United States Patent

[11] 3,539,097

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[54] **ELECTRO-MECHANICAL ACTUATOR**
11 Claims, 10 Drawing Figs.

[52] U.S. Cl. 234/115
[51] Int. Cl. G06k 1/05
[50] Field of Search 234/94, 97, 111, 114, 109, 115, 119

[56] **References Cited**

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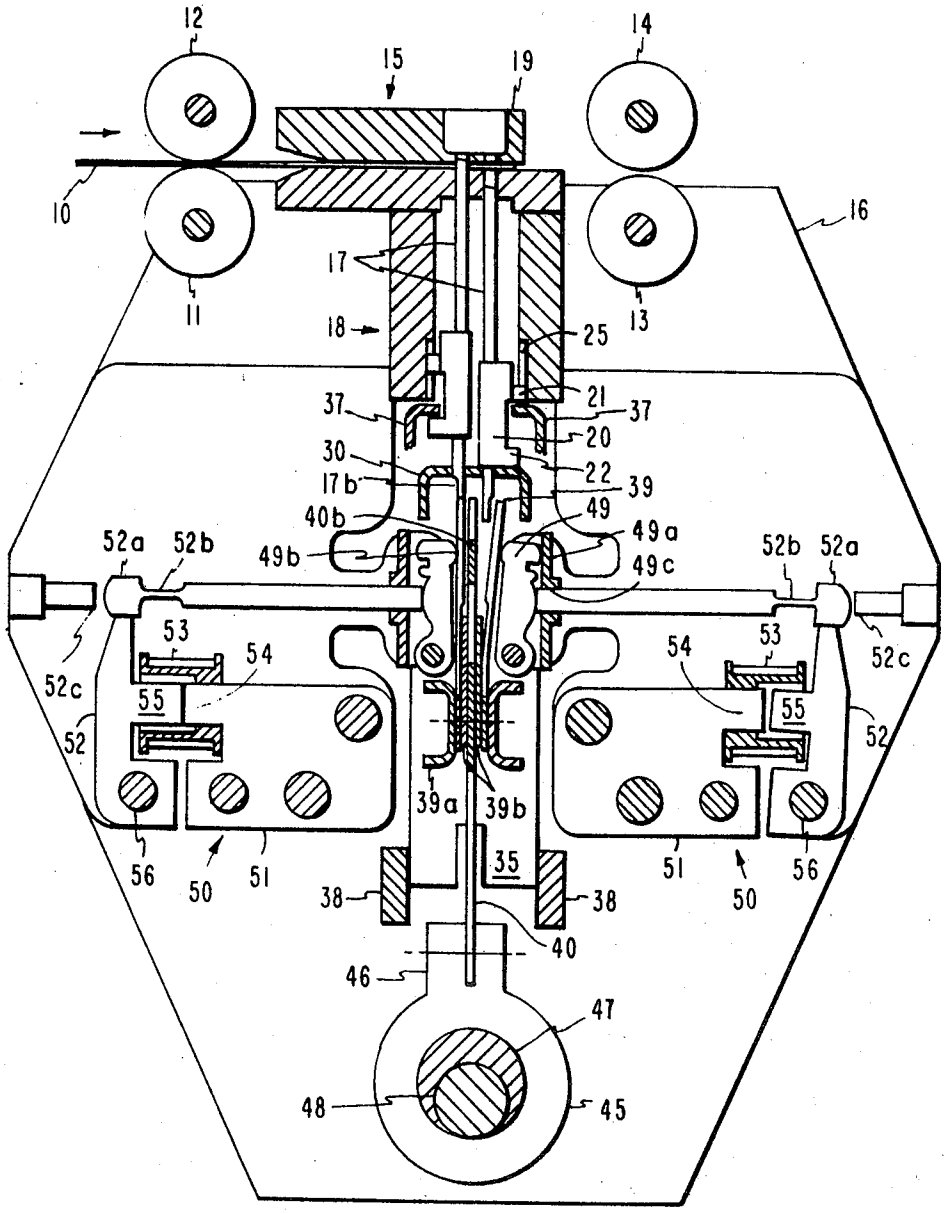
ABSTRACT: An electro-mechanical actuator is provided where an interposer spring attached to a reciprocating bail is selectively permitted or prevented, under control of a magnet armature, from contacting the element to be actuated.



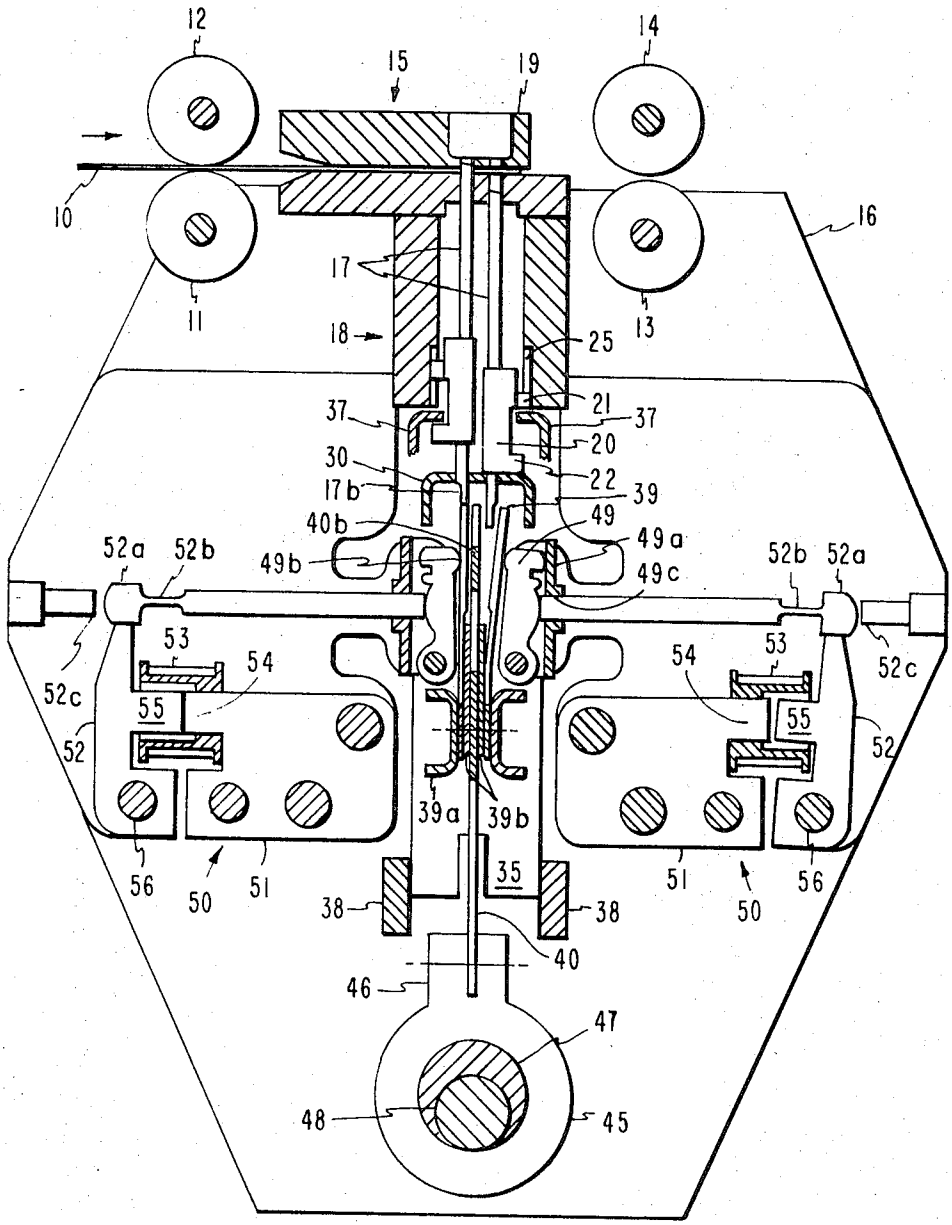


FIG. 1

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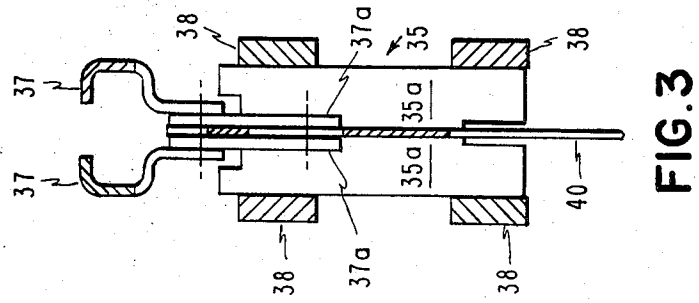

FIG. 3

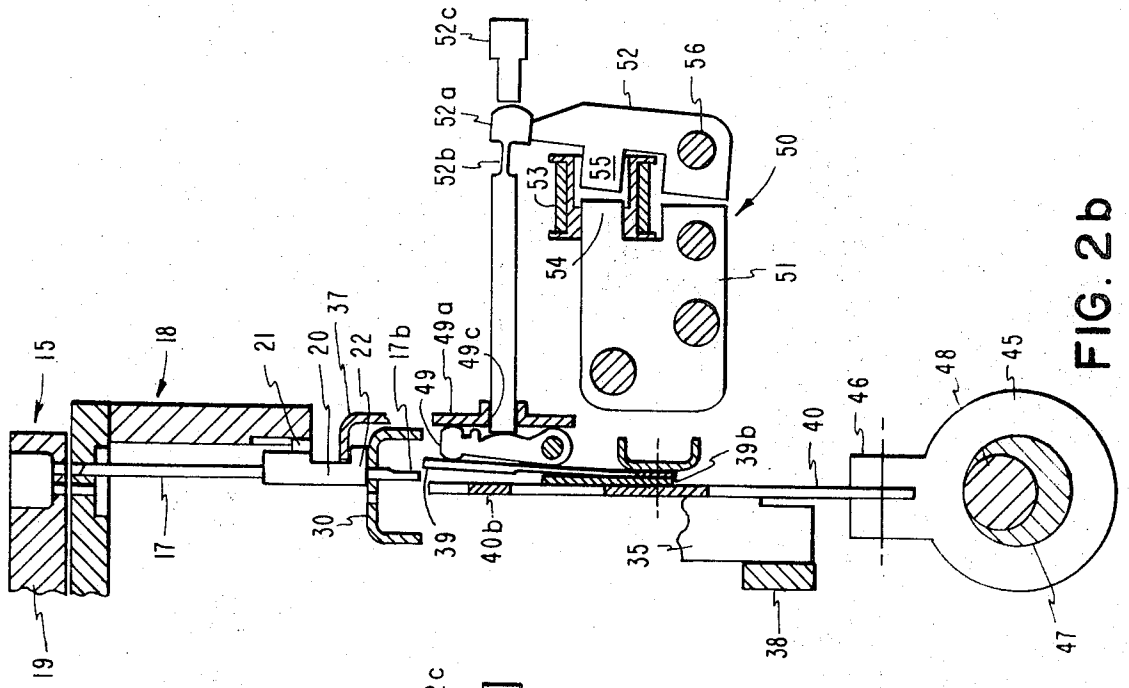

FIG. 2b

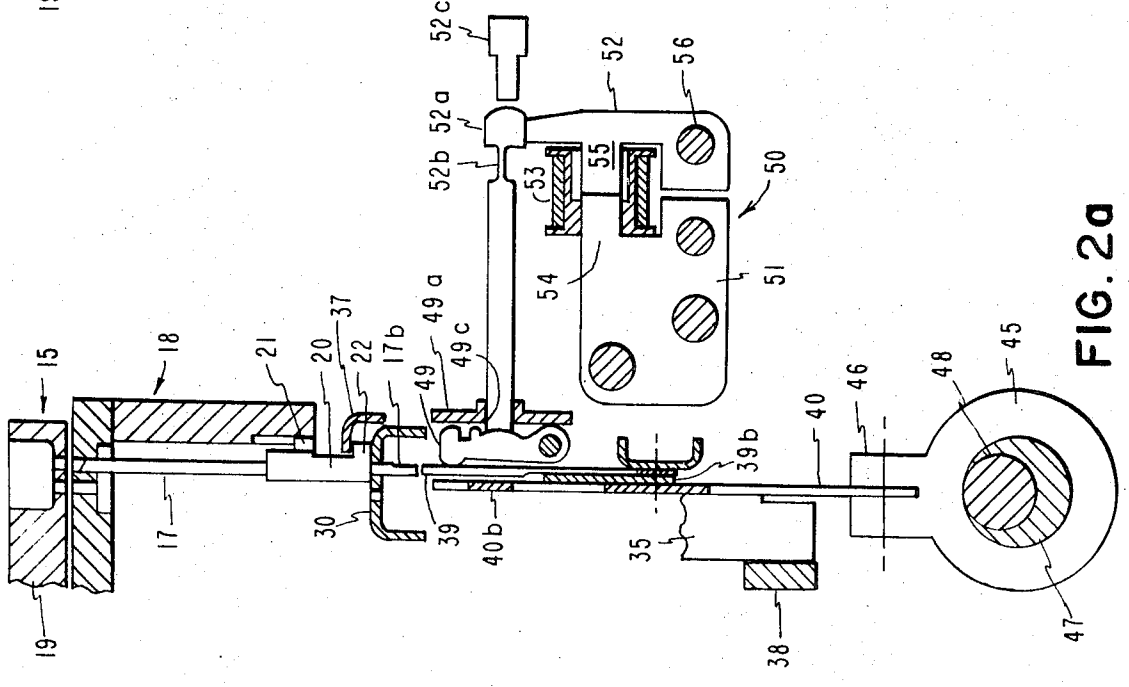

FIG. 2a

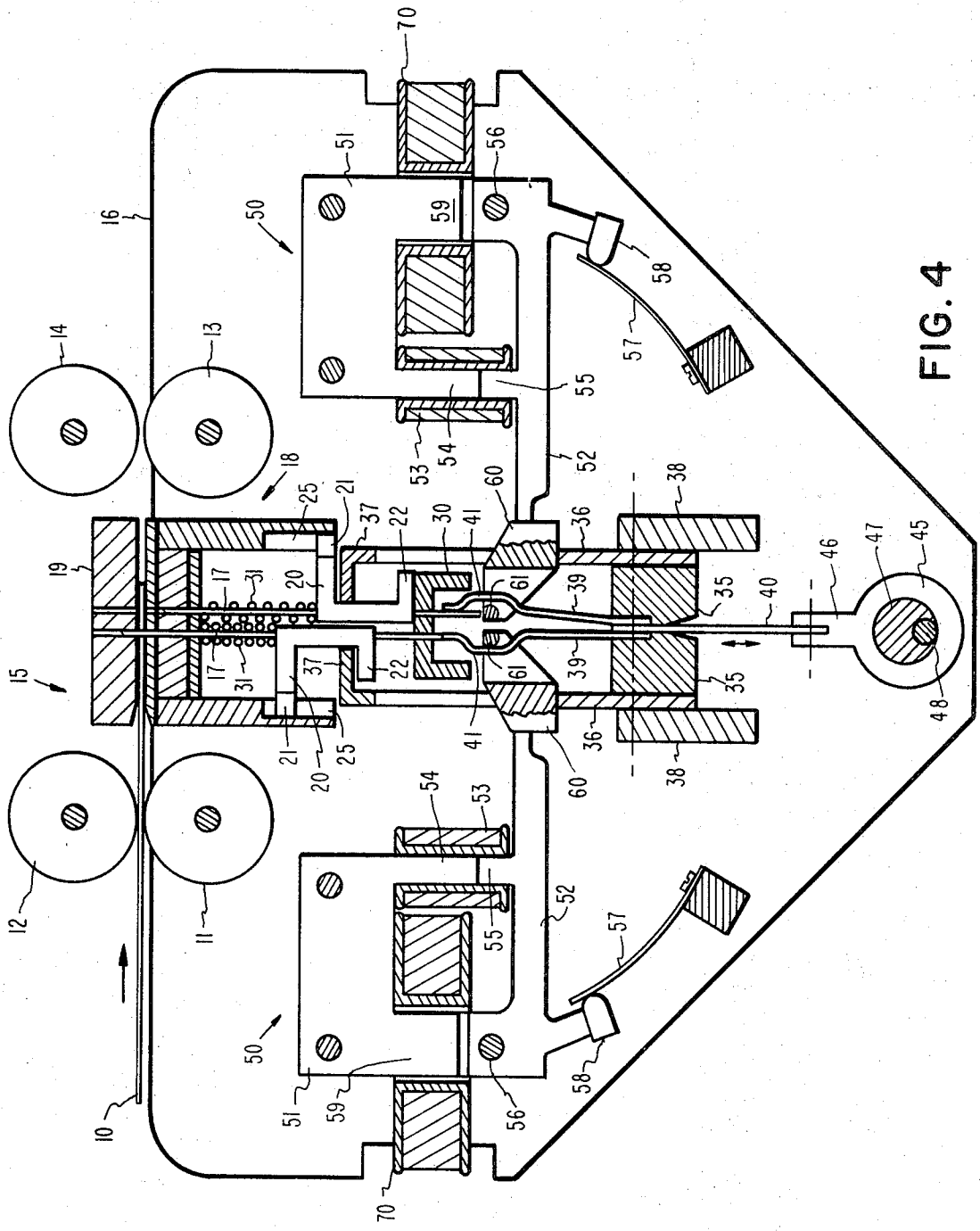
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FIG. 4

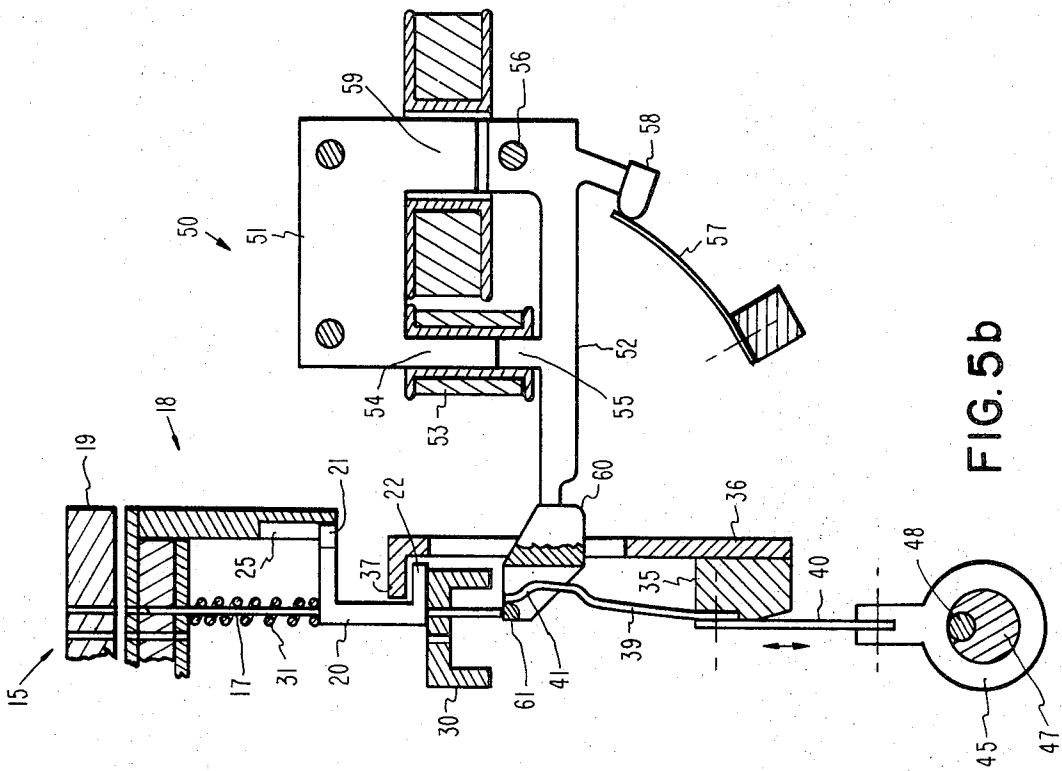
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FIG. 5b

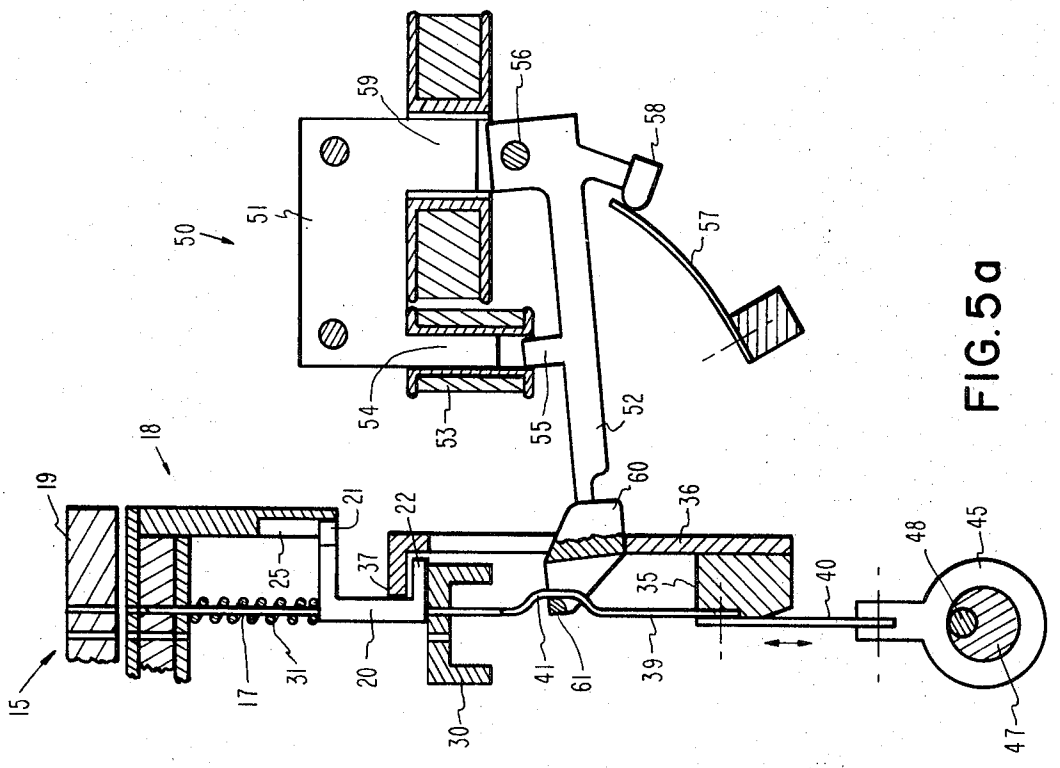
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FIG. 5a

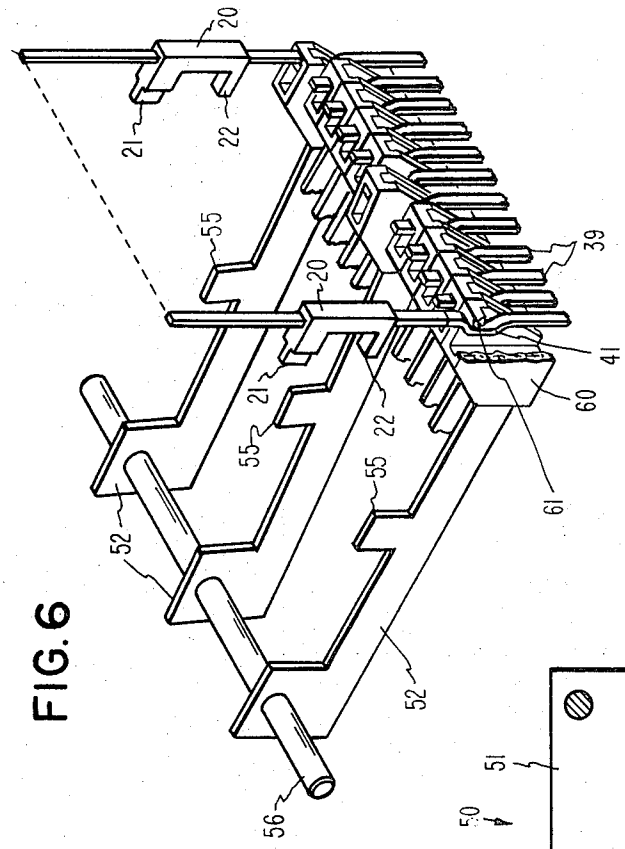

FIG. 6

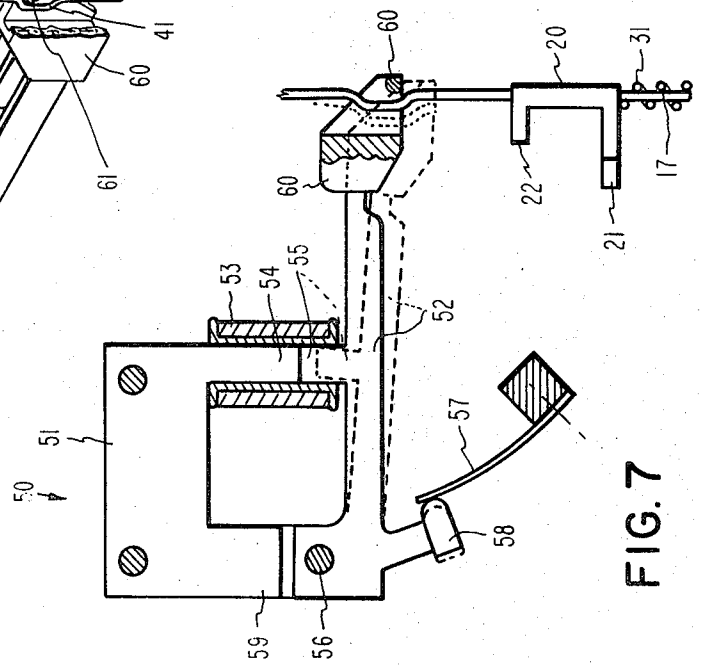

FIG. 7

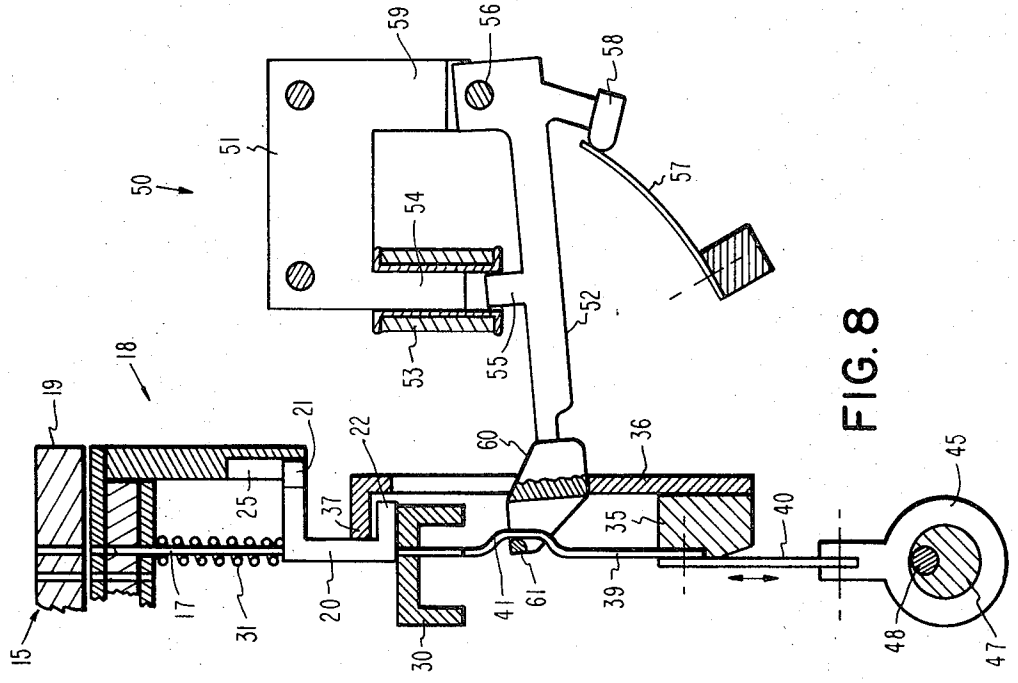

FIG. 8

ELECTRO-MECHANICAL ACTUATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to selectively operable electro-mechanical actuators and more particularly to such actuators where the armature of the control magnet is effective to displace or prevent displacement of an interposer to a position where the interposer can act upon the element to be actuated.

The invention is particularly suitable for use as an actuator in record card punching machines. Card punches function to enter holes in record cards and the holes represent data in coded form. The data positions on the cards are usually arranged in rows and columns and the cards are advanced either row by row or column by column, relative to the punches. If the card is advanced column by column, the punching machine is referred to as a serial machine. On the other hand, if cards are fed row by row, the machine is called a parallel card punch. The present invention can be incorporated into either a serial or parallel punching machine. Further, the invention can be embodied with either a single or double row of punches.

2. Description of the Prior Art

In the past, it has been the practice to either attach the interposer to the magnet armature or have the armature itself serve as the punch interposer or the punch. For example, in U.S. Pat. No. 3,194,494, the interposer is attached to the armature. The interposer is shifted from a restored position to a position between the punch bail and punch to effect a punching operation. In U.S. Pat. Nos. 2,831,355; 3,106,339; 3,232,525 and 3,279,690, the punch interposer is also the armature of the control magnet. The punch itself acts as the magnet armature in U.S. Pat. No. 3,104,053.

In the present invention, the interposer is attached to the punch bail so as to move therewith as the punch bail is reciprocated. In a preferred embodiment of the invention, the interposer is in the form of a flat spring stressed so as to normally not underlie the punch. The armature of a control magnet is provided with an integral flexure or push rod which operates upon a pivotally mounted link when the control magnet is energized to align the interposer under the punch. Then, as the bail moves the interposer, the punch is engaged and moved through a punch stroke. Thereafter, the punch is withdrawn by a punch restore bail as the punch bail returns. Of course, the interposer returns with the punch bail and is free to move to its normal position during the return of the bail providing the control magnet is deenergized. More specifically the magnet can be deenergized immediately after the bail reaches its fully up position. Then as the bail moves downward, a slight gap is formed between the ends of the punch and interposer. The stressed interposer spring is no longer restrained and it will move to its normal position.

In another embodiment of the invention, the end of the interposer normally underlies the punch. The interposer has a crook which functions as a cam. A cam follower attached to the end of the armature of the control magnet is adapted to lie within this crook if punching is to take place. To prevent punch action, the cam follower is moved to a position to underlie the associated punch and thereby displace the interposer to a position to prevent it from engaging the punch, as the bail moves the interposer toward the punch. These arrangements have all of the advantages of the devices which do not have the interposer connected to the armature of the control magnet and have the additional advantage of more positive control. Also, the interposer does not have to be made of ferromagnetic material. This permits a choice of materials according to speed and wear requirements. It also permits improved reliability to be built into the actuators. Additionally, since the interposer reciprocating with the bail is not the armature of the control magnet, motion multiplication is possible. Hence, for high speed operation, it is possible to displace the interposer the required amount with relatively small movement of the armature.

SUMMARY OF THE INVENTION

The principal object of the invention is to provide an improved, selectively operable electro-mechanical actuator which:

a. provides positive control over the interposer;
b. permits the interposer to be made of nonferromagnetic materials;
c. is relatively simple in construction;
d. is relatively inexpensive;
e. has improved reliability; and
f. is operable at relatively high speeds.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front elevational view partially in cross section of a preferred embodiment of the invention as incorporated in a card punch;

FIGS. **2***a* and **2***b* are fragmentary front elevational views of the preferred embodiment of the invention illustrating the relative positions of the interposer and punch components, wherein in FIG. **2***a* the punch bail is Down and the control magnet is energized so that punching will take place and in FIG. **2***b* the bail is punch Down and the control magnet is deenergized whereby the interposer is not positioned under the punch and punching will not take place;

FIG. **3** is a fragmentary view illustrating the connection of the punch restore bail to the punch bail;

FIG. **4** is a front elevational view partially in cross section showing another embodiment of the invention as incorporated in a card punch;

FIGS. **5***a* and **5***b* are fragmentary views of this other embodiment showing the relative positions of the interposer and punch components, where in FIG. **5***a* the bail is Down and punching is to take place and in FIG. **5***b* the bail is Down and punching is not to take place, respectively;

FIG. **6** is a fragmentary view in perspective of the embodiment of FIG. **4** to show in greater detail the cam follower attached to the armature and the relationship of the cam follower with respect to the punch interposer and the punch;

FIG. **7** is an embodiment of the invention similar to that of FIG. **4** but where the control magnet must be energized to prevent actuation of the punch; and

FIG. **8** is an embodiment of the invention similar to FIG. **7** but where the control magnet must be energized to permit actuation of the punch.

DETAILED DESCRIPTION

With reference to the drawings and particularly to FIG. **1**, the invention is shown by way of example as being incorporated in a record card punching machine. Cards to be punched are fed one at a time in seriatim from a card hopper, not shown, and transported along a card path to a pair of cooperating feed rolls **11** and **12** which are driven incrementally to advance card **10** step by step through punch station **15**. Punching, of course, takes place while the card is at rest. Feed rolls **11** and **12** advance card **10** partially through the punch station. Incrementally driven feed rolls **13** and **14** operating in synchronism with feed rolls **11** and **12** function to feed card **10** through punch station **15** after feed rolls **11** and **12** relinquish control over card **10**.

The punch mechanism is contained between parallel side plates **16**, only one being shown. In this particular example, the punch station **15** is shown with two rows of punches **17**. It should be understood that the invention can be implemented with a single row of punches or with a single punch without departing from the spirit of the invention. Punches **17** are adapted to move relative to a stationary guide assembly **18** and through card **10** into punch die **19**. Punches **17** extend through C-shaped members **20** which are attached to punches **17** to move therewith. C-shaped members **20** have several functions. Extension **21** of member **20** rides within slot **25** formed in member **18** to guide punch **17** during its travel and to prevent punch **17** from turning if the same has a round con-

figuration. Arm 22 is adapted to be engaged by the punch restore bail 37 which positively restores punch 17 to the home position whereby arm 22 rests upon stop and guide member 30. This relationship is best seen in FIGS. 2*a* and 2*b*.

Punch restore bail 37 as best seen in FIG. 3, moves with punch bail 35. Restore bail spacers 37*a*, together with the elements 35*a* forming the punch bail 35 are attached to drive spring 40. Flexure legs of drive spring 40 are secured to extensions 46 of housings 45, see FIGS. 1, 2*a* and 2*b*. Housing 45 embraces eccentric 47 which is attached to shaft 48 to rotate therewith. The motion of punch bail 35 is restricted to one plane by guides 38. Punch bail 35 will be considered to have two positions. One position is a home or restored position, *i.e.*, the bail is Down as in FIGS. 2*a* and 2*b*. The other position is with the bail in the operated or Up position, as in FIG. 1. Of course, these terms are relative and used only for the purpose of clarity and simplification of the description of the invention.

In FIG. 1, bail 35 is shown in the operated or Up position. Punch interposer springs 39 are attached to drive spring 40 so as to move with bail 35. The interposer springs 39 are sandwiched between channel members 39*a* and plates 39*b*. Plates 39*b* function to prevent gross buckling of the interposer springs 39. The interposer springs 39 are cantilevered with a free portion thereof normally urging pivotally mounted interposer link 49 against stop plate 49*a*. Essentially, the interposer spring 39 has line contact with an arcuate portion 49*b* of link 49. The interposer spring 39 does not normally underlie the end of the associated punch 17. Hence, even though the interposer springs 39 reciprocate with the punch bail 35, punching does not take place unless an associated interposer link 49 has been pivoted so as to move interposer spring 39 to a position so as to underlie the end of the associated punch 17.

The pivoting of interposer links 49 is under control of magnets 50. A control magnet 50 is provided for each punch position. Magnet 50 includes a U-shaped core 51 and an armature 52. Magnet 50 sometimes called a work magnet, also includes a coil 53 which embraces leg 54 of core 51 and projection 55 of armature 52. Armature 52 is pivotally mounted on pin 56. One end of armature 52 terminates in a push rod 52*a* which is integral therewith. Push rod 52*a* is disposed so as to pass through an opening 49*b* in stop plate 49*a*. Push rod 52*a* includes a flexure section 52*b*, which facilitates horizontal movement of 52*a* through opening 49*c*. Push rod 52*a* is essentially captured between back stop 52*c* and interposer link 49. However, a slight amount of clearance is provided to insure that the push rod is not in operative engagement with interposer link 49 when coil 53 is deenergized. When coil 53 is deenergized the push rod 52*a* is returned by spring 39. Back stop 52*c* limits the rearward travel of push rod 52*a* and interposer link 49 limits its forward travel because link 49 is held against stop 49*a* by interposer spring 39. Push rod 52*a* thus settles somewhere between back stop 52*c* and interposer link 49. Push rod 52*a* can be made of plastic material and be molded onto armature 52 which, of course, is made from ferromagnetic material.

In FIGS. 2*a* and 2*b*, punch bail 35 is in the Down position. Under this condition, the interposer spring 39 can be moved to underlie the associated punch. It should be noted that the amount of motion necessary for the interposer spring to move from the no-punch to the punch position is minimal because of relief 17*b* formed in the end of punch 17. FIG. 2*b* shows magnet 50 deenergized. Under this condition, punching does not take place as the punch bail is moved to the Up position as in FIG. 1. This is the condition shown on the right in FIG. 1. Interposer spring 39 merely slides on interposer link 49 and remains out of contact with punch 17. On the other hand, if magnet 50 is energized when bail 35 is in the Down position as in FIG. 2*b*, the interposer spring 39 is moved to underlie the end of punch 17. It should be noted that section 40*b* integral with the drive spring 40 functions as an overthrow stop for interposer spring 39. It should also be noted that there is sufficient clearance between the end of punch 17 and the end of interposer spring 39 to permit interposer spring 39 to be moved to the position where it underlies the end of punch 17. With the interposer spring 39 in the position shown in FIG. 2*a*, punching will take place as the punch bail is moved to the Up position. This is represented in the left-hand side of FIG. 1.

Another embodiment of the invention is shown in FIG. 4. Elements of this embodiment which are similar to those of the preferred embodiment of FIG. 1 are given like reference characters. It should be noted however, in this embodiment arm 22 of member 20 is urged against stop and guide member 30 by spring 31 when punch 17 is in the home position. Arm 22 is engaged by punch restore bail 37 which positively restores punch 17 to the home position.

Punch restore bail 37 is attached to move with punch bail 35 and is integral with armature restore bail 36. Armature restore bail 36 is attached to punch bail 35 to move therewith. Punch bail 35 is attached to one end of flexure 40. The other end of flexure 40 is secured to an extension 46 of housing 45. Housing 45 embraces eccentric 47 which is attached to shaft 48 to rotate therewith. The motion of punch bail 35 is restricted to one plane by guide 38. The punch bail 35 will be considered to have two positions. One position is a home or restored position, *i.e.*, the bail is Down, as in FIGS. 5*a* and 5*b*. The other position is with the bail in the operated or Up position, as in FIG. 4. Of course, these terms are relative and used only for the purpose of clarity and simplification of the description of the invention.

In FIG. 4, bail 35 has been moved to the operated or Up position. Punch interposers 39 are attached at one end to bail 35 to move therewith. The other end of each interposer 39 is free and is adapted to engage the end of the associated punch 17 which extends through C-shaped member 20. A crook or cam 41 is formed in each interposer 39. The significance of crook 41 will be seen shortly. In FIG. 4, the interposer 39 on the left was permitted to engage the associated punch 17 as the punch bail 35 moved from the Down to the Up position. The interposer 39 on the right was prevented from engaging the associated punch 17. Determination as to whether or not the punch interposer 39 will engage and drive the associated punch is under control of magnets 50.

A control magnet 50 is provided for each punch position. Magnet 50 includes a U-shaped core 51 and an armature 52. Release or buck coil 53 embraces leg 54 of core 51 and projection 55 of armature 52. Armature 52 is pivotally mounted on pin 56 and is normally urged to pivot by cantilever spring 57, which bears against armature extension 58. The free end of armature 52 is attached to an operator element 60. Of course, operator element 60 could be an integral part of armature 52. However, in this example, element 60 is not an integral part of armature 52 because it is formed from a different material, such as plastic, whereas armature 52 is made from ferromagnetic material. The shape of element 60 is best seen in FIG. 6. Although the shape of element 60 is not critical, it is essential to have a portion thereof which is able to assume a position over the associated punch to prevent the interposer 39 from engaging the end of the associated punch. In this example, a block or cam follower element 61 is provided to perform the blocking function.

Armature restore bail 36 which moves with punch bail 35 restores armatures 52 to the position shown in FIG. 4. The armatures 52 are held in this position by hold coil 70 which encircles all of the legs 59 of magnet cores 51. The armatures 52 are restored when bail 35 is in the Up position as in FIG. 4. Thereafter, when the punch bail 35 is returned to the unoperated or Down position, the interposers 39 will be in a condition as shown either in FIG. 5, 5*a* or 5*b*, depending upon whether or not buck coil 53 was energized. It is seen in FIG. 5*b* that element 61 overlies a punch and prevents the free end of the associated interposer 39 from engaging the end of the punch. If element 61 is permitted to remain in this position as the punch bail 35 moves to the operated or Up position, then punching will not take place. However, if release coil 53 is energized when bail 35 is in the Up position, the holding flux

of hold coil **70** will be canceled for the particular magnet associated with the energized release coil and spring **57** will cause armature **52** to follow restore bail **36** to the position shown in FIG. *5a*. Essentially, element **61** lies within crook **41** as shown on the right in FIG. **4**. As the bail **35** is restored to the Down position, the two elements **41** and **61** move together and as the bail **35** arrives in the Down position, the end of interposer **39** snaps over to the left to underlie the associated punch **17**. Then as punch bail **35** moves to the operated position, punching takes place as seen on the left-hand side of FIG. **4**. Further, armature **52** is restored. If another punching operation is desired, it would be necessary to again energize release coil **53**.

FIG. **7** shows another embodiment for the invention. Hold coil **70** has been removed. Armature **52** will follow restore bail **36** unless coil **53** is energized. Thus, it is seen that to permit punching to take place, it is necessary to deenergize coil **53**. If coil **53** is energized, element **61** will be held in a position to underlie punch **17** to prevent punching. Of course, it is obvious that magnet **50** could be inverted as in FIG. **8** whereby spring **57** normally holds element **61** in a position to underlie punch **17**. With this arrangement, it would be necessary to energize coil **53** to effect a punching operation. Further, it would not be necessary to include the armature restore bail because the spring would function to return the armature whereby element **61** would underlie the punch.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. An electro-mechanical actuator comprising:
- a resilient interposer mounted for reciprocating movement and having a free end displaceable transversely to the direction of reciprocating movement, said free end being adapted to engage the element to be actuated;
- means for reciprocating said interposer; and
- electromagnetic means having armature means in slidable contact with said interposer, said electromagnetic means being operable to actuate said armature means to effect displacement of said free end of said interposer transversely to the direction of reciprocating movement to prevent and permit engagement of said interposer with said element to be actuated as said interposer is reciprocated, said free end of said resilient interposer being stressed so as to be normally disposed out of confrontation with said element to be actuated.

2. An electro-mechanical actuator comprising:
- a resilient interposer mounted for reciprocating movement and having a free end displaceable transversely to the direction of reciprocating movement, said free end being adapted to engage the element to be actuated;
- means for reciprocating said interposer; and
- electromagnetic means having armature means in slidable contact with said interposer, said electromagnetic means being operable to actuate said armature means to effect displacement of said free end of said interposer transversely to the direction of reciprocating movement to prevent and permit engagement of said interposer with said element to be actuated as said interposer is reciprocated, said armature means including:
  - a pivotally mounted ferromagnetic element;
  - a push rod formed integral with said ferromagnetic element; and
  - a pivotally mounted interposer link positioned to be engaged by said push rod and being in sliding contact with said resilient interposer.

3. The actuator of claim **2** wherein said push rod includes a flexure section.

4. The actuator of claim **2** further comprising:
- means limiting the movement of said interposer link toward said push rod; and
- means for limiting the movement of said push rod away from said interposer link.

5. An electro-mechanical actuator comprising:
- a resilient interposer mounted for reciprocating movement and having a free end displaceable transversely to the direction of reciprocating movement, said free end being adapted to engage the element to be actuated;
- means for reciprocating said interposer; and
- electromagnetic means having armature means in slidable contact with said interposer, said electromagnetic means being operable to actuate said armature means to effect displacement of said free end of said interposer transversely to the direction of reciprocating movement to prevent and permit engagement of said interposer with said element to be actuated as said interposer is reciprocated, said interposer having a crook intermediate of its ends and said armature being provided with a cam follower slidably engaging said interposer within said crook.

6. The electro-mechanical actuator of claim **5** wherein said magnetic means is operable to position said cam follower over the element to be actuated and thereby prevent said interposer from engaging said element to be actuated as said interposer is reciprocated.

7. An electro-mechanical actuator comprising:
- a resilient interposer mounted for reciprocating movement and having a free end displaceable transversely to the direction of reciprocating movement, said free end being adapted to engage the element to be actuated;
- means for reciprocating said interposer; and
- electromagnetic means having armature means in slidable contact with said interposer, said electromagnetic means being operable to actuate said armature means to effect displacement of said free end of said interposer transversely to the direction of reciprocating movement to prevent and permit engagement of said interposer with said element to be actuated as said interposer is reciprocated, said electro-mechanical actuator further comprising means for urging said armature for movement in a timed relationship with reciprocation of said interposer.

8. The electro-mechanical actuator of claim **7** wherein said magnetic means includes a hold coil for developing flux for holding the armature in one position and a release coil for developing a flux for cancelling the effect of the flux developed by said hold coil.

9. An electro-mechanical actuator comprising:
- an interposer in the form of a leaf spring mounted as a cantilever for reciprocating movement in a direction generally longitudinal of the spring and having its free end displaceable transversely to the direction of reciprocating movement so that said free end in one position is disposed in confrontation with the element to be actuated whereby said element is actuated on a reciprocation of the interposer and said free end in another position is disposed out of confrontation with the element to be actuated;
- means for reciprocating said interposer;
- a pivotally mounted lever adapted to have sliding contact with said interposer adjacent the end of the lever for moving said interposer from one of its positions to its other position; and
- electromagnetic means effective on said lever at a place between its pivot and its end for moving said lever so as to thereby move said interposer.

10. The actuator of claim **9** wherein said interposer is normally disposed out of confrontation with said element to be actuated.

11. The actuator of claim **9** wherein said interposer is normally disposed in confrontation with said element to be actuated.