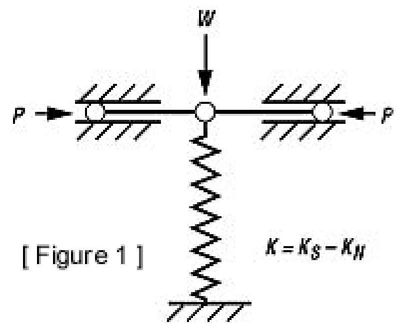
How it Works

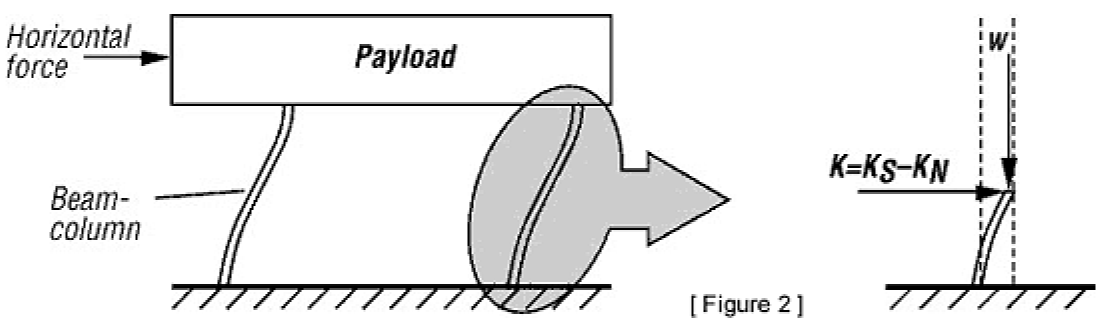
Nano-K® vibration isolators employ a revolutionary concept in low-frequency vibration isolation. Vertical-motion isolation is provided by a stiff spring that supports a weight load, combined with a negative-stiffness mechanism (NSM). The net vertical stiffness is made very low without affecting the static load-supporting capability of the spring. Beam-columns connected in series with the vertical-motion isolator provide horizontal-motion isolation. The horizontal stiffness of the beam-columns is reduced by the "beam-column" effect. (A beam-column behaves as a spring combined with an NSM.) The result is a compact passive isolator capable of very low vertical and horizontal natural frequencies and very high internal structural frequencies.

Nano-K® isolators typically use three isolators stacked in series: a tilt-motion isolator on top of a horizontal-motion isolator on top of a vertical-motion isolator. A vertical-motion isolator is shown in **Figure 1**. It uses a conventional spring connected to an NSM consisting of two bars hinged at the center, supported at their outer ends on pivots, and loaded in compression by forces P. The spring is compressed by weight W to the operating position of the isolator, as shown in Figure 1. The stiffness of the isolator is $K=K_S-K_N$ where K_S is the spring stiffness and K_N is the magnitude of a negative stiffness which is a function of the length of the bars and the load P. The isolator stiffness can be made to approach zero while the spring supports the weight W.



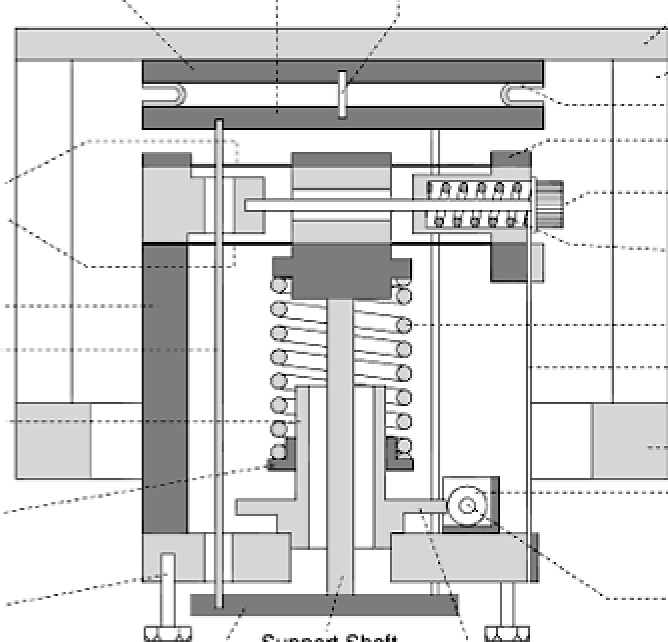
[Figure 1]

A horizontal-motion isolation system consisting of two beam-column isolators is shown in **Figure 2**. Each isolator behaves like two fixed-free beam columns loaded axially by a weight load W. Without the weight load the beam-columns have horizontal stiffness K_S. With the weight load the lateral bending stiffness is reduced by the "beam-column" effect. This behavior is equivalent to a horizontal spring combined with an NSM so that the horizontal stiffness is $K=K_S-K_N$, and K_N is the magnitude of the beam-column effect. Horizontal stiffness can be made to approach zero by loading the beam-columns to approach their critical buckling load.



[Figure 2]

Figure 3 shows a schematic of a Series SP-1 vibration isolation platform consisting of a weighted platform supported by a Series SM-1 vibration isolator incorporating the isolators of Figures 1 and 2. Flexures are used in place of the hinged bars shown in Figure 1. A tilt flexure serves as the tilt-motion isolator. A vertical stiffness adjustment screw is used to adjust the compression force on the negative-stiffness flexures thereby changing the vertical stiffness. A vertical load adjustment screw is used to adjust for varying weight loads by raising or lowering the base of the support spring to keep the flexures in their straight, unbent operating position. This feature is automated in single-isolator systems and to achieve automatic leveling in multiple-isolator systems.


Isolator
Mounting Plate
Upper
Column Plate
Tilt
Flexure
Platform
Tube
Tilt Damper
Clamp
Vertical
Negative-Stiffnes
Flexures
Vertical Stiffness
Adjustment Screw
Compression Spring
Rigid Support
Beam-Column
Support Spring
Flexible Support
Support Tube
(Threaded)
Weight
Worm
Movable
Spring Support
Vertical Load
Adjustment Screw
Leveling Screw
Lower
Column Plate
Support Shaft
Gear
[Figure 3]