

Oct. 25, 1955

D. SOUTER

2,721,904

DRIVING APPARATUS

Filed July 3, 1951

FIG. 1

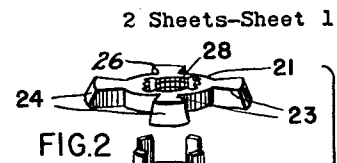
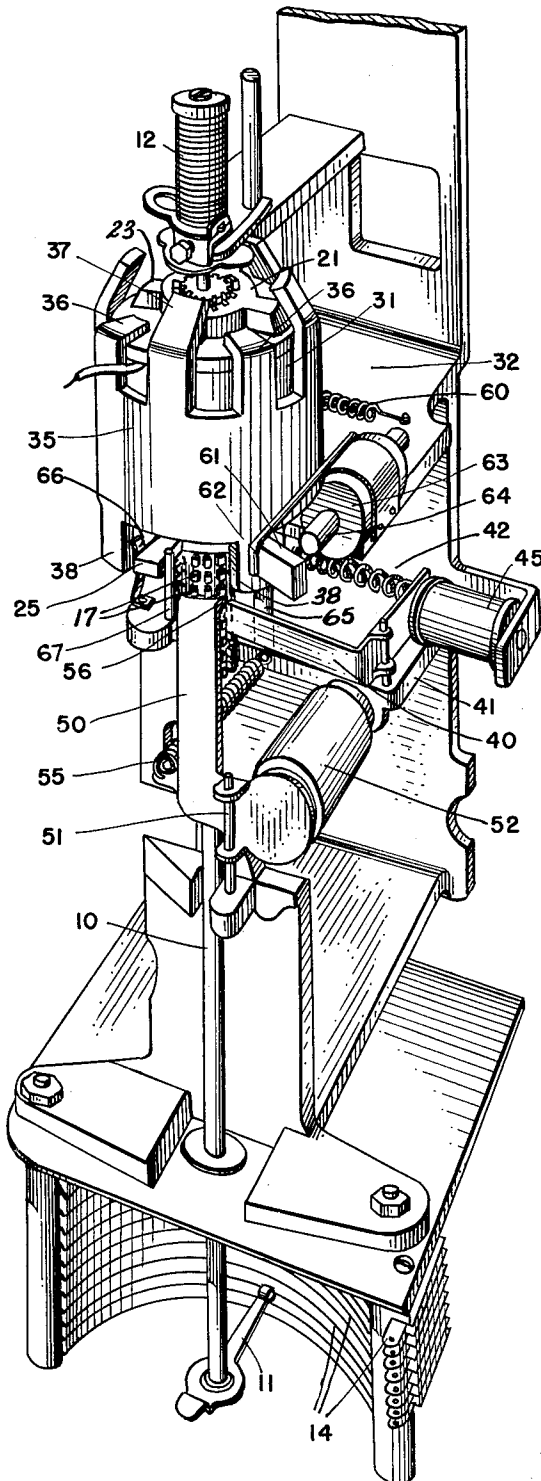
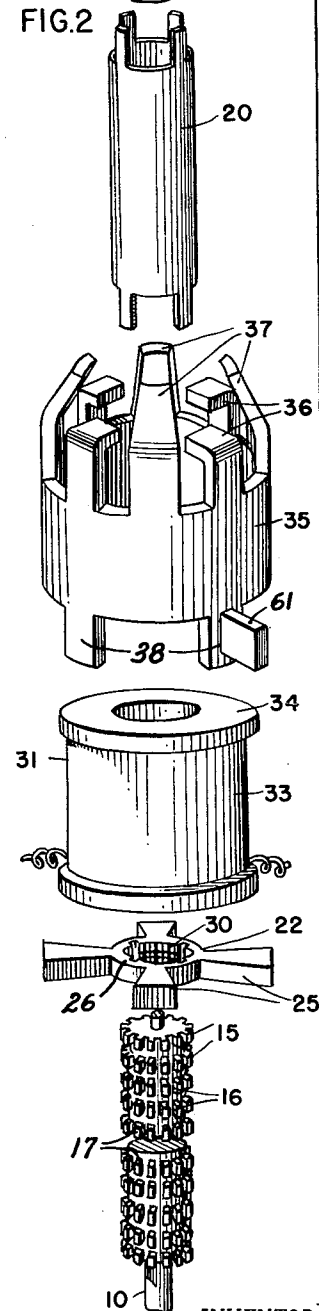


FIG. 2

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FIG. 3

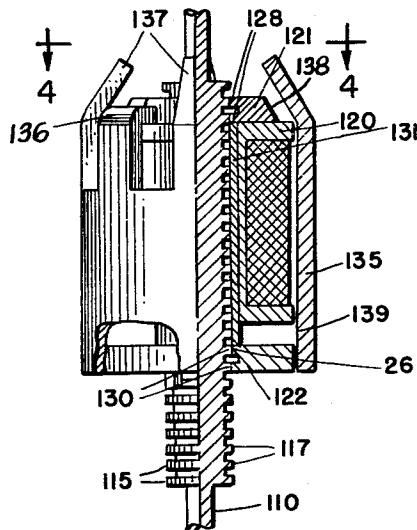


FIG. 4

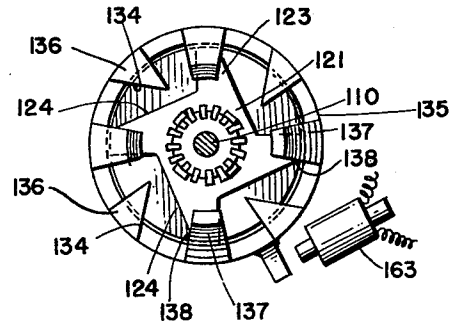


FIG. 6

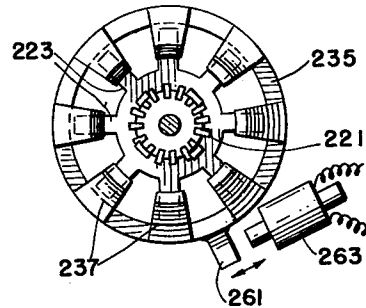


FIG. 5

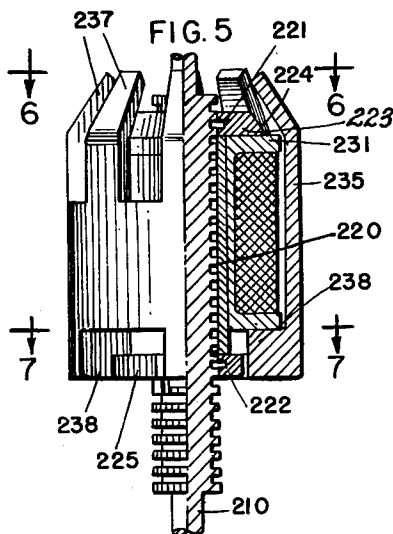
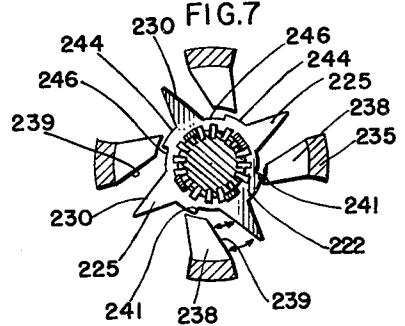


FIG. 7



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2,721,904

DRIVING APPARATUS

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Application July 3, 1951, Serial No. 234,974

17 Claims. (Cl. 179—27.52)

This invention relates to driving apparatus, and more particularly to driving apparatus of a type to be used with a selector switch mechanism.

An object of the invention is to provide new and improved driving apparatus.

A further object of the invention is to provide new and improved driving apparatus of a type to be used with selective switching apparatus.

Another object of the invention is to provide a magnetic type selective switching apparatus.

Another object of the invention is to provide pawl and ratchet means wherein magnetic force is used to clutch and drive pawl and ratchet means.

An apparatus illustrating certain features of the invention may include magnetic ratchet means composed of magnetic material, magnetic pawl means composed of magnetic material positioned near the ratchet means and movable between two positions. Electromagnetic means may be provided for moving the pawl means from one of said positions to the other and introducing flux into the ratchet means through the pawl means to move the ratchet means with the pawl means.

A complete understanding of the invention may be obtained from the following detailed description of apparatus forming specific embodiments thereof, when read in conjunction with the appended drawings, in which:

Fig. 1 is a fragmentary, perspective view of an apparatus forming one embodiment of the invention;

Fig. 2 is an exploded perspective view of portions of the apparatus shown in Fig. 1;

Fig. 3 is a fragmentary, partially sectional view of an apparatus forming a second embodiment of the invention;

Fig. 4 is a horizontal section taken along line 4—4 of Fig. 3;

Fig. 5 is a fragmentary, partially sectional view of an apparatus forming a third embodiment of the invention;

Fig. 6 is a horizontal section taken along line 6—6 of Fig. 5, and

Fig. 7 is a horizontal section taken along line 7—7 of Fig. 5.

Referring now in detail to the drawings, there is shown in Fig. 1 an apparatus for selectively raising a rod 10 having a contactor 11 thereon, and then turning the rod 10 to turn the contactor 11 through a predetermined angle against the action of a torsion spring 12 connected to the rod 10 to move the contactor to a predetermined one of arcuately disposed switch contacts 14—14 of vertically stacked cards. The rod 10 is composed of magnetic material, such as soft iron, or the like, and collars 15—15 are formed thereon at spaced portions therealong. The collars 15—15 are provided with aligned radial slots 16—16 formed therein to form teeth 17—17 having air gaps therebetween. The distance from the bottom of each of the collars 15—15 to the bottom of the collar just

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below it is equal to the distance from one level of the contacts to the next level thereof.

The collared portion of the rod 10 is mounted slidably in a sleeve 20 composed of non-magnetic material, such as brass, or the like, and the sleeve 20 is fixed to rings 21 and 22. Arms 23—23 having bevelled end portions 24—24 project from the ring 21, and arms 25—25 project from the ring 22. Each of the rings 21 and 22 is provided with an annular channel 26, which has a width the same distance as the spacing between the collars 15—15, and the thickness of each of the teeth 28—28 formed on the ring 21 having radially spaced points thereon equal to the spacing of the teeth 17—17 formed by the collars 15—15, and teeth 30—30 formed on the ring 22 are oriented with and aligned laterally with the teeth 28—28. The sleeve 20 is mounted slidably in an electromagnetic coil 31 fixed on a mounting bracket 32. The coil 31 includes a winding 33 mounted on a spool 34 composed of non-magnetic material. A shell 35 composed of magnetic material, such as soft iron, or the like, is mounted rotatably on the coil 31 and is fixed against downward movement relative to the coil 31 by turning arms 36—36 resting on the top of the coil 31 and extending between each adjacent pair of the arms 23—23. The shell 35 also has lifting arms 37—37 sloping parallel to the bevelled ends 24—24 of the arms 23—23 and spaced around the shell 35 the same as spacing of the arms 23—23 around the ring 21, with the vertical distance between the ends 24—24 and the arms 37—37 being slightly greater than the combined thickness of an adjacent pair of collars 15—15 and the air gap therebetween. The shell 35 has turning arms 38—38 at the bottom thereof located at the same points around the shell as those at which the arms 36—36 are located.

A horizontal pawl 40 pivotally mounted on a plate 41 is urged in a counterclockwise direction, as viewed in Fig. 1, by a tension spring 42, and engages the slots 16—16 between the teeth 17—17 to prevent rotation of the rod 10 by the spring 12. However, the pawl 40 has a tooth-engaging portion of such configuration that rotation of the rod 10 in a direction opposite to that in which it is urged by the torsion spring 12 is permitted by the pawl. An electromagnet 45 is energizable to pivot the pawl 40 in a clockwise direction, as viewed in Fig. 1, to move the pawl out of engagement with the teeth 17—17 thereby permitting the torsion spring 12 to turn the rod to a position in which the contactor 11 is completely out of engagement with the contacts 14—14.

A vertical pawl 50 mounted pivotally on a pin 51 may be pulled to a releasing position by energization of an electromagnet 52 to permit the rod 10 to drop. The pawl 50 is normally swung in a clockwise direction, as viewed in Fig. 1, by a tension spring 55 which holds a latching portion 56 thereof in engagement with the rod 10 in a position between two adjacent collars 15—15. The configuration of the collar-engaging portion 56, and the strength of the spring 55 is such that the pawl 50 holds the rod 10 positively against downward movement relative thereto when the electromagnet 52 is not energized, and offers negligible opposing force to upward movement of the rod 10 relative to the pawl 50.

The shell 35 normally is urged by a tension spring 60 to a position in which a lug 61 engages a stop 62, which position is designated a lifting position. Whenever an electromagnet 63 is energized, it holds the lug 61 against a core 64 thereof to pivot the sleeve 35 in a counterclockwise direction, as viewed in Fig. 1, to a turning position and holds it in this position. A pin 65 supporting the coil 31 acts as a stop to limit clockwise movement of the rings 21 and 22 and the sleeve 20, and is in the path of one of the arms 25—25. This arm 25 is normally urged

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in a counterclockwise direction by a leaf spring 66 against a stop pin 67.

Operation of apparatus shown in Figs. 1 and 2

With the electromagnets 45, 52 and 63 deenergized and the rod 10 in its unoperated position, the contactor 11 is positioned below the contacts 14—14 completely out of the arc of these contacts. The coil 31 is pulsed the desired number of times. On each pulse of the coil 31, it builds up flux through a flux path including the portion of the rod 10 therein, the ring 21 including the arms 23—23 thereof, the arms 37—37 of the shell 35, the shell 35, the arms 25—25 of the ring 22 and the ring 22. The pull between the arms 37—37 of the shell 35 and the arms 23—23 pulls the ring 21, the sleeve 20 and the ring 22 upwardly until the ring 22 engages the bottom end of the coil 31. As the rings 21 and 22 are pulled upwardly, the teeth 17—17 on the collars 15—15 are prevented from sliding or turning relative to the rings 21 and 22 because such sliding or turning would increase the reluctance of the magnetic path between the collars 15—15 and the rings 21 and 22. Hence, the rod 10 is lifted with the rings 21 and 22. During each pulse, the rod 10 is lifted slightly over the distance between each horizontal layer of contacts 14—14, and, as the pulse ceases, the rod 10 drops the excess over this distance and is held by the ratchet 50, and the rings 21 and 22 and the sleeve 20 drop back by gravity to their starting positions.

After the rod 10 has been stepped upwardly the distance desired to place the contactor 11 at the desired level, the electromagnet 63 is energized to pull the lug 61 into engagement therewith and swing the sleeve 35 through a predetermined angle. This shifts the lifting arms 37—37 from positions directly over the arms 23—23 of the ring 21 to positions offset therefrom, and moves the turning arms 36—36 from positions bisecting the angles between the arms 23—23 to positions closer to the arms on the counterclockwise side of each of the arms 36—36. Then the coil 31 is pulsed a predetermined number of times, and at each pulse the turning arms 36—36 and 38—38 pull the rings 21 and 22 in a clockwise direction, as viewed in Fig. 1, through a predetermined angle until the lugs 36—36 are engaged by the arms 23—23, which angle is just slightly greater than the angle between each of the adjacent teeth 17—17 formed on the collars 15—15. Slipping between the rings 21 and 22 and the collars 15—15 is prevented since there are air gaps between each of the teeth 17—17 formed on the collars 15—15 and each of the teeth formed on the rings 21 and 22. After each pulse of the coil 31, the leaf spring 66 moves the rings 21 and 22 back to their normal positions and the pawl 40 prevents movement of the rod 10 therewith. After cessation of the use of the particular contact 14 into engagement with which the contactor 11 has been moved, the electromagnet 45 is energized to pull the pawl 40 to a releasing position, and the torsion spring 12 swings the contactor in a counterclockwise direction to move it completely out of engagement with the contact 14—14. The electromagnet 52 then is energized to pull the pawl 50 to a releasing position, and the rod 10 drops to its unoperated position.

Second embodiment (Figs. 3 and 4)

The apparatus shown in Figs. 3 and 4 is identical with that shown in Figs. 1 and 2, except for features described hereinafter. It includes a rotating and lifting ring 120 and a disc 122, which are provided with teeth 128—128 and 130—130 identical with the teeth 28—28 and 30—30. The teeth 128—128 are aligned laterally with the teeth 130—130, and the ring 121 is identical with the ring 21, except that the ring 121 is provided with four arms 123—123, having cam faces 124—124 facing cam surfaces 134—134 formed on arms 136—136 of a shell 135. The disc 122 is placed close to but slidable in a cylindri-

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cal skirt portion 139 of the shell 135 so that there is a low reluctance path therebetween. A rod 110 identical with the rod 10 has rings of teeth 117—117 laterally aligned with the teeth on the ring 121 and the disc 122. The spacings between the rings of teeth 117—117 and that of the teeth on the ring 121 and the disc 122 are identical. An electromagnet 163 is designed to swing the shell 135 in a counterclockwise direction, as viewed in Fig. 4, when energized.

Operation of second embodiment

The operation of the apparatus shown in Figs. 3 and 4 is identical with that of the first-described embodiment of the invention except that the inclined arms 137—137 pull the ring 121 and the elements connected thereto upwardly when the arms 123—123 of the ring 121 are positioned directly under the arms 137—137. In this position, the spacing between the surfaces 134—134 on the horizontal arms 136—136 and the cam surfaces 124—124 on the arms 123—123 are so far apart, that there is no tendency for the ring 121 to be rotated, and since the disc 122 is positioned close to the cylindrical skirt portion 139 of the shell 135, the reluctance of the magnetic circuit is low. Hence, the intensity of the field between the arms 137—137 and the bevelled ends 138—138 of the arms 123—123 is high.

After the rod 10 is raised to the desired position, the electromagnet 163 is actuated to shift the shell in a counterclockwise direction relative to the ring 121. This shifts the beveled end portions 138—138 of the arms 123—123 out of alignment with the inclined arms 137—137, and brings the cam surfaces 134—134 into close proximity to the cam surfaces 124—124. Then, when the coil 131 is pulsed, there is no tendency for the ring 121 and the disc 122 to be lifted, and the large area of the cam surfaces 134—134 and 124—124 in close proximity to one another swing the ring 121 and the elements connected thereto mechanically and magnetically in a clockwise direction, as viewed in Fig. 4.

Third embodiment (Figs. 5, 6 and 7)

The construction of the apparatus shown in Figs. 5, 6 and 7 is identical with that shown in Figs. 1 and 2, except as indicated hereinbelow. It includes a rod 210 mounted slidably in a brass sleeve 220 secured fixedly at its ends to an upper lifting ring 221 and a rotating ring 222. A shell 235 is provided with sloping lifting arms 237—237, which are spaced around the shell 235, the same as the spacing of arms 223—223 of the lifting ring 221. The arms 223—223 are provided with bevelled end portions 224—224, which are parallel with the sloping arms 237—237.

The rod-rotating ring 222 has arms 225 having cam surfaces 230—230, and also is provided with longitudinally extending grooves 246—246 positioned on the clockwise side, as viewed in Fig. 7, of each of the arms 225—225. The shell is provided with rotating arms 238—238, which project between the arms 225—225 and have cam surfaces 239 and arcuate ends 241—241. The shell 235 is movable by an electromagnet 263 and a lug 261 from a lifting position in which the arms 237—237 are directly over the arms 223—223, and the arms 238—238 are positioned substantially midway between the arms 225—225 with the arcuate ends 241—241 of the arms 238—238 adjacent to raised portions 244—244 of the ring so that a low reluctance path is formed between the arcuate end portions of the arms 238—238 and the ring 222, and the flux between the arms 238—238 and the arms 225—225 is at a minimum. The shell may be shifted in a counterclockwise direction, as viewed in Figs. 6 and 7, from its lifting position to a rotating position thereof in which the cam surfaces 239—239 on the arms 238—238 are close to the cam surfaces 230—230 on the arms 225—225, and the end portions 241—241 of the arms 238—238 are

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close to the grooves 246—246 to form a high reluctance path therebetween. In this position the arms 237—237 of the shell 235 are moved out of lateral alignment with the arms 223—223 of the ring 221 so that no lifting action occurs. At this time, the ends of the arms 223—223 are adjacent to the wall of the shell 235, so that a low reluctance path is formed therebetween.

Operation of embodiment shown in Figs. 5, 6 and 7

When the electromagnet 263 is not energized, the shell 235 is urged to its lifting position, and when the coil 231 is energized the arms 237—237 lift the ring 221, the shell 220, the ring 222 and the rod 210 therewith. During the lifting operation the arcuate ends 241—241 of the arms 238—238 are adjacent to the raised portions 244—244 to form a low reluctance path between the shell 235 and the ring 222. To turn the rod 210, the electromagnet 263 is energized to shift the shell from its lifting position to its rotating position, and the arms 238—238 are moved away from the raised portions 244—244 to the grooves 246—246, and create a high reluctance path therebetween, and the cam-shaped surfaces 239—239 of the arms 238—238 are shifted fairly close to the cam-shaped surfaces 230—230 of the arms 225—225. Then, on each pulse of the coil 231, the high intensity magnetic field between the cam surfaces 239—239 and the cam surfaces 230—230 turns the ring 222 in a clockwise direction, as viewed in Fig. 7, and the rings 222 and 221 turn the rod 210 therewith.

The above-described apparatus turns the rods 10, 110 and 210 through selected angles and raises these rods through selected vertical distances through the single operating coils 31, 131 and 231. Furthermore, the stepping is very quiet, inasmuch as no mechanical raising and rotating pawls are used.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of the invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A drive, which comprises a driven member composed at least partially of magnetic material and having parallel ridges of magnetic material spaced thereon, means mounting the driven member movably in a direction transverse to the ridges, means for holding the driven member in a position to which it is moved, a driving member composed at least partially of magnetic material and provided with ridges of magnetic material spaced substantially identically with the spacing of the ridges on the driven member, means mounting the driving member in a position in which the ridges thereon are juxtaposed to the ridges on the driven member for movement along a path adjacent to the driven member so as to be capable of forming a portion of a flux path therewith, electromagnetic means for inducing magnetic flux in the driving member and the driven member, and means mounting the electromagnetic means in such a position as to move the driving member in one direction along said path when the electromagnetic means is energized, whereby the driven member is moved therewith.

2. A drive, which comprises a drivable member composed at least partially of magnetic material, means mounting the drivable member for rotary movement and linear movement, an armature, means mounting the armature adjacent to the drivable member for movements generally parallel to the permitted movements of the drivable member, magnetic means for inducing flux in the armature and the drivable member to tend to hold them against movement relative to one another, and means for shifting the magnetic means between a position such as to move the drivable member linearly and a position such as to rotate the driving member.

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3. An electromagnetic drive, which comprises an elongated driven member composed at least partially of magnetic material and provided with teeth mounted in spaced positions thereon, means mounting the driven member for movement along the longitudinal axis and turning movement about the longitudinal axis thereof, an armature having teeth at spaced positions thereon, means mounting the armature adjacent to the driven member in a position in which the teeth on the armature are juxtaposed to the teeth on the driven member for movement parallel to the longitudinal axis of the driven member and turning movement about that axis, magnetic means shiftable between a position in which it moves the armature in said parallel direction and a position in which it turns the armature about said axis for forming a flux path with the armature and the driven member, selectively operable means for shifting the magnetic means between said positions, and means for inducing magnetic flux in the armature, the driven member and the magnetic means to lock the armature and the driven member together and move them relative to the magnetic means.

4. An electromagnetic drive, which comprises a coil, a generally annular armature having generally radial arms, means mounting the armature rotatably on one end of the coil and movably toward and away from the coil, a rod composed of magnetic material, means mounting the rod slidably in the coil and the armature, a pole piece composed of magnetic material extending from the portion of the rod at the end of the coil opposite to the end at which the armature is mounted along a path outside the coil to a point beyond the other end of the coil spaced in a direction parallel to the longitudinal axis of the coil from the armature, and means mounting the pole piece for movement between a position in which the pole piece is aligned with one of the arms to magnetically pull the armature longitudinally of the coil and a position in which the pole piece is positioned between the arms to turn the armature.

5. An electromagnetic drive, which comprises a coil, a generally annular armature, means mounting the armature rotatably on one end of the coil and movably toward and away from the coil, a rod composed of magnetic material, means mounting the rod slidably in the coil and the armature, and a pole piece composed of magnetic material extending from the portion of the rod at the end of the coil opposite to the end at which the armature is mounted along a path outside the coil to a point at the other end of the coil and a portion thereof is spaced from the armature in a direction parallel to the longitudinal axis of the coil, said armature having an annular groove in the portion thereof adjacent to the rod, said rod also having an annular groove therein juxtaposed with respect to the groove in the armature to prevent slipping between the rod and the armature when the rod and the armature are magnetized by the coil.

6. An electromagnetic drive, which comprises a coil, a generally annular armature, means mounting the armature rotatably on one end of the coil and movably toward and away from the coil, said armature being provided with inwardly extending projections spaced along the armature from one another a predetermined distance apart, a rod composed of magnetic material, means mounting the rod slidably in the coil, said rod having outwardly extending projections spaced along the rod from one another the same distance apart as the spacing of the projections on the armature, and a pole piece extending from the rod at the end of the coil opposite to the end at which the armature is mounted along a path outside the coil to a point at the other end of the coil spaced from the armature in a direction parallel to the longitudinal axis of the coil.

7. A step-by-step switch drive, which comprises an electromagnetic coil, an elongated rod composed of magnetic material having a series of wide, thick teeth pro-

jecting in rings spaced equally along a portion of the rod, said rod being mounted slidably and rotatably in the coil, a collar composed of magnetic material mounted slidably and rotatably on the rod at one end of the coil and having inwardly projecting, wide, thick teeth spaced in rings similarly to the spacing of the teeth on the rod, said collar having cam-shaped arms provided with bevelled ends projecting outwardly therefrom at predetermined points, a shell composed of magnetic material held against longitudinal movement relative to the coil and being rotatable on the coil, said shell having rod-sliding arms sloping inwardly and axially thereof parallel to the bevelled ends of the arms of the collar at points on one end thereof spaced therearound similarly to the spacing of the arms on the collar, said shell also having cam-shaped arms on the last-mentioned end thereof projecting inwardly between the arms of the collar, and means for shifting the shell between a rod-sliding position in which the rod-sliding arms are aligned with the ends of the arms of the collar and the cam-shaped arms of the shell are spaced substantially from all points of the collar and a rod-rotating position in which the rod-sliding arms are offset from the arms of the collar and are spaced substantially therefrom and each of the cam-shaped arms of the shell is spaced close to one of the adjacent arms of the collar and far from the other adjacent arm of the collar.

8. A step-by-step switch drive, which comprise an electromagnetic coil, an elongated rod composed of magnetic material having a series of wide, thick teeth projecting in rings spaced equally along a portion of the rod, said rod being mounted slidably and rotatably in the coil, a collar composed of magnetic material mounted slidably and rotatably on the rod at one end of the coil and having inwardly projecting wide, thick teeth spaced in rings similarly to the spacing of the teeth on the rod, said collar having cam-shaped arms provided with bevelled ends projecting outwardly therefrom at predetermined points, a shell composed of magnetic material held against longitudinal movement relative to the coil and being rotatable on the coil, said shell having rod-sliding arms sloping inwardly and axially thereof parallel to the bevelled ends of the arms of the collar at points on one end thereof spaced therearound similarly to the spacing of the arms on the collar, said shell also having cam-shaped arms on the last-mentioned end thereof projecting inwardly between the arms of the collar, means for shifting the shell between a rod-sliding position in which the rod-sliding arms are aligned with the ends of the arms of the collar and the cam-shaped arms of the shell are spaced substantially from all points of the collar and a rod-rotating position in which the rod-sliding arms are offset from the arms of the collar and are spaced substantially therefrom and each of the cam-shaped arms of the shell is spaced close to one of the arms of the collar and far from the other arm of the collar, the cam-shaped arms of the shell and the arms of the collar being chordal to the shell on one side of each with the chordal side of each of the cam-shaped arms of the shell facing the chordal side of one of the arms of the collar, pawl means for controlling sliding movement of the rod, and pawl means for controlling rotating movement of the rod.

9. A step-by-step switch drive, which comprises an electromagnetic coil, an elongated rod composed of magnetic material having a series of teeth having flat ends projecting in rings spaced equally along a portion of the rod, a sleeve of non-magnetic material freely slidable on the rod, a rod-sliding collar composed of magnetic material having arms provided with bevelled ends projecting outwardly therefrom secured to one end of the sleeve, said collar also having inwardly projecting rings of teeth having flat ends fitting closely but slidably and rotatably around the teeth on the rod and spaced apart the same distance that the rings of teeth on the rod are spaced apart, a rod-rotating collar composed of magnetic material fixed to the other end of the sleeve having cam-shaped

arms projecting outwardly therefrom, said rod-rotating collar having inwardly projecting ring of teeth having flat ends fitting closely but slidably and rotatably around the teeth on the rod and spaced apart the same distance that the rings of teeth on the rod are spaced apart, a shell of magnetic material mounted rotatably on the outside of the coil and held against movement along the coil, said shell having rod-sliding arms on the end thereof adjacent to the rod-sliding collar provided with surfaces extending parallel to the bevelled ends of the arms of the rod-sliding collar and spaced circumferentially the same as the spacing of the arms of the rod-sliding collar, said shell also having cam-shaped arms on the end thereof adjacent to the rod-rotating collar projecting between the arms on the rod-rotating collar, and means for shifting the shell relative to the collars and the coil from one of a rod-sliding position in which the rod-sliding arms thereof are aligned with the bevelled ends of the arms of the rod-sliding collar and the cam-shaped arms thereof are positioned between adjacent arms of the rod-rotating collar in magnetic balance with the adjacent arms of the rod-rotating collar and a rod-rotating position in which the rod-sliding arms thereof are offset from the bevelled ends of the arms of the rod-sliding collar and the cam-shaped arms thereof are in magnetic unbalance with the adjacent arms of the rod-rotating collar to the other of said position.

10. A step-by-step switch drive, which comprises an electromagnetic coil, an elongated rod composed of magnetic material having a series of teeth having flat ends projecting in rings from points equally spaced along a portion of the rod, a sleeve of non-magnetic material freely slidable on the rod, a rod-sliding collar composed of magnetic material having arms provided with bevelled ends projecting outwardly therefrom secured to one end of the sleeve, said collar also having inwardly projecting rings of teeth having flat ends fitting closely but slidably and rotatably on the teeth on the rod and spaced along the collar the same distance that the rings of teeth on the rod are spaced along the rod, a rod-rotating collar composed of magnetic material fixed to the other end of the sleeve having cam-shaped arms projecting outwardly therefrom, said rod-rotating collar having an inwardly projecting ring of teeth having flat ends fitting closely but slidably and rotatably on the teeth on the rod and spaced apart the same distance that the teeth on the rod are spaced apart, a shell of magnetic material mounted rotatably on the outside of the coil and held against movement along the coil, said shell having rod-sliding arms on the end thereof adjacent to the rod-sliding collar provided with surfaces extending parallel to the bevelled ends of the arms of the rod-sliding collar and spaced circumferentially the same as that spacing of the arms of the rod-sliding collar, said shell also having cam-shaped arms on the end thereof adjacent to the rod-rotating collar projecting between the arms on the rod-rotating collar, and means for shifting the shell between a rod-sliding position in which the rod-sliding arms thereof are aligned with the bevelled ends of the arms of the rod-sliding collar and the cam-shaped arms thereof are positioned between adjacent arms of the rod-rotating collar in magnetic balance with the adjacent arms of the rod-rotating collar and a rod-rotating position in which the rod-sliding arms thereof are offset from the bevelled ends of the arms of the rod-sliding collar and the cam-shaped arms thereof are in magnetic unbalance with the adjacent arms of the rod-rotating collar, the configurations of the cam-shaped arms of the shell and the rod-rotating collar being such that the ends of the cam-shaped arms of the shell are spaced close to the central portion of the rod-rotating collar to form a low reluctance path therebetween and are spaced substantially from the arms of that collar when the shell is in its rod-sliding position and the ends of the cam-shaped arms of the shell are spaced substantially from the central por-

tion of the rod-rotating collar to form a high reluctance path therebetween and each is spaced close to one of the adjacent arms of the rod-rotating collar and substantially from the other of those arms when the shell is in its rod-rotating position.

11. A drive, which comprises an electromagnetic coil, an elongated rod composed of magnetic material having a series of wide, thick teeth projecting radially from the rod, means mounting the rod rotatably in the coil, a collar composed of magnetic material, means mounting the collar rotatably on the rod at one end of the coil, said collar having inwardly projecting wide, thick teeth spaced similarly to the spacing of the teeth on the rod, said collar also having cam-shaped arms projecting outwardly therefrom at predetermined points therearound, a shell composed of magnetic material, means mounting the shell rotatably on the coil, said shell having cam-shaped arms projecting inwardly between the arms of the collar, and means for shifting the shell between one position in which the cam-shaped arms of the shell are spaced substantially from the arms of the collar and a rod-rotating position in which each of the cam-shaped arms of the shell is spaced close to one of the adjacent arms of the collar and far from the other arm of the collar, said collar being provided with a lobe portion spaced close to an end of one of the arms of the shell when the shell is in the first-mentioned position and also provided with recessed portions most adjacent to the ends of the arms of the shell when the shell is in its rod-rotating position.

12. A magnetic drive, which comprises an electromagnetic coil of a predetermined length having a central passage therethrough, a member composed of magnetic material of a length greater than that of the coil, means mounting the member slidably in a position extending along the coil, an armature composed of magnetic material, means mounting the armature at one end of the coil movably with respect to the coil and the member, the armature being spaced near the member to form a flux path therewith, a puller composed of magnetic material for moving the armature relative to the coil, means urging the armature against movement by the puller, and means mounting the puller in a position in which there is a flux gap between the puller and the armature, said member-mounting means and said puller-mounting means serving to mount one of said puller and said member in the passage through the coil and the other of said puller and said member outside the coil and extending lengthwise of the coil.

13. A selector switch drive, which comprises an electromagnetic coil having an axial passage therethrough, means mounting the coil vertically, a rod slidable in the passage through the coil, a portion of the rod in the coil being composed of magnetic material and having circumferential grooves therein at equally spaced points therealong, the portions of the rod between the grooves being slotted longitudinally of the rod to form teeth, a nonmagnetic sleeve mounted slidably in the passage in the coil between the upper portion of the rod and the coil, a ring composed of magnetic material secured to one end of the nonmagnetic sleeve and fitting slidably on the rod, said ring having arms having bevelled ends projecting generally radially therefrom, said ring being provided with an inner arcuate groove substantially as wide as the thickness of the space between the teeth on the rod and also having longitudinal inner slots to form teeth spaced circumferentially the same as the spacing of the teeth on the rod, a shell composed of magnetic material having sliding arms sloping generally complementarily to the bevels on the ends of the arms of the ring mounted rotatably on the outer portion of the shell with the arms spaced longitudinally from and at the same end of the coil as the arms on the rings, said shell also having rotating arms projecting between the arms of the ring, said shell forming a flux path from the end of the coil to the

other end thereof, means urging the shell to a position in which the sliding arms are circumferentially aligned with the bevelled ends of the arms of the rings and each of the rotating arms is spaced equally from the arms of the ring, and means operable selectively for rotating the shell against the shell-urging means to a position in which the sliding arms are offset circumferentially from the arms of the ring to increase the spacing therefrom and each of the rotating arms is substantially closer to one of the arms on the ring bracketing it than to the other of those arms.

14. A selector switch drive, which comprises an electromagnetic coil having an axial passage, a rod mounted slidably in the passage through the coil and being of such a length as to extend completely through the coil, the portion of the rod slidable through the coil being composed of magnetic material and having rings of teeth having wide, thick ends projecting therefrom at equally spaced points therealong, a ring composed of magnetic material mounted at one end of the coil and fitting closely around the toothed portion of the rod, means mounting the ring rotatably and axially movably relative to the coil, said ring having arms having bevelled ends projecting generally radially therefrom, said ring having rings of teeth spaced therealong and projecting inwardly to the teeth on the rod in juxtaposed positions relative thereto, a shell composed of magnetic material having ring-sliding arms sloping complementarily to the bevels on the ends of the arms of the ring mounted rotatably on the outer portion of the shell with the sliding arms at the same end of the coil and spaced from the arms on the ring, means preventing axial movement of the shell relative to the coil, said shell also having ring-rotating arms projecting between the arms of the ring, means for holding the shell in a position in which the ring-sliding arms are aligned with the ends of the arms of the ring and each of the ring-rotating arms is spaced substantially equally from the adjacent arms of the ring, and means for rotating the shell to a position in which the ring-sliding arms are offset from the arms of the ring to increase the spacing therefrom and each of the ring-rotating arms is substantially closer to one of the adjacent arms on the ring than to the other of those arms.

15. A selector switch drive, which comprises an electromagnetic coil having an axial passage therethrough, a rod mounted slidably in the passage through the coil and being at least as long as the coil, the rod being composed of magnetic material and being slotted longitudinally of the rod, a collar composed of magnetic material fitting closely and rotatably around the slotted portion of the rod, said collar having an arm projecting outwardly therefrom, said collar also having longitudinal inner slots spaced circumferentially the same as the spacing of the longitudinal slots in the rod, a magnetic member composed of magnetic material mounted on the outer portion of the coil and forming a low reluctance path from one end of the coil to the other, said member having a rod-rotating arm projecting toward the ring, means for holding the shell in a position in which the rod-rotating arm is spaced closely to the arm of the collar so that the arm of the collar is drawn toward the arm of the member when the coil is energized, and means urging the collar toward a position in which the arm thereof is spaced from the arm of the member.

16. A selector switch drive, which comprises an electromagnetic coil having a central passage therethrough, a rod mounted slidably in the passage through the coil, the portion of the rod extending through the passage being composed of magnetic material and having circumferential grooves therein at equally spaced points therealong, a collar composed of magnetic material fitting closely and slidably around the portion of the rod at one end of the coil, means urging the collar toward the coil and permitting movement of the collar away from the coil a distance slightly greater than the distance between the

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grooves, the collar being provided with an inner arcuate groove substantially as wide as the width of the grooves in the rod, and a member composed of magnetic material and having an arm, means mounting the member in a position extending along the exterior of the coil from one end thereof to the other and in which the arm extends beyond the collar and pulls the collar away from the coil when the coil is energized.

17. A magnetic drive, which comprises an electromagnetic coil having a central passage therethrough, a rod composed of magnetic material mounted slidably in the passage through the coil and being of such a length as to extend beyond each end of the passage in the coil, the rod having circumferential grooves therein at equally spaced points therealong, the portions of the rod between the grooves being slotted longitudinally of the rod to form teeth, a nonmagnetic sleeve mounted slidably in the passage in the coil between the rod and the coil, a ring composed of magnetic material secured to the one end of the sleeve beyond one end of the coil and fitting closely around the rod, said ring having arms having bevelled ends projecting generally radially therefrom, a second ring composed of magnetic material secured to the other end of the sleeve and fitting closely around the rod, the rings being spaced apart such a distance greater than the length of the coil that the rings and the rod may move longitudinally of the coil a distance slightly greater than the distance from one side of one ring of teeth on the rod to the same side of the next ring of teeth on the rod, means urging the first-mentioned ring toward the coil, one of the rings being provided with an inner arcuate

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groove substantially as wide as the width of the grooves in the rod and also having longitudinally extending inner slots to form teeth spaced circumferentially the same as the spacing of the teeth on the rod, a shell composed of magnetic material having rod-sliding arms sloping complementarily to the bevels on the ends of the arms of the first-mentioned ring mounted rotatably on the outer portion of the shell with the rod-sliding arms positioned beyond the arms on that ring, said shell also having rod-rotating arms projecting between the arms of the first-mentioned ring, means urging the shell to a position in which the rod-sliding arms are juxtaposed to the ends of the arms of the first-mentioned ring and each of the rod-rotating arms is spaced magnetically equally from the arms of the first-mentioned ring, and means for rotating the shell against the shell-urging means to a position in which the rod-sliding arms are offset from the arms of the first-mentioned ring to increase the spacing therebetween and each of the rod-rotating arms is magnetically closer to one of the arms on the first-mentioned ring bracketing it than to the other of those arms.

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