

April 7, 1959

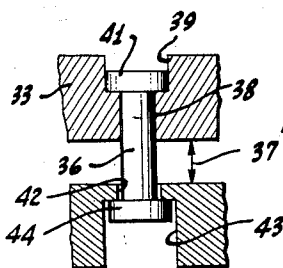
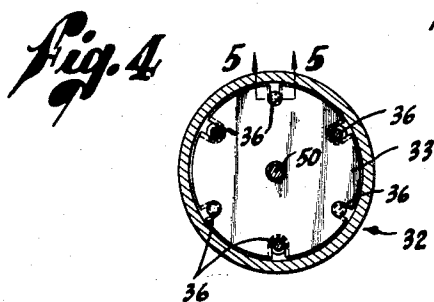
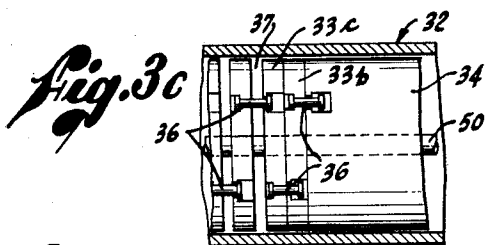
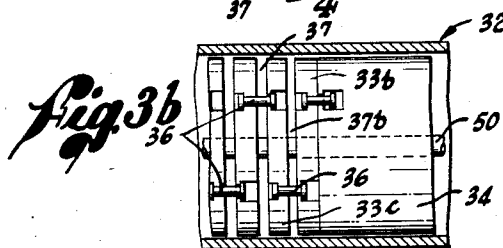
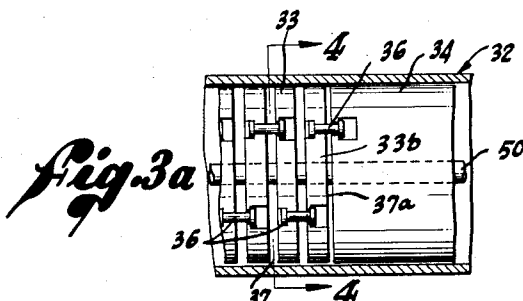
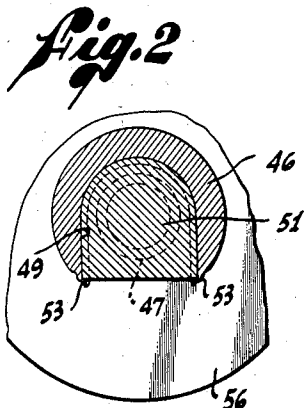
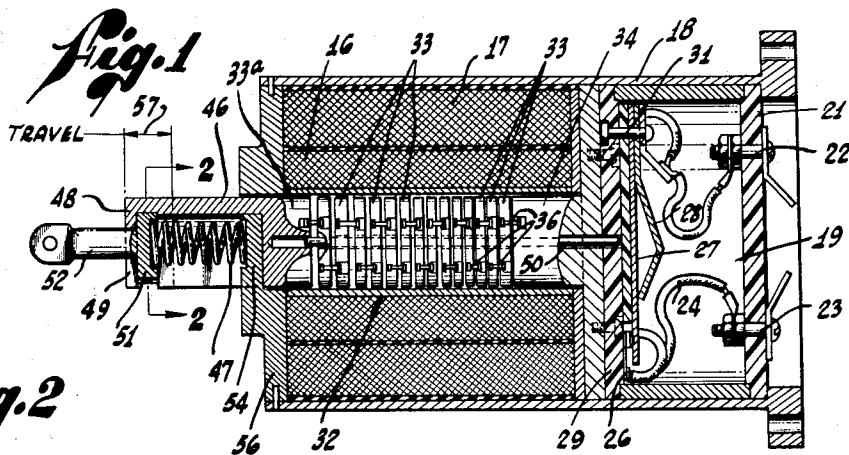
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2,881,367

ARTICULATED ARMATURE MEANS

Filed June 18, 1956

2 Sheets-Sheet 1



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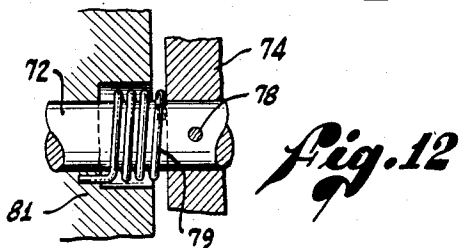
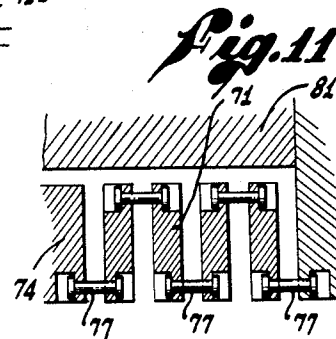
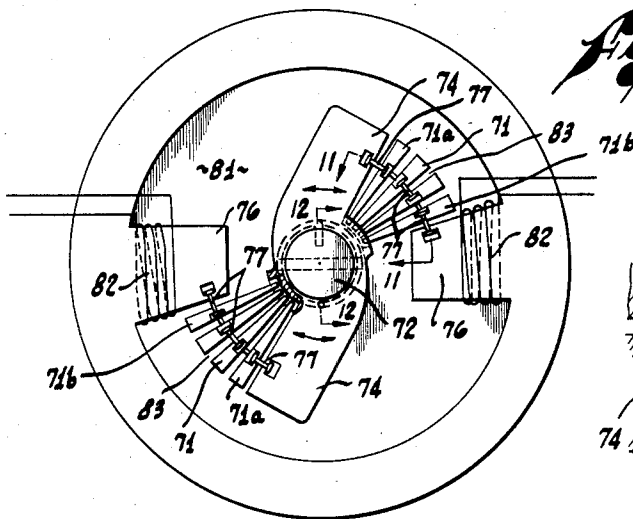
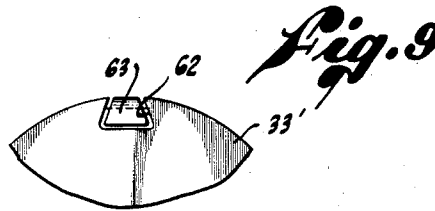
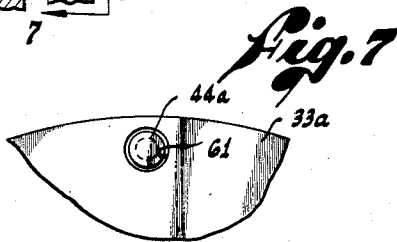
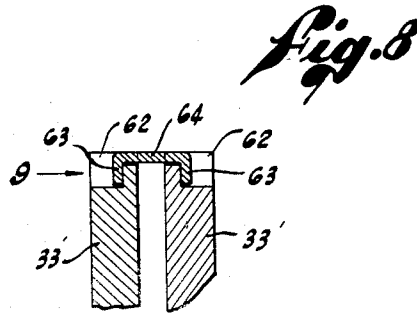
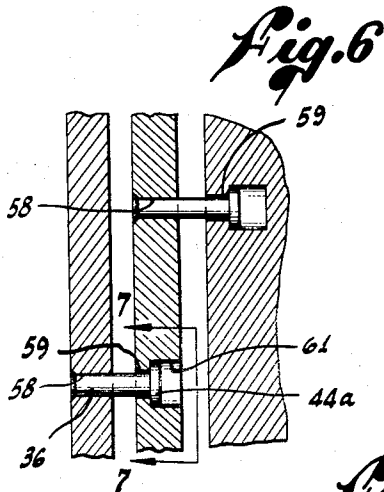
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2,881,367

ARTICULATED ARMATURE MEANS

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2 Sheets-Sheet 2



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2,881,367

ARTICULATED ARMATURE MEANS

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2 Claims. (Cl. 317—199)

This invention relates to electric actuating means, and particularly to such a means as includes a sectioned articulated plunger therein.

In the operation of mechanisms which include the drawing in of a member by an attracting field, as for example the actuation of an armature or solenoid plunger through the action of a magnetic field, the force of the plunger or armature is far from uniform over the travel span thereof. For example, in a typical solenoid, the plunger is surrounded by a cylindrical coil and is drawn against a stop member or anvil within the coil, by magnetic action whenever the coil is energized. This stop member is conventionally made of paramagnetic material and serves to help complete the magnetic circuit, thereby rendering the useful function of increasing the magnetic flux and hence the pulling-in power of the plunger, as well as to stop the plunger in its inward travel.

In such an apparatus, the pulling-in force generally varies inversely with the gap between the plunger and the anvil. Thus, at the start of travel of the plunger, the force is relatively low, and increases as the plunger moves inward, becoming extremely high just before the plunger strikes the stop or anvil.

The result of this non-uniform pulling force is that sufficient iron and ampere turns must be provided to start the plunger moving inward against the force of any restraining load, and from that point on, the rapidly increasing force serves only to accelerate the plunger, so that it strikes the anvil with a blow which is often very severe. So severe is this striking force, that considerable attention has been given to absorbing the extra and unwanted force which necessarily results from the inherent structure of the plunger.

It is an object of this invention to provide a plunger which, when operated upon by an attracting field, such as a magnetic field, will exert a more or less uniform pull on its load from its most outward excursion of travel until it is pulled in finally to its most inward position.

The interior of a solenoid coil has only a definite limited volume. This volume is shared by iron in the form of an armature or plunger means, and by air in the form of one or more axial air gaps. It is an object of this invention to make maximum use of the volume inside of a solenoid coil by achieving optimum distribution of iron and air through proper configuration and distribution of the plunger therein.

It is another object to provide an armature as above having a plurality of air gaps in the magnet path which are successively closed as the armature is pulled inward.

It is a further object of this invention to provide such an armature having a plurality of parts between which are a plurality of air gaps, said parts being articulated or linked together by a plurality of link members so disposed as to preclude canting or jamming of the articulated armature.

In accordance with these and other objects which will

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become apparent hereinafter, preferred forms of the present invention will now be described with reference to the accompanying drawings wherein:

Figure 1 is a longitudinal cross section showing one form of the present invention;

Figure 2 is a cross section taken on line 2—2 in Figure 1;

Figures 3a, 3b, and 3c are similar views illustrating the plunger means of the present invention in successive steps in operation;

Figure 4 is a cross section taken on line 4—4 in Figure 3a;

Figure 5 is a fragmentary section taken on line 5—5 in Figure 4;

Figure 6 is a fragmentary section illustrating an alternative method of linking adjacent plunger members together;

Figure 7 is a fragmentary view looking along line 7—7 in Figure 6;

Figure 8 is a sectional view showing still another method and means for linking adjacent plungers together;

Figure 9 is a view taken in the direction of arrow 9 in Figure 8;

Figure 10 is an illustration of another form of the present invention as applied to a hinged or pivoted armature means;

Figure 11 is a sectional view taken on line 11—11 of Figure 10; and

Figure 12 is a fragmentary section taken on line 12—12 in Figure 10.

It has been found in accordance with the present invention, that the efficiency and operation of an operating member, as, for example, a solenoid having an armature in the form of a plunger, is very dependent upon what is done with the iron and air space inside the solenoid coil. For example, tests were conducted in the development of the present invention on a plunger having a diameter of approximately $\frac{11}{16}$ inch. Using a one piece or solid paramagnetic plunger, and providing a gap of .300 inch between the plunger and the anvil within the solenoid, resulted in a pull of 230 ounces, which is approximately $\frac{3}{4}$ of an ounce for each .001 inch air gap. Reducing the gap to $\frac{2}{3}$ of the original, or .100 inch, produced a pull of 600 ounces, or 6 ounces per .001 inch. Reducing the gap to $\frac{1}{5}$ of the original, or .020 inch, produced a pull of 1200 ounces, or 50 ounces per .001 inch.

These figures indicate that air gaps should be made as minute as possible for maximum efficiency, and a sufficient number of gaps provided to produce the desired total movement.

While this automatically reduces the thickness of each plunger member (in an axial direction) it has been found that the reduction in pull due to the reduction in thickness of the plunger member is much less than the offsetting increase due to the ensmalling of the air gap.

It has been found in practice that the only limitation to the number of air gaps which can be provided within the interior of the coil (with iron between in the form of an articulated plunger) was the practical limitation imposed by mechanical strength required of each plunger section. That is, each plunger section had to be of sufficient thickness (axial dimension) to provide firm anchorage and operating room for the articulating linking members, and also to provide sufficient strength against bending.

It was consequently found, in accordance with the present invention, that several linking members should be provided between each plunger section, with the linking members spaced radially outward from the center

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line of the plunger and distributed substantially equally around the center line. This construction of the linking members obviates any cramping effect which would result from distribution of the plunger members or sections on a single centrally located linking member.

Referring to the drawings, and particularly Figure 1, there is illustrated an electric actuating means including a pair of coaxial solenoid coils 16 housed within a casing 18. The right hand end of the casing 18 is occupied by a switch and terminal compartment 19 through the outer wall 21 of which pass a pair of terminals 22 and 23. Terminal 23 is connected by means of a wire 24 to a contact button 26, against which a movable spring-like switch arm 27 is pressed by means of a spring 28. The contact button 26 is secured to an inner insulating wall 29, as is a connecting rivet 31 electrically and mechanically in engagement with the upper end of the switch arm 27. One side or terminal of each of the coils 16 and 17 is connected to the terminal rivet 31. The other side of the coil 16 is permanently connected to the wire 24. The other side of the coil 17 is connected to the contact button 26, so that this coil is de-energized whenever the switch arm 27 is moved from the button 26 in a manner which will be described hereinafter. Thus, whenever voltage is applied across the terminals 22 and 23, both of the coils 16 and 17 will be energized to exert an axial magnetic flux therein, and whenever the switch 27 is moved away from the contact button 26, only the coil 16 will be left energized.

The electric actuating means of Figure 1 includes an armature in the form of a plunger means 32 axially reciprocable within the innermost coil 16 of the two coils 16 and 17. The means 32 comprises a plurality of armature or plunger members 33 which are aligned for oscillation along a given imaginary line, this line being in Figure 1 the center or axis of the coils 16 and 17.

In the embodiment shown in Figure 1, each of the plunger members 33 comprises a relatively thin, circular disc having opposite faces which are substantially normal to the above mentioned axis of the coils 16 and 17. As readily seen in Figure 1, the thickness of each plunger member 33 in the direction of this axis is preferably only a minor fraction of the width or diameter of the disc 33.

Since the coils 16 and 17 produce a magnetic field, each of the plunger discs 33 is made of paramagnetic material, so as to be attracted to the next adjacent disc upon energization of the coils 16 and 17.

At the inner end of the plunger means 32, there is secured a stop member 34 in the form of an anvil, also preferably composed of paramagnetic material. In cross section, the anvil 34 is preferably circular to conform to the discs 33.

Each of the members 33 and 34 is connected or linked to the member next adjacent by means of a plurality of links 36. Each link is loosely connected at at least one end thereof to the corresponding plunger member, so as to allow all of the members to be drawn together in articulated fashion, while at the same time permitting them to be separated at predetermined distances to form between adjacent plunger members a plurality of air gaps 37. In order to minimize cocking or canting of the plunger discs, each disc is linked to the next adjacent disc by a plurality of such links, which are spaced from and about the central axis. This spacing is substantially symmetrical and in the embodiment shown (Figure 4) there are three such links for each connection. Thus in Figure 4, three of the links 36, spaced 120° apart, are employed to connect the disc 33 to the adjacent disc on one side thereof, while the other three links 36, which are intercalated among the first mentioned links, are employed to connect the disc 33 to the adjacent disc on the other side thereof.

A convenient method of linking the discs 33 together

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is illustrated in Figures 4 and 5, showing a notch 38 formed in the periphery of the disc 33 and countersunk as shown at 39 to receive the head 41 of a pin-like link 36 which is pressed into the notch 38. In the opposite or bottom disc 33 as shown in Figure 5, the receiving notch 42 is made larger than the pin body 36 so as to be freely slidable therein. A countersink 43 associated with the notch 42 is made large enough to readily and freely accommodate the opposite head 44. The structure shown in Figure 5 illustrates how the pins or links 36 are held in position to limit the separation between the two discs 33 to the predetermined air gap 37, and at the same time permit the discs 33 to be brought firmly against each other by magnetic action whenever the coils 16 and 17 are energized.

The plunger member most distant from the stop member 34, shown at 33a in Figure 1, is provided with a suitable load connecting means, shown in Figure 1 as an extending arm 46 which may be formed integral with the member 33a if desired.

In the embodiment shown in Figures 1 and 2, the arm 46 is made arcuate in cross section so as to accommodate a return spring 47 that serves to bias the plunger means 32 outwardly of the coils 16 and 17. This is effected by providing the arm 46 with an inturned portion 48, slotted at 49 to receive the T-head of an actuating rod. The head 51 is kept in position by peening over the edges of the portion 48 as shown at 53. The spring 47 is compressed between the head 51 and an inwardly extending portion 54 formed integral with the end plate 56 of the housing 18. To the operating rod 52 is connected whatever load it is desired should be moved by the actuating means shown in Figure 1.

In order to render the pull of the plunger means 32 more uniform, the successive gaps 37 are made of successively increasing magnitude, starting at the stop member 34 and proceeding toward the load connecting end 33a.

The switch 27, previously described, is actuated by a non-conducting push rod 50, which rides freely in an axial bore starting at the plate or wall 29 and extending leftward to terminate in a dead end in the plunger member 33.

In operation, whenever the coils 16 and/or 17 are energized, a magnetic flux is applied axially to the plunger means 32. This flux causes the first of the plunger discs 33b to be drawn toward the anvil or stop member 34 closing the air gap 37a as shown in Figure 3b. This gap closes first because it is the shortest and the one which is subjected to the maximum flux density. This action, by virtue of the linkage between the successive plunger members, causes the load connecting member 46 and the actuating rod 52 to be drawn inward a distance equal to the magnitude of the air gap 37a. As soon as this gap is closed, the next member 33c is drawn against 33b, which is now in effect the anvil, thereby closing gap 37b, as shown in Figure 3c. Thus the plunger means 32 is successively and rapidly shortened in articulated fashion.

The total travel of the operating rod 52 is indicated by the arrowed line 57 and is equal to the sum of the air gaps 37 when the plunger means is in extended position.

Because the effective air gap which is being closed at any given instant, by the action of the magnetic flux is never very large, the pull-in force at the start of travel is large compared to conventional structures where the air gap is relatively large at the start. Successive air gaps are made of increasing magnitude as explained hereinbefore, because as each gap is closed, the reluctance of the magnetic path is successively decreased and thus the structure is enabled to accommodate successively increasing air gaps with resultant approximately constant pull-in force.

This structure not only produces substantially uniform

pull-in force, but associated closely therewith is the elimination of the heavy impact which occurs when a single solid plunger is used and strikes forcefully the stop member or anvil 34.

Rightward movement of the member 33' pushes the rod 50 to open the switch 27, thereby de-energizing the coil 17. This leaves coil 16 energized to hold the plunger in. When the plunger moves back under the spring 47, the spring 28 forces the rod 50 back.

An alternative form or method of linking adjacent plunger discs together is shown in Figures 6 and 7 wherein the linkage pins 36a are welded or upset into bores 58 and extend through somewhat larger bores 59 that are counter-bored at 61 to accommodate the heads 44a. As shown in Figure 7, these linkage pins 36a need not be located at the edge of the plunger disc 33a, but may be spaced inward from the edge. It is preferable, however, as indicated hereinbefore, to provide a plurality of such pins 36a between each pair of opposed plunger discs 33a and to space them from the center line or axis.

A still further form or method of linking the discs together is shown at Figures 8 and 9, wherein each disc 33' is provided with a trapezoidal shaped countersink 62 into which correspondingly shaped clips 63 are pressed, the reduced center portion 64 of each clip extending across the edges of adjacent discs.

In Figures 10, 11 and 12, there is shown a form of the present invention wherein the armature members do not reciprocate on a straight line axis but instead oscillate through a small angle along an arcuate axis. As shown in Figure 10, the armature members are formed as clappers 71 pivoted or hinged about a shaft 72. Each of the clappers 71 is loosely mounted at 73 to a heavier arm 74. A stationary stop or anvil 76 extends radially into the path of oscillation of the clappers 71 and arm 74. The clapper 71a adjacent the arm 74 is linked to the arm 74 by a linkage pin 77; the clapper 71b adjacent the anvil 76 is linked thereto by a similar linkage pin 77; and each of the intermediate clappers 71 is linked to each of its neighbors by similar pins 77. The pins 77 are similar to the pins 38 previously described and serve an equivalent function of permitting the clappers 71 to separate a limited extent in articulated fashion while still permitting them to be drawn together in tight abutment.

As shown in Figure 10, the arm 74, clappers 71 and the anvil 76 are duplicated on the opposite side of the shaft 72 to form a balanced structure.

The two arms 74 together form an integral structure and are secured to the shaft 72 by a transverse pin 78. The arms 74 and shaft 72 are biased counterclockwise by a torsion spring. One end of the spring 79 is secured to the shaft 78 and the other is secured to a supporting structure 81. The stationary supporting structure 81 for the apparatus is preferably of non-magnetic material to limit leakage flux.

Coils 82 encircle the anvils 76, which also form pole pieces for the apparatus. When the coils 82 are energized, magnetic flux passes from the anvil 76 through the several air gaps 83 between adjacent clappers 71 thence to the arm 76. The flux then crosses to the other arm 74 and returns through the clappers to the other pole piece or anvil 76.

As in the case of the linear form shown in Figure 1, the armatures or clappers 71 are drawn successively to-

ward the stationary anvils or pole pieces 76 to rotate the shaft 72 against the bias of the spring 79. By virtue of the segmented nature of the armature, the pull is much more uniform than would be the case with a single air gap and a single armature; and the initial pull at the start of travel is, of course much greater, as in the case of the linear plunger shown in Figure 1.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims.

What is claimed is:

1. Electric actuating means including armature means comprising a plurality of armature members aligned for oscillation along a given imaginary line, a stop member located adjacent one of said armature means, a plurality of links linking each said member to the next adjacent member, said links being spaced from and about said line with substantial angular symmetry, said links permitting face to face abutment of said members and also limiting separation of each member from the next adjacent member to effect gaps of predetermined distances between said members, load connecting means secured to the armature member located most distant from said stop member, said gaps being of successively increasing magnitude from said stop member toward said load connecting means, and means for imparting an attracting field across said gaps to cause said members to be successively drawn together to ensmall said armature means in articulated fashion.

2. Electric actuating means including casing means having a bore therein; and plunger means reciprocally disposed in said bore and comprising a plurality of disc-like plunger members aligned for reciprocation along the center line of said bore, a stop member located adjacent one end of said plunger means, a plurality of links linking each said member to the next adjacent member, said links being spaced from and about said line and each member being of substantially uniform thickness throughout and of diameter slightly less than that of said bore, thereby to preclude cocking and jamming of said plunger means, said links permitting face-to-face abutment of said members, and also limiting separation of each member from the next adjacent member, to effect gaps of predetermined magnitude between said members, load connecting means secured to the plunger member located most distant from said stop member, said gaps being of successively increasing magnitude from said stop member toward said load connecting means, and means for imparting an attracting field across said gaps to cause said members to be successively drawn together to shorten said plunger means in articulated fashion.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,881,367

April 7, 1959

James P. Watson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the drawings, Sheet 1, Fig. 3a, the second disk from the anvil 34 should be numbered -- 33c -- instead of "33"; Sheet 2, Fig. 6, the lower pin in the figure should be numbered -- 36a -- instead of "36"; Fig. 10, the inner mounting of the clappers 71 should be denominated by an arrowed line 73; in the printed specification, column 1, line 27, for "fo" read -- of --; line 38, for "step" read -- stop --; column 3, line 8, after the numeral "16" insert -- and 17 --; column 4, line 7, for "be freely slidable therein" read -- provide free sliding therebetween --; line 43, for the numeral "33" read -- 33a --; column 5, line 5, for "33" read -- 33a --; line 41, for the numeral "38" read -- 36 --; same column 5, line 60, for the numeral "76" read -- 74 --.

Signed and sealed this 3rd day of May 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE
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