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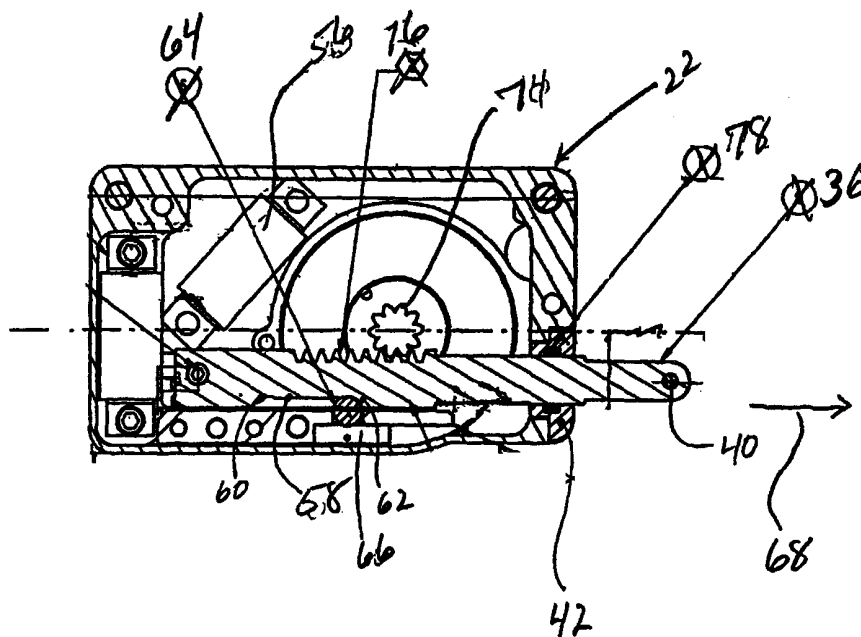
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(54) Title: **SAFE ARM ACTUATOR APPARATUS FOR BOMB RACKS**



(57) Abstract: An apparatus (20) for actuating a locking mechanism for a bomb rack includes a motor armature and pinion assembly (44) mounted in a housing (27). The motor drives a gear which meshes with a toothed longitudinal rack (36) that extends out of the housing (22) to engage the locking mechanism of the bomb rack to release the lock to permit operation of the bomb rack. An electronic relay circuit (56) actuates the motor to control extension and retraction of the longitudinal rack (36). A detent mechanism (58) and rotatable member (64) coact to limit movement of the rack (36) into and out of the housing (22).

5 **TITLE: SAFE ARM ACTUATOR APPARATUS FOR BOMB RACKS**

SPECIFICATION

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

10 The present invention relates to actuators for bomb racks or stores management systems aboard aircraft and particularly, to apparatus used to actuate a locking mechanism for a bomb rack or stores management system which can then be released for deployment.

15 **DESCRIPTION OF THE RELATED ART**

 Locking devices of various types utilizing rack and gears are known and disclosed in the following patents.

 U.S. Patent No. 655,476 to Carleton discloses an electric lock having a magnet which attracts a latch to allow a knob to
20 rotate a gear. The gear moves along a rack of a bolt to open the door.

 U.S. Patent No. 3,947,060 to Zimmer et al discloses a bolt mechanism with manual override consisting of a switch to
25 actuate a control switch for controlling a motor which drives a gear train on a rack to deploy a dead bolt.

 U.S. Patent No. 4,633,688 to Beudat et al discloses a lock device consisting of a locking bolt moved by screw threads driven by an electric motor. A rack and gears manually move the entire assembly to unlock the device.

U.S. Patent No. 5,199,288 to Merilainen et al discloses an electromechanical door lock consisting of a complex locking mechanism having an electrical driven worm and gear key lock mechanism to control an electrically driven gear train.

5 U.S. Patent No. 5,280,881 to Karmin discloses a high security locking device consisting of a solenoid to operate a bolt with an inner core. A rack on the solenoid bolt can be activated manually by a gear for the mechanism.

10 Other types of locking mechanisms are disclosed in the following patents.

15 U.S. Patent No. 5,577,781 to Kallies et al discloses an apparatus for locking an aircraft door consisting of a membrane which segregates two chambers within a housing. Air pressure of the cabin interior of the airplane is provided to one of the chambers, while exterior air pressure at the outside of the cabin is provided to the other chamber. The membrane moves in response to the pressure differential to provide a pneumatic-mechanical locking apparatus which operates without electrical components.

20 U.S. Patent No. 5,823,473 to Odell et al discloses a lock mechanism for load carrying airplane cargo doors. The device utilizes a mechanical coupling for the cargo doors having straight-through drive shafts mounted on the cargo door. The shafts each extend outwardly from either side of a power driven unit at the door to a side of the cargo door and end in a latch cam. A locking pawl is positioned and constructed not to move into a locked position unless the latch cams are in their latch position.

Many conventional aircraft employ pressurized gas to actuate pistons which forcibly eject the weapon away from the aircraft. A device therefore is needed which is safe, reliable, and effective to trigger or actuate the bomb rack or ejection mechanism for its intended use aboard the aircraft.

U.S. Patent Nos. 5,583,312 and 5,932,829, to Jakubowski, Jr., disclose an ejector rack for releasing stores (bombs or the like), and a suspension and release apparatus capable of carrying and releasing various types of weapons including bombs and missiles. The safe arm actuator apparatus of the present invention will provide the safe arm function for the ejector rack and suspension -release equipment as disclosed in the Jakubowski, Jr. patents when such function is required by the particular aircraft.

None of the devices of the patents identified above disclose or suggest an actuator according to the present invention.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a simplified, more efficient locking mechanism for a bomb rack or a stores management system (collectively referred to as a "bomb rack").

It is also an object of the present invention to provide a fast operating locking and release mechanism for a bomb rack.

It is another object of the present invention to provide a safe arm actuator mechanism for a bomb rack which supplies a high amount of torque.

5 It is an another object of the present invention to provide an actuator mechanism which operates at a low current.

It is another object of the present invention to provide an electronic actuator adapted for moving at .1/10 second to produce a stroke.

10 It is a further object of the present invention to provide an actuator mechanism which is highly reliable.

Another object of the present invention is to provide an actuator mechanism which operates with a high degree of safety.

15 Another object of the present invention is to provide an actuator which completes a circuit aboard the craft to arm craft weapons.

20 These objects are achieved with the actuator apparatus according to the present invention which includes a motor armature and pinion assembly adapted to control longitudinal movement of a rack to remove a blocking element so that the bomb rack can be operated. An electronic relay circuit actuates the motor to control the operation.

BRIEF DESCRIPTION OF THE DRAWINGS

25 For a more complete understanding of the present invention, reference may be had to the following description of exemplary embodiments of the present invention considered in connection with the accompanying drawings, of which:

FIG. 1 is a perspective view of a safe arm actuator apparatus according to the present invention;

FIG. 2 is an end view of the actuator taken along line 2-2 of **FIG. 1**;

5 **FIG. 3** is a side perspective view of the actuator according to the present invention shown in **FIG. 1**;

FIG. 4 is a top view of the actuator showing an electrical connector for the apparatus of the present invention;

10 **FIG. 5** is a side view of the actuator apparatus according to the present invention taken along line 5-5 in **FIG. 4** ;

FIG. 6 is an end view of the actuator apparatus according to the present invention taken along line 6-7 of **FIG. 5**;

FIG. 7 is a cross-sectional view of the actuator apparatus according to the present invention;

15 **FIG. 8** is a partial cross-sectional view of the actuator apparatus according to the present invention;

FIGS. 9A, 9B are cross-sectional and end views, respectively, of an armature assembly of the actuator apparatus according to the present invention; and

20 **FIGS. 10, 11** show electrical schematic views of the actuator apparatus according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in **FIG. 1**, a safe arm actuator apparatus for a bomb rack according to the present is indicated generally at 20. The apparatus 20 is used to actuate an external locking mechanism (locking mechanism, not shown) for a bomb rack (not shown), so that the rack can be released for deployment of the armament or other stores retained by the rack.

Referring to **FIGS. 1-6**, the actuator 20 includes a housing 22 consisting of portions or halves 24,26.

A connector 28 extends from the housing 22. The connector is provided with a polarizing keyway 30. The connector 28 is used to supply electrical power to the actuator 20.

Referring to **FIG. 5**, the housing 22 at the connector 28 is provided with a ramp 27 or surface area having a grade of approximately 11° from the vertical, as indicated by angle 29.

A screw 32 releasably secures together the portions 24,26 of the housing,22. A pin 34 or stud extends from the portion 22 near the connector 28.

A rack 36 extends through an opening 38 in the housing 22 and includes a pin 40 or dowel extending through an end of the rack 36. A plate 42 seals the opening 38 and supports the rack 36 where the rack passes through the opening and out of the housing 22.

All external holes of the housing 22 are preferably sealed with a transparent sealant.

Referring to **FIGS. 7,8**, mounted within the housing 22 is a motor and pinion assembly 44 having bearing journals 46,48 rotatable within ball bearings at upper and lower ends. The motor is adapted to stall if it "deadends" for more than one half second to dissipate energy and prevent burnout of the motor. The motor 44 includes a rotatable armature 50 and electromagnetic field winding 52 which are controlled by a switch 54 and relay 56, or a suitable electronic control circuit. The relay 56 transfers power to drive the rack 36 to the extended or retracted position.

On a side of the rack 36 opposite to the end having the pin 40 is a detent 58 having stops 60,62 constructed and arranged at opposed ends of the detent 58. A rotatable ball 64 is supported on a plate 66 secured to a side of the housing 22. In the locked or off position, the ball 64 contacts the stop 62 at the forward end of the detent 58. When the motor and gear are actuated in the unlocked position, the rack 36 moves forwardly in the direction of arrow 68 with the detent surface 58 riding on the ball 64 until the ball 64 contacts the stop 60 at the other end of the detent 58 to coact therewith to limit the movement of the rack 36. After release of the locking mechanism, the electrical control is switched back to the locking or off position, with the rack 36 being retracted into the housing 22 until it again reaches the limit set by the detent 58 at the forward end, i.e., when the ball 64 contacts the stop 62 for similar coaction as discussed above. The actuator 20 is capable of producing a twenty pound force output over a half inch stroke within 0.5 seconds. Ball bearings are provided at 70,72 for bearing journals 46,48, respectively.

When the switch 54 is actuated, a direct electrical current is applied by the relay 56 through brushes to the motor winding 52, which causes rotation of the armature 50 and the motor shaft and pinion assembly 44. A gear train 74 is connected to the end of the armature 50 shaft. The gear train 74 meshes with teeth 76 along the rack 36, which moves forward from a retracted position through the opening 38 to extend from the housing 22 to engage a locking mechanism for a bomb rack (not shown). An O-ring 78 at the opening 38 provides a seal for the housing 22. The pin 40 at the end of the rack 36 engages the locking mechanism (not shown), which mechanism is then released to permit deployment of the armament.

When the rack 36 is in the retracted position within the housing 22, the switch 54 is actuated by the rack 36. The switch 56 when actuated completes a circuit for the system, which permits operation of the aircraft bomb system or storage management system for the aircraft weapons. A failsafe for the system prevents electrical power from being applied to the system while the aircraft is being armed or the craft's weight is supported on its wheels. Once the aircraft becomes airborne, a switch (not shown) is closed which signals an absence of weight on the wheels, thereby permitting the storage management system to be operated. The system is not armed when the aircraft is on the ground.

FIGS. 9A, 9B show a side cross-sectional view and an end view, respectively, of the motor armature 50, winding 52 and gear train 74 which coact to drive the rack 36 to release the locking mechanism.

It is preferable to apply a light coat of thread lock to the threads of mechanical fasteners used to assemble the housing 22 of the actuator 20.

It is also preferable to apply a thin coat of lubricant, such as grease, to the teeth 76 of the rack 36, and to avoid contact of the grease with the motor and pinion assembly 44.

With respect to **FIG. 6**, there is a sufficient amount of space 76 on the housing 22 to provide a warning about cycling of the actuator 20 and procedures for using the actuator 20.

FIG. 10 is an electrical schematic showing the electrical connections of a motor control circuit 72 with an electronic relay switching the circuit between an unlock and lock position.

FIG. 11 is an electrical schematic showing the electrical connections and relay circuit in a locked condition with a lock/unlock indicator switch 82 in the lock position.

The actuator 20 of the present invention has a mechanical efficiency between approximately 85-90%. This means that the rack 36 can be moved by a force external to the actuator 20. For example, a knob (not shown) associated with the bomb rack (not shown) can be connected to a rotary blocking cam (not shown) of the bomb rack. By rotating the cam, the rack 36 of the actuator 20 can be extended or retracted. Instructions (not shown) associated with the bomb rack and proximate to the knob will indicate the direction to rotate the knob for the safe or armed position.

It is preferable that the actuator 20 of the present invention be used with one external mechanism or bomb rack.

5 It will be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.

CLAIMSWhat is claimed is:

1. An actuator for a locking device, comprising:

a housing having an opening in one wall;

5 an electric motor mounted within said housing, said motor including a rotatable armature and a concentric electromagnetic winding around said armature;

gear means secured to an end of said armature;

10 a longitudinal rack having gear teeth along one surface disposed in the path of said gear means for engagement therewith, said rack having one end extending through said wall opening and being movable in extended and retracted positions through said opening;

15 a detent extending along an opposite surface of said longitudinal rack and having stops at opposite ends of said detent;

rotatable means supported at another wall of said housing for contacting with said detent; and

20 electrical switching and control means applying a first current to said electric motor to rotate said armature and gear means to cause said rack to move in said extended position out of said opening for said one end to engage and actuate an external mechanism, and applying a second current to cause said armature and gear means to rotate in
25 an opposite direction to disengage from said external mechanism and retract said rack, said rotatable means

contacting said stops at said opposite ends of said detent to limit movement of said rack with respect to said housing.

5 2. The actuator of claim 1, wherein said electrical switching and control means includes a switch and electrical relay, said relay having an unlock position for causing extension of said rack to engage said external mechanism, and a lock position to retract said rack and disengage from said external mechanism.

10 3. The device of claim 2, including an indicator switch indicating said lock and unlock positions.

4. The device of claim 1, wherein said rotatable means includes a ball, said detent being movable over said ball, said ball being arranged to contact said stops at opposite ends of said detent.

15 5. The device of claim 2, wherein said electric motor is a direct current motor and said relay provides a direct current to said motor.

6. The device of claim 1, wherein said one end of said rack includes means for engagement with said external mechanism.

20 7. The device of claim 6, wherein said engagement means includes a pin protruding from said one end of said rack.

25 8. The device of claim 1, wherein said housing includes electrical connector means for connecting a source of electrical current to said electrical switching and control means and said motor.

9. The device of claim 1, including means for sealing said opening in said housing around said rack end.

10. An actuator for a locking device, comprising:

a housing having an opening in one wall;

5 a direct current electric motor mounted within said housing, said motor including a rotatable armature and a concentric electromagnetic winding around said armature;

gear means secured an end of said armature;

10 a longitudinal rack having gear teeth along one surface disposed in the path of said gear means for engagement therewith, said rack having one end extending through said wall opening and being movable in extended and retracted positions through said opening, said end of said rack including means for engagement with an external mechanism;

15 means for sealing said opening in said housing around said rack end;

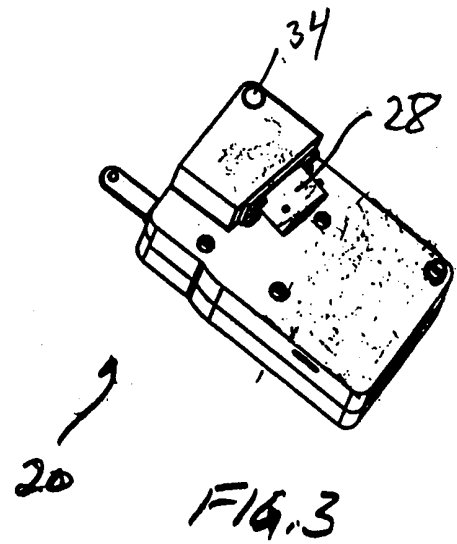
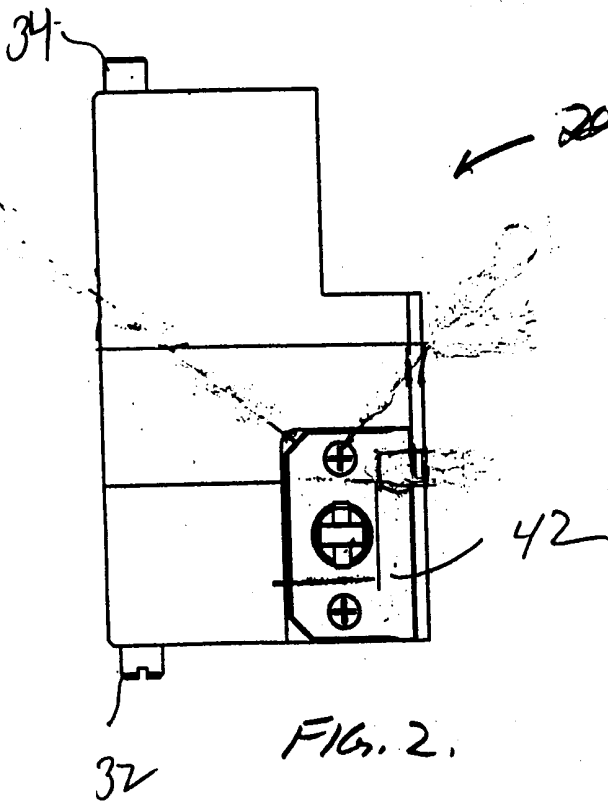
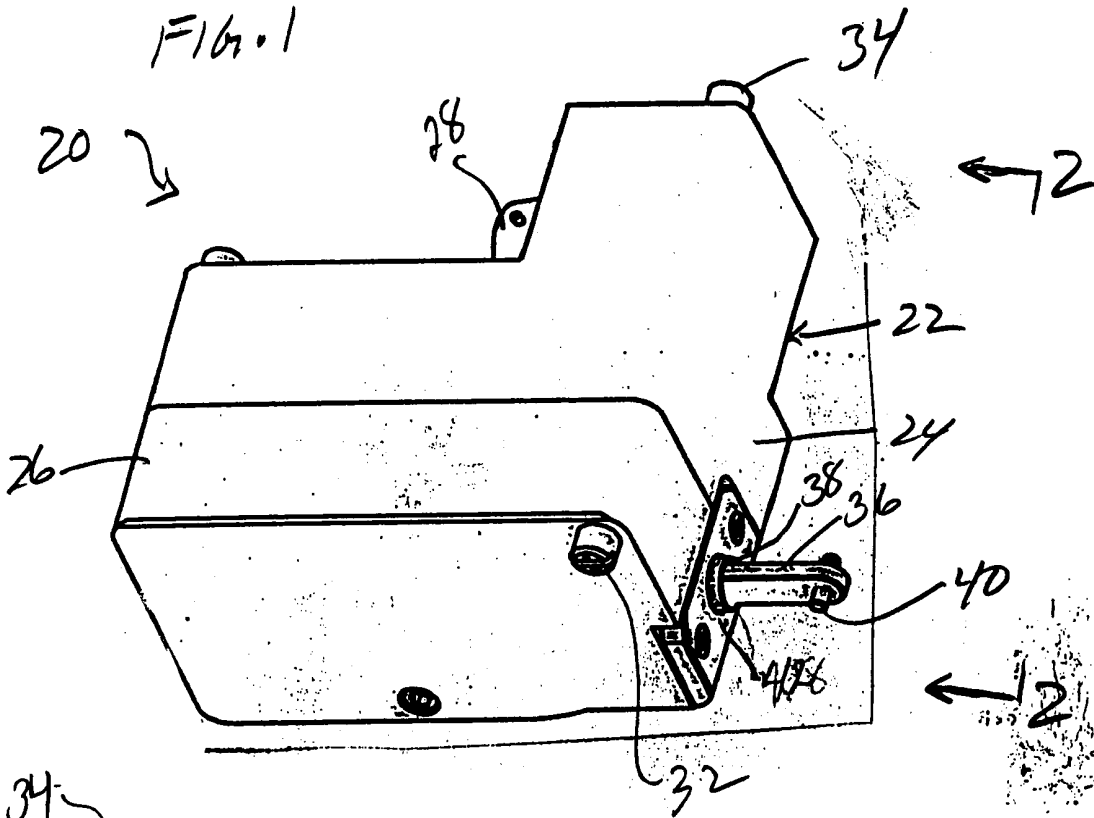
a detent extending along an opposite surface of said longitudinal rack and having stops at opposite ends of said detent;

20 rotatable means supported at another wall of said housing for contacting with said detent, said rotatable means including a ball, said detent being movable over said ball, said ball being arranged to contact said stops at opposite ends of said detent;

5 electrical switching and control means applying a first
electrical current to said motor to rotate said armature
and gear means to cause said rack to move in said extended
position out of said opening for said engagement means to
engage and actuate said external mechanism, and applying
a second current to cause said armature and gear means to
rotate in an opposite direction to disengage from said
external mechanism and retract said rack, said rotatable
means contacting said stop at said ends of said detent to
10 limit movement of said rack out of and into said housing,
said electrical switching and control means including a
switch and electrical relay applying a direct current to
said motor, said relay having an unlock position for
causing extension of said rack to engage said external
15 mechanism and a lock position to retract said rack and
disengage from said external mechanism;

an indicator switch indicating said lock and unlock
positions; and

20 electrical connector means on said housing for connecting
a source of direct electrical current to said electrical
switching and control means and said motor.



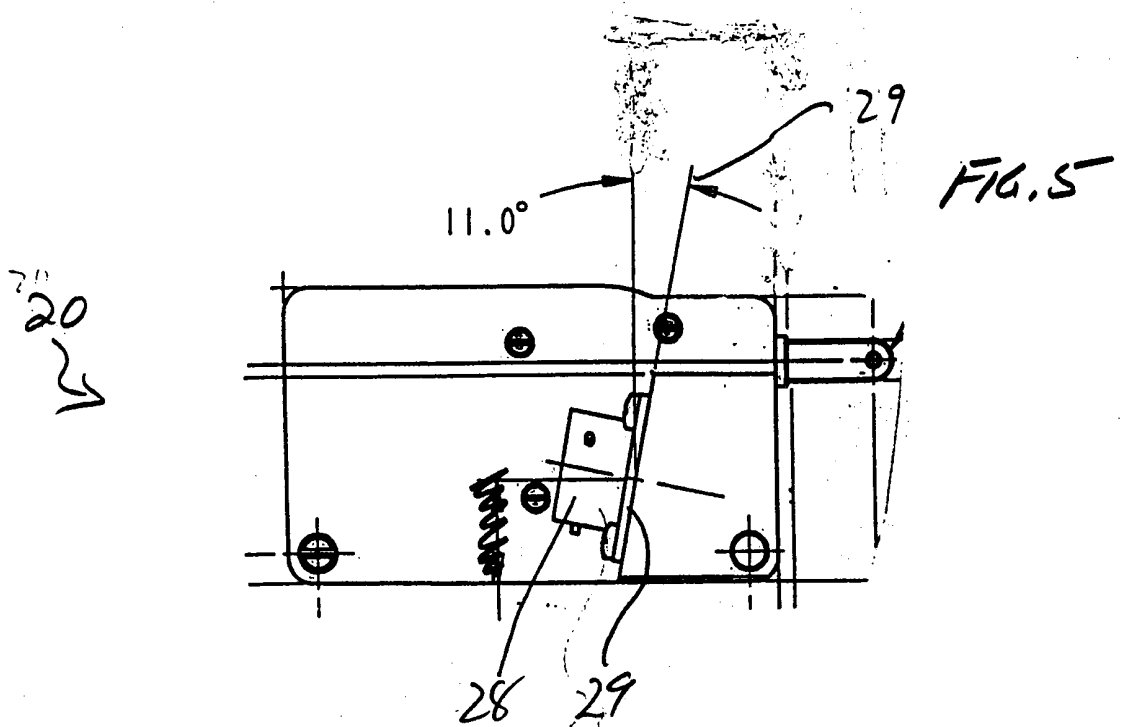
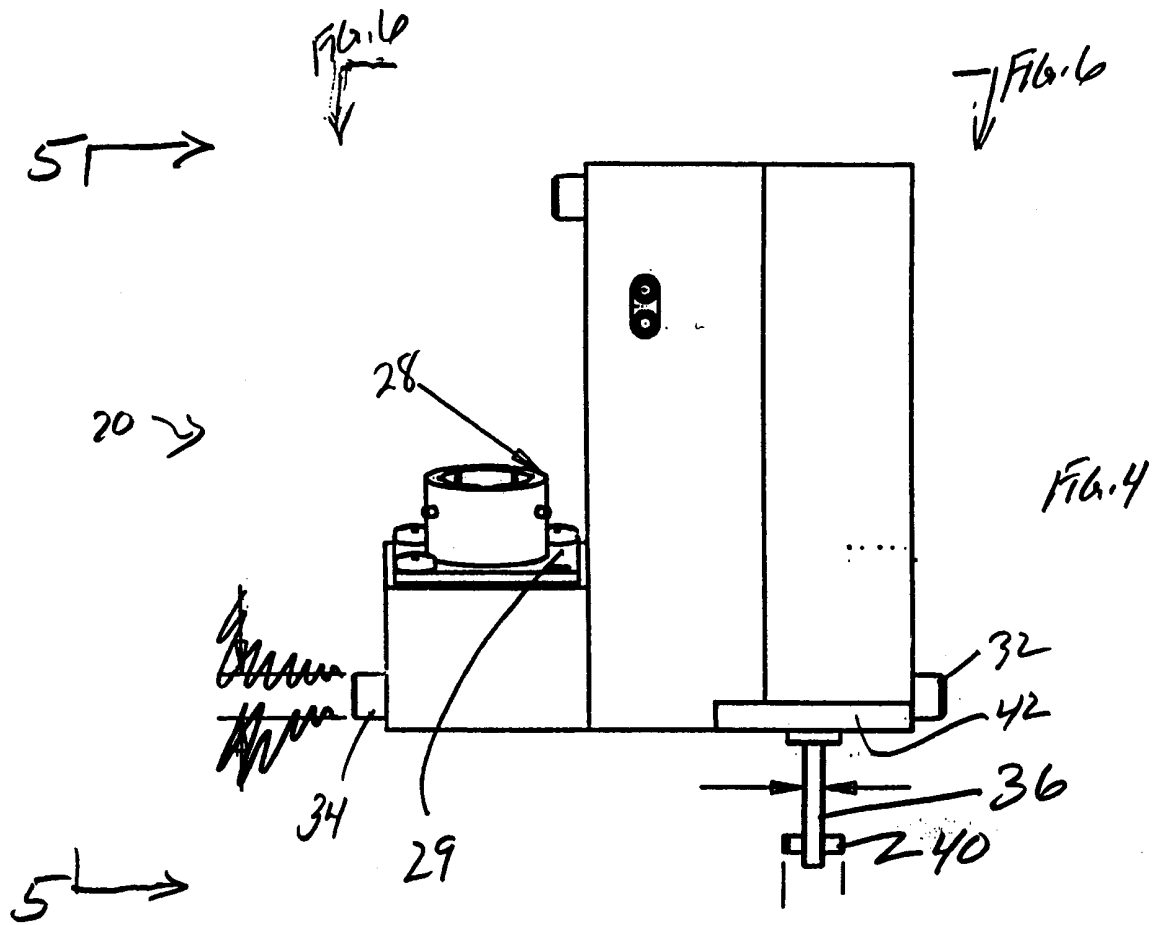
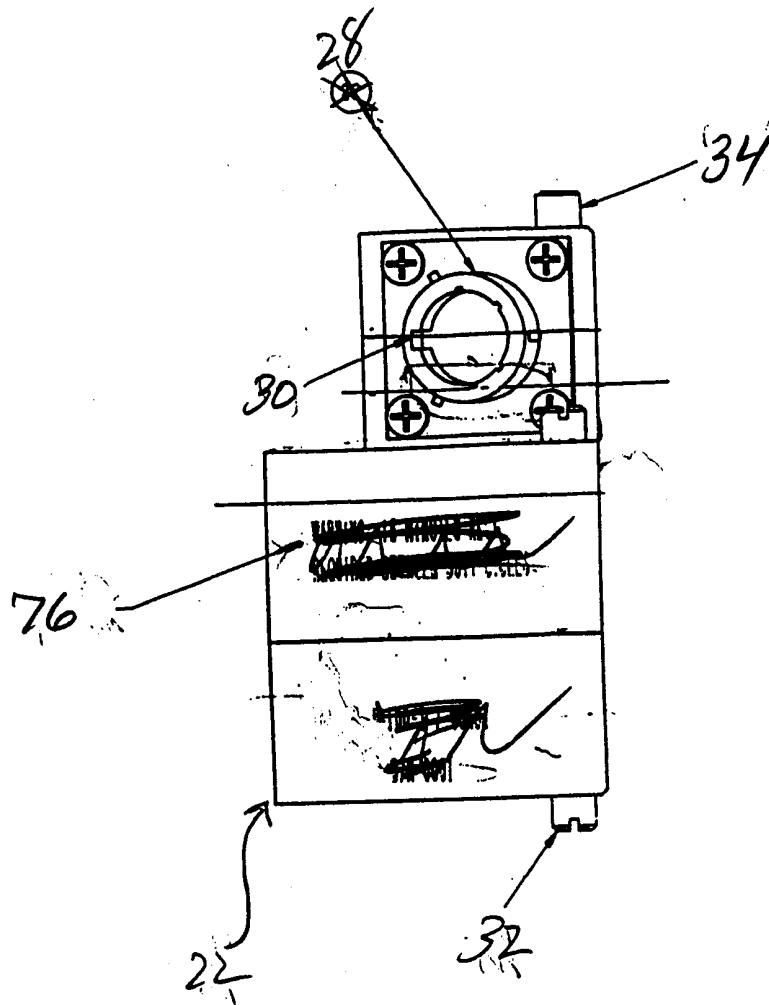


FIG. 6



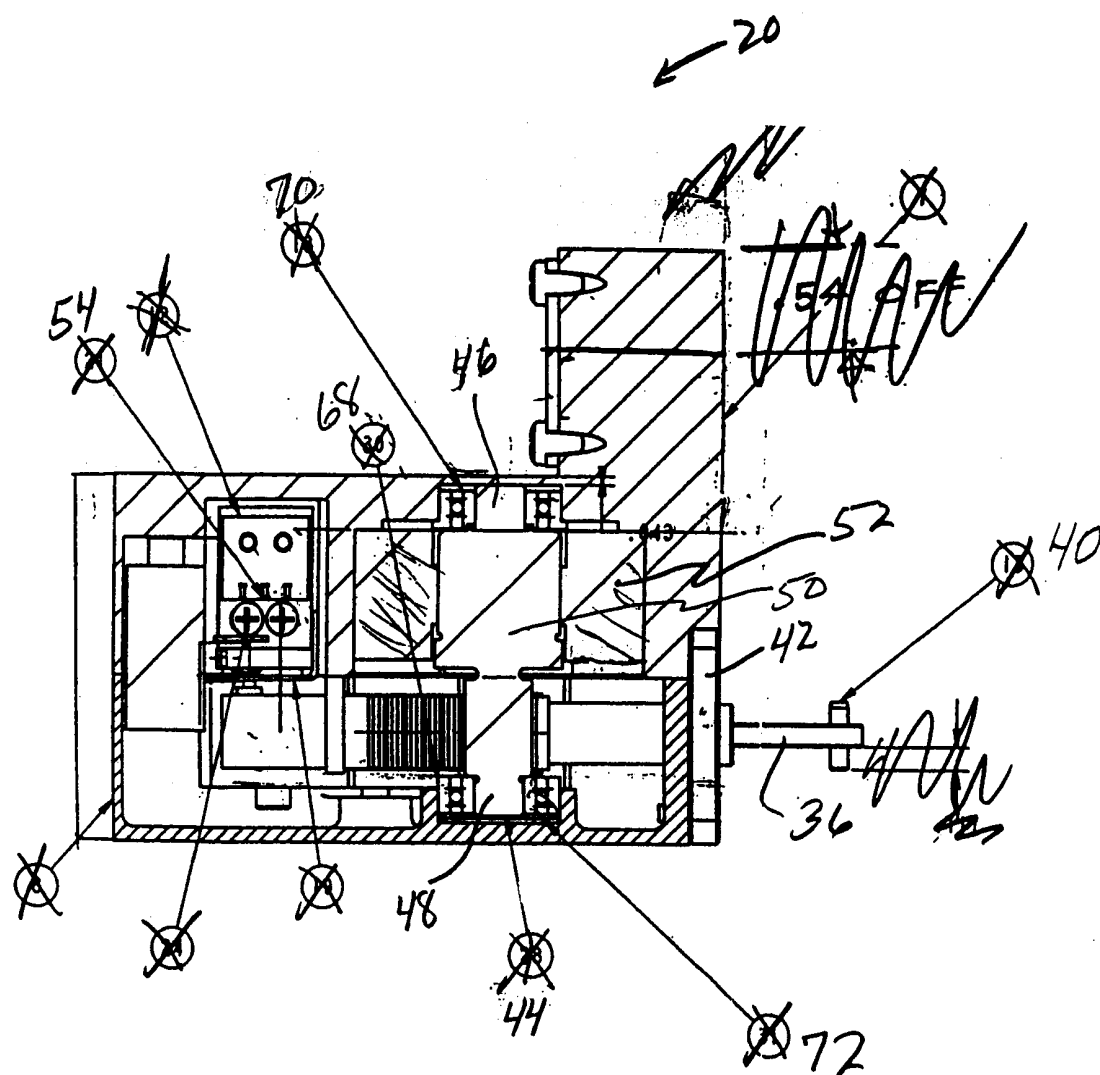
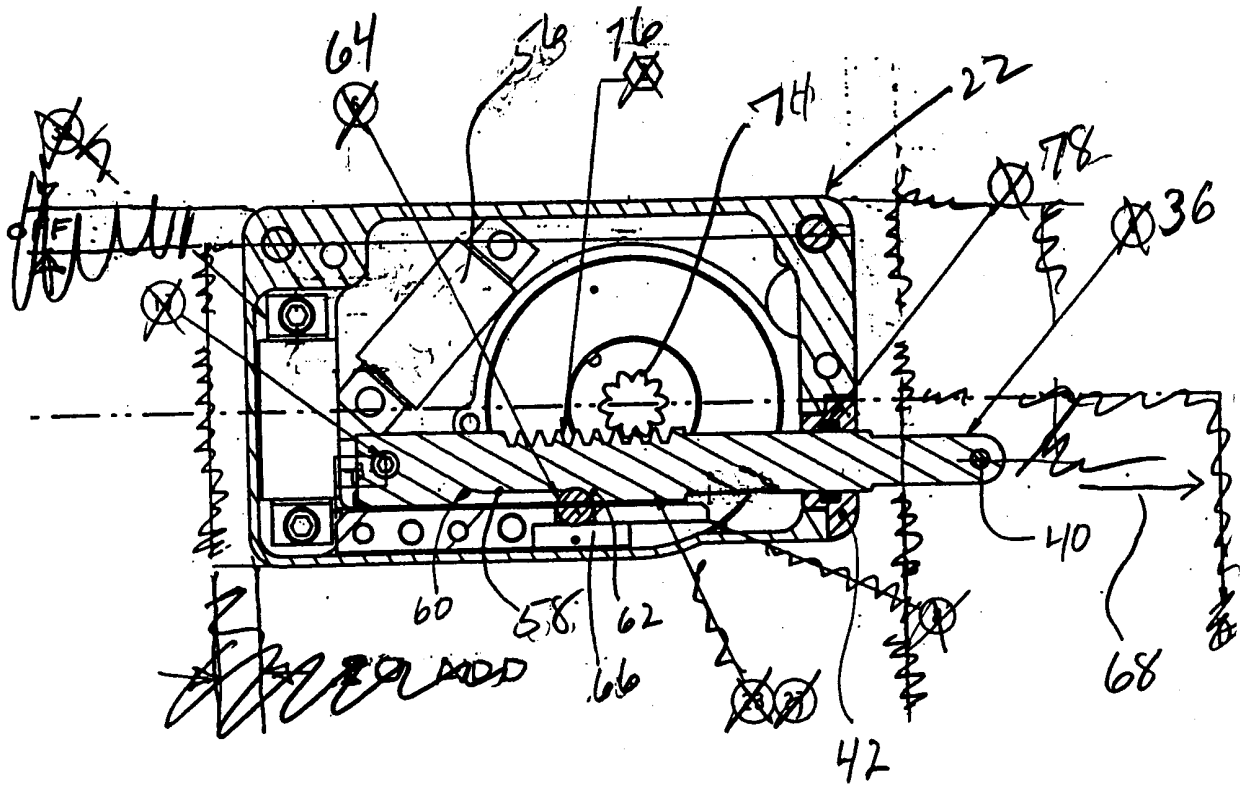


FIG. 7



176.8

FIG. 9B

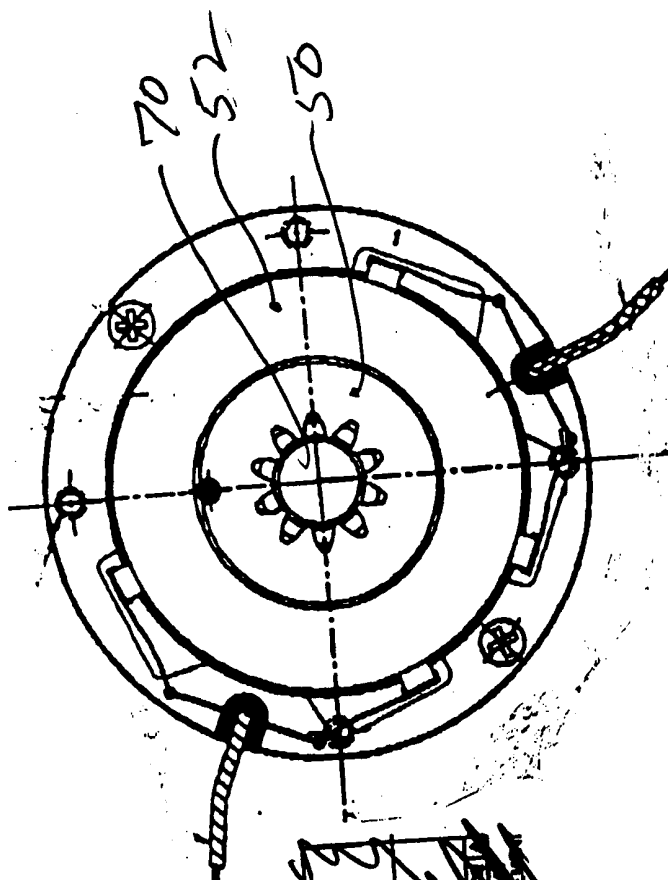
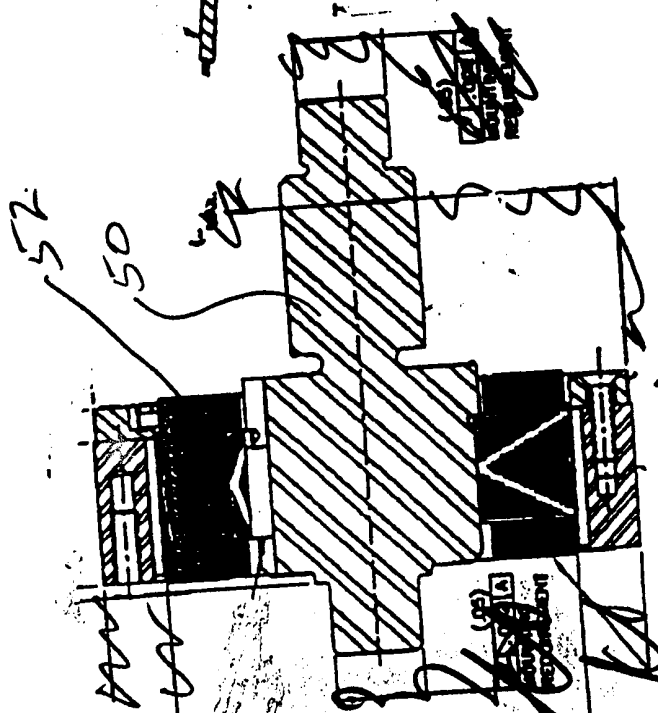


FIG. 9A



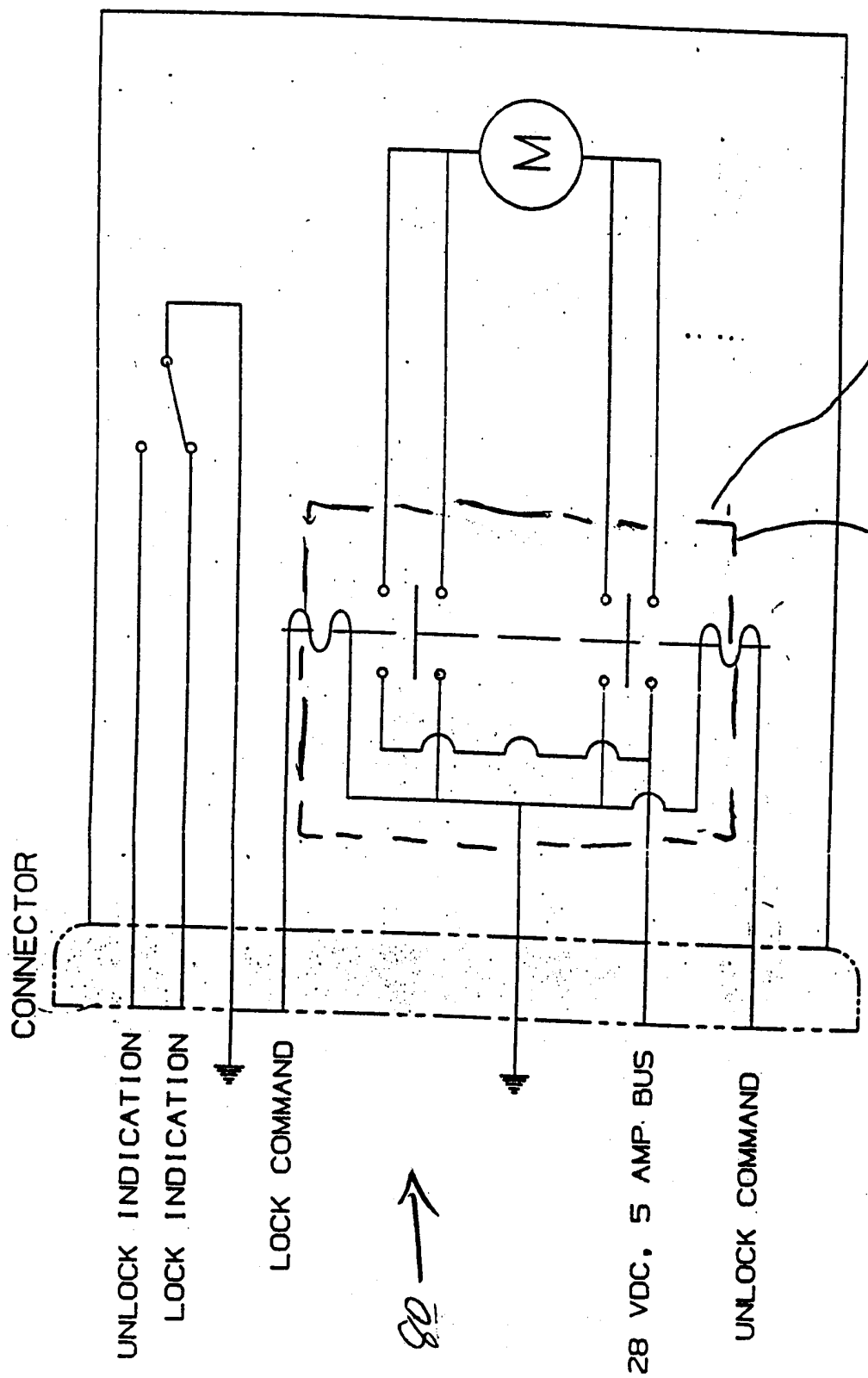


Fig. 10

