

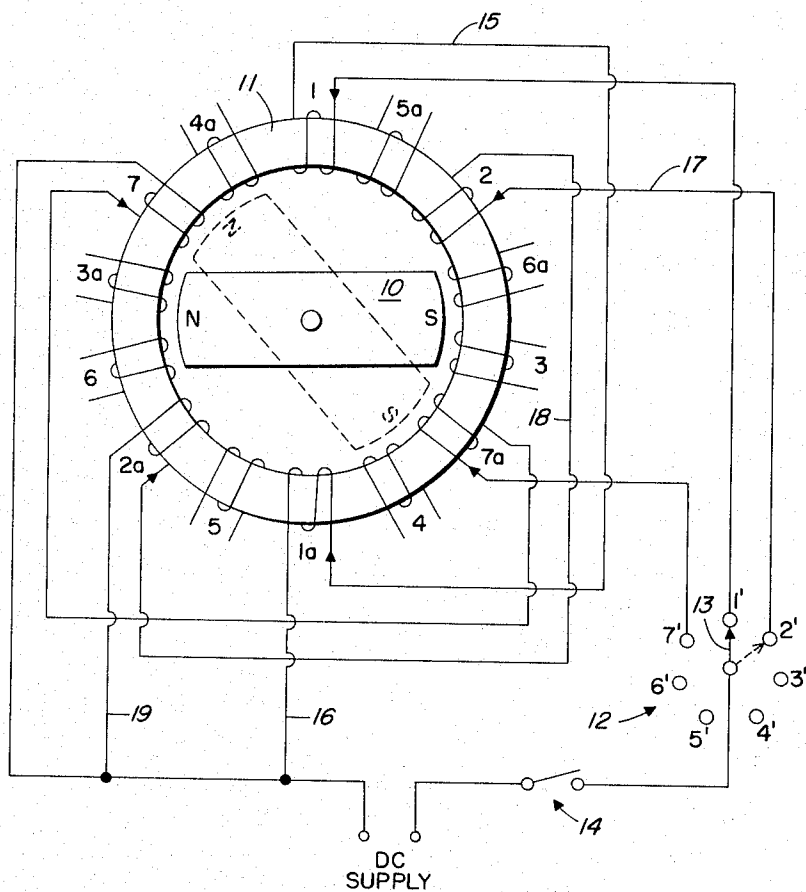
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ELECTROMAGNETIC STEPPING DEVICE

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ELECTROMAGNETIC STEPPING DEVICE

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ABSTRACT OF THE DISCLOSURE

This invention describes an electromagnetic stepping device in which a rotatable member can be rotated in incremental fashion without the necessity of changing the polarity of the energizing source. The device is composed of a toroidal magnetic core around which is wound a plurality of pairs of coils. The coils of each pair are spaced 180° apart on the core and are serially connected. An odd number of pairs of coils is utilized and therefore a rotatable member which is located within the toroidal core is never required to rotate exactly 180°. This feature prevents the rotor from hanging up at instances requiring approximately a half revolution of rotation. A stepping switch having a number of contacts equal to the number of pairs of coils is also provided. The successive contacts of the switch are connected to alternate pairs of coils. Because the contacts and pairs of coils are connected in this manner the rotor is capable of a full 360° rotation in a smooth incremental fashion.

This invention relates to an apparatus for controlling the angular position of the rotor of an electromagnetic device in incremental fashion through a full revolution.

In the prior art devices a change of rotor position exceeding 180° and the reversal of the direction of rotor rotation requires a change of polarity of the energizing source. This requirement is undesirable because:

(1) It prohibits a smooth rotation of the rotor.

(2) The time required for the decay of the existing magnetic field and the build-up of a new magnetic field unduly restricts the response time of the device.

(3) A switching of two leads is required.

The present invention overcomes this disadvantage by using a uniquely wound toroidal core in conjunction with a novel switching arrangement. These novel features enable the rotor of the electromechanical device to be rotated either clockwise or counterclockwise through a full revolution by the switching of a single lead. These features are of particular significance in the control of a radio tuning dial, the control of aircraft control surfaces, and the recording of computer information where a smooth rotor movement is necessary and space and weight considerations are important.

It is an object of this invention to provide an electromagnetic stepping device which can be rotated through a full revolution without a change of polarity of the energizing source.

It is another object of this invention to provide said device with a switching arrangement which enables the rotor of the device to be rotated in either direction by the switching of a single lead.

Novel features which are believed to be characteristic of the invention, both as to construction and method of use, together with further objects and advantages, may best be understood by reference to the following description of a preferred embodiment taken in conjunction with the accompanying drawing in which the only figure shows a schematic presentation of the novel concept.

The figure shows a toroidal magnetic core 11 wound with a number of identical coils numbered 1 through 7 and 1a through 7a. A rotor 10 is concentrically positioned

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within the core for rotation about an axis perpendicular to the plane of the core 11, rotor 10 being polarized at its ends as shown in the figure. A switch 12 comprising seven contacts 1' to 7' and a conductive rotatable arm 13 connected to a DC supply through a switch 14 controls the rotation of rotor 10. Arm 13 is connected at its pivot end to switch 14 to energize a selected pair of coils. The coils are spaced at equal angular distances around coil 11 so that each is 180° from another. The figure shows coils 1 and 1a, 2 and 2a, etc. to be 180° apart to form seven pairs of coils, the coils comprising each pair being connected in series. Because of the series connection, the coils, when energized, will form magnetic fields which coact to hold the rotor in a position between the energized coils wherein the polar axis of the rotor (i.e., N to S along the rotor) is perpendicular to a line drawn through the two coils. This position is maintained until arm 13 is moved to a different contact on switch 12 thereby energizing a different pair of coils and de-energizing the first pair, such energization causing the rotor 13 to assume a similar position between the newly energized coil pair. Switch 14 is used to de-energize the entire system and can be incorporated into the DC supply.

In the figure only the three contacts identified 1', 2' and 7' are shown wired to coil pairs 1, 2, and 7 respectively. The remaining four contacts are similarly wired, the wiring being omitted for simplicity. Contact 1' is shown connected to the right side of coil 1 to enable current to pass through the coil 1, via conductor 15 to the right side of coil 1a through coil 1a and via conductor 16 to the ground side of the DC supply. With arm 13 in this position, rotor 10 assumes the position shown in the figure. Upon movement of arm 13 from contact 1' to contact 2' current is seen to flow via conductor 17 into the right side of coil 2 through said coil and via conductor 18 into the right side of coil 2a through said coil and on to the ground side of the DC supply via conductor 19. With coils 2 and 2a energized, rotor 10 assumes the position shown in broken lines in the figure. A change of arm 13 to the successive switch positions 3' through 7' and back to 1' will therefore effect a 360° rotation of rotor 10. It can readily be seen that a movement of arm 13 from position 1' to 7' will cause rotor 10 to rotate counterclockwise to a position perpendicular to a line connecting coils 7 and 7a. It is therefore evident that rotation of arm 13 counterclockwise through contacts 7' to 1' will cause a 360° counterclockwise rotation of rotor 10. The continuous 360° rotation of rotor 11 is possible because successive switch contacts are connected to alternate coil pairs. This is evidenced by the figure where coil 5a is shown between coils 1 and 2 but switch positions 1' and 2' are adjacent.

The coils 1 to 7 and 1a to 7a are identically wound over a portion of core 11 such that each coil covers a portion of the core equal to $180/2n+1$ where $2n+1$ equals the number of pairs of coils. By energizing a contact on switch 12 immediately following its adjacent contact the rotor is caused to rotate through an angular increment equal to $360/2n+1$. It is therefore evident that the increments of angular rotation of rotor 10 can be decreased by increasing the number of pairs of coils wound about core 11. In the embodiment shown, seven pairs of coils are used. However, it should be noted that any odd number of pairs of coils can be used within the purview of the instant invention.

Although this invention has been described with respect to a particular embodiment thereof, it is not to be so limited, as changes and modifications may be made therein which are within the spirit and scope of the invention as defined by the appended claim.

I claim:

1. A rotary stepping device comprising, a toroidal magnetic core, a two-pole rotor mounted concentrically within said core for rotation therein, $2n+1$ pairs of coils wound around said core, where n is an integer, each coil covering $180/2n+1$ degrees of said core, and the two coils comprising each pair being serially connected and spaced 180° apart, a switch having a rotatable arm and $2n+1$ permanent contacts, each succeeding contact being connected through alternate pairs of said coils to a single ground lead, said arm being connected to said ground lead so that positioning said arm against one of said contacts energizes the pair of said coils connected to said contact and effects rotation of said rotor through an

angular increment equal to $360/2n+1$ degrees to a position between the coils comprising said pair, the movement of said arm to the next succeeding contact effecting rotation of said arm to a position between an alternate pair of coils.

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