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INSTRUMENT FOR DETECTING CRITICAL FREQUENCY

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Abstract: *The paper aims to present a new type of detector of critical frequencies which is able to operate like a visual or sound warning device for critical resonance frequencies.*
The device is simple and small hence, its horizontal and vertical mounting presents no difficulties. It takes over vibrations on several directions. It allows an easy adjustment over a large frequency range and can be used for frequency measuring.
The description of the device is followed by a theoretical study using a mathematical-mechanical model.
Key words: *vibrations, critical frequencies, detector*

1.INTRODUCTION

The paper aims to present the construction and operation of a new model of the critical frequency detector working as a visual and sound adapter as well as for critical resonance frequencies. A theoretical study on a mathematical model is presented, also.
Instruments designed on the basis of various principle should have been used for the measurement and recording of mechanical vibrations. The less known instruments are those with visual and sound warming of critical resonance frequencies. These frequencies are dangerous for machine-tool or aggregate operation.
The available instruments based on the mechanical dynamometer principle differ one from the other by their field measuring frequencies, sensitiveness and precision. These instruments have a more restricted domain of utilization. They take over vibrations on certain directions and the technology of execution is complex.
The instrument designed and tested in the laboratory of mechanics within the *"Transilvania"* University of Brasov is based on an entirely new principle covered by the patent [1], This instrument operates as a critical resonance frequency detector and a frequency meter as well, with a large technical applicability. It uses a mechanical-elastic system with a seismic mass. The instrument is easy to be mounted vertically or horizontally which permits, vibrations on several directions. It has been noticed that a beam fixed at one end and free at the other end, in a vibratory state with a very large range of frequency values, tends to break loose. Hence, there appears an axial gripping force which cannot be neglected. The above mentioned instrument shown in fig, 1 makes this force evident and even measures it by means of a compensating spiral, spring 3. The tests performed with this instrument confirmed a direct connection between magnitude of the axial force and the oscillation frequency of the beam.

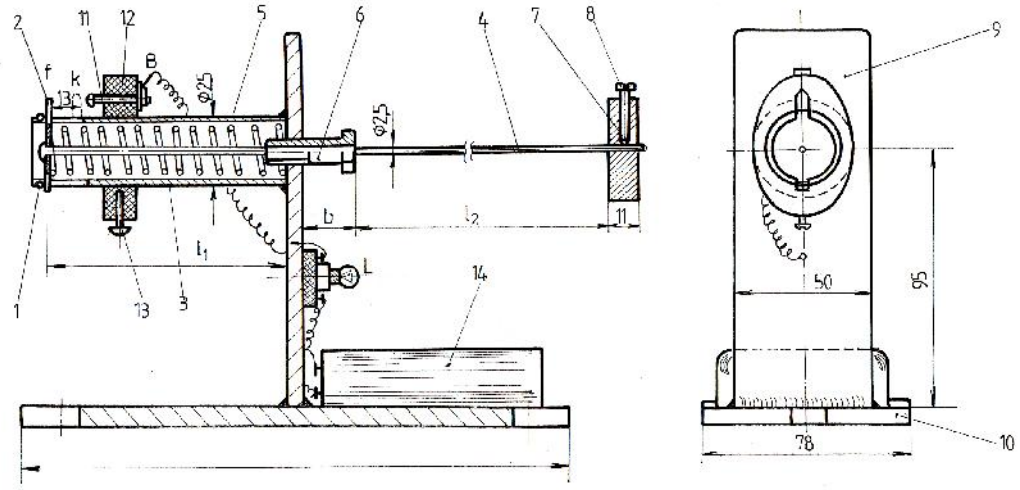

Figure 1. Detector of critical frequencies

The instrument operating as the break loose principle shown in Figure 1 is composed of a steel rod 4 with a seismic mass 7 fixed at one end by means of a screw 8. The seismic mass 7 moves on the rod 4 can be fixed in any position, thus having the possibility to change continuously the frequency of the instrument in a large value range by the change of the length l_2.
The steel rod 4 can be considered fixed by the guide screw 6 and being able to slide. A locking device 2 with the peak "f" for the indication of the displacement or the force developed in the spiral spring 3 is fixed at the opposite end of the elastic rod. The spring is introduced into a protective tube 5 fixed on the supporting plate 9. The instrument can be fixed by the basic plate 10 in any positron on the machine which critical vibration we intend to detect.
It is well-known the necessity and the importance of warning the critical frequencies in order to prevent resonance and to avoid material losses. A visual and sound warning electric circuit easily attached to this instrument can detect the critical frequency. Also, the disturbing force can be automatically controlled by using a microprocessor or a switching relay attached to the instrument. During the vibrations of the elastic system, the periodical disturbing force causes the displacement to the right of the indicating point "f" of the locking device 2. The compression of the spring 3 closes the contact K of the advertising electric circuit (fig.1). The electric circuit remains closed when the critical frequency has been reached and is maintained.
If the frequency decreases, then the locking device is returned to the initial position by the spiral spring 3, the connection K is opened and the bulb "L" is switched off.
Advantages such like small mass and size, sensitiveness and possibility of automatic control of critical frequency make possible the application of this instrument in many domains.

2. MATHEMATICAL AND MECHANICAL MODEL

In the figure 2 presents the mathematical and mechanical model of this instrument. We will determine the proper frequency of the elastic system by means of the transfer matrixes, using the Myklestad - Prohl method.

$$\begin{bmatrix} \overline{y} \\ \overline{\gamma} \\ \overline{M} \\ \overline{T} \end{bmatrix}_2^D = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \mu & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & -3.18 & 0 & 0.17 \\ 0 & -7.76 & 0 & 0.28 \\ 0 & -6.75 & 0 & 0.75 \\ 0 & -6 & 0 & 1 \end{bmatrix} \begin{bmatrix} \overline{y_0} \\ \overline{\varphi_0} \\ \overline{M_0} \\ \overline{T_0} \end{bmatrix} \tag{1}$$

Putting the limit condition to the right end: $\overline{M}_2^D = \overline{T}_2^D = 0$

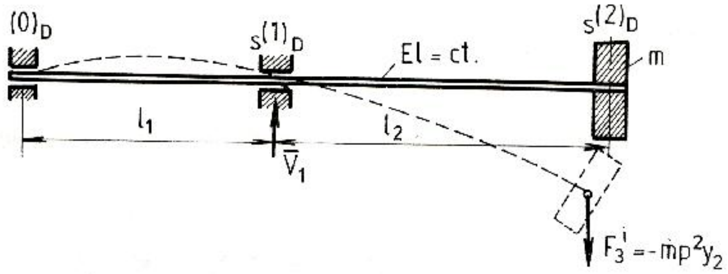

Figure 2. Mechanical model

results the pulsation equation:

$$\Delta = \begin{bmatrix} -6.75 & 0.75 \\ (-3.18\mu - 6) & (0 - 07\mu + 1) \end{bmatrix} = 0$$

or □□□□□□□□□

(2)

hence the natural pulsation is:

$$p = \sqrt{\frac{\mu EI}{ml_2}} = \sqrt{\frac{1.176 \cdot 4.21.10^{-1}}{0.1 \cdot 0.12^3}} = 53{,}52\left[\frac{rad}{s}\right] \tag{3}$$

It results the natural frequency:

$$\nu = \frac{p}{2\pi} = 8.51\text{Hz}$$

The experimental data obtained by this critical frequency detector confirms the theoretical results with a deviation of about 8%. The natural resonance frequency of approximatively 9Hz has been detected by turning on the bulb at a displacement of

12mm of the indicating point "f". The force developed in the spring corresponding to this displacement of 12 mm is 7N.

3. THE CARACTERISTICS OF INSTRUMENT

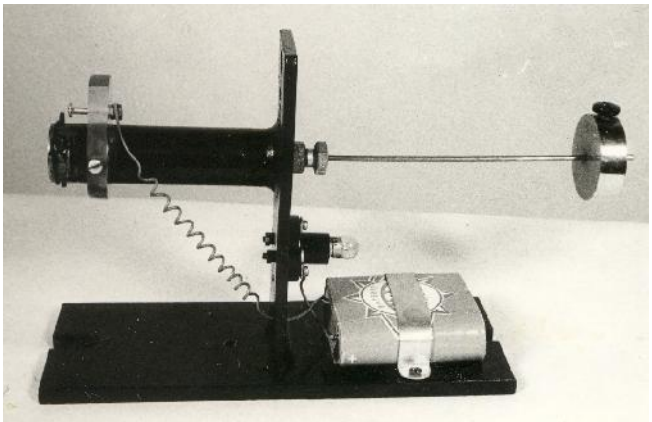

Figure 3. The instrument tested in the laboratory

- Size ……………………………………….. 80 x 120 x 240 mm
- Useful mass …………………………….............. 1.2 Kg
- Batteiy feeding source ………………………… 4.5 V
- Seismic mass, m ………………………………….. 0.1 Kg
- Spring constant (3) …………………………. 538 N/m
- Elastic rod diameter (4), d …………………… 2.5 mm
- Natural resonance frequency ………………………… Adjustable
- Mounted spring length, l_1 …………………………….. 90 mm
- Free length l_2 at $f_n = 9$ Hz ………………………….. 120 mm
- Rod rigidity, EI ………………………………….. 0.421 N - m^2

(E-tension-compression modulus of elasticity; I-moment of inertia of area)

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