# SUMMARY
of doctoral thesis entitled

# "RESEARCH CONCERNING PANTOGRAPH MECHANISMS USED FOR TRANSPORT VEHICLES"

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CONTENTS

Keywords :

calculations pantograph mechanism, homothety, locomotive pantograph, pantograph dynamic, pantograph for metro, pantograph vibration

## Summaries of the main parts of the thesis

Part I contains 6 chapters where are presented data from the literature about the pantograph mechanisms.

In Chapter 1, "Geometry of pantograph mechanisms" are presented general considerations concerning the pantograph mechanisms used for transforming curves in other curves by a report of homothety. Are shown theoretical considerations which formed the basis of these mechanisms, and the two types of pantograph mechanisms, type Scheiner and Sylvester.

In Chapter 2, " Domains using pantograph mechanisms" are several different subchapters which presented different fields using pantograph mechanisms such as:

- 2D and 3D pantograph mechanisms used for milling and engraving machines at different scales, produced by different companies;
- cutting water pressure machines using pantograph mechanisms;
- pantograph mechanisms used to built transport pallets of different types with different types of drives, used for lifting or transport of loads of different values to different heights;
- pantograph mechanisms to scale back the design plan. Are presented different types of pantograph mechanisms at different scales used for copying the drawings. In this chapter are presented pantograph mechanism which makes double orthogonal symmetry, double orthogonal axial symmetry, three orthogonal axial symmetry as well as other construction.

In Chapter 3, "Other pantograph mechanisms" are presented pantograph mechanisms used in marine, in the construction of electrical devices, architecture, art, door access, manipulators and robots.

In Chapter 4 "Pantograph mechanisms used in railway transport " are presented pantograph mechanisms used to transfer electricity from the mains supply to electrical equipment of railway vehicles. This chapter shows the evolution from the first pantographs used since the nineteenth century and until the modern transport vehicles such as: metros, trams, electric multiple units, electric locomotives. There are presented different types of pantographs,

symmetrical or asymmetrical, for low, medium or high speed, for normal or special applications.

In Chapter 5, "Methods of analysis and synthesis of pantograph mechanisms used in robots" are presented analysis and synthesis methods used by researchers who used different mechanisms to achieve pantograph walking robots. In several sub-studies are presented the analysis and synthesis of pantograph mechanisms which realize a virtual interface, pantograph mechanisms with elastic elements and joints with high deformation and research on analysis and synthesis of a pantograph mechanism used to inspect pipes.

In Chapter 6, " Issues concerning dynamic of pantograph mechanisms used to transfer current in railway transport " are presented studies on the interaction between pantograph of railway vehicles and fixed network of power supply. In this chapter are presented various approaches to the complex phenomenon of pantograph-catenary interaction, the results of simulations and tests carried out in real conditions of service of pantographs.

Part II contains 9 chapters that are the results of own research conducted in connection with the pantograph mechanisms used for transport vehicles.

In Chapter 7 "Research on the structure of pantograph mechanisms" are presented own research concerning the structure of four pantograph mechanisms used for transport vehicles, three of which are asymmetric, the fourth being symmetrical. For each of them is presented their decomposition in kinematic groups.

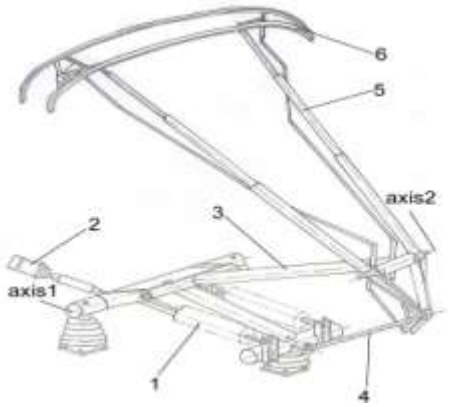

Fig.1

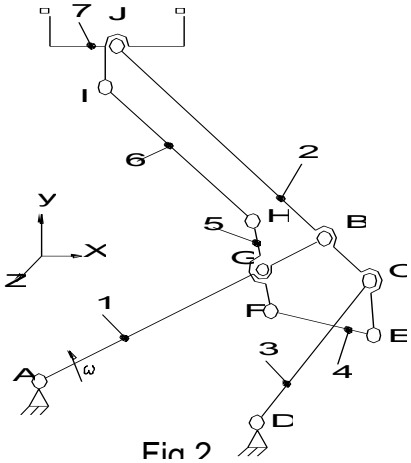

Fig.2

Among the pantograph mechanisms studied in terms of their structure is included asymmetric pantograph EP2 which has equipped LE 5100 kW electric locomotives, produced by SC Electroputere SA., which is shown in fig.1 and fig.2. The second pantograph mechanism studied was produced by the Faiveley company, which is driven by pneumatic bellows and is presented in fig.3 and fig.4.

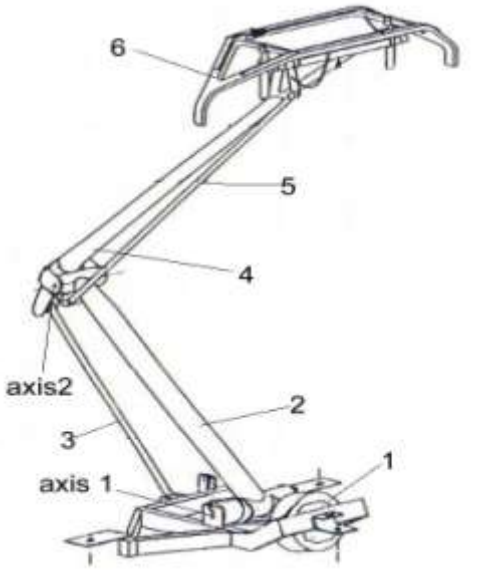


Fig.3

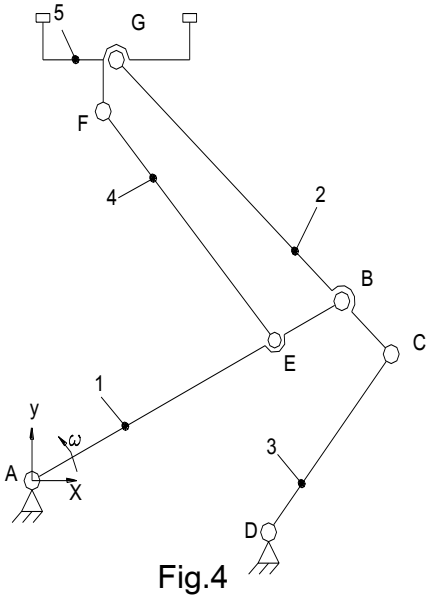


Fig.4

Was also studied the structure of double pantograph mechanism produced by Faiveley company, which has equipped TGV high speed trains. In fig. 5 and fig.6 is shown this pantograph mechanism.

Fig.5

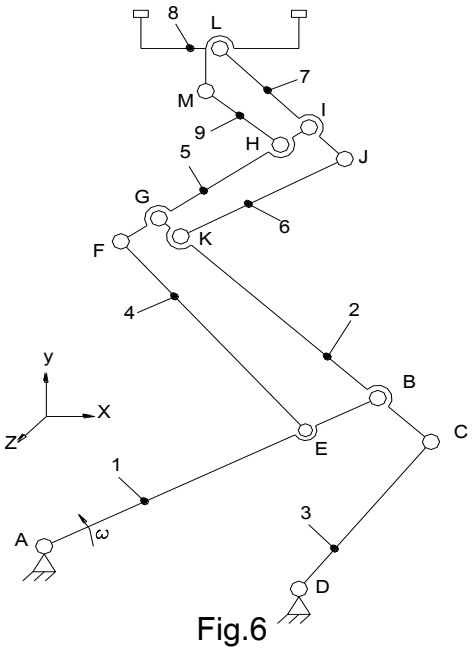


Fig.6

In Chapter 8 "Research on kinematics of pantograph mechanisms" is presented own research concerning the kinematic of pantograph mechanisms which were analyzed in Chapter 7. For each of these mechanisms are presented the kinematic diagrams and mathematical relationships for determining the position, velocity and acceleration starting with the driving element and getting to the collector head of pantograph mechanisms.

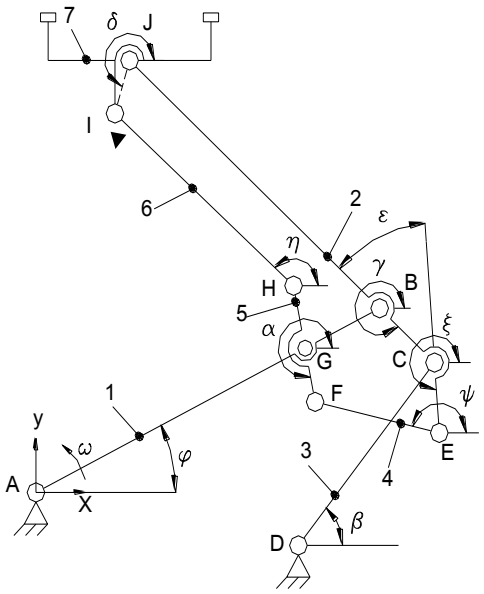


Fig.7

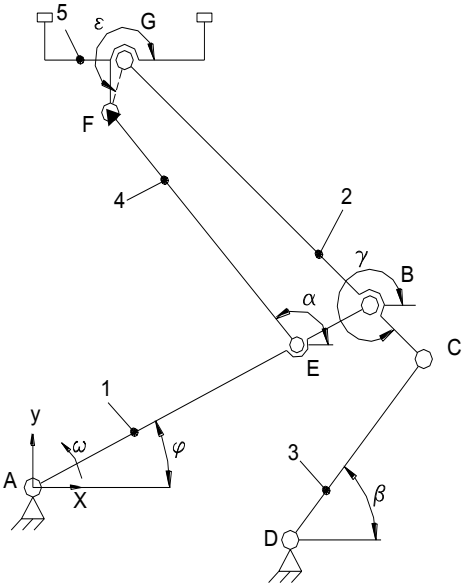


Fig.8

Was studied kinematic of pantograph mechanism EP2 shown in fig. 7, and kinematics of pantograph mechanism driven with pneumatic bellow, shown in fig.8, made by Faiveley company. Was also studied the kinematic of a symmetric pantograph mechanism

In Chapter 9, "Research on geometric synthesis of an original pantograph mechanism" is presented own research concerning the geometrical synthesis of a pantograph mechanism for LE 5100 kW electric locomotives, some constructive variants theoretically possible, as well as geometric synthesis results.

In Chapter 10, " Constructive presentation of an original pantograph mechanism for LE 5100 kW electric locomotive " are shown original solutions used to design pantograph mechanism for LE 5100 kW electrical locomotive which used a collector head with two collector strip with independent suspension. There are presented few assemblies and subassemblies of the pantograph. General Assembly of the pantograph is shown in fig.9

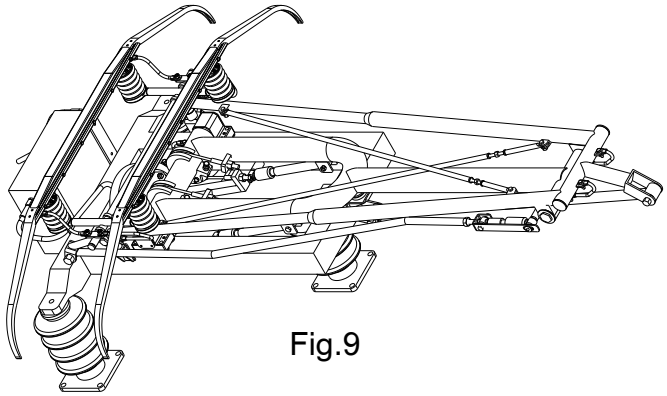

Fig.9

In Chapter 11 "Redesigned pantograph for metro" is presented a pantograph mechanism for metro which has redesigned the upper frame, collector head provided with suspension, the upper frame control bar and control bar of collector head. The are presented all the constructive solutions used and kinematics diagram of mechanism.
In fig.10 is shown the 3D model of the redesigned pantograph mechanism for metro.

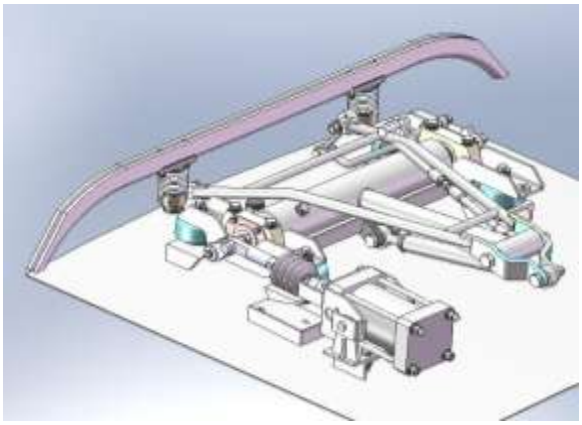

Fig.10

In Chapter 12 " Experimental research. Analysis of the results obtained. Description of testing bench for pantograph. " show the testing bench built to achieve the dynamic characteristics of the pantograph for metro.
There are shown the constructive solutions used to build it, attachment of the pantograph on the testing bench, and the way of functioning. It is presented the electronic equipment used for the acquisition of data recorded during trials, and results. 5 records have been made, two at lifting of pantograph and 3 on its descent at different operating conditions of the pneumatic cylinder.
Graphs are presented with recorded measurements and calculated values such as speed and acceleration of different elements of pantograph mechanism.
Is shown the value of contact force between collector head and supply network for different positions on the vertical axis of the collector head. Recordings made are in the form of graphics as the one shown in fig.11.

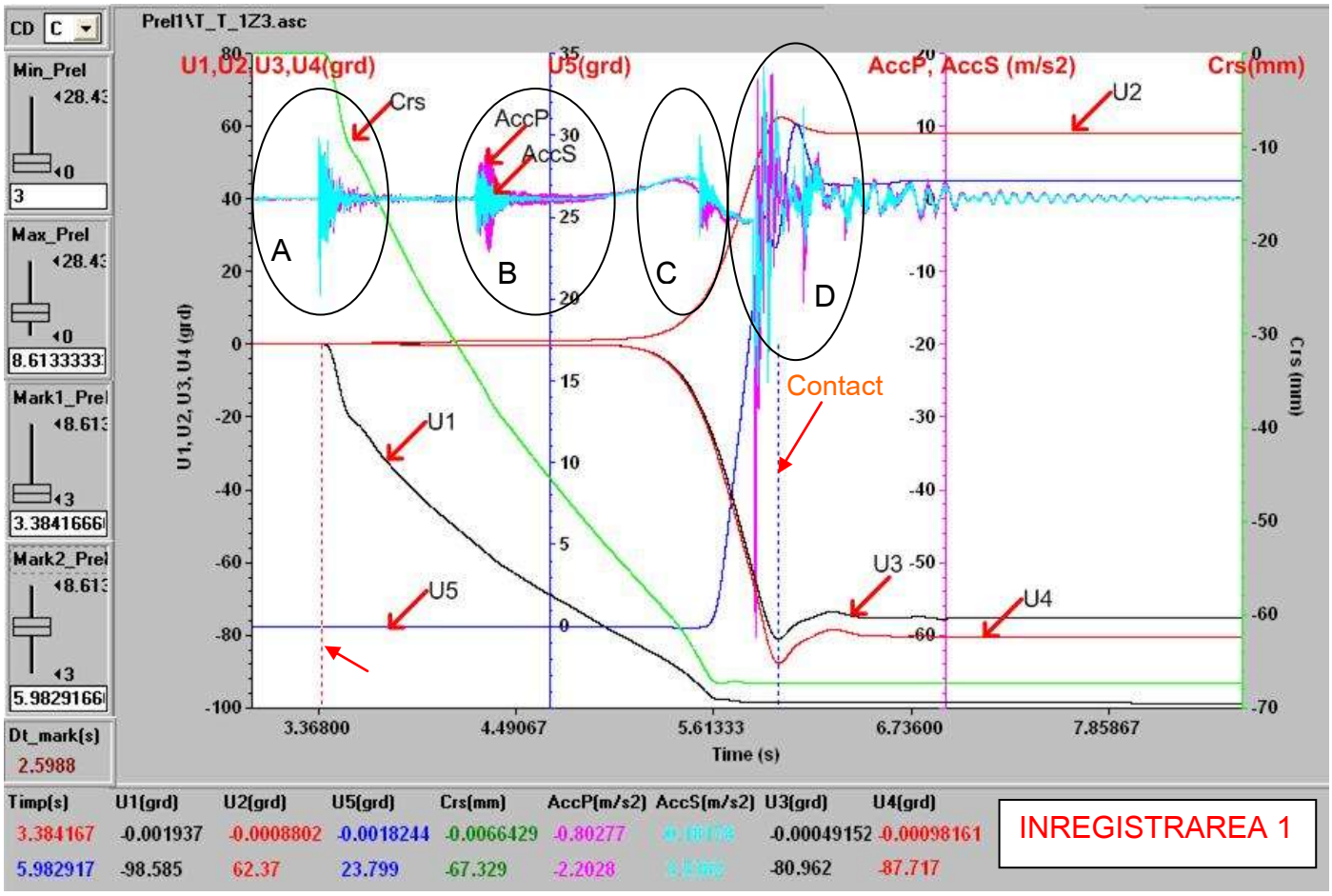


Fig.11

In Chapter 13 " Study the dynamics of pantograph using specialized computer programs" is shown how 3D model has been used to perform dynamic simulation using specialized computer programs. It also presents the conditions imposed to model and the results of simulations. Come forward and study how the mass of upper pantograph framework, influences its dynamic behavior, and the possibilities of regulating the contact force between collector head and power network. Are presented graphs and values obtained from simulations carried out. In fig.12 is presented as a graph with values obtained from simulation performed.

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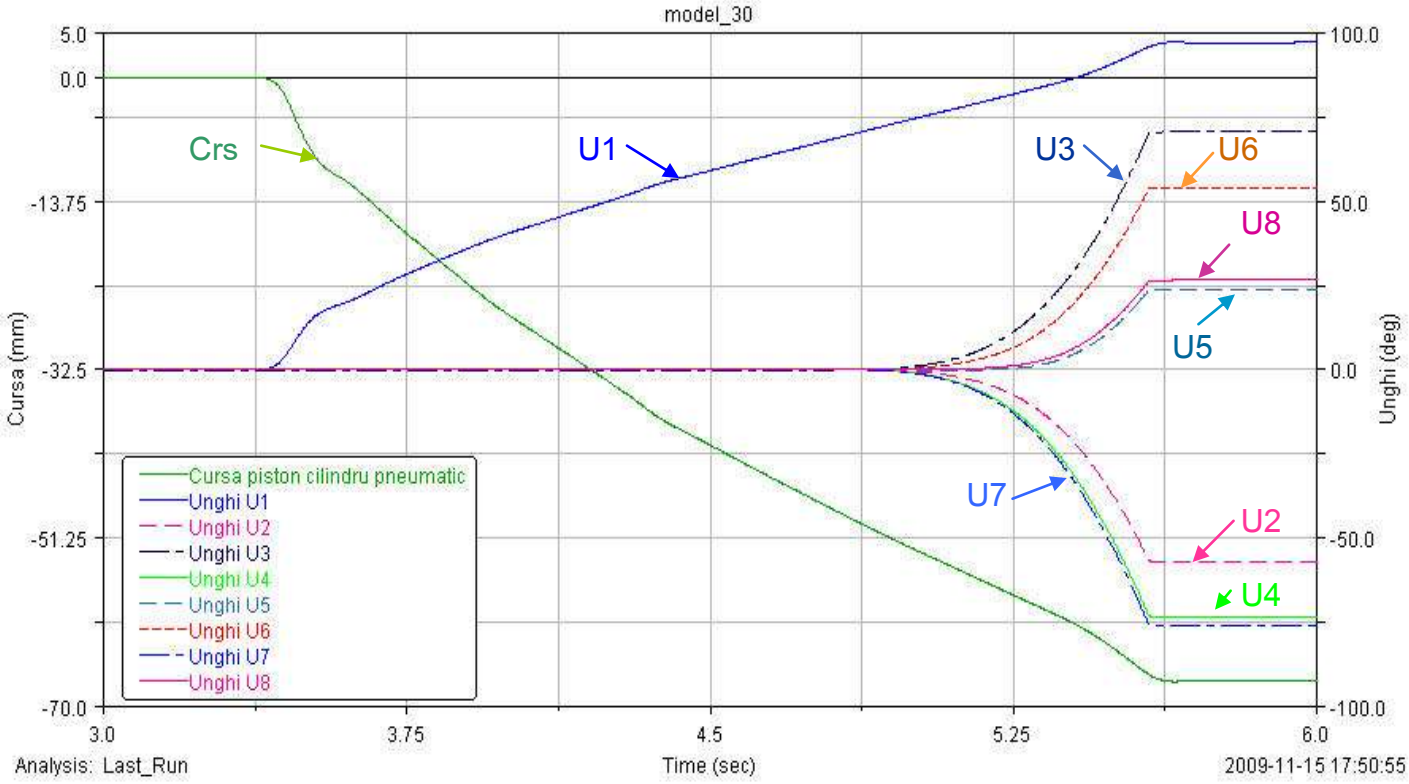


Fig.12

In Chapter 14, "Issues concerning vibrations pantograph" are shown the ways to determine frequency response functions on the horizontal-vertical and transverse directions and locations of measurement and the excitation. Described the equipment used for the acquisition of values, how the work and results. It presents the frequency response functions and forms of oscillation of the pantograph mechanism at different frequencies on vertical and horizontal directions.

Are presented the vibrations of pantograph when it is excited with the values recorded on the support brackets located on the roof of the pantograph frame when the metro is in travel by rail. In this chapter is studied pantograph fitted in two variants, one with the suspension of collector head blocked and other with the suspension active.

In Chapter 15, "General conclusions. Own contributions "are presented some general conclusions and recommendations for improving the dynamic behavior of pantograph mechanism studied. Own contributions are also presented.