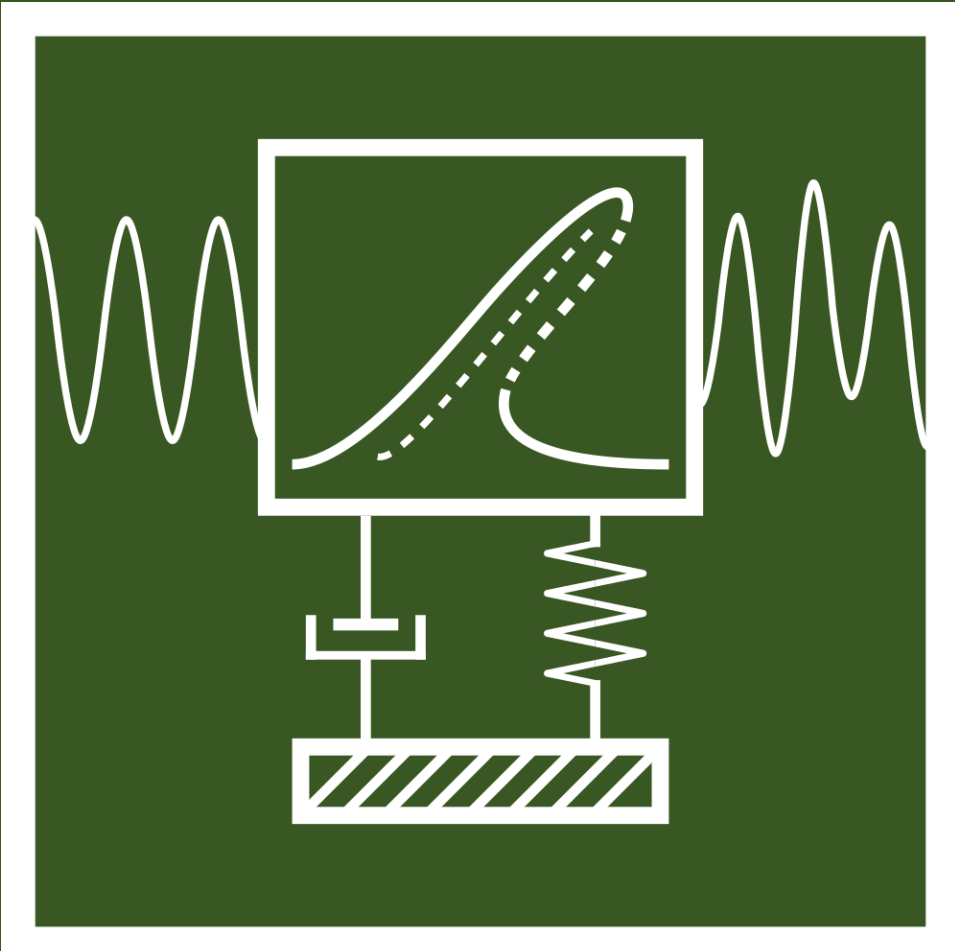


Vibrational stimulation of the bovine udder

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A Abstract

This work summarises research on mechanical stimulation of the bovine udder: a coupled rotor model [1], a pneumatic teat cup system [2], and experiments during milking [3]. It also presents the continuation of Kazimieras Ragulskis's research.

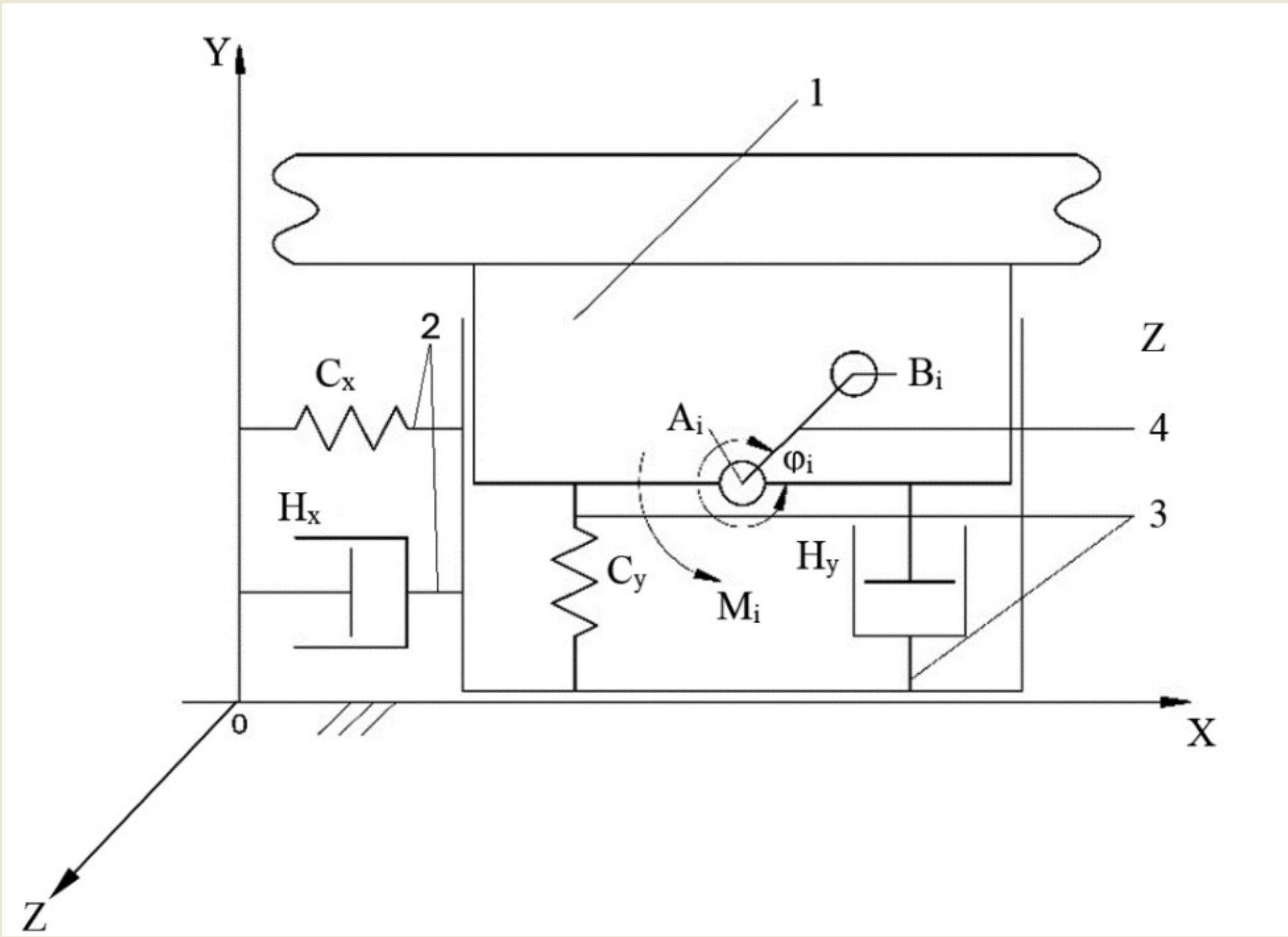
01 Methods

The model describes four unbalanced rotors coupled through an elastic support with viscous damping [1]. Electromechanical experiments used artificial udder models and in vivo measurements during milking at 15–60 Hz [3].

02 Results

Numerical investigations demonstrated self-synchronization, with steady motion after approximately 9–11 oscillation periods under the modelled conditions [1].

Patent LT 7148 B describes hollow elastic rings fitted around teat cups and driven by pulsating airflow at 10–27 Hz [2].



$$\begin{aligned} \left(m_0 + \sum_{i=1}^4 m_i\right) \ddot{x} - \sum_{i=1}^4 m_i r_i (\ddot{\phi}_i \sin \phi_i + \dot{\phi}_i^2 \cos \phi_i) + C_x \dot{x} + H_x x &= 0, \\ \left(m_0 + \sum_{i=1}^4 m_i\right) \ddot{y} + \sum_{i=1}^4 m_i r_i (\ddot{\phi}_i \cos \phi_i - \dot{\phi}_i^2 \sin \phi_i) + g \sum_{i=1}^4 m_i + C_y \dot{y} + H_y y &= 0, \\ (I_i + m_i r_i^2) \ddot{\phi}_i + m_i r_i (-\ddot{x} \sin \phi_i + \ddot{y} \cos \phi_i) - g m_i r_i \cos \phi_i &= M_i(\phi_i), \end{aligned} \quad (2)$$

Fig. 1. Dynamic model and equations of motion [1].

03 Discussion

LT 7148 B was K. Ragulskis's final Lithuanian patent [2]. He personally developed and wrote the mathematical equations published posthumously in 2026 [1]. He had presented this research direction at the Lithuanian Academy of Sciences.

04 Conclusions

Research continues with low-frequency ultrasound applied to bovine teats. A newly awarded Research Council of Lithuania project will investigate vibration motors during milking.

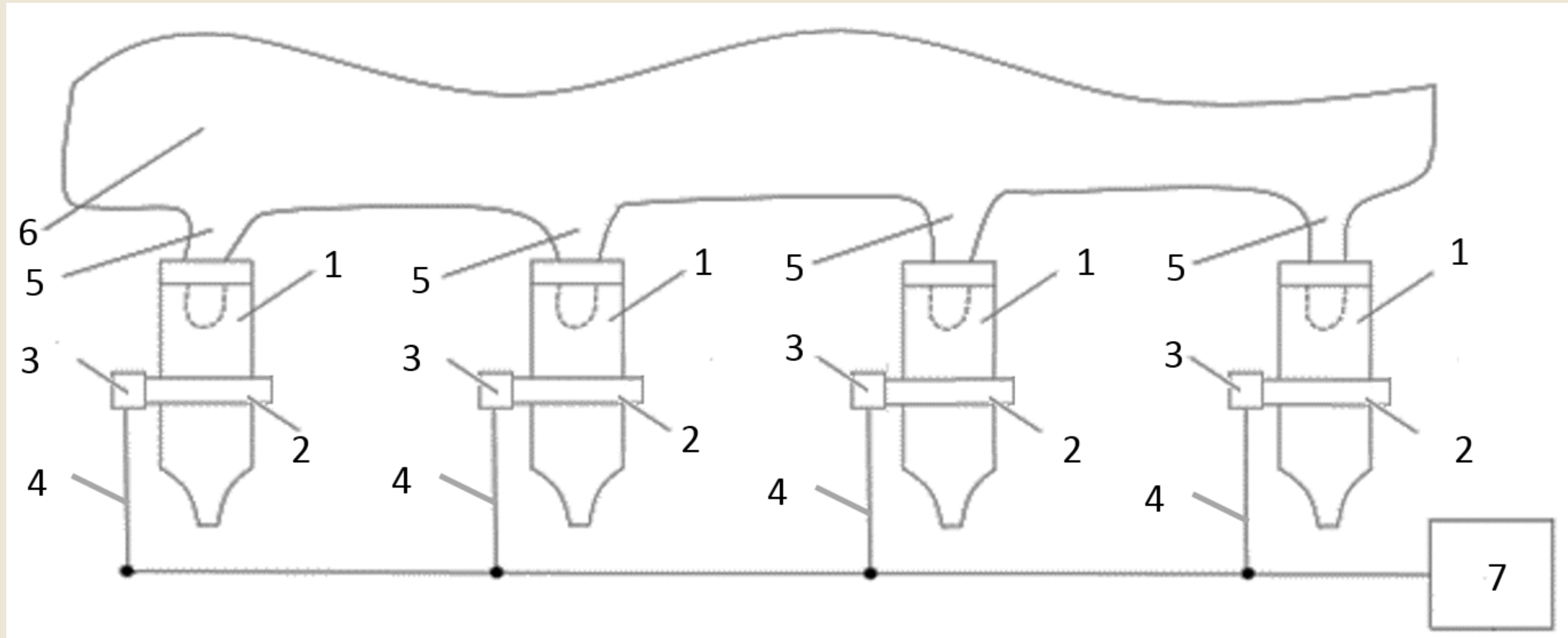


Fig. 2. Pneumatic stimulation system [2].

1 teat cups; 2 pneumatic rings; 3 air connections; 4 air tubes; 5 teats; 6 udder; 7 airflow generator.

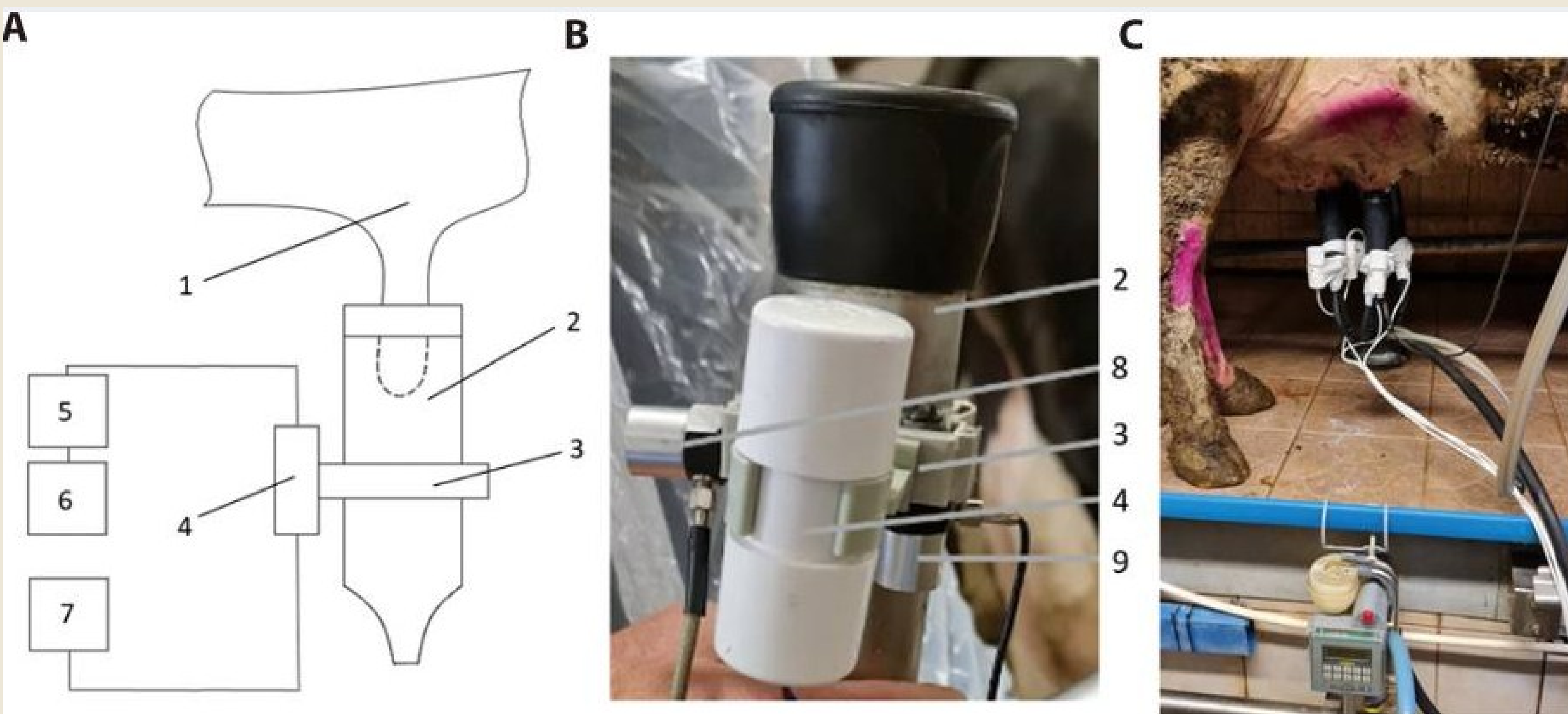


Fig. 3. Electromechanical setup and measurements during milking [3].

Acknowledgements

In memory of Academician Kazimieras Ragulskis.



References

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