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M. B. COTTON

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LATCHING MEANS FOR SOLENOID DEVICES

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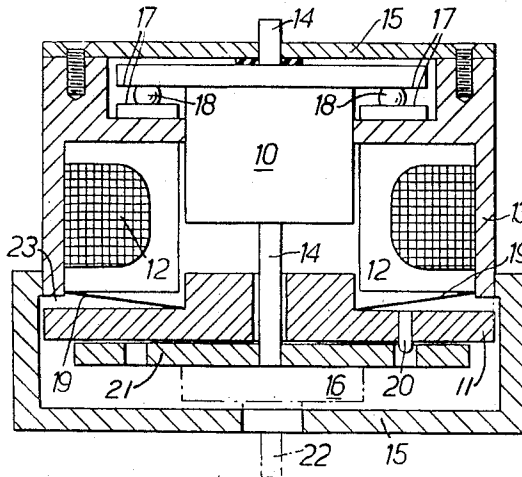


FIG. 1.

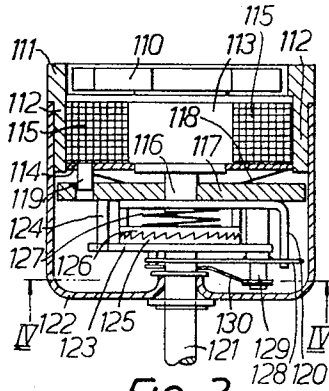


FIG. 2.

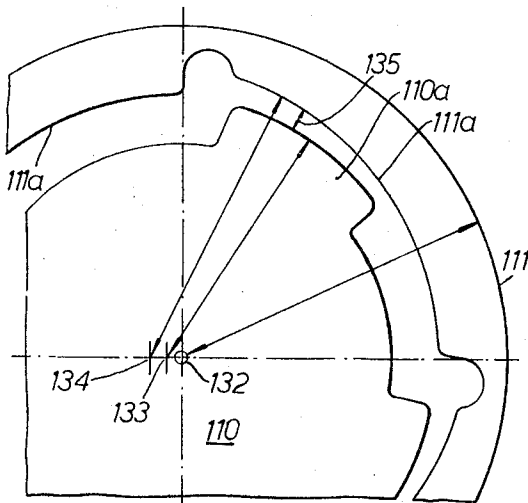


FIG 4

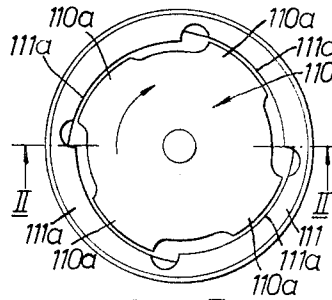


FIG. 3.

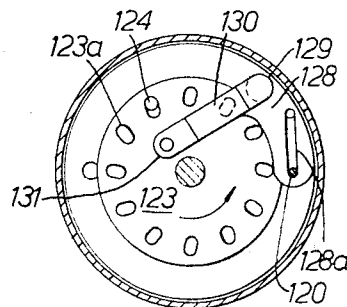


FIG. 5.

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LATCHING MEANS FOR SOLENOID DEVICES

Michael B. Cotton, Emsworth, England, assignor to Plessey-UK Limited, Ilford, England, a British company

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6 Claims. (Cl. 335—253)

This invention relates to electro-magnetic solenoid devices.

According to the invention, an electro-magnetic solenoid device includes a pair of co-operating magnetic pole pieces forming part of a magnetic circuit and arranged for relative movement when the magnetic circuit is energized by a magneto-motive force to a minimum reluctance relative position, the device having an output member moving in correspondence with a relative movement of the pole pieces and a locking member normally preventing movement of the output member and being disengaged to permit movement of the output member on and by energization of the magnetic circuit.

According to a feature of the invention the locking device includes a further pole piece (hereinafter termed locking device pole piece) movable between positions in which it causes the engagement and disengagement respectively of the locking device, the locking device pole piece being part of a magnetic circuit of solenoid device and arranged so that an airgap separating the locking device pole piece and one of the first mentioned pole pieces is engaged position than when the locking device pole piece is in its disengaged position.

The invention is particularly, though not exclusively, applicable to solenoid devices for producing rotary movement; according to another feature of the invention in such a device the two pole pieces have opposed faces which together define an air-gap in the magnetic circuit of the device, the mutually opposed area of the two said faces being constant irrespective of the relative position of the pole pieces and each said face being an arcuate surface having its axis parallel with and opposite from the axis of relative rotation of the pole pieces.

The foregoing and other features of the invention will be evident from the following description of two solenoid devices embodying preferred forms of the invention. The description refers to the accompanying drawings, in which:

FIGURE 1 shows an axial cross section of one form of solenoid device,

FIGURE 2 shows an axial cross section of a second form of solenoid device,

FIGURE 3 shows in plan the arrangement of the pole pieces of the device shown in FIGURE 2,

FIGURE 4 shows on a larger scale the profile of the pole pieces shown in FIGURE 3, and

FIGURE 5 shows a cross section of the device shown in FIGURE 2 on the line marked IV—IV in that figure.

The device shown in FIGURE 1 includes a pair of pole pieces 10 and 11 of magnetic material mounted for relative movement within the magnetic field produced by a winding 12. The lower pole piece 11 cannot rotate in relation to the frame 13 of the device, but has a limited degree of axial movement. The other pole piece 10 can rotate relative to pole piece 11 by the rotation of a shaft 14 to which it is secured and by which it is located in the end plates 15 of the device. A ratchet mechanism 16, not detailed, is free to slide axially in the bearings by which it is located in the end plates 15.

Movement of the pole pieces 10 and 11 towards each other in response to the energization of the magnetic circuit by winding 12 is translated into rotary motion of

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the shaft 14 by means of a pair of opposed cam surfaces 17, separated by a series of ball bearings 18, one of the cam surfaces being attached to a frame member and the other rotating with shaft 14.

A rotational return spring biases shaft 14 towards the angular position corresponding to the maximum separation of pole pieces 10 and 11. A further spring 19 biases the lower pole 11 away from the upper pole piece 10.

A stud carried by the lower pole piece 11 engages, when the pole pieces are in their rest position, in one of a series of holes in a locking disc 21, located on the shaft 14 and driven by it through a conventional ratchet mechanism 16, not detailed. The locking disc 21 carries the housing of the ratchet mechanism and the output shaft 22.

When the winding 12 is energized the two pole pieces are attracted towards each other. Movement of pole piece 10 is prevented since shaft 14 to which it is attached is locked by stud 20 engaging locking disc 21. The initial relative movement of the pole pieces is therefore made by the lower pole piece 11, which moves axially until it closes the air-gap 23 and in so doing lifts the locking stud 20 out of the hole in disc 21. The lower of the two end plates 15 is made of non-magnetic material to avoid shunting the air-gap 23. The shaft 14 is thereby freed and can rotate in response to continued relative movement of the pole pieces and can thereby rotate the output shaft 22 through the ratchet mechanism. When the magnetic circuit is de-energized the pole pieces are urged towards their rest positions, the locking stud 20 entering the hole in the plate 21 corresponding to the next index position and holding it there while the shaft 14 rotates to its rest position on the free stroke of the ratchet.

In the embodiment of the invention shown in FIGURES 2 to 5 of the drawings, the rotor and stator of the solenoid device are arranged for rotational relative movement on energization without the unwanted axial movement inherent in the device described with reference to FIGURE 1. The relatively moving pole pieces in this form of the invention comprises a disc 110 of magnetic material provided with projecting pole pieces 110a, and an annular pole ring 111, provided with pole face areas 111a that will be defined in more detail later and forming the upper part of an annular magnetic shell member 112. The magnetic circuit also includes a central pole piece 113, fixed in relation to the body of the device and retained in position by non-magnetic locating discs 114 which also embrace and secure in position the energizing coil 115 of the magnetic circuit.

The rotatable armature 110 is fixedly secured to a shaft 116 journaled in the coil end plates 114. A locking device pole piece 117 in the form of a disc of magnetic material fits loosely over the shaft 116, being free to slide on this shaft and being biased away from the rim of the outer shell member 112 by a light spring 118. Rotation of the locking device pole piece 117 in relation to the body of the device is prevented by a fixed peg 119 which enters the hole in the disc 117. A driving cage 120 is fixedly secured to the lower end of the shaft 116.

The output shaft 121 of the device is journaled in the non-magnetic casing 122 enclosing the lower part of the mechanism, and has a locking disc 123 secured to its upper end. A pin 124 secured to the locking device pole piece 117 co-operates with any one of a series of short slots 123a formed in the locking disc 123 so as to prevent movement of the output shaft 121. The locking disc 123 also carries a ratchet wheel 125, which co-operates with a similar ratchet wheel 126 driven through the driving cage 120 from the armature shafts 116 and biased downwardly into engagement with the output ratchet wheel by a spring 127.

A secondary locking arm 128 pivoted on a mounting pin 129 is biased towards the under face of the locking disc 123 by a spring 130, so that a pin 131 carried by the end of the secondary locking arm 128 can, if the arm is suitably positioned, enter one of the slots 123 in the locking disc. The arm 128 is rotated by the engagement of the bent-over end of the driving cage 120 with a slot 128a formed in the locking arm.

With the energizing winding 115 de-energized, the output shaft 121 is locked against rotation by the engagement of pin 124 with one of the slots in the locking disc 123. If the winding 115 is energized, the first result is that the magnetic flux in the circuit comprising the central core 113 of the winding, the armature 110, the outer pole shell 112 and the locking device pole piece 117 causes the last mentioned pole piece to move upwardly so as to reduce or close the air-gap between its peripheral face and the end face of the outer pole shell 112. In performing this action against the bias of spring 118 the locking device pole piece 117 causes its locking peg 124 to be retracted from the corresponding slot in the locking disc 123.

With the moving system now free to turn, the rotating system moves through an angle of about 30° under the influence of the magnetic flux across the air-gaps separating the opposed faces of the fixed and moving pole pieces 110a and 111a. The form of these pole pieces is more clearly shown in FIGURE 4 of the drawings. In this figure, reference 132 denotes the axis of rotation of the moving system, which is also the axis of the cylindrical outer surface of the fixed pole piece 11. The co-operating pole piece faces 110a and 111a are arcuate in form and also have approximately the same radius of curvature: but their axes 133 and 134 are offset from the principal axis 132 of the device. The opposed area of any one pair of co-operating pole surfaces thus remains constant and equal to the armature pole piece area 110a irrespective of the relative position of the fixed and moving pole pieces; but the air-gap 135 separating the two pole faces decreases progressively during rotation of the rotatable pole piece 110 through an angle of perhaps 30° or 45° in a clockwise direction. The effect of a magnetic flux traversing this air-gap is therefore to cause rotation of the armature 110 so reducing the air-gap 135 to a minimum reluctance value.

The armature 110 in thus rotating drives the output shaft 121 through the engaged ratchet wheels 125 and 126. During this rotation the secondary locking arm 128 is rotated across the face of the locking disc 123 by the movement of the driving pin 120 in its slot 128a. At the end of the working stroke of the device the peg 131 carried by the secondary locking arm engages with one of the slots 123a in a locking disc 123, arresting the movement of the output shaft and providing positive indexing of the output shaft at the end of its working stroke. This condition continues as long as the winding 115 is energized.

When the winding is de-energized the locking device pole piece 117 moves outwardly under the influence of its spring 118 and the locking peg carried by it enters the same slot in locking disc 123 as the secondary locking pin 131, which is pushed out of engagement with the locking disc. Simultaneously, armature 110 returns to its rest position under the action of the re-set spring (not shown) and in so doing returns the secondary locking arm 128 to the rest position shown in FIGURE 5 of the drawings. The device is thus reset for the next operation. The arrangement shown in these drawings thus permits a stepping solenoid to be operated without the occurrence of unwanted axial movement of the armature, rotational movement being generated directly and imparted to the output shaft through the ratchet device.

What I claim is:

1. An electromagnetic solenoid device including electromagnetic driving means having an armature and an energizing winding, said armature being arranged for movement to a minimum reluctance position in response to the energization of said winding, an output member coupled to said armature, and a first locking means for preventing movement of said output member in the de-energized condition of said winding, said locking means including a magnetic member displaceable by the magnetic flux produced in response to the energization of said winding to render the locking means ineffective and thereby release the output member for movement by said armature.

2. An electromagnetic solenoid device as claimed in claim 1, comprising a rotatable armature and rotatable output member, the locking device including a slidably mounted magnetic member arranged to be displaced to a minimum reluctance position when the winding is energized to effect the withdrawal of pin means of the locking means from an aperture thereby releasing the output member so that the said output member can rotate in response to rotation of said armature.

3. An electromagnetic solenoid device as claimed in claim 2, including second locking means operable at the completion of a predetermined angular movement of said armature to arrest the output member, clutch means for preventing the rotation of the armature to its starting or initial position while the output member is held against such movement by the locking means on the de-energization of the winding.

4. An electromagnetic solenoid device as claimed in claim 3, wherein the clutch means comprises inter-engaging ratchet wheels coupled respectively to the output member and said armature, spring means acting on said armature and biasing said armature against movement thereof upon the energization of said winding, said spring means being effective upon the de-energization of said winding to cause relative rotation between said ratchet wheels to permit restoration of said armature to its starting position.

5. An electromagnetic solenoid device as claimed in claim 4, in which the first locking means includes a pin mounted on the slidably mounted magnetic member which selectively engages in apertures in an apertured plate fastened to the output member and in which the second locking means includes pin means arranged to engage in apertures of the apertured plate at the end of a predetermined movement of the armature, the pin means of the second locking means being ejected from the apertured plate by the pin of the first locking means consequent upon the de-energization of the winding and the restoration of the slidably mounted magnetic member to its normal position.

6. An electromagnetic solenoid device as claimed in claim 1, comprising a rotatable armature including pole pieces and a stator structure also including pole pieces, said armature and stator pole pieces having opposed faces which together define an air gap, the mutually opposed area of the two said faces being constant irrespective of the relative position of the pole pieces and each said face having an arcuate surface having its axis parallel with an offset from the axis of relative rotation of the pole pieces.

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BERNARD A. GILHEANY, *Primary Examiner*.

G. HARRIS, *Assistant Examiner*.