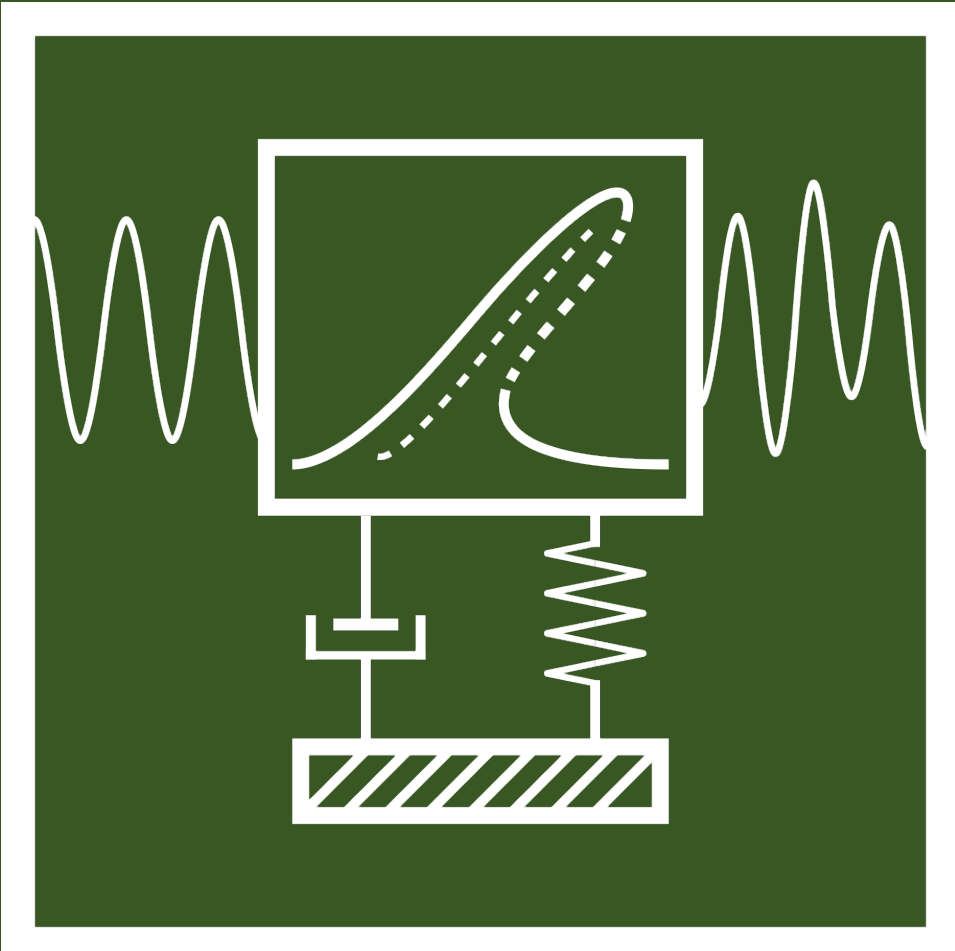


Origin and development of vibrotechnologies for the aviation industry at the Lviv School named after Volodymyr Povidailo

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A

Abstract

This review traces the development of vibrotechnologies for aviation at the Lviv School founded by Professor Volodymyr Povidailo. It connects the school's historical vibration equipment with current aircraft-manufacturing and testing applications: strengthening, grinding and polishing of titanium and high-strength aluminium-alloy parts; vibration-assisted composite processing and adhesive joining; and experimental reproduction of cyclic loads. Three test stands are considered: non-resonant eccentric-pendulum, resonant hydraulic-coupled, and inter-resonant three-mass electromagnetic systems.

01

Methods

A technology-focused review was prepared from the authors' research and previously developed equipment. The structural principles and operating regimes of the three stands were compared. Mathematical models of the oscillatory systems were used to determine principal operating parameters; reported characteristics were confirmed experimentally where indicated. The comparison covers two-mass non-resonant and resonant systems and a three-mass inter-resonant system.

02

Results

The three concepts provide different routes to efficient excitation. The non-resonant eccentric-pendulum stand is structurally simple and provides rapid start-up/shutdown. The resonant stand uses a hydraulic coupling: the Sommerfeld effect locks the unbalance speed near the resonance peak, enabling near-pre-resonant operation without an expensive speed-control system. The three-mass electromagnetic stand operates between resonances and uses resonance superposition to obtain high dynamic efficiency.

Stand	Acceleration	ω , rad/s	Drive power
Non-resonant	4 g	300	3000 W
Resonant	7 g	300	1500 W
Inter-resonant	9 g	628	300 W

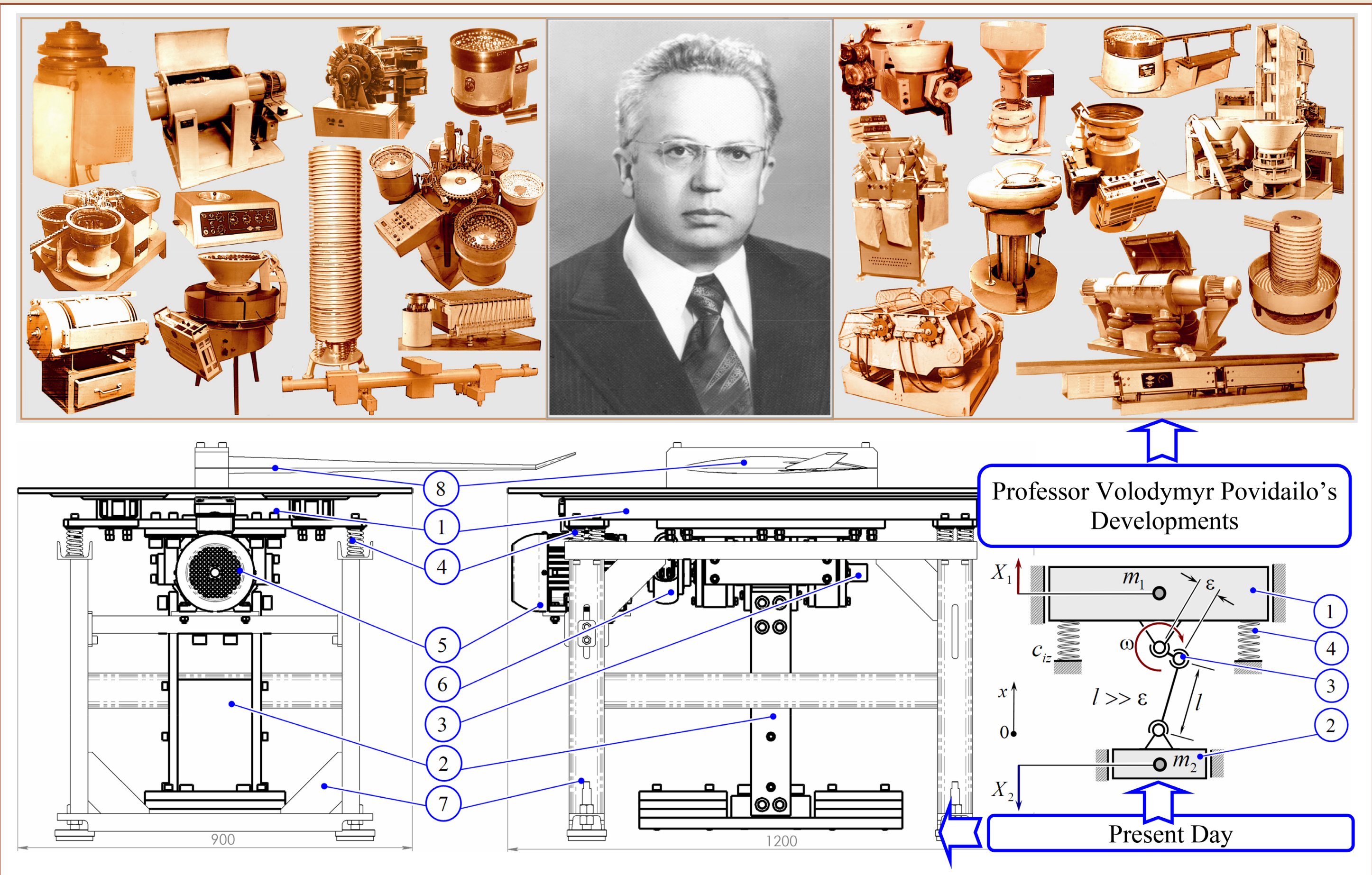


Fig 1. Projection views and simplified schematic diagram of the non-resonant eccentric-pendulum vibration test stand, where: 1 – active oscillating mass; 2 – reactive oscillating mass in the form of a pendulum; 3 – shaft with eccentricity ε ; 4 – vibration isolators; 5 – electric motor; 6 – flexible disc coupling; 7 – frame; 8 – glider wing cantilever-mounted to the active oscillating mass 1

03

Discussion

The Lviv School demonstrates a continuous transition from vibration-based technological processing to controlled dynamic testing. Vibration can improve surface-layer quality in difficult-to-machine titanium and high-strength aluminium alloys. In composite manufacture and adhesive joining, controlled vibration can support compaction, air removal, more uniform impregnation and adhesive distribution, and reduction of defects. Resonance-based test stands can reduce drive-power demand while maintaining substantial excitation.

04

Conclusions

- The Povidailo scientific school established a foundation for modern aviation vibrotechnologies.
- Vibration technologies support aircraft-component finishing, composite processing and cyclic-load testing.

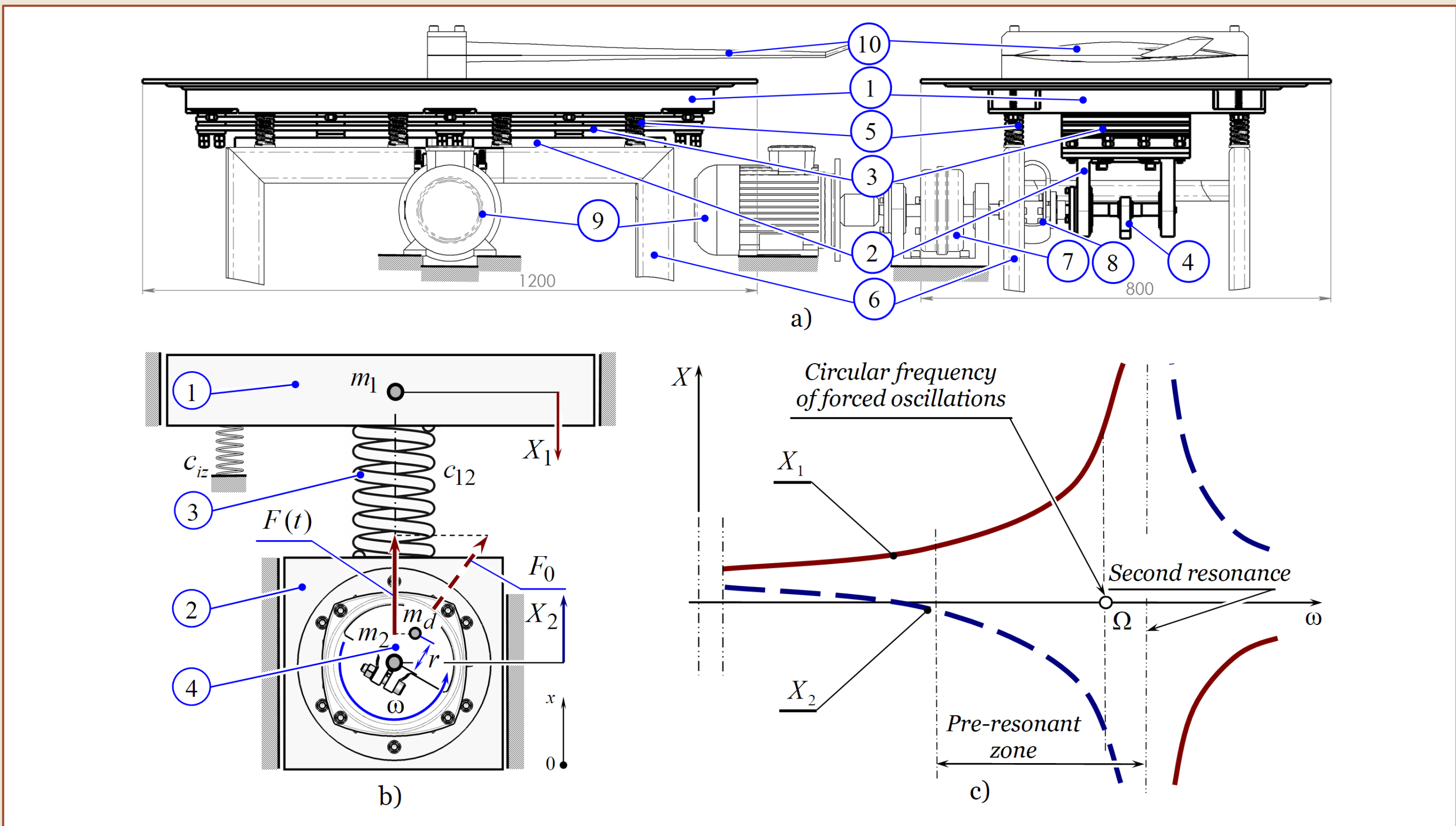


Fig 2. Projection views (a), simplified schematic diagram (b), and amplitude-frequency response (c) of the resonant vibration test stand with an unbalanced drive, where: 1, 2 – active and reactive oscillating masses; 3 – resonant elastic unit; 4 – unbalance; 5 – vibration isolators; 6 – frame; 7 – hydraulic coupling; 8 – flexible disc coupling; 9 – asynchronous electric motor; 10 – glider wing

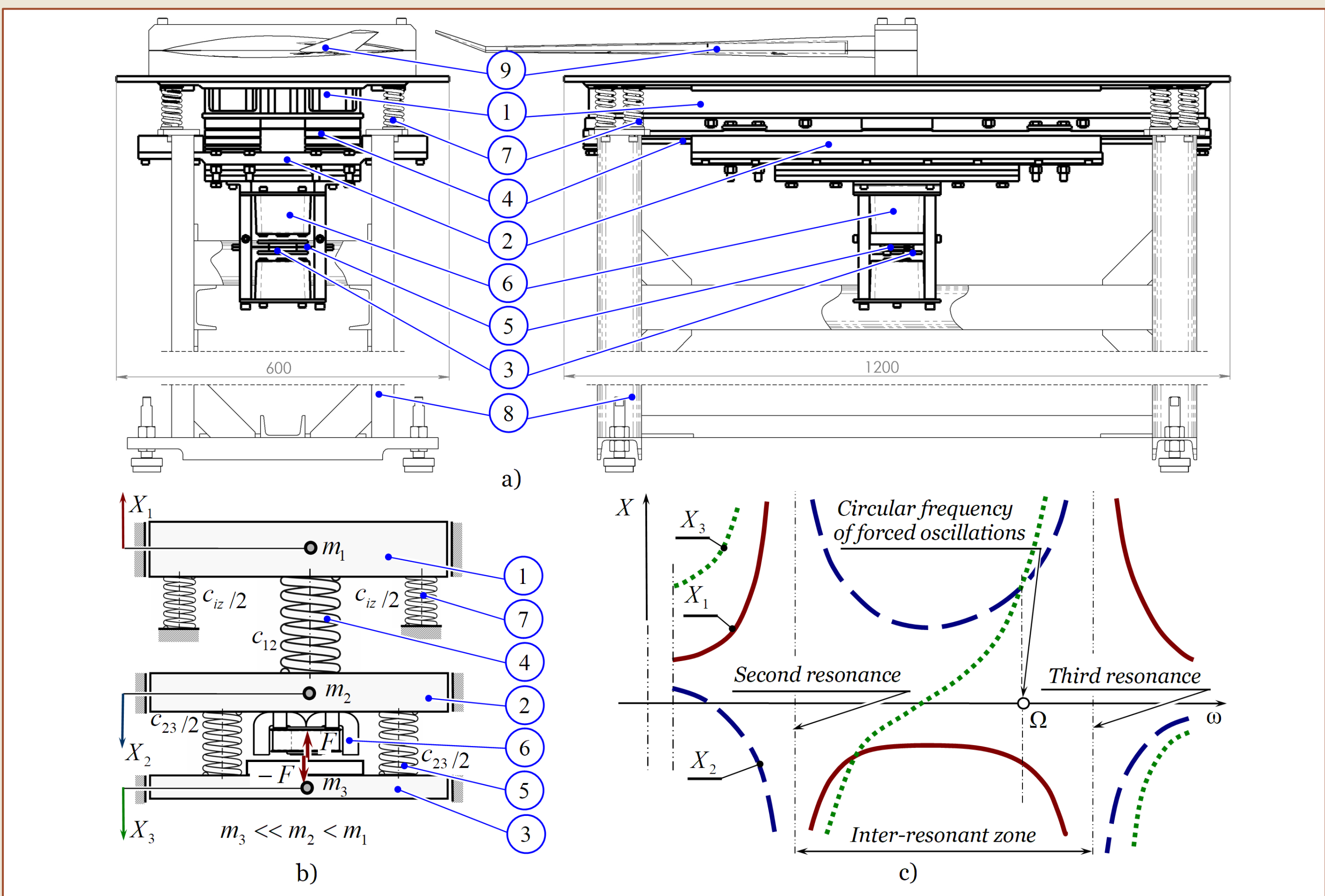


Fig 3. Projection views (a), simplified schematic diagram (b), and amplitude-frequency response (c) of the inter-resonant vibration test stand with an electromagnetic drive, where: 1, 2, and 3 – active, intermediate, and reactive oscillating masses, respectively; 4, 5 – resonant elastic units; 6 – electromagnetic vibration exciter; 7 – vibration isolators; 8 – frame; 9 – glider wing

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