

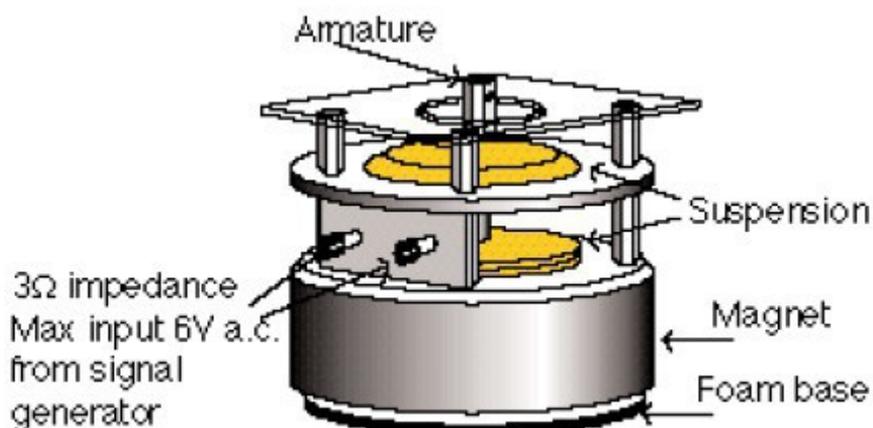
Vibration Generator

Purpose:

The Vibration Generator is a robust source of low frequency, large amplitude, and mechanical oscillations. It has a 3Ω coil supported by triple suspension in a powerful magnetic field and the driving piston has considerable sideways rigidity. Radial loads of up to 200g are allowable.

It must be used with a signal generator capable of driving a low resistance load.

Description:



Safety advice:

Max input 6V/1A. Dimensions: 100 x 100 x 120mm.

Safety time delay 2A fuse built into the unit designed to prevent overloading of the unit.

Instructions for use:

Connection to the power signal generator (G85793) is through standard 4mm plug cables, with one cable from the yellow low impedance socket and one from the black socket (to the right) next to it, these cable plug into the front of the vibration generator, either configuration will result in operation of the generator. To drive the generator, the frequency, amplitude and waveform can be chosen and altered as desired depending upon the vibration you wish to generate. The vibration generator performs best over the frequency range of 1Hz - 10kHz, which can be adjusted as desired by altering the frequency range dial.

Vibration Generator Accessory Kit

Purpose:

The Vibration Generator accessory kit is intended to be used with the vibration generator (H30701) in order to demonstrate kinetic theory, standing waves and resonances. Please refer to NFU 653 for instructions on correct operation of the vibration generator.

Contents:

Coil Spring
Thick Rubber cord
Thin Rubber cord
Tapered Rubber strip
Chladni plate
Piano wire loop
Steel strips
Transparent tube
20 coloured plastic balls

NOTE: Signal Generator Not Supplied

Safety advice:

Max input 6V/1A. Dimensions: 100 x 100 x 120mm.

Safety time delay 2A fuse built into the unit designed to prevent overloading of the unit.

Kinetic Theory Demonstration:

Screw the black disc to the armature and place the perspex tube over it (Figure 1). Set the frequency to about 50Hz, insert 10 orange balls, and raise the output to about 1V. The motion represents molecules in a liquid, gradually changing places, but never becoming very far apart. Raise the output voltage to increase the average kinetic energy (temperature) of the "molecules". Evaporation is represented when a "molecule" acquires enough energy to escape, momentarily, from its neighbours.

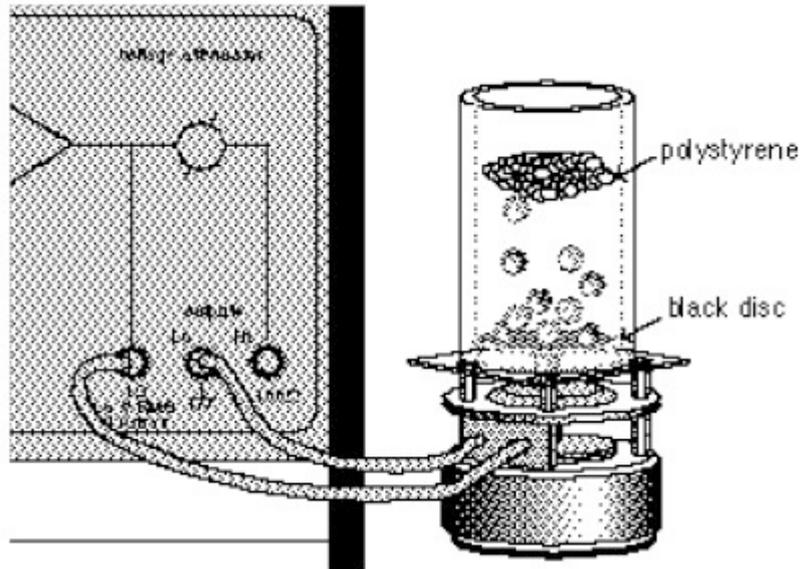


Figure 1: Kinetic theory demonstration.

When the output voltage is at maximum, the average separation between "molecules" may be more than 10 diameters, thus representing a gas. At this stage, a piece of expanded polystyrene packing material, cut to a rough 5cm circle, may be dropped in. This shows how the "molecules" are able to exert an upward force, by repeated random collision (gas pressure). Diffusion may be illustrated by dropping one blue "molecule" into 10 orange "molecules" which are vibrating slightly (say 1.5 V at 50Hz). This could also represent the behaviour of a conduction electron in a metal when it is **not** carrying a current.

Longitudinal standing waves:

Hook the lower end of the large coil spring to the armature and its upper end to a fixed point about 1 metre above. Wait for transients to die down, then **slowly** raise voltage at about 15Hz. By carefully varying the frequency a longitudinal standing wave will be produced. Now, by turning the vibrator on to its side, transverse standing waves may be set up in the same spring. It is apparent that the speed of transverse waves is not the same as the speed of longitudinal waves. In Nuffield 'A' level Physics, the need to illustrate standing waves of **non-constant wavelength** is explained. The next two accessories help demonstrate these effects. These accessories are also sometimes demonstrated at GCSE level when considering wave properties in more detail.

Transverse waves

Attach the thin rubber cord to the armature of the vibration generator. Attach the free end to a heavy retort stand, keeping the cord roughly horizontal and lightly tensioned.

Apply a signal at about 1Hz initially, and SLOWLY increase the frequency until a standing wave is observed. Small changes in frequency will make the standing wave disappear.

Several different standing waves can be created. For each one, measure the wavelength and note the frequency of the signal generator. It is quite easy to test the relationship

$c = f\lambda$ in this way, showing that doubling the frequency halves the wavelength.

Multiply f , the frequency, by λ , the wavelength in metres, for any standing wave to get the speed of propagation of these waves, c , in metres per second, for the rubber cord.

Waves at a boundary:

Knot together the thick and thin rubber cords. Secure the thin one about 50cm from the knot to the vibrator and hold the thick one about 50cm from the knot. Using a frequency of about 15Hz and light tension, two sets of standing waves may be obtained. Those in the thicker cord have half the speed (and therefore half the wavelength) of those in the thinner cord.

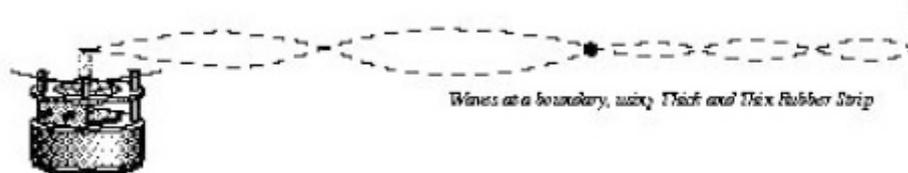


Figure 2: Waves at a boundary.

Tapered rubber strip:

Hook the narrow end over the vibrator, and clamp the broad end to a bench top. Apply about 60Hz at full voltage, and adjust the tension by moving and rotating the vibrator slightly until about 5 nodes can be seen. Note the variation of wavelength with width.

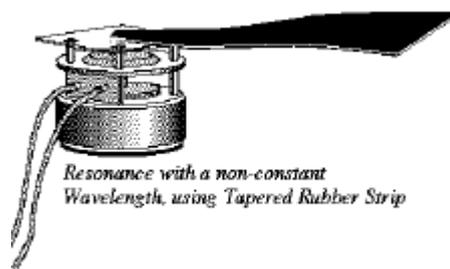


Figure 3: Tapered rubber strip.

Resonance of metal strips:

Screw all 3 strips, to the armature, spaced by about 60° . Apply full voltage and observe harp fundamental resonances at about 11, 15, 21, 36 and 50 Hz, as the frequency is slowly increased. Very interesting harmonics may be seen at frequencies up to about 300Hz, and heard up to about 900Hz.

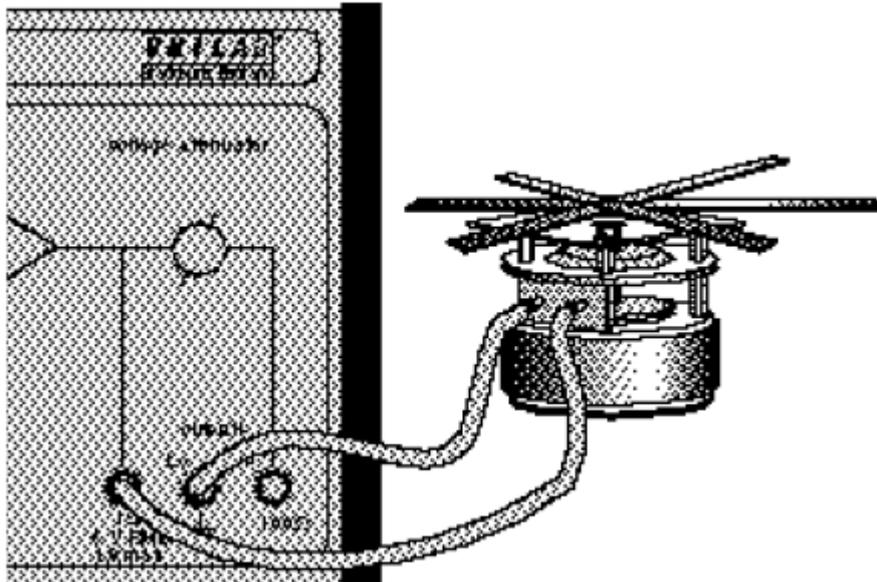


Figure 4: Metal strip resonance.

Chladni plate resonances:

Screw the stiff rectangular plastic plate to the armature and place the vibration generator in a tray on a level surface. The tray is to catch powder which falls off the Chladni plate during the experiments.

Sprinkle lightly with any dark, freely running powder, e.g. sand. With the output set to about 3 volts, increase the frequency slowly through the 100 to 1000Hz range. At several frequencies the plate can be heard to resonate, whereupon powder will move until it reaches nodal lines.

The signal voltage may be raised to increase the effect. After a few seconds at any resonant frequency, turn the signal down to zero, to observe the position of the nodal lines. An example is shown below (Figure 5).

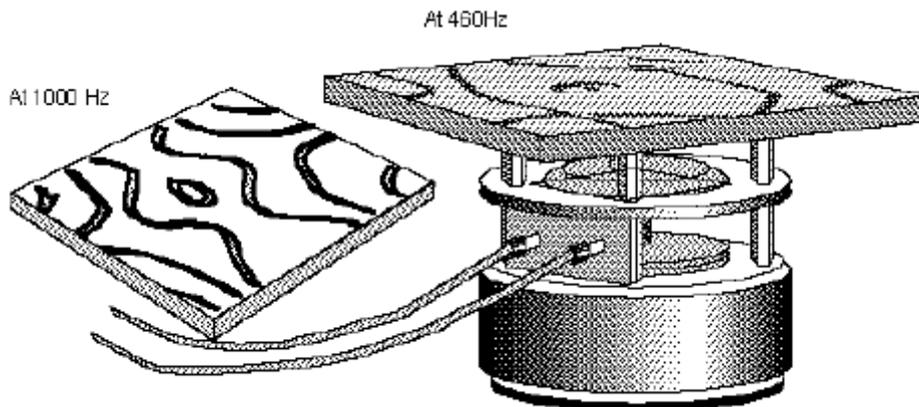


Figure 5: Chladni plate resonances.

The Chladni patterns could be captured using a digital still or video camera, for the purpose of recording a student's investigations.

Other shapes of plate could be tried, to model resonances in a guitar, or door panel of a car for instance.

Resonance of a wire loop:

Insert both ends of the strip of wire into the transverse hole at the top of the vibration generator spindle, from opposite sides, and tighten the screw. Operate the vibration generator at different frequencies 5 - 300Hz as well as varying the amplitude for best effect.

At high frequencies you can feel the vibration by moving a finger lightly around the loop. In this way, it is possible to detect nodes and antinodes which are otherwise invisible.

N.B. During this experiment, the wire may snap due to the mechanical forces acting on it. A safety screen or safety goggles should be used to protect students and teachers!

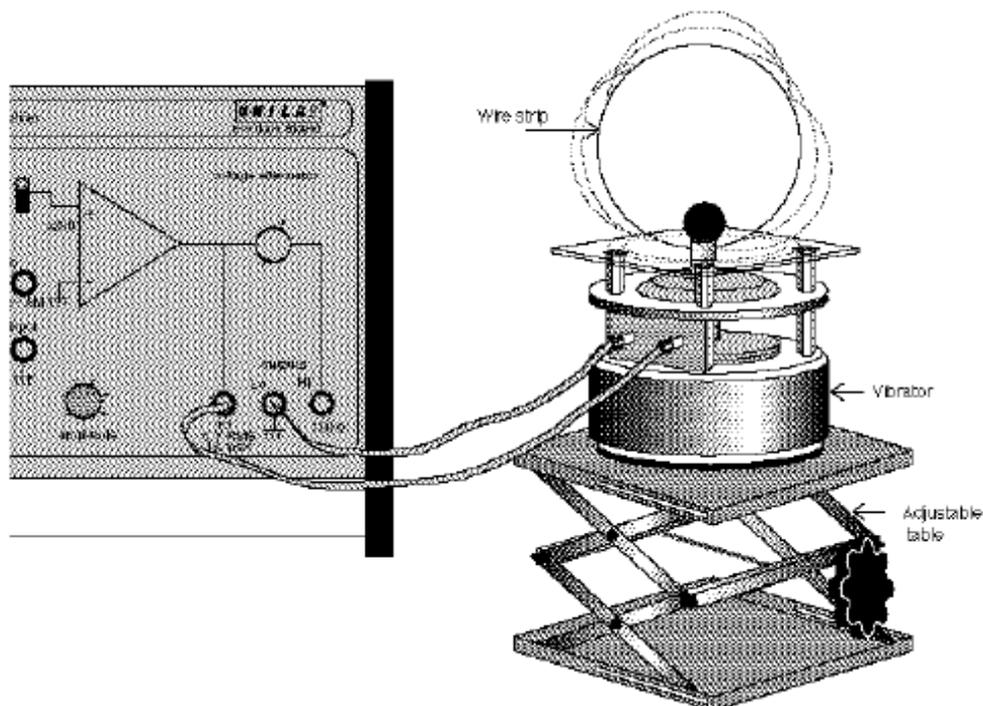


Figure 6: Resonance of piano wire.