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## GRIPPER-TYPE LINEAR MOTION DEVICE

## BACKGROUND OF THE INVENTION

This invention relates to linear motion devices and in particular to the type which are hermetically sealed and operated by magnetic coils which move slugs to effect lifting and also move grippers into and out of engagement with the shaft.

Linear motion devices of the type contemplated operate by using a magnetic field to move a slug a predetermined distance. A separated magnetic field is regulated to engage and disengage grippers so that the lifting slug may be moved back and forth alternately disengaging and engaging the gripper to effect a stepping motion of the shaft. Separate latching means have been supplied to latch the shaft and hold it in place between steps of the lifting coil.

In many uses such as control rod drives for nuclear reactor, it is important that the shaft be positioned as accurately as possible. Since this type of apparatus can only operate in discrete steps, this requires relatively small steps to obtain control. Dynamic forces due to the magnetic action in bringing the slug into a new position are high and increase as the length of step increases. Therefore, while rapid movement would be a desirable feature of these drives, it is limited by the size of step which may be taken on each cycle.

## SUMMARY

In my invention there is no latching means which operates simply to hold the shaft. Two latching members are supplied but each of these operates alternately as a lifting member. Since each slug operates to lift, the rod may be moved twice as fast as the prior art in each cycle or if desired the size of the steps may be decreased thereby improving placement and reducing dynamic forces due to the movement.

Simultaneous operation of a central coil withdraws the upper slug in preparation for the lift portion of its cycle while simultaneously lifting the lower slug with the shaft latched thereto. The same type of operation in reverse results in a more rapid controlled descent of the shaft.

## BRIEF DESCRIPTION OF THE DRAWING

The FIGURE illustrates a sectional side elevation of the linear motion device.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Shaft 12 extends vertically through the linear motion device. This shaft which is to be moved axially and positioned has thereon a number of axially spaced projections 13 with these projections being spaced one-half inch apart. Tubular housing 14 is constructed of a magnetic material such as ferritic steel and is designed to withstand substantial pressure in the order of 2,000 p.s.i. This housing has five coils concentrically surrounding it at different elevations. These coils are operated to lift, lower, latch, and unlatch the shaft as will be described below. Fixed sleeve 15 is mounted inside the tubular housing and securely attached thereto so that there is no vertical movement between the sleeve and the housing. This sleeve includes a lower stop 17, a central stop 18, an upper stop 19. A lower slug 22 includes an upper stop 23 and a lower stop 24. This slug surrounds the sleeve near the lower end and is retained in the space between the sleeve and the tubular housing. Buffer springs 25 are located at the upper and lower ends of the lower slug to absorb impact when the slug meets the stationary member. The spacing between the lower slug 22 and stops 17 and 18 of the sleeve is such as to leave a one-half inch free travel with full spring compression which matches the spacing between the projections on shaft 12.

Nonmagnetic inserts 27 are located in the housing just below each of the surrounding magnetic coils. These inserts force the magnetic field to flow in through the shaft and axially slide slugs located within the housing. Coil E when energized creates a magnetic field passing through stops 24 and 17 which causes the lower slug 22 to be drawn downwardly

against stop 17. Similarly coil C operates to cause stops 23 and 18 to be brought together raising lower slug 22 against stop 18 of sleeve 15.

In a similar manner upper slug 32 has an upper stop 33 and lower stop 34. Shock absorbing washers 35 are located at the upper and lower ends to absorb impact on movement of the upper slug. The clearance between the upper slug 32 and stops 18 and 19 of the sleeve is such that one-half inch free travel is permitted with full compression of the springs. Energizing coil A operates to close the upper gap raising upper slug 32 against stop 19 while energizing coil C operates to pull down upper slug 32 against stop 18.

Coil D operates to engage lower latch 42. This latch is pivotally connected to the lower slug 22 and also pivotally connected to a lower latching slug 43. As slug 43 is moved upwardly relative to lower slug 22, the lower latching member 42 is forced inwardly into engagement with projections 13 on the shaft. An opening 44 is provided in the sleeve so that the latching member may pass therethrough. Energizing coil D operates to close the gap between upper stop 23 of lower slug 22 and the coil latching slug 43. Since this moves slug 43 upwardly relative to lower slug 22, it effects engagement of the latch 42. Coil spring 45 operates to press the slug 43 downwardly away from upper stop 23 so as to effect disengagement when coil D is deenergized.

Similarly an upper latch 52 is pivotally connected to upper slug 32 and to upper latching slug 53. Operation of coil B closes the gap between the upper latching slug 53 and upper stop 33 to effect engagement of upper latch 52. Coil spring 54 operates to force the latch out of engagement when coil B is deenergized.

Rapid movement of shaft 12 is effected by sequentially energizing selected coils. In considering the lifting operation, the position of the elements is assumed initially as shown in the illustration with coils A, B, and E being energized. Coil A maintains the upper slug 32 against upper stop 19, coil B effects latching between the upper slug and the shaft, and coil E holds the lower slug 22 in the downward position.

As a first step coil D is energized which operates to effect latching of the lower latch 42.

Coil B is then turned off. This effects disengagement of upper latch 52 so that the entire weight of the shaft is now carried on lower latch 42.

Coils A and E are next turned off while coil C is turned on. Deenergizing coil A releases the upper slug from upper stop 19 while deenergizing coil E releases the lower slug from lower stop 17. Energizing coil C draws the upper slug 32 downwardly while simultaneously lifting lower slug 22 together with shaft which is at this time latched to the lower slug.

Coil B is then energized which causes upper latch 52 to engage the projections of the shaft.

Coil D is then deenergized which releases lower latch 42 so that the weight of the shaft is now carried on the upper latch 52.

Coil C is then deenergized while coils A and E are energized. Deenergizing coil C releases both the upper and lower slugs from central stop 18. Energizing coil E draws the lower slug 22 downwardly. Energizing coil A raises the upper slug 32 along with the shaft which is latched thereto.

At this point the cycle is complete and continued lifting is accomplished by again energizing coil D and continuing through the above described cycle.

Lowering of the shaft may be accomplished as follows. In a position as illustrated in the drawing, coil A, B, and E are energized with the shaft held by the upper latch and having the upper slug held upwardly against upper stop 19. At the same time coil E has lower slug 22 drawn down.

Coils A and E are deenergized while coil C is energized. Deenergizing coils A and E release the upper and lower slugs from stops 19 and 17, respectively. Energizing coil C draws both of these slugs against the central stop 18. The shaft 12 which is latched to the upper slug is moved downwardly one-half inch.

Coil D is then energized which causes lower latch 42 to move into engagement with the shaft.

Coil B is deenergized thereby releasing upper latch 52 so that the entire weight of the shaft is carried on the lower latch 42.

Coil C is then deenergized while coils A and E are energized. The deenergizing coil C releases both slugs from central stop 18. Energizing coil A draws the upper slug against upper stop 19 while energizing coil E draws the lower slug down against lower stop 17. The shaft being latched to the lower slug is moved downwardly one-half inch during this step.

Coil B is then energized which causes upper latch 52 to engage the shaft.

Coil D is then deenergized which causes lower latch 42 to move out of engagement with the shaft so that the weight of the shaft is carried on the upper latch 52. At this point a cycle has been completed and further lowering of the shaft is accomplished by again repeating the cycle.

While I have illustrated and described a preferred embodiment of my invention it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes as fall within the purview of my invention.

What I claim is:

1. An apparatus for linearly moving a shaft having a plurality of axially spaced projections thereon comprising: an upper slug surrounding said shaft and moving a limited distance axially; a lower slug surrounding said shaft and moving a limited distance axially; an upper latching slug moving axially with said upper slug and also relative to said upper slug; a lower latching slug moving axially with said lower slug and also relative to said lower slug; an upper latching means pivotally connected to said upper slug and said upper latching slug so that the latching means moves inwardly and latches to said shaft when said upper slug and upper latching slug are moved together; a lower latching means pivotally connected to said lower slug and said lower latching slug so that the latching means moves inwardly and latches to said shaft when said lower slug and lower latching slug are moved together; means for drawing said upper latching slug and said upper slug together to effect latching of said upper latching means; and means for drawing said upper latching slug and said upper slug apart to disengage said upper latching means; means for draw-

ing said lower latching slug and said lower slug together to effect latching of said lower latching means, and means for drawing said lower latching slug and said lower slug apart to disengage said lower latching means; means for lifting said upper slug a predetermined distance; means for pulling said lower slug down a predetermined distance; and means for simultaneously lifting said lower slug and pulling down said upper slug.

2. An apparatus as in claim 1 wherein said upper latching slug is coextensive with a portion of said upper slug, said upper slug extending both above and below said upper latching slug; and said lower latching slug is coextensive with a portion of said lower slug, said lower slug extending both above and below said lower latching slug.

3. An apparatus as in claim 2 wherein said upper latching slug surrounds said upper slug; and said lower latching slug surrounds said lower slug.

4. An apparatus as in claim 1 wherein said means for drawing said upper latching slug and said upper slug together comprises a first coil for establishing a magnetic field in the area of said upper latching slug and said upper slug; said means for drawing said lower latching slug and said lower slug together comprises a second coil for establishing a magnetic field in the area of said lower latching slug and said lower slug; said means for lifting said upper slug comprising a third coil for establishing a magnetic field in the area of said upper slug; said means for pulling said lower slug down comprising a fourth coil for establishing a magnetic field in the area of said lower slug; and said means for simultaneously lifting said lower slug and pulling down said upper slug comprising a fifth coil for establishing a magnetic field in the area of said lower slug.

5. An apparatus as in claim 4 wherein said means for drawing said upper latching slug and upper slug apart comprises a spring biasing the members apart and said means for drawing said lower latching slug and lower slug apart comprises a spring biasing the members apart.

6. An apparatus as in claim 5 wherein said upper slug has an upper portion terminating adjacent said third coil and lower portion terminating adjacent said fifth coil; said lower slug having an upper portion terminating adjacent said fifth coil and lower portion terminating adjacent said fourth coil.

7. An apparatus as in claim 6 wherein said upper latching slug surrounds and is coextensive with a portion of said upper slug; and said lower latching slug surrounds and is coextensive with a portion of said lower slug.

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