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NOISE AND VIBRATION OF A RECIPROCATING AIR COMPRESSOR

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ABSTRACT

Noise occurs as a result of mechanical systems motion during normal operation and may be associated with its various moving parts. In this work, vibration as well as noise measurements are carried out on two case studies; a simple beam structure and an air compressor. The comparison of vibration and noise spectra has been very useful in identifying dominant noise sources. This represents the first step in selecting an economic method for noise control. In the case of the compressor, the addition of rubber pads under its base has greatly reduced both the overall noise level and its fluctuations with time.

INTRODUCTION

Requirements for higher productivity have led to the design of high-speed machines with lighter moving components. Consequently, the problems of vibration, noise, stability and wear have increased.

The main problem of noise in the working environment is the risk of employee hearing impairment as a result of prolonged exposure to excessive noise levels. In addition, the efficiency and productivity of workers are greatly reduced due to fatigue and loss of concentration. Therefore, a great effort has been devoted in the last decade to enhance the techniques of noise control in order to protect peoples and environment [1-3].

Sound radiation from a machine may be caused by two essential sources : aerodynamic sources due to instabilities in the air introduced by the motion of the system, and vibro-acoustic sources caused by the vibrations of the members themselfs. Examples of sound radiating sources are vibrating surfaces, mechanical impact, pulsating gas flows, compression &rarefaction of the surrounding medium and flow of air around obstructions.

The problem of sound radiation by machines has been investigated in earlier works. For example, Koss and Moffatt [4] , has studied the variation of radiation ratio, mode shapes and dampings of a punch press as a function of frequency. Ochiai and Nakano [5] studied the relation between crankshaft torsional vibration and diesel engine noise. From the results of the advanced cases, it can be recognized that noise in machines is highly related

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The beam was then excited by a broad-band random force (20 to 20000 Hz) to simulate the actual behaviour of a machine in operation, where most of the resonance may be excited at the same time. The acceleration and noise signals were recorded simultaneously and then analyzed in the frequency domain. A review on acoustic noise measurement and analysis is given in Reference [6] .

Case Study B; Compressor Experiment

Heavy duty compressors are obvious sources of high noise levels in factories and on construction sites, where they supply compressed air to central systems and/or pneumatic tools. Therefore, a laboratory test rig consisting of a reciprocating compressor driven by an electric motor is used to demonstrate the problem of noise control. A photography of the system is given in Fig. 4. A belt- drive is used to transmit the motion from the motor to the compressor. The motor speed is 2600 rpm, while that of the compressor is 570 rpm.

The vibration of the system was measured using an accelerometer (B & K type) located at different positions of the test rig : compressor casing, motor, stand and floor. The sound pressure level was measured using a ½" diameter condenser microphone (B & K type). All the measurements were tape recorded and then frequency analyzed using 1/3-octave band pass filter.

RESULTS AND DISCUSSION

A- Beam Experiment :
The comparison of sound pressure levels radiated at different resonances of the beam (Fig.3) indicates that the most significant modes are those at 630 and 870 Hz. The sound levels corresponding to frequencies less than 200 Hz and greater than 5000 Hz are very low.

The comparison of vibration and noise spectra of the beam excited by a broad-band random force (Fig.5) indicates a strong coincidence between major spectral peaks. The higher peaks occur at 630 and 870 Hz, which was already shown in the previous test. Certain peaks of noise spectrum which are missing in vibration spectrum obtained by the accelerometer at position (1) may be detected when the accelerometer position is changed to position 2 (Fig.1. and Fig. 5).

This means that it may be very useful in vibration testing to use both sound and acceleration signals.

the control of noise in such case may be accomplished by different approaches : stiffness, mass and damping control. Structural stiffening involves the addition of gussets, ribs, etc to a structure in order to raise its natural frequencies above the range of the excitation frequencies. The addition of mass may be also applied to shift the resonance frequencies away from the resonance point. Vibration damping is an absorption technique in which vibrational energy is transformed into heat. The most common method is to apply a layer of a visco-elastic material to the surface of a vibrating part to reduce the amplitude of vibration at resonance.

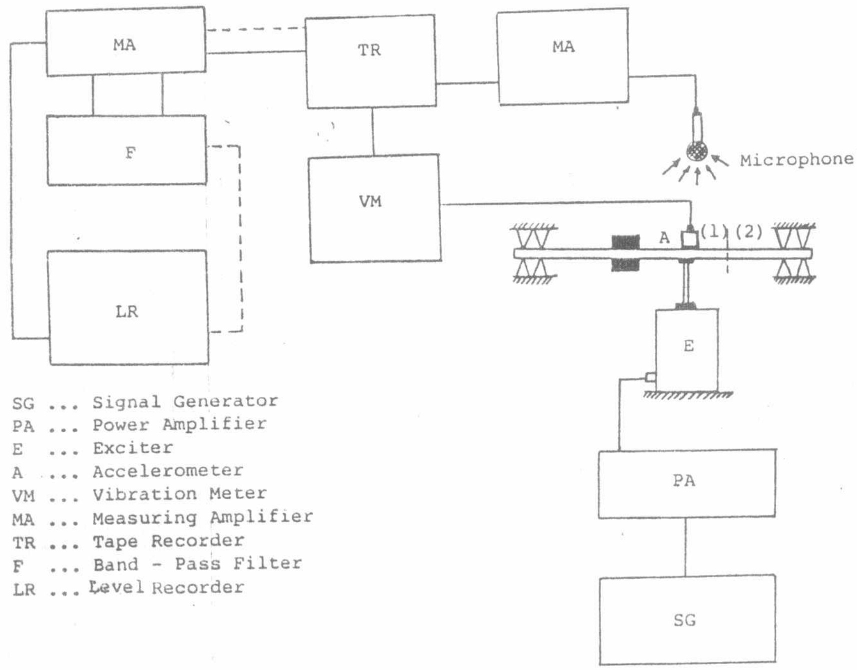


Fig.1. Scheme of Measuring Devices, Beam Experiment.

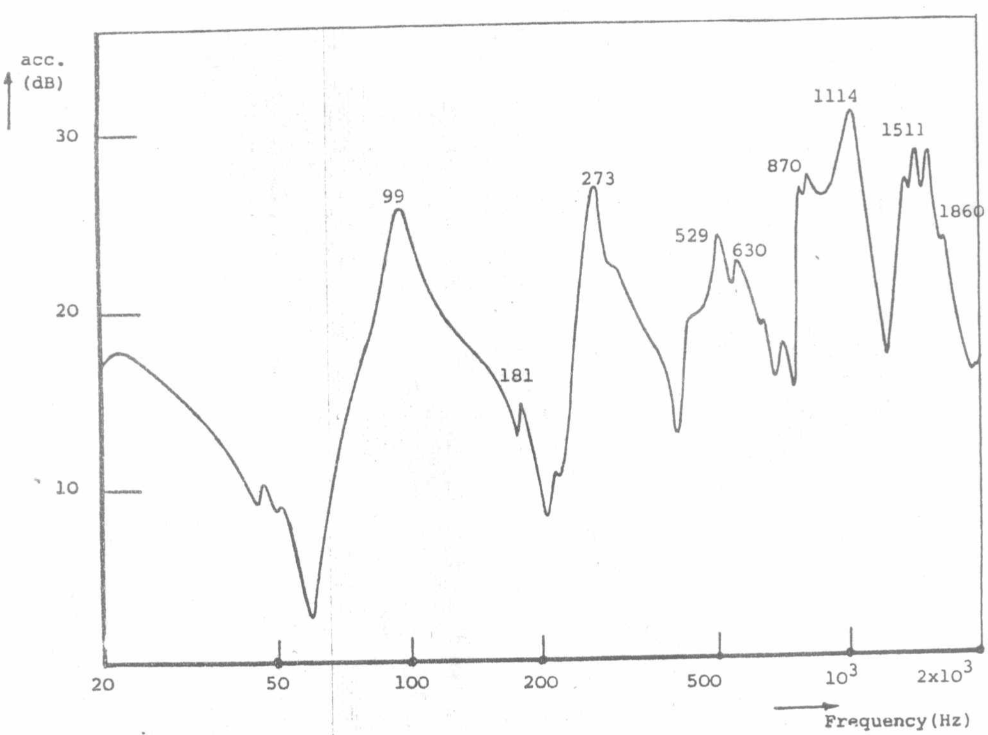


Fig.2. Frequency Response (Harmonic Excitation).

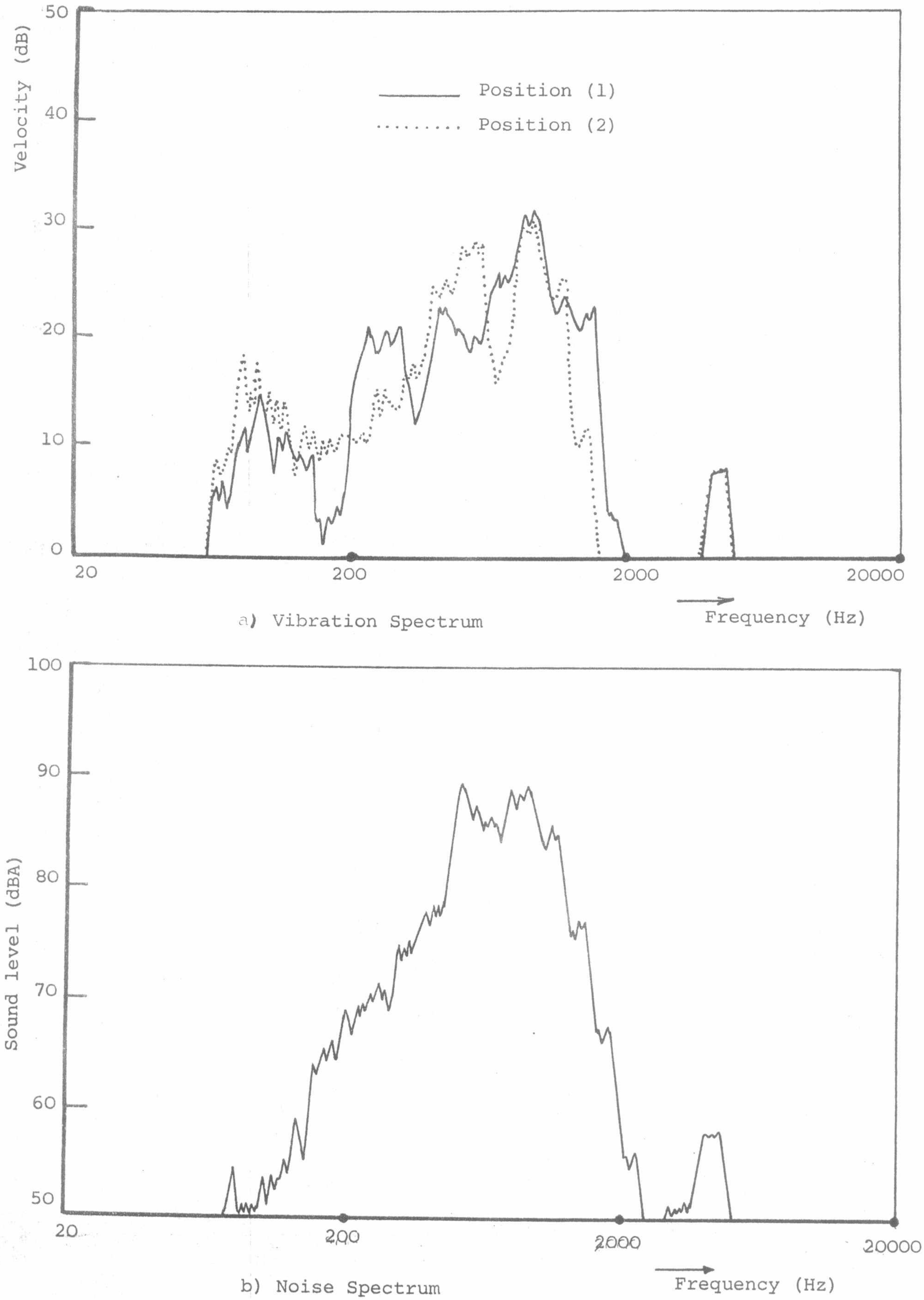
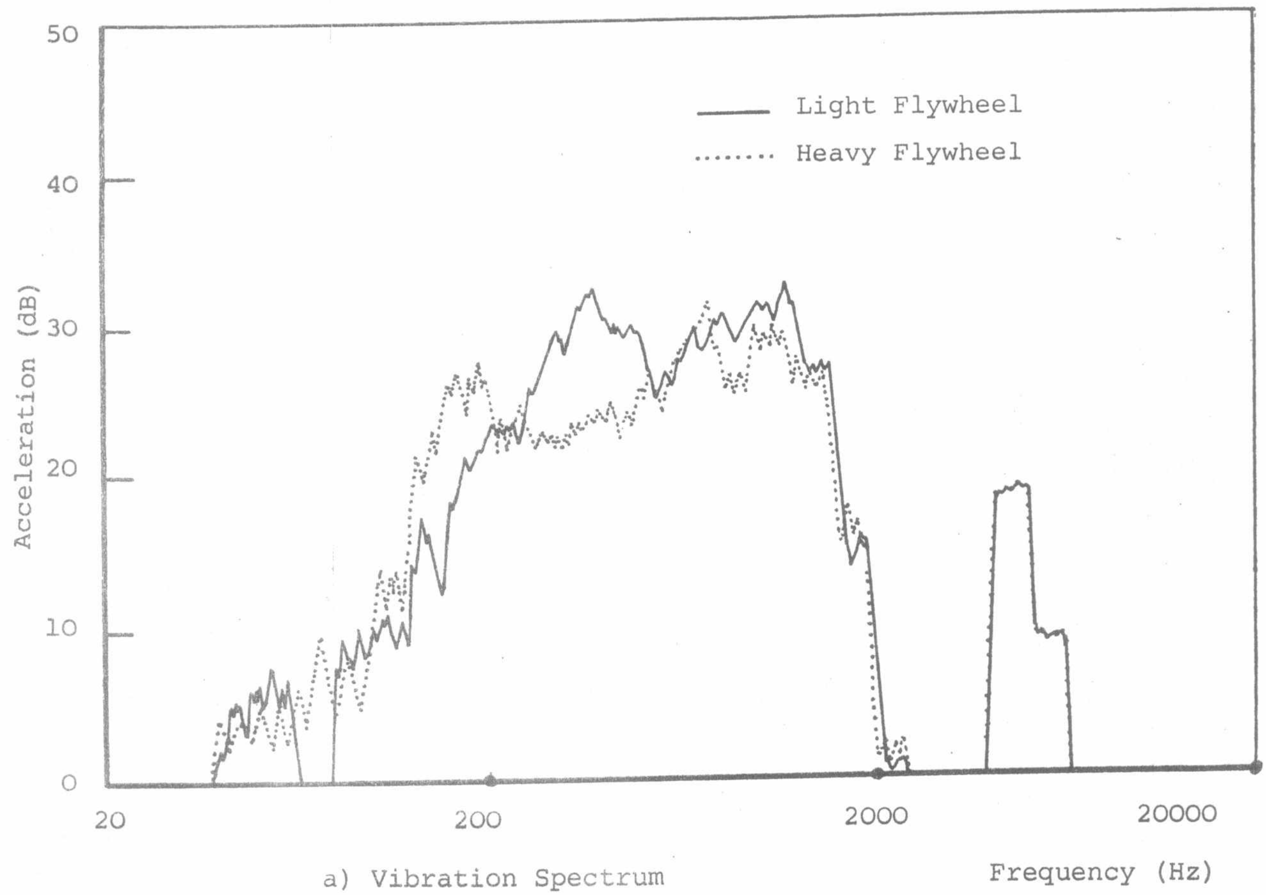
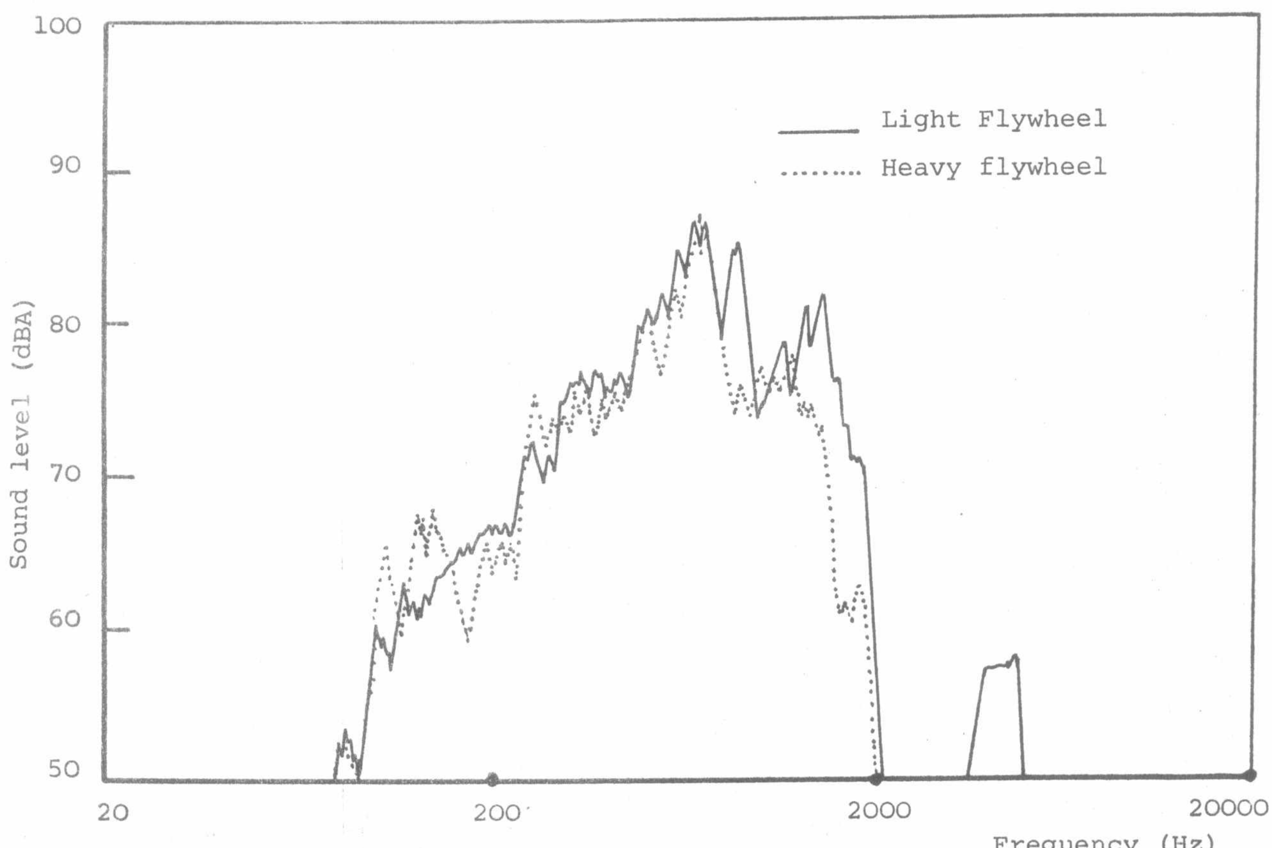


Fig.5. Noise and Vibration Spectra of the Beam.



a) Vibration Spectrum



b) Noise Spectrum

Fig. 8. Effect of Flywheel Size on Noise and Vibration spectra (Compressor).

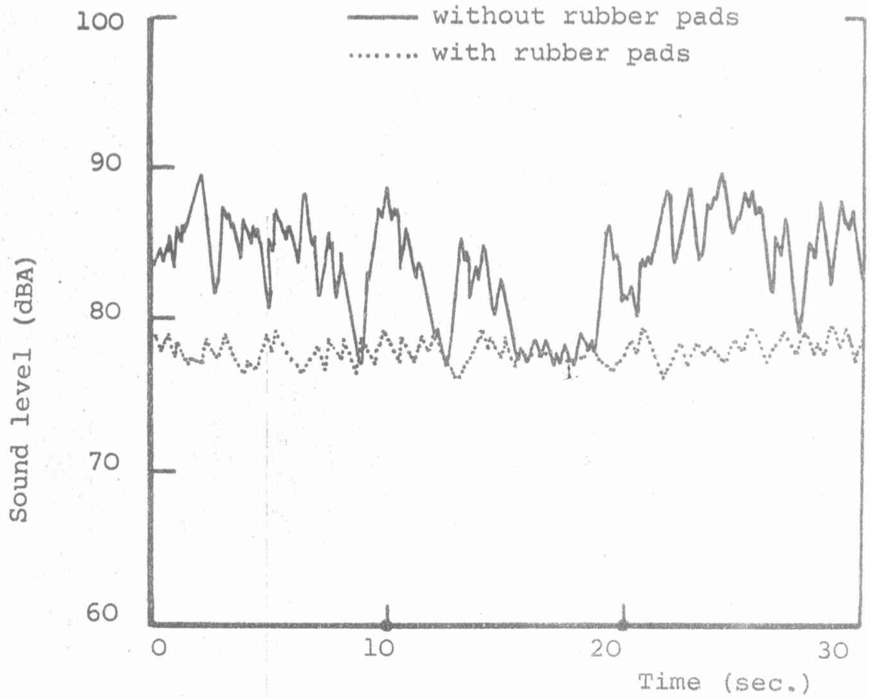


Fig.11. Fluctuations of overall Sound level with time.
(Compressor).

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