

Door lock

Field of technology

- 5 This invention relates to a door lock comprising a lock body fitted with a front plate and a dual-action bolt. The bolt can be moved with reciprocal linear motion between a withdrawn position and a locking position protruding out from the lock body.

Prior art

- 10 An electrically controlled door lock often uses a solenoid or other actuator to control deadbolting means in the lock as to lock the bolt in the deadbolting position. In the deadbolting position, the bolt is out; in other words, protruding out from the lock body. The solenoid is also used to release the deadbolting means from the deadbolting position, which allows the bolt to move into the lock body to the
15 withdrawn position.

- In prior art solutions, the solenoid or other actuator is functionally linked to a deadbolting piece that can be moved so that it locks the bolt in the deadbolting position. In a typical implementation, the deadbolting piece is linked to the solenoid shaft, and a spring is used to arrange the shaft to protrude outwards from the
20 solenoid. When the solenoid is de-energised, the spring holds the deadbolting piece in the deadbolting position, and when the solenoid is energised, the solenoid tries to move the deadbolting piece out of the deadbolting position against the spring force.

- The spring must be sufficiently strong to hold the locking piece securely in the deadbolting position. This, in turn, means that the solenoid must be sufficiently
25 powerful to be able to move the locking piece against the spring force.

 When the door is closed and the lock is in the locked state, seals between the door and the door frame tend to press the lock bolt against the striker plate in the door frame. In case of a dual-action bolt, the bolt also tends to push into the lock body; in other words, it pushes against the deadbolting piece controlled by the solenoid.

These external forces counteract the force of the solenoid or other actuator when the solenoid is operated to move the locking piece out of the locking position.

Thus the solenoid or other actuator must be sufficiently powerful to be able to control the deadbolting piece. If the solenoid/actuator is too weak in power, this will
5 cause disruptions in lock operation such as unwanted locked states.

Exit doors are often also equipped with a mechanical actuator such as a bar that must be able to open the door. The bar is called an emergency exit bar. The emergency exit bar is used by pressing it down to release the locked state of the lock. Being an actuator, the bar is also pushed towards the door, particularly in an
10 emergency. This may impose a great force between the striker plate and the bolt. Therefore the force conveyed from the actuator to the lock can be quite great, which may cause the deadbolting parts of the lock to jam and result in unreliable operation.

Short description of invention

15 The objective of the invention is to reduce the electrical energy needed by a lock body to control the lock and, simultaneously, use a lower-power actuator such as a solenoid. It is desired that operation of the lock is reliable also when using mechanical actuators such as an emergency exit bar. The objectives will be achieved as described in the independent claim. The dependent claims describe various
20 embodiments of the lock according to the invention.

The transfer of external force to the locking piece is reduced, which reduces the power requirement for the electric actuator. The impact of external mechanical force on the operation of the locking piece is smaller. The reduction of external force is arranged in two stages of transmission. At the first stage of transmission, the
25 transmitted force is reduced using a wedge part that is in force transmission contact with a lever. The second stage of transmission consists of different leverages at different points of the lever. The lever has a locking surface that can be arranged to contact the locking piece.

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In the following, the invention is described in more detail by reference to the enclosed drawings, where

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|----|-----------------|---|
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| 10 | | with the bolt moving in, |
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| 15 | Figure 6 | illustrates an example of a door lock wedge support piece according to the invention, |
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| 20 | Figure 9 | illustrates the locking piece and the solenoid shaft plunger element. |

Description of the invention

- Figure 1 illustrates an example of a door lock 1 according to the invention. The door lock comprises a lock body 3 fitted with a front plate 2; the lock body has a dual-
25 action bolt 4 that can be moved with reciprocal linear motion between a withdrawn position and a locking position protruding out from the lock body through the bolt opening 5 (Figure 2) in the front plate 2. The bolt 4 comprises a body part 6, and in

the embodiment of Figure 1, two bolt pieces 7. The bolt 4 is spring-loaded towards said protruding position. The door lock 1 further comprises deadbolting means 8 that can be moved to a deadbolting position in which they prevent the dual-action bolt from being moved from the protruding position to the withdrawn position in the lock body 3. The lock of this embodiment also comprises a solenoid 9 for controlling the deadbolting means.

The door lock usually also comprises other control means for controlling the deadbolting means. The lock may have an auxiliary bolt 16 and/or control spindle means 17. The auxiliary bolt prevents the bolt from moving to deadbolting when the door is open but allows it when the door is closed. The control spindle means 17 comprises, for example, a cylinder body, a handle and/or a knob. The connection from the control spindle means and auxiliary bolt to the locking piece 15 within the deadbolting means is simply marked with dashed lines. Thus in the embodiment of Figure 1, the locking piece can be controlled with the solenoid 9, the auxiliary bolt 16 and the control spindle means.

The lock may also be arranged to receive control from an emergency exit bar. In this case very great external forces may be conveyed to the deadbolting means of the lock. This will happen, for example, if the emergency exit bar is simultaneously pushed, imposing great force between the striker plate in the door frame and the lock bolt. This force tends to push the dual-action bolt intensively into the lock body, which may jam the deadbolting means.

Figure 2 illustrates an embodiment of a lock according to the invention viewed from the front side of the front plate. It can be seen from the figure that in this embodiment, the edge of the bolt opening 5 has projections 18 that are required for the bolt pieces 7 used in the embodiment. Some other type of dual-action bolt can certainly also be used in a lock according to the invention.

The deadbolting means comprise a wedge 10 between the body part 6 of the bolt and the lock body 3. The wedge is arranged to move transversely to the linear path of the bolt. The deadbolting means also comprise a locking piece 15 and a lever 11 comprising a support point 12, a support surface 13 and a locking surface 14. The

lever 11 is pivotably supported on the lock body 3 at the support point 12. The support surface 13 is arranged to cooperate with the wedge 10.

The support surface 13 and locking surface 14 can be turned with the lever in relation to the support point 12 between the lever's outward turning position towards the front plate and inward turning position towards the back edge of the lock body. The locking surface 14 is farther away from the support point 12 than the support surface 13. The lever 11 is spring-loaded towards the outward turning position.

The locking piece 15 can be moved against the locking surface 14 to lock the lever and wedge in a deadbolting position, in which deadbolting position the lever 11 is in the outward turning position and the support surface 13 is against the wedge 10, and the wedge is wedged between the bolt body 6 and the lock body 3.

Figure 1 illustrates the lock with the bolt 4 out and the deadbolting means 8 in deadbolting state. In Figure 3, the bolt 4 has moved somewhat inside the lock body 3. In Figure 4, the bolt is fully inside the lock body; in other words, in the withdrawn position. In Figures 3 and 4, the deadbolting piece 15 is driven to the open position in which it does not prevent the other deadbolting parts from moving into the withdrawn position.

Figures 5A – 5D illustrate an embodiment of the wedge 10. The wedge 10 comprises a first 19 and a second 20 bevelled surface transversal to the linear path of the bolt. The angle between the bevelled surfaces opens towards the lever support surface 13. The bolt body 6 comprises a first counter surface 21 for the first bevelled surface, and the lock body comprises a second counter surface 22 for the second bevelled surface.

When the deadbolting piece 15 is driven to the open position and the door is being opened, the bolt 4 tends to push inwards under pressure from the striker plate. When using a dual-action bolt, one of the bolt pieces 7 turns in the same direction as the other bolt piece, making the bevelled surfaces of the bolt pieces congruent. The striker plate in the door frame presses against this congruent bevelled surface while simultaneously pushing the bolt into the lock body. It can be seen in Figure 3 how one of the bolt pieces has turned and the wedge is being pushed away from the path

of the bolt. This is caused by the first counter surface 21 pushing the first bevelled surface 19 of the wedge. At this time, the wedge slides along the second counter surface 22 in the lock body. The second bevelled surface 20 of the wedge is against the second counter surface 22.

- 5 While the wedge slides away from the path of the bolt, the wedge presses the support surface 13 of the lever, and the lever 11 tends to turn in relation to the support point 12. A support counter surface 23 for the support surface of the lever is arranged in the wedge.

10 The external force that pushes the bolt 4 inwards into the lock body is divided to different components in the wedge and in the lever. The transfer of external force to the locking surface 14 of the lever can be kept minor. The wedge and its connections with the other parts constitute the first stage of transmission at which the external force imposed on the bolt body 6 can be reduced by a factor of 0.6 to 0.8 at the support surface 13 of the lever. The rest of the external force is directed through the
15 second bevelled surface 20 to the lock body 3. The second stage of transmission consists of different leverages at different points of the lever 11. Due to the external force, the lever tends to turn in relation to the support point 12 towards the back part of the lock body. Because the external force component at the support surface 13 of the lever is closer to the support point 12 of the lever than the locking surface 14 of
20 the lever, less force is required at the locking surface to hold the lever 11 in the desired position compared to the force component at the support surface 13. The second stage of transmission reduces the external force by a factor of 0.2 to 0.4 at the locking surface 14. Both stages of transmission combined reduce the external force by a factor of 0.12 to 0.32. The transmission factors depend on the
25 implementation of the embodiment according to the invention.

30 It can be seen in Figure 3 that the location of the connection between the wedge 10 and the lever 11 in relation to the lever support point 12 depends on the positions of the wedge and lever. The cooperation between the lever support surface 13 and the wedge 10 is arranged so that at a certain position after the wedge has moved away from the path of the bolt, the effect of the support surface 13 counteracting the movement of the wedge is reduced. This is achieved so that the support counter

surface 23 of the wedge is a curved surface and that the lever support surface is arranged to always be perpendicular to the support counter surface 23. This way the distance between the force component vector affecting the lever support surface 13 and the lever support point 12 depends on the position of the lever. The distance of the force component vector affects the magnitude of the transmission factor at the second stage of transmission. In practice this is evident in that the force counteracting the inward movement of the bolt is initially great when the bolt is out. The counteracting force is clearly reduced when the bolt has moved somewhat into the lock body. Figure 3 illustrates such a situation in which the lever support surface 13 has moved past the curve in the support counter surface 23, due to which the transmission factor has changed.

At a certain position, when the bolt 4 pushes into the lock body, the wedge 10 moves completely away from the linear path of the bolt, allowing the bolt to move to the withdrawn position without obstruction from the first counter surface 19. At that time the bolt is allowed to move to the withdrawn position illustrated in Figure 4. When the force pushing the bolt inwards ceases to have effect, the spring pushes the bolt out of the lock body.

Because the stages of transmission substantially reduce the effect of external force on the lever locking surface 14 – that is, at the locking piece 15 – it is more reliable to drive the locking piece to the desired position compared to a situation in which the external force would affect the locking piece as such. The solenoid or other actuator is not required to be too powerful, which means that the lock body may include a smaller and less expensive solenoid or other actuator. The lock body may also be smaller, making it easy to install the lock in tight quarters. Therefore the electric current required by the solenoid/actuator may also be smaller.

In the present embodiment, the support surface 13 of the lever is a projection, and the support counter surface 23 of the wedge is a cut-out. The support surface is preferably a circular surface. A projection with a circular surface can be conveniently created so that it is a roller attached to the lever 11 in a rotating fashion and its outer surface is said circular surface. The cut-out 23 in the wedge is preferably shaped so that the circular surface 13 is in contact with the wedge regardless of the position of

the lever 11. It is certainly also possible that the connection between the lever and wedge is formed in some other way. The rotating roller may be attached to the wedge, and the curved support surface may be in the lever.

It is preferable to locate the lever locking surface 12 at the end of the lever, which provides the maximum length of leverage in relation to the lever support point 12. The locking surface can be, for example, a shear surface. It is preferable that the locking surface is radial to the shaft formed by the support 12.

It is preferable to create the second counter surface 22 in the lock body using a wedge support piece 24. The wedge support piece is attached to the lock body. The second counter surface 22 can also be formed directly in the lock body but the use of a wedge support piece is preferred for ease of manufacture. Depending on other parts of the lock, the wedge support piece can be shaped in different ways. Figure 6 illustrates an embodiment of the wedge support piece 24. The embodiment of the wedge in Figures 5A – 5C comprises a base part 25 that settles on the opposite side of the wedge support piece 24 in relation to the top part 26 comprising the support counter surface. The intermediate part 27, which comprises the first 19 and second 20 bevelled surface, connects the base part and the top part. The second bevelled surface 20 settles against the second counter surface 22.

Figures 7A – 7C illustrate an embodiment of the locking piece 15. The locking piece comprises a plate 28, the side 29 of which can be arranged against the locking surface. In this embodiment, the locking piece comprises a roller 30 pivotably supported on the lock body, which contains said plate. The side is preferably curved. Of course, a more conventional locking piece that is directly connected to the solenoid shaft can be used in a lock according to the invention.

Figure 8 illustrates the positions of the parts of the locking means in relation to each other. The figure shows how the wedge 10 is against the body 3 and how the roller of the lever with its support surface 13 is in the cut-out of the wedge against the support counter surface 23. Figure 9 illustrates the bearing 31 of the roller 30 used as the locking piece, as well as the solenoid shaft plunger element 32. The plunger element of this embodiment comprises two screws 33, either one of which is

arranged so that the solenoid is able to use it to turn the roller 30 in relation to the axis formed by the bearing with linear motion of the solenoid shaft.

Even though the lock in the example described above is fitted with a solenoid, it can be replaced with some other actuator such as an electric motor, piezoelectric
5 motor or smart metal actuator. The smart metal actuator can be, for example, a so-called MSM (Magnetically Controlled Shape Memory) device based on a controlled magnetic field. The magnetic field can be controlled electrically. Another option is that a lock according to the invention has no electric actuator at all. An emergency exit bar can be connected to a lock according to the invention. Because the
10 deadbolting means reduce the effect of external force before the locking piece, the lock is reliable even if the force conveyed to the lock due to the operation of the emergency exit bar was great.

As can be noted, an embodiment according to the invention can be achieved through many different solutions. It is thus evident that the invention is not limited to
15 the examples mentioned in this text.

Therefore any inventive embodiment can be implemented within the scope of the inventive idea.

Claims

1. A door lock comprising a lock body (3) fitted with a front plate (2); the lock body has a dual-action bolt (4) that can be moved with reciprocal linear motion between a withdrawn position and a locking position protruding out from the lock body through a
5 bolt opening (5) in the front plate (2), said bolt comprising a body part (6) and being spring-loaded towards said protruding position, and said door lock further comprising deadbolting means (8) that can be moved to a deadbolting position in which they prevent the dual-action bolt from being moved from the protruding position to the withdrawn position in the lock body (3),
- 10 **characterised** in that the deadbolting means (8) comprise a wedge (10) between the body part (6) of the bolt and the lock body (3), said wedge being arranged to move transversely to the linear path of the bolt, and
- a lever (11) comprising a support point (12), a support surface (13) and a locking
15 surface (14), said lever being pivotably supported on the lock body at the support point (12), said support surface (13) being arranged to cooperate with the wedge, said support surface and locking surface being turnable in relation to the support point between the lever's outward turning position towards the front plate and inward turning position towards the back edge of the lock body, while the locking surface (14) is farther away from the support point (12) than the support surface (13), said
20 lever being spring-loaded towards the outward turning position,
- and a locking piece (15) that can be moved against the locking surface (14) to lock the lever and wedge in a deadbolting position, in which deadbolting position the lever (11) is in the outward turning position and the support surface (13) is against the wedge (10), and the wedge is wedged between the bolt body (6) and the lock body
25 (3).
2. A door lock according to Claim 1, **characterised** in that the wedge (10) comprises a first (19) and a second (20) bevelled surface transversal to the linear path of the bolt, the angle between said bevelled surfaces opening towards the lever support surface (13), said bolt body (6) comprising a first counter surface (21) for the

first bevelled surface, and the lock body (3) comprising a second counter surface (22) for the second bevelled surface,

said wedge (10) being arranged so that at a certain position between the outward turning position and the inward turning position of the lever (11), it is away from the linear path of the bolt (4), allowing the bolt to move to the withdrawn position without obstruction from the first counter surface (19).

3. A door lock according to Claim 2, **characterised** in that the cooperation between the lever support surface (13) and the wedge (10) is arranged so that at a certain position after the wedge has moved away from the path of the bolt (4), the effect of the support surface counteracting the movement of the wedge is reduced.

4. A door lock according to Claim 3, **characterised** in that the wedge (10) comprises a support counter surface (23) for the lever support surface (13).

5. A door lock according to Claim 4, **characterised** in that the support surface (13) is a projection and the support counter surface (23) is a cut-out.

6. A door lock according to Claim 5, **characterised** in that the support surface (13) is a circular surface.

7. A door lock according to Claim 6, **characterised** in that the cut-out (23) is shaped so that the the circular surface (13) is in contact with the wedge regardless of the position of the lever (11).

8. A door lock according to Claim 7, **characterised** in that the projection (13) is a roller attached to the lever (11) in a rotating fashion and its outer surface is said circular surface (13).

9. A door lock according to any of the Claims from 1 to 8, **characterised** in that the locking surface (14) is at the end of the lever (11).

10. A door lock according to Claim 9, **characterised** in that the locking surface is a cut-out.

11. A door lock according to any of the Claims from 1 to 10, **characterised** in that the locking surface (14) is radial to the shaft formed by the support (12).

12. A door lock according to any of the Claims from 1 to 11, **characterised** in that the locking piece (15) comprises a plate (28), the side (29) of which can be arranged against the locking surface (14).

13. A door lock according to Claim 12, **characterised** in that the locking piece
5 comprises a roller (30) pivotably supported on the lock body, which contains said plate.

14. A door lock according to Claim 12 or 13, **characterised** in that the side (29) is curved.

15. A door lock according to any of the Claims from 1 to 14, **characterised** in that
10 the lock body (3) comprises a wedge support piece (24), the support piece comprising said second counter surface (22).

16. A door lock according to any of the Claims from 1 to 15, **characterised** in that the lock body comprises a solenoid (9) or other actuator for controlling the deadbolting means.

15 17. A door lock according to any of the Claims from 1 to 15, **characterised** in that an emergency exit bar is functionally linked to the lock body.