CINEMATIC AND STRUCTURAL PROBLEMS AT A STEPPING MECHANISM USED FOR TOYS

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Abstract. *We do a short history of the mechanisms for stepping toys and we analyse such a mechanism from the structural and cinematic viewpoint, establishing the diagrams of displacements. We also do the movement simulation. We structurally study a mechanism rotating the head and the eyes of the same toy, by finding a complicated structure.*

Key words: stepping mechanism, toy mechanisms

1. Introduction

In the technique history, we know certain stepping mechanisms used for different toys [3]. Thus, Leonardo da Vinci in the 16^{th} century built a lion that moved its legs, rotated his head and his tail a little bit (fig. 1) [5]. It is also known Cebâşev's mechanism in fig. 2, that acted as a toy-horse that moved its legs and stepped [1].

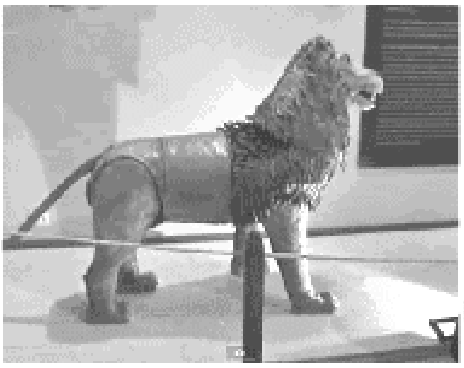

Fig. 1

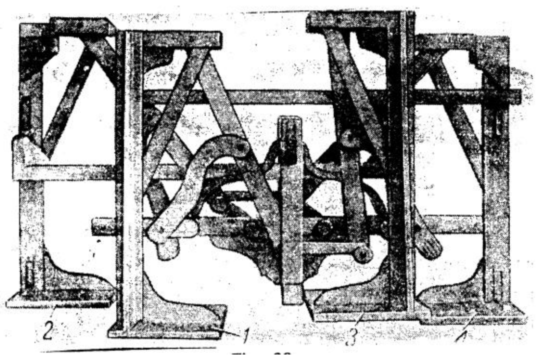

Fig. 2

After the robots appeared, many works that treat displacement by stepping were created, by using electro-mechanic actions and electronic commands. In [2] they study mechanic stability problems of certain stepping devices based on mechanisms. They establish the moving cycles and elaborate mechanic models that are studied in detail. They present then the stepping mechanism for a mechanic toy, achieving structural and cinematic studies.

2. Cinematic scheme and the operation of the mechanism

The mechanism of an animal that steps and moves its eyes was studied. The action is made by a small electric engine powered by batteries.

For stepping, the toy has 4 legs, the legs from behind also have wheels, and also a platen that rotates around the vertical axis, and it also has two wheels that are made solid by a tree that receives the movement from the same cinematic chain as the platen, as the movements are correlated.

The action block having an electric engine and a reducing tool, rotates the cam 1 (fig. 3) that displaces the tappet 2 forward and backward.

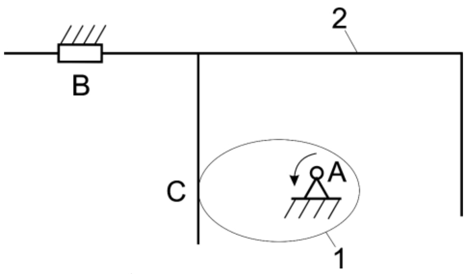

Fig. 3

There are two prominences of the tappet that penetrate, in backlash, the channel of a connecting rod that makes the legs work.. Fig. 4 gives the cinematic scheme of the mechanism.

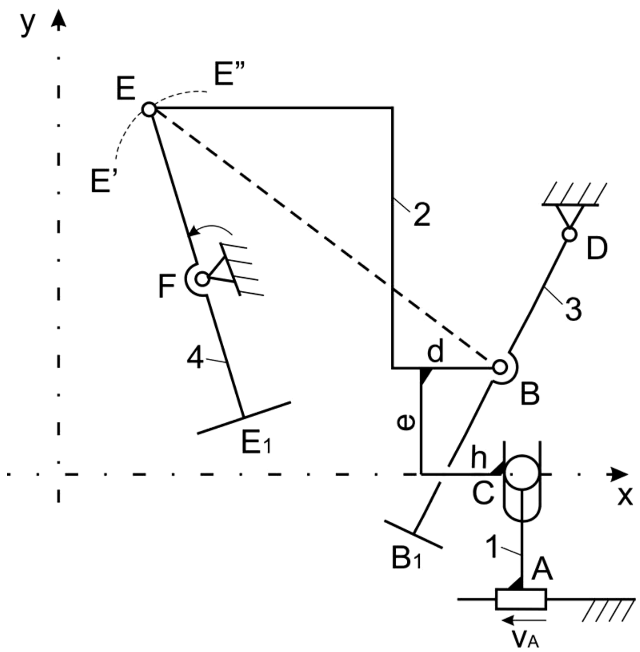

Fig. 4

From outside we receive a translation movement from the tappet. The connection between tappet 1 and the connecting rod 2 is made by a toy in backlash, so in the cinematic scheme there is a higher wire of the 4th class in C. Structurally, we replaced the wire of C by an element 2' (fig. 5) and the wires C' and C.

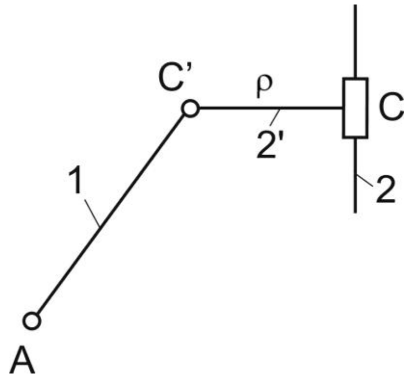

Fig. 5

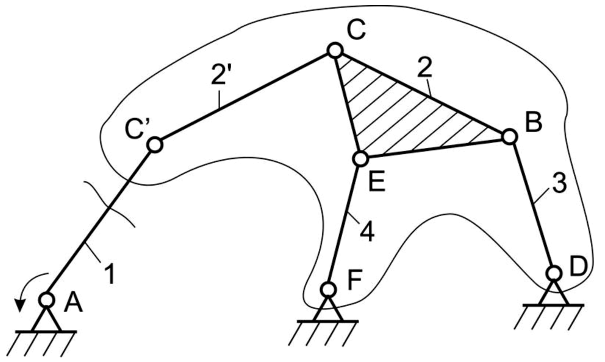

Fig. 6

Therefore, the resulting structural scheme is given in fig. 6. We find that the stepping mechanism is formed of a leading element and a triad.

There are two symmetric stepping mechanisms, one of them making the left legs work, the other one making the right ones work. The maximum rotation angle of the element DBB_1 (fig. 4) is about 40 degrees.

For simulating the leg movement, we considered as known the movement of the element 3 (fig. 4) and we calculated the movement of BEF.

Fig. 7 shows the successive positions of the left legs.

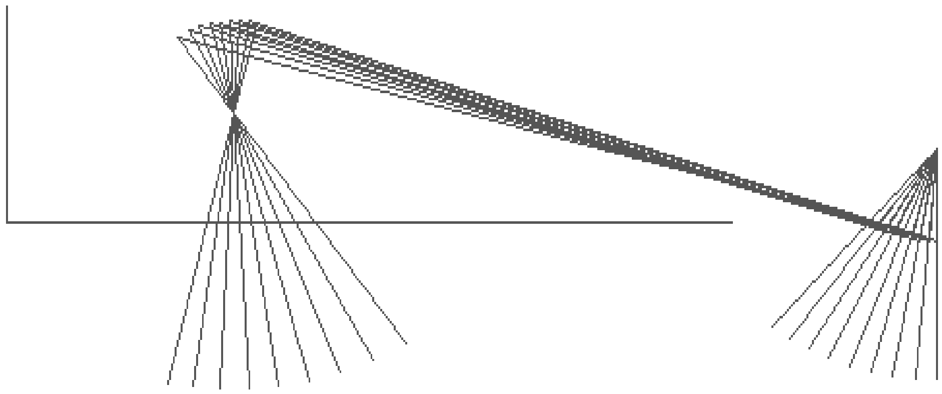

Fig. 7

Fig. 8 gives the variation curves of the coordinates of points B and B_1 (depending on the rotating angle of the stem DB), and fig. 9 – the curves for the coordinates of the points E and E_1. We may notice that the points representing the tiptoes have negative values, as they are under the adopted x axis (fig. 4).

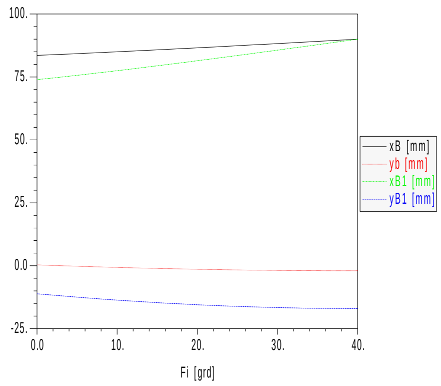

Fig. 8

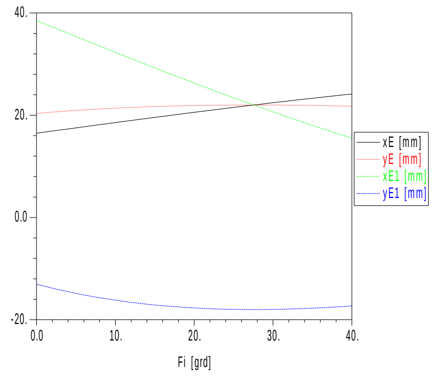

Fig. 9

From fig. 9 it results that, for the vertical position of EF, the abscises are equal; in the diagram, there is an overlapping of three curves, that is actually an optical illusion, because x_F is in fact 2 mm bigger than FE.

At the same toy, there is also a very complicated ***spatial mechanism***. It is about two symmetric mechanisms that rotate, with a certain angle, the animal's "eyes".

The movement starts from another cam mechanism, symmetric to the previous one. The tappet of fig. 10 has a small hole in the middle on the right, where the left side of stem 3 enters. This stem articulates at the chassis and makes the "eye" work.

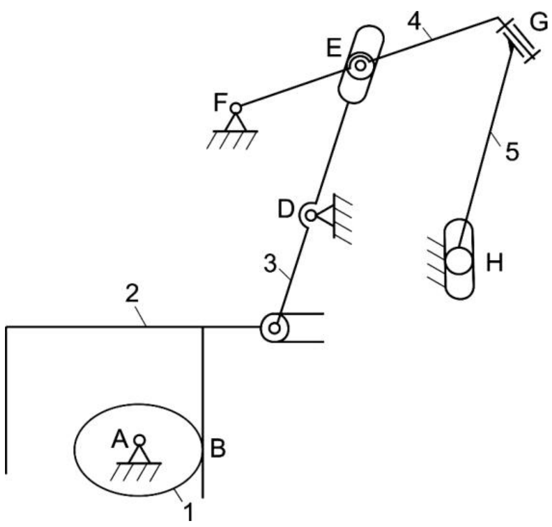

Fig. 10

The movement starts from cam 1 that makes tappet 2 work, and by means of roll it gets to element 3. The elements 3 and 4 form the oscillating link mechanism of fig. 11.

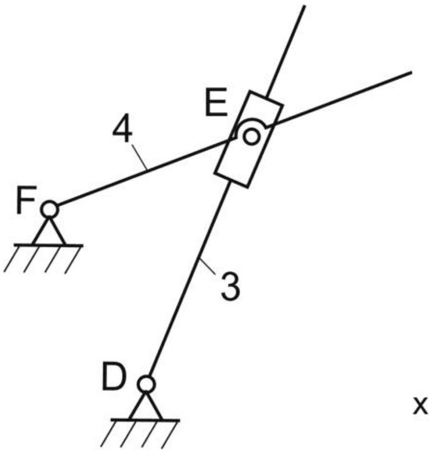

Fig. 11

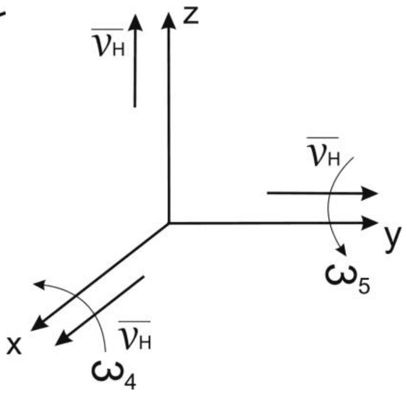

Fig. 12

Up to this point, we met plain mechanisms that were known. The remained mechanism, FGH is spatial and its leading element is FG with the rotation movement. In H there is a bolt moving in a very large place. This is associated to the oscillating “eye”.

The element 4 is the animal’s “head” that has an oscillating movement. The place of the chassis is large also because there is the bolt of the symmetrical mechanism.

By analysing the possible movements for the elements, we found the scheme of fig. 12. It results that the mechanism belongs to the family 1.

The mobility degree is:

$M=5n-4C_5-3C_4-2C_3-C_2 = 5.2-4.2-0.3-1.1=1$, so in H there is a wire of the 2^{nd} class.

3. Conclusions

Based on the facts above, we can establish the following conclusions:

- the toy corresponds to the purpose, meaning that it simulates an animal’s stepping, the rotation of the head and eyes;
- the mechanisms are desmodrom;
- the toy contains two interesting mechanisms: one for stepping and another spatial one for the movement of “the head and eye”;
- both of the mechanisms have difficulties at the cinematic calculations;
- the constructor accomplished many wires with backlash in order to obtain the desired movements, and this is not correct according to Mechanism Theory.
- the constructive solutions based on big backlashes in wires, allow the functioning of the mechanisms, without imposing a big accuracy.
- the mechanisms were empirically accomplished, but they meet the required conditions.

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