ACTIVE CONTROL MICROTREMOR ISOLATION SYSTEMS

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Recently, problems caused by microvibrations are increasing in advanced science and high technology industries. Therefore, the alignment of high precision equipment and the isolation of microvibrations are becoming important subjects in various areas.

To meet these demands, we at Takenaka Corporation have developed an epoch-making vibration system called TACMI (Takenaka Active Control Microtremor Isolation system), which is entirely different from conventional vibration isolation systems. TACMI is an ACTIVE vibration control system which can eliminate microtremors in a wide frequency range. Photos 1 and 2 are of the layout of the TACMI System.

Outline of the TACMI System:

The TACMI System consists of:

1. A highly efficient passive vibration isolation table supported by soft air springs,
2. highly sensitive vibration sensors which sense microvibrations of the table,
3. a digital servo-module which computes the optimal control force, and
4. actuators which effectively transmit the computed control force to the table.

The passive vibration isolation table of TACMI itself can compete with conventional vibration isolation tables on the market since its natural frequency is as low as 1 - 3 Hz. We further added to the table active vibration control equipment to bring about a highly efficient vibration isolation effect from low vibrations in the area. of a few seconds to some tens of Hz.

The highly sensitive and wide dynamic range vibration sensor and the digital servo-module compute the optimal control force in a mili.sec. and operate the actuator immediately.

We have developed two types of systems using different actuators in consideration of the environment where the actuators could be installed, and each has the following features:

1. TACMI-1 uses linear motors and is designed to control a high frequency area.
2. TACMI-2 uses air actuators which have high driving power and is designed to have a large loading capacity, i.e. large and heavy machinery and tools.

TACMI System has a vibration control ability of six degrees of freedom (the x, y, z axes and their rotations as shown in Figure 2) and it can create a static position as if the table were floating.

With conventional passive vibration isolation systems, which use vibration transfer characteristics, you cannot expect the vibration isolation effect except for the area where the vibration range is higher than the natural frequency. (See Figure 3).

To enlarge the vibration isolation range, it is necessary to lower the natural frequency. However, there is a limit to this, because by lowering the natural frequency, the vibration isolation system itself may become unstable.

The passive vibration isolation system is effective in eliminating disturbances from the floor, but when a force works on the table directly, the force will cause a large vibration. For example, when you touch the table carelessly and add an impulsive force to the table, it will create free vibrations and the table will vibrate for a long period of time and it will lead to trouble.

TACMI, however, exerts control force against direct disturbances and makes the table return to the static state in a very short period of time (within 0.1 sec.). (Figure 4).

When disturbances are random vibrations in a wide frequency range, TACMI works to eliminate the vibrational amplification and it can lessen the microtremor to a further extent (from a few seconds to several tens of Hz.), while conventional passive vibration systems cannot avoid the vibrational amplification in the area of the natural frequency.

Ultimately, TACMI can lower the microtremor (about 1 gal., 1 μm) in a relatively good vibrational environment to lower than 1/10. (Figure 5).

Figure 6 shows an example of the transfer function on the table affected by floor vibration. You can see how free of vibration the table is.

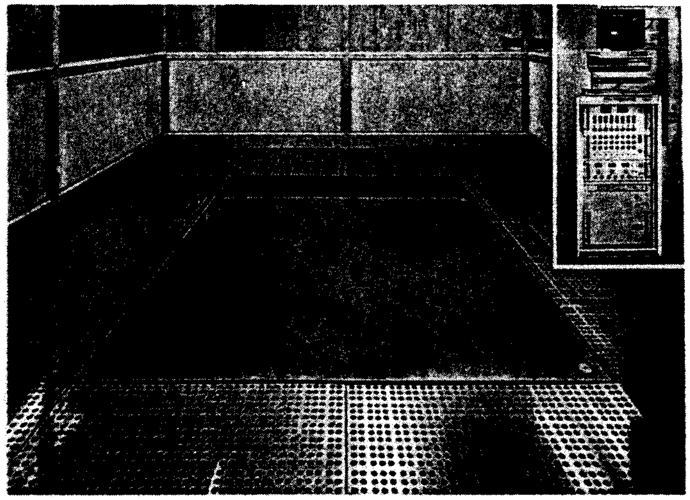
Moreover, since TACMI is structured so as to not have a friction portion in the system, it can also meet the demands of the “clean environment” standard.

Either TACMI-1 or TACMI-2 can take about 1 ton of loading and therefore either system is good for practical use.

With regards to shape and loading capacity, we can satisfy various demands.

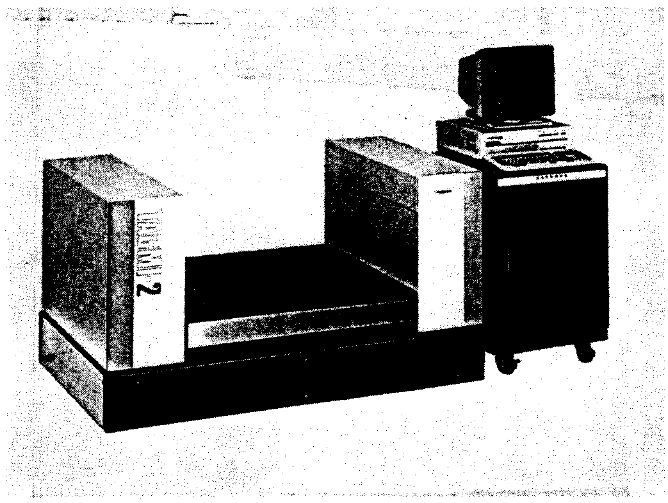
We have developed this system bearing in mind its application to future semi-conductor industries, but we believe that it can be applied to accelerator alignment and other scientific areas also.

We are going to apply this system to the linear accelerator at KEK.



TACMI 1(リニアモーター利用) Incorporating Linear Motor

PHOTO-1 TACMI-1:LINEAR MOTOR ACTUATOR TYPE



TACMI-2 (エアアクチュエータ利用) Incorporating Air Actuator

PHOTO-2 TACMI-2:AIR ACTUATOR TYPE

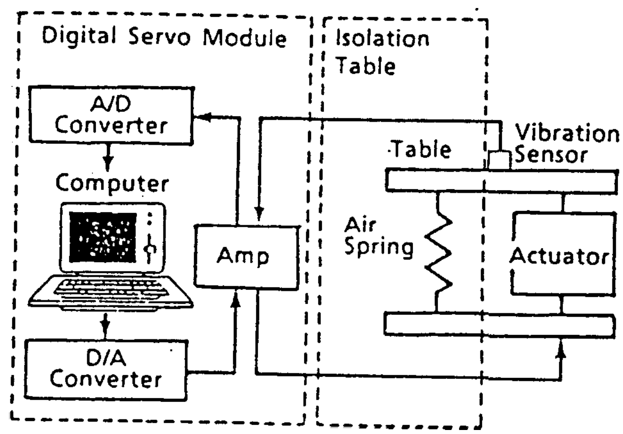


FIGURE-1 COMPOSITION of TACMI SYSTEM

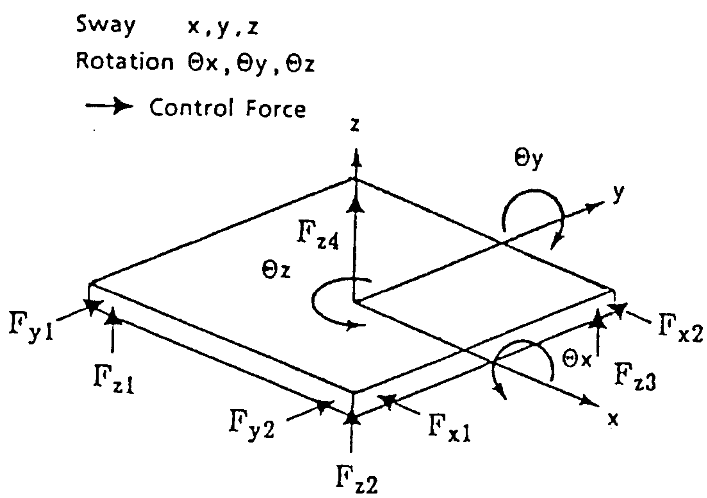


FIGURE-2 CO-ORDINATES of CONTROL FORCE

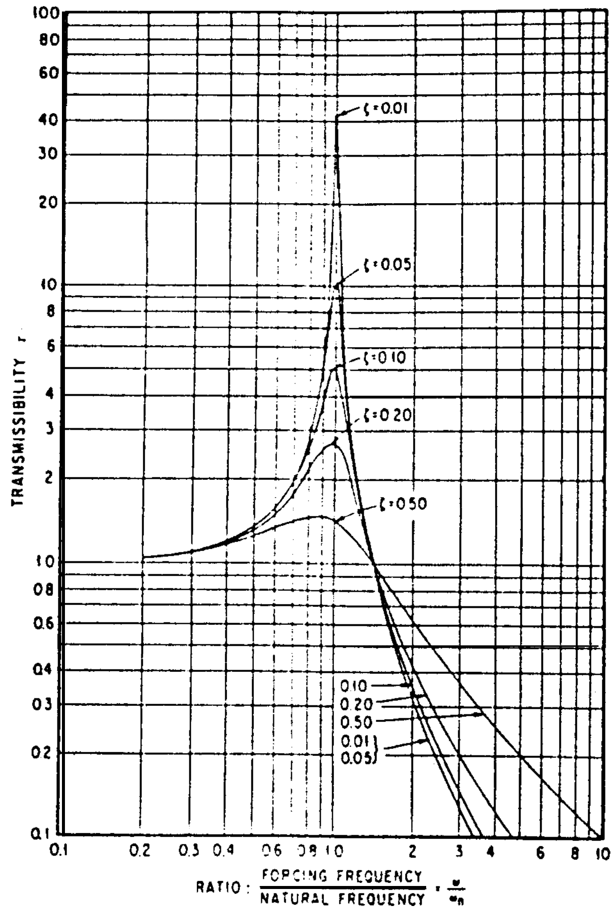


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FIGURE-3 TRANSFER FUNCTIONS of ONE MASS VIBRATION SYSTEM

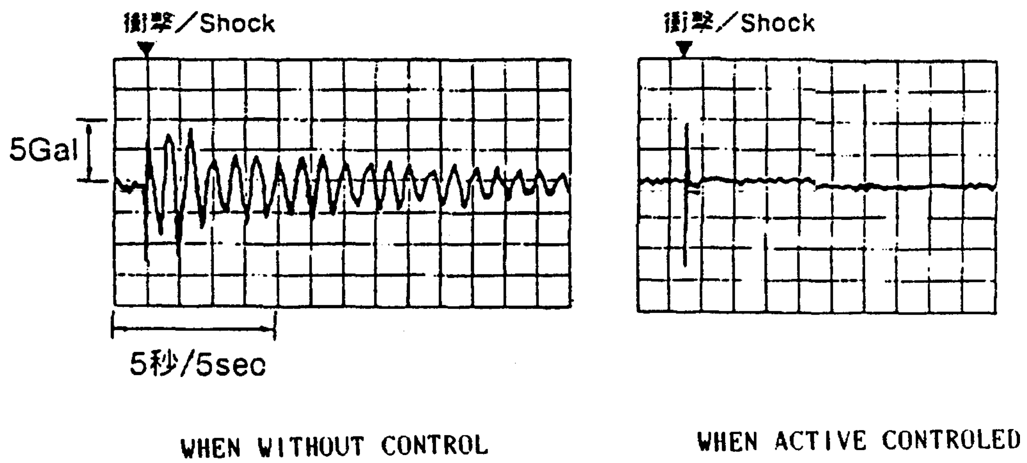
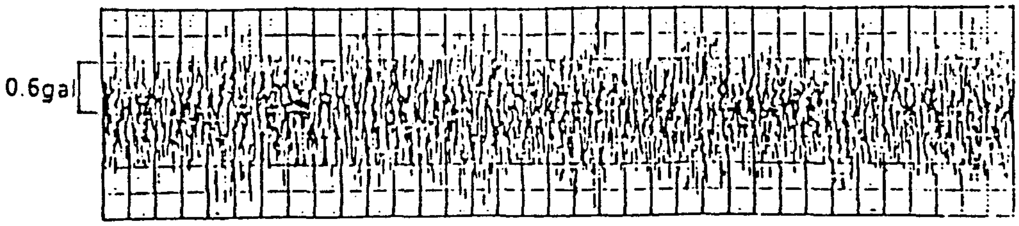
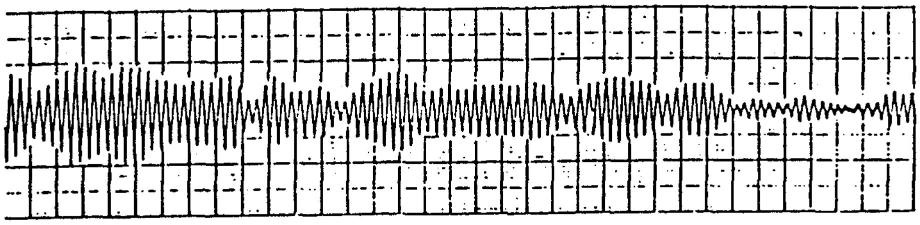


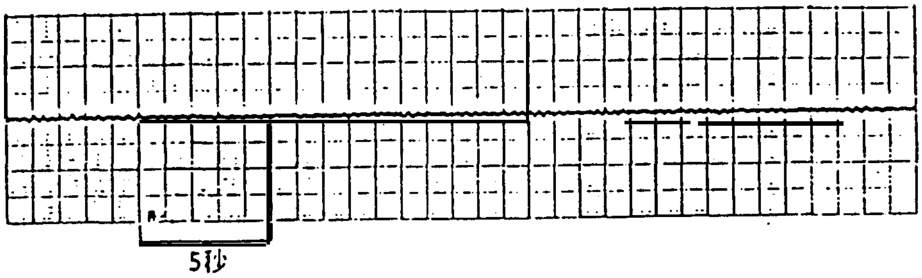
FIGURE-4 RESPONSE WAVEFORM of THE TABLE WHEN IMPULSIVE FORCE ADDED



(a) ON THE FLOOR

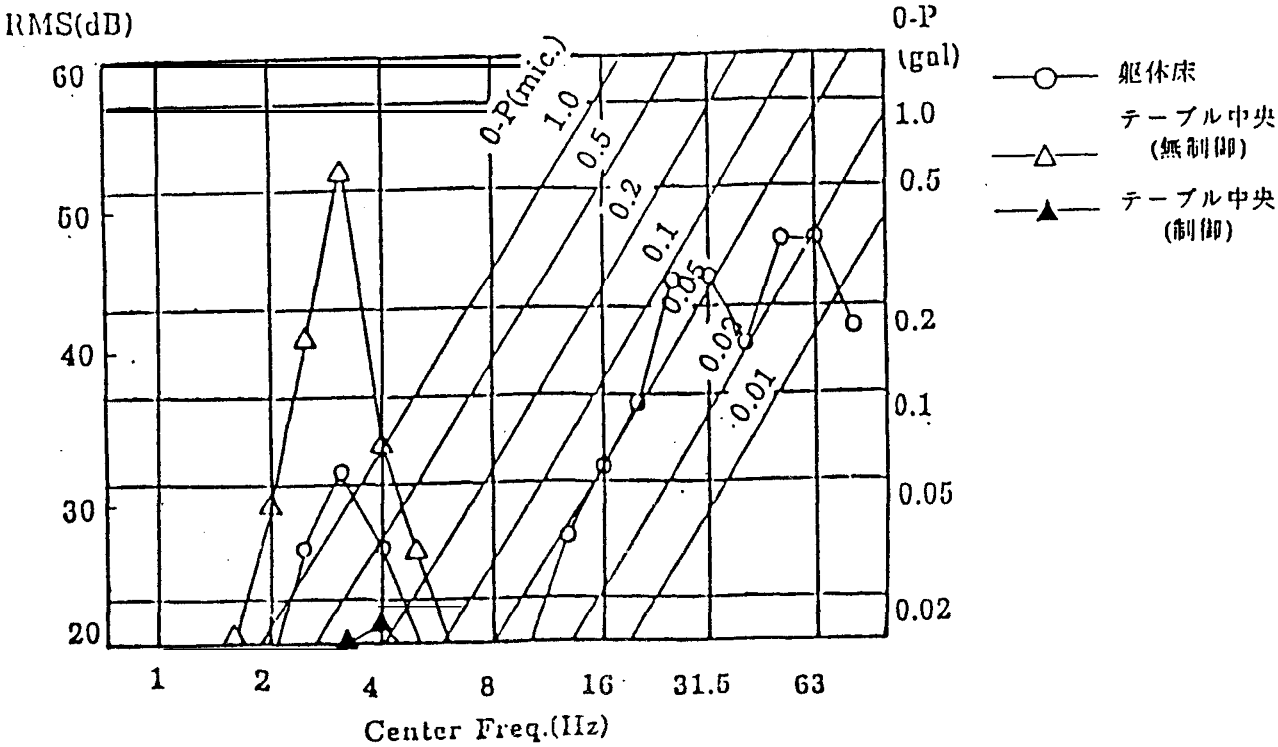


(b)CENTER of THE TABLE WHEN WITHOUT ACTIVE CONTROL



(c)CENTER of THE TABLE WHEN ACTIVE CONTROLED

FIGURE-5 COMPARISON WAVEFORM



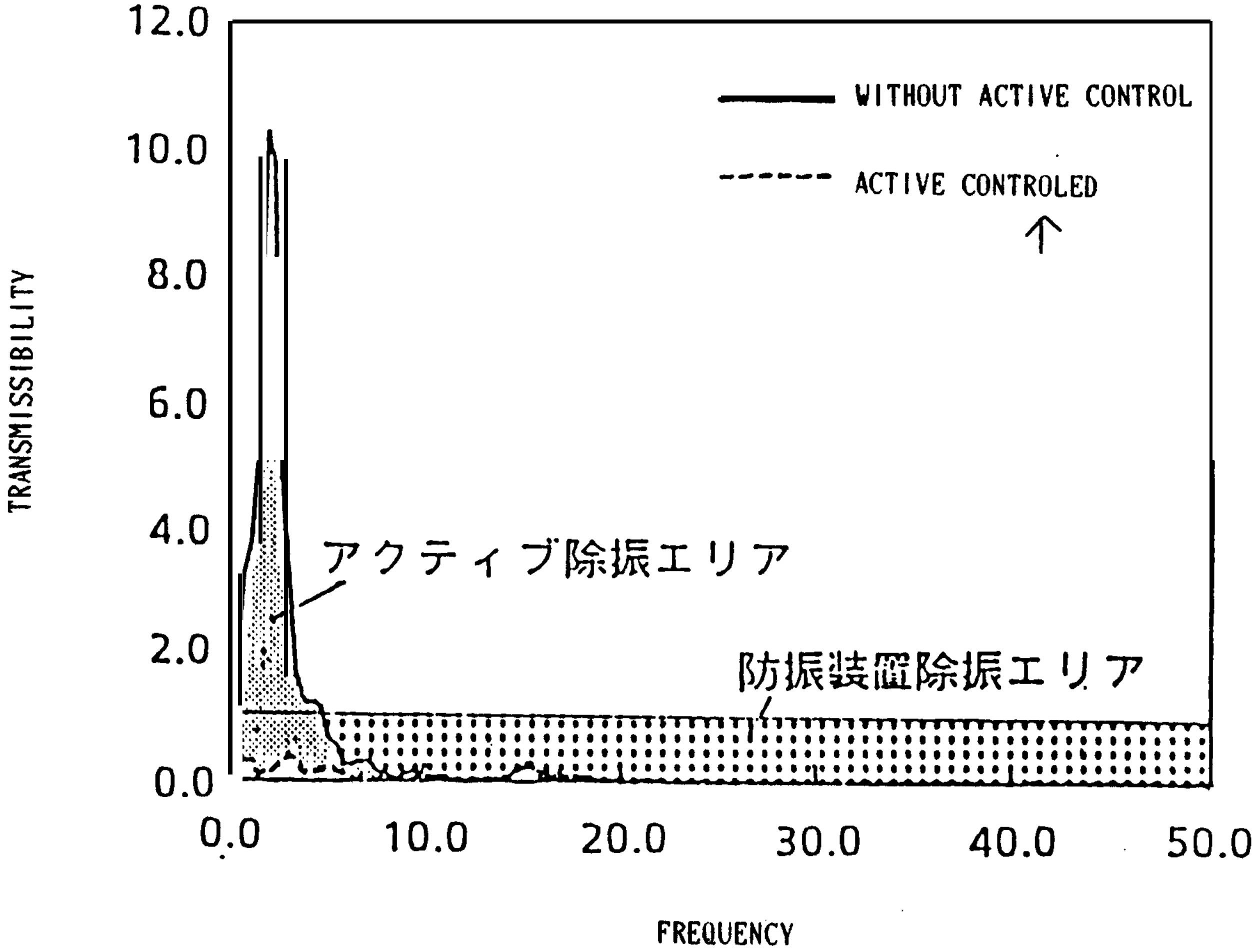


FIGURE-6 VIBRATIONAL TRANSFER CHARACTERISTICS of TACMI SYSTEM