Fail-safe means for solenoid actuated devices, such as door locks, valves and the like, wherein the actuated element is operable to an active position upon energization of the solenoid, and upon deenergization of the solenoid is activated by a compression spring to an inactive position. A pair of permanent magnets provide the fail-safe feature, whereby the actuated element will be moved to its inactive position, in the event of spring failure. One of these magnets is fixedly mounted, and the other is carried by the actuated element, the magnets being so oriented as to present closely confronting like magnetic poles in a repulsion mode when the actuated element is in its active position.

3 Claims, 4 Drawing Figures
FAIL-SAFE MEANS FOR SOLENOID ACTUATED DEVICES

This is a continuation of application Ser. No. 47,959, filed June 22, 1970.

BACKGROUND OF THE INVENTION

The present invention relates to fail-safe electric actuators for devices.

While the present invention has general application for operating different types of devices, it is believed that it will be best understood by considering its use in connection with a particular type of device, and for such purpose the background of the invention will be discussed with respect to electrically operable door locks.

Hereinafter, it has been generally known to provide electrically controlled and actuated locking mechanisms for doors, and such mechanisms have embodied a variety of arrangements and constructions. As exemplary of one of the herefore known electro-magnetic lock structures, it may be noted that in U. S. Patent to Cavanaugh et al., No. 1,958,940 a bolt is operable by means of an electromagnet from an unlocked to a locked position against the force of a spring, this spring being operative upon deenergization of the electromagnet to withdraw the bolt to an unlocked position.

An electrically controlled lock according to the concepts of this patent obviously provides a simple locking mechanism which is not dependent upon the continuity of an electric supply source, and in the event of failure or opening of the energizing circuit to the energizing coil of the electromagnet, the bolt will in a sense provide a fail-safe feature. However, this is not a truly fail-safe feature since the lock will not be actuated to an unlocked position, should the spring become broken or otherwise fail to function.

The present invention therefore contemplates an improved fail-safe actuator of the electrical-spring type, and which will overcome the inherent disadvantage of the actuator as disclosed and taught by the Cavanaugh et al. U.S. Patent No. 1,958,940. More specifically, in the present invention the spring which is utilized for moving the bolt to unlocked position is supplemented by magnetic force generating means which will act independently to move the bolt to unlocked position in the event that the spring should fail, due to malfunction or to breakage, for example, due to crystallization or other reasons.

SUMMARY OF THE INVENTION

The present invention relates generally to fail-safe electric actuators for devices, and is more particularly concerned with an improved actuator of such type in which a member is electrically actuated as by a solenoid to an active position, and upon deenergization of the solenoid will be actuated by a spring to an inactive position, and which incorporates as a fail-safe feature magnetic force generating means for supplementing the spring action and assure movement of the member to the inactive position even though the spring should fail.

The present invention is especially useful for providing a new and dependable fail-safe security concept for protecting property, particularly in public buildings that are used as a gathering place for large numbers of people.

The problem solved by the herein described invention arises because of the provisions contained in existing fire laws and regulations that public and private buildings and/or rooms that are occupied by a stipulated number of people, must be provided with exits that may be opened without special knowledge or effort. The normal installation complies with this provision by utilizing panic exit bolts on the doors which can be opened merely by pushing down on a bar release permitting the door to be outwardly opened to provide instant exit.

The above described ease of exiting, while solving one problem, creates a severe problem of general security of the building. It is a known fact that a piece of bent wire can be inserted between pairs of doors on most buildings having exit doors of the above type, and by pulling down on the exit rod it is comparatively simple to gain unlawful entry. In other cases where, because of badly fitting hardware, improper engagement of bolt latches or rods, twisted or warped doors compromising security, the building owners or managers may resort to makeshift methods in order to properly secure the building.

It is also a well known fact that unauthorized persons occasionally hide within the building until after closing hours, and then remove valuables simply by walking out the exit doors equipped with panic exit devices.

In some cases, the building owners, in an effort to prevent theft and vandalism, have resorted to makeshift arrangements which are contrary to the Fire Safety and Building Code Regulations, and may even be such as to place authorized persons remaining in the building after working hours in jeopardy in the event of fire or other conflagration necessitating that they evacuate the premises.

With the foregoing in mind, it is a feature of the present invention to provide locking units which will remain locked when electrically energized, and will automatically unlock upon deenergization. The supply of electrical energy is controlled by an alarm device, for example, a fire alarm system in the building, which upon activation will open the energizing circuit to the lock and permit it to automatically move to its unlocked position.

A further object is to provide a fail-safe arrangement in which movement of the lock to unlocked position will not be solely dependent on the operation, for example, of a spring, and which will operate in the event of spring failure or malfunction.

A further object is to provide a solenoid actuator for devices which incorporates fail-safe means including magnetic force generating means for moving an actuated element from an active to inactive position when normal electric control means are deenergized.

Another object of the invention is to provide improved door locking means embodying a fail-safe solenoid actuator.

Another object is to provide a valving device embodying a fail-safe solenoid actuator as herein described.

Further objects of the invention will be brought out in the following part of the specification, wherein detailed description is for the purpose of fully disclosing the invention without placing limitations thereon.
BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the accompanying drawings, which are for illustrative purposes only:

FIG. 1 is a perspective view illustrating the cooperative association of door locking means, incorporating fail-safe solenoid actuator means according to the present invention;

FIG. 2 is a longitudinal elevational section of a solenoid actuated locking mechanism according to the present invention, and showing the cooperative relationship of the components, together with the schematic control circuitry;

FIG. 3 is a fragmentary detail view of a modified arrangement of a control switching device as utilized in the control circuitry; and

FIG. 4 is a fragmentary sectional view showing a fail-safe solenoid actuator according to the present invention, as applied to a valve mechanism.

DESCRIPTION OF THE SEVERAL EMBODIMENTS OF THE INVENTION

For illustrative purposes, there is shown in FIG. 1 a door locking arrangement in which an electrically operable lock, as generally indicated at 10, is mounted on a first door part 11 for cooperation with a strike, as generally indicated at 12, mounted on a second door part 13. The door parts are relatively movable and may comprise, for example, a door jam and a swinging door or sliding door. The lock 10 includes a housing 14 of suitable metal, plastic, or other material which is shaped to provide a container of generally rectangular configuration. A cover member 15 closes one side of the housing and is provided with an opening 16 for receiving a projecting portion 17 of the strike therethrough into a locking position.

As best shown in FIG. 2, the lock components are shown as comprising a bolt element 18 preferably constructed of a suitable plastic or other non-magnetic strong material. The bolt is secured to a suitable axially aligned stem member 19 which may be made from steel, an annular flange 20 being formed at the juncture of the bolt element and stem. The opposite end of the bolt element is guidedly supported within a tubular passage 21 of a supporting bracket 22 secured at its periphery to adjacent walls of the housing 14 as by screws 23. The flange 20 is guidedly movable within a surrounding sleeve 24 having one end recessed in the bracket 22, and at its other end attached to an annular end member 25 secured as by screws 26 to one end of a solenoid actuator, as generally indicated at 27.

The actuator is supported within the housing by a bracket 28 which may be secured to the walls of the housing as by appropriate screws 29. The actuator comprises a solenoid coil 30 of conventional construction and preferably wound on a spool structure 31 having an axially extending passage 32 with its longitudinal axis aligned with the axis of the sleeve 24. The outer end of the passage 32 is closed by an end plate 33 which forms an abutment for one end of a solenoid plunger 34 positioned for movement therein. The plunger 34 is engaged by the adjacent end of the stem member 19, and a compression spring 35 surrounding the bolt element, one end of this spring extending into and being seated in the bracket 22, while the other end of the spring bears against the flange 20. The spring as thus arranged normally urges the bolt element 18, the stem 19 and solenoid plunger 34 towards the right as seen in FIG. 2, until the plunger is at the limit of its travel in abutment with end plate 33. It will be observed that in this position the longitudinal center of the plunger is displaced to the right of the longitudinal center of the coil 30 so that upon energization of the coil, the plunger will tend to a central position between the ends of the coil. During this movement the bolt element 18 will be projected towards the left, against the force of spring 35, into a locking position wherein the bolt extends through a transverse passage 36 of the strike 12 in the closed position of the door. It will be obvious that upon deenergization of the solenoid actuator, the spring 35 will urge a return of the bolt element to its unlocked position.

From the foregoing description, it will be apparent that the spring 35 in a sense provides a fail-safe action which will unlock the bolt in the event that energization of the solenoid actuator is terminated for any reason.

In certain installations, however, as for example in the case of exit doors of public buildings, failure of the spring by crystalization or malfunction can produce a most dangerous situation. It is therefore a very important feature of the present invention to augment the pseudo fail-safe characteristic of the solenoid actuated lock as previously described in a manner to positively open the lock and move the bolt element to its unlocked position, even though the spring 35 should fail to operate. For such purpose, means are provided for generating magnetic forces which will operate to move the bolt element to an unlocked position, when the solenoid actuator is deenergized.

For generating the magnetic forces, a pair of permanent magnets 37 and 38 are utilized. The magnet 37 is embraced within the outer end of the bolt element with its end 37' projecting slightly therefrom. As thus mounted, the magnet will move with the bolt to its locked and unlocked positions. The other magnet 38 is embraced by a surrounding casing 39 of suitable plastic or other material which is mounted in a bracket 40 positioned on the opposite side of the strike receiving cavity from the bracket 22, and is similarly secured to the housing wall as by screws 41. The magnet 38 is axially aligned with the magnet 37 and has its end 38' slightly projecting from the supporting bracket and in confronting relation to the end 37' of the other magnet. The magnets are so mounted that the ends 37' and 38' will comprise like poles which are oriented in a repulsion mode. In this case the adjacent ends constitute north poles of the magnets. As thus arranged, it will be readily apparent that in the closed or locked position of the bolt element 18, the magnet ends 37' and 38' will be in close confronting relation. Also, that upon deenergization of the solenoid actuator, the repulsion force of the magnets will supplement the force of spring 35 to move the bolt to its unlocked position. In the event that the spring 35 malfunctions or does not operate, the repulsion force will be sufficient to complete the retraction of the bolt to unlocked position, thereby providing a dependable positive fail-safe characteristic.

In utilizing the locking device which incorporates the fail-safe actuator of the present invention, particularly in the case of exit doors, the lock or locks, as the case may be, will be connected with a control system supplied with electricity from a suitable electric source as indicated at 42. The circuit from the source is carried through a main control switch 43 and thence through
closed contacts 44 of an alarm device 45, for example, a fire alarm device which in case of fire will operate to open the contacts 44. From the contacts 44, the circuit is carried to the coil 30 of the solenoid actuator, one side of this circuit containing a switch 46 mounted in the lock housing, this switch having normally open contacts (not shown) actutable to closed position by an actuating member 47 projecting through an opening in the cover 15 in the path of travel of a closing door part as it is moved to closed position. In accordance with the operation according to the present invention, the actuation of switch 46 will operate to energize the solenoid actuator 27 to lock the door automatically whenever it is moved to closed position. However, when it is desired to unlock the door, this can be manually accomplished by opening the switch 43, or in case of fire, the operation of the alarm device will open the contacts 44, whereupon the lock will be opened so as to permit personnel to leave by way of the exit doors and prevent them being trapped.

For visually indicating the condition of the lock, an indicating lamp 48 is connected across the terminals of the coil 30 so as to be energized and deenergized concurrently with the coil. For convenience the lamp is placed adjacent an opening 49 in a wall of the housing.

Referring to FIG. 3, there is shown a modified switch arrangement to that of the switch 46. In this arrangement, a reed type switch 50 is utilized, this switch being mounted adjacent the opening 16 in the lock housing. The switch is provided with normally open contacts which are operable in a conventional manner to closed position, when the switch is subjected to an adjacent magnetic field. For operating the switch in a closed door position, the strike carries a permanent magnet 51 which will be juxtaposed to the reed switch in the door closed position. The operation of the reed switch is the same as switch 46, and is connected in a similar manner into the control circuit.

As previously stated, the solenoid fail-safe actuator, as embodied in the present invention, is susceptible of use with various types of devices. Referring to FIG. 4, the actuator is disclosed as being incorporated in a valve structure which comprises a valve body 60 of conventional construction. As shown, the body is formed to provide a bonnet portion 61 having inlet and outlet connections 62 and 63 respectively. The inlet and outlet connections are connected with a flow passage including an annular seat 64 which defines an inlet flow passage into a valve chamber 65 contained within the valve body. Outflow from this chamber is by way of the outlet connection 63.

Cooperatively associated with the seat 64 is a valve member 66 in the form of a disc which may be of any suitable material adapted to make good seating engagement with the valve seat in the closed position of the valve. The valve member is carried by a member 18', which corresponds to the lock member 18 as previously described, but in this case is utilized as a valve stem mounted for reciprocable movement in the head portion of the bonnet 61. In the raised position of the valve member, the valve member is arranged to engage a sealing ring 67 which will prevent leakage in the open position of the valve.

In the valving device, permanent magnets 37 and 38 are similarly arranged, and cooperate in the same manner as previously described in connection with the lock mechanism shown in FIG. 2, except that in this case the magnets operate so as to assure movement of the valve to open position upon deenergization of the solenoid actuator even though the associated compression spring 35 should fail to function.

From the foregoing description and drawings, it will be clearly evident that the delineated objects and features of the invention will be accomplished.

Various modifications may suggest themselves to those skilled in the art without departing from the spirit of my invention, and hence, I do not wish to be restricted to the specific form shown or uses mentioned, except to the extent indicated in the appended claims.

I claim:

1. A fail-safe lock structure, comprising:
   a. a housing;
   b. a bolt reciprocating within the housing to an active position and an inactive position;
   c. a keeper engaged by the bolt when in active position;
   d. a bolt actuator within the housing, including a solenoid coil and a solenoid plunger, the bolt being connected to the plunger and being moved to active position upon energization of the solenoid coil;
   e. spring means operatively associated with the bolt and being compressed when the bolt is actuated to active position and forcing the bolt to inactive position upon deenergization of the solenoid coil;
   f. a first magnet carried by the keeper engaging end of the bolt;
   g. a second magnet mounted in the housing in alignment with the bolt;
   h. the two magnets being mounted in their respective positions with like poles in face-to-face relationship whereby to produce in the active position of said bolt a force to normally augment the force of said spring in moving the bolt to its inactive position, upon deenergization of the solenoid coil, and upon failure of said spring provide a solely acting force for moving said bolt to said inactive position.

2. A fail-safe lock structure according to claim 1, wherein the first magnet is fixedly mounted on the keeper engaging end of the bolt, and the second magnet is fixedly mounted on an opposite side of said keeper from said bolt.

3. A fail-safe lock structure according to claim 1, including an energizing circuit connecting said solenoid core with an electrical source; switch means having normally open contacts in said circuit operable to circuit closing position in response to movement of said door parts to a door closed position; and a supplemental device having normally closed contacts in said circuit ahead of the contacts of said switch means, for interrupting the circuit upon activation of said supplemental device.