MODELING THE MOVEMENT OF A MECHANISM WITH TWO DYADS AND TWO LEADING ELEMENTS

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Abstract. Our researches started with the study of a mechanism with two dyads and two leading elements. The second leading element is connected to another element for the movement over a plane. Using the method of contours we wrote the equations specific to this mechanism, used afterward to implement a program employed for plotting various trajectories. Some of these trajectories cannot be found at other mechanisms which generate rod trajectories.

Keywords: mechanism, equations.

1. Introduction

Over time, the mechanisms with two dyads have been intensively studied. An exhaustive study on all possible alternatives is presented in [6]. Details, along with programs performing the calculations related to Kinematics and examples are provided by [5].

The above mentioned studies, and others similar to them, addressed only mechanisms with two dyads driven by a single leading element. Many papers dealing with mechanisms having a mobility degree M equal to 1 or 2 were published. Mechanisms with values for M belonging to the set {2, 3, 4, 5}, applicable to stepping robots, are studied in [2]. The reference [3] is dedicated to studies on a manipulator based on two plane mechanisms, providing discussions on the classification of these mechanisms and their characteristic curves. The working space for a manipulator with the mobility degree equal to 2 is analyzed in [4]. This mechanism has 5 couplings belonging to the class V, either of rotation or of prismatic type. An algebraic system with two equations of 2nd grade is obtained and results corresponding to an example are provided.

A stochastic model for an articulated quadrilateral mechanism used to generate trajectories is presented in [1], where statistic methods are used to provide the imposed accuracy. For a prescribed trajectory, the synthesis of mechanism is performed and examples are given.

Studies on the movement of a mechanism with two dyads, having two leading elements instead of one, are presented below. The second leading element is not related to the base. Instead, it is connected to an element which executes moves inside a plane.

2. The studied mechanism

The studied mechanism is depicted by Fig. 1. It is composed by the first leading element R (AB), the dyad RRT (BCC), the second leading element R (DE) and the dyad TTR (EEF). A characteristic feature for this mechanism is related to the modality to transmit the movement toward the second leading element.

The coupling D, which moves along a curve described by a connecting rod, is responsible for this transmission. The element BD performs a plane movement.

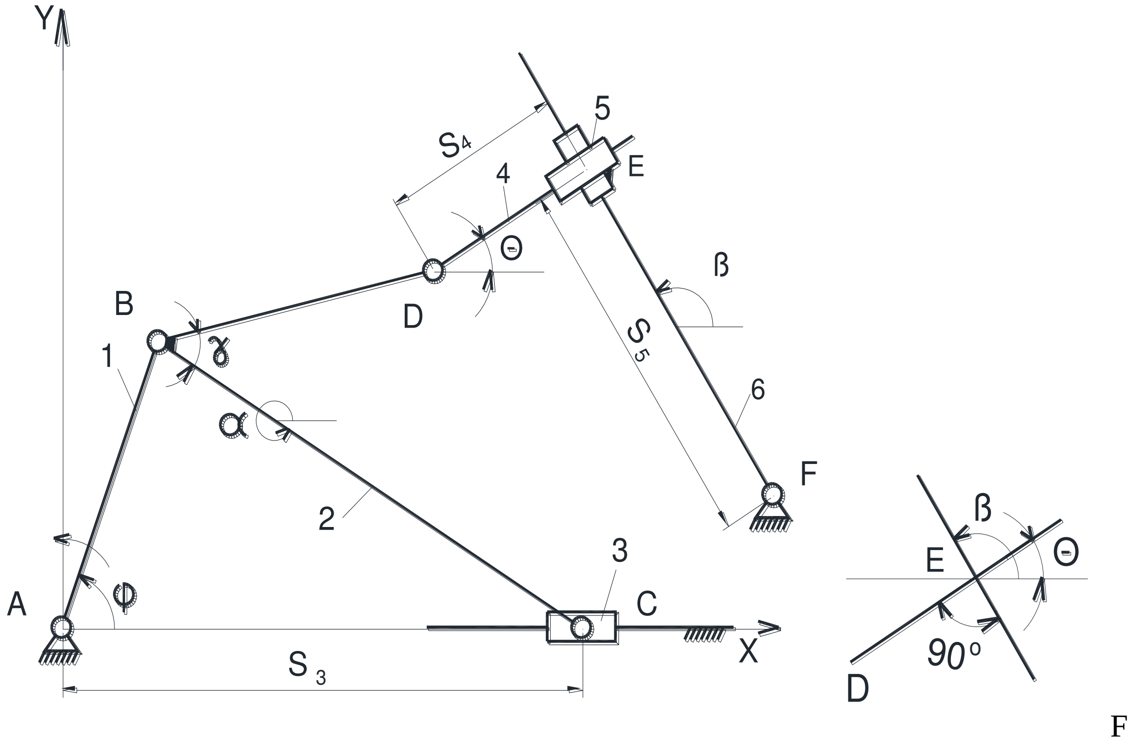


Fig. 1

3. Kinematics of the mechanism

Using the elements from Fig.1 and the contour method, the following equations could be deduced:

$$\begin{cases} x_B = AB.\cos\varphi \\ y_B = AB.\sin\varphi \end{cases} \quad (1)$$

$$\begin{cases} x_C = x_B + BC.\cos\alpha = S_8 \\ y_C = y_B + BC.\sin\alpha = 0 \end{cases} \quad (2)$$

$$\begin{cases} x_D = x_B + BD.\cos(\alpha+\gamma) \\ y_D = y_B + BD.\sin(\alpha+\gamma) \end{cases} \quad (3)$$

$$\begin{cases} x_E = x_D + S_4.\cos\theta = x_F + S_5.\cos\beta \\ y_E = y_D + S_4.\sin\theta = y_F + S_5.\sin\beta \end{cases} \quad (4)$$

$$\beta = 90 + \theta \quad (5)$$

$$(x_F + S_5.\cos\beta - x_D).\tan\theta = y_F + S_5.\sin\beta - y_D \quad (6)$$

$$S_5 = \frac{y_F - y_D - (x_F - x_D).\tan\theta}{\cos\beta\,.\tan\theta - \sin\beta} \quad (7)$$

$$S_4 = \frac{x_F + S_5.\cos\beta - x_D}{\cos\theta} \quad (8)$$

Initially the cinematic chain ABCD was calculated, by using the knowledge on the movement of the leading element AB. Afterward, knowing the movement of the second leading element, DE, we could determine the movement of the chain EEF.

In order to evaluated the values of θwe used the linear dependency$\theta = c.\varphi$. Modern driving systems also allow the use of polynomial dependencies.

4. Results

Considering the cinematic schema executed at a different scaled in order to check the results, we considered the following set of values: AB=30; BC=55; BD=45;$x_F = 103$;$y_F = 17$; $\gamma = 180^o$.

Fig. 2 corresponds to the above mentioned initial values and represents the basic position of the mechanism. The results were double-checked.

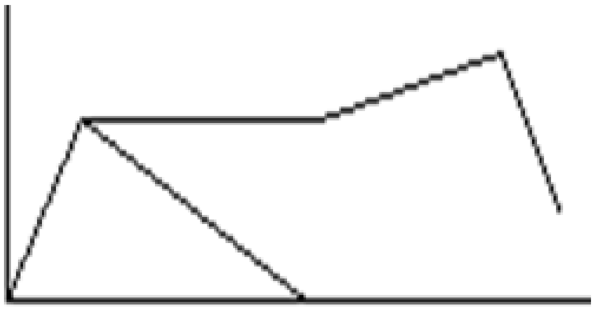


Fig. 2

Fig. 3.a depicts the trajectory of D (in the left side) and of E (including the loop), for the variable parameters indicated inside the figure. Here "Se" is used to denote the sign preceding the square root involved in the calculation of the angleα(the second possible position of the mechanism). Other curves are obtained for different values of these parameters (Fig. 3.b).

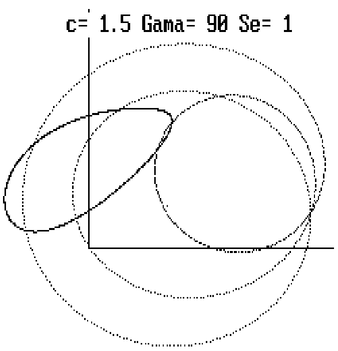


Fig. 3.a

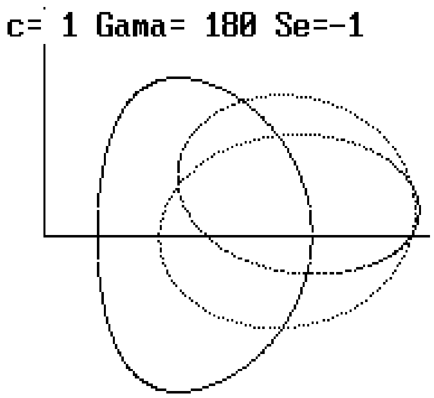


Fig. 3.b

For the data corresponding to Fig. 3.b, the variations of the trajectories S_3, S_4 and S_5 depicted by Fig. 4 were obtained.
The variation of the trajectory $S_3=x_C$ is characteristic for the "crank and connecting rod" mechanism ABC (that is a symmetric law). The trajectory S_4 is characterized only partially by symmetry, because a nonlinear variation is involved. A certain similarity can be noticed with respect to the trajectory S_5 – a curve shifted from that of S_4. These variations can be useful in certain applications.

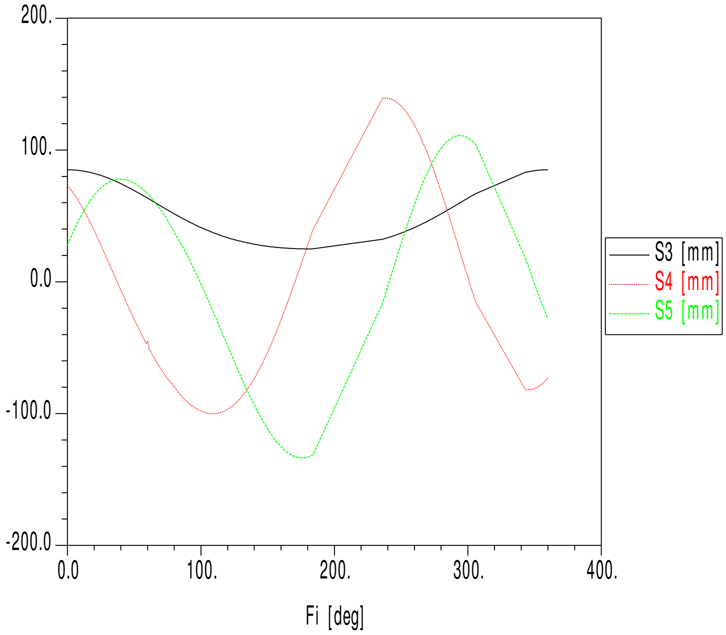


Fig. 4

In order to generate more interesting curves, firstly we performed a cycling of γ and made a study over the resulted types of rod curves. The most complicated ones were selected afterward. Fig. 5 depicts the rod curves described by the points D and E when cycling γ with a step of 30°, when Se=1. Fig. 6 corresponds to Se= - 1.

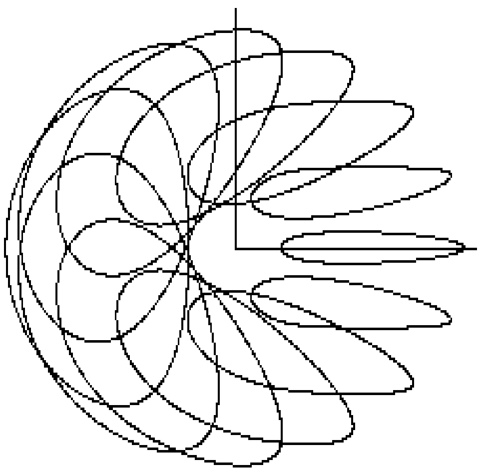


Fig. 5

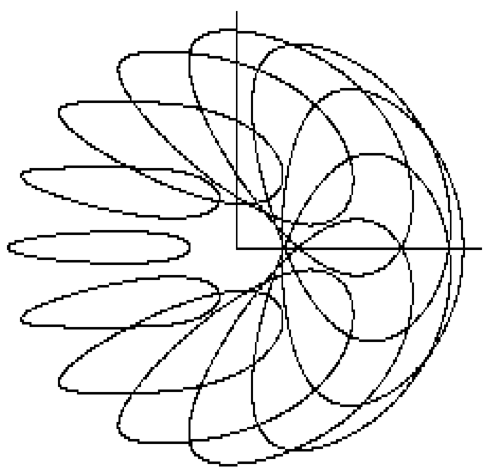


Fig. 6

Because the curves from Figs. 5 and 6 are symmetric with respect to the axis y, only the particular case Se=1 will be studied further on.

The mechanism sizes were modified as follows: AB=30; BC=40; BD=115; x_F=103; y_F=17.

More interesting and complicated trajectories were obtained for D, as depicted by Fig. 7.

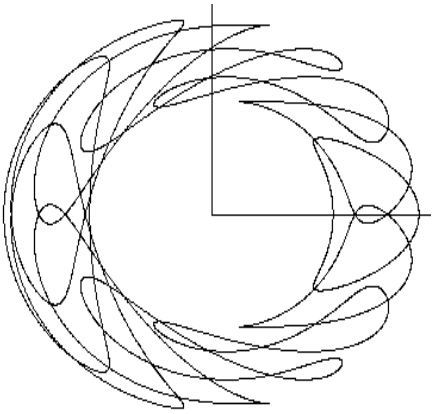


Fig. 7

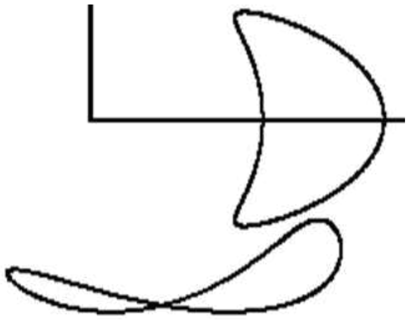


Fig. 8

The most interesting of the above mentioned trajectories are those obtained for γ =0 (represented along the horizontal axis in Fig. 7, indicated in Fig. 8), and will be considered further on.
Fig. 8 also includes the trajectory for γ=300°. The next step was to consider γ=0 (which means that D is placed on BC).

Also we have modified the values for the coefficient c from the relation $\theta = c.\varphi$ and we got different trajectories of E and movement laws.
Fig. 9 depicts the trajectory of E for c=0.1 – an interesting curve which is not often meat for rod curves.

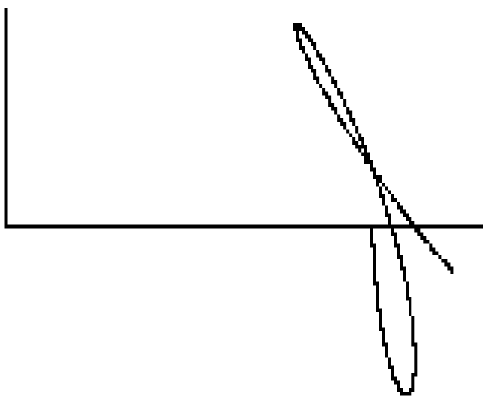


Fig. 9

Fig. 10 reveals that, unlike the curves from Fig. 4, the trajectory of S_4 is significantly modified – no symmetries being revealed.

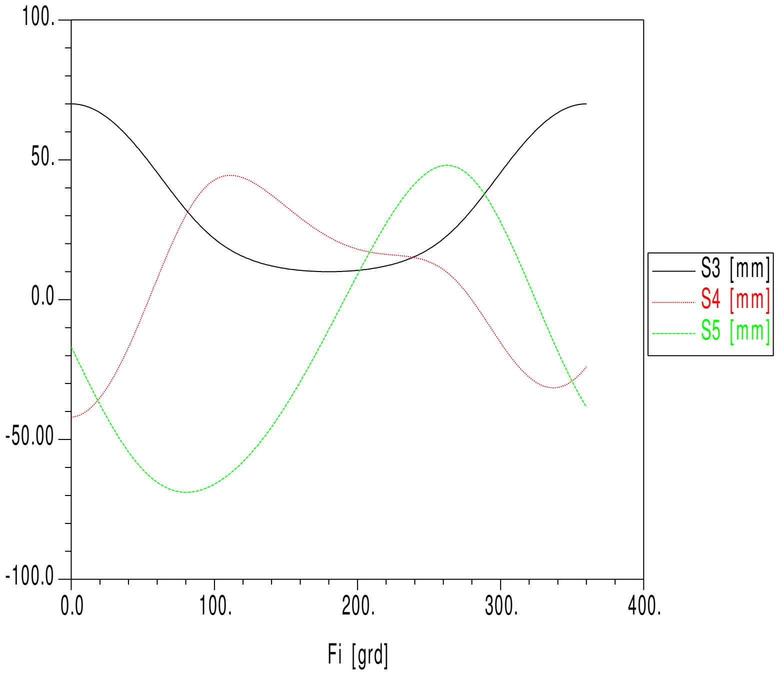


Fig. 10

Others trajectories of E are provided (Figs. 11...27), for various values of c.

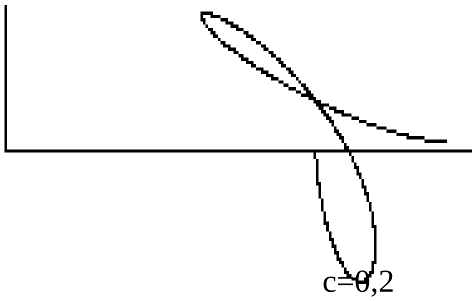


Fig. 11

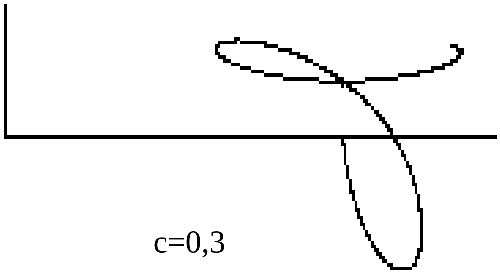


Fig. 12

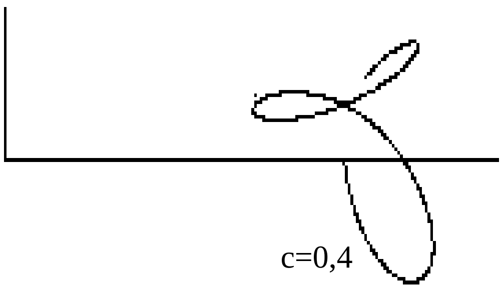


Fig. 13

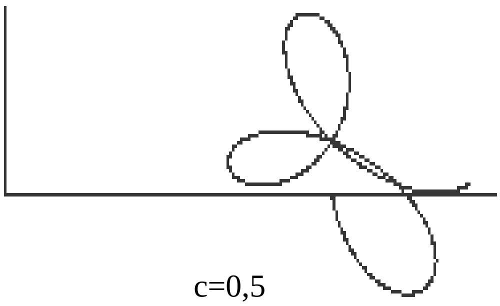
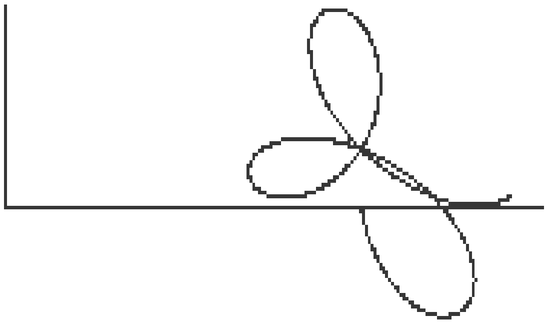
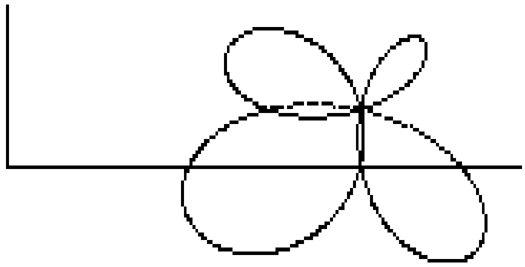


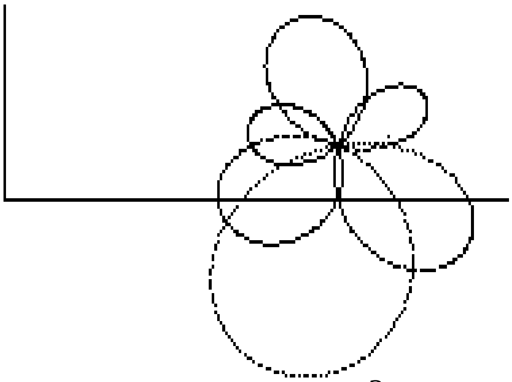
Fig. 14



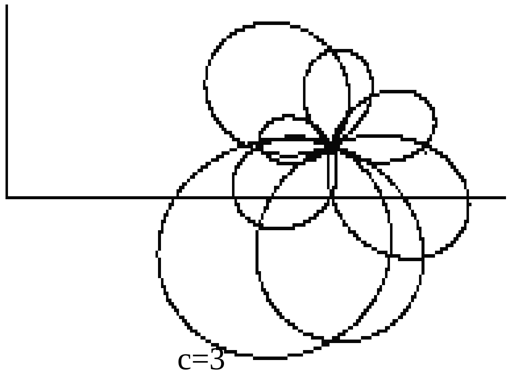
c=0,7
Fig. 15



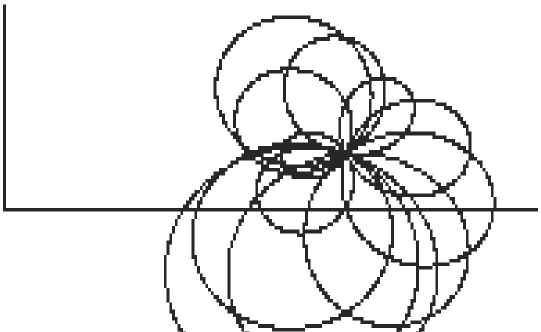
c=1
Fig. 16



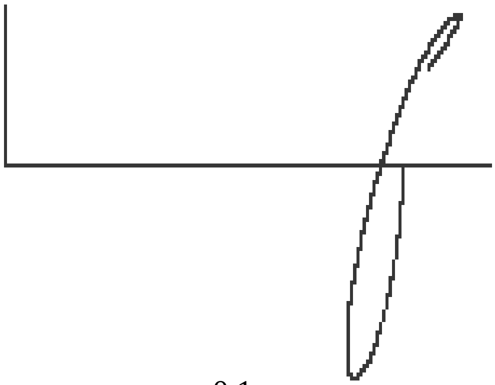
c=2
Fig. 17



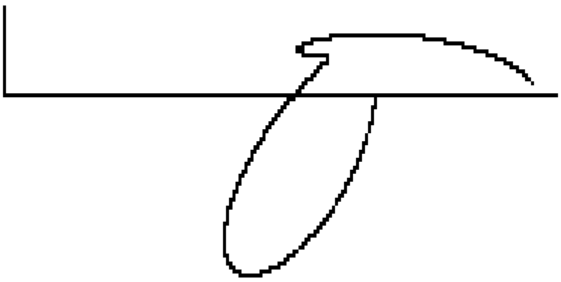
c=3
Fig. 18



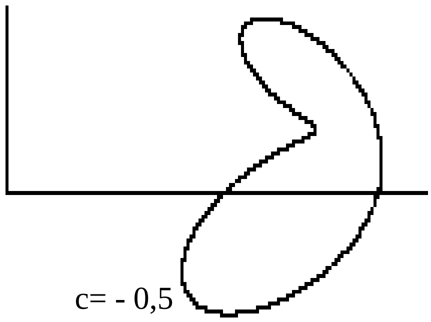
c=5
Fig. 19



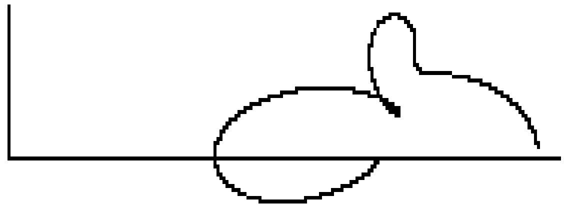
c= - 0,1
Fig. 20



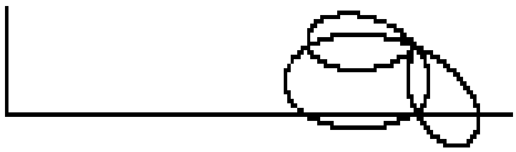
c= - 0,3
Fig. 21



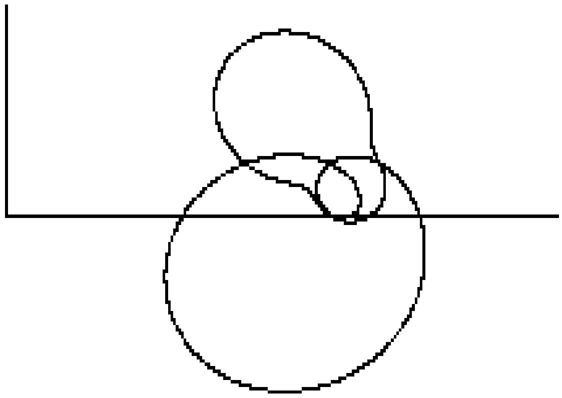
c= - 0,5
Fig. 22



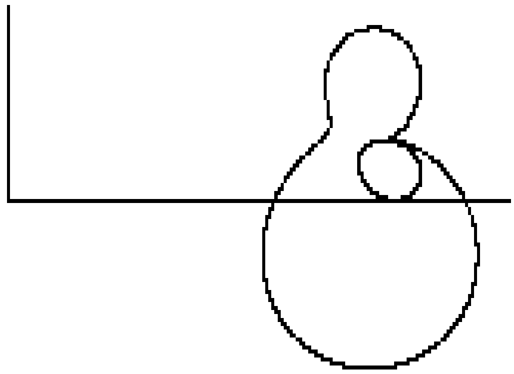
c= - 0,8
Fig. 23



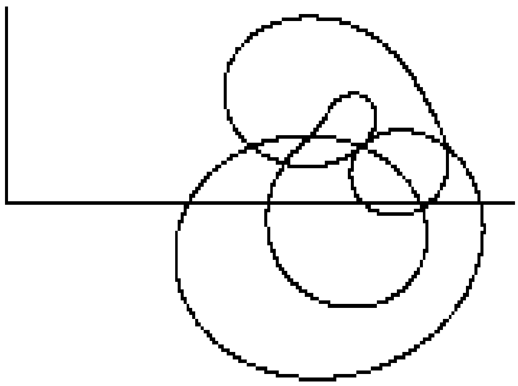
c= - 1
Fig. 24



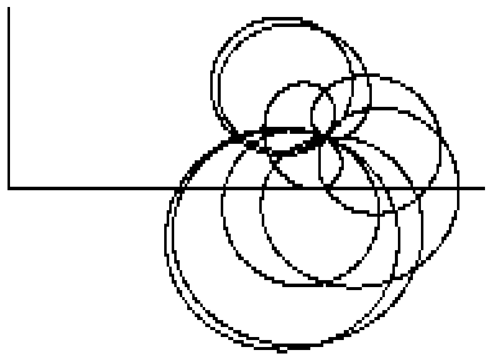
c= - 2
Fig. 25



c= - 1,5
Fig. 26



c= - 2,5
Fig. 27



c= - 5
Fig. 28

Special curves were obtained, with shapes varying from simple (but unusual) ones, to others more complicated, including several lobes.

5. Conclusions

- The analyzed mechanism is able to generate trajectories which were not detected at other mechanisms (as those from Figs. 9…18, 20, 22, 25 and 26).

- The trajectories described by the point D are known from the movement of the mechanism crank-rod.

- Some of the trajectories are closed curves, including loops, whilst others are open curves.

- For some trajectories a more detailed study, considering geometric aspects, might reveal more interesting conclusions.

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