotator at a predetermined position on the rotator,
- (ii) rotating the rotatable disc at a known rotational velocity,

- (iii) detecting the detectable feature on the rotatable disc,
 - (iv) determining an arrival time when the sample will arrive at a sampling location after the detecting,
 - (v) desorbing or ablating at least a portion of the sample one or more times per revolution of the rotatable disc, and
 - (vi) analysing the desorbed or ablated sample.
19. The method of claim 18, further comprising repeating steps (i) through (vi).
20. The method of claim 18, further comprising ablating or desorbing at least a portion of each of the samples from the rotatable disc with a laser beam.
21. The method of claim 18, wherein the step of detecting comprises detecting a detectable feature with a detector so that the angular position of the sample is known relative to the detectable feature.
22. A system for determining the position of at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc, and sampling at least a portion of the sample from the disc, said at least one sample being located at a known position on said disc relative to said one or more detectable features, said system comprising:
- (i) a rotator for rotating the rotatable disc;
 - (ii) a detector for detecting the detectable feature on the rotatable disc;
 - (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector, and
 - (iv) a sampler for sampling at least a portion of the sample at the arrival time said sampler being coupled to said processor.
23. The system of claim 22, wherein the system further comprises an enabler for enabling the sampler to sample the sample at the sampling location.
24. A system for determining the position of at least one sample disposed on a rotatable disc comprising one or more detectable features disposed on the disc,

sampling at least a portion of the sample from the disc, and analysing said portion, said at least one sample being located at a known position on said disc relative to said feature, said system comprising:

- (i) a rotator for rotating the rotatable disc at a known rotational velocity,
- 5 (ii) a positioner for positioning the rotatable disc on a rotator at a predetermined position on the rotator,
- (iii) a detector for detecting the detectable feature on the rotatable disc,
- (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled
- 10 to said detector, and
- (v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

25. The system of claim 24, wherein the system further comprises an analyser for
15 analysing the desorbed or ablated sample.

26. The system of claim 24, wherein the sampler is capable of desorbing or ablating at least a portion of the sample at the arrival time one or more times per
20 revolution of the rotatable disc.

27. A rotatable cylinder or cone comprising one or more detectable features.

28. A rotatable cylinder or cone comprising:

- 25 (i) one or more detectable features on the rotatable cylinder or cone,
- (ii) a sample disposed on the rotatable cylinder or cone at a known position relative to the one or more detectable features.

29. A rotatable cylinder or cone comprising:

- 30 (i) one or more detectable features on the rotatable cylinder or cone,
- (ii) one or more samples disposed on the rotatable cylinder or cone, wherein the azimuth of each of the samples is known relative to the detectable feature(s) and the distances from the top or

bottom of the rotatable cylinder or cone is known for each of the samples and the one or more detectable features.

- 5 30. A combination of (a) a rotatable cylinder or cone comprising one or more positioners to position the cylinder or cone on a rotator at a predetermined position and (b) one or more rotors for coupling the one or more positioners and a rotator wherein:
- 10 (i) at least one detectable feature(s) is on at least one of the rotors;
 - (ii) the rotatable cylinder or cone, the one or more rotors and the rotator are capable of being coupled together such that the rotatable cylinder or cone is at a predetermined angular orientation relative to the rotator, and
 - 15 (iii) one or more samples disposed on the rotatable cylinder or cone, wherein the azimuth of each of the samples is known relative to the detectable feature(s) and the distances from the top or bottom of the rotatable cylinder or cone is known for each of the samples and the one or more detectable features.
- 20 31. A rotatable cone or cylinder comprising:
- (i) one or more detectable features on the rotatable cone or cylinder,
 - 25 (ii) one or more samples, each sample being disposed in a matrix, and being positioned wherein the angle subtended in a horizontal plane parallel to the end or bottom of the cylinder or cone between each sample, the central longitudinal axis of the cone or cylinder and an imaginary vertical line running from the top of the cylinder or cone to the bottom of the cylinder or cone and intersecting the detectable feature(s) is known and the length coordinates of the detectable feature(s) and each of the samples on the cone or cylinder is known relative to the top or bottom of the rotatable cone or cylinder.
- 30 32. A combination of a rotatable cylinder or cone, a support comprising one or more detectable features and a linker for linking the support and the rotatable cylinder or cone.

33. The combination of claim 32, wherein the combination further comprises one or more samples on the rotatable cylinder or cone wherein the latitude and the altitude of the detectable features are known and the latitude and the longitude of each of the samples is known.

5

34. A method for determining the position of at least one sample on a rotatable cylinder or cone, and subsequently sampling the sample, said rotatable cylinder or cone comprising a detectable feature and wherein said at least one sample is located at a known position on said cylinder or cone relative to said feature, said method comprising:

10

(i) rotating the rotatable cylinder or cone at a constant frequency about the central longitudinal axis of the cylinder or cone,

(ii) detecting the detectable feature,

(iii) determining an arrival time of the sample at a sampling location after the detecting,

15

(iv) sampling at least a portion of the sample at the arrival time.

35. The method of claim 34, further comprising repeating steps (i) to (iv).

20

36. A method for determining the position of at least one sample on a rotatable cylinder or cone, and subsequently releasing the sample from the cylinder or cone, said rotatable cylinder or cone having a registration mark and said at least one sample being located at a known position on said cylinder or cone relative to said feature, said method comprising:

25

(i) storing the known locations of the samples,

(ii) rotating the rotatable cylinder or cone at a known rotational velocity,

(iii) registering the detected registration mark signal,

(iv) determining the time at which the particular sample will arrive at a sampling location,

30

(v) directing the sampler to desorb at least a portion of the sample one more times per revolution of the rotatable cylinder or cone, and

(vi) analysing the desorbed sample.

37. The method of claim 36, further comprising repeating steps (i) through (vi).

38. A system for determining the position of at least one sample disposed on a rotatable cylinder or cone comprising one or more detectable features disposed on the cylinder or cone, and sampling at least a portion of the sample from the cylinder or cone, said at least one sample being located at a known position on said cylinder or cone relative to said one or more detectable features, said system comprising:
- (i) a rotator for rotating the rotatable cylinder or cone;
 - (ii) a detector for detecting the detectable feature on the rotatable cylinder or cone;
 - (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector; and
 - (iv) a sampler for sampling at least a portion of the sample at the arrival time, said sampler being coupled to said processor.
39. The system of claim 38, wherein the system further comprises an enabler for enabling the sampler to sample a sample at the sampling location.
40. A system for determining the position of at least one sample disposed on a rotatable cylinder or cone comprising one or more detectable features disposed on the cylinder or cone, sampling at least a portion of the sample from the cylinder or cone, and analysing said portion, said at least one sample being located at a known position on said cylinder or cone relative to said feature, said system comprising:
- (i) a rotator for rotating the rotatable cylinder or cone at a known rotational velocity,
 - (ii) a positioner for positioning the rotatable cylinder or cone on a rotator at a predetermined position on the rotator,
 - (iii) a detector detecting the detectable feature on the rotatable cylinder or cone,
 - (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled to said detector, and

- (v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

- 5 41. The system of claim 40, wherein the system further comprises an analyser for analysing the desorbed or ablated sample.
42. A rotatable sphere comprising one or more detectable features.
- 10 43. A rotatable sphere comprising:
- (i) one or more detectable features on the rotatable sphere,
 - (ii) one or more samples disposed on the rotatable sphere, wherein the latitude and longitude of each of the samples is known relative to the detectable feature(s).
- 15 44. A combination of a rotatable sphere, a support comprising one or more detectable features and a linker for linking the support and the rotatable sphere.
- 20 45. A combination of a rotatable sphere, a support comprising one or more detectable features and a linker for linking the support and the rotatable sphere and one or more samples on the rotatable sphere wherein the latitude and the altitude of the detectable feature are known and the latitude and longitude of each of the samples is known.
- 25 46. A combination of (a) a rotatable sphere comprising one or more positioners to position the sphere on a rotator at a predetermined position and (b) one or more rotors for coupling the one or more positioners and a rotator wherein: (i) at least one detectable feature(s) on at least one of the rotors; (ii) the rotatable sphere, the one or more rotors and the rotator are capable of being coupled together such
- 30 that the rotatable sphere is at a predetermined angular orientation relative to the rotator, and (iii) one or more samples disposed on the rotatable sphere, wherein the latitude and longitude of each of the samples is known relative to the detectable feature(s).

47. A rotatable sphere comprising:

- (i) one or more detectable features on the rotatable sphere,
- (ii) one or more samples, each sample being disposed in a matrix, and being positioned on the rotatable sphere, wherein the latitude and longitude of each of the samples is known relative to the detectable feature(s).

5

48. A rotatable sphere comprising:

- (i) one or more detectable features on the rotatable sphere,
- (ii) a sample disposed on the rotatable sphere at a known position relative to the one or more detectable features.

10

49. A rotatable sphere comprising:

- (i) one or more registration mark(s) on the rotatable sphere wherein the latitude and longitude of the registration mark(s) is known,
- (ii) one or more samples disposed on the rotatable sphere,

15

wherein the latitude and longitude of each of the samples is known.

50. A rotatable sphere comprising a rotor and a registration mark disposed on the rotor, said sphere comprising:

20

- (i) one or more positioners for positioning the rotatable sphere on a rotator at a predetermined angular orientation relative to the rotator about the axis of rotation of the sphere, and
- (ii) a sample disposed at known coordinates such as longitude and latitude on the rotatable sphere,

25

wherein the latitude of the samples is known relative to the equatorial latitude of the rotatable sphere and the longitude of the sample is known relative to the registration mark on the rotor.

30

51. The rotatable sphere of claim 50, wherein the rotatable sphere has one or more polygon-shaped cavities or apertures.

52. A rotatable object comprising one or more detectable features.

53. A rotatable object comprising:

- (i) one or more detectable features on the rotatable object,
- (ii) at least one sample disposed on the rotatable object at a known position relative to the one or more detectable features.

5

54. The rotatable object of claim 53, wherein there is provided a plurality of samples.

10

55. A combination of a rotatable object, a support comprising one or more detectable features and a linker for linking the support and the rotatable object.

15

56. A combination of a rotatable object, a support comprising one or more detectable features and a linker for linking the support and the rotatable object and one or more samples disposed on the rotatable object wherein the position of each of the samples is known relative to the position and altitude of the detectable feature.

20

57. A combination of (a) a rotatable object comprising one or more positioners to position the object on a rotator at a predetermined position and (b) one or more rotors for coupling the one or more positioners and a rotator wherein:

25

- (i) at least one detectable feature(s) is disposed on at least one of the rotors;
- (ii) the rotatable object, the one or more rotors and the rotator are capable of being coupled together such that the rotatable object is at a predetermined angular orientation relative to the rotator, and
- (iii) one or more samples disposed on the rotatable object

30

wherein the position of each of the samples is known relative to the position and altitude of the detectable feature.

58. A rotatable object comprising:

- (i) one or more detectable features on the rotatable object,

- (ii) one or more samples, each sample being disposed in a matrix, disposed on the rotatable object wherein the position of each of the samples is known relative to the position and altitude of the detectable feature.

5 59. The rotatable object of claim 58, wherein the rotatable object further comprises a means for positioning the object on a rotatating member at a predetermined position.

10 60. The rotatable object of claim 59, wherein the means for positioning the object is one or more spindles protruding from the rotatable object.

61. A method for determining the position of at least one sample on a rotatable object, and subsequently sampling the sample, said rotatable object comprising a detectable feature and wherein said at least one sample is located at a known position on said object relative to said feature, said method comprising:

- 15 (i) rotating the rotatable object at a constant frequency optionally about the central longitudinal axis of the object,
- (ii) detecting the detectable feature,
- (iii) determining an arrival time of the sample at a sampling location after
20 the detecting,
- (iv) sampling at least a portion of the sample at the arrival time.

62. The method of claim 61, further comprising repeating steps (i) to (iv).

25 63. The method of claim 61 or 62, further comprising enabling a sampler to enable sampling at the sampling location.

64. A method for determining the position of at least one sample on a rotatable object, and subsequently releasing the sample from the object, said rotatable object having a registration mark and said at least one sample being located at a known position on said object relative to said feature, said method comprising:

- 30 (i) storing the known locations of the samples,
- (ii) rotating the rotatable object at a known rotational velocity optionally about the central longitudinal axis of the object,

- (iii) detecting the registration mark,
 - (iv) determining the time at which the sample will arrive at a sampling location,
 - (v) directing a sampler to desorb or ablate at least a portion of the sample one more times per revolution of the rotatable object,
 - (vi) analysing the desorbed sample.
65. The method of claim 64, further comprising repeating steps (i) through (vi).
66. The method of claim 64 or 65, further comprising enabling a sampler to enable sampling of the sample at the sampling location.
67. A system for determining the position of at least one sample disposed on a rotatable object comprising one or more detectable features disposed on the object, and sampling at least a portion of the sample from the object, said at least one sample being located at a known position on said object relative to said one or more detectable features, said system comprising:
- (i) a rotator for rotating the rotatable object;
 - (ii) a detector for detecting the detectable feature on the rotatable object;
 - (iii) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting of the detectable feature, said processor being coupled to the detector; and
 - (iv) a sampler for sampling at least a portion of the sample at the arrival time said sampler being coupled to said processor.
68. The system of claim 67, further comprising an enabler for enabling the sampler to sample a sample at the sampling location.
69. A system for determining the position of at least one sample disposed on a rotatable object comprising one or more detectable features disposed on the object, sampling at least a portion of the sample from the object, and analysing said portion, said at least one sample being located at a known position on said object relative to said feature, said system comprising:
- (i) a rotator for rotating the rotatable object at a known rotational velocity,

- (ii) a positioner for positioning the rotatable object on a rotator at a predetermined position on the rotator,
- (iii) a detector detecting the detectable feature on the rotatable object,
- (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled to said detector, and
- (v) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

70. The system of claim 69, wherein the sampler is capable of desorbing or ablating at least a portion of the sample at the arrival time one or more times per revolution of the rotatable object.

71. A system for determining the position of at least one sample disposed on a rotatable object comprising one or more detectable features disposed on the object, sampling at least a portion of the sample from the object, and analysing said portion, said at least one sample being located at a known position on said object relative to said feature, said system comprising:

- (i) a rotator for rotating the rotatable object at a known rotational velocity,
- (ii) a positioner for positioning the rotatable object on a rotator at a predetermined position on the rotator,
- (iii) a detector detecting the detectable feature on the rotatable object,
- (iv) a processor for determining an arrival time when the sample will arrive at a sampling location after the detecting said processor being coupled to said detector, and
- (vi) a sampler for desorbing or ablating at least a portion of the sample at the arrival time said sampler being coupled to said processor.

72. The system of claim 71, wherein the system further comprises an analyser for analysing the desorbed or ablated sample.

73. A Matrix Assisted Laser Desorption Ionisation Time-Of-Flight (MALDI) comprising a system for determining the position of at least one sample disposed on a rotatable object as claimed in claim 52 or 53.

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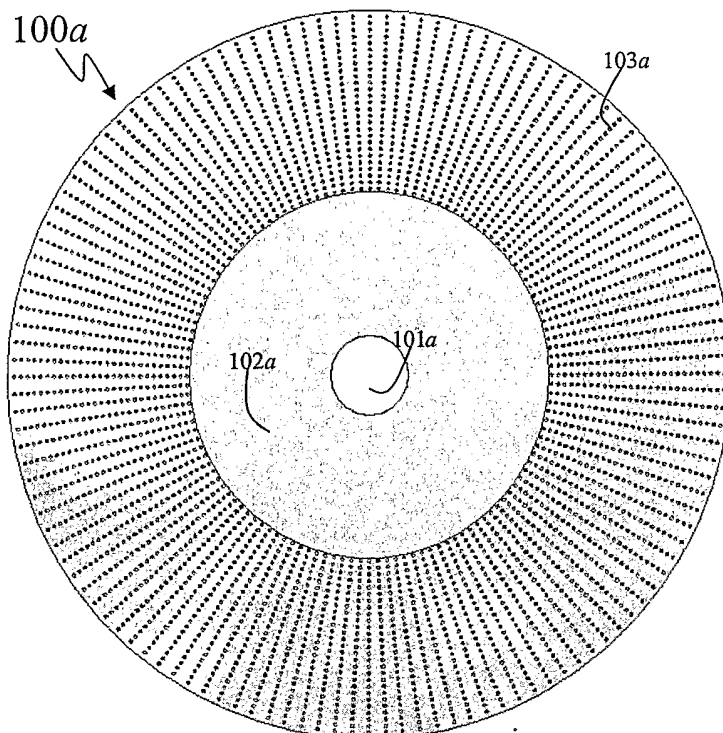


Fig. 1a

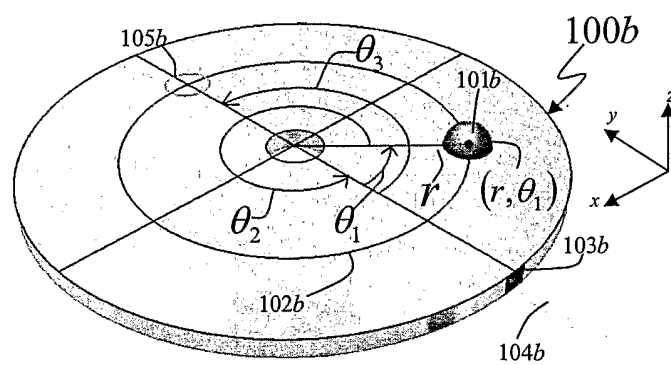


Fig. 1b

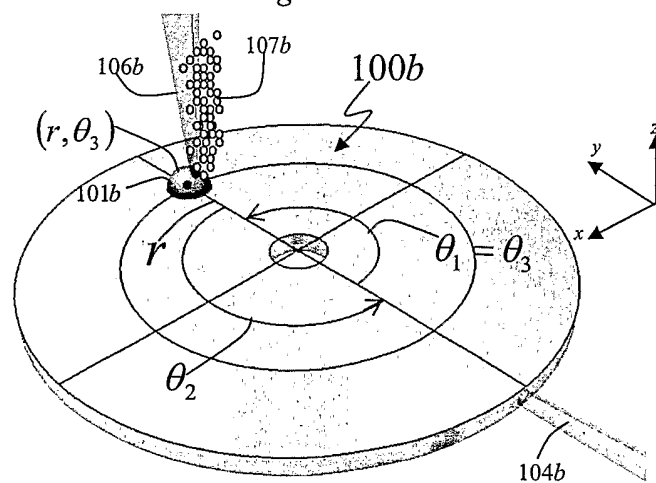


Fig. 1c

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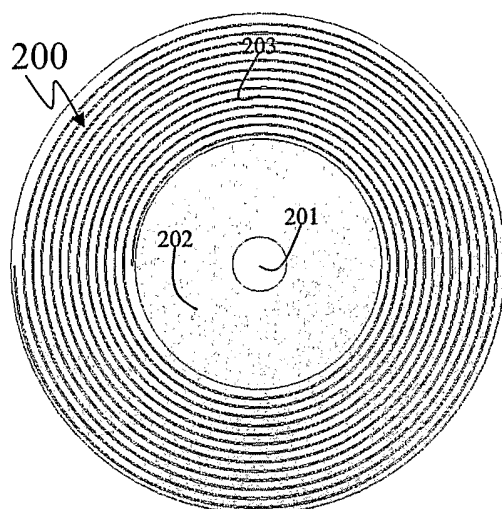


Fig. 2

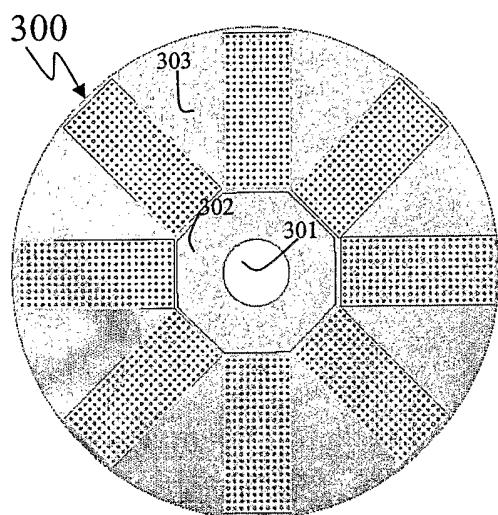


Fig. 3

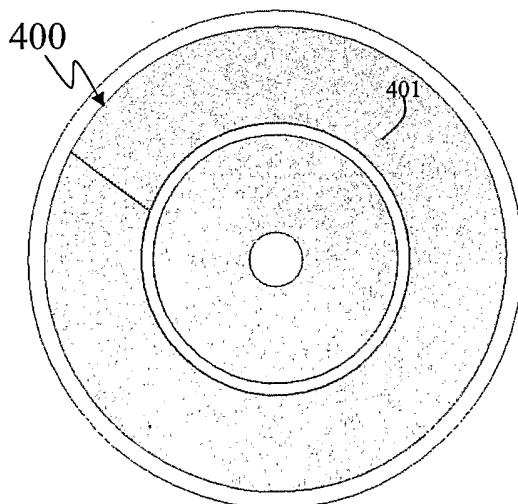


Fig. 4

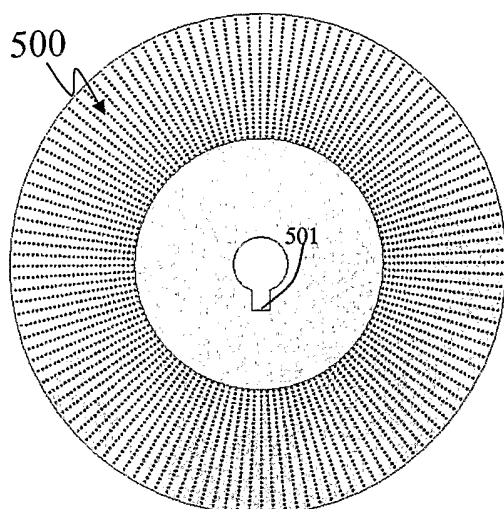


Fig. 5

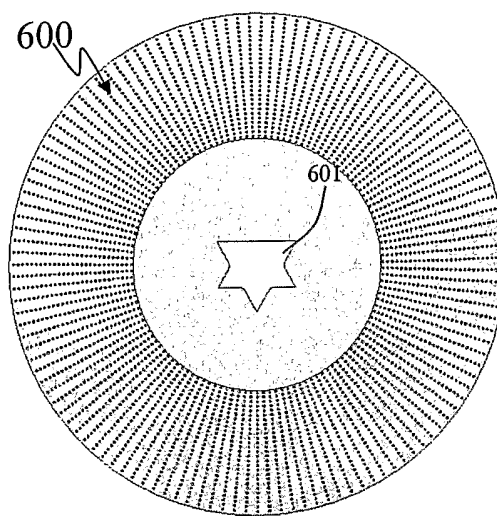


Fig. 6

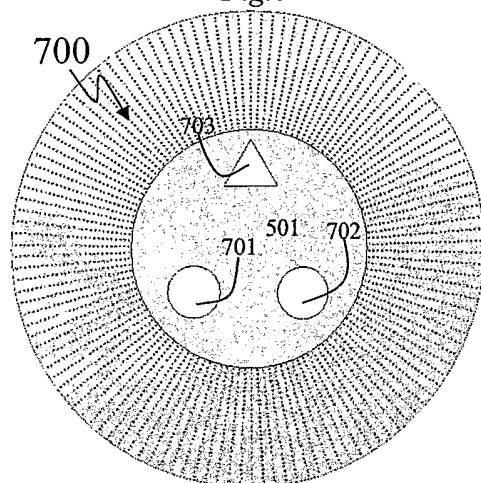


Fig. 7

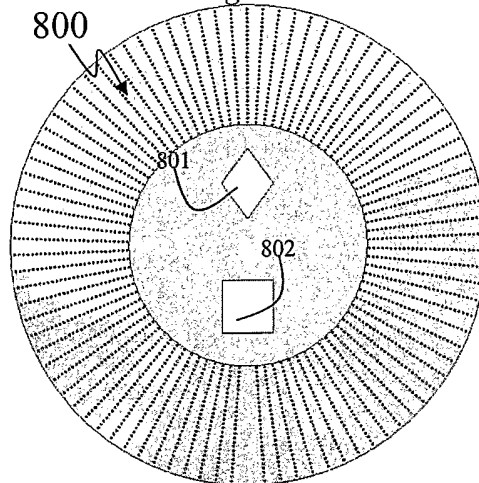


Fig. 8

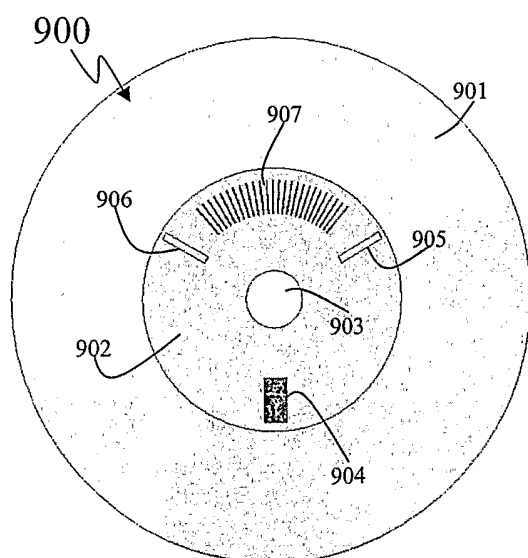


Fig. 9

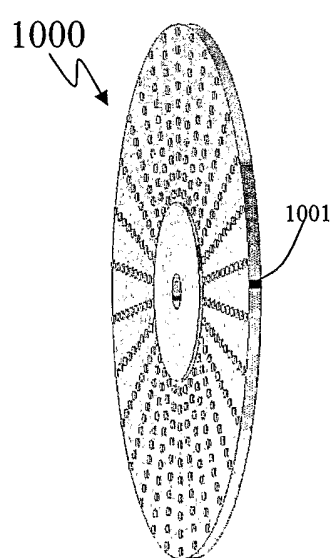


Fig. 10

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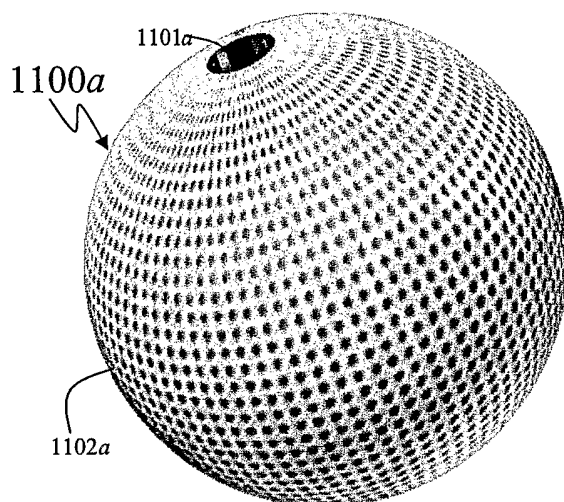


Fig. 11a

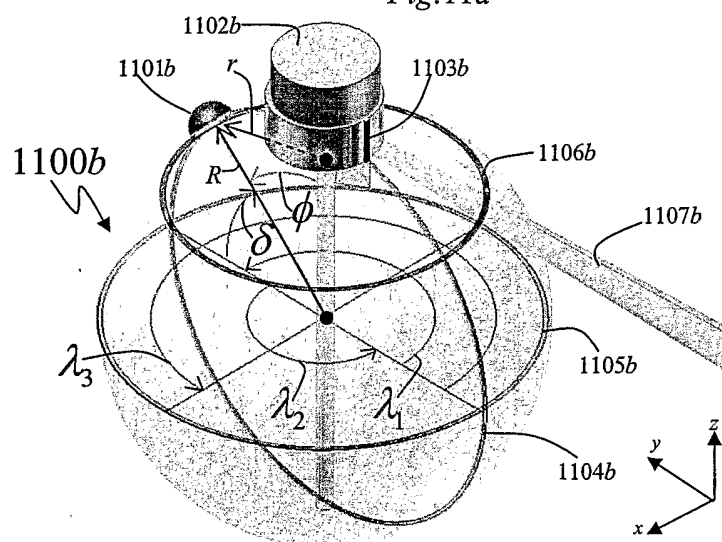


Fig. 11b

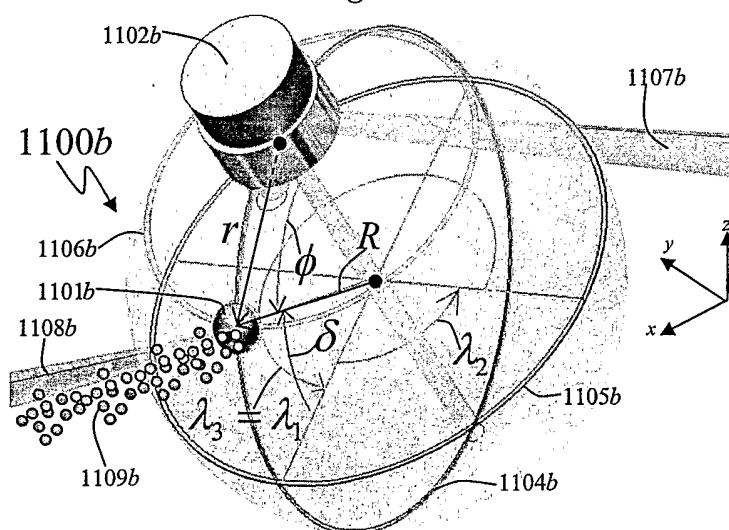


Fig. 11c

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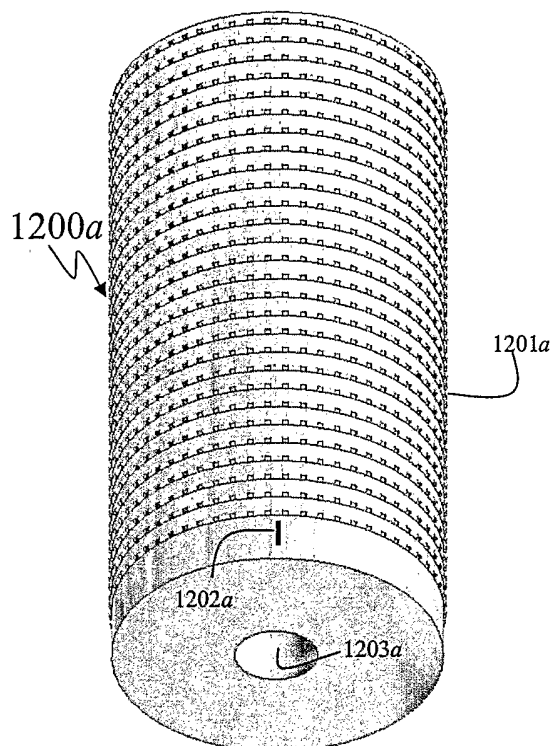


Fig. 12a

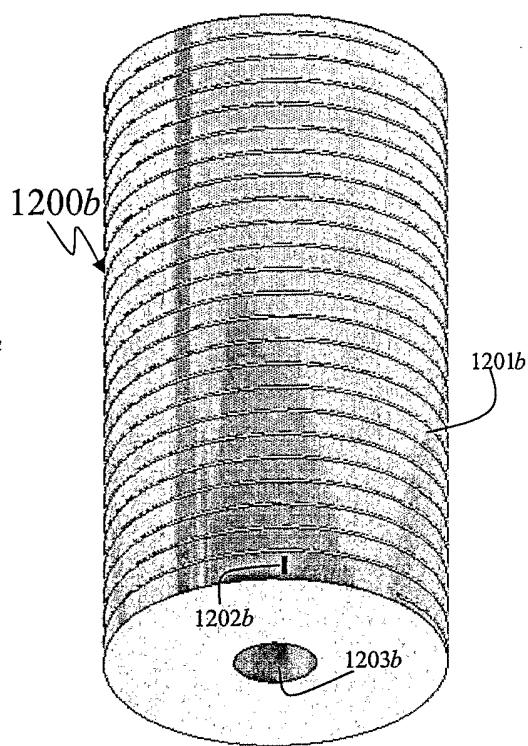


Fig. 12b

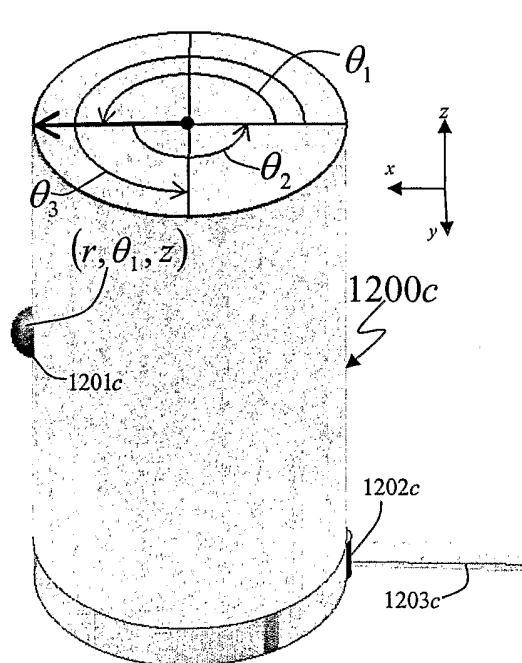


Fig. 12c

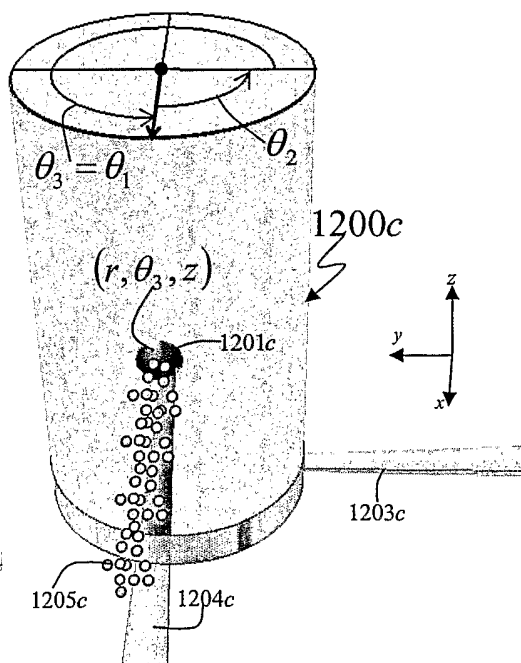


Fig. 12d

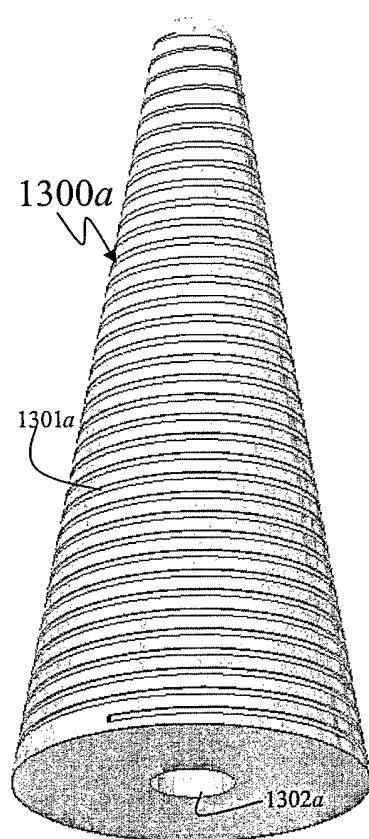


Fig.13a

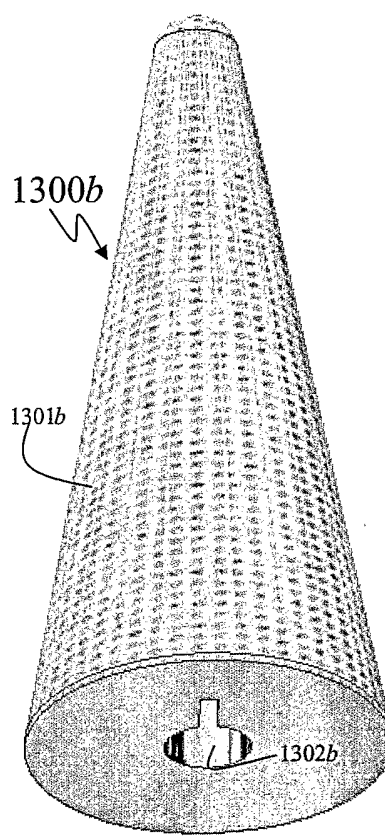


Fig.13b

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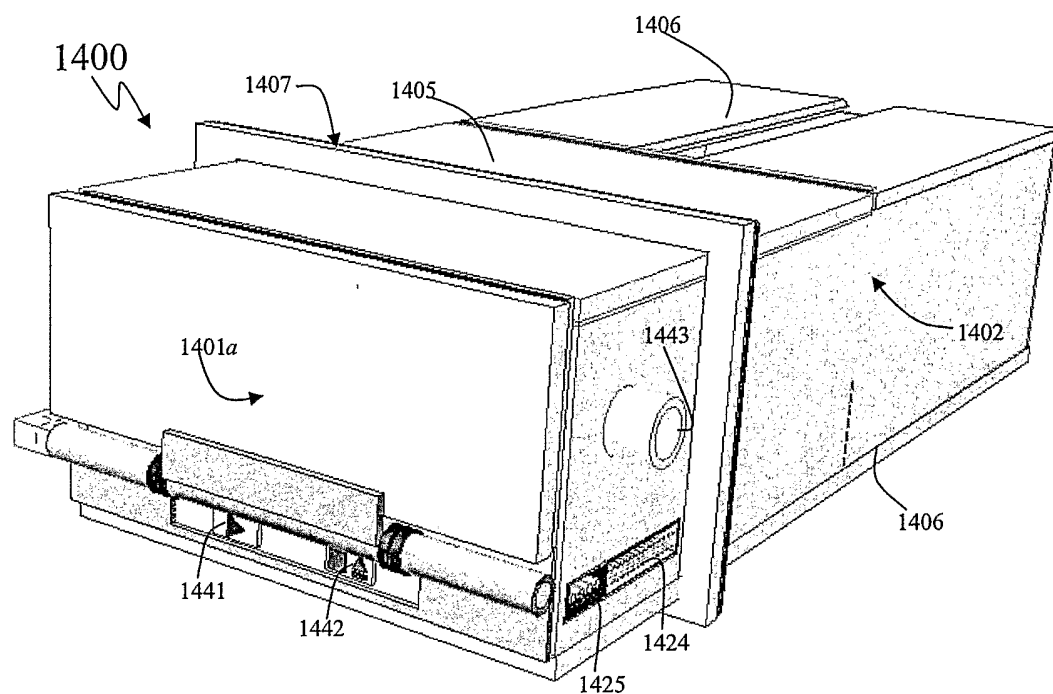


Fig.14a

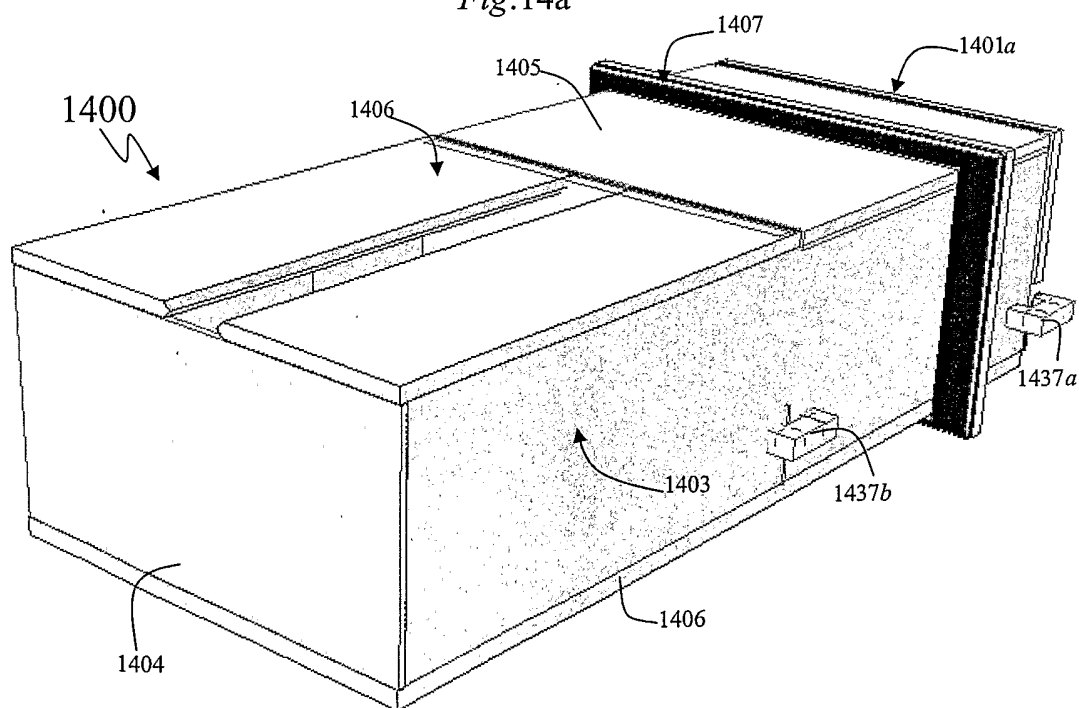


Fig.14b

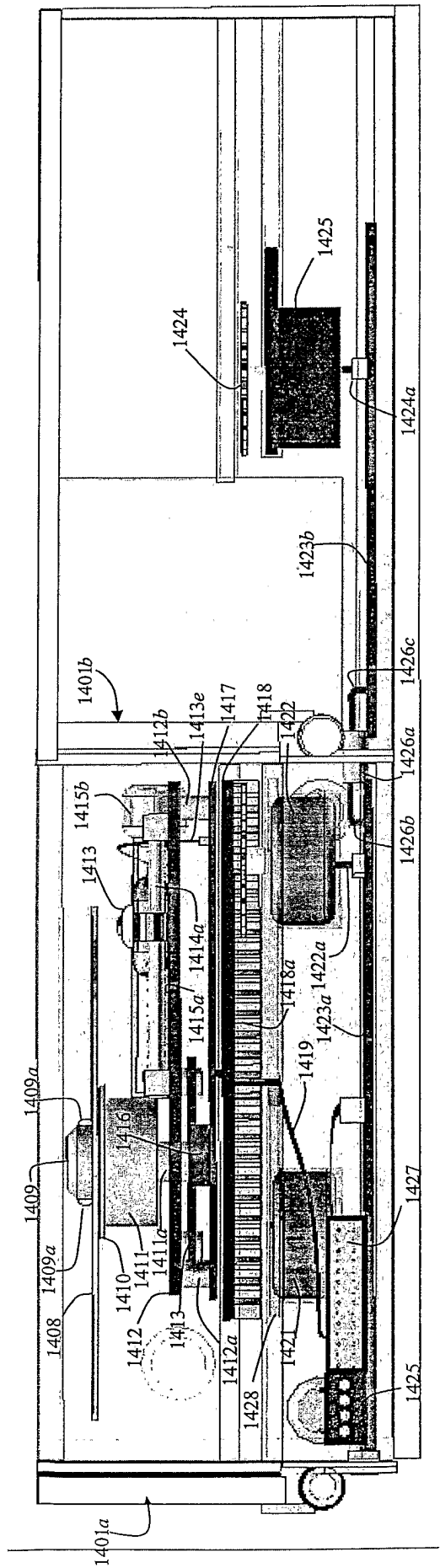


Fig. 14c

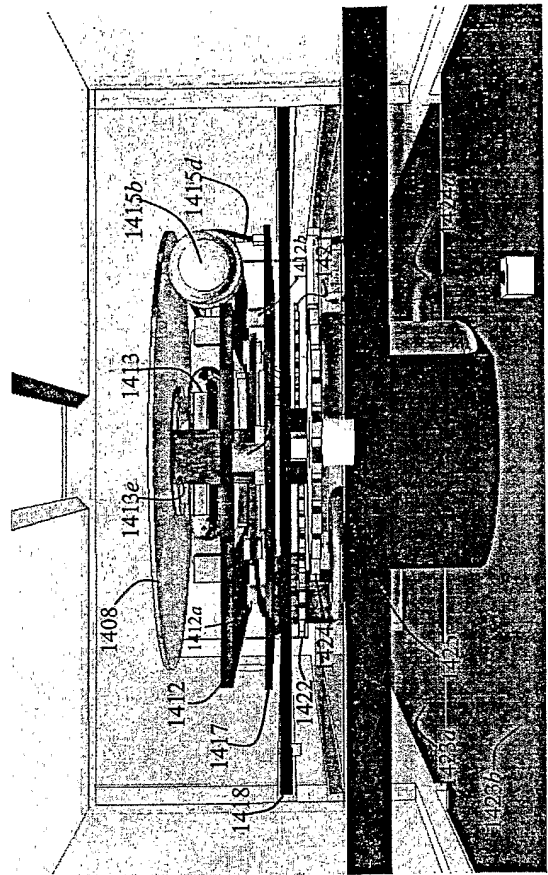


Fig. 14e

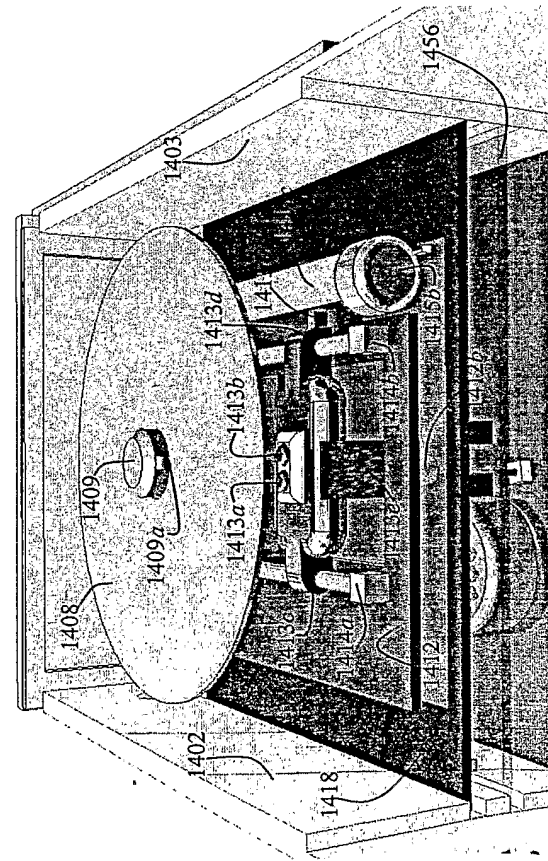


Fig. 14d

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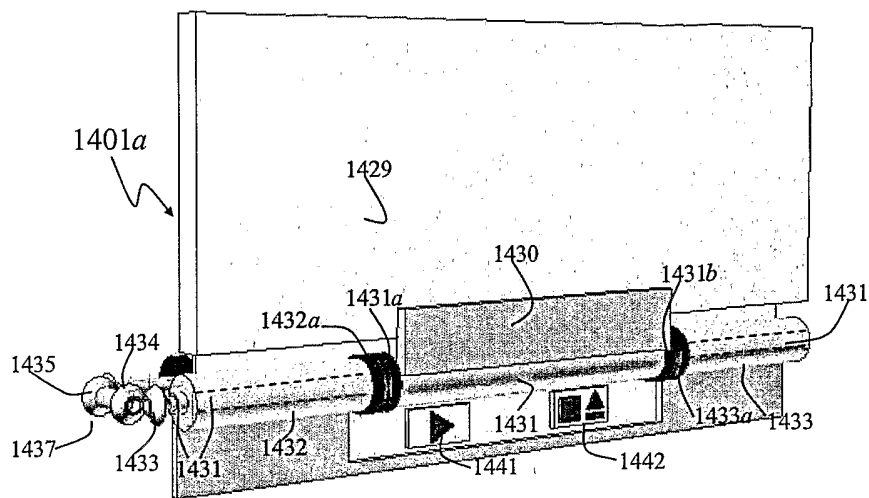


Fig. 14f

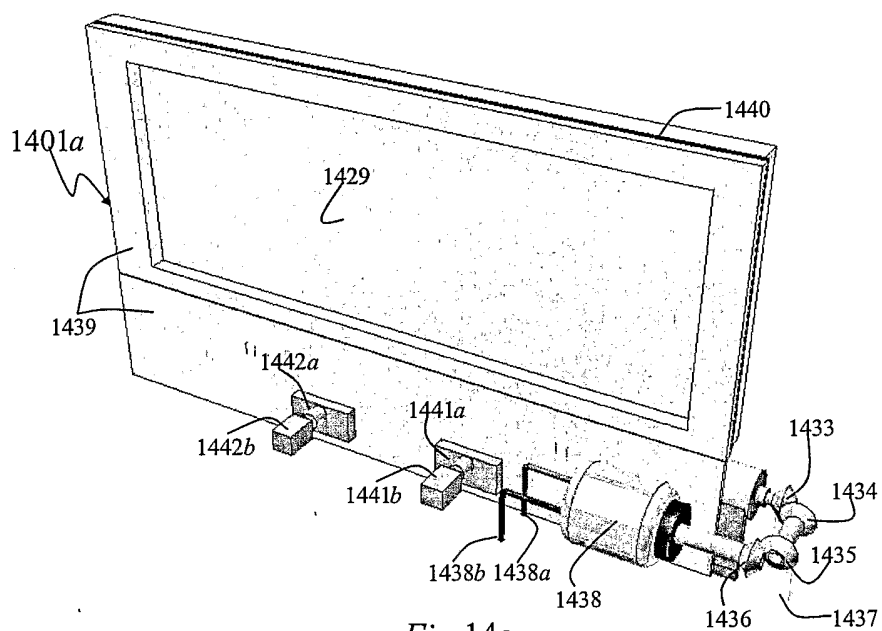


Fig. 14g

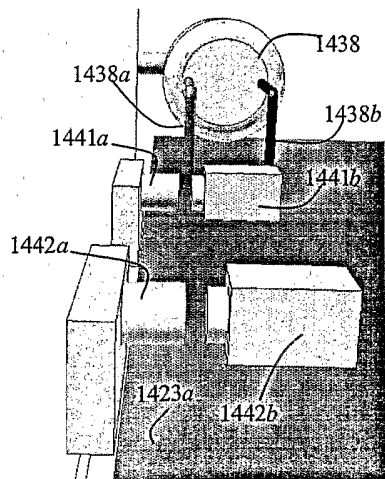


Fig. 14h

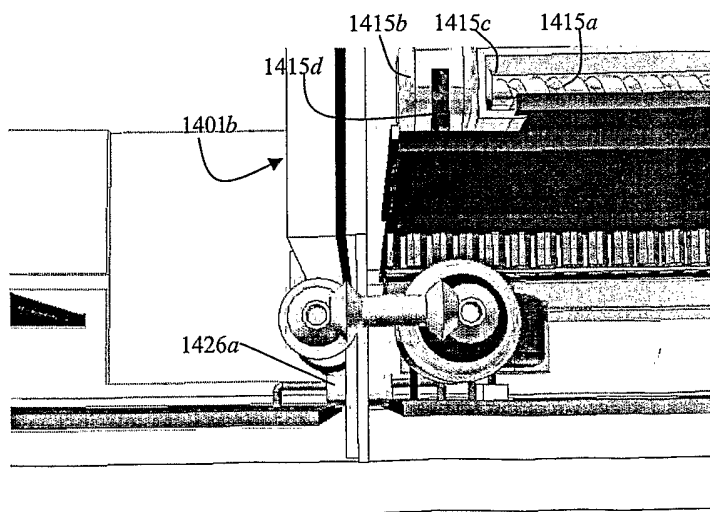


Fig. 14i

10/24

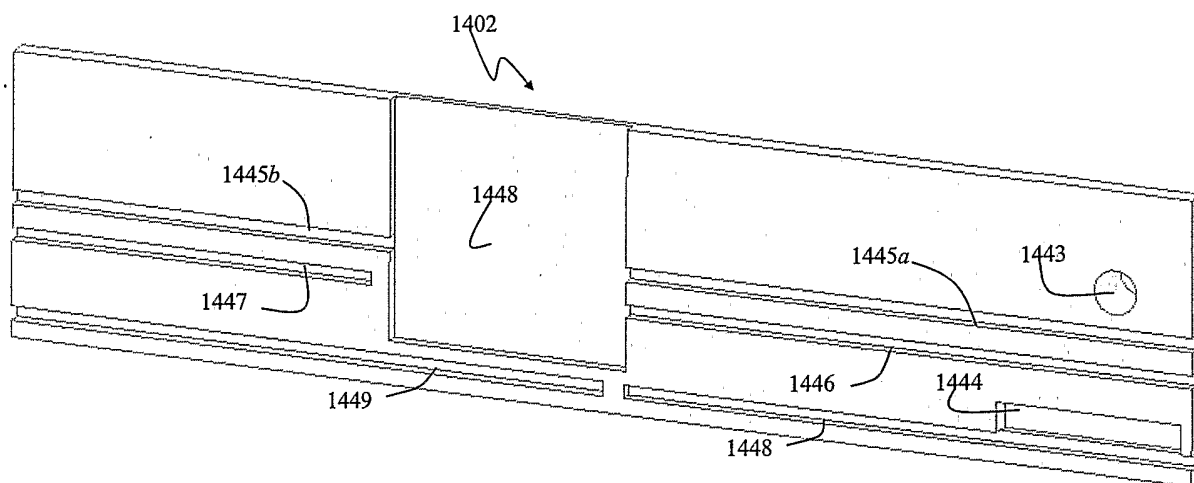


Fig.14j

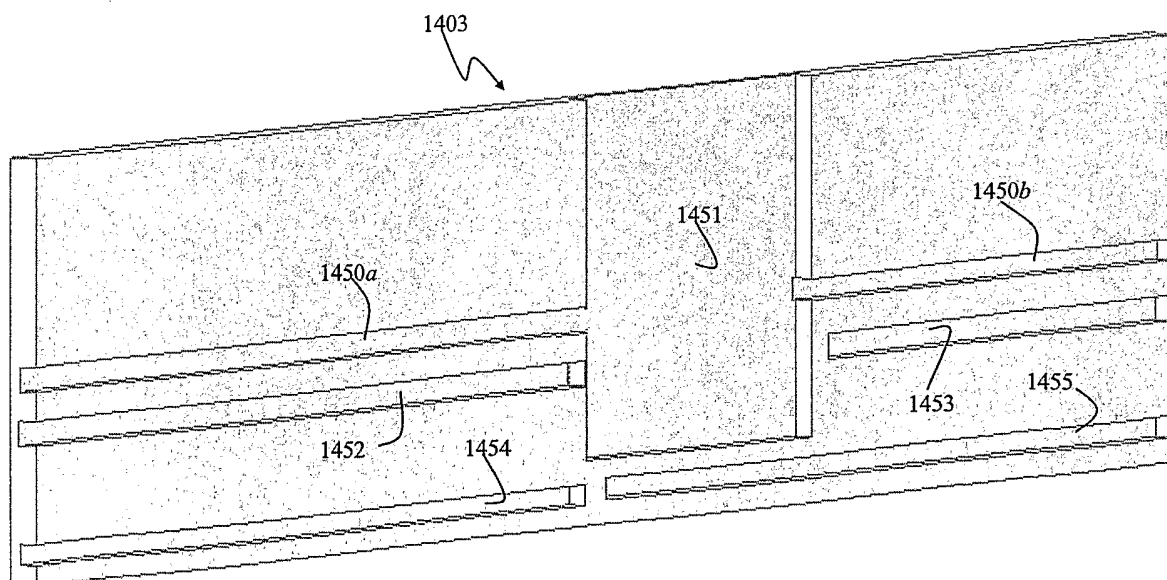


Fig.14k

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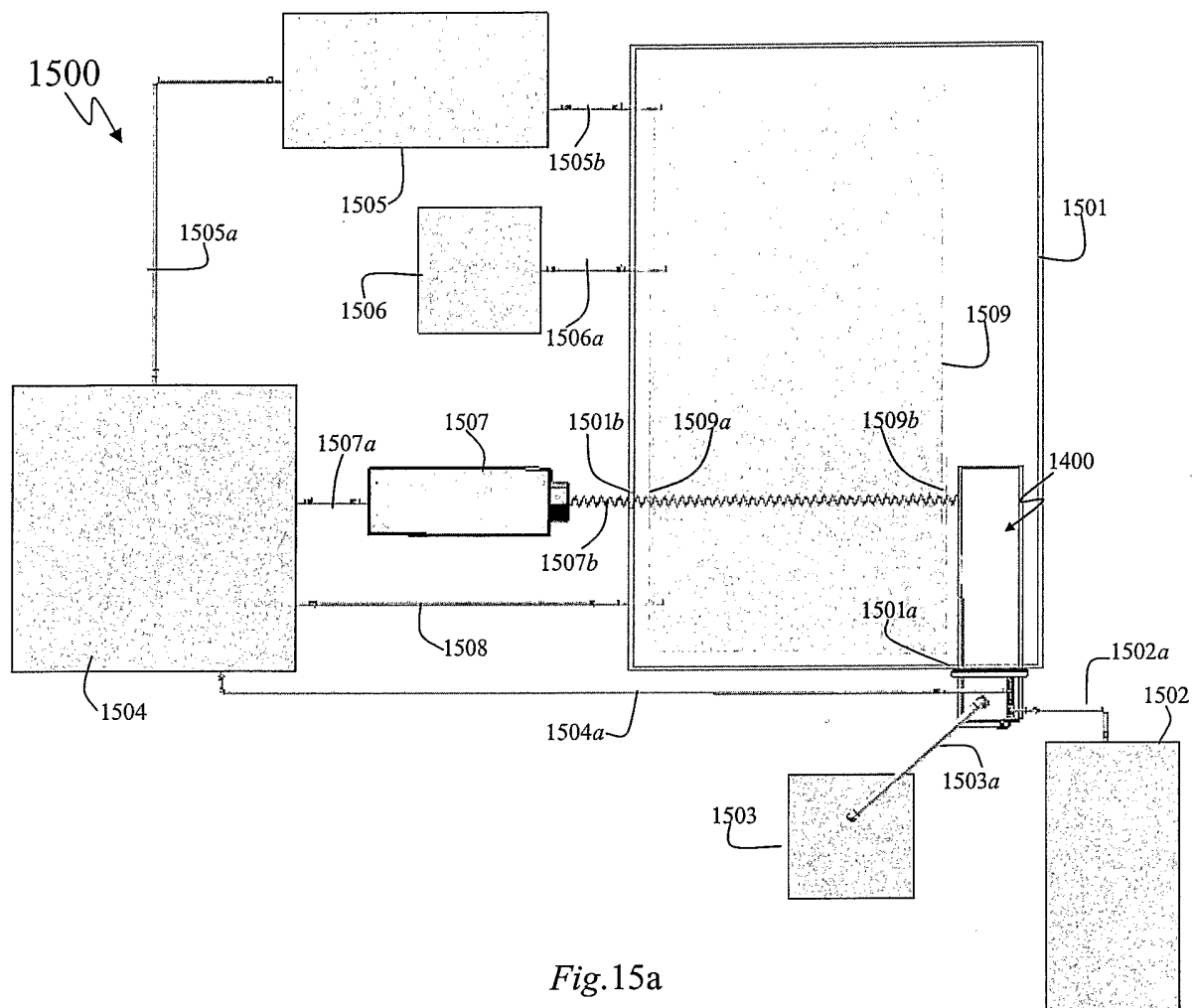


Fig.15a

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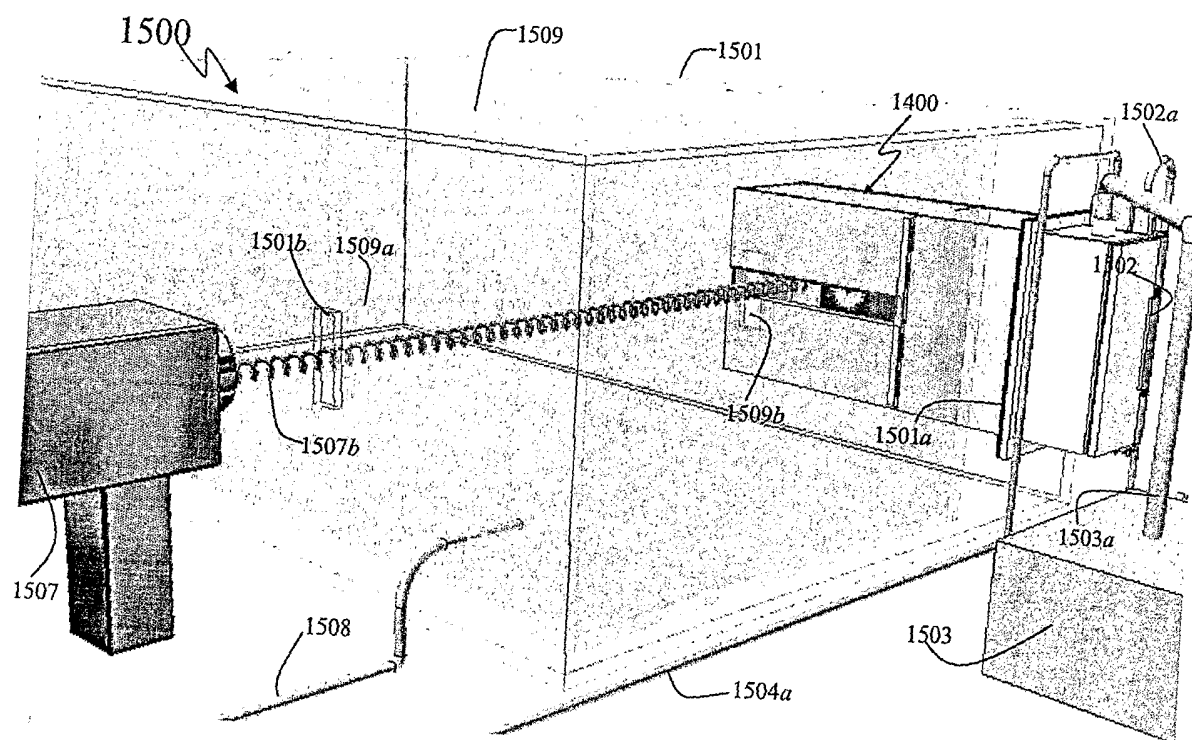


Fig. 15b

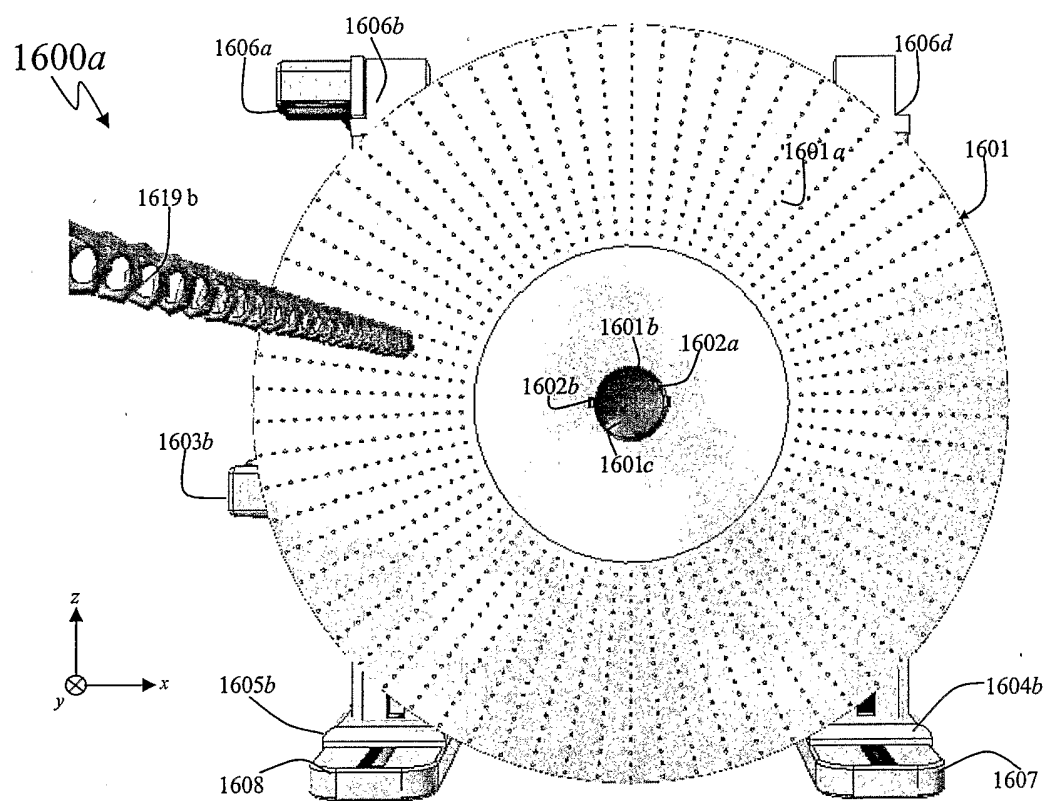


Fig. 16a

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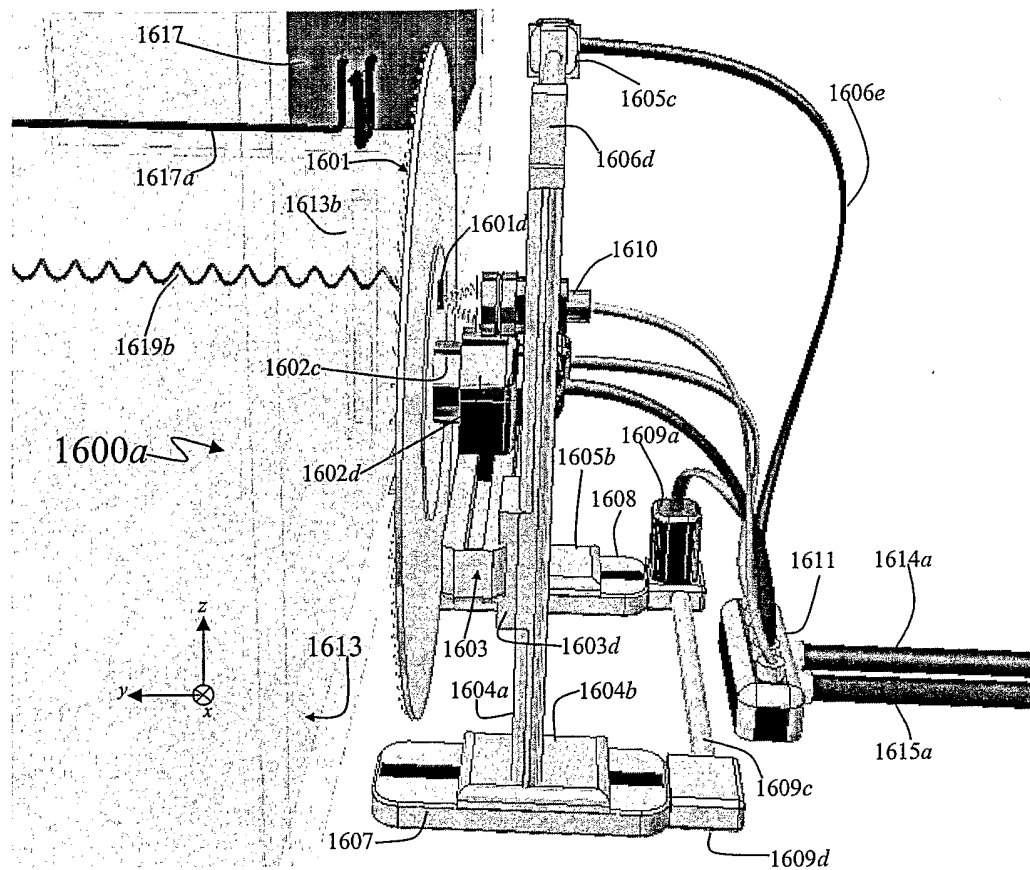


Fig. 16b

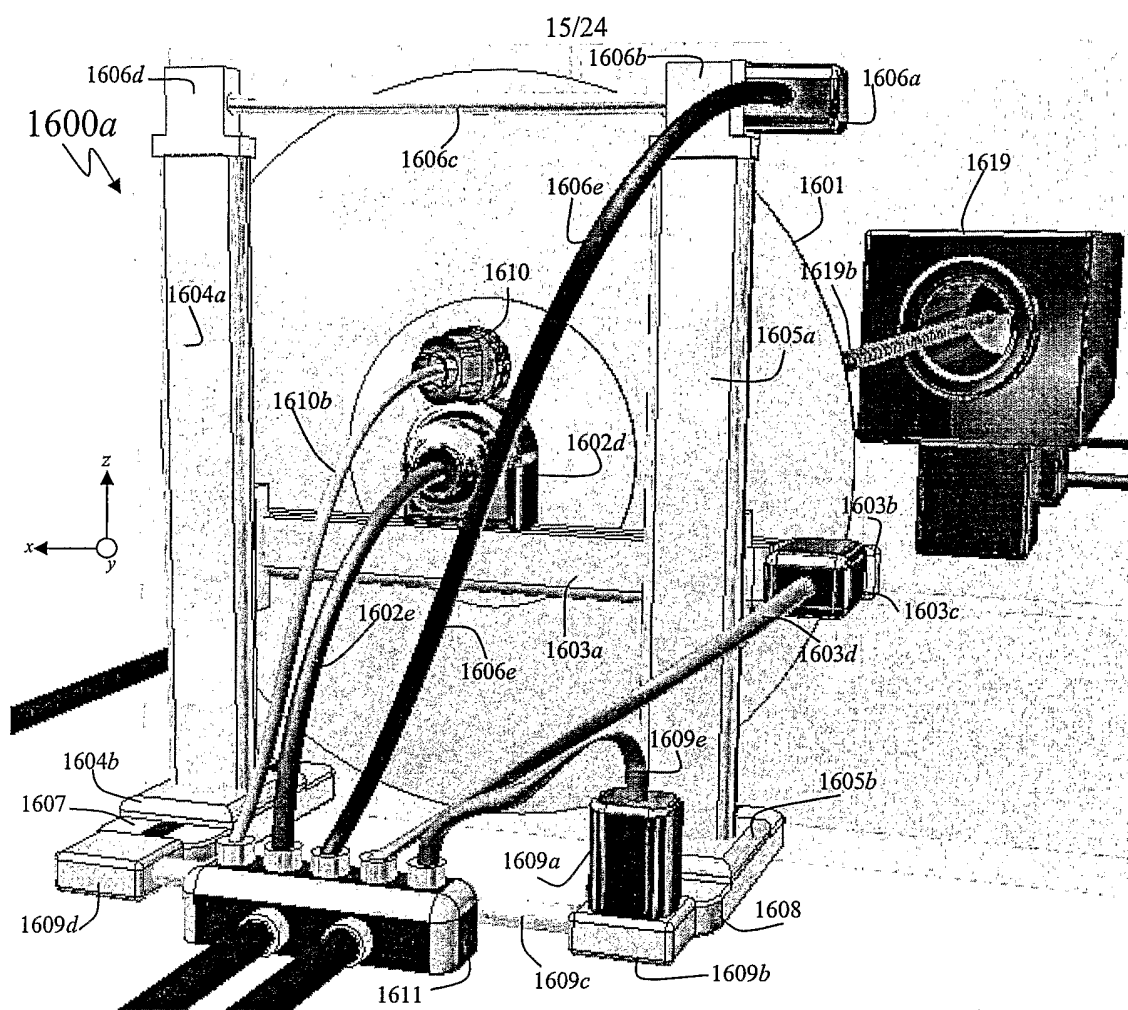


Fig.16c

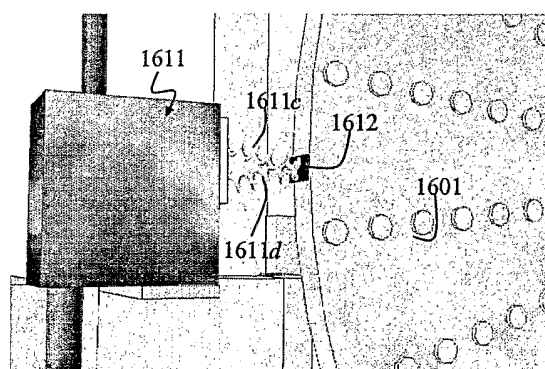


Fig.16d

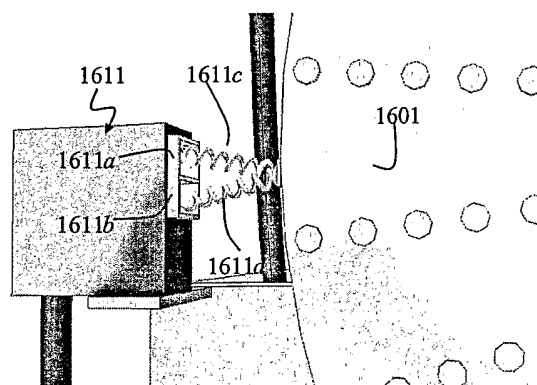
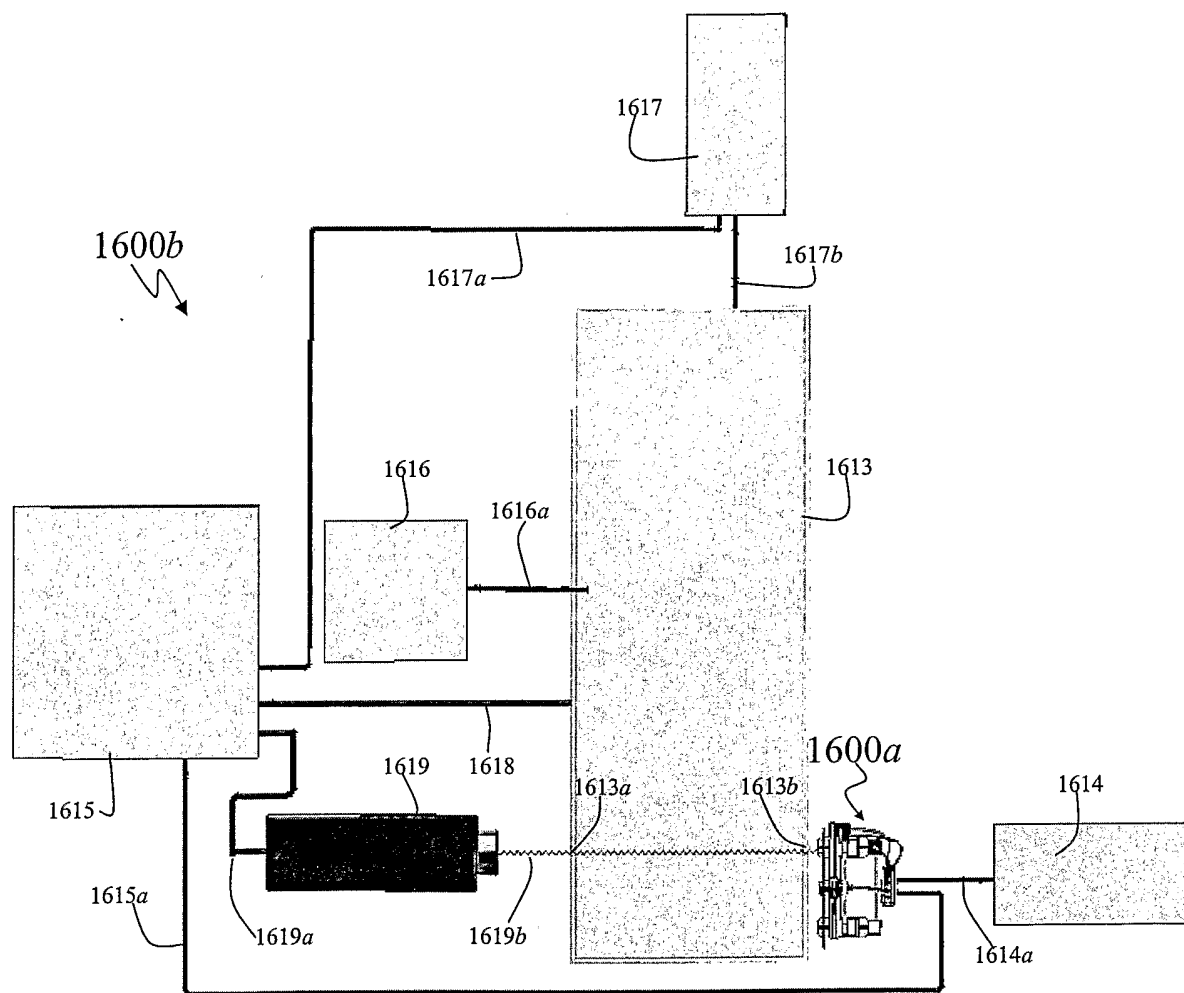


Fig.16e



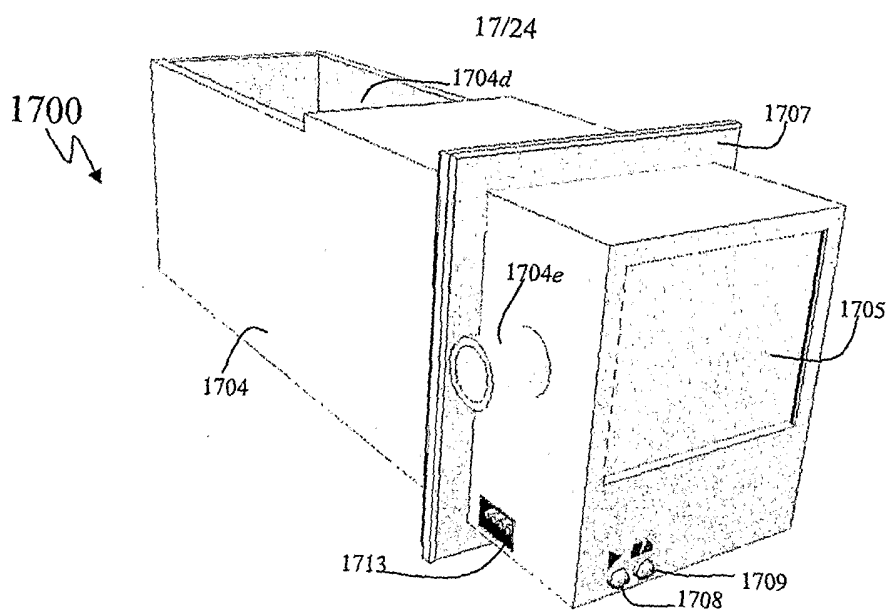


Fig. 17a

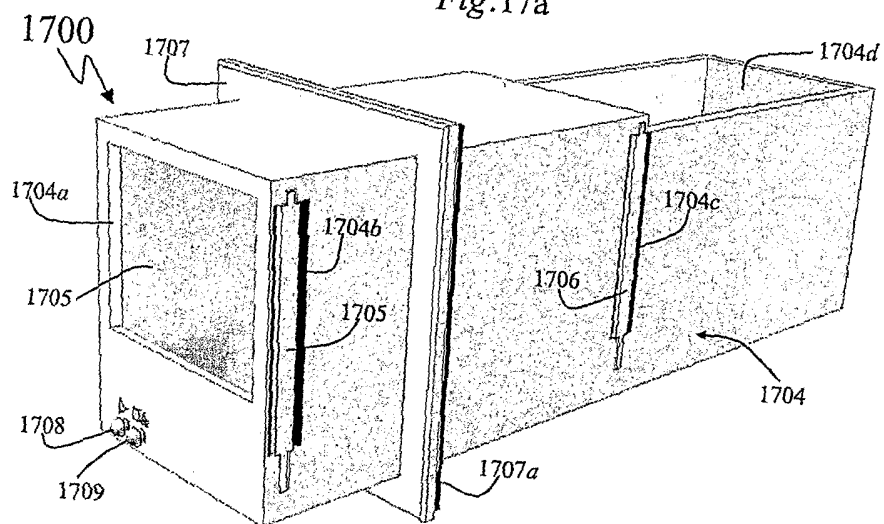


Fig. 17b

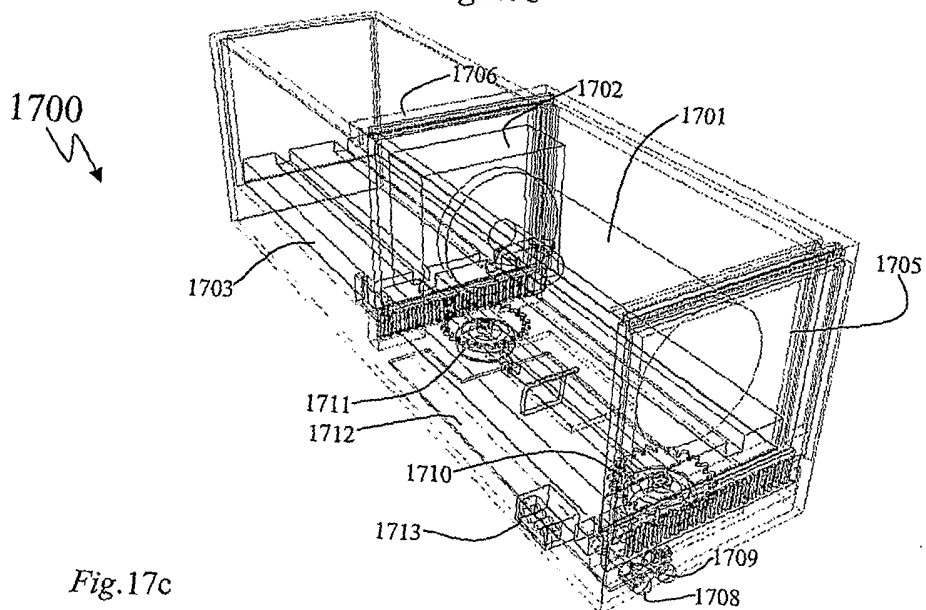


Fig. 17c

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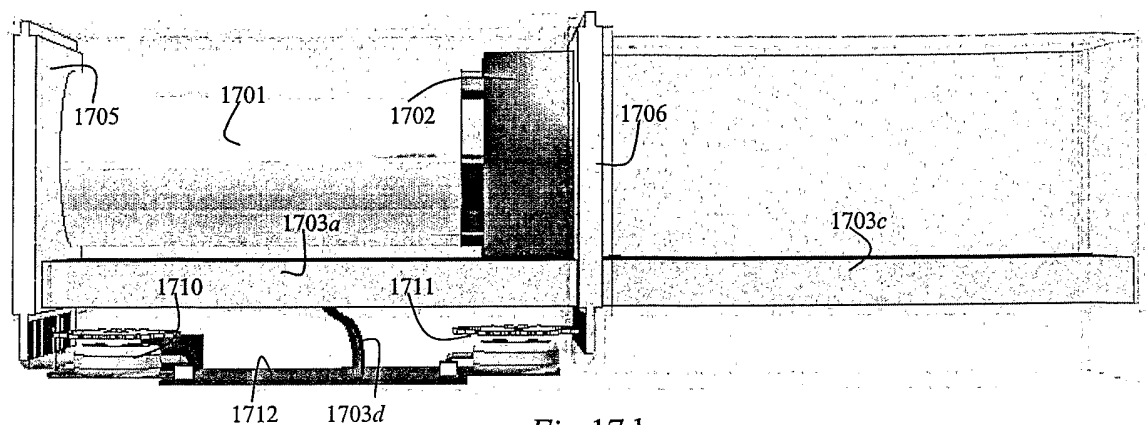


Fig. 17d

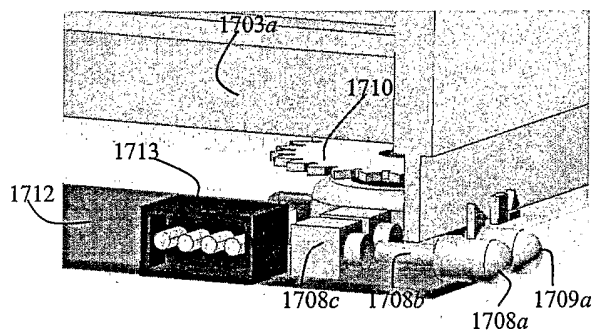


Fig. 17e

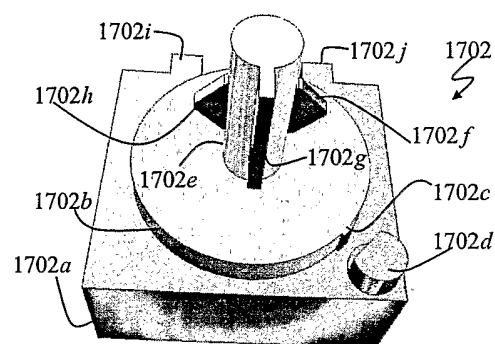


Fig. 17f

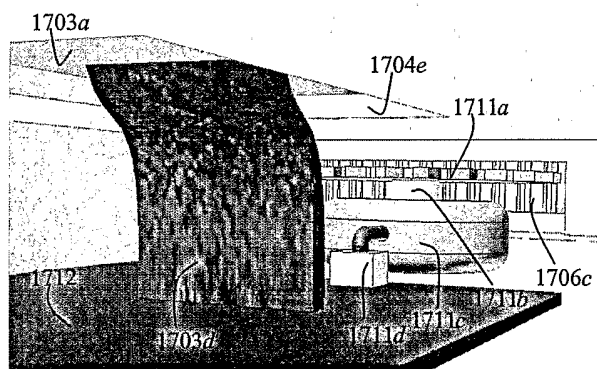


Fig. 17g

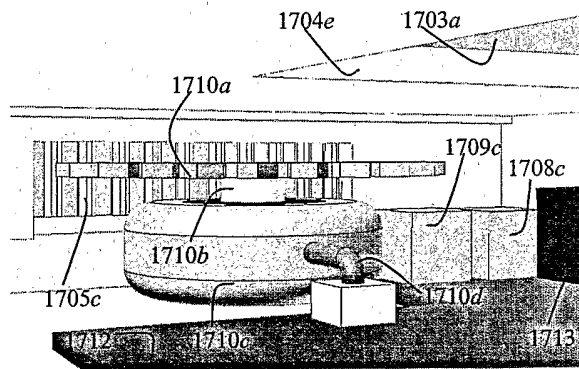
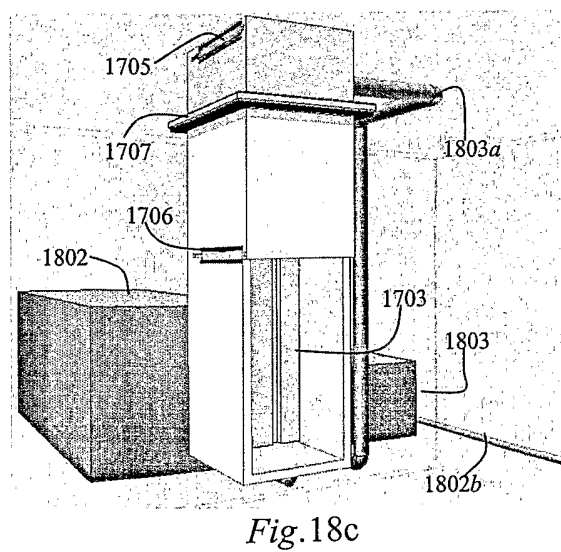
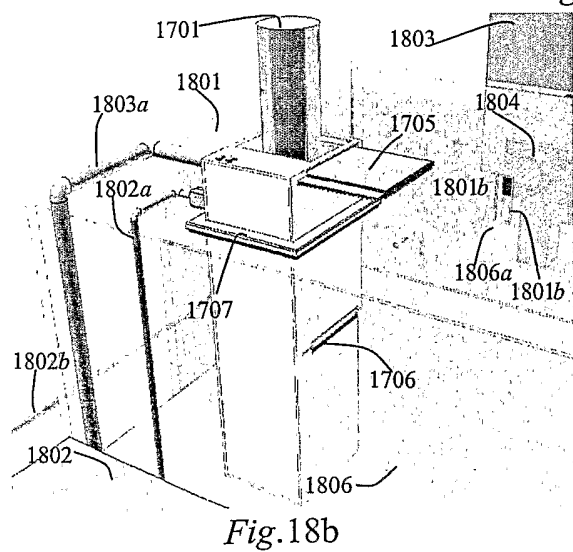
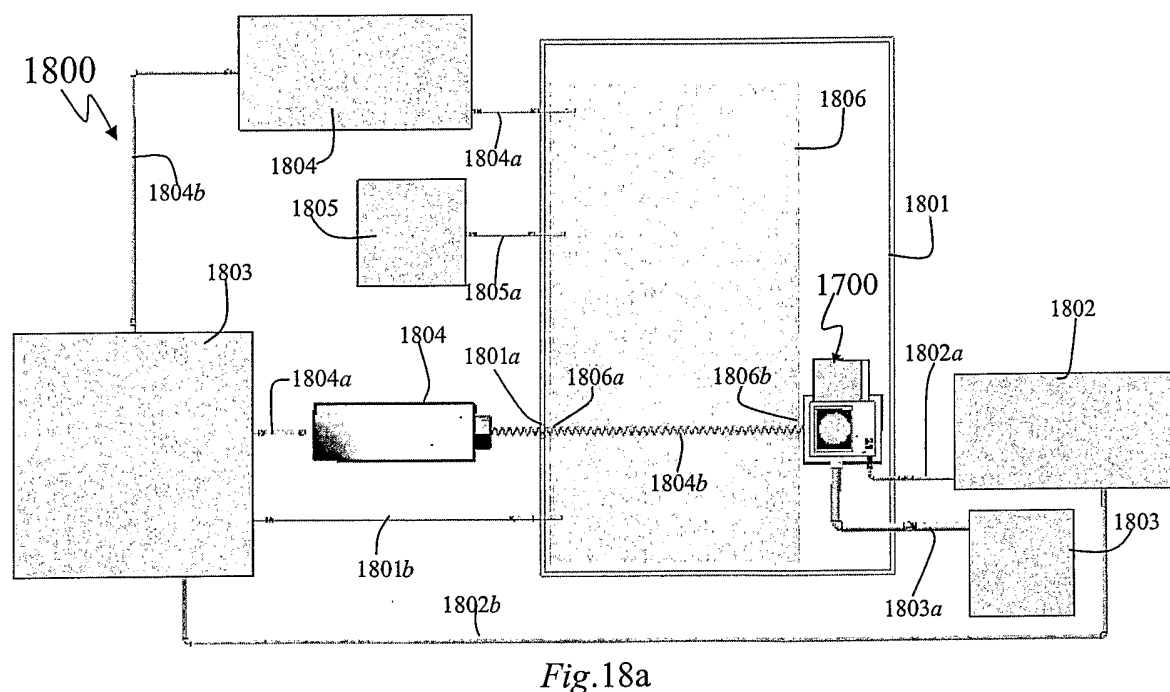
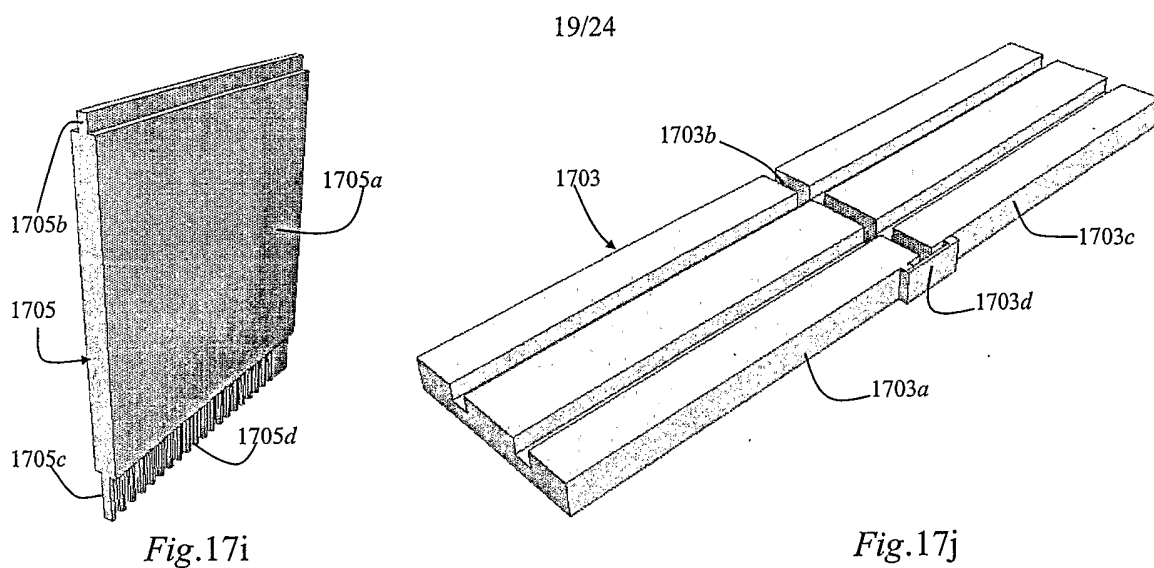


Fig. 17h



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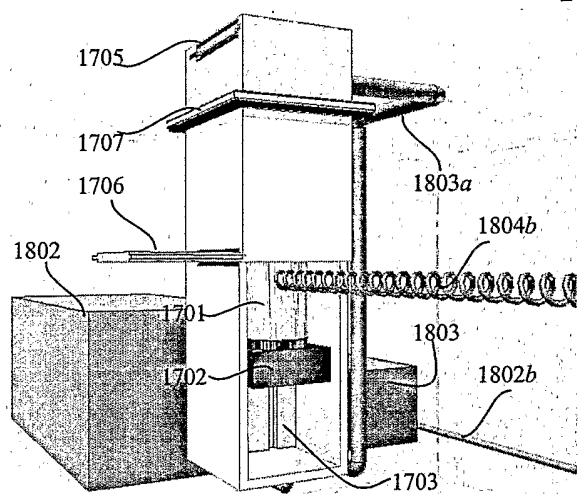


Fig.18d

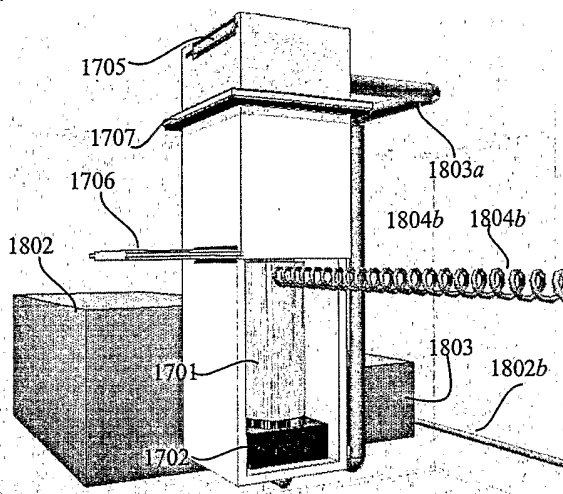


Fig.18e

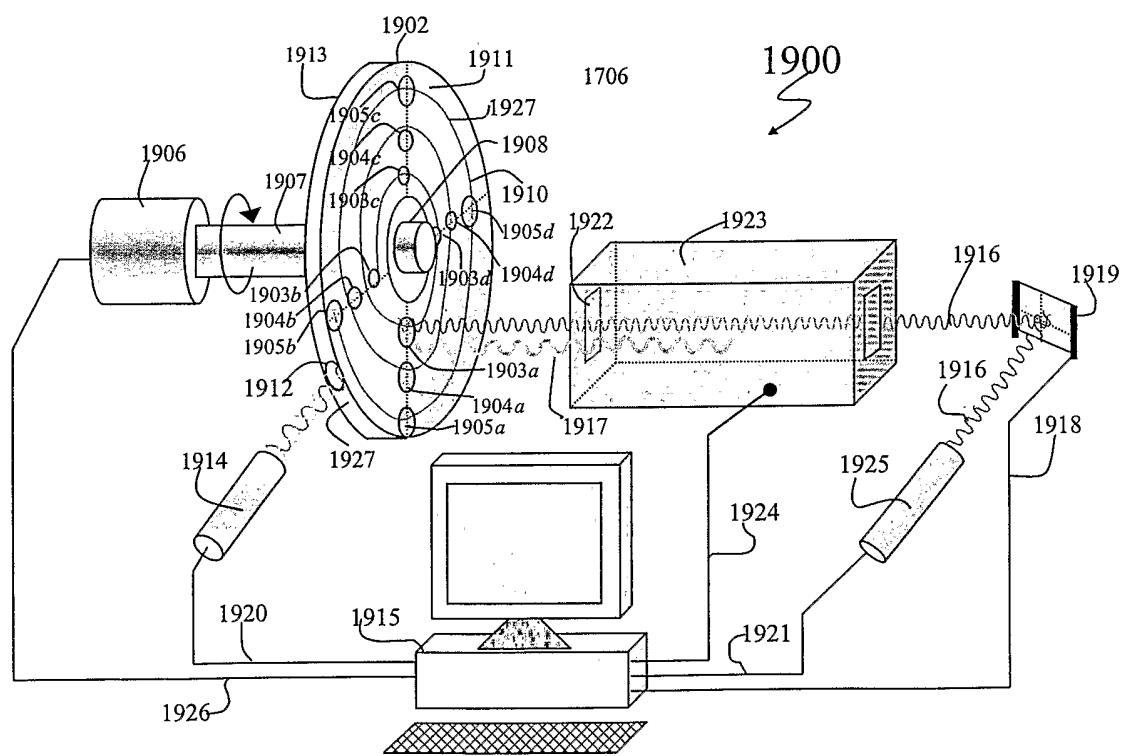


Fig.19

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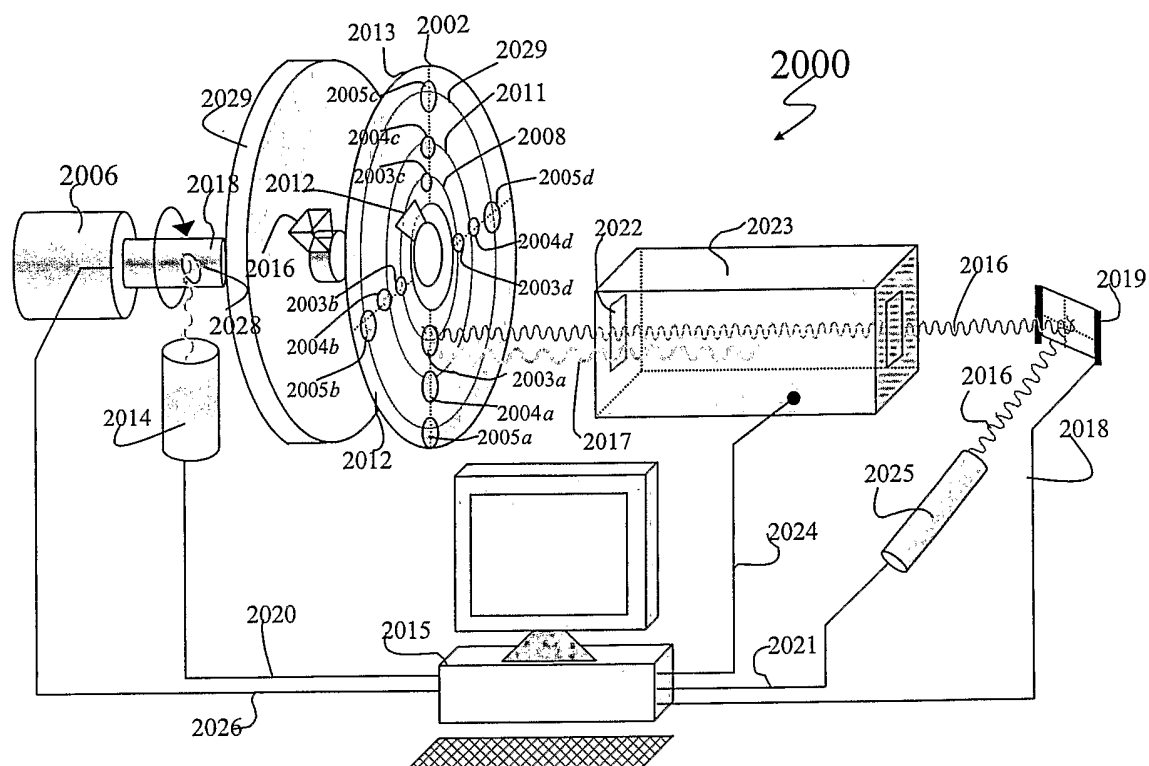


Fig. 20

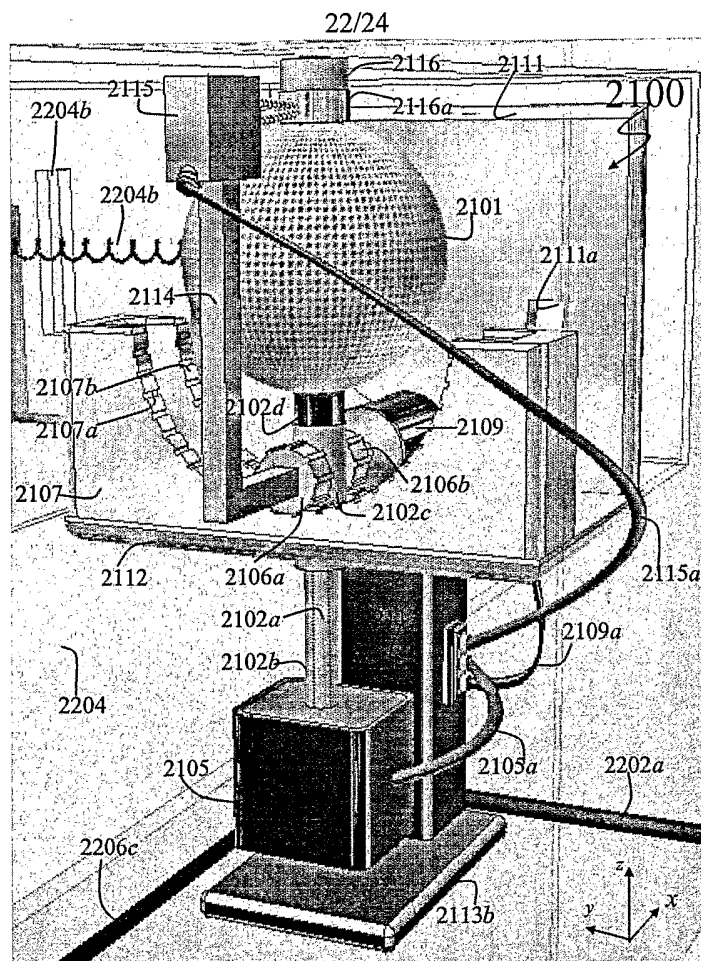


Fig. 21a

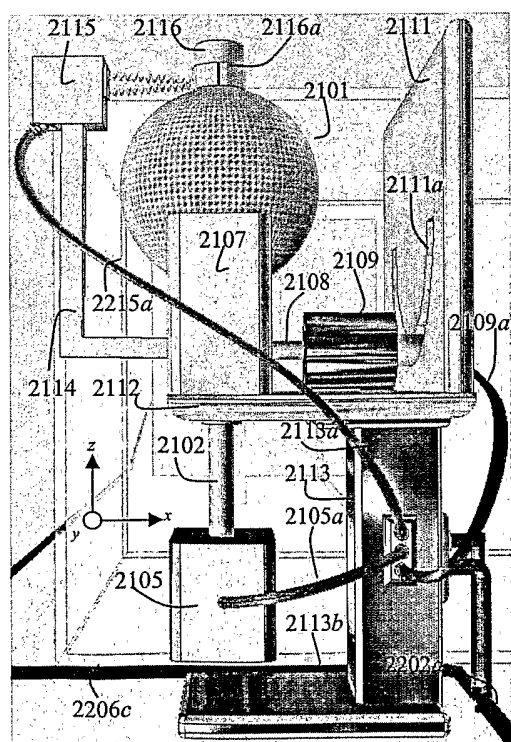


Fig. 21b

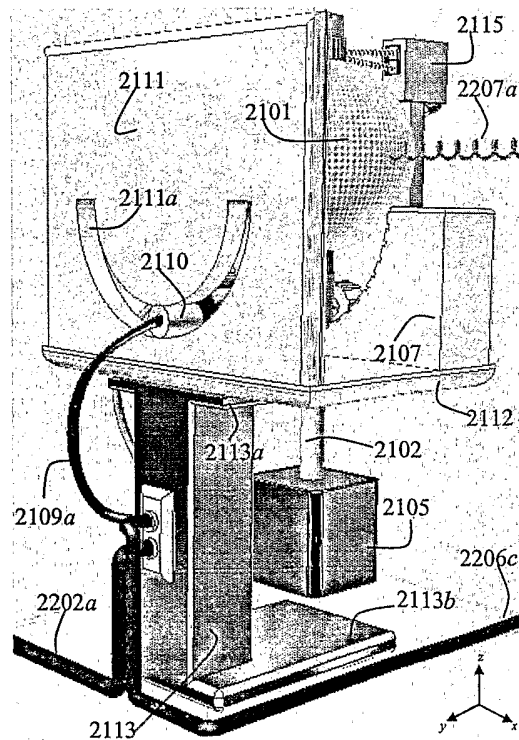


Fig. 21c

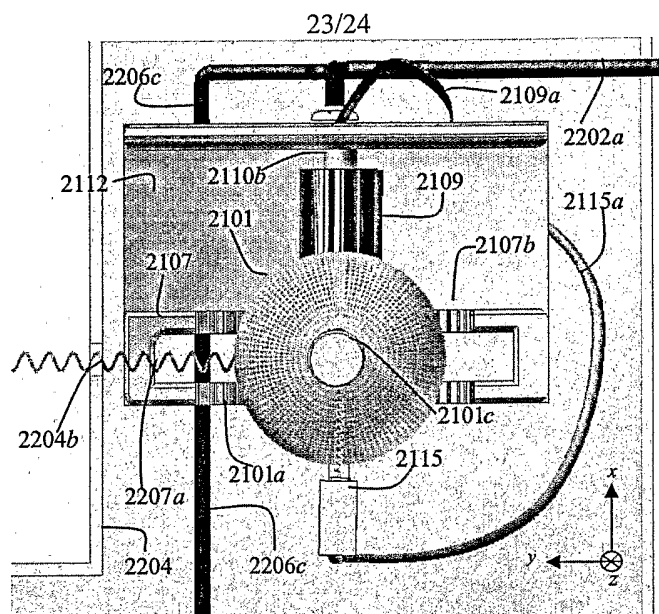


Fig. 21d

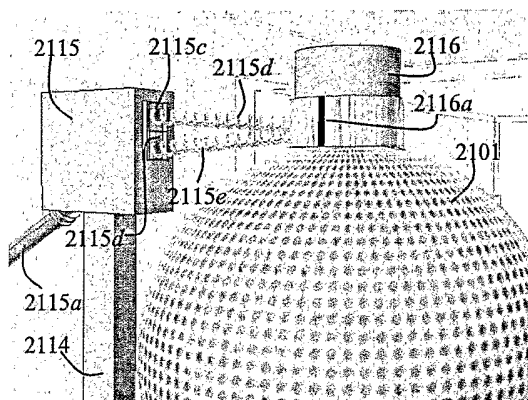


Fig. 21e

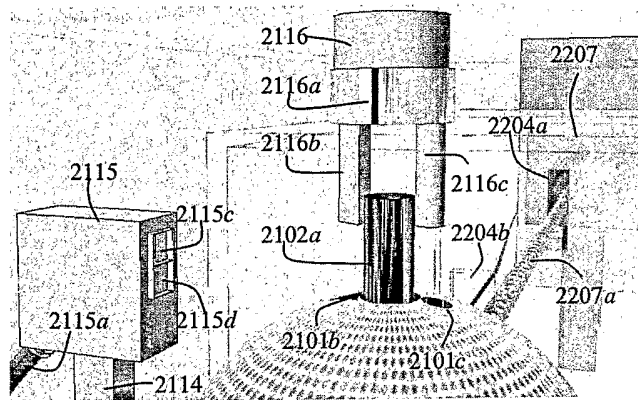
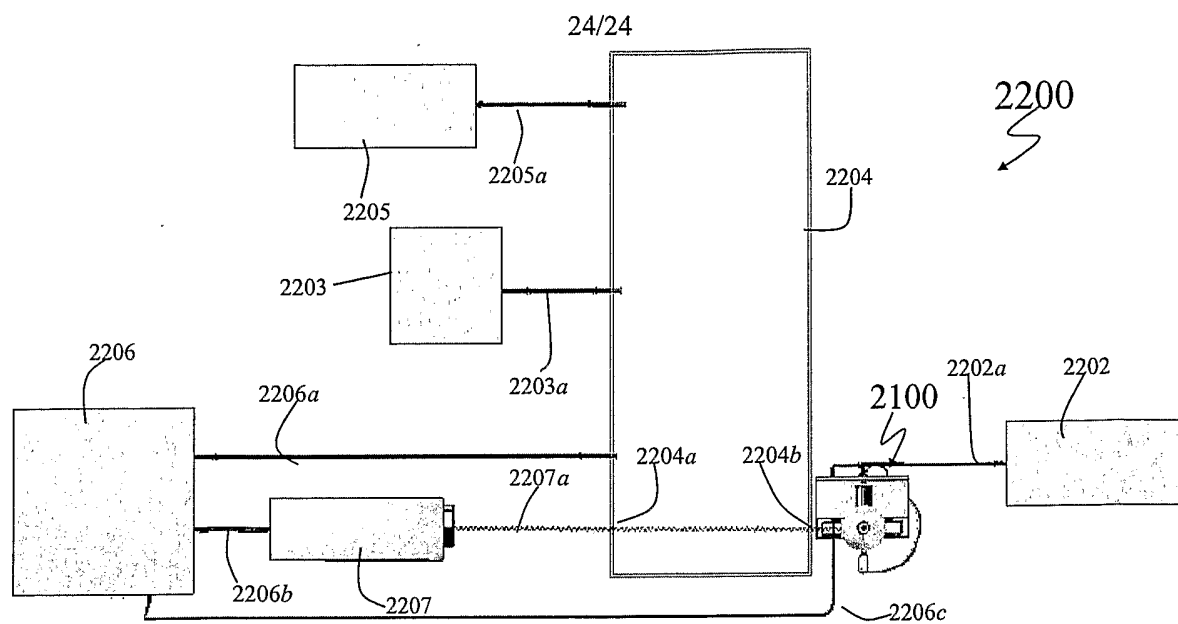


Fig. 21f

*Fig. 22*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2005/001338

A. CLASSIFICATION OF SUBJECT MATTER												
Int. Cl. ⁷ : G01N 35/00												
According to International Patent Classification (IPC) or to both national classification and IPC												
B. FIELDS SEARCHED												
Minimum documentation searched (classification system followed by classification symbols)												
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched												
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) DWPI and JAPIO:: {(G01N and (specimen or sample) and (rotate or turn or spin or revolve or spun)) and {[reference or indicate or distinct or known or fiducial or registration (2d) (mark or line or dot or feature or point)] or [(predetermined or relative or known or approach or near or arrive)(2d)(distance or arrive)] or [(constant or stable or fixed)(s)(velocity or speed)]}												
C. DOCUMENTS CONSIDERED TO BE RELEVANT												
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.										
X	WO 2002/048678 A2 (THE ROCKEFELLER UNIVERSITY) 20 June 2002 See page 7 lines 9-25.	1-73										
X	EP 1 063 513 A2 (WARDLAW et al) 27 December 2000 See claim 1 and para 39.	1-73										
X	US 5 892 577 A (GORDON) 6 April 1999 See abstract and col 9 lines 15-23.	1-73										
X	WO 2002/047071 A2 (BURSTEIN TECHNOLOGIES, INC) 13 June 2002 See page 19 lines 15-19 and page 9 line 5- page 10 line 28.	1-14,27-33,52-60,73										
☒ Further documents are listed in the continuation of Box C ☒ See patent family annex												
* Special categories of cited documents: <table border="0"> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"E" earlier application or patent but published on or after the international filing date</td> <td>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	"P" document published prior to the international filing date but later than the priority date claimed	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention											
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone											
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art											
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family											
"P" document published prior to the international filing date but later than the priority date claimed												
Date of the actual completion of the international search 18 November 2005		Date of mailing of the international search report 29 NOV 2005										
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929		Authorized officer S. T. PRING Telephone No : (02) 6283 2210										

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2005/001338

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 628 208 A1 (TRIPETTE & RENAUD SA) 8 September 1989 See abstract.	27-33
X	WO 2001/042769 A1 (CORNING INCORPORATED) 14 June 2001 See abstract.	1-73
X	EP 1 087 220 A2 (BRIDGESTONE CORP) 28 March 2001 See abstract.	27-33
A	WO 2003/069891 A1 (PROTEOME SYSTEMS INTELLECTUAL PROPERTY PTY LTD) 21 August 2003	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2005/001338

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
WO	2003/069891	AU	2003244791		
WO	2001/042769	US	6 317 209	US	6 765 671
		WO	2001/42750	US	2003227622
WO	2002/048678	AU	43345/02	US	2002074517
EP	1 063 513	US	6 384 906	US	2005077460
		US	2002012116	US	6 441 890
		US	2002012117		
US	5 892 577	AU	34815/95	BR	9509021
		CA	2384665	CA	2200562
		EP	0782 705	CN	1158659
		JP	2002-107289	EP	1 338 887
		US	6 327 031	JP	2002-022651
		US	6 803 999	US	2005-164615
		WO	1996/09548	US	6 256 088
				US	6 476 907
				US	2002085202
				US	2002135754
WO	2002/047071	AU	39484/02	AU	39552/02
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		EP	1410 026	EP	1 409 988
		US	2002071359	EP	1 410 027
		US	2002145960	US	2002071362
		WO	2002/46761	US	2002097658
				US	2005018583
				WO	2002/046721
EP	1 087 220	US	6 417 918	WO	2002/046762
FR	2 628 208	JP	2001-159584		
		NONE			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
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