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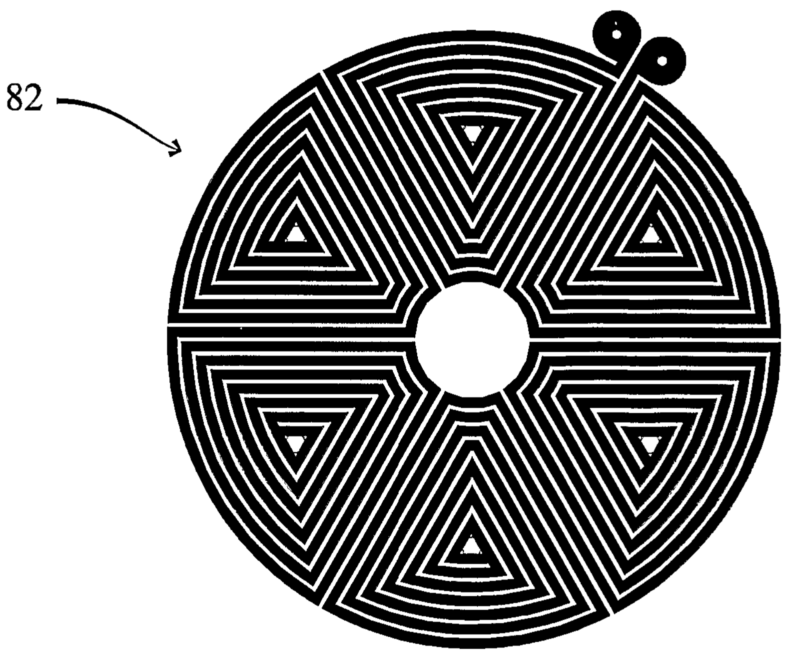
**(54) Title:** A COIL, MOTOR/GENERATOR, ROTATABLE MIRROR, BEARING AND AN APPARATUS INCORPORATING SAME FOR DENTAL AND MEDICAL OR OTHER USE




**(57) Abstract:** A coil (82) for generating an electromagnetic field or electrical power. The coil (82) comprises a planar insulative substrate and a flat electrically conductive track formed thereon, embodied on a circular disk printed circuit board. The board is divided into an even number of equi-angular sectors (90, 92, 94, 96, 98, 100) and the track is arranged in a radially increasing or decreasing spiral configuration upon the substrate to define a coil element in each sector. Adjacent tracks of the coil element are turned all one way or the other to terminate at an inner end (102, 104) centrally of the coil element and extend to an outer end of the coil element. The outer end of the coil element can be contiguously connected with a portion track (108) with the outer end of an opposite turned track of an adjacent coil element of the same coil (82), and the inner end (102) can be electrically connected to the corresponding inner end (110) of another track of a coil element of an adjacent coil (84), or to a power supply or load. A winding using the coil, an axial motor/generator using the winding, a rotatable mirror for dental or medical use driven by the motor/generator, components of the mirror, and a speed control for the motor/generator are also described.

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# "A coil, motor/generator, rotatable mirror, bearing and an apparatus incorporating same for dental and medical or other use"

## Field of the Invention

The present invention relates to an a coil, a motor/generator incorporating same, a mirror, a bearing, and an apparatus for dental and medical use including a mirror that is retained and rotates within a bearing as driven by a motor/generator in order to keep its surface clean enough to maintain a clear image.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

## Background Art

The following discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was part of the common general knowledge as at the priority date of the application, or is limiting in any way as to the nature of the invention.

A conventional hand-held mirror, as used by a dentist, comprises an elongate handle formed integrally with a disk-shaped head portion. A mirror having a reflective surface is fixedly mounted to the head portion.

The main problem with conventional dental mirrors is that, in use, particulate matter and moisture accumulate on what is supposed to be a reflective surface; so the mirror must be frequently removed and cleaned by wiping or blasting intra-orally with compressed air or water.

Surfactants have been used to alleviate this problem, but with limited success due to the large volumes of water and debris that are generated whilst working in the mouth with rotary cutting instruments.

In addition, mirrors tend to 'fog' when placed in a mouth. One technique employed to prevent fogging involves wiping the mirror against the cheek or dipping the mirror in hot water. Condensation is less likely to form on the hot mirror and fogging is suppressed for a short time. Once the mirror cools, fogging again occurs on the mirror.

Having to repeatedly remove the mirror from a patient's mouth, for cleaning or dipping in hot water, is both time-consuming and generally inconvenient.

More recently, hand-held dental instruments incorporating a rotary mirror have become available. A rotary mirror has advantages over a fixed mirror for dental applications since centrifugal force created by rotation of the mirror acts to push particulate material and moisture radially off the mirror, thereby increasing the visibility afforded by the mirror.

Existing rotary mirrors use an electrical motor of radial design with windings provided on a shaft that rotates in a container with bearings, the shaft being connected to the external mirror to cause rotation thereof. Such bearings must tightly seal the container, to prevent intrusion of moisture and matter into the motor in order to keep the mirror hygienic and sterile. Temperature and moisture variations, especially during autoclaving, make moisture-exclusion practically impossible. The seals and bearings can not both allow surfaces to slide freely, yet disallow the intrusion of moisture and dirt as a result of expansion and contraction of the air within the body of the motor.

In existing rotating mirrors of this type, some power is wasted because of the tightness of sliding surfaces, especially for rotating mirrors that have seals and bearings surrounding the perimeter of the rotating mirror itself.

Thus, radial electrical motors are not well suited for use in such applications, because of the difficulties in providing an instrument that is both sterilisable and useable. Also, radial electrical motors add unacceptable amount of inertia to the moving mirror elements, resulting in danger to the patient when contact occurs.

Alternative types of motors may use rotating elements axially aligned to the non-moving elements, so as to overcome the need for enclosing the rotating elements in a container separate from the actual rotating mirror. However, existing axial motors face difficulties with efficiency due to the limited space, within the body of the mirror, for managing the magnetic fields, and the inability to close the magnetic field at the surface of the mirror. Efficiency is important where power is supplied by batteries, which is preferable for hand-held dental instruments.

Many existing rotary mirrors have requirements related to the electrical power needed to rotate a tightly-fitting set of bearings and rotating elements in addition to the power to rotate the actual mirror. To supply enough energy is impractical using batteries. External, wired power connections are inconvenient during surgery.

Existing rotary dental mirrors have difficulties providing an instrument that is practical, reliable and sterilisable.

Rotary dental mirrors have also been powered by compressed air or suction, however such mirrors have the difficulty of the external air hoses hindering the surgeon, and great difficulty keeping no-load speed controlled to levels safe for contact with patients.

Electric motors and generators generally involve metal components and iron cored wire coil windings that generate magnetic fields externally of the motor/generator, requiring some kind of shielding to mitigate their effect on the surrounding environment. In addition, due to the inertia of such motors/generators and imperfect commutation and speed checking, speed control is generally imprecise especially at higher speeds. The use of metal brings with it ancillary problems associated with weight such as increased stresses on bearings and susceptibility of the motor/generator to resonance and vibration.

Wire coil windings are generally wound about an iron cored former and consequently exhibit magnetic hysteresis and generate eddy currents within the core. These windings are typically of long length and made using wire that is round in cross-section, which results in increased "skin" or "surface" resistance to switched or alternating current passing therethrough as the frequency of the current increases.

**Disclosure of the Invention**

It is an object of corresponding aspects of the present invention to mitigate or eliminate some or all of the aforementioned problems associated with coils, windings, motors/generators or dental mirrors, as applicable to the particular aspect hereinafter defined.

In accordance with a first aspect of this invention, there is provided a coil for generating an electromagnetic field or electrical power comprising a planar insulative substrate and a flat electrically conductive track formed thereon, said track being arranged in a radially increasing or decreasing spiral configuration upon said substrate to define a coil element, with adjacent tracks being turned one way or the other to terminate at an inner end centrally of the coil element and extend to an outer end of the coil element; wherein one or the other, or both the ends of said coil element may be contiguous with an opposite turning of said track in an adjacent coil element of the same coil, or electrically connected to another track of an electrically adjacent coil or to a power supply or load.

Preferably, said substrate is a disk and said coil element is formed on a sector or sectors of said disk.

Preferably, said track of a coil element describes a pattern substantially corresponding to the peripheral shape of said sector having outer and inner transverse portions of successively spirally decreasing radius and length, and interconnecting radial portions of successively spirally decreasing length, said track being turned one way or the other from the outer end of the coil element to the inner end of the coil element, so that said inner end is disposed generally centrally of the sector.

Preferably, said transverse portions are arcuate.

Preferably, said radial portions are substantially rectilinear.

Preferably, said disk comprises an even number of corresponding, equi-angularly disposed sectors; and discrete coil elements of said track are disposed in discrete sectors with adjacent pairs of coil elements being oppositely turned, certain adjacent pairs of oppositely turned coil elements being contiguous at their respective outer ends to produce a magnetic field with a different polarity from one coil element to an adjacent coil element of said track.

Preferably, said inner end of each said coil element of said track is electrically connected to the inner end of an oppositely turned track of a coil element within an axially aligned, sector of a parallel, axially aligned disk of an adjacent coil, juxtaposed thereto to form a winding.

Preferably, said substrate is circular.

Preferably, said substrate is mounted to a shaft either fixedly for rotation therewith, or rotatably for rotation relative thereto.

Preferably, said substrate is a printed circuit board.

In accordance with a second aspect of the present invention, there is provided a winding for an electromagnetic apparatus comprising a plurality of coils of even number as defined in the first aspect of the invention.

Preferably, an outer end of one coil element of the track of a coil disposed at one end of the winding, and the outer end of another coil element of the track of a coil disposed at the opposite end of the winding are respectively adapted for connection to a power supply or load; and the remaining ends of said coil elements of the tracks of the coils are contiguous or electrically connected in series to form a single continuous pathway for current flow therealong from one said outer end to the other.

Preferably, said coils are axially aligned in parallel relationship to each other, together with the sectors of different disks; wherein the turning of the tracks of axially aligned coil elements of juxtaposed sectors is opposite to the other to reinforce the magnetic field linking the same.

Preferably, an outer end of a further coil element of the track of a coil disposed at one end of the winding, and the outer end of another further coil element of the track of a coil disposed at the opposite end of the winding, said further coil elements being disposed adjacent to, and not contiguous with, said one and other coil elements respectively, are electrically connected to each other in the absence of an intermediary pair of coils, or to the outer end of one or other coil elements of an intermediary pair of coils to maintain said single continuous pathway for current flow therealong in a direction reinforcing the linking of the magnetic field between juxtaposed sectors.

Preferably, the printed circuit board is a multi-layer printed circuit board, each coil comprising a layer of the printed circuit board, said layers being interconnected in pairs via through-holes formed in the printed circuit board coincident with the inner end of each coil element of said tracks, and the pairs of layers being interconnected via intermediary outer pads provided at the outer ends of said coil elements that are electrically connected.

In accordance with a third aspect of the present invention, there is provided a motor comprising: an armature having a plurality of magnets provided therein; a winding including a plurality of coil elements for generating a magnetic field to move the armature relative to the winding; bearing means for rotatably mounting the armature relative to the winding; and a control circuit comprising: (i) a sensor arranged to detect the net magnetic field resulting from the coil elements of the winding and the magnets of the armature, (ii) polarity reversal means arranged to reverse the polarity of power applied to the coil elements when the sensor indicates the coil elements and the magnets are aligned, and (iii) speed regulating means arranged to control the application of power to the coil elements in accordance with the speed of rotation of the armature.

Preferably, the winding is of a form as defined in the second aspect of the invention.

Preferably, said control circuit is arranged to not power the coil elements when the sensor indicates that the magnets and the coil elements are aligned.

Preferably, said speed regulating means is responsive to said sensor to determine the speed of rotation of said armature according to the time interval between the magnets and the coil elements being aligned.

Preferably, said sensor is disposed in a plane that extends diametrically of the axis of rotation of the armature and which is spaced between the coil elements.

Preferably, said sensor is radially spaced from the coil elements and the magnets.

Preferably, said speed regulating means includes timer means arranged to produce a timing signal according to the elapsed time since the timing means was last triggered, the timing signal being compared with a threshold upon the sensor indicating that the magnets and the coil elements are aligned, wherein if the timing signal is above the threshold, power to the coil elements is disabled, the timer means being triggered upon completion of the comparison.

In accordance with a fourth aspect of the present invention, there is provided an apparatus for dental and medical use, comprising: a head portion attached to a handle and including at least two coil elements; bearing means provided on said head portion; a mirror comprising a body and an axial stem extending from said body, said body including at least two magnets and a substantially reflective surface, the axial stem being received in said bearing means and being selectively removable therefrom; and a control circuit arranged to provide power to said coil elements to effect rotation of said mirror.

Preferably, said head portion includes a recess into which said mirror is received when said axial stem is received in said bearing means.

Preferably, the bearing means is arranged to be selectively detachable from the head portion.

Preferably, said recess includes a side wall and a recessed surface, wherein a passageway is defined between the recessed surface and the body of the mirror when said axial stem is received in said bearing means. More preferably, said passageway tapers towards the axial stem.

Preferably, the side walls are arched.

Preferably, said recess includes a first aperture formed generally centrally in said recessed surface, said bearing means being receivable in said first aperture.

Preferably, the first aperture extends through the head portion.

Preferably, the first aperture includes a tapered portion arranged to retain said bearing means.

Preferably, said axial stem includes a protuberance arranged to mate with said bearing means.

Preferably, the body and the axial stem are formed of a resilient material.

Preferably, said reflective surface is coated with a transparent, resilient material. More preferably, said transparent, resilient material is hydrophobic.

In one arrangement, said reflective surface includes at least one non-reflective portion.

Preferably, said magnets are integrally disposed with said body.

Preferably, said magnets are arranged such that the poles of each magnet are positioned axially relative to said body.

Preferably, adjacent magnets are arranged such that their poles are of opposing polarity.

Preferably, the bearing means comprises a base and a plurality of arms extending from said base, said arms being arranged to receive the axial stem of the mirror.

Preferably, the arms are spaced apart to define a cylindrical passage therebetween into which said axial stem is receivable.

Preferably, each arm includes a widened section at a distal end thereof so as to retain said protuberance on the axial stem.

Preferably, the bearing means further comprises a plurality of bearing protrusions, each of which taper towards said base, said bearing protrusions engaging with the tapered portion of said aperture in the recessed surface to retain the bearing means on the head portion.

Preferably, each bearing protrusion and each arm are formed of a resilient material.

Preferably, the base includes a plurality of bores extending therethrough, said bores being in communication with said passageway formed between the recessed surface and the body of the mirror.

Preferably, said second apertures are provided between said arms.

Preferably, the coil elements form part of a coil of a form as defined in the first aspect of the invention.

Preferably, the coil elements form part of a winding of a form as defined in the second aspect of the invention.

Preferably, the control circuit includes at least one sensor arranged to detect the proximity of a magnet to a coil element, said control circuit arranged to power said coil elements when said magnets are proximate said coil elements only.

Preferably, said winding, bearing means, magnets and control circuit form part of a motor as defined in the third aspect of the invention and said mirror incorporates the armature of the motor.

Preferably, the bearing means is provided with sufficient flexibility to recommence rotation after stalling . This allows the mirror to wobble enough for magnetic variations to recommence as an alternative to an operator of the apparatus finding and using the main on/off switch.

In accordance with a fifth aspect of this invention, there is provided a bearing comprising: a base and a plurality of arms extending from said base, said arms being arranged to receive a stem.

Preferably, the arms are spaced apart to define a cylindrical passage therebetween into which said axial stem is receivable.

Preferably, each arm includes a widened section at a distal end thereof so as to retain a radial protuberance on the stem.

Preferably, the bearing further comprises a plurality of bearing protrusions, each of which taper towards said base, said protrusions arranged to engage with the tapered portion of an aperture to retain the bearing.

Preferably, each protrusion and each arm are formed of a resilient material.

Preferably, the base includes a plurality of second apertures extending therethrough. Preferably, said second apertures are provided between said arms.

In accordance with a further aspect of this invention, there is provided a mirror comprising: a body and an axial stem extending from said body, said body including at least two magnets and a substantially reflective surface.

Preferably, said magnets are integrally disposed within said body at equi-angular locations about the centre thereof.

Preferably, said magnets are arranged such that the poles of each magnet are positioned axially relative to said body.

Preferably, adjacent magnets are arranged such that their poles are of opposing polarity.

Preferably, the body and the axial stem are formed of a resilient material.

Preferably, said reflective surface is coated with a transparent, resilient material. More preferably, said transparent, resilient material is hydrophobic.

In one arrangement, said reflective surface includes at least one non-reflective portion.

In accordance with another aspect of the present invention, there is provided a speed control for a motor having an armature, a winding with coil elements to produce a magnetic field to drive the armature, and a sensor arranged to detect the net magnetic field resulting from the coil elements of the winding and the armature, comprising:

(i) polarity reversal means arranged to reverse the polarity of power applied to the coil elements when the sensor indicates the magnetic fields from the coil elements and the magnetic fields from the armature are aligned; and

(ii) speed regulating means arranged to control the application of power to the coil elements in accordance with the speed of rotation of the armature.

Preferably, the speed regulating means applies power to the coil elements only when the sensor indicates the magnetic fields from the coil elements and the magnetic fields from the armature are not aligned.

Preferably, the speed regulating means does not power the coil elements when the sensor indicates that the magnetic fields from the coil elements and the magnetic fields from the armature are directly aligned.

Preferably, the speed regulating means is responsive to the sensor to determine the speed of rotation of the armature according to the time interval between the times of direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature.

Preferably, the speed regulating means includes timer means arranged to produce a timing signal according to the elapsed time since the timer means was last triggered, the timing signal being compared with a threshold upon the sensor indicating the actual alignment of the magnetic fields from the coil elements and the magnetic fields from the armature, wherein if the timing signal is above the threshold, power to the coil elements is disabled, the timer means being triggered upon completion of the comparison.

In accordance with a further aspect of the invention, there is provided a method for controlling the speed of a motor having an armature and a winding with coil elements to produce a magnetic field to drive the armature, comprising:

(i) reversing the polarity of power applied to the coil elements when the sensor indicates the magnetic fields from the coil elements and the magnetic fields from the armature are aligned; and

(ii) controlling the application of power to the coil elements in accordance with the speed of rotation of the armature.

Preferably, the method includes applying power to the coil elements only when the magnetic fields from the coil elements and the magnetic fields from the armature are not aligned.

Preferably, the method includes not applying power to the coil elements when the magnetic fields from the coil elements and the magnetic fields from the armature are directly aligned.

Preferably, the method includes determining the speed of rotation of the armature according to the time interval between the times of direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature.

Preferably, the method includes:

(i) producing a dynamic timing signal indicative of the time interval that has elapsed between the last time of direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature and the present time;

(ii) comparing the timing signal with a threshold at the time when the magnetic fields from the coil elements and the magnetic fields from the armature are next in direct alignment;

(iii) determining if the timing signal is above the threshold;

(iv) if true, then disabling power to the coil elements, or if not enabling power to the coil elements;

(v) resetting the dynamic timing signal; and

producing a new dynamic timing signal indicating the next time interval elapsing from the direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature just been.

**Brief Description of the Drawings**

The accompanying drawings to which the following description of the best modes for carrying out the invention refer, are as follows:

Figure 1 is a cross-sectional side view of the head portion of a first embodiment of the invention;

Figure 2a is a side view of the apparatus of the first embodiment;

Figure 2b is a front view of the apparatus of the first embodiment;

Figure 3 is a top view of the bearing of the first embodiment;

Figure 4 is a cross-sectional view through section A-A in figure 3;

Figure 5 is a top view of the mirror of the first embodiment;

Figure 6 is a cross-sectional view of the mirror through section B-B of figure 5;

Figure 7a shows the top layer of a printed circuit board winding of the coils;

Figure 7b is a cross-sectional view of the mirror through section C-C of figure 6;

Figure 7c is a cross-sectional view of the mirror through section D-D of figure 7b;

Figures 8A-8D show consecutive layers of a multi-layer PCB forming coils of the first embodiment;

Figure 9 is a flow chart of the operation of the control circuit of the first embodiment;

Figure 10 is a schematic diagram of the control circuit;

Figure 11 is a diagrammatic representation of when the coils are powered by the control circuit relative to the position of the magnets;

Figure 12 is a fragmentary perspective drawing of the head portion according to a second embodiment, to show components in their relative positions;

Figure 13 is a cross-sectional side view of the head portion of figure 12;

Figure 14 is a schematic diagram of the control circuit according to the second embodiment of the invention;

Figure 15is a diagrammatic representation of the signals produced by the sensor and the control circuit in figure 12 as the mirror rotates; and

Figure 16 is a diagrammatic representation of when the coils are powered by the control circuit relative to the position of the magnets in accordance with the second embodiment.

**Best Mode(s) for Carrying Out the Invention**

The best modes for carrying out the invention will now be described with reference to specific embodiments directed towards the implementation of the invention in the form of a rotary dental mirror. However, it should be appreciated that the invention can be applied in other areas, not limited to dental or medical apparatus.

The first embodiment is directed towards a hand-held rotary dental mirror 10 comprising a head portion 12 attached to a handle 14.

The head portion 12 extends from the handle 14 at an angle so as to be inclined thereto. The head portion 12 has an outer surface 16 and an inner surface 18. A recess 20 defined by side walls 22 and a recessed surface 24 is provided in the inner surface 18. The recess 20 is provided generally centrally on the inner surface 18.

The head portion 12 further includes a recess 26 extending from the outer surface 16 to the recessed surface 24 such that the aperture 26 extends through the head portion 12. The aperture 26 includes a tapered portion 28, which tapers from the recessed surface 24 toward the outer surface 16, and a widened portion 30 adjacent the surface 16 in communication with the tapered portion 28. The recess 26 is provided generally centrally in the recessed surface 24.

The rotary dental mirror 10 further includes a bearing 32 comprising a base 34 of generally circular configuration which is arranged to be received snugly within the widened portion 30 of the aperture 26. A bore 36 is provided generally centrally in the base 34. The bearing 32 further comprises three arms 38 which extend from the base 34 and are equally spaced around the bore 36. The arms 38 form a cylindrical passageway 40 therebetween which is in communication with the bore 36. Each arm 38 includes a widened section 42 at the distal end from the base 34. The widened sections 42 result in the cylindrical passageway 40 defined by the arms 38 being narrower at the distal ends of the arms 38 than elsewhere along the arms 38.

The bearing 32 further comprises three protrusions 44 provided at spaced locations on the base 34. Three further bores 46 are provided between the protrusions 44. Each protrusion 44 has an inclined outwardly facing surface 48 defining a taper towards the base 34, such that each protrusion 44 is narrower adjacent the base than at its end distal from the base 34.

The bearing 32 is made from a resilient material such that the arms 38 and the protrusions 44 are able to flex slightly. The protrusions 44 and the inclined surfaces 48 thereof are arranged to engage the tapered portion 28 of the aperture 26 and retain the bearing 32 in place when in use but allow the bearing 32 to be removed from the head portion 12 when desired.

The rotary dental mirror 10 further includes a mirror 50 comprising a base 52 of generally circular configuration and an axial stem 54 extending perpendicularly therefrom at the centre of the body 52.

The base 52 includes a front, reflective surface 56 and a rear surface 58. The axial stem 54 extends from the rear surface 58. A raised portion 60 is provided on the rear surface 58 surrounding the axial stem 54.

The axial stem 54 includes a radial protuberance 62 provided thereon. The axial stem is receivable within the cylindrical passageway 400 defined by the arms 38 of the bearing 32 so as to be retained thereby. When the axial stem 54 is fully received within the cylindrical passageway 40, the distal ends of the arms 38 and protrusions 44 abut the raised portion 60 of the rear surface 58.

The rear surface 58 is slightly convex, such that the base 52 is narrower at its circumference than at its centre, so as to define a passageway 64 between the recessed surface 24 and the rear surface 58 of the mirror 50 when the mirror 50 is received in the bearing 32. The passageway 64 tapers toward the aperture 26. The passageway 64 is in communication with the further bores 46 provided in the base 34 of the bearing 32.

The mirror 50 further includes six magnets 66 provided within the base 52. The magnets 66 are equally spaced around the base 52 as shown in figure 5. The magnets are arranged such that half of the magnets have their north pole facing the recessed surface 24 and half of the magnets have their south pole facing the recessed surface 24, with the north and south poles being alternately arranged, north, south, north, south, north, south.

The rear surface 58 has six depressions 68 formed therein, one between each pair of adjacent magnets 66. Each depression 68 extends radially from the raised portion 60 to the circumference of the base 52.

The head portion 12 further includes a winding 70 comprising four discrete coil layers, each coil comprising six interconnected coil elements spaced around the aperture 26. Further, first and second sensors 72 and 74, respectively, are provided in the head portion 12. The winding 70 and the first and second sensors 72 and 74 are connected to a control circuit 76 provided in the handle 14 via printed circuit boards 78 and 80.

In the embodiment, each coil comprises a planar insulative substrate and a flat electrically conductive track of substantially constant thickness and breadth formed thereon. The coils coil are conveniently implemented on a multi-layer printed circuit board. Figures 8a - 8d show the schematic layout of tracks on the four layers 82, 84, 86 and 88 of the multi-layer printed circuit board. The substrate of the printed circuit board is in the form of a circular disk divided into an even number of corresponding equi-angularly disposed sectors, and the track is divided into discrete coil elements, one coil element being disposed in each sector.

The first layer 82 is shown in figure 8a and is arranged into six sectors 90, 92, 94, 96, 98 and 100. Each sector includes a coil element comprising a generally radially increasing or decreasing spiral configuration of the track, with adjacent tracks being spaced apart a substantially constant distance and turned one way or the other to terminate at an inner end centrally of the coil element where a through-hole 102 is provided, and extend to an outer end. The track of a coil element essentially describes a pattern substantially corresponding to the peripheral shape of a sector. Accordingly it has outer and inner arcuate transverse portions of successively spirally decreasing radius and length from the outer transverse portion to the inner transverse portion, and interconnecting rectilinear radial portions successively spirally decreasing length from the outer radial portions towards the inner end.

The coil element in the first sector 90 is connected to an input pad 104 and the coil element in the sixth sector 100 is connected to an intermediate output pad 106.

In the first layer 82, the coil element in the sector 92 is connected contiguously to the coil element in the sector 94 via a portion of track 108. Similarly, the coil element in the sector 96 is connected to the coil element in the sector 98 contiguously via a further portion of track 108. Coil elements in sectors 90 and 100 on the first layer 82 are not connected to any other coil elements on the first layer.

The second layer 84 comprises coil elements in sectors 90', 92', 94', 96', 98', and 100'. The second layer 84 is arranged to be positioned directly beneath the first layer 82, in parallel, axial alignment, such that the sectors 90 and 90' are positioned directly above each other. Each of the coil elements in sectors 90'-100' on the second layer 84 are of a generally spiral configuration in a similar manner to the coil elements on the first layer 82. Similarly, each of the sectors 90'-100' has a through-hole 110 formed at its centre which is electrically connected to the corresponding through-hole 102 on the first layer 82, such that the through-hole 110 on the sector 90' is electrically connected to the through-hole 102 on the sector 90 and so forth.

Importantly, each coil element is of opposite turn to the coil element in its adjacent sector, both within the same coil layer, and axially where juxtaposed coil elements of axially aligned sectors are electrically interconnected via their respective through-holes.

In the second layer 84, the coil elements in sectors 90' and 92' are connected contiguously via a portion of track 108'. Similarly, the coil elements in sectors 94' and 96' are connected via a portion of track, as are the coil elements in sectors 98' and 100'.

Thus, when current from a power supply is applied to the input pad 104, it flows in a spiral manner through the coil element in sector 90 and passes through the through-hole 102 to the through-hole 110 on the coil element in sector 90' and continues in a spiral direction, passing to the coil element in sector 92', through the through-hole 110 therein to the through-hole 102 in the coil element in sector 92, continuing in a spiral direction to the coil element in sector 94 and so forth around to the intermediate output 106. The spiral coil elements of the axially juxtaposed sectors 90 and 90' are arranged such that the magnetic fields produced by the current flowing through the spiral track in each coil element reinforces the other. Further, the spiral coil elements in the transversely adjacent sectors 90 and 92 are oppositely turned such that the current flows in opposite directions, to produce magnetic fields of opposing polarity. Thus, the coil elements in sectors 90, 94 and 98 will produce magnetic fields of one polarity whilst the coil elements in sectors 92, 96 and 100 will produce magnetic fields of opposing polarity.

The third layer 86 comprises segments 90", 92", 94", 96", 98" and 100". The coil element in sector 90" is connected to an output pad 112 and the coil element in sector 100" is connected to an intermediate input pad 114 that is connected to the intermediate output pad 106 in the first layer 82. The third layer 86 is of a similar configuration to the first layer 82, with the coil elements in transversely adjacent sectors 92" and 94" being connected together by a portion of track , and the segments 96" and 98" being connected together by another portion of track. In this regard, since the current is flowing in the opposite direction around the third layer 86 compared with the first layer 82, the spiral coil elements in each sector on the third layer 86 are turned in an opposite direction to the corresponding sector on the first layer 82.

The fourth layer 88 comprises six sectors, numbered 90'"-100'". The fourth layer is of a similar configuration to the second layer 84 with the spiral coil elements in each sector turned in an opposite direction to the corresponding spiral coil element on the second layer 84. Thus, current will flow from the input pad 104 through the first and second layers 82 and 84 to the intermediate output pad 106 and thereafter to the intermediate input pad 114 around the third and fourth layers 88 and 86 from the coil element in sector 100" to the coil element in sector 90" and thereafter to the output pad 112.

When all of the layers 82-88 are superimposed on one another, the effect is that the magnetic fields created in the axially aligned sectors 90, 90', 90" and 90'" act to reinforce each other as do the magnetic fields created in corresponding sectors on each layer.

Further, it should be noted that this principle can be extended to incorporate more layers in the printed circuit board as desired.

It should be noted that whilst in the present embodiment the winding arrangement is designed for a motor, where the input pad 104 and output pad 112 are connected to a power supply, in other embodiments the winding arrangement can be used in a generator, transformer or sensing applications, where the input and output pads may be connected to either a power supply or load. Further, the winding arrangement may be fixedly disposed within a body, such as the head portion 12 in the present embodiment, or be mounted to a shaft for fixed or rotatable rotation therewith, in other embodiments.

The control circuit 76 is shown in figure 10 and comprises a first re-triggerable one-shot trigger 116, a logic and register circuit 118, a first timer 120, a second re-triggerable one-shot trigger 122, a first peak detector 124, a second peak detector 126, an OR gate 128, a first register 130, a NOR gate 132, a second timer 134, a third peak detector 136, a first time delay circuit 138, a second register 140, a second logic circuit 142, a third register 144, a third logic circuit 146, a second time delay circuit 148 and a driver circuit 150.

The control circuit 76 sets uni-directional rotation of mirror 50 at an ideal rate but switches power off if the mirror 50 rotation rate falls below a pre-set limit.

When power is initially applied to the unit, the first timer 120 acts to trigger the second one-shot trigger 122. The non-inverting output of the second one-shot trigger 122 is connected to the NOR gate 132 which in turn is connected to the second timer 134. The output of the second timer 134 and the outputs of the third register 144 are connected to the third logic circuit 146 which is in turn connected to the second time delay circuit 148 which controls operation of the driver circuit 150. During initial power-up, second timer 134 enables the driver circuit 150 to power the coils 70 unconditionally, at the polarity set by third register 144, to effect initial rotation of the mirror 50. If, during power-up, magnets 66 have been both attracted to and are at the centre of magnetism 154 (see Figure 11), then to avoid power-down when one-shot trigger 122 times out, instead second timer 134 enables power while power is reversed by the inverting output of trigger 122 being gated by 128 to third register 144, thereby repelling the magnets 66 and initiating rotation of the mirror 50.

Thereafter, the operation of the control circuit 76 is determined by the presence of magnets beneath one of the first or second sensors 72 and 74 or a third sensor 152.

Reference will now be made to Figure 11 in more detail to assist in understanding the operation of the control circuit 76. Figure 11 is a diagrammatic representation of the rotation of the magnets 66 on the mirror 50 and the relative on and off switchings of the coils 70. The magnets 66 are represented by circles, with the arrow showing the direction of rotation thereof.

The first sensor 72 acts as an "on" sensor and detects the presence of an approaching magnet. The sensor 72 is connected to the third peak detector 136. When a magnet is detected by the first sensor 72, the polarity of the magnet is loaded into the third register 144 via first time delay circuit 138, the second register 140 and the second logic circuit 142. Further, the presence of a magnet 66 beneath the first sensor 72 is communicated to the second one-shot 122 via the first timing circuit 120 and to the first register 130 to activate the NOR gate 132 and thereby power the coils 70. The presence of a magnet beneath the first sensor 72 is also communicated to the logic and timing circuit 118.

The polarity of the magnet 66 beneath the first sensor 72 being loaded into the third register 144 ensures that when power is applied to the coils 70, the coils act to attract the magnet and thereby cause acceleration of the mirror 50. In figure 11, the centre of magnetism of the coil 70 is presented by line 154.

The third sensor 152 is arranged to detect the presence of a magnet a few degrees before the centre of magnetism 154. The third sensor is connected to the first peak detector 124 and acts as a "change" sensor to trigger a change in polarity of power applied to the coils, such that as the magnet passes the centre of magnetism 154 the power to the coils is reversed and acts to repel the magnet and thereby continue accelerating the mirror 50.

When the third sensor 152 detects the presence of a magnet therebeneath, the first peak detector 124 outputs a signal to the OR gate 128 which in turn outputs a signal to the first register 144 to effect a change in polarity of the output of the register 144. This change in the output of the register 144 acts to immediately disconnect power to the coils 70 and, after a time delay according to the second time delay 148, reactivate power to the coils in the reversed polarity. The point at which power is reactivated to the coils is represented in Figure 11 at 156.

The second sensor 74 acts as an “OFF” sensor to determine when power should be disconnected from the coil 70. The second sensor 74 is connected to the second peak detector 126. When the second sensor 74 detects the presence of a magnet therebeneath, the second peak detector 126 outputs a signal to the first register 130 which acts to disconnect power to the coil 70 via the NOR gate 132. In addition, the signal output from the second peak detector 126 is output to the first one-shot circuit 116 and the logic and register circuit 118. The first one-shot circuit 116 and the logic and register circuit 118 act as a speed regulator for the rotary dental mirror 10. If the time delay between the “ON” and “OFF” signals is sufficiently small, the output from the logic and register circuit 118 will act to disable power being applied to the coil 70 when a magnet next approaches the “ON” sensor 72.

The driver circuit 150 comprises first pairs of transistors 158 and second pairs of transistors 160 and a first control transistor 162 and a second control transistor 164. The first control transistor 162 controls operation of the first pairs of transistors 158 and the second control transistor 164 controls operation of the second pairs of transistors 160. The first and second pairs of transistors 158 and 160 act to power the coil 70 with different polarity. Accordingly, the register 144, the third logic circuit 146 and the second time delay circuit 148 act to ensure that only one of the control transistors 162 and 164 are activated at any one time.

The control circuit 76 acts to efficiently power the mirror 50 by only applying power when the attractive or repulsive force is strongest and by not applying power when the magnet is directly beneath the centre of magnetism, where the attractive or repulsive force is insignificant.

To further assist in understanding the operation of the control circuit 76, a chart outlining operation of the control circuit 76 is shown at Figure 9.

To ensure starting, even if the magnets are central with respect to the coil elements, the control circuit 76 enables the coil's power unconditionally for an interval after power-up, as shown at state 171. If the ON criteria are met, as shown at state 173, then the control circuit enables the coil's power at the polarity set by ON or by CHANGE. The motor coil's fields then alternately push-pull on the magnets' fields, as shown at state 175.

Three detection states are operated by the control circuit 76 during the operation of the motor:

(i) detecting the arrival and polarity of a magnet at the ON position (that is a few degrees BEFORE the centre of a coil), at state 177;

(ii) detecting the arrival of a magnet at the CHANGE position (at a coil's centre), at state 179; and

(iii) detecting the arrival of a magnet at the OFF position (that is a few degrees AFTER the centre of a coil), at state 181.

In the case of state 177 being true, then four processes are enabled:

- at state 183 power to the coils is normally enabled;
- at state 185 the DC voltage polarity of power to the motor coils is set, either as matching the magnet that caused the ON pulse, or after a CHANGE (change-polarity signal);
- at state 187 power is removed if stalled, ie if time-out then power off. Time out is started at power-on and reset by each ON signal. If time-out, then change polarity; and

- at state 189 time taken between every OFF signal and the next ON signal is measured.

State 187 subsequently invokes state 173 if the ON criteria are met.

State 189 subsequently invokes a further state 191 for speed control limiting the rate of rotation. If an OFF-to-ON time difference is too small, then the coils' power is disabled for the next segment. State 173 is subsequently invoked again via state 191 if the ON criteria are met.

In the case of state 179 being true, then this invokes state 188 and state 191. With state 188, this is invoked with a CHANGE either from the detection of a magnet at the CHANGE position, or from a time-out after initial power-on. This state subsequently invokes state 187 to set the DC voltage polarity to the coils and then invoke state 173 once the ON criteria is met. With state 185, this in turn invokes state 187, which in turn invokes state 173 if the ON criteria are met. With state 191, this similarly invokes state 173.

In the case of state 181 being true, then this invokes state 189, and subsequently states 191 and 173 as appropriate; and also state 183 to disable power to the coils.

In use, the mirror 50 is easily removable simply by a flicking the rotary dental mirror into a hand to dislodge the mirror 50 from the bearing 32. Thus the mirror 50 is easily replaceable in situ if necessary. Further, once the mirror is removed, the bearing 32 can be removed simply by pushing the bearing from the recessed surface 24. Importantly, the simple design of the bearing 32 and the mirror 50 provide for effective autoclaving and ease of reassembly.

Further, the tapering passageway 64 encourages particulate material to escape from behind the mirror 50. In addition, the further bores 46 prevent particulate material from blocking up the bearing 32 and enable the mirror to be flushed with water in use.

The second embodiment is directed towards a rotary dental mirror of the same general form as the first embodiment. However, the second embodiment differs from the first embodiment in the form of bearing and mirror interconnection, and also the control circuit used to power the coils.

As shown in figures 12 and 13, the rotating mirror disk has a resilient surface 301 with a reflective coating 320 underneath on the protected side of the resilient surface 301.

The base 302 of the mirror, being the rotating element of the instrument, is made of tough flexible resilient material able to be deformed, during manual cleaning, assembly and disassembly, without breaking. The base 302 returns reliably to the normal free-to-turn position after deformation.

The resilient surface 301 is disposable, being removable by heat and moisture during the autoclave sterilization process. Thus, the resilient surface 301 is a replaceable self-adhesive addition to the base 302.

A shaft 303 connects the base 302 to a ball bearing assembly 304. The shaft 303 is integral with the base 302 and has a diameter slightly larger than the centre of the bearing 304 into which it fits. The shaft 303 is squeezed into and held tightly by the bearing assembly 304.

The bearing assembly 304 has a socket 305 made of tough resilient material. The socket 305 has a slightly wider diameter on the outside than the hole in the head portion of the body 316 of the instrument into which the socket 305 is squeezed. The socket 305 also has a slight taper ("draft") because of the moulding process requirements; so the increased diameter is additional to the accommodating hole in the body 316 being tapered in the opposite direction.

The hole for the socket 305, in the body 316, can be tapered slightly for moulding manufacturing purposes, however this taper must be increased above such manufacturing requirements so that the hole can hold socket 305 positively. When the flexible socket 305 is squeezed by its hole in the body 316, the grip of socket 305 is further increased on the bearing 304 to further ensure against accidental disassembly.

The socket 305 may have a hole or holes under the shaft 303 to allow circulation of cleaning fluid (liquid or air) against contaminants that would cause jamming of rotation during normal operation after such contaminants intruded the front of the instrument via the air-gap 317. The choice of socket 305 with or without such ventilation depends on the nature of the operation being performed with the help of the instrument.

306 points to the motor coils A winding area 306 for the motor coils is provided that is integral with the body 316 after the printed circuit board that contains the tracks of the coil elements has been moulded into its place in the instrument.

One of the disk magnets 307 is shown uncut in figure 12 and sliced in figure 13.

An air gap 308 is provided between the socket 305 and the base 302.

A taper effect 309 is provided by the magnets 307 being mounted at an angle so as to remain as close as possible to the coils area 306, despite the base 302 needing this taper to allow easier rejection of contaminants that can get under the disk via air-gap 317 or via optional ventilation spaces or holes in the socket 305.

The body 316 of the instrument is provided with a shield 310 that shields the base 302 to allow the mirror to rotate in situations where otherwise it would be stopped. The shield 310 rises above the surface 301 on base 302 of the mirror so fluid and debris, from the top and bottom surfaces of the base 302, can be routed out via gap 311.

In the present embodiment the gap 311 is provided in the shield 310 of the body 316 at the front of the instrument head. In other embodiments more than one gap is provided.

An area 312 is provided in the base 302 for another magnet similar to magnet 307 to be positioned.

One of two connecting electrically conductive paths 313 is provided between a printed circuit board 314 and the coil elements in the windings area 306. Such paths 313 must be long enough to be flexible and resilient so as to allow the body

316 to flex slightly without metal-fatigue crystallization of the conductors that would happen if such paths 313 were too short.

The printed circuit board 314 provides an electronic power supply, switching and speed controls for the instrument.

A single sensor 202, as shown in figure 14, is physically located at position 315. The position 315 of the sensor is radially spaced from the coil elements and the magnets and is precisely determined by the sensitivity of the sensor. The sensor 202 is a directional non-polarised magnetic field-strength sensor that provides the signals for commutating the polarity of power applied to coils in the body 316 so as to maintain rotation of the mirror.

The body 316 of the instrument is where the head area extends to an ergonomic handle and battery pack (not shown).

A taper 318 is provided on the edge of the base 302 for moulding purposes, however, despite the need for the air-gap 317 to present an ever increasing egress path for debris and fluid from the base area of the mirror, the taper 318 has to be minimal so as to present a virtually flat surface for accurate positioning of the base 302 during replacement of the mirror's reflective surface 320.

The air gap 317 is tapered satisfactorily by the draft on (angle of) the inside of the surrounding shield 310 of the body 316.

Holes 319 are disposed in the printed-circuit-board 314 for the conductors 313. The holes 319 can be positioned under the magnetic sensor at the position 315, if this position needs to be as close as possible to the magnets. For the sensitivity of the sensors presently available for this embodiment, the holes 319 are disposed in front of the position 315.

The actual position of the reflective coating 320 is protected on the non-exposed side of the surface 301 of the base 302.

Figure 14 shows the control circuit 200 of the embodiment with like reference numerals denoting like parts to those used in the first embodiment.

In the control circuit 200 shown in Figure 14, 202 is a passive magnetic sensor with a differential output that is proportional to the absolute strength of any magnetic field within the vicinity of the sensor. The sensor 202 replaces the three sensors 72, 74 and 152 used in the first embodiment. The sensor 202 is positioned within proximity of the head 12, so as to detect whether the magnetic field that surrounds the mirror 50 and coils 70 is either balanced or not balanced, independent of polarity. The sensor 202 is connected to a comparator 204, and the output variations of the sensor 202 range from virtually zero voltage difference (when the fields are balanced) to enough for comparator 204 to output a logical "I" (high) when the fields are not balanced.

The sensor 202 is placed adjacent the mirror 50 and coils 70, at whatever angle is convenient, positioned so that when the magnets 66 are positioned exactly under the centres of the coils 70 the magnetic fields detected by the sensor 202 are balanced to virtually zero. The sensor 202 is positioned so that the magnetic fields from the coils 70 are balanced to zero whether or not the magnets 66 are rotated or not relative to the coils 70, to a position within a small number of degrees of the centres of the coils 70. Placing the sensor 202 equidistant from the closest coils 70 thereto achieves this effect.

There is a conceptual difference between this method of using a magnetic sensor and the application of magnetic sensor/s in prior art brushless electric motors: prior art locates sensors to detect individual components that affect the magnetic field, such as the presence of an individual permanent magnet of the motor, or the position of an individual piece of metal for example a gear's tooth or a metal marker of the position of rotation within a motor. For this invention, the single sensor 202 is used to summarise the total of the magnetic fields of the motor, to determine when to turn power off then on again in the reverse polarity.

When the magnets are close to the coils 70, the coils 70 will have negligible turning effect on the mirror 50. At this position, the output of the comparator 204 changes from high (magnetic field present) to low (magnetic field balanced close to being zero), which is used to remove electric power from the coils 70. The output of the comparator 204 is input to an inverter 206 in the form of an XOR gate with one input tied high. The output of the inverter 206 is to load data regarding the speed of rotation of the mirror into a register 208, and to change the polarity of the power applied to the coils 70 when next power is enabled via a register 209.

Comparator 204 output, when low connects to a capacitor 210 via a diode 212 and a resistor 214 which discharges the capacitor 210. Diode 212 blocks the high output from the comparator 204 from reaching capacitor 210, whereby the capacitor 210 is charged via a resistor 216. The output from the comparator 204 and the capacitor 210 form inputs to an XOR gate 218. If the capacitor 210 is charged sufficiently to form a logical high at the input of XOR gate 218, it is assumed that the rotation of the mirror 50 has stalled. If the mirror rotation has stalled while the magnets 66 are not aligned with the coils 70, then when the capacitor 210 reaches a “high” level and XOR gate 218 sees a logical high on both inputs, the output of XOR gate 218 goes low, disabling power to the coils 70 via NAND gate 220, NOR gate 222 and NAND gates 224 and 226.

If the mirror rotation is stalled when the magnets 66 are aligned with the coils 70, this is the normal “Off” position and power is removed from the coils 70 normally.

Speed control of the mirror 70 is set by the time taken for timer-network 228 to be discharged via resistor 230. Whenever register 209 changes the polarity, its output, which is used to determine the polarity of the power applied to coils 70, generates a pulse via resistor-capacitor time-delay 232 and XOR gate 234, sufficient to fully charge the capacitor via the limiting-resistor and diode forming the timer-network 228. If the capacitor in timer-network 228 has not discharged to below the logical “I” (high-positive) level, before the magnets 66 next align with the coils 70, the “High” is loaded into register 208 when the output from the inverter 206 goes high.

Thus speed-control is achieved by comparing the time taken for rotation to get from an “Off” position (when the magnets 66 are aligned with the coils 70) to the next “Off” position and if timer-network 228 has not discharged in this time then the arrival of the “Off” signal loads a high value at the data input of register 208 which disables power to the coils 70 via NAND gate 220, NOR gate 222, and NAND gates 224 and 226. Power to the coils 70 is disabled until the magnets 66 are next aligned with the coils 70, whereupon the speed comparison is performed again via the timer-network 228.

If the speed of rotation of the mirror 50 is not above the predetermined speed, then the timer-network 228 has discharged to a low data level when the magnets 66 are next aligned with the coils 70. As a result, a low data level is loaded into the register 208 when the output from the inverter 206 rises from low to high. It should be noted that the output from XOR gate 234 takes time to recharge the capacitor in the timer-network 228, by which time the data has been loaded into the register 208.

When the magnets 66 are aligned with the coils 70, the output of the inverter 206 changes from low to high which acts to toggle the output of the register 209 in the configuration shown in the embodiment. Alternatively, a magnetic polarity sensor may be connected to the data input of the register 209 in alternative embodiments. The non-inverting output of the register 209 is used to control the polarity of the power supply to the coils 70 via the XOR gate 236 and NAND gate 224.

A switch 238 connects the other input of the XOR gate 236 to a logical high voltage. When pressed, the switch 238 acts to reverse the direction of rotation of the mirror. This can be useful to assist in avoiding particulate matter from becoming wedged between the inside surface of the mirror 50 and the surface 24 of the head portion 12.

For use in a dental mirror, the direction of rotation of the mirror 50 is immaterial, and accordingly a magnetic polarity sensor is not needed. Either direction of rotation of the mirror 50 is equally useful in dislodging particulate matter and water from the surface of the mirror 50. Occasional reversal of the direction of rotation is useful to avoid particulate matter becoming wedged within the bearing 32 and between the mirror 50 and the head portion 12.

When power is first applied to the control circuit 200, power is initially applied to the coils 70 in one direction and then in the opposite direction to ensure start of rotation of the mirror 50. If power was applied to the mirror 50 in one direction only, and the magnets 66 were initially positioned aligned with the coils 70 then the mirror 50 may not commence rotation. This is achieved by RC networks 240, 242 and 244.

Upon power initially being applied to the control circuit 200, the RC network 240, 242 and 244 are all initially in a logic low state because the capacitors in the RC networks are not charged. The RC network 242 is connected to the set input of the register 209 and the RC network 244 is connected to the reset input of the register 209, both of which are active low. The register 209 has internal logic such that if both of its not-reset and not-set inputs are at low levels, the output of the register 209 is unconditionally high. Accordingly, for a short period of time after power is initially applied to the control circuit 200, the register 209 outputs a logical high. The RC network 240 is connected to an input of the NOR gate 222, which ensures that power is initially applied to the coils 70 due to the logic low level of the RC network 240.

The RC networks 240, 242 and 244 are arranged such that the RC network 242 reaches a logic high first, whereupon the output of the register 209 changes to a logical low level which acts to reverse the polarity of power applied to the coils 70 via XOR gate 236.

Shortly after the RC network 242 reaches a logic high, the RC network 244 also reaches a logic high, whereupon the register 209 functions as normal according to its clock and data inputs. However, this period is sufficient for the mirror 50 to commence rotation.

A capacitor 246 is provided across the inputs to the comparator 204 to filter noise from the output of the sensor 202. This helps to ensure that the output from the sensor 202 incident upon the comparator 204 is due only to the net magnetic field resulting from the coils 70 and the magnets 66.

The arrangement of the coils 70 shown in figures 8a - 8d in the first embodiment results in a linear torque being applied to the mirror 50 throughout its rotation whilst power is applied to the coils 70. In contrast to the first embodiment, the control circuit 200 of the second embodiment applies power to the coils 50 throughout rotation of the mirror while the magnets 66 are not aligned with the coils 70.

A feature of the motor formed by the magnets 66, the coils 70, the sensor 202, the control circuit 200 and the bearing 32 is that the magnetic field from both the coils 70 and the magnets 66 balance to zero a short distance from the head portion 12. As a result, minimal magnetic shielding is needed around the head 12. Any such shielding would be necessary only to ensure that magnetic material does not become attracted to the magnets 66. In contrast, the prior art tends towards teaching motors having electric fields that reach out a significant distance from the motor.

It is also worth noting that the motor of the invention does not require any additional magnetic material to focus or direct any of the magnetic fields in order to achieve rotation. However, if the sensor 202 is positioned at a considerable distance from the magnets 66, magnetic material may be adopted to improve the sensitivity of the sensor 202.

Figure 15 shows the manner of operation of the control circuit 200.

Graph 250 shows the output of the comparator 204 as the mirror 50 rotates. At the top of figure 13 there is shown one layer of coils 70. The arc indicated at 252 is the portion of rotation where the magnets are sufficiently aligned with the corresponding segment of the coils 70 to produce a low output from the comparator 204. During the low output, power to the coil elements is switched "off" and back on during the "high", which occurs after further rotation of the magnets passed this "dead" region.

Graph 254 shows the output of the sensor 202 during rotation of the mirror 50, where the sensor 202 provides an output signal dropping below a threshold value for the comparator 204 to switch on when the magnetic field is in balance, and is rectified to rise above the threshold value when the magnetic field increases at either polarity.

Graph 256 shows the magnetic field produced by the coil element at sector 92' alternating in polarity North-South, South-North, and graph 258 shows the magnetic field produced by the coil element at sector 90'. As can be seen, the opposite directions of turning of the coil element at sectors 92' and 90' produce opposed magnetic field strengths for the solenoid effect of each sector of the coil windings. However, the radial sections of the coil elements conduct current in parallel to result in a field that is close to the coils and uniform in its reaction to a close by permanent magnet.

It should be appreciated that this invention is not limited to the particular embodiment described above.

In particular, it should be appreciated that the coils are not confined to being wound only in series, but may be provided in series or parallel or combinations thereof as appropriate.

Further, it should be appreciated that although a minimum of two segments are required to produce rotation of the mirror on a single layer, it is preferred to use at least two layers of segments each having 4 or more segments.

**The Claims Defining the Invention are as Follows**

1. A coil for generating an electromagnetic field or electrical power comprising a planar insulative substrate and a flat electrically conductive track formed thereon, said track being arranged in a radially increasing or decreasing spiral configuration upon said substrate to define a coil element, with adjacent tracks of said coil element turned one way or the other to terminate at an inner end centrally of the coil element and extend to an outer end of the coil element; wherein one or the other, or both the ends of said coil element may be contiguous with an opposite turning of said track in an adjacent coil element of the same coil, or electrically connected to another track of a coil element of an electrically adjacent coil or to a power supply or load.

2. A coil as claimed in claim 1, wherein said substrate is a disk and said coil element is formed on a sector or sectors of said disk.

3. A coil as claimed in claim 2, wherein said track of a coil element describes a pattern substantially corresponding to the peripheral shape of said sector having outer and inner transverse portions of successively spirally decreasing radius and length, and interconnecting radial portions of successively spirally decreasing length, said track being turned one way or the other from the outer end of the coil element to the inner end of the coil element, so that said inner end is disposed generally centrally of the sector.

4. A coil as claimed in claim 3, wherein said transverse portions are arcuate.

5. A coil as claimed in claim 3 or 4, wherein said radial portions are substantially rectilinear.

6. A coil as claimed in any of claims 2 or 5, wherein said disk comprises an even number of corresponding, equi-angularly disposed sectors; and discrete coil elements of said track are disposed in discrete sectors with adjacent pairs of coil elements being oppositely turned, certain adjacent pairs of oppositely turned coil elements being contiguous at their respective outer ends to

produce a magnetic field with a different polarity from one coil element to an adjacent coil element of said track.

7. A coil as claimed in claim 6, wherein said inner end of each said coil element of said track is electrically connected to the inner end of an oppositely turned track of a coil element within an axially aligned sector of a parallel, axially aligned disk of an adjacent coil, juxtaposed thereto to form a winding.

8. A coil as claimed in any one of the preceding claims, wherein said substrate is circular.

9. A coil as claimed in claim 8, wherein said substrate is mounted to a shaft either fixedly for rotation therewith, or rotatably for rotation relative thereto.

10. A coil as claimed in any one of the preceding claims, wherein said substrate is a printed circuit board.

11. A winding for an electromagnetic apparatus comprising a plurality of coils of even number as claimed in any one of claims 1 to 10.

12. A winding as claimed in claim 11, wherein an outer end of one coil element of the track of a coil disposed at one end of the winding, and the outer end of another coil element of the track of a coil disposed at the opposite end of the winding are respectively adapted for connection to a power supply or load; and the remaining ends of said coil element of the tracks of the coils are contiguous or electrically connected in series to form a single continuous pathway for current flow therealong from one said outer end to the other.

13. A winding as claimed in claim 12, as dependent on claim 2, wherein said coils are axially aligned in parallel relationship to each other, together with the sectors of different disks; wherein the turning of the tracks of axially aligned coil elements of juxtaposed sectors is opposite to the other to reinforce the magnetic field linking the same.

14. A winding as claimed in claim 13 including a plurality of pairs of coils, wherein an outer end of a further coil element of the track of a coil disposed at one end of the winding, and the outer end of another further coil element of the track of a coil disposed at the opposite end of the winding, said further coil elements being disposed adjacent to, and not contiguous with, said one and other coil elements respectively, are electrically connected to each other in the absence of an intermediary pair of coils, or to the outer end of one or other coil elements of an intermediary pair of coils to maintain said single continuous pathway for current flow therealong in a direction reinforcing the linking of the magnetic field between juxtaposed sectors.

15. A winding as claimed in any one of claims 11 to 14, as dependent on claim 10, wherein the printed circuit board is a multi-layer printed circuit board, each coil comprising a layer of the printed circuit board, said layers being interconnected in pairs via through-holes formed in the printed circuit board coincident with the inner end of each coil element of said tracks, and the pairs of layers being interconnected via intermediary outer pads provided at the outer ends of said coil elements that are electrically connected.

16. A motor comprising: an armature having a plurality of magnets provided therein; a winding including a plurality of coil elements for generating a magnetic field to move the armature relative to the winding; bearing means for rotatably mounting the armature relative to the winding; and a control circuit comprising: (i) a sensor arranged to detect the net magnetic field resulting from the coil elements of the winding and the magnets of the armature, (ii) polarity reversal means arranged to reverse the polarity of power applied to the coil elements when the sensor indicates the coil elements and the magnets are aligned, and (iii) speed regulating means arranged to control the application of power to the coil elements in accordance with the speed of rotation of the armature.

17. A motor as claimed in claim 16, wherein the winding is of a form as claimed in any one of claims 11 to 15.

18. A motor as claimed in claim 16 or 17, wherein said control circuit is arranged to power said coil elements only when said sensor indicates said magnets are not proximate to said coil elements.

19. A motor as claimed in any one of claims 16 to 18, wherein said control circuit is arranged to not power the coil elements when the sensor indicates that the magnets and the coil elements are aligned.

20. A motor as claimed in any one of claims 16 to 19, wherein said speed regulating means is responsive to said sensor to determine the speed of rotation of said armature according to the time interval between the magnets and the coil elements being aligned.

21. A motor as claimed in any one of claims 16 to 20, wherein said sensor is disposed in a plane that extends diametrically of the axis of rotation of the armature and which is spaced between the coil elements.

22. A motor as claimed in any one of claims 16 to 21, wherein said sensor is radially spaced from the coil elements and the magnets.

23. A motor as claimed in any one of claims 16 to 22, wherein said speed regulating means includes timer means arranged to produce a timing signal according to the elapsed time since the timing means was last triggered, the timing signal being compared with a threshold upon the sensor indicating that the magnets and the coil elements are aligned, wherein if the timing signal is above the threshold, power to the coil elements is disabled, the timer means being triggered upon completion of the comparison.

24. An apparatus for dental and medical use, comprising: a head portion attached to a handle and including at least two coil elements; bearing means provided on said head portion; a mirror comprising a body and an axial stem extending from said body, said body including at least two magnets and a substantially reflective surface, the axial stem being received in said bearing means and

being selectively removable therefrom; and a control circuit arranged to provide power to said coil elements to effect rotation of said mirror.

25. An apparatus as claimed in claim 24, wherein said bearing means is adapted to be selectively detachable from the head portion.

26. An apparatus as claimed in claim 24 or 25, wherein said head portion includes a recess into which said mirror is received when said axial stem is received in said bearing means.

27. An apparatus as claimed in claim 26, wherein said recess includes a side wall and a recessed surface, wherein a passageway is defined between the recessed surface and the body of the mirror when said axial stem is received in said bearing means.

28. An apparatus as claimed in claim 27, wherein said passageway tapers towards the axial stem.

29. An apparatus as claimed in claim 27 or 28, wherein the side walls are arched.

30. An apparatus as claimed in any one of claims 26 to 29, wherein said recess includes a aperture formed generally centrally in said recessed surface, said bearing means being receivable in said aperture.

31. An apparatus as claimed in claim 30, wherein said aperture extends through the head portion.

32. An apparatus as claimed in claim 30 or 31, wherein said aperture includes a tapered portion arranged to retain said bearing means.

33. An apparatus as claimed in any one of claims 24 to 32, wherein the body and the axial stem are formed of a resilient material.

34. An apparatus as claimed in any one of claims 24 to 33, wherein said reflective surface is coated with a transparent, resilient material.

35. An apparatus as claimed in claim 34, wherein said transparent, resilient material is hydrophobic.

36. An apparatus as claimed in any one of claims 24 to 35, wherein said reflective surface includes at least one non-reflective portion.

37. An apparatus as claimed in any one of claims 24 to 36, wherein said magnets are integrally disposed within said body at equi-angular locations about the centre thereof.

38. An apparatus as claimed in any one of claims 23 to 37, wherein said magnets are arranged such that the poles of each magnet are positioned axially relative to said body.

39. An apparatus as claimed in claim 38, wherein adjacent magnets are arranged such that their poles are of opposing polarity.

40. An apparatus as claimed in any one of claims 24 to 39, wherein said axial stem includes a protuberance arranged to mate with said bearing means.

41. An apparatus as claimed in claim 40, wherein said bearing means comprises a base and a plurality of arms extending from said base, said arms being arranged to receive the axial stem and protuberance of the mirror.

42. An apparatus as claimed in claim 41, wherein the arms are spaced apart to define a cylindrical passage therebetween into which said axial stem and protuberance is receivable.

43. An apparatus as claimed in claim 41 or 42, wherein each arm includes a widened section at a distal end thereof so as to retain said protuberance.

44. An apparatus as claimed in any one of claims 41 to 43, as dependent on claim 32, wherein the bearing means further comprises a plurality of bearing protrusions, each of which taper towards said base, said bearing protrusions

engaging with the tapered portion of said aperture to retain the bearing means in the recessed surface on the head portion.

45. An apparatus as claimed in claim 44, wherein each bearing protrusion and each arm are formed of a resilient material.

46. An apparatus as claimed in any one of claims 24 to 39, wherein said bearing means includes a base incorporating a socket and a ball bearing assembly frictionally retained within said socket to mate with said axial stem.

47. An apparatus as claimed in claim 46, as dependent on claim 32, wherein said bearing means includes a spigot portion of marginally larger diameter than said aperture and tapered distally to engage with the tapered portion of said aperture and retain the bearing means in the recessed surface on the head portion.

48. An apparatus as claimed in any one of claims 41 to 47, wherein the base includes a plurality of bores extending therethrough, said bores being in communication with said passageway formed between the recessed surface and the body of the mirror.

49. An apparatus as claimed in claim 48, as dependent on claim 41, wherein said bores are provided between said arms.

50. An apparatus as claimed in any one of claims 24 to 49, wherein said coil elements form part of a coil of a form as claimed in any one of claims 1 to 10.

51. An apparatus as claimed in any one of claims 24 to 50, wherein said coil elements form part of a winding of a form as claimed in any one of claims 11 to 15.

52. An apparatus as claimed in any one of claims 24 to 51, wherein said winding, bearing means, magnets and control circuit form part of a motor of a form as

claimed in any one of claims 16 to 23, and wherein said mirror incorporates said armature.

53. An apparatus as claimed in any one of claims 24 to 52, wherein the bearing means is provided with sufficient flexibility to be manually flexed after stalling so as to create magnetic variations sufficient to recommence rotation.

54. A bearing comprising: a base and a plurality of arms extending from said base, said arms being arranged to receive a stem, said arms being spaced apart to define a cylindrical passage therebetween into which said axial stem is receivable, each arm including a widened section at a distal end thereof so as to retain a radial protuberance on the stem.

55. A bearing as claimed in claim 54, including a plurality of bearing protrusions, each of which taper towards said base, said protrusions being arranged to engage with the tapered portion of an aperture to retain the bearing therein.

56. A bearing as claimed in claim 55, wherein each bearing protrusion and each arm are formed of a resilient material.

57. A bearing as claimed in any of claims 54 to 56, wherein said base includes a plurality of bores extending therethrough.

58. A bearing as claimed in claim 57, wherein said bores are provided between said arms.

59. The bearing means of an apparatus as claimed in any one of claims 24 to 53.

60. A mirror comprising: a body and an axial stem extending from said body, said body including at least two magnets and a substantially reflective surface.

61. A mirror as claimed in claim 60, wherein said magnets are integrally disposed within said body at equi-angular locations about the centre thereof.

62. A mirror as claimed in claim 60 or 61, wherein said magnets are arranged such that the poles of each magnet are positioned axially relative to said body.

63. A mirror as claimed in claim 62, wherein adjacent magnets are arranged such that their poles are of opposing polarity.

64. A mirror as claimed in any one of claims 60 to 63, wherein the body and the axial stem are formed of a resilient material.

65. A mirror as claimed in any one of claims 60 to 64, wherein said reflective surface is coated with a transparent, resilient material.

66. A mirror as claimed in claim 65, wherein said transparent, resilient material is hydrophobic.

67. A mirror as claimed in any one of claims 60 to 66, wherein said reflective surface includes at least one non-reflective portion.

68. A speed control for a motor having an armature, a winding with coil elements to produce a magnetic field to drive the armature, and a sensor arranged to detect the net magnetic field resulting from the coil elements of the winding and the armature, comprising:

(i) polarity reversal means arranged to reverse the polarity of power applied to the coil elements when the sensor indicates the magnetic fields from the coil elements and the magnetic fields from the armature are aligned; and

(ii) speed regulating means arranged to control the application of power to the coil elements in accordance with the speed of rotation of the armature.

69. A speed control as claimed in claim 68, wherein speed regulating means applies power to the coil elements only when the sensor indicates the magnetic fields from the coil elements and the magnetic fields from the armature are not aligned.

70. A speed control as claimed in claim 68 or 69, wherein speed regulating means does not power the coil elements when the sensor indicates that the magnetic fields from the coil elements and the magnetic fields from the armature are directly aligned.

71. A speed control as claimed in any one of claims 68 to 70, wherein said speed regulating means is responsive to the sensor to determine the speed of rotation of the armature according to the time interval between the times of direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature.

72. A speed control as claimed in any one of claims 68 to 71, wherein said speed regulating means includes timer means arranged to produce a timing signal according to the elapsed time since the timer means was last triggered, the timing signal being compared with a threshold upon the sensor indicating the actual alignment of the magnetic fields from the coil elements and the magnetic fields from the armature, wherein if the timing signal is above the threshold, power to the coil elements is disabled, the timer means being triggered upon completion of the comparison.

73. A method for controlling the speed of a motor having an armature and a winding with coil elements to produce a magnetic field to drive the armature, comprising:

(i) reversing the polarity of power applied to the coil elements when the sensor indicates the magnetic fields from the coil elements and the magnetic fields from the armature are aligned; and

(ii) controlling the application of power to the coil elements in accordance with the speed of rotation of the armature.

74. A method as claimed in claim 73, including applying power to the coil elements only when the magnetic fields from the coil elements and the magnetic fields from the armature are not aligned.

75. A method as claimed in claim 73 or 74, including not applying power to the coil elements when the magnetic fields from the coil elements and the magnetic fields from the armature are directly aligned.

76. A method as claimed in any one of claims 73 to 75, including determining the speed of rotation of the armature according to the time interval between the times of direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature.

77. A method as claimed in any one of claims 73 to 75, including:

(i) producing a dynamic timing signal indicative of the time interval that has elapsed between the last time of direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature and the present time;

(ii) comparing the timing signal with a threshold at the time when the magnetic fields from the coil elements and the magnetic fields from the armature are next in direct alignment;

(iii) determining if the timing signal is above the threshold;

(iv) if true, then disabling power to the coil elements, or if not enabling power to the coil elements;

(v) resetting the dynamic timing signal; and

(vi) producing a new dynamic timing signal indicating the next time interval elapsing from the direct alignment of the magnetic fields from the coil elements and the magnetic fields from the armature just been.

78. A coil for generating an electromagnetic field or electrical power substantially as herein described with respect to the accompanying drawings as appropriate.

78. A coil for generating an electromagnetic field or electrical power substantially as herein described with respect to the accompanying drawings as appropriate.

79. A winding for an electromagnetic apparatus substantially as herein described with respect to the accompanying drawings as appropriate.

80. A motor substantially as herein described with respect to the accompanying drawings as appropriate.

81. An apparatus for dental and medical use substantially as herein described with respect to the accompanying drawings as appropriate.

82. A bearing substantially as herein described with respect to the accompanying drawings as appropriate.

83. A mirror substantially as herein described with respect to the accompanying drawings as appropriate.

84. A speed control for a motor substantially as herein described with respect to the accompanying drawings as appropriate.

85. A method for controlling the speed of a motor, the method substantially as herein described with respect to the accompanying drawings as appropriate.

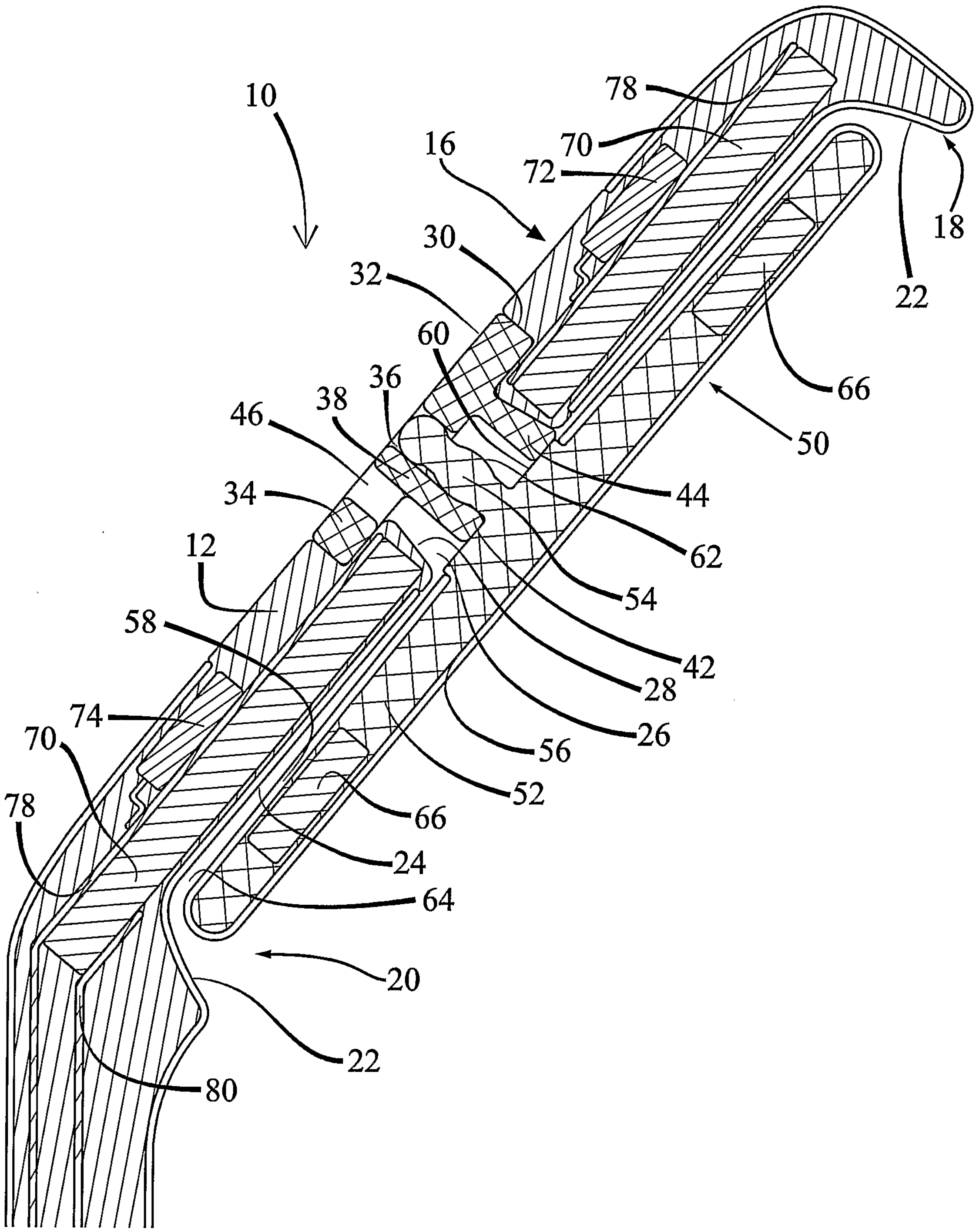
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Fig.1

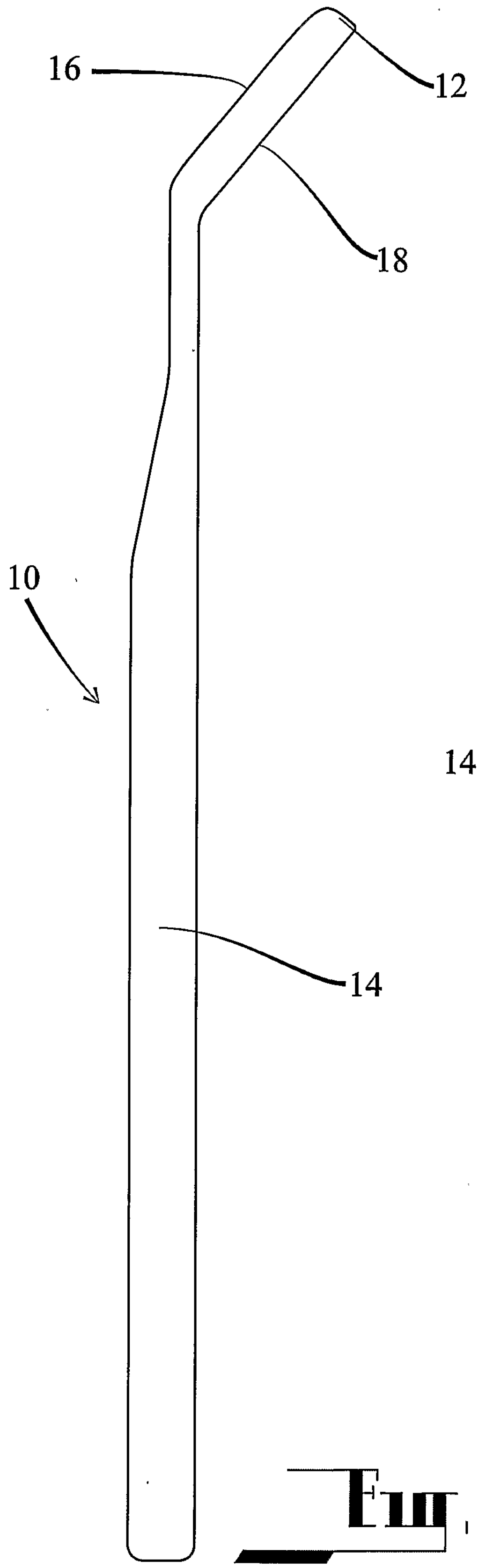


Fig. 2A

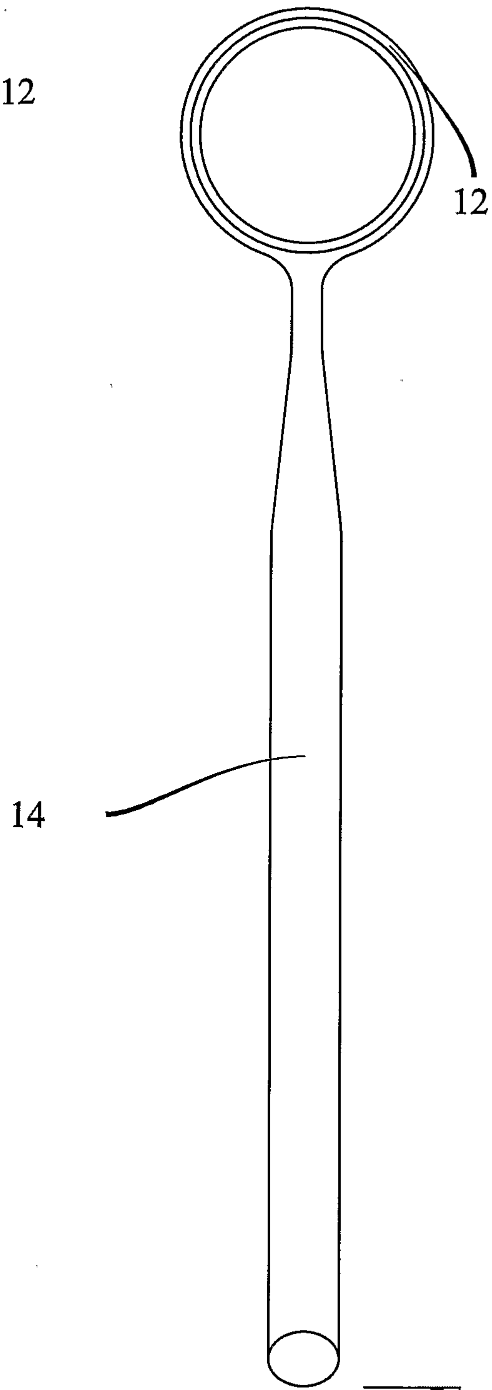


Fig. 2B

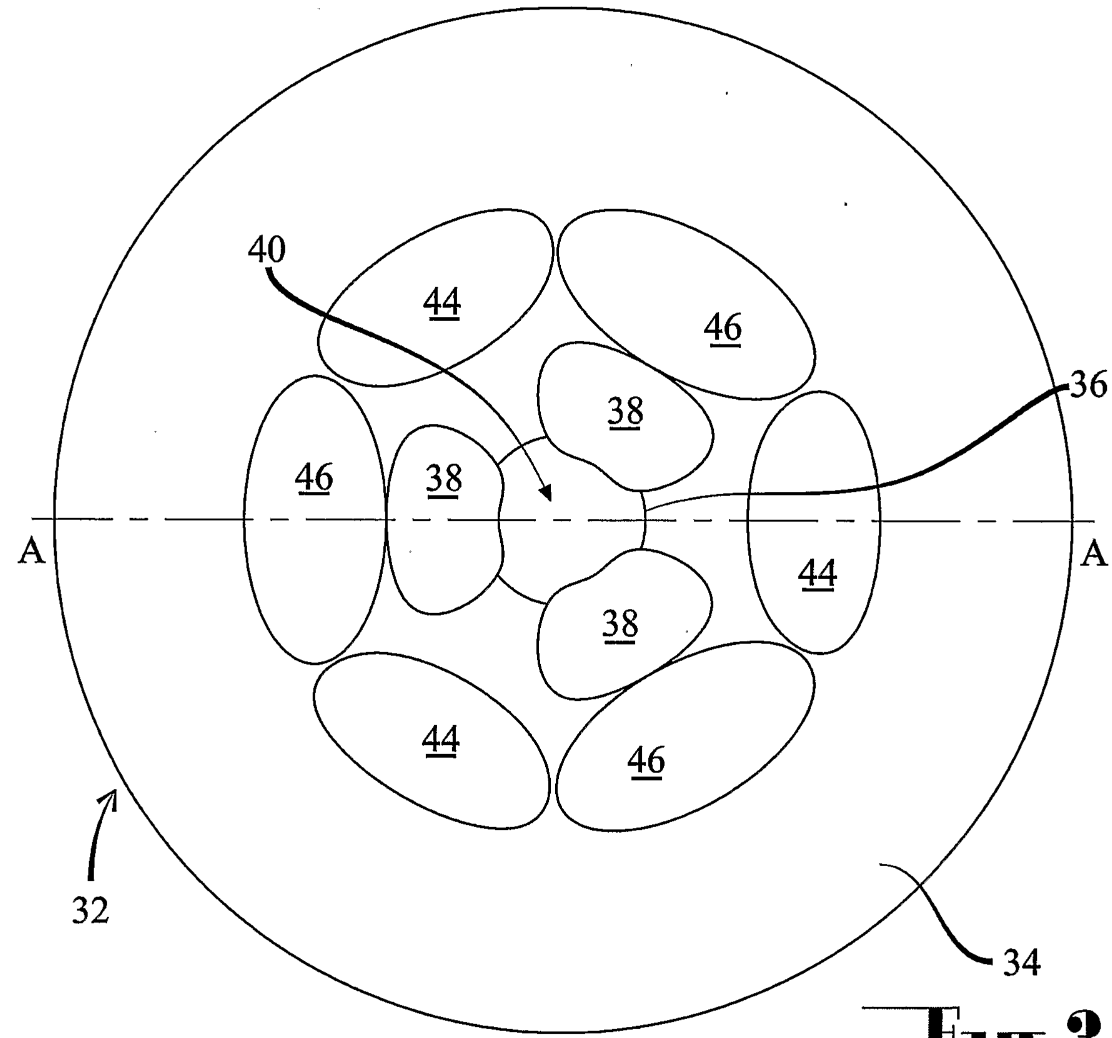


Fig 3

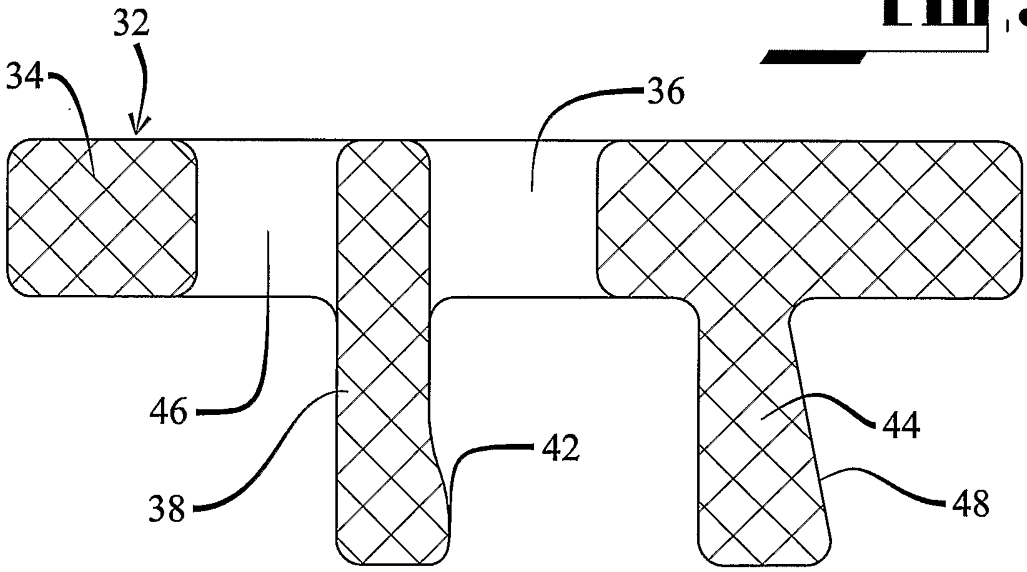


Fig 4

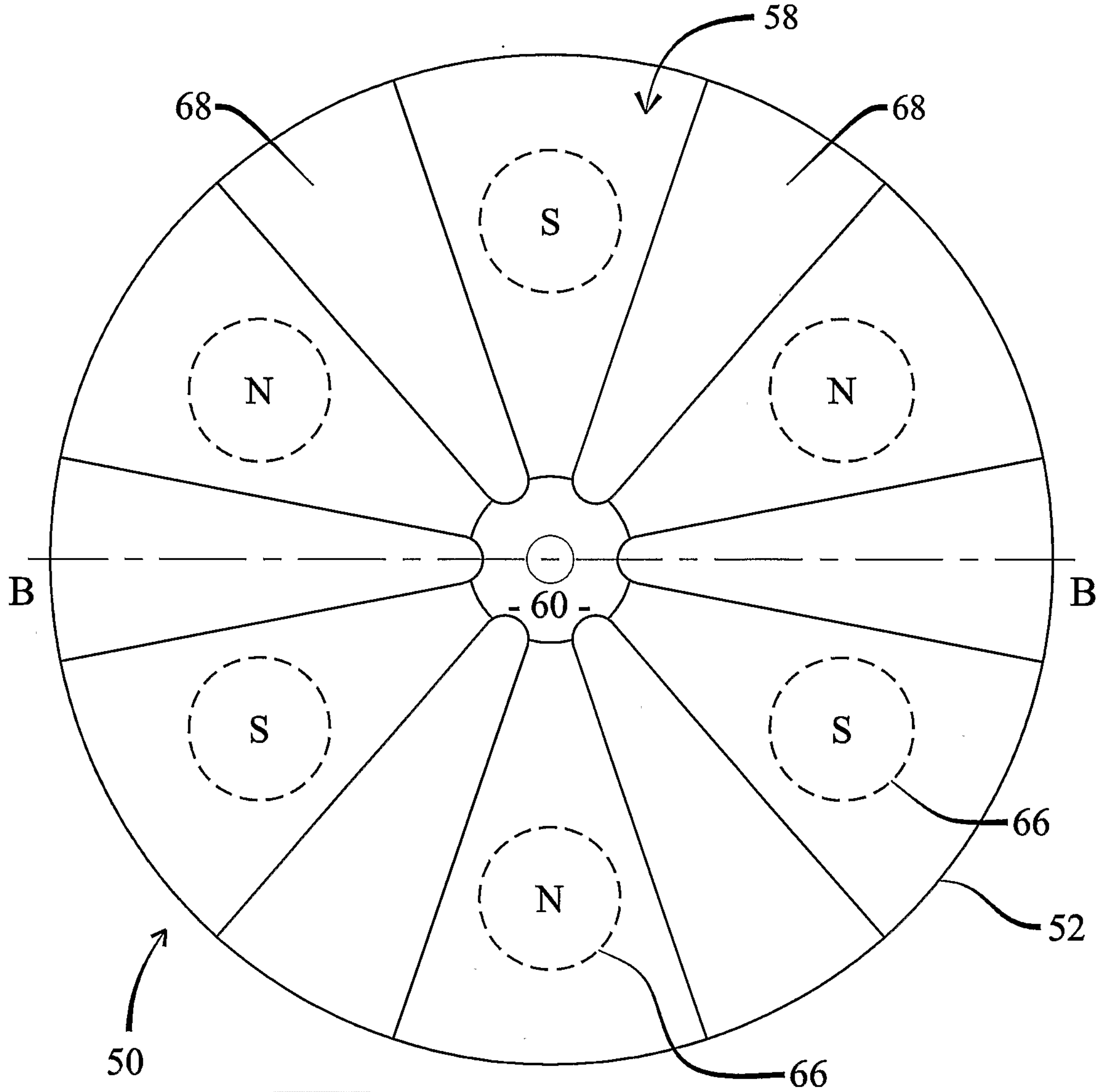


Fig 5

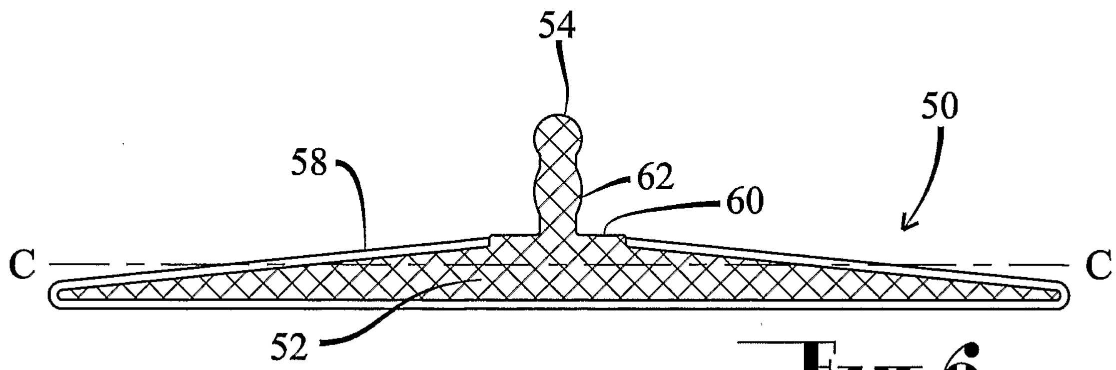


Fig 6

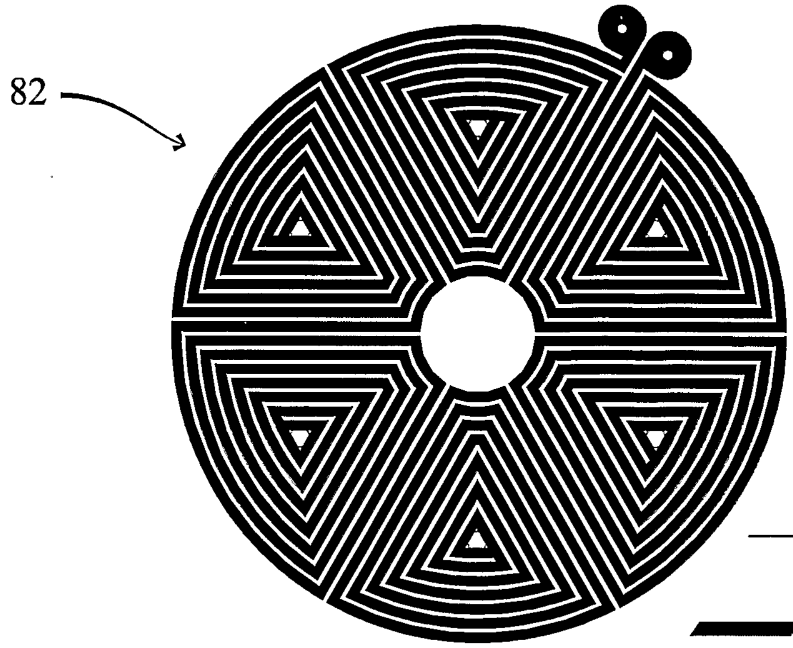


Fig 7A

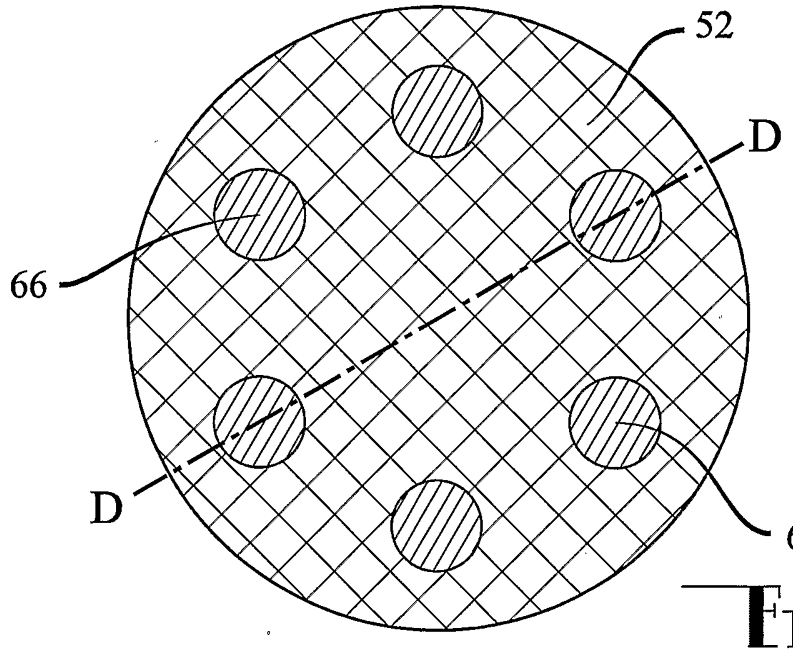


Fig 7B

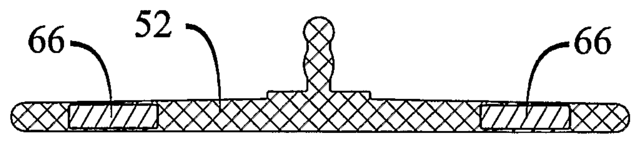


Fig 7C

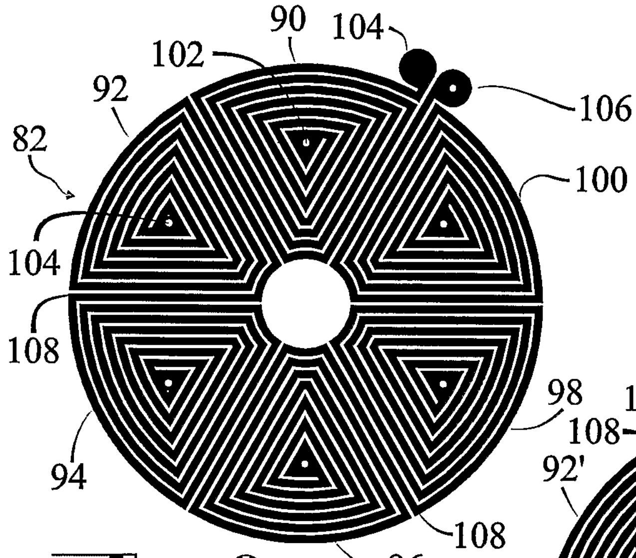


Fig 8A

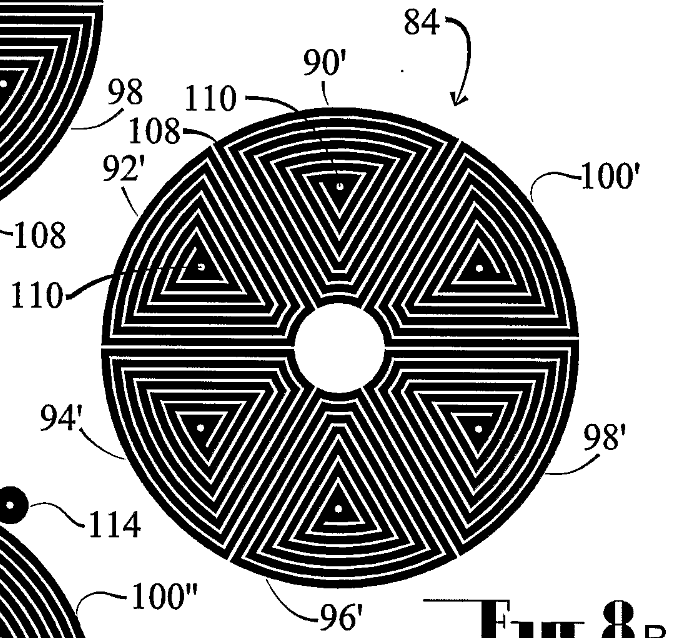


Fig 8B

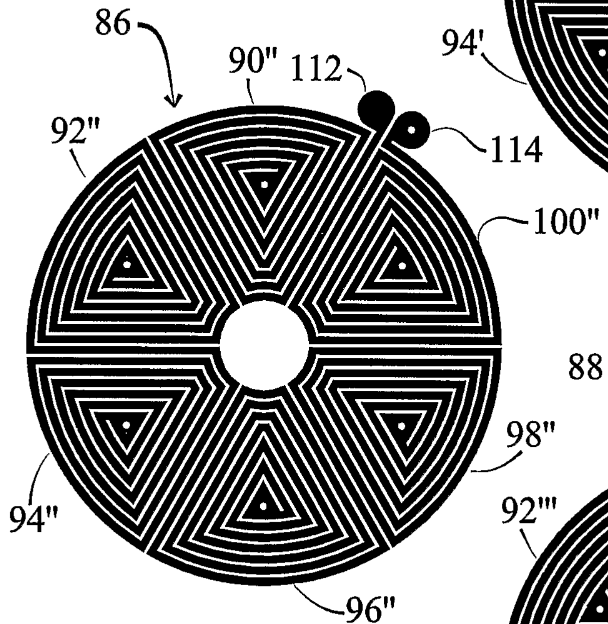


Fig 8C

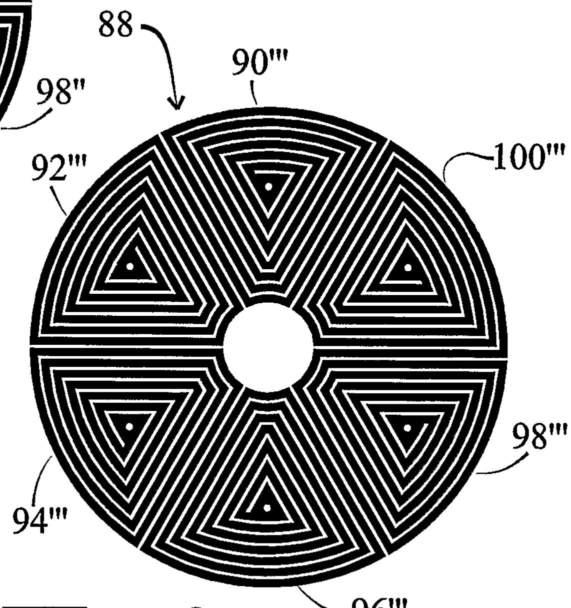


Fig 8D

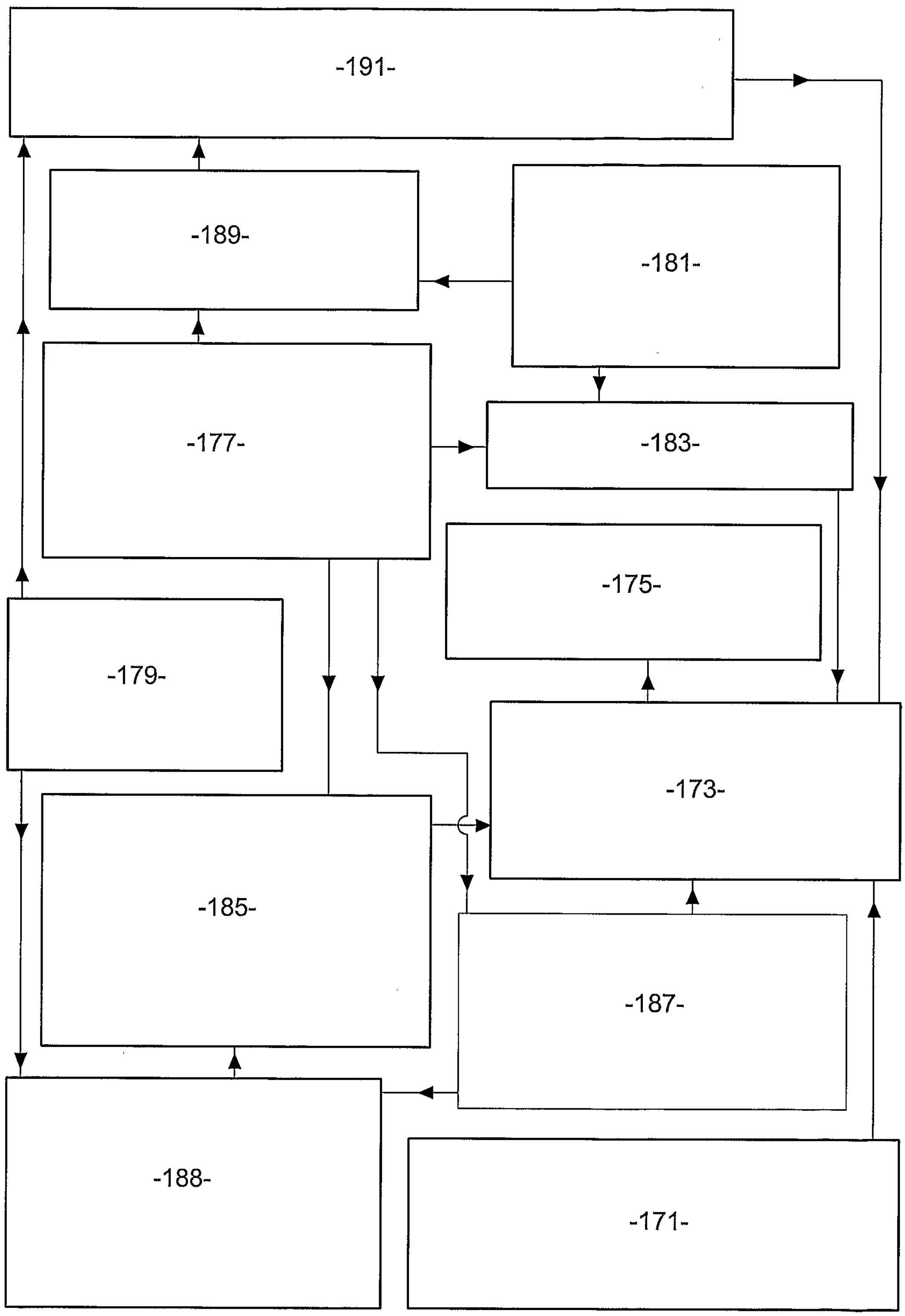


Fig 9

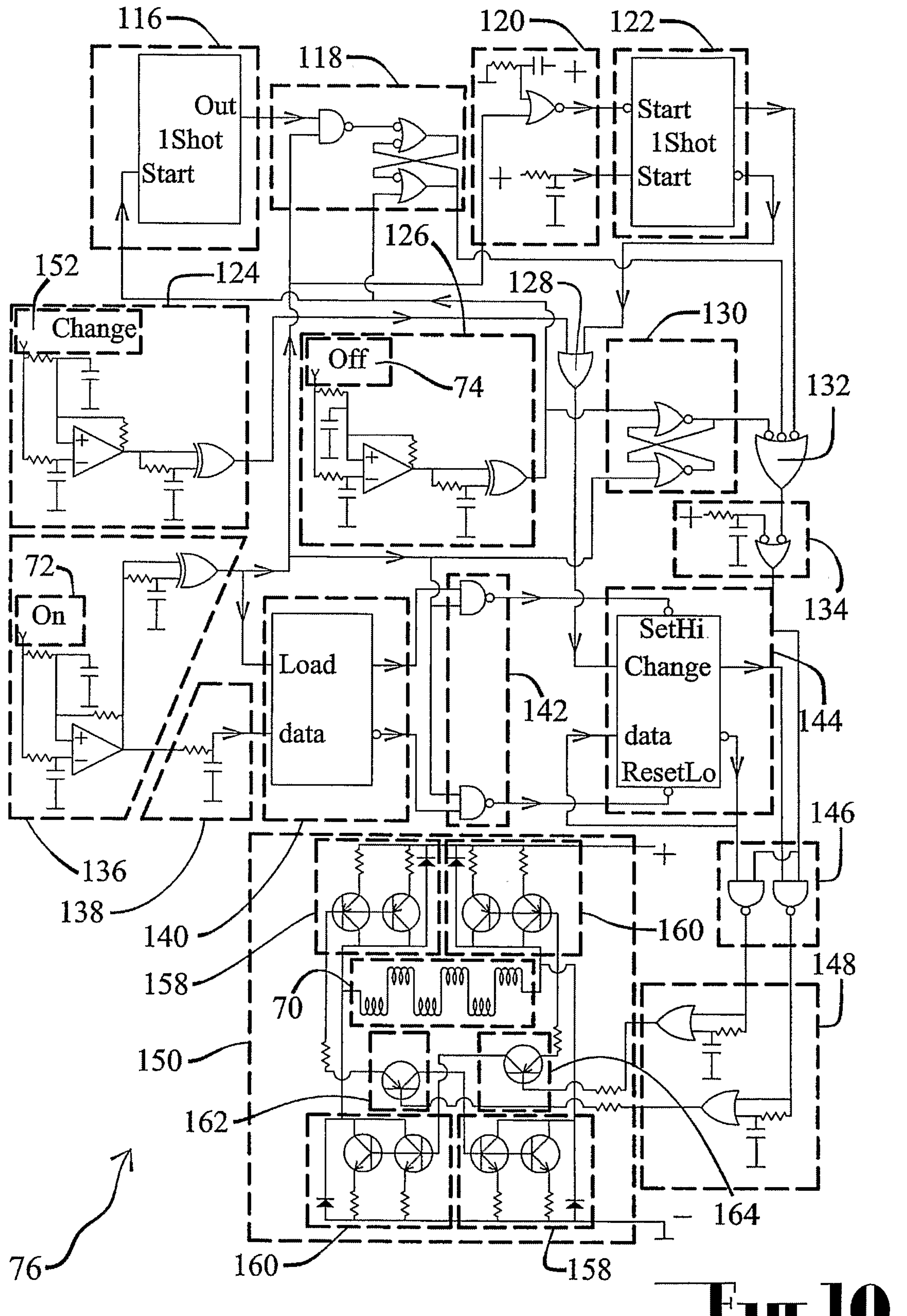
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Fig 10

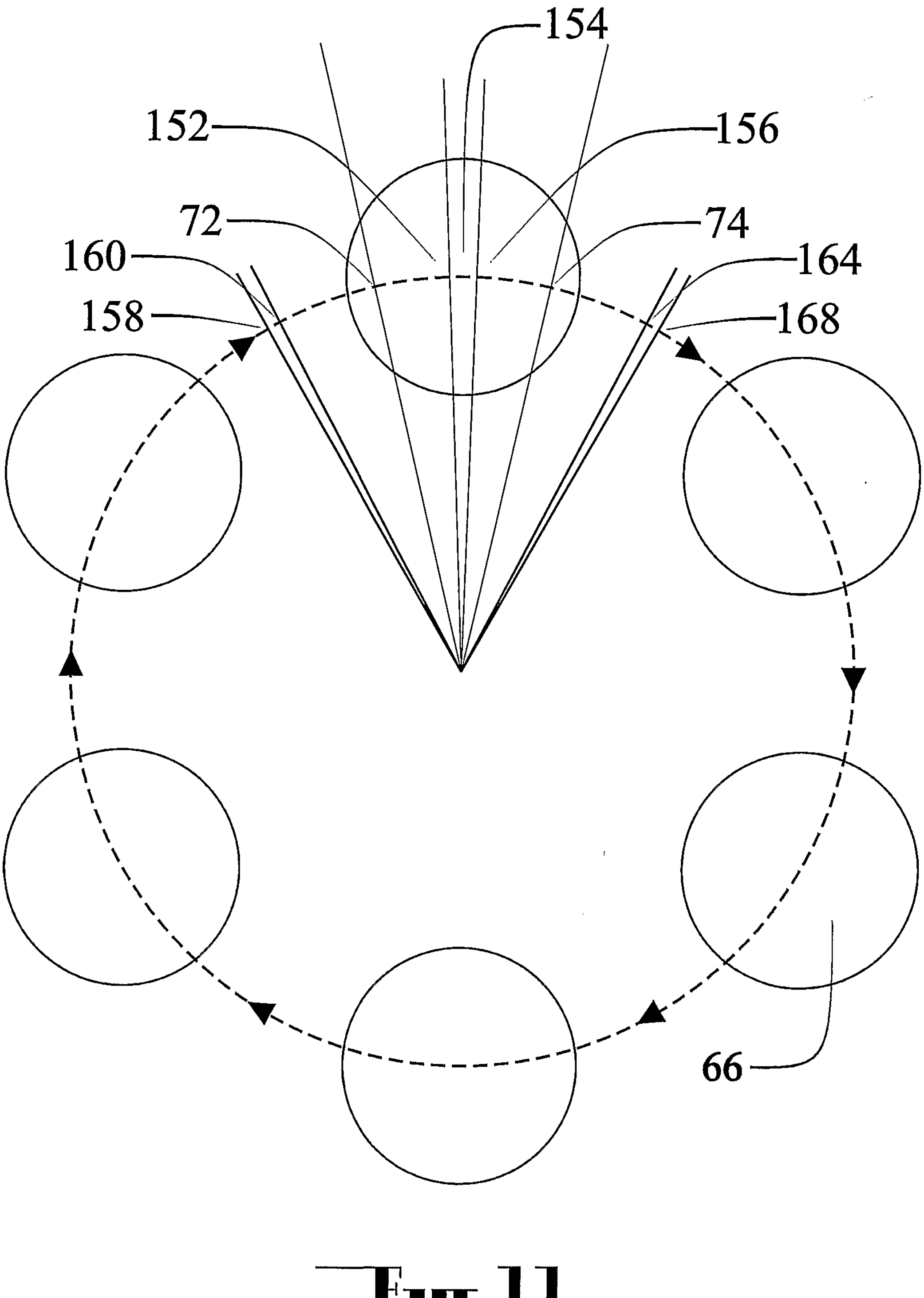


Fig 11

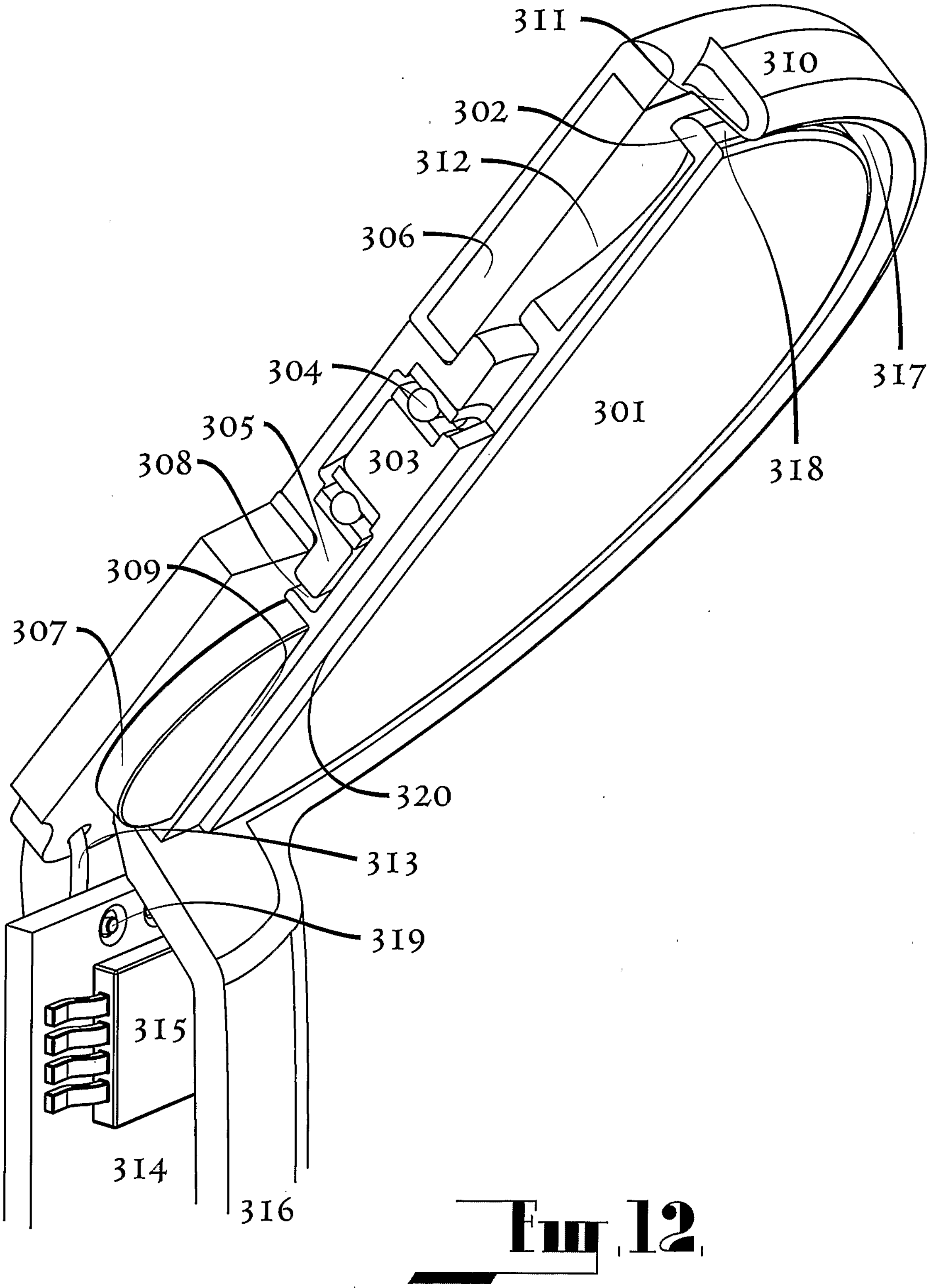
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Fig 12

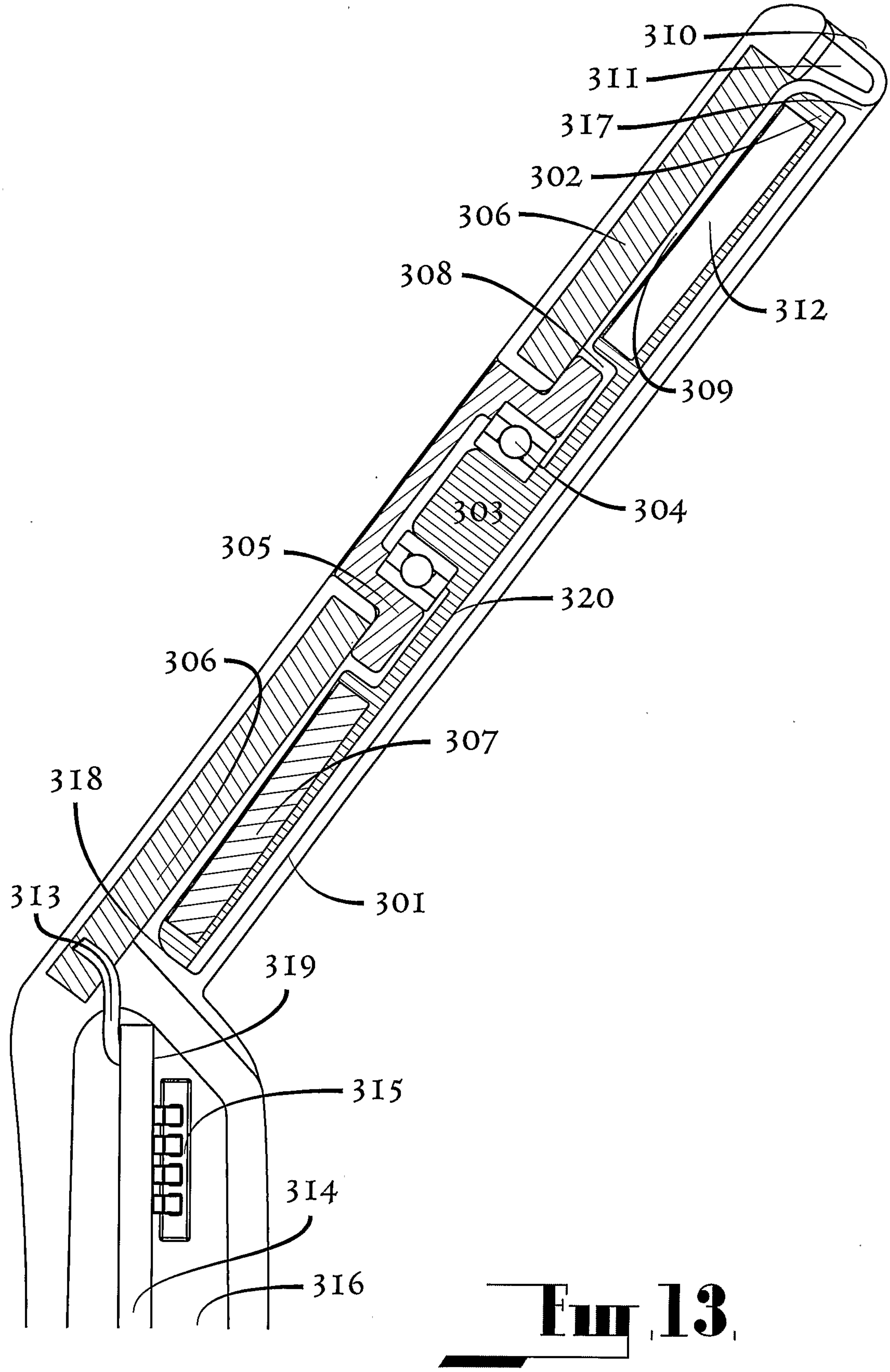
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Fig 13

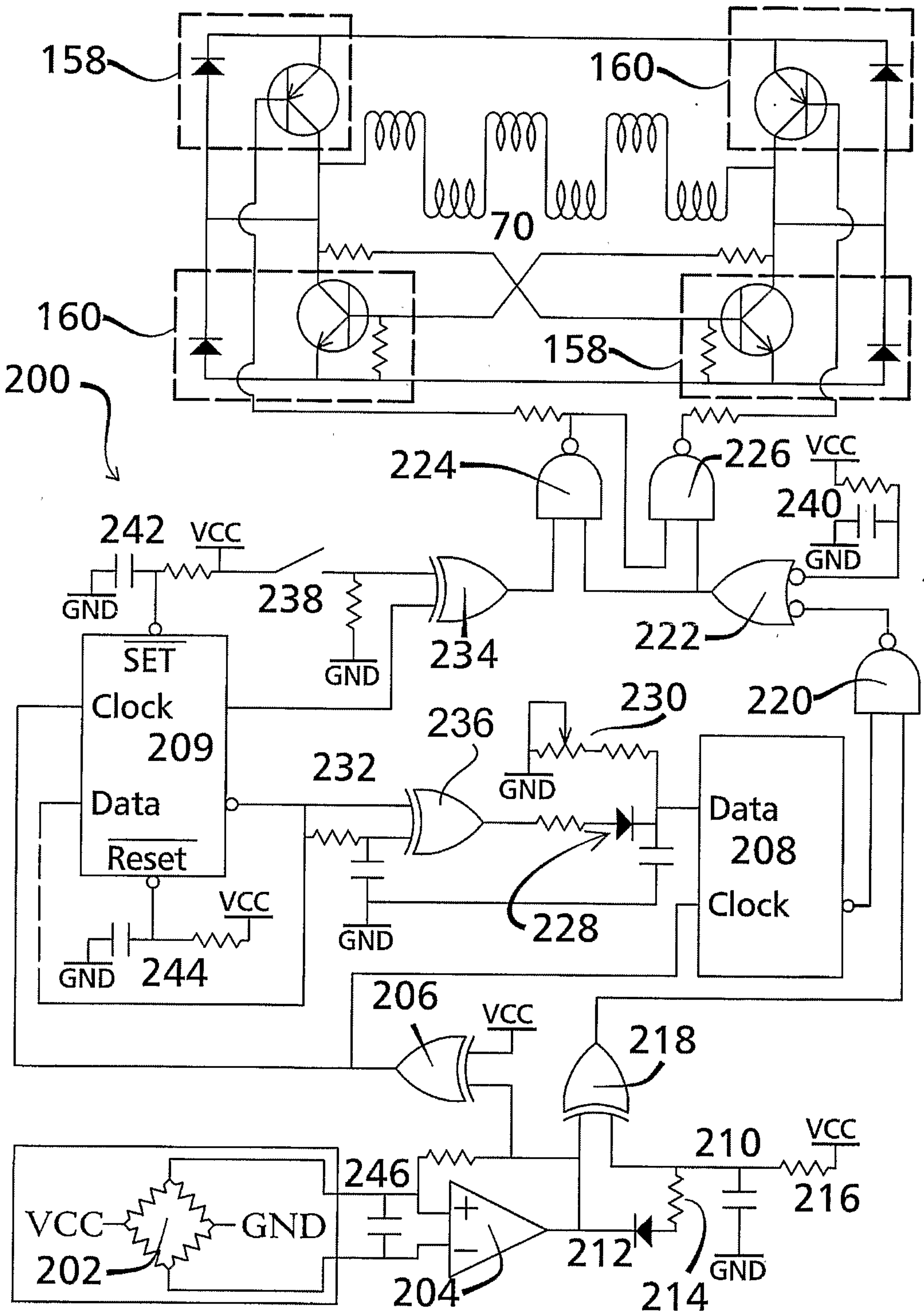
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Fig 14

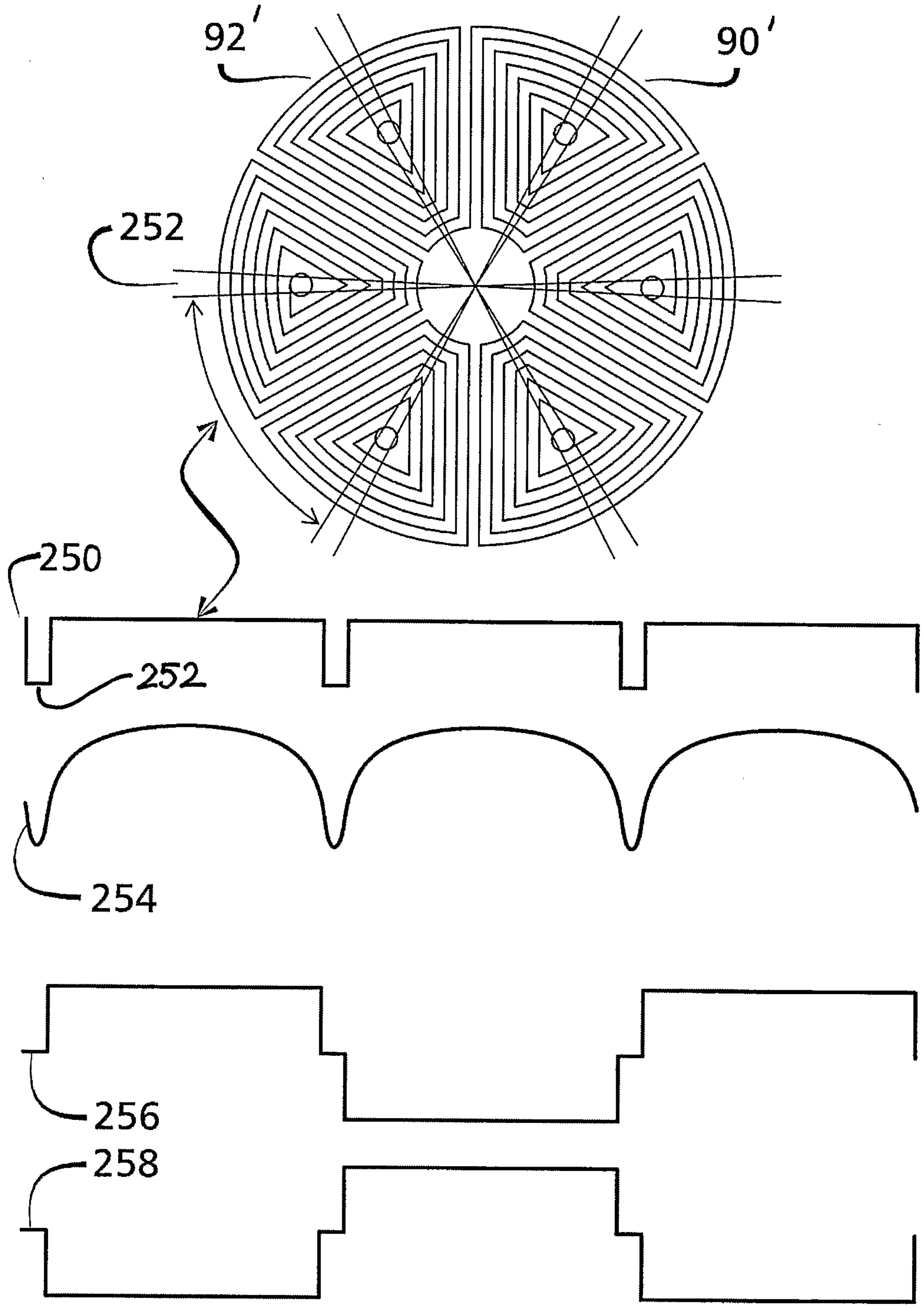


Fig 15

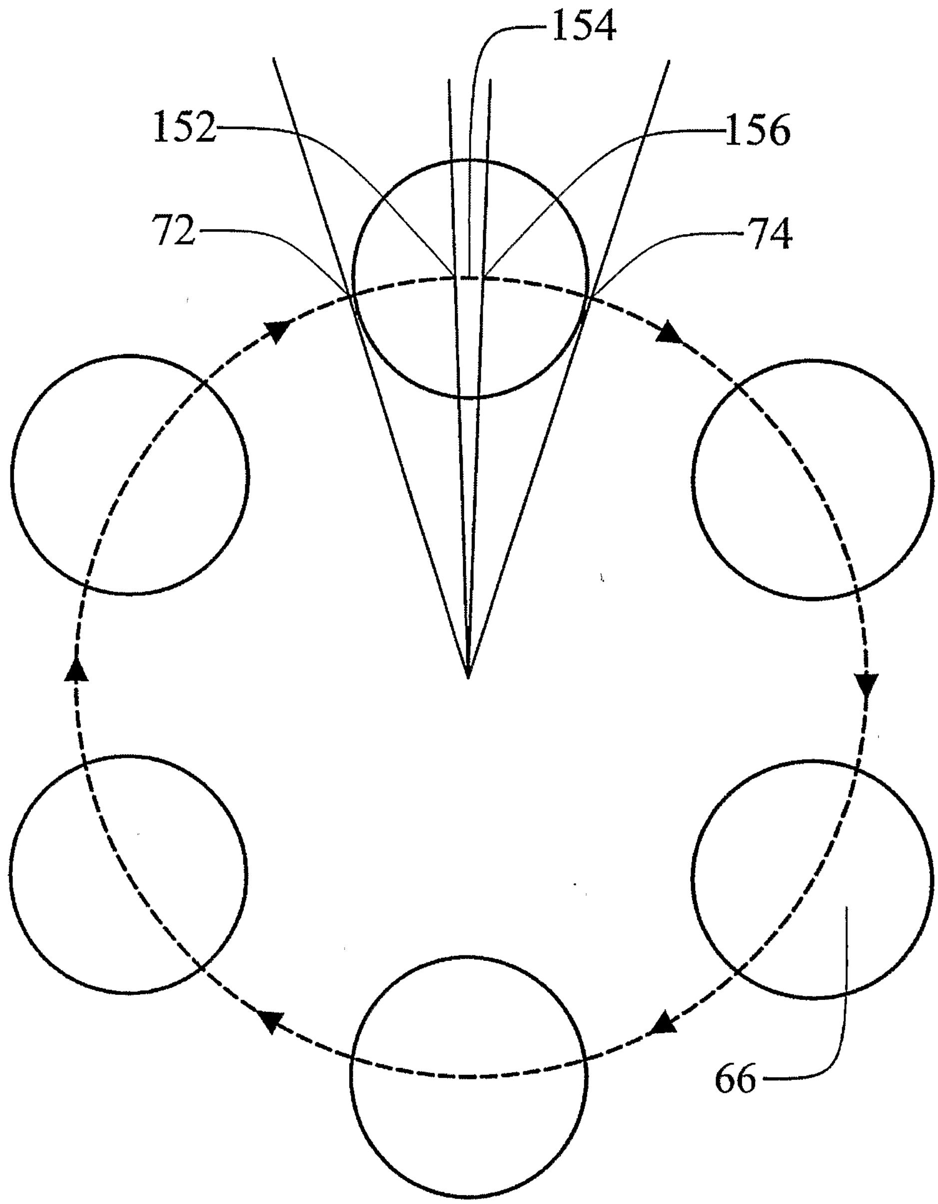


Fig 16

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/000038**

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: H01F 5/00, A61B 1/253, H02K 3/26

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, USPTO: IPC H01F, H02K, H05K, H02N, H02P, A61B, A61C, A61D, G02B 5/08, G02B 7/18, A47G 1/-, A45D 42/ & keywords: coil, planar, spiral, motor, control, sensor, polarity, speed, dental, mirror, rotating, stem, rod, arm, shaft, plurality, magnet, and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | DE 19920048 A1 (REIN CLAUS) 26 October 2000<br>Whole document | 1-15, 78,79 |
| X | WO 1995/034935 A1 (PHILLIPS ELECTRONICS N.V.) 21 December 1995<br>See whole document, especially page 1 lines 1-15, page 5 line 5 - page 12 line 6 | 1-15, 78,79 |
| X | Patent Abstracts of Japan, JP 09-233797 A (SONY CORPORATION)<br>5 September 1997<br>See abstract and Fig. 2 of the original document | 1-15, 78,79 |

[X] Further documents are listed in the continuation of Box C  [X] See patent family annex

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "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)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "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
- "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
- "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
- "&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 May 2004 | 20 MAY 2004 |
| Name and mailing address of the ISA/AU<br>AUSTRALIAN PATENT OFFICE<br>PO BOX 200, WODEN ACT 2606, AUSTRALIA<br>E-mail address: pct@ipaustralia.gov.au<br>Facsimile No. (02) 6285 3929 | Authorized officer<br>**KAREN VIOLANTE**<br>Telephone No : (02) 6283 7933 |

## INTERNATIONAL SEARCH REPORT

| International application No. |
|---|
| **PCT/AU2004/000038** |

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | Patent Abstracts of Japan, JP 05-236716 A (SONY CORPORATION) 10 September 1993<br>See abstract and Figs.1, 3, 5 and 6 of the original document | 1-15, 78,79 |
| X | US 6222333 B1 (GARNETT ET AL) 24 April 2001<br>See whole document, especially abstract, column 1 lines 10-66, Figs. 1, 3, 4a-d | 16, 18-23, 68-77, 80, 84,85 |
| X | US 6104152 A (COLES ET AL) 15 August 2000<br>See whole document, especially column 1 lines 20-45column 3 lines 9-20, column 5 lines 1-35 | 16, 18-23, 68-77,80, 84,85 |
| X | US 6219260 B1 (GOTOH ET AL) 17 April 2001<br>See whole document, especially column 3 lines 34-60, column 4 lines 8-40 and Fig.2 | 16, 18-23, 68-77,80 84,85 |
| X | US 4672274 A (SUGANUMA) 9 June 1987<br>See whole document, especially column 1 lines 5-63, column 2 lines 49-62 | 16, 18-23, 68-77,80, 84,85 |
| X | US 4731554 A (HALL ET AL) 15 March 1988<br>See whole document, especially column 1 lines 50-55, column 2 lines 24-39, column 3 lines 19-29 | 16, 18-23, 68-77,80, 84,85 |
| X | US 4130769 A (KARUBE) 19 December 1978<br>See whole document, especially column 1 lines 47-54, column 6 lines 33-55, Figs.9,10 | 16, 18-23, 68-77,80, 84,85 |
| X | US 4261637 A (KING) 14 April 1981<br>See whole document | 24-53,81 |
| P,X | US 2004/0076019 A1 (TSIMERMAN ET AL) 22 April 2004<br>Whole document, in particular Figures 2 and 17. | 24-53, 81 60-67, 83 |

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/000038**

| C (Continuation) | DOCUMENTS CONSIDERED TO BE RELEVANT | |
|---|---|---|
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | Patent Abstracts of Japan, JP 56-134325 A (MATSUSHITA ELECTRIC IND CO LTD) 21 October 1981<br>See abstract and Fig. 1 of the original document | 60-67, 83 |
| X | Patent Abstracts of Japan, JP 11-271595 A (AIDA ENG LTD) 8 October 1999<br>See abstract and Figs. 1- 4 of the original document | 60-67, 83 |
| A | Patent Abstracts of Japan, JP 59-191148 A (MITSUBISHI ELECTRIC CORP) 30 October 1984<br>See abstract and Figs. 1, and 2 of the original document | 60-67, 83 |

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/000038**

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box III for full explanation.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
   1-53, 60-81, 83-85
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☒ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

**Supplemental Box**
(To be used when the space in any of Boxes I to VIII is not sufficient)

**Continuation of Box No: III**

Following inventions have been identified in relation to respective groups of claims:

1. Claims 1-15, 78, 79 are directed to a coil or winding comprising a planar insulative substrate and a flat conductive track.

2. Claims 16-23, 68-77, 80, 84 and 85 are directed to a speed control circuit for a motor, comprising a magnetic field generator, a polarity reversal means and the means to control the power applied to coil elements, and a motor comprising such a speed control circuit.

3. Claims 24-53, 60-67, 81 and 83 are directed to a mirror comprising a body having a two magnets, and an axial stem, and an apparatus for dental and medical use comprising such a mirror.

4. Claims 54-59, 82 are directed to a bearing comprising a base and a plurality of arms.

Since the above mentioned groups of claims do not share any of the technical features identified, a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept, a priori.

It is considered that search and examination for the second, third and fourth inventions would require more than a negligible additional search and examination effort over that for the first invention.

As the applicant has only paid additional search fees for inventions 2 and 3, only inventions 1-3 have been searched and examined.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
**PCT/AU2004/000038**

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 | | | | | |
|---|---|---|---|---|---|---|---|
| DE | 19920048 | | NONE | | | | |
| WO | 9534935 | EP | 0765540 | US | 5644183 | | |
| JP | 9233797 | | NONE | | | | |
| JP | 5236716 | | NONE | | | | |
| US | 6222333 | | NONE | | | | |
| US | 6104152 | AU | 13891/97 | EP | 0873587 | US | 6124688 |
| | | WO | 9725767 | | | | |
| US | 6219260 | JP | 2000354389 | | | | |
| US | 4672274 | DE | 3609218 | JP | 61218384 | JP | 61218385 |
| US | 4731554 | | NONE | | | | |
| US | 4130769 | JP | 51051708 | JP | 51056902 | | |
| US | 4261637 | | NONE | | | | |
| US | 2004/0076019 | WO | 2004/034891 | | | | |
| JP | 56-134325 | | NONE | | | | |
| JP | 11-271595 | | NONE | | | | |
| JP | 59-191148 | | NONE | | | | |

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX