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STEPPING MECHANISMS

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Fig. 1

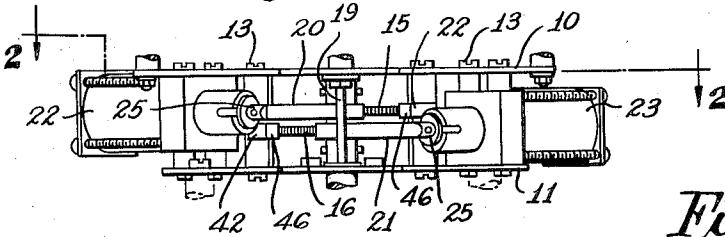


Fig. 4

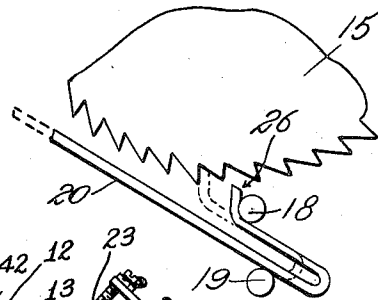


Fig. 2

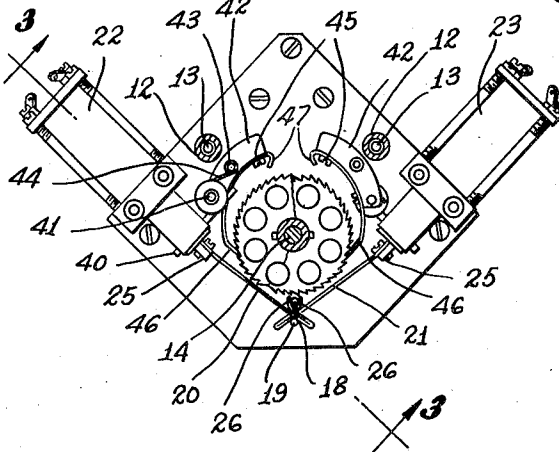
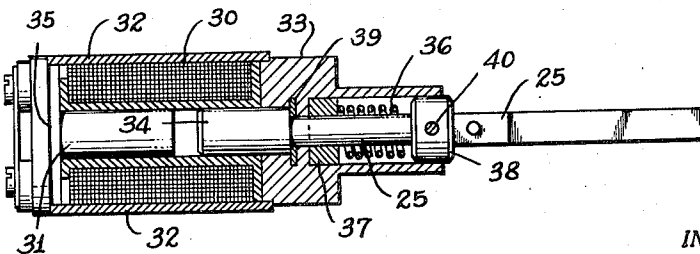


Fig. 3



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STEPPING MECHANISMS

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12 Claims. (Cl. 74—128)

This invention relates to electrical stepping mechanisms of the kind in which a rotatable member is rotated in stepwise movements by two solenoids, one or other of which is operated in accordance with the required direction of rotation.

It is one of the objects of the present invention to provide an improved construction of mechanism of this kind which will reliably drive the rotatable member by only one step at a time in response to each impulse on a solenoid without any possibility of either missing a step or jumping two steps.

According to this invention in an electrical stepping mechanism of the kind set forth above, said rotatable member has two sets of ratchet teeth arranged in opposite directions and associated respectively with the two solenoids, each of which solenoid is arranged, when energised, to operate a claw so as to engage a tooth of the associated set and pull that tooth through one step and also, when energised, to operate a spring-loaded escapement mechanism associated with the other set of teeth, so as to disengage, at the beginning of the operating stroke, the pawl which prevents rotation and to engage, at the end of the stroke, a latch for preventing further rotation in the same direction. With this construction neither of the operating claws are normally in engagement with the teeth. The two pawls in engagement with their respective sets of teeth will normally hold the rotatable member against rotation in either direction. When one of the solenoids is operated its claw moves into engagement with one set of teeth and at the same time the solenoid releases the appropriate pawl to permit rotation in one direction only. The claw pulls the rotatable member around but, even if this member should acquire substantial momentum, it is prevented from moving more than one step by the engagement of the latch at the end of the operating stroke. This latch stops the rotatable member. During the return movement of the claw there is no possibility of the rotatable member being turned in the opposite direction since the second pawl is still in engagement. This return movement of the operating claw and of its associated armature in its solenoid will release the spring-loaded escapement so as to allow the pawl to fall back into engagement with its teeth. The rotatable member is thereby locked against movement in either direction by the two pawls. It will be appreciated that with this construction the two solenoids must not be operated simultaneously and provision would be made in the electrical operating circuits to ensure this.

Each escapement mechanism may comprise a rigid member freely pivoted and spring-loaded in a direction to engage the pawl and conveniently the movable part of each solenoid assembly has a portion adapted to bear against a roller mounted on the escapement mechanism. By this arrangement the solenoid, when operated, moves the rigid member to disengage the pawl but the pawl and rigid member can be moved freely against the spring-loading without operation of the solenoid. This freedom

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of movement of the spring-loaded pawl ensures that when the rotatable member is being turned in one direction the pawl preventing rotation in the other direction can ride over its associated teeth but is maintained by the spring-loading in engagement with the teeth. In this construction the pawl and latch of each escapement mechanism may be formed of a length of stiff spring strip attached to the pivoted rigid member and extending on either side of the pivot axis. The spring strip is made substantially stiffer than the spring loading the rigid member and merely provides a slightly resilient pawl and latch thereby taking up any shocks on engagement. Conveniently the pawl is formed by a relatively long arm of the spring strip so that it is quickly disengaged when the rigid member is turned about its pivot axis by the solenoid. The latch on the other hand need only be on a relatively short arm so as to be engaged only at the very end of the operating stroke.

The claws may each be formed of a spring strip which extends from the solenoid alongside the toothed member, the end portion of the strip being bent back so that the end of the strip can engage its associated teeth. In this construction guide means may be provided on either side of the bent part of the strip to ensure that the end of the strip engages the teeth when the solenoid is energised but is held clear of the teeth when the solenoid is not energised. These guide means may comprise a pair of pins which are freely rotatable or have freely rotatable sleeves between which the bent part of the strip extends. Conveniently a single pair of pins are spaced on a line extending from the centre of rotation of said rotatable member and the two solenoids are arranged with their directions of operation at right angles to one another and at 45 degrees to this line so that both strips can pass between the single pair of pins.

Each solenoid preferably comprises an armature movable into a coil, which coil has a ferro-magnetic core extending from inside the coil at one end thereof externally around the coil to embrace the armature at the other end of the coil, the armature and core being arranged so that, when the armature is fully into the coil, there is an air gap introduced between the armature and the external part of the core on the last part of the stroke. This air gap ensures that there is some reluctance in the magnetic circuit thereby facilitating the release of the armature. The return movement of the armature may conveniently be effected by a spring.

The following is a description of one embodiment of the invention reference being made to the accompanying drawings in which:

Figure 1 is a vertical elevation of a stepping mechanism;

Figure 2 is a section along the line 2—2 of Figure 1;

Figure 3 is a sectional view of a solenoid and armature along the line 3—3 of Figure 2; and

Figure 4 is an enlarged fragmentary plan view of one of the two operating claws shown on a smaller scale in Figure 2.

Referring to Figures 1 and 2 of the drawing, there is shown a stepping mechanism comprising a pair of parallel plates 10, 11 which are held in fixed spaced relationship by means of spacers 12 and bolts 13. Extending between these plates and journaled therein is a shaft 14 on which are secured two ratchet wheels 15, 16. These ratchet wheels are similar except that their teeth are arranged in opposite directions. As seen in Figure 2, on a radial line from the axis of the spindle are two pins 18, 19 which are rotatably journaled in the plates 10, 11 and which are parallel to the shaft 14 carrying the ratchet wheels 15, 16. These pins form guides for two operating claws 20, 21 which are attached to the armatures of sole-

noids 22, 23 respectively, these armatures having their lines of operation at right angles to one another and at 45 degrees to the radial direction of the two pins 18, 19. Each of the claws 20, 21 comprises a strip of stiff spring metal which at one end is attached to a rod 25 secured to the respective armature of the associated solenoid. The other end of the strip is bent back on itself as shown at 26 (Figure 4) to form a V-shaped portion such that the end of the strip points towards the axis of said shaft 14. These V-shaped portions of the two claws lie between the two pins 18, 19 and these pins form guides maintaining the strips 20, 21 in the correct position so that when the armature of a solenoid is withdrawn, the end of the strip is brought into engagement with a tooth on the associated wheel and moves with the tooth through one step.

As is shown in Figure 3, each of the solenoids comprises a coil of wire 30 wound upon the central arm 31 of a core, this arm extending about half the length of the coil. The outer part of the core is in the form of a cylinder 32 extending around the outside of the coil and is joined to a further core piece 33 which embraces the armature 34 at the far end of the coil i. e. the end remote from the plate 35 which completes the magnetic circuit between the core 31 and cylinder 32. The armature 34 is provided with an extension forming the aforementioned rod 25 to which the operating claw (20 or 21) is attached. Around this rod 25 is arranged a helical spring 36 one end of which bears against a bush 37 secured in the core piece 33 and the other end of which bears against a collar 38 on the rod 25 so as to urge the armature outwardly from the coil. The bush 37 and collar 38 are made of sintered bronze impregnated with oil to form self-lubricating bearings. The armature is formed so that, when the coil 30 is energised so as to attract the armature into the coil, an air gap is opened between the armature 34 and the embracing portion 33 of the core on the last part of the stroke. This air gap ensures that there is some reluctance in the magnetic circuit when the solenoid energising circuit is broken and thereby enables the armature 34 to be readily returned by the helical spring 36. A small brass washer 39 is arranged between the armature 34 and the part 33 of the core in order to ensure that the magnetic field enters the armature at right angles to the axis of the armature thereby facilitating the rapid movement of the armature when the coil 30 is energised.

A transverse pin 40 (Figure 2) is arranged to extend through the aforementioned collar 38 and this pin 40 serves not only to secure the collar to the rod 25 but also extends through slots in the core piece 33 and bears against a roller 41 mounted on one side of an escapement member 42. Two such escapement members are provided, associated respectively with the two solenoids. Each escapement member is freely pivoted at 43 between the plates 10 and 11 but is provided with a spring 44 which biases the roller 41 to bear against the pin 40. The escapement members 42 are each formed of a rigid arcuate member pivoted near its centre and having attached on its near side a stiff spring strip 45. The end 46 of the strip which is biased towards the ratchet wheels is arranged as a pawl which engages one of the ratchet wheels in such a manner as to prevent rotation of the wheels in one direction. The two escapements engage the two wheels 15, 16 respectively and normally hold the wheels against rotation. Initial movement of one of the solenoids, however, releases the pawl 46 on one escapement so as to permit rotation of the wheels by the appropriate solenoid-operated claw 20 or 21. The arm of each escapement member remote from the pawl is formed into a latch 47 which engages, at the end of the operating stroke of the appropriate solenoid, the same ratchet wheel as is released by the pawl. The latches on the two escapements serve to stop the wheels rotating at the end of each stroke even if they should have acquired momentum

during the operating of the armature. The spring biasing on each escapement mechanism permits movement of that escapement when the ratchet wheels are rotated in the direction permitted by the pawl of that escapement but it serves to keep the pawl in engagement so as to prevent any reverse movement of the ratchet wheels on the return movement of the operating claw.

It will be seen that in the above described stepping mechanism, the escapements serve to ensure that the wheels can rotate only one step in the appropriate direction whenever a solenoid is engaged. If the armature of the solenoid moves through the small travel necessary, the wheels will rotate one step and there is no possibility of either missing a step or of jumping two steps.

I claim:

1. An electrical stepping mechanism comprising a main frame, a rotatable member rotatably mounted in said frame and having two sets of ratchet teeth arranged in opposite directions, a pair of solenoids one or other of which is energised in accordance with the required direction of rotation, a pair of armatures operated respectively by said solenoids, a pair of claws, one on each armature, arranged to engage respectively said sets of ratchet teeth when the appropriate solenoid is energised to pull said rotatable member through one step, a pair of spring-loaded escapement mechanisms associated respectively with said two sets of teeth and each having a pawl and a latch and means coupling the armatures respectively to the two escapement mechanisms so that when a claw is moved by an armature to engage one set of teeth, the pawl of the escapement mechanism associated with the other set of teeth is disengaged at the beginning of the operating stroke to permit of rotation of the rotatable member in the required direction and the latch is engaged at the end of the stroke to prevent further rotation in the same direction.

2. An electrical stepping mechanism as specified in claim 1 in which each escapement mechanism includes a rigid member carrying said pawl and latch, a pivot freely pivoting said rigid member on said frame, spring means urging said rigid member in a direction to engage the pawl with the ratchet teeth, and a roller mounted on the rigid member; and in which the armature of each solenoid includes a portion adapted to engage said roller upon movement of the armature.

3. An electrical stepping mechanism as specified in claim 2 in which the pawl and latch of each escapement mechanism comprises a length of stiff spring strip attached to the rigid member and disposed with the ends thereof on opposite sides of said pivot.

4. An electrical stepping mechanism as specified in claim 1 in which the claws are each carried near one end of a spring strip secured at its other end to the armature of the solenoid and extending alongside the rotatable member; in which a pair of spaced pins are secured to the frame on a radial line extending from the center of rotation of said rotatable member; and in which the two solenoids are arranged to dispose said spring strips between said pair of pins to ensure that the claws engage the teeth when the solenoids are energized but are held clear of the teeth when the solenoids are not energized.

5. An electrical stepping mechanism as specified in claim 3 in which the two solenoids are arranged to dispose said spring strips at right angles to each other and at 45° to said radial line.

6. An electrical stepping mechanism comprising: a main frame; a rotatable member rotatably mounted in said frame and having two sets of ratchet teeth arranged in opposite directions; a solenoid; an armature operated by said solenoid; a claw on said armature arranged to engage one of said sets of ratchet teeth when said solenoid is energized to pull said rotatable member through one step; a spring loaded escapement mechanism having a pawl and a latch disposed to cooperate

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with the other of said sets of ratchet teeth, said pawl being normally engaged therewith and said latch being normally disengaged therefrom; and means coupling the armature to the escapement mechanism so that when the claw is moved by the armature to engage said one set of teeth, the pawl of the escapement mechanism is disengaged from the other set of said teeth at the beginning of the operating stroke to permit of rotation of the rotatable member and the latch is engaged therewith at the end of the stroke to prevent further rotation.

7. An electrical stepping mechanism as specified in claim 5 in which said escapement mechanism includes a rigid member carrying said pawl and latch, a pivot freely pivoting said rigid member on said frame, spring means urging said rigid member in a direction to engage the pawl with the ratchet teeth, and a roller mounted on the rigid member; and in which the armature includes a portion adapted to engage said roller upon movement of the armature.

8. An electrical stepping mechanism as specified in claim 6 in which the pawl is disposed a relatively great distance from said pivot and the latch is disposed a relatively short distance therefrom.

9. An electrical stepping mechanism as specified in claim 5 in which the claw is carried near one end of a spring strip secured at its other end to the armature of the solenoid and extending alongside the rotatable member.

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10. An electrical stepping mechanism as specified in claim 8 in which said claw comprises a portion of said strip adjacent said one end bent back upon itself and inwardly toward said rotatable member to dispose said end in a position to engage said ratchet teeth upon movement of said armature.

11. An electrical stepping mechanism as specified in claim 9 in which guide means are provided embracing the bent part of the strip to ensure that the end of the strip engages the teeth when the solenoid is energized but is held clear of the teeth when the solenoid is not energized.

12. An electrical stepping mechanism as specified in claim 5 in which said solenoid comprises a coil, an armature movable into said coil, a ferro-magnetic core extending from inside the coil at one end thereof and externally around the coil to a core piece embracing the armature at the other end of the coil, the armature and said core piece being so arranged that an air gap is introduced between the armature and the core piece when the armature is fully into the coil.

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