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DEMONSTRATION MODELS FOR TEACHING KINEMATICS

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Abstract—A brief description of a showcase, with working models of plane mechanisms, developed at the 2nd Institute for Geometry, The Technical University, Vienna, as an aid to the teaching of kinematics.

KINEMATICS, or the science of motion, provides the theoretical basis for the analysis and synthesis of all mechanisms. An introduction to this important discipline forms the basis of the various practical applications of the science of mechanisms. Such introduction has for a long time been given to the students of mechanical engineering of the Technical University, Vienna, as part of the lectures and tutorials in descriptive geometry. In view of the fact that the students in these classes are in their first year, there is a definite need for visual demonstration material. The idea of making a showcase containing a number of typical mechanism models as an aid to the lecture programme was generated by impressions received during visits to the Technical Universities of Berlin and Dresden. In those Universities, kinematics can look back upon an older tradition founded by the work of F. Reuleaux and L. Burmester. In contrast to the examples in Berlin and Dresden, however, the models in Vienna were to be operated singly in order to concentrate the attention of the viewers.

The showcase, Fig. 1, was built in collaboration with the Wiener Schwachstromwerke (Vienna Light Current Engineering Co.), the details of the different models being planned by my chief assistant, W. Fuhs. It has been installed in the drawing office of the 2nd Institute for Geometry for more than a year and is available for use by the students during tutorial hours.

The top part of the case, as shown in Fig. 1, is made of steel sheet and has the dimensions 173 × 120 × 30 cm. It is supported on a slightly protruding wooden plinth about 70 cm high which serves for storing additional models. The top portion has 20 compartments which carry the same number of individual models. Square elements (dimensions 25 × 25 × 17·5 cm) can slide into these compartments under slight pressure and are held in position by latches. Repeated pressure releases the latch so that these removable elements can be exchanged easily. A central mechanical locking device, accessible from the right-hand side of the case, prevents unauthorized withdrawal. Each element contains in its frontal one-third the mechanism model which is covered by clear Plexiglas. The rear portion contains a 220-volt synchronous a.c. motor for driving the model. The motor can be started by a push button at the right-hand side of the case. A time release switches the motor off after a pre-set period which can be adjusted between 1 and 50 seconds. The electrical equipment has been designed in such a manner that only one model is in operation at a time and the simultaneous pressing of several push buttons has no effect. A main switch located at the right-hand side of the case and operated by a special safety key makes it possible to have the showcase operative only at certain times and this is indicated by a signal lamp.

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At the back of each sliding element are two pins which provide electrical contact with the element when it is pushed into its compartment. This makes it possible also to use the element with its model in the lecture room. For transporting the elements, carrying cases have been developed with corresponding openings in the back whilst the front can be removed for easy viewing.

All models were precision built in the workshops of the Wiener Schwachstromwerke (1031 Wien, Apostelgasse 12). The movable elements are made from coloured light alloy, the particular colour indicating the function of the particular member. The bearings and joints are provided with permanent lubrication; important path curves are shown by dotted lines.

The twenty models which are at present available can be seen in order in Fig. 1, and cover the following:

1. Elliptical movement generated by rolling a pinion inside an internal gear wheel of twice the pitch diameter (Cardan Circles). Two points on the pitch line of the pinion trace two orthogonal straight lines (as in trammels). Any general point traces an ellipse.

2. Elliptical movement generated by three gear-wheels, all with external teeth. Four points of the moving polode (a circle, not shown) attached to the outer gear trace four diameters of the fixed polode, also a circle.

3. Parallelogram linkage with circular coupler curve (parallel crank mechanism).

4. Crossed parallelogram linkage with elliptical polodes and a coupler curve with cusp.

5. Rhomboid linkage (Galloway mechanism) for non-uniform velocity with average 1 : 2.

6. Symmetrical four-bar linkage tracing a coupler curve containing an undulation point or fourth order tangency (the approximate straight-line mechanism of Roberts).

7. Generation of the same coupler curve by three separate cognate four-bar linkages (Roberts' Theorem).

8. Mechanism for driving a double-rocker linkage by means of a Burmester focal point mechanism (the approximate straight-line mechanism of Tschebyscheff having proportions $a : b : c : d = -2 : 1 : 0 : 4$) (see ref. [1]).

9. Generation of the same coupler curve by means of the crank-and-rocker mechanism derived by Roberts Theorem (Tschebyscheff's Lambda mechanism).

10. Closely approximate straight line mechanism discovered by Tschebyscheff ($a : b : c : r = 5{\cdot}025 : 1 : 0{\cdot}990 : 7{\cdot}213$; $t^2 = 1/200$) (see ref. [1]).

11. Four-bar linkage with two similar coupler curves (the Watt and Evans types of straight-line mechanisms).

12. The exact straight-line linkage of Darboux, using a particular form of Stephenson's six-bar linkage. One member describes an elliptical path and makes it possible to generate ellipses by means of a pivoted system.

13. Dwell mechanism, derived from a symmetrical coupler curve by utilizing the invariant radius of curvature of a segment of the loop.

14. Symmetrical slider-crank mechanism with a (connecting rod) coupler curve.

15. Symmetrical crank-and-slotted-arm linkage with one coupler curve (a cross conchoid of the 6th order).

16. Planetary motion with loci for the speed ratio $\omega_1 : \omega_2 = 1 : 3$ (looped, cusped and simple epitrochoids of the 6th order) (see ref. [2]).

17. Planetary motion with loci for the speed ratio $\omega_1 : \omega_2 = -1 : 3$ (looped, cusped and simple hypotrochoids of the 6th order) (see ref. [2]).

18. Steiner's planetary mechanism with $\omega_1 : \omega_2 = -2 : 1$ with its three-cusped hypocycloid generated as the common path of two points and the envelope of one diameter of the rolling circle.

19. Approximation of a square traced by a point of a three-step planetary gear. ($\omega_1 : \omega_2 : \omega_3 = 1 : -3 : 5$, and $a_1 : a_2 : a_3 = 23{\cdot}10 : -4{\cdot}89 : 1$) (see ref. [3]).

20. Geneva mechanism for film transport (intermittent drive with non-uniform motion).

There are already plans for doubling the number of models in the future. Models numbered 2, 7, 8 and 19 have been on exhibition in the Austrian Pavilion of the World Exhibition, 1967, in Montreal.

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