NEW KINEMATICS SCHEME OF THE MECHANISMS FOR THE POWER SWITCHER WITH V EXTINGUISHING CHAMBERS

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ABSTRACT: The paper presents two new kinematic schemes of the V switcher mechanisms for medium and high power. The proposed schemes consist of triadic chains that ensure transmission angles near to the optimum values. The geometric and kinematic analyses of the proposed mechanisms, with driven components that have to move with high speeds on disengaging process in the extinguishing chamber, have been achieved. In the second section of the paper, an optimum kinematic scheme of the V power switcher with triadic chain type 4R+2T has been presented.
KEYWORDS: kinematic scheme, switcher mechanisms, extinguishing chamber, triadic chain

1. INTRODUCTION

The current mechanism of the power switcher with V placed extinguishing chambers (fig. 1.1a) is based on two kinematic dyadic chains T+(3R)+(2R+T). Keeping the same structure of the kinematic couplings used, the two dyadic chains can be configured into a triadic chain (fig. 1.1*b*).

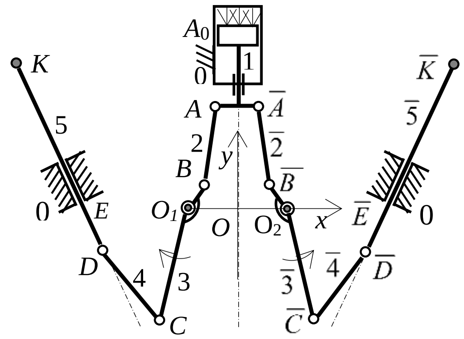


Fig. 1.1*a*. The current kinematic diagram

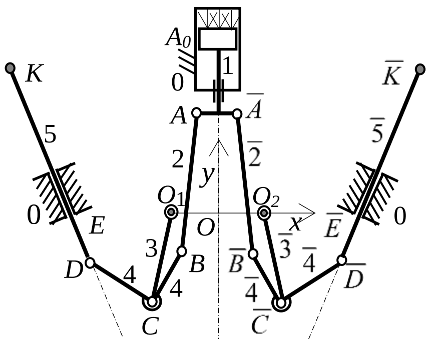


Fig. 1.1*b*. Kinematic diagram of the new mechanism

With the current kinematic diagram (fig. 1.1*a*), the structural and topological formula of the leading mechanism is:

$$MM = MA(0,1) + \begin{cases} LD(2,3) + LD(4,5) \\ LD(\overline{2},\overline{3}) + LD(\overline{4},\overline{5}) \end{cases} \quad (1.1)$$

With the new kinematic diagram (fig. 1.1*b*) the structural and topological formula is written:

$$MM = MA(0,1) + \begin{cases} LT(2,3,4,5) \\ LT(\overline{2},\overline{3},\overline{4},\overline{5}) \end{cases} \quad (1.2)$$

For this new structural and geometrical diagram, the kinematic elements 4 and $\overline{4}$ are central elements of the 3rd degree of the corresponding triadic chain $LT(2,3,4,5)$ and $LT(\overline{2},\overline{3},\overline{4},\overline{5})$ of the 5R+T type (fig. 1.1*c*).

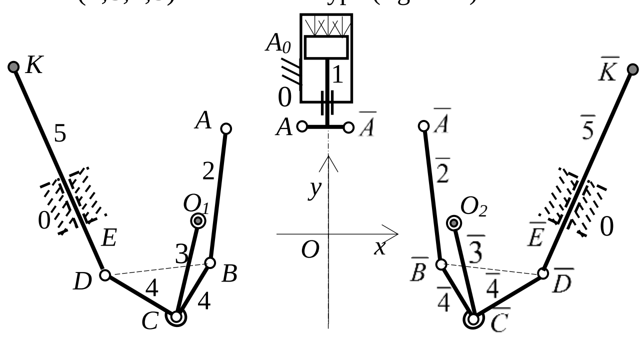


Fig. 1.1*c*. Kinematic diagrams of MA(0,1) and of the symmetrical (left and right) triadic chains LT

2. SYNTHESIS OF A NEW GEOMETRICAL VERSION OF THE V MECHANISM

We can design structural geometrical versions of the triadic chains $LT(2,3,4,5)$ and $LT(\overline{2},\overline{3},\overline{4},\overline{5})$, where the 3 articulations (B, C and D) respectively $(\overline{B},\overline{C},\overline{D})$ of the central elements 4 and $\overline{4}$ are collinear (fig. 2.1*a*).

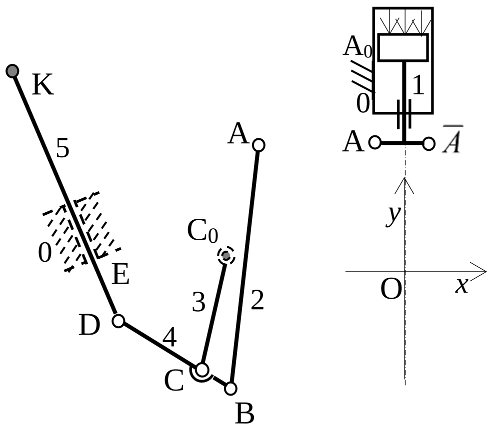


Fig. 2.1*a*. Version of the kinematic diagram of the triadic chain LT(5R+T)

We can notice the particularity of this kinematic diagram of the triadic chain LT (fig. 2.1*a*) which consists in placing the three articulations B, C and D on the same straight line. The rotation semi-couplings A and C_0, as well as the translational semi-coupling E are called potential kinematic couplings by means of which the triadic chain LT(2,3,4,5) is connected to the leading element 1 and to the fixed element 0.

The equivalent kinematic diagram of the triadic chain LT(2,3,4,5) is obtained by replacing the bar 5 with a shoe 5^* that slides along the fixed guide Δ_5 (fig. 2.1*b*).

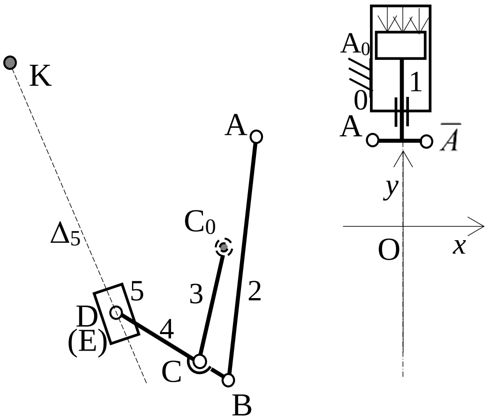


Fig. 2.1*b*. Equivalent kinematic diagrams of the triadic chains LT (left and right)

With this triadic chain LT(2,3,4,5) we may notice that the central element 4 having a rotation – translational motion (plane-parallel) does an instantaneous rotation around the I_{40} point (the instantaneous rotation centre) situated upon the intersection of the equalizing bar 3 with the line drawn through the articulation D and perpendicular on the guide Δ_5 (fig. 2.1*c*).

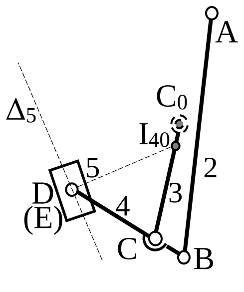


Fig. 2.1*c*. Positioning of the instantaneous rotation centre I_{40}

3. KINEMATIC GEOMETRY OF THE TRIADIC CHAIN MECHANISM

We shall consider the kinematic diagram of the 3rd class mechanism (with a triadic chain) of a V power switcher (fig. 3.1*a*).

For a geometrical kinematic analysis of the proposed mechanism, we isolate the triadic chain LT(2,3,4,5) of the 5R+T type (fig. 3.1*b*).

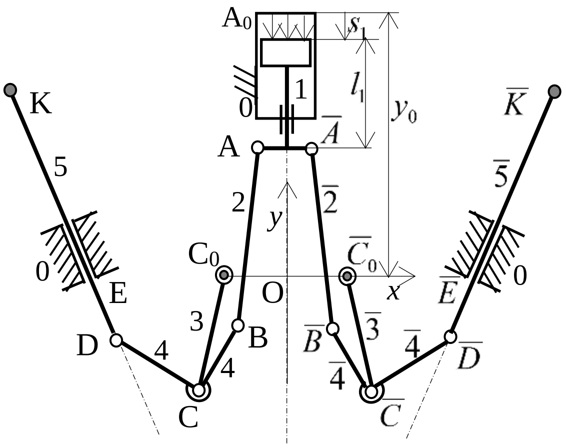


Fig. 3.1*a*. Kinematic diagram of the proposed mechanism

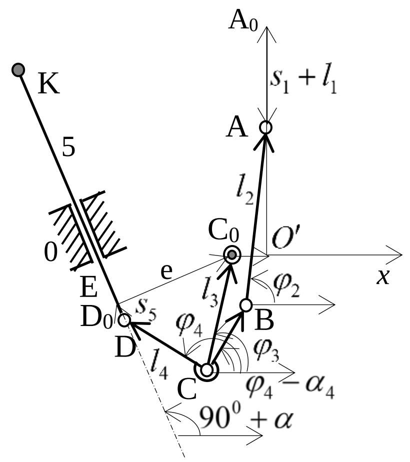


Fig. 3.1*b*. The associated vector contour lines

We identify two vector contour lines associated to this kinematic chain, where each side is suitably oriented and positioned by means of the trigonometrically oriented angle.

The two independent contour lines selected are (fig. 3.1*b*): $O'A_0ABCC_0O'$ and $C_0CDD_0C_0$.

For each independent contour line we write the closing vector equation:

$$\overrightarrow{O'A_0} + \overrightarrow{A_0A} - \overrightarrow{BA} - \overrightarrow{CB} + \overrightarrow{CC_0} + \overrightarrow{C_0O'} = 0 \quad (3.1)$$

$$\overrightarrow{CC_0} - \overrightarrow{CD} - \overrightarrow{DD_0} - \overrightarrow{D_0C_0} = 0 \quad (3.2)$$

The two vector equations are written in a suitable way so as to have the vectors containing unknown variables to the left:

$$\overrightarrow{BA} + \overrightarrow{CB} - \overrightarrow{CC_0} = \overrightarrow{O'A_0} + \overrightarrow{A_0A} + \overrightarrow{C_0O'} \quad (3.3)$$

$$\overrightarrow{CC_0} - \overrightarrow{CD} - \overrightarrow{DD_0} = \overrightarrow{D_0C_0} \quad (3.4)$$

The scaling equations related to the vector equations (3.3) and (3.4) are expressed as follows (fig. 3.1*b*):

$$l_2\cos\varphi_2 + l_4'\cos(\varphi_4-\alpha_4) - l_3\cos\varphi_3 = C_0O';$$
$$l_2\sin\varphi_2 + l_4'\sin(\varphi_4-\alpha_4) - l_3\sin\varphi_3 = y_0 - l_1 - s_1;$$
$$l_3\cos\varphi_3 - l_4\cos\varphi_4 - s_5\cos(90^0+\alpha) = e\cdot\cos\alpha; \quad (3.5)$$
$$l_3\sin\varphi_3 - l_4\sin\varphi_4 - s_5\sin(90^0+\alpha) = e\cdot\sin\alpha.$$

The system (3.5) consists of four scaling equations with four unknown variables, of which three angles $(\varphi_2,\varphi_3,\varphi_4)$ and a linear displacement (s_5):

$$\begin{cases} l_2\cos\varphi_2 + l_4'\cos(\varphi_4-\alpha_4) - l_3\cos\varphi_3 = x_{O'} - x_{C_0}; \\ l_2\sin\varphi_2 + l_4'\sin(\varphi_4-\alpha_4) - l_3\sin\varphi_3 = y_0 - l_1 - s_1; \\ l_3\cos\varphi_3 - l_4\cos\varphi_4 + s_5\sin\alpha = e\cdot\cos\alpha; \\ l_3\sin\varphi_3 - l_4\sin\varphi_4 - s_5\cos\alpha = e\cdot\sin\alpha. \end{cases} \quad (3.6)$$

In the particular case when the articulationse B, C and D are collinear (fig. 3.1*d*), the angle α_4 is null $(\alpha_4 = 0)$, so that the scaling equations (3.6) become:

$$\begin{cases} l_2\cos\varphi_2 + l_4'\cos\varphi_4 - l_3\cos\varphi_3 = x_{O'} - x_{C_0}; \\ l_2\sin\varphi_2 + l_4'\sin\varphi_4 - l_3\sin\varphi_3 = y_0 - l_1 - s_1; \\ l_3\cos\varphi_3 - l_4\cos\varphi_4 + s_5\sin\alpha = e\cdot\cos\alpha; \\ l_3\sin\varphi_3 - l_4\sin\varphi_4 - s_5\cos\alpha = e\cdot\sin\alpha. \end{cases} \quad (3.7)$$

To solve the system consisting of four partially non-linear scaling equations (3.7) with 4 unknown variables, we can apply the linearization method.

Thus, in the initial position of the mechanism ($s_1 = 0$) we measure (on the scaled kinematic diagram) the angles $\varphi_2^0, \varphi_3^0, \varphi_4^0$ and the linear displacement s_5^0.

In a position of the plane mechanism (from the vicinity of the initial position) for s_1 imposed, the four variables become:

$$\varphi_2^0 + \Delta\varphi_2, \varphi_3^0 + \Delta\varphi_3, \varphi_4^0 + \Delta\varphi_4 \text{ and } s_5^0 + \Delta s_5. \quad (3.8)$$

The linearization of the (3.7) equations is done with the formulae:

$$\cos(\varphi_i + \Delta\varphi_i) = \cos\varphi_i - \Delta\varphi_i\cdot\sin\varphi_i;$$
$$\sin(\varphi_i + \Delta\varphi_i) = \sin\varphi_i + \Delta\varphi_i\cdot\cos\varphi_i.\ i = 2,3,4 \quad (3.9)$$

The system of non-linear equations becomes a system of linear equations:

$$\begin{cases} a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 = b_1; \\ a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 = b_2; \\ a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + a_{34}X_4 = b_3; \\ a_{41}X_1 + a_{42}X_2 + a_{43}X_3 + a_{44}X_4 = b_4. \end{cases} \quad (3.11)$$

The following notations were used in this system of equations:

$$a_{11} = l_2\sin\varphi_2^0; a_{12} = l_3\cos\varphi_3^0; a_{13} = l_4'\sin\varphi_4^0; a_{14} = 0;$$
$$b_1 = l_2\cos\varphi_2^0 + l_4'\cos\varphi_4^0 + l_3\cos\varphi_3^0 + x_{C_0} - x_{O'};$$
$$a_{21} = l_2\cos\varphi_2^0; a_{22} = -l_3\cos\varphi_3^0; a_{23} = l_4'\ \cos\varphi_4^0; a_{24} = 0;$$
$$b_2 = y_0 - l_1 - s_1 - l_2\sin\varphi_2^0 + l_3\sin\varphi_3^0 - l_4'\sin\varphi_4^0;$$
$$a_{31} = 0; a_{32} = l_3\sin\varphi_3^0; a_{33} = -l_4\sin\varphi_4^0; a_{34} = \sin\alpha;$$
$$b_3 = l_3\cos\varphi_3^0 - l_4\cos\varphi_4^0 + s_5^0\sin\alpha + e\cdot\cos\alpha;$$
$$a_{41} = 0; a_{42} = l_3\cos\varphi_3^0; a_{43} = -l_4\cos\varphi_4^0; a_{44} = -\cos\alpha;$$
$$b_4 = e\cdot\sin\alpha - l_3\sin\varphi_3^0 + l_4\sin\varphi_4^0 + s_5^0\cdot\sin\alpha.$$
$$X_1 = \Delta\varphi_2; X_2 = \Delta\varphi_3;\ X_3 = \Delta\varphi_4;\ X_4 = \Delta s_5.$$

4. THE KINEMATIC CALCULATION OF THE PLANAR TRIADIC CHAIN MECHANISM

We begin from the final stage of the *geometrical* calculation of the plane triadic chain mechanism, when we know the angular or linear positions of the component elements. The methods used in the kinematic calculation are methods that also meet in the papers [5], [6], [7].

To determine the angular and linear *velocities* of the kinematic elements in the structure of the mechanism, we consider the previously determined position scaling equations (3.7).

$$\begin{cases} l_2\cos\varphi_2 + l_4'\cos\varphi_4 - l_3\cos\varphi_3 = x_{O'} - x_{C_0}; \\ l_2\sin\varphi_2 + l_4'\sin\varphi_4 - l_3\sin\varphi_3 = y_0 - l_1 - s_1; \\ l_3\cos\varphi_3 - l_4\cos\varphi_4 + s_5\sin\alpha = e\cdot\cos\alpha; \\ l_3\sin\varphi_3 - l_4\sin\varphi_4 - s_5\cos\alpha = e\cdot\sin\alpha. \end{cases} \quad (4.1)$$

Each scaling equation is differentiated with respect to time, resulting in the linear system:

$$\begin{cases} -l_2\sin\varphi_2\cdot\dot\varphi_2 - l_4'\sin\varphi_4\cdot\dot\varphi_4 + l_3\sin\varphi_3\cdot\dot\varphi_3 = 0; \\ l_2\cos\varphi_2\cdot\dot\varphi_2 + l_4'\cos\varphi_4\cdot\dot\varphi_4 - l_3\cos\varphi_3\cdot\dot\varphi_3 = -\dot s_1; \\ -l_3\sin\varphi_3\cdot\dot\varphi_3 + l_4\sin\varphi_4\cdot\dot\varphi_4 + \dot s_5\sin\alpha = 0; \\ l_3\cos\varphi_3\cdot\dot\varphi_3 - l_4\cos\varphi_4\cdot\dot\varphi_4 + \dot s_5\cos\alpha = 0. \end{cases} \quad (4.2)$$

We know the linear velocity of piston 1 ($\dot s_1$), and the unknown variables in the equations forming this system are the angular velocities

$$\dot\varphi_2 = \omega_2 = x_1, \dot\varphi_3 = \omega_3 = x_2, \dot\varphi_4 = \omega_4 = x_3,$$

as well as the linear velocity $\dot s_5 = v_5 = x_4$.

The linear equations system (4.2) shall be generally written:

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 = b_1; \\ a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 = b_2; \\ a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{33}x_4 = b_3; \\ a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 = b_4. \end{cases} \quad (4.3)$$

In the equations of the system (4.3), we used the following notations for coefficients:

$$a_{11} = -l_2\sin\varphi_2; a_{12} = l_3\sin\varphi_3; a_{13} = -l_4'\sin\varphi_4; a_{14} = 0; b_1 = 0;$$
$$a_{21} = l_2\cos\varphi_2; a_{22} = -l_3\cos\varphi_3; a_{23} = l_4'\cos\varphi_4; a_{24} = 0; b_2 = -\dot s_1;$$
$$a_{31} = 0; a_{32} = -l_3\sin\varphi_3; a_{33} = l_4\sin\varphi_4; a_{34} = \sin\alpha; b_3 = 0;$$
$$a_{41} = 0; a_{42} = l_3\cos\varphi_3; a_{43} = -l_4\cos\varphi_4; a_{44} = \cos\alpha; b_4 = 0.$$

The angular / linear accelerations are obtained by differentiating with respect to time the velocity scaling equations (4.2), resulting in:

$$\begin{cases} l_2\cos\varphi_2\cdot\dot\varphi_2^2 + l_2\sin\varphi_2\cdot\ddot\varphi_2 + l_4'\cos\varphi_4\cdot\dot\varphi_4^2 + l_4'\sin\varphi_4\cdot\ddot\varphi_4 - \\ \qquad - l_3\cos\varphi_3\cdot\dot\varphi_3^2 - l_3\sin\varphi_3\cdot\ddot\varphi_3 = 0; \\ l_2\sin\varphi_2\cdot\dot\varphi_2^2 - l_2\cos\varphi_2\cdot\ddot\varphi_2 + l_4'\sin\varphi_4\cdot\dot\varphi_4^2 - l_4'\cos\varphi_4\cdot\ddot\varphi_4 - \\ \qquad - l_3\sin\varphi_3\cdot\dot\varphi_3^2 + l_3\cos\varphi_3\cdot\ddot\varphi_3 = \ddot s_1; \\ -l_3\cos\varphi_3\cdot\dot\varphi_3^2 - l_3\sin\varphi_3\cdot\ddot\varphi_3 + l_4\cos\varphi_4\cdot\dot\varphi_4^2 - \\ \qquad - l_4\sin\varphi_4\cdot\ddot\varphi_4 + \ddot s_5\sin\alpha = 0; \\ -l_3\sin\varphi_3\cdot\dot\varphi_3^2 + l_3\cos\varphi_3\cdot\ddot\varphi_3 + l_4\sin\varphi_4\cdot\dot\varphi_4^2 - \\ \qquad - l_4\cos\varphi_4\cdot\ddot\varphi_4 + \ddot s_5\cos\alpha = 0. \end{cases}$$

(4.4)

Keeping to the left of the above equations the terms containing accelerations, the system of linear equations (4.4) shall be written:

$$\begin{cases} l_2\sin\varphi_2\cdot\ddot\varphi_2 + l_4'\sin\varphi_4\cdot\ddot\varphi_4 - l_3\sin\varphi_3\cdot\ddot\varphi_3 = \\ \qquad = -l_2\cos\varphi_2\cdot\dot\varphi_2^2 - l_4'\cos\varphi_4\cdot\dot\varphi_4^2 + l_3\cos\varphi_3\cdot\dot\varphi_3^2; \\ -l_2\cos\varphi_2\cdot\ddot\varphi_2 - l_4'\cos\varphi_4\cdot\ddot\varphi_4 + l_3\cos\varphi_3\cdot\ddot\varphi_3 = \\ \qquad = \ddot s_1 - l_2\sin\varphi_2\cdot\dot\varphi_2^2 - l_4'\sin\varphi_4\cdot\dot\varphi_4^2 + l_3\sin\varphi_3\cdot\dot\varphi_3^2; \\ -l_3\sin\varphi_3\cdot\ddot\varphi_3 + l_4\sin\varphi_4\cdot\ddot\varphi_4 + \ddot s_5\sin\alpha = \\ \qquad = l_3\cos\varphi_3\cdot\dot\varphi_3^2 - l_4\cos\varphi_4\cdot\dot\varphi_4^2; \\ l_3\cos\varphi_3\cdot\ddot\varphi_3 - l_4\cos\varphi_4\cdot\ddot\varphi_4 + \ddot s_5\cos\alpha = \\ \qquad = l_3\sin\varphi_3\cdot\dot\varphi_3^2 - l_4\sin\varphi_4\cdot\dot\varphi_4^2. \end{cases} \qquad (4.5)$$

Solving the system of 4 linear equations (4.5) the 4 accelerations shall be inferred as unknown variables:

$$\ddot\varphi_2 = \varepsilon_2;\ \ddot\varphi_3 = \varepsilon_3;\ \ddot\varphi_4 = \varepsilon_4;\ \ddot s_5 = a_5.$$

5. OPTIMIZATION OF THE KINEMATIC SCHEME WITH TRIADIC CHAIN TYPE 4R+2T

In order to minimize the space occupied by the mechanism of the V power switcher, in the kinematic diagram of the triadic chains LT(2,3,4,5) and LT($\overline{2},\overline{3},\overline{4},\overline{5}$), (fig. 5.1), we replace the articulations C(3,4) and $\overline{C}(\overline{3},\overline{4})$ with a transational coupling between elements 3 and 4 respectively $\overline{3}$ and $\overline{4}$ (fig. 5.1*a*).

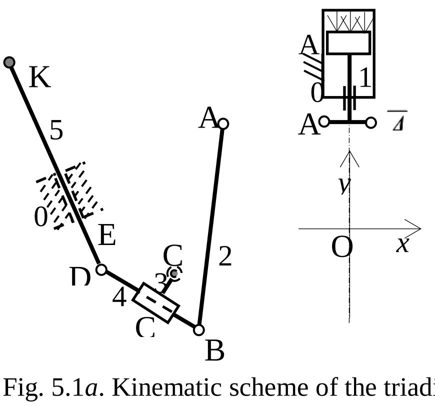


Fig. 5.1*a*. Kinematic scheme of the triadic chains 4R+2T

In the topological structure of the new version of the triadic kinematic chain LT(2,3,4,5) 4 rotation couplings are identified (A, B, C_0, D) as well as 2 translational couplings (C, E).

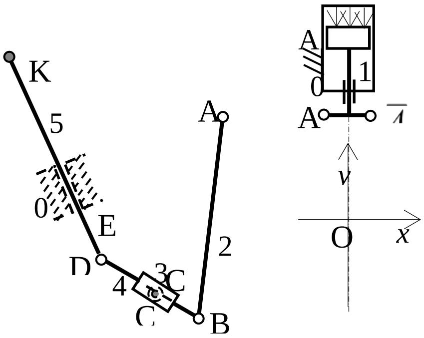


Fig. 5.1*b*. Kinematic scheme of the triadic chain with superposed couplings

Also, the length CC_0 of the equalizer 3 can significantly decrease to zero (fig. 5.1*b*), when the fixed articulation C_0 lies in the direction of the bar 4 in parallel superposed planes.In this new scheme (fig. 5.1*b*) kinematic geometry is much simpler. Thus, when the point A moves to the position A' (on the vertical Δ_1), the motion is transmitted by means of the bars 2 and 4 to the bar 5 which translates into the fixed guide E.

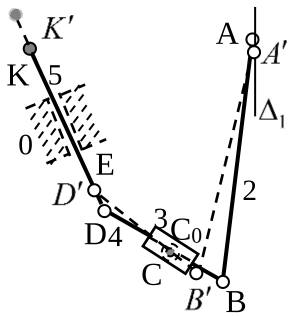
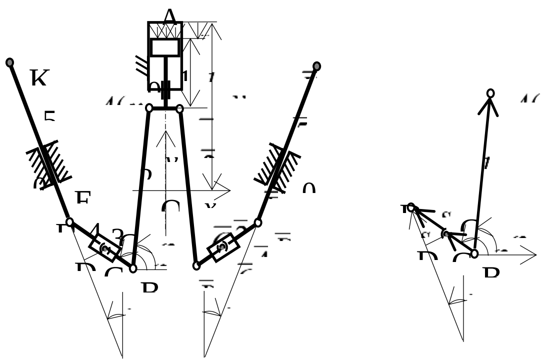


Fig. 5.1*c***.** Drawing a new position of the triad.

6. THE GEOMETRICAL POSITIONAL CALCULATION OF THE NEW TRIADIC CHAIN MECHANISM

We consider the kinematic scheme of the V mechanism (fig. 6.1*a*) where two symmetrical triadic chains are identified LT(2,3,4,5) and LT($\overline{2},\overline{3},\overline{4},\overline{5}$).



a1) *a2)*

Fig. 6.1*a*. Kinematic diagram of the new V mechanism (*a1*) and vector contour lines (*a2*)

Depending on the y_0 coordinate, the point A_0, the displacement s_1 of piston 1 and the lengths l_1 and $l_1' = 0{,}5A\overline{A}$ we determine the coordinates of the articulations A and $\overline{A}$:

$$x_A = -l_1';\ y_A = y_0 - l_1 - s_1;$$

$$x_{\overline{A}} = l_1';\ y_{\overline{A}} = y_0 - l_1 - s_1.$$

Also, the Cartesian coordinates of the fixed articulations C_0 and $\overline{C}_0$ are known:

$$x_{C_0} = -x_{\overline{C}_0};\ y_{C_0} = y_{\overline{C}_0}.$$

The two fixed guides of the bars 5 and $\overline{5}$ (fig. 9.4.1*a*) are inclined at an α angle as to the axis of the coordinates.

Following only the left kinematic chain, the fixed point C_0 is situated as to the guide Δ_5 at the distance $C_0D_0 = e$, and displacement of the point D as to D_0 is $D_0D = s_5$.

The constant lengths of the bars 2 and 4 are known: $AB = l_2$; $DB = l_4$.

We noted as C the mobile point on the bar 4, whose position as to the articulation D was noted as $CD = s_{43}$ and symbolises the relative displacement between elements 4 and 3.

To determine the instantaneous positions of the proposed mechanism (fig. 6.1*a*), we identify two independent closed contour lines containing the elements *02430* and 03450.

Using the method of the associated vector contour [7], we obtain the following scaling equations:

$$l_2\cos\varphi_2 - l_4\cos\varphi_4 + s_{43}\cos\varphi_4 = x_A - x_{C_0};\ (6.1)$$

$$l_2\sin\varphi_2 - l_4\sin\varphi_4 + s_{43}\sin\varphi_4 = y_A - y_{C_0};\ (6.2)$$

$$s_5\sin\alpha - s_{43}\cos\varphi_4 = e\cdot\cos\alpha; \qquad (6.3)$$

$$s_5\cos\alpha - s_{43}\sin\varphi_4 = e\cdot\sin\alpha. \qquad (6.4)$$

It should be noticed that the first two scaling equations are non-linear having the angular unknown variables φ_2 and φ_4, while the last two equations are partially linear having the unknown variables s_{43} and $s_5 = s_{50}$.

7. DETERMINING VELOCITIES AND ACCELERATIONS FOR THE NEW TRIADIC CHAIN V MECHANISM

Depending on the instantaneous known position of the analysed mechanism (fig. 6.1*a*), we can determine the *angular and linear velocities* of the led kinematic elements forming the triadic chains $LT(2,3,4,5)$ and $LT(\overline{2},\overline{3},\overline{4},\overline{5})$ of the 4R+2T type.

We consider the positions/ displacements scaling equations (7.1, 2, 3, 4) that are differentiated with respect to time, resulting in the velocities equations:

$$-l_2\sin\varphi_2\cdot\dot\varphi_2 + (l_4 - s_{43})\sin\varphi_4\cdot\dot\varphi_4 + \cos\varphi_4\cdot\dot s_{43} = \dot x_A;\ (7.1)$$

$$l_2\cos\varphi_2\cdot\dot\varphi_2 - (l_4 - s_{43})\cos\varphi_4\cdot\dot\varphi_4 + \sin\varphi_4\cdot\dot s_{43} = \dot y_A;\ (7.2)$$

$$s_{43}\sin\varphi_4\cdot\dot\varphi_4 - \cos\varphi_4\cdot\dot s_{43} + \sin\alpha\cdot\dot s_5 = 0; \qquad (7.3)$$

$$s_{43}\cos\varphi_4\cdot\dot\varphi_4 + \sin\varphi_4\cdot\dot s_{43} - \cos\alpha\cdot\dot s_5 = 0. \qquad (7.4)$$

The obtained equations (7.1, 2, 3, 4) are linear equations forming a linear system that leads to the further calculation of the angular / linear velocities $\dot\varphi_2 = \omega_2$, $\dot\varphi_4 = \omega_4$, $\dot s_{43} = v_{43}$, $\dot s_5 = v_5$.

The angular (φ_2, φ_4) and linear (s_{43}, s_5) positions of the elements of the triadic chain are determined in the previous stage. The components of the point A velocity are:

$$\dot x_A = 0;\ \dot y_A = -v_1. \qquad (7.5)$$

Generally, the velocity scaling equations are written:

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 = 0; \\ a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 = -v_1; \\ a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{34}x_4 = 0; \\ a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 = 0. \end{cases} \qquad (7.6)$$

The following notations were used in the system of linear scaling equations (7.6):

- for variable or constant coefficients:

$$a_{11} = -l_2\sin\varphi_2; a_{12} = (l_4 - s_{43})\sin\varphi_4; a_{13} = \cos\varphi_4; a_{14} = 0;$$

$$a_{21} = l_2\cos\varphi_2; a_{22} = -(l_4 - s_{43})\cos\varphi_4; a_{23} = \sin\varphi_4; a_{24} = 0;$$

$$a_{31} = 0; a_{32} = s_{43}\sin\varphi_4; a_{33} = -\cos\varphi_4; a_{34} = \sin\alpha;$$

$$a_{41} = 0; a_{42} = s_{43}\cos\varphi_4; a_{43} = \sin\varphi_4; a_{44} = -\cos\alpha.$$

- for unknown variables / angular or linear velocities:

$$x_1 = \dot\varphi_2; x_2 = \dot\varphi_4; x_3 = \dot s_{43}; x_5 = \dot s_5.$$

In the third stage, knowing the angular / linear velocities of the kinematic elements 2, 3, 4 and 5 from the triadic chain, we determine the *angular / linear accelerations* of these kinematic elements. Thus, the explicit scaling equations (7.1, 2, 3, 4) are differentiated with respect to time and the following are obtained:

$$\begin{aligned} &-l_2\sin\varphi_2\cdot\ddot\varphi_2 + (l_4 - s_{43})\sin\varphi_4\cdot\ddot\varphi_4 + \cos\varphi_4\cdot\ddot s_{43} = \\ &\qquad l_2\cos\varphi_2\cdot\dot\varphi_2^2 - l_4\cos\varphi_4\cdot\dot\varphi_4^2 + 2\sin\varphi_4\cdot\dot s_{43}\cdot\dot\varphi_4; \end{aligned} \qquad (7.7)$$

$$\begin{aligned} &l_2\cos\varphi_2\cdot\ddot\varphi_2 - (l_4 - s_{43})\cos\varphi_4\cdot\ddot\varphi_4 + \sin\varphi_4\cdot\ddot s_{43} = \\ &\qquad l_2\sin\varphi_2\cdot\dot\varphi_2^2 - l_4\sin\varphi_4\cdot\dot\varphi_4^2 - 2\cos\varphi_4\cdot\dot s_{43}\cdot\dot\varphi_4; \end{aligned} \qquad (7.8)$$

$$\begin{aligned} &s_{43}\sin\varphi_4\cdot\ddot\varphi_4 - \cos\varphi_4\cdot\ddot s_{43} + \sin\alpha\cdot\ddot s_5 = \\ &\qquad - s_{43}\cos\varphi_4\cdot\dot\varphi_4^2 - 2\sin\varphi_4\cdot\dot s_{43}\cdot\dot\varphi_4; \end{aligned} \qquad (7.9)$$

$$\begin{aligned} &s_{43}\cos\varphi_4\cdot\ddot\varphi_4 - \sin\varphi_4\cdot\ddot s_{43} + \cos\alpha\cdot\ddot s_5 = \\ &\qquad - s_{43}\sin\varphi_4\cdot\dot\varphi_4^2 - 2\cos\varphi_4\cdot\dot s_{43}\cdot\dot\varphi_4. \end{aligned} \qquad (7.10)$$

From this system of linear equations we determine the accelerations: $\ddot\varphi_2, \ddot\varphi_4, \ddot s_{43}, \ddot s_5$.

8. CONCLUSIONS

Starting from the current dyadic chain kinematic scheme of the V high voltage power switcher, the paper suggests new kinematic diagrams with a triadic structure.

For the first kinematic scheme proposed, based on a triadic chain of the 5R+T type, we have analysed two versions having a different geometrical structure.

The second kinematic scheme is based on a triadic chain of the 4R+2T type, having the possibility to optimize the operation of the V mechanism.

For each new kinematic scheme the geometrical and kinematic analysis method has been developed, presenting all the stages of the analytic calculations of displacements, velocities and accelerations, especially for the translating bar with the power switch point.

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