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PARABOLIC SNAIL AND OTHER SIMILAR CURVES DRAWN BY A MECHANISM

Abstract: *An Artobolevskii mechanism that generates the parabolic snail is being studied. The structural analysis of the mechanism proved to be difficult, finally establishing that one element and two kinematic couples with which it binds are structurally parasitic. By the contour method the calculation relations were established obtaining the desired curve. The mechanism for different values of the angles between the sides considered initially constant was further studied, obtaining a range of curves generated by this mechanism. The positions of the straight segments (horizontal and vertical) which are guides of the sliders have also changed.*

Key words: *parabolic snail, mechanism of the parabolic snail, contour method, radius of curvature.*

1. INTRODUCTION

A graphic construction of the parabolic snail it is represented by Winston in [6]. Another example of this curve that appears in the living world on a snail shell is given in [4]. We can find the parabolic snail curve in the nature, in some gastropods (Figure 1) [2].

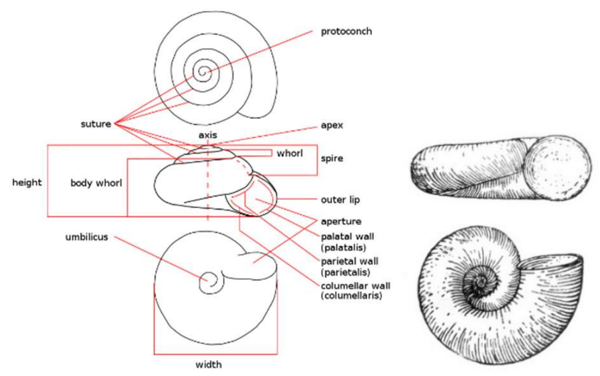

Figure 1 Geometry of gastropods [2]

This curve can be used in cam mechanisms for different kind of movements (Figure 2) [5].

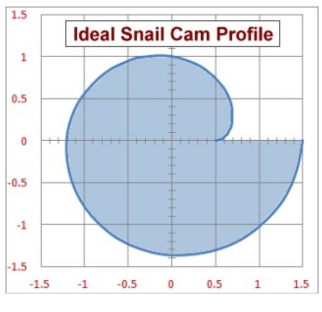

Figure 2 Ideal snail cam [5]

Other examples of mechanisms by other authors using this curve are given. Pascal's snail has been studied a lot in terms of geometry and the mechanisms that can generate it. This curve can be study as a trajectory obtained by solving differential equations [3]. In the same time, we will present a mechanism that generates this curve, a mechanism that is studied below [1].

2. KINEMATIC AND STRUCTURAL SCHEME

Artobolevskii's mechanism for the parabolic snail [1] is represented in figure 3.

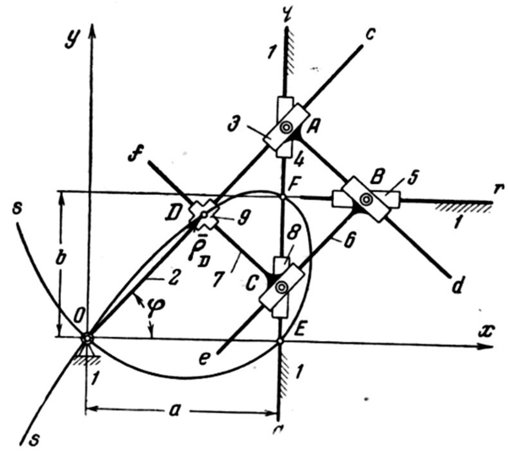

Figure 3 Artobolevskii's mechanism for the parabolic snail [1]

Starting from the mechanism presented above, we constructed the kinematic scheme (Figure 2) that we will take into the study of this paper.

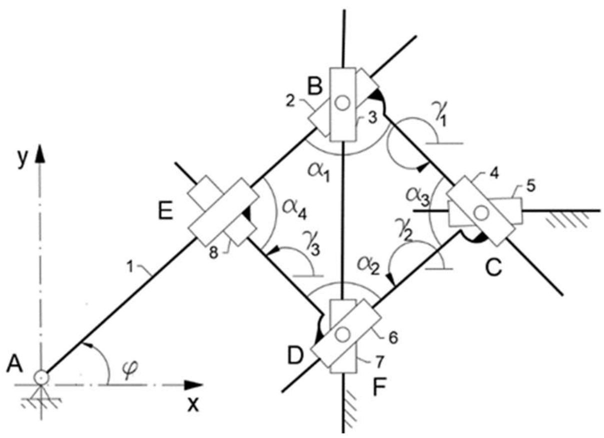

Figure 4 Kinematic scheme

The structural scheme is represented in figure 5.

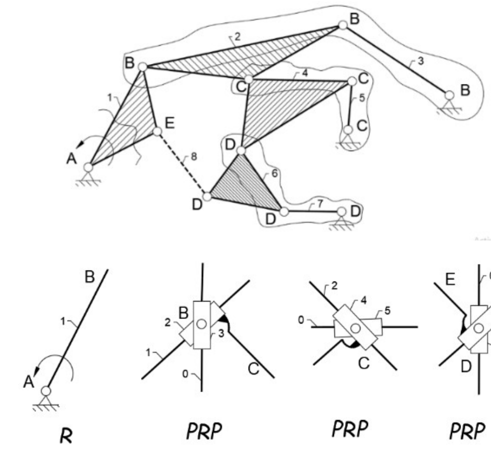

Figure 5 The structural scheme of the mechanism

The degree of mobility is: 3.8-2.12 M = 2, which is incorrect, in reality M = 1.

Regarding the mechanism shows in figure 4 it is observed that the leading element 1 transmits the motion to the dyad 2-3, kinematically defined by the motion of 1 and 0, i.e. of the base BD (fixed). Element 2 transmits the motion to dyad 4-5, which also receives motion from C base. Dyad 6-7 is defined as kinematic resolution receiving motions from element 4 and from the base BF. Next element 6 has the known motion, like element 1, therefore there is no need for element 8 and couplings 1-8 and 6-8, the movement of point E being defined by the intersections of the lines DE with AB, therefore element 8 materializes the point of intersection, it having no kinematic role. Therefore, element 8 and its two couplings are structurally parasitic. In this way it becomes possible to decompose into kinematic groups like in figure 5.

The method of contours is not used [1], but relations are given by the polar radius (of curvature). The mechanism is of type R-PRP-PRP-PRP.

3. CALCULATION OF THE POSITIONS OF THE ELEMENTS

The following relations are written using the method of contours, based on elementary geometry:

$$X_B = AB\cos\varphi = X_F = const. \quad (1)$$
$$Y_B = AB\sin\varphi \quad (2)$$
$$AB = X_B/\cos\varphi \quad (3)$$
$$X_C = X_B + BC\cos(\varphi+\pi+\alpha_1) \quad (4)$$
$$Y_C = Y_B + BC\sin(\varphi+\pi+\alpha_1) = const. \quad (5)$$
$$BC = \frac{Y_C - Y_B}{\sin(\varphi+\pi+\alpha_1)} = \frac{Y_C - Y_B}{\sin\gamma_1} \quad (6)$$
$$X_D = X_C + CD\cos\gamma_2 = X_F = const. \quad (7)$$
$$Y_D = Y_C + CD\sin\gamma_2 \quad (8)$$
$$\gamma_2 = \alpha_3 - \pi + \gamma_1 \quad (9)$$
$$\gamma_1 = \varphi + \pi + \alpha_1 \quad (10)$$

From Eq. (2) Y_B, and from Eq. (3) the stroke AB are obtained. From Eq. (4), (5) and (6) the results for dyad 4-5 are obtained. Similarly, with relations from Eq. (7), (8), (9), (10) the dyad 6-7 is solved.

The coordinates of E point, as the point of intersection of two given directions, are calculated with the relations from Eq. (11), (12), (13). (14) and (15).

$$X_E = X_D + DE\cos\gamma_3 = AE\cos\varphi \quad (11)$$
$$Y_E = Y_D + DE\sin\gamma_3 = AE\sin\varphi \quad (12)$$
$$\gamma_3 = \alpha_2 - \pi + \gamma_2 \quad (13)$$
$$DE = \frac{X_D\, tg\,\varphi - Y_D}{\sin\gamma_3 - \cos\gamma_3\, tg\,\varphi} \quad (14)$$
$$AE = \frac{Y_D + DE\,\mathrm{si}\quad{}_3}{\sin\varphi} \quad (15)$$

4. OBTAINED RESULTS

The following initial data were taken: $X_F = 68$: $X_B = X_F$: $Y_C = 35$, the angles α equal to 90 degrees.

With these data, measured on the draft sketch (Figure 4), the mechanism for the position φ= 45 degrees is shown in figure 6 and the parabolic snail obtained in figure 7.

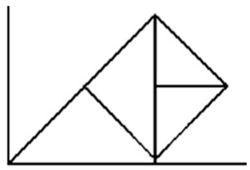

Figure 6 The position of the mechanism for $\varphi=45^0$

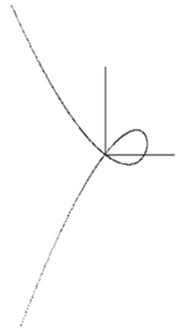

Figure 7 The parabolic snail

We can observe that the snail does not have a symmetrical right loop.

5. OTHER CURVES OBTAINED BY THE SAME MECHANISM

It is observed that by modifying X_F the shape of curve is maintained, but the dimensions of the loop are changed (Figures 8 to14).

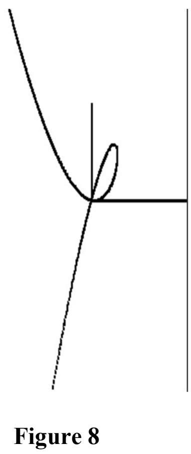

Figure 8 The curve for X_F=10

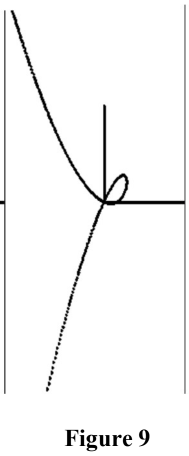

Figure 9 The curve for X_F=20

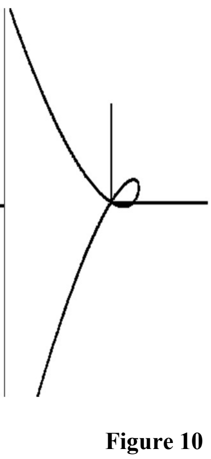

Figure 10 The curve for X_F=35

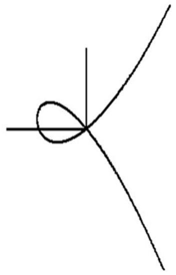

Figure 11 The curve for X_F=90

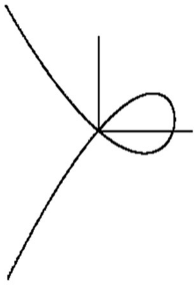

Figure **12** The curve for X_F=120

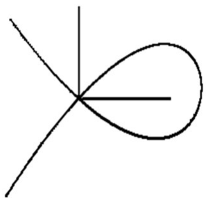

Figure 13 The curve for X_F=200

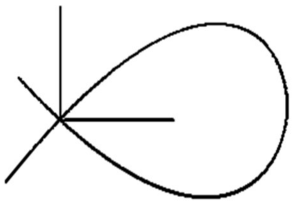

Figure 14 The curve for X_F=300

If the line DB overlaps with the ordinate, a parabola is obtained (Figure 15).

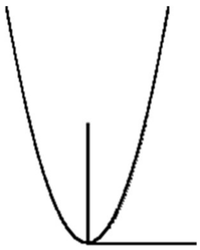

Figure 15 The curve for X_F=0

If point F reaches the left of the ordinate, the curves are rotated 180 degrees relative to the above (Figures 16 to 20).

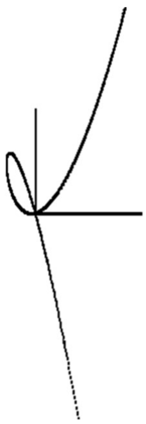

Figure 16 The curve for X_F=-10

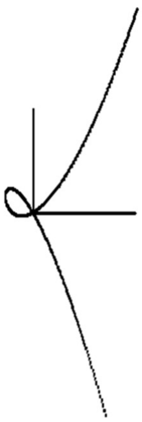

Figure 17 The curve for X_F=-30

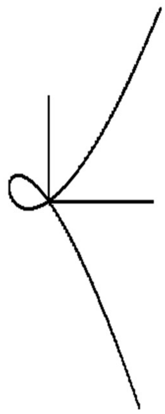

Figure 18 The curve for X_F=-50

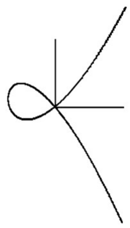

Figure 19 The curve for X_F=-100

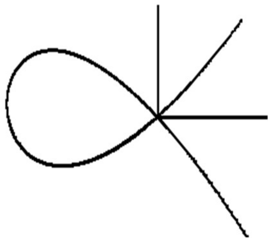

Figure 20 The curve for X_F=-200

Next, the position of the fixed bar passing through point C was changed, i.e the elevation Yc, the results being given in figures 21 to 25.

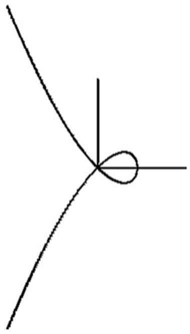

Figure 21 The curve for Yc=0

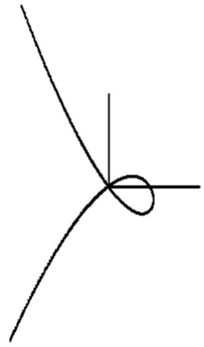

Figure 22 The curve for Yc=-40

Figure 23 The curve for Yc=-100

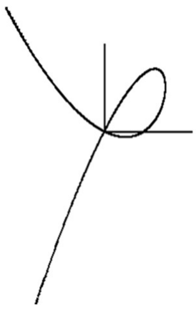

Figure 24 The curve for Yc=100

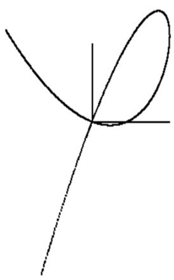

Figure 25 The curve for Yc=150

Following the changes made by us, we notice the change in the shape and size of the curl loops, which still remain the same.

Curves were also generated for different values of the angles α_i, obtaining the shapes from figures 26 to 34.

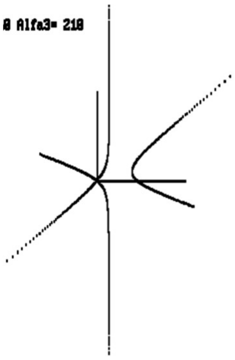

Figure 26 The curve for $\alpha_1=20$; $\alpha_2=40$; $\alpha_3=210$

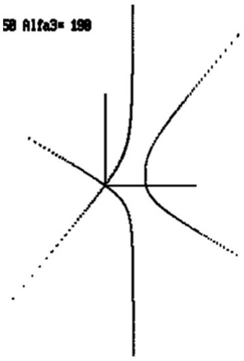

Figure 27 The curve for $\alpha_1=30$; $\alpha_2=50$; $\alpha_3=190$

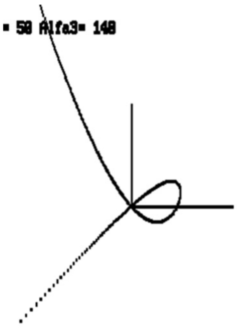

Figure 28 The curve for $\alpha_1=80$; $\alpha_2=50$; $\alpha_3=140$

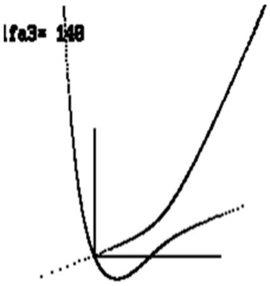

Figure 29 The curve for $\alpha_1=110$; $\alpha_2=50$; $\alpha_3=140$

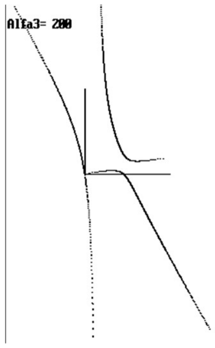

Figure 30 The curve for $\alpha_1=60$; $\alpha_2=10$; $\alpha_3=200$

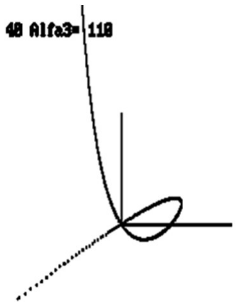

Figure 31 The curve for $\alpha_1=120$; $\alpha_2=40$; $\alpha_3=110$

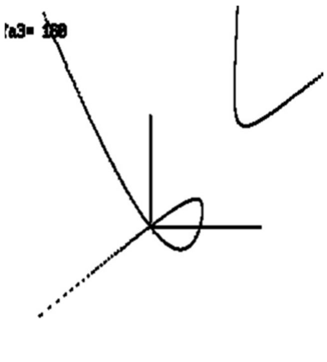

Figure 32 The curve for $\alpha_1=70$; $\alpha_2=40$; $\alpha_3=160$

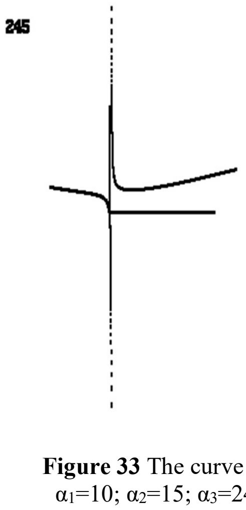

Figure 33 The curve for $\alpha_1=10$; $\alpha_2=15$; $\alpha_3=245$

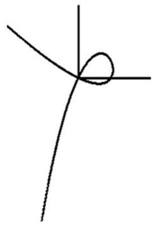

Figure 34 The curve for $\alpha_1=50$; $\alpha_2=100$; $\alpha_3=120$

7. CONCLUSION

We started from an Artobolevskii mechanism that generates the parabolic snail and its possibilities were studied.

It was found that the mechanism has an element and two structurally parasitic kinematic couplings, so that the calculation of trajectories by the contour method was further solved, unlike Artobolevskii who calculated the radius of curvature by geometric methods.

After that, other curves generated by this mechanism were established by modifying the angles between the sides, initially set at 90 degrees and then changed randomly. The positions of the fixed lines have also changed: one horizontal and one vertical.

We can observe that there are many types of curves generated by this mechanism.

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