AUTOMOTIVE DOOR LATCH MECHANISMS

Ovidiu **ANTONESCU**[1], **I**oana **POPESCU**[2], **D**aniela **ANTONESCU**[3]
[1]) Politehnica University of Bucharest, e-mail: oval33@hotmail.com
[2]) Iuliu Maniu High School of Bucharest, e-mail: ioana.popescu@yahoo.com
[3]) Iuliu Maniu High School of Bucharest, e-mail: daniela.mihalache@yahoo.com

ABSTRACT: The mechanisms utilized as latching systems of the automotive door, are designed as planar or spatial (mono mobile or multiple mobile) mechanisms. These mechanisms can be grouped in three major categories: Hood latches (engine hood), Deck lid latches (luggage compartment hood), Side door latches (front and rear side doors). Side doors have the locking/unlocking feature integrated within the latch which can be manually actuated from the outside of the vehicle through a key lock cylinder or from the inside via a rod or via a cable attached to the door inside handle lock knob.

KEYWORDS: automotive door, latching system, hood latch, deck lid latch, side door lactch.

1. General Aspects

Construction of mechanisms utilized as latching systems of the automotive door, vary from one manufacturer to another [1]. These systems are designed as planar or spatial (mono mobile or multiple mobile) mechanisms [2]. These mechanisms can be grouped in three major categories [3, 4]: a) Hood latches (engine hood), b) Deck lid latches (luggage compartment hood), c) Side door latches (front and rear side doors).

Usually, hood latches are manually actuated. Once the hood is released under its own weight, the latching occurs while a striker assembly attached to the hood is entrapped by a latch component named fork bolt (commonly named as catch) [1]. A ratchet (commonly named pawl) is designed to block the catch in its latched position. The unlatching takes place when the pawl is being released via a cable-handle system from the inside of the vehicle.

Deck lids have rather similar latching systems that can be locked or unlocked and unlatched via a key lock cylinder attached to the latch via a rod or a cable [1].

Side doors have the locking/unlocking feature integrated within the latch which can be manually actuated from the outside of the vehicle through a key lock cylinder or from the inside via a rod or via a cable attached to the door inside handle lock knob.

Optionally, the lock unlock function can be electrically achieved via a power actuator. Rear doors have latches equipped with child lock features and in most of the cases they can be locked and unlocked only from the inside of the car.

2. Hood Latch Mechanism

During latching, the striker bolt 7 attached to the hood performs a rotation in a vertical plane until it contacts the catch 3 (fig. 1). Through a rotation motion, clock wise, the catch captures the striker bolt blocking the hood. The pawl follows the catch exterior profile while actuated via the spring 6 until is blocking the catch in the fully latched condition.

The hood latch mechanism catch 3 and pawl 4 interface can be further described by using a kinematical representation of the release chain (fig.1).

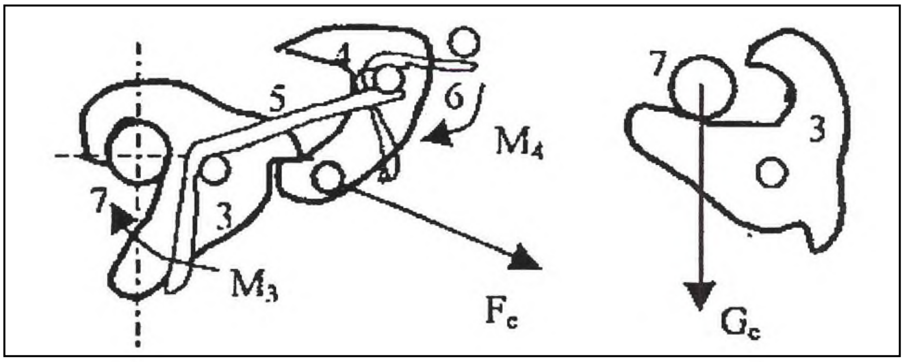

Fig. 1. Kinematical representation of a hood latch mechanism

In the right hand side of the figure 1 we show the catch at the beginning of the latching stage, when the inertia force G_c (percentage of hood weight) transferred through striker bolt 7 into the latch is rotating the catch 3 counterclockwise.

Once the catch rotates towards latched position, the catch spring 5 is in tension applying to the catch a tension moment M_3. The catch 3 is blocked in latched condition through the pawl 4 on which a tension moment M_4 is being applied through the catch spring 6. To unlatch the system we must apply a force F_C through the cable system. If the cable breaks we can unlatch the system by actuating the lever 2 through a rod, the access of the lever being made through the engine compartment from the bottom side of the vehicle.

In the stage when the striker bolt 7 is in direct contact with the planar surface of the catch 3, the kinematical representation becomes spatial with 2 mobile elements 7 and 3 (fig. 1). The fixed rotation axes D_7 and D_3 are random positions while the contact (7, 3) is a point. Hood latches are mono-mobile type mechanisms and their kinematical release chain (fig.2) can be represented as following [4].

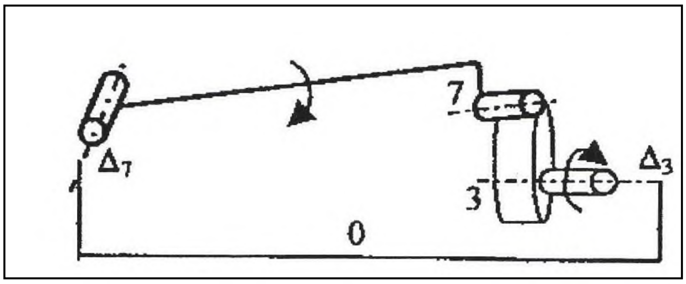

Fig. 2. The spatial hood latch mechanism.

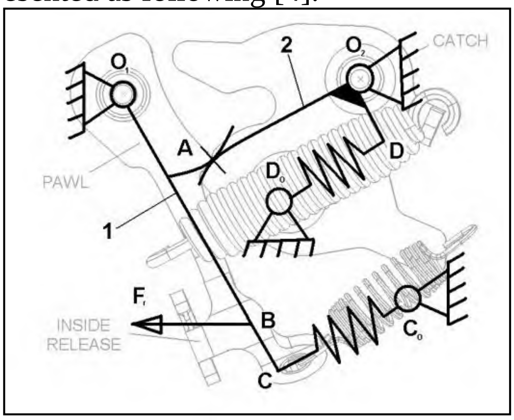

Fig. 3. Hood latch kinematical scheme

3. Luggage Compartment Door (Decklid) Latch Mechanism

We consider the mechanical scheme (fig. 3) of a planar mechanism having two kinematical components 1 (catch) and 2 (pawl) articulated on the base 0 (represented by a open frame plate attached to the vehicle body or to the decklid).

In the open position (fig 4a), the striker bolt 4 (assumed to be attached to the decklid in this case) is resting against the catch interior rectilinear profile. In this case the contact between the catch 1 and the pawl 2 is maintained through the extension spring 3.

Element 2 is in fact a ratchet in a neutral position in regarding to the fork bolt (catch) 1. The system latches when applying pressure on the decklid and the striker bolt is getting engaged within the catch until the pawl 2 achieves the blocking position against the catch (latching is achieved) (fig 4b). Once the catch is being rotated the spring 3 is in extension applying a closing force between the pawl against the catch.

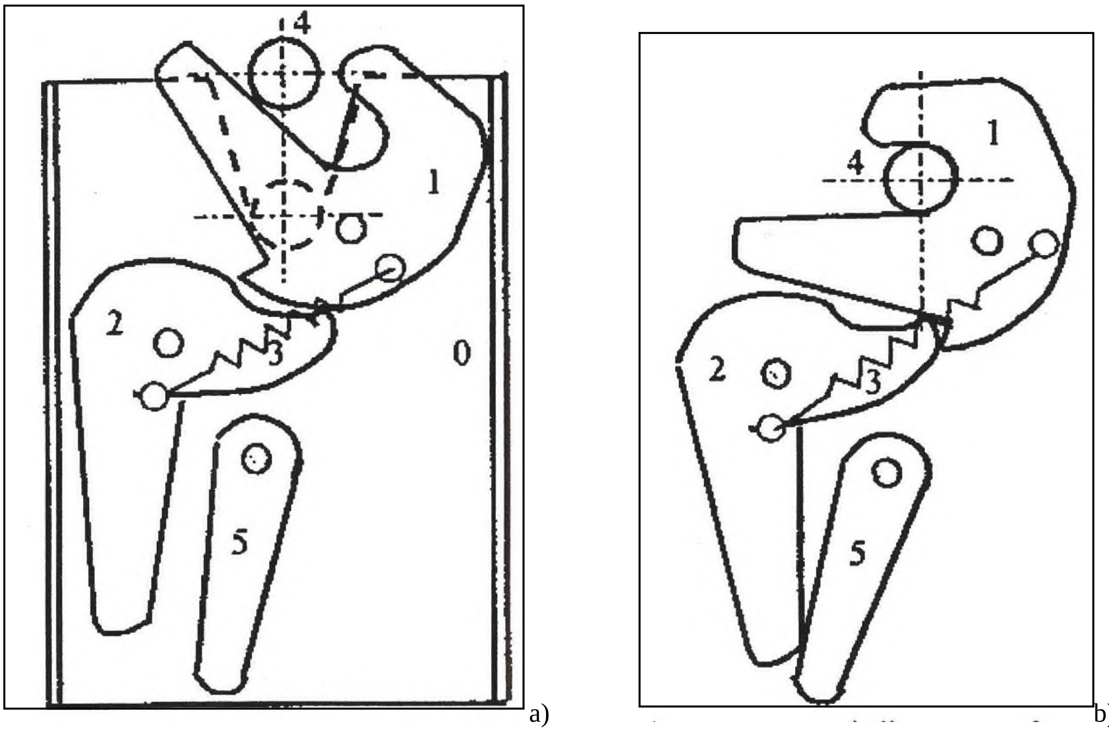

Fig. 4. Typical components of a decklid latch – open (**a**) and closed (latched) position (**b**)

To unlatch the catch 1 (fig. 4b) of such system one must rotate clock wise the lever 5 via a special key or a key lock system. Lever 5 will transfer a force to the pawl 2. The pawl under this load rotates clockwise until it releases the catch 1. After unlatching is achieved, the tension within the extension spring 3 moves the catch in fully open position, releasing the striker bolt 4 (fig. 4a).

4. Side Door Latch Mechanism

The mechanisms involved in automotive side door latches are rather complicated in comparison to the ones used for hoods or decklids. Their complexity is due to the additional operating requirements imposed by the customer usage of a side door (inside release, outside release, lock/unlock and child lock features for rear doors).

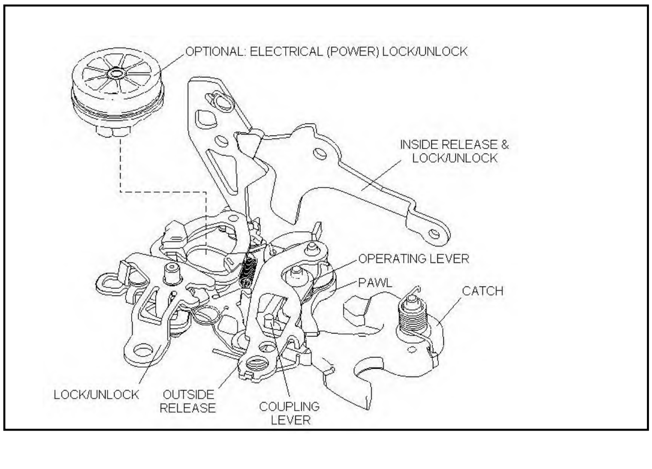

Fig. 5. Isometric view of the catch release chain (Ford-NGL2)

Let's consider a typical Ford corporate side door latch (fig. 5, 6), next generation latch – NGL2, with the basic components shown on fig. 7 and 8, and its locking system shown on fig. 10. The isometric view of the catch release chain (fig. 5) indicated the main components and an optional electrical actuator [5].

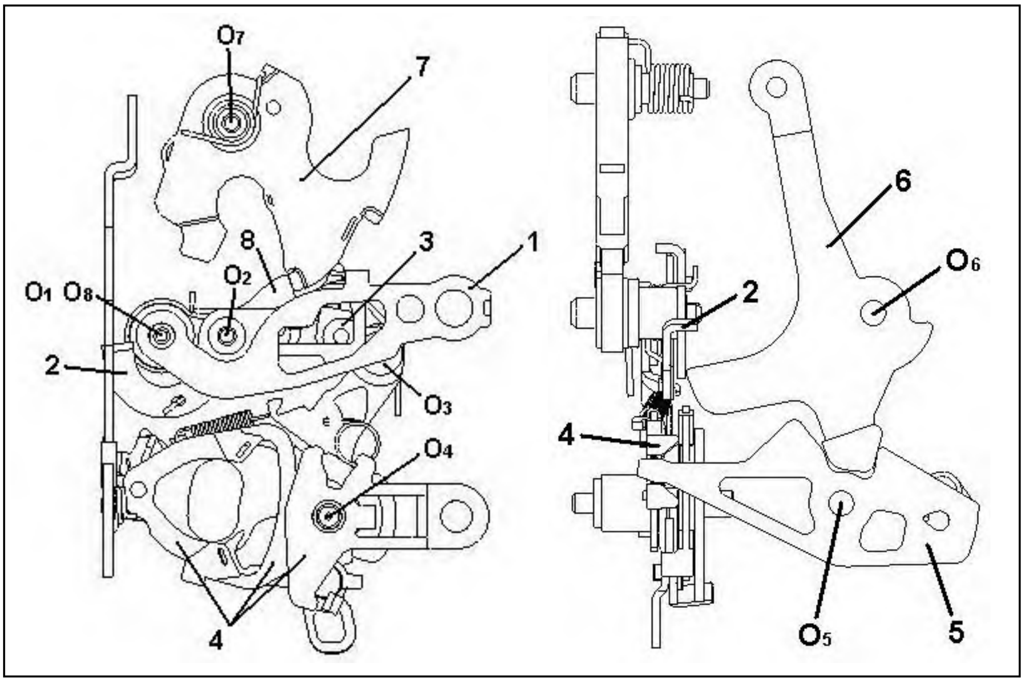

Fig. 6. Catch release chain – side door latch (Ford-NGL2)

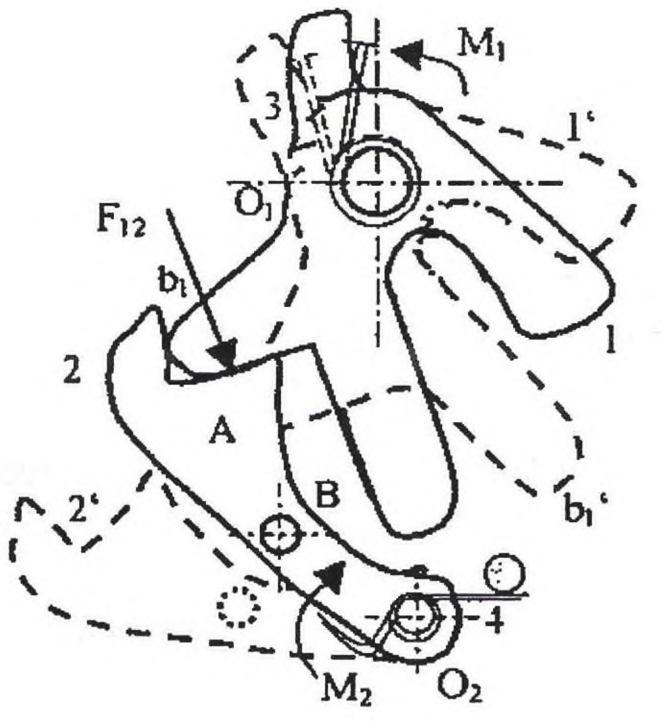

Fig. 7. Kinematical schema of a catch/pawl interface –closed and open (dotted line)

To achieve the closed condition (latched position), the catch 1 rotates clockwise around pivot O_1 under a tension M_1 generated by the torsion catch spring 3 until the pawl 2 blocks the arm b_1 of the catch.

Because of the torsion moment M_1, the arm b_1 (in blocked position) pushes with the force F_{12} against the pawl contact point A. The moment achieved through the force F_{12} around the pawl pivot point O_2, is less than the moment M_2 achieved by pawl spring 4.

Without taking in to consideration the door seal loads transferred to the latch catch when the striker bold is engaged, the catch is in static equilibrium condition under the torsion moment M_1 and the reaction force $F_{21} = -F_{12}$ on contact point A. To release the catch 1, a load on rivet pin B, attached to the pawl 2, can be applied moving the pawl in position 2' (dotted line).

The catch spring 3 rotates the catch 1 counterclockwise (trigonometric) moving into location 1' (dotted line). Applying a force F_5 on point C we rotate lever 5 (fig. 8a) around pivot point O_5 until the rivet pin B, on the pawl 2, is actuated (fig. 6, 7) for unlatching.

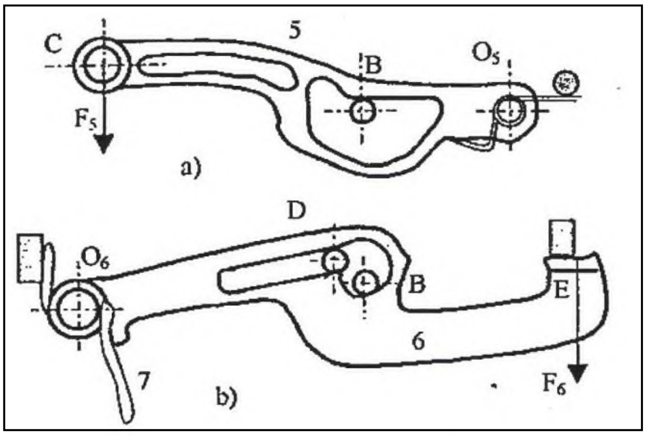

Fig. 8. Outside latch release: lever inside the latch (a) and outside (b)

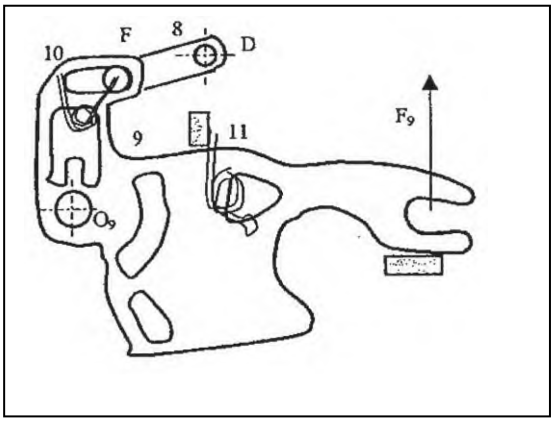

Fig. 9. Inside latch release and lock/unlock levers

Similar unlatching effect of pawl can be achieved when a force F_6 is applied on point E of the inside release lever 6 (fig. 8b). In this example we must mention the fact that when actuating the outside release lever 5, in order to achieve pawl 2 unlatching, we actuate together with lever 6 through the rivet pin B. Actuating release lever 6 in order to achieve pawl unlatching does not actuate the release lever 5 due to the clearance offered by its specifically designed internal profile.

The second pin, shown on D (fig. 8b), belongs to the coupling lever 8 (fig. 9) that is articulated to the transfer lever 9 in point F. The coupling lever 8 moves inside a slot in the lever 9 under a spring load offered by torsion spring 10. The transfer lever 9 can rotate anti-clockwise around O_7, under a force F_9, blocking (locking) the latch. Lever 9 is toggled between lock and unlock position via toggle spring 11 (fig 9).

The kinematical scheme (fig. 10) of this mechanism shows five fix articulations [4]. Two are common: O_2 and O_5. The mechanism of a side door latch is shown in latched condition, with the catch 1 blocked by pawl 2. The pawl 2 can rotate only counterclockwise and is against the resistant torsion moment M_2.

If we consider the mechanism made out of components 2, 5, 6, 8 and 9 (fig. 10) we can identify 5 rotation kinematical couples and 3 planar rotation-translation kinematical couples (simple type in B and double in D). The degree of mobility of this mechanism can be calculated using the planar mechanisms formula Grübler [5, 6]:

$$M = 3 \cdot n - 2 \cdot C_5 - C_4 \qquad (1)$$

Or using the general formula [2, 3, 6],

$$M = \sum_{m=1}^{5} m \cdot C_m - \sum_{r=2}^{6} r \cdot N_r \qquad (2)$$

N_r representing the number of closed contours independent of rank r of the space associated with the kinematical contour, and C_m is the number of kinematical couples of functional class m.

The topological matrix of mechanism (fig. 10) is:

$$\begin{bmatrix} C_1 & C_2 & C_3 & C_4 & C_5 \\ N_2 & N_3 & N_4 & N_5 & N_6 \end{bmatrix} = \begin{bmatrix} 5 & 3 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 \end{bmatrix} \qquad (3)$$

Using the above information the equation (2) becomes:

$$M = (1 \cdot 5 + 2 \cdot 3) - 3 \cdot 3 = 2 \qquad (4)$$

The two degrees of mobility are represented by the position of element 9 combined with either one of the elements 5 or 6.

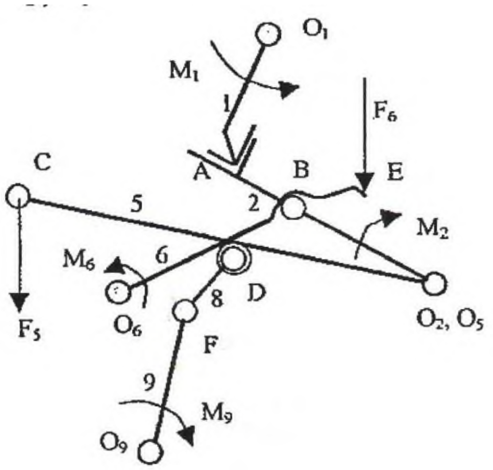

Fig. 10. Kinematical scheme of a side door latch

5. Lift Gate/Swing Gate Door Latches

Similar with hood latches, lift/swing gate latches have usually only one release lever for unlatching function [4].

The release can be made either manual via rods attached to a gate door handle or have optional electrical (power) release via a motorized system in most of the cases.

For the purpose of this study we shall concentrate on lift gate door latches.

The catch release chain for unlatching is shown (fig. 11).

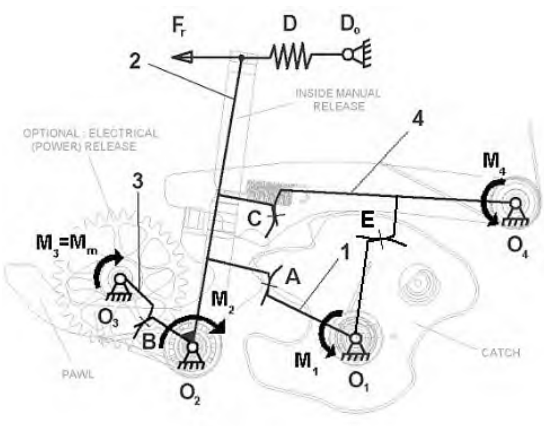

Fig. 11. Constructive and kinematical scheme of lift mechanism

For manual unlatching one condition we must consider includes the following elements: catch, pawl, and the memory lever contact with the pawl, while the active contacts are in points A and C.

The kinematical scheme is represented by two contours of the elements: 0120, 0240; elements (n=3): 1, 2, 4; rotation couples (C_5=3): O_1, O_2, O_4; rotation-translation couples (C_4=2): A, C.

Applying equation (1), for n=3, C_5=3, C_4=2 (fig. 11) we obtain:

$$M_{unlachmanual} = 3\cdot 3 - 2\cdot 3 - 2 = 1 \quad (5)$$

For the optional power unlatching the only condition we must consider refer to the following elements: catch, pawl, and the memory lever contact with the pawl. The active contacts are in points A, B and C (fig. 11).

All in all speaking, the number of latch component parts is dictated by the design requirement, packaging environment and engineering specifications. The final design is established based on latching system requirements.

6. REFERENCES

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