Isolators

The concepts of isolation system can be best understood by presenting damper design first, followed by the isolation systems.

1. DAMPER TYPES

A conventional high performance fluid damper is depicted in Figure 1. A photograph of a conventional damper is shown in Figure 2. An expanded section in Figure 1 depicts the fluid orifices that generate damping forces. Many types of damper orifice styles exist. However, the extreme high velocities associated with underwater shock limit the available type of orifices that can be used. Figure 1 depicts (without much detail) the orifice construction most often used by Taylor Devices for shock associated with weapons detonation. This is called a "fluid control" orifice and has no moving parts. Instead, specially shaped and contoured passages are used to achieve the desired damping output. Damping fluid used is non-flammable silicone.

The generalized output equation for this type of damper is:

$$F_D = C\dot{X}^{\alpha}$$

where,

F_D = Damper Force

$\dot{X}$ = Damper Velocity

C = Damper Constant, specified by analysis

α = Damper Exponent, specified by analysis , can be any fixed value between 0.2 and 1.8

This type of damper has been often used for systems subjected to potential nuclear weapons attack. It will operate at speeds up to 15 m/s without degradation or performance change. This type of damper often uses orifices that function at internal oil velocities in excess of twice the speed of sound in oil. This allows the damper to operate at high internal pressures, up to 1400 bars and higher. This means that a damper rated at 200 tonnes output force could be as small as 250 mm in outside diameter.

Fluidic orifices can also be specially designed to provide a greatly reduced response under conditions of vibration, with high frequencies and low amplitudes. Yet, at higher level shock inputs the damper responds in a normal way to shock.

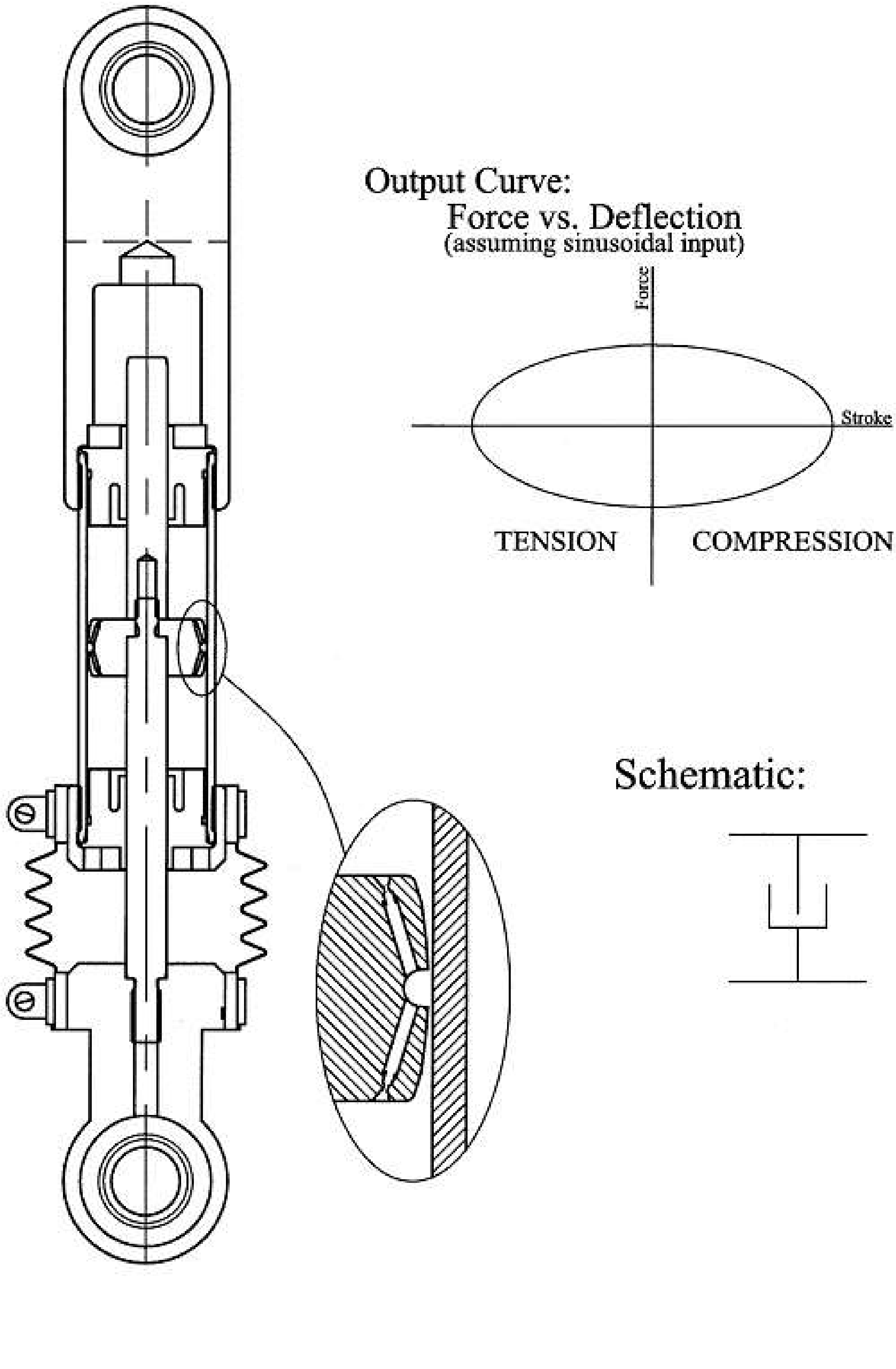

FIGURE 1
Conventional High Performance Fluid Damper

FIGURE 2
200 Tonne Force Dampers for Highway Bridge Deck

1.1 Sealed Metal Bellows Damper

The sealed metal bellows damper is a conventional damper where the normal sliding oil seals are replaced with a flexible metal bellows. This allows the damper to cycle under continuous vibration for long periods with no maintenance. The metal bellows seal by flexing of metal elements, rather than by sliding. This provides a vibration response with virtually no friction from seals. Additionally, bellows are typically stressed below the fatigue endurance limit, in order to guarantee a completely leak free and infinite life.

Figure 3 shows a cutaway view of the sealed metal bellows damper, Figure 4 is a photograph of this device.

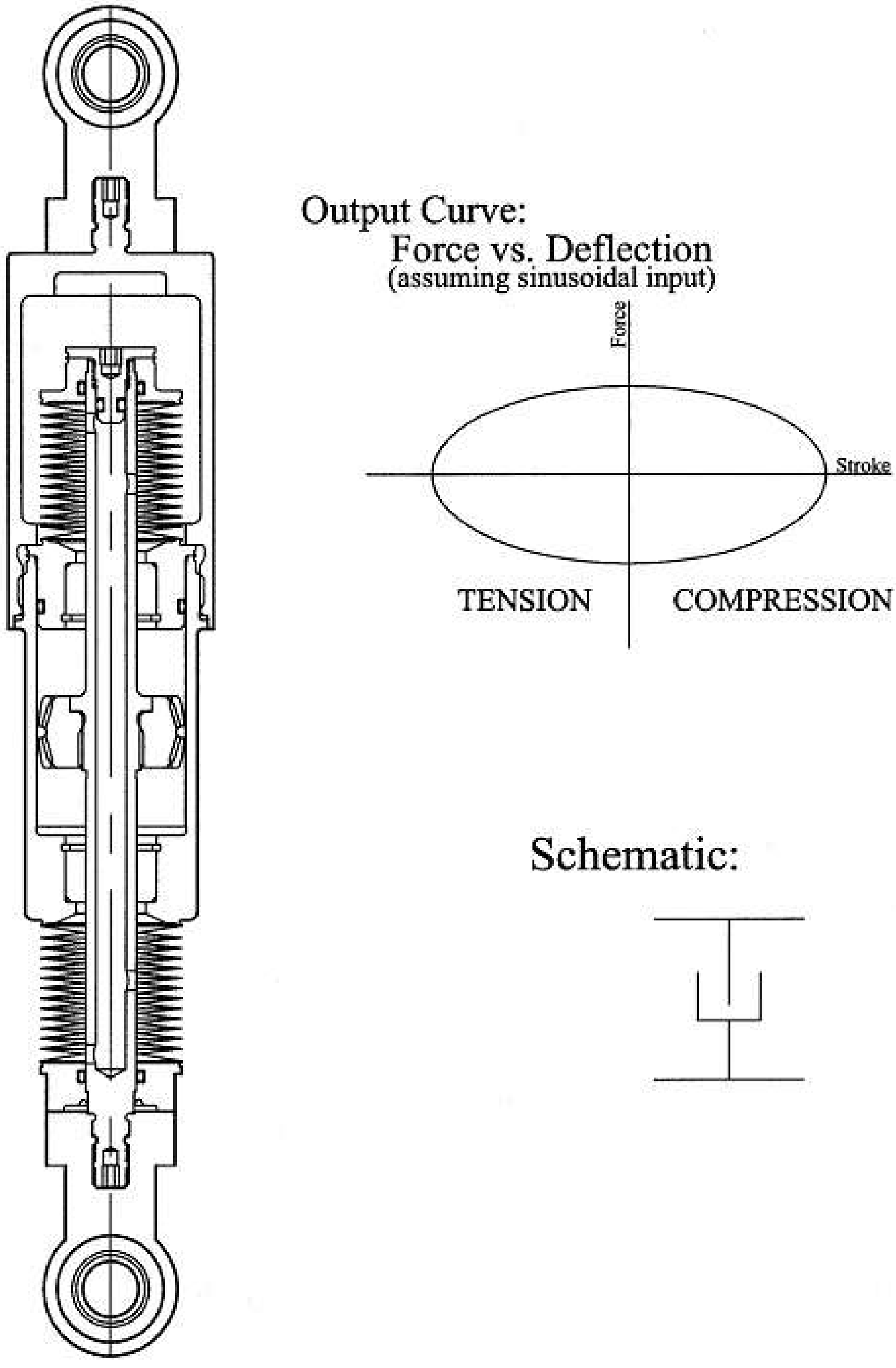

FIGURE 3
Cutaway View of the Sealed Metal Bellows Damper

FIGURE 4
Sealed Metal Bellows Damper for Solar Arrays
On Commercial Satellites, Iridium Phone System

1.2 Conventional Damper with Series Spring

This configuration combines a damper with an in-line spring, and is depicted in Figure 5. The particular spring element shown is a Taylor Devices modular machined spring which can be easily manufactured in the relatively high stiffness' normally used for a series damper-spring connection. The purpose of the series spring is to attenuate small vibrations without causing the damper to stroke. A secondary advantage is that it modifies the damper response under shock, giving a slightly "softer" change in output force under the initial conditions of the transient.

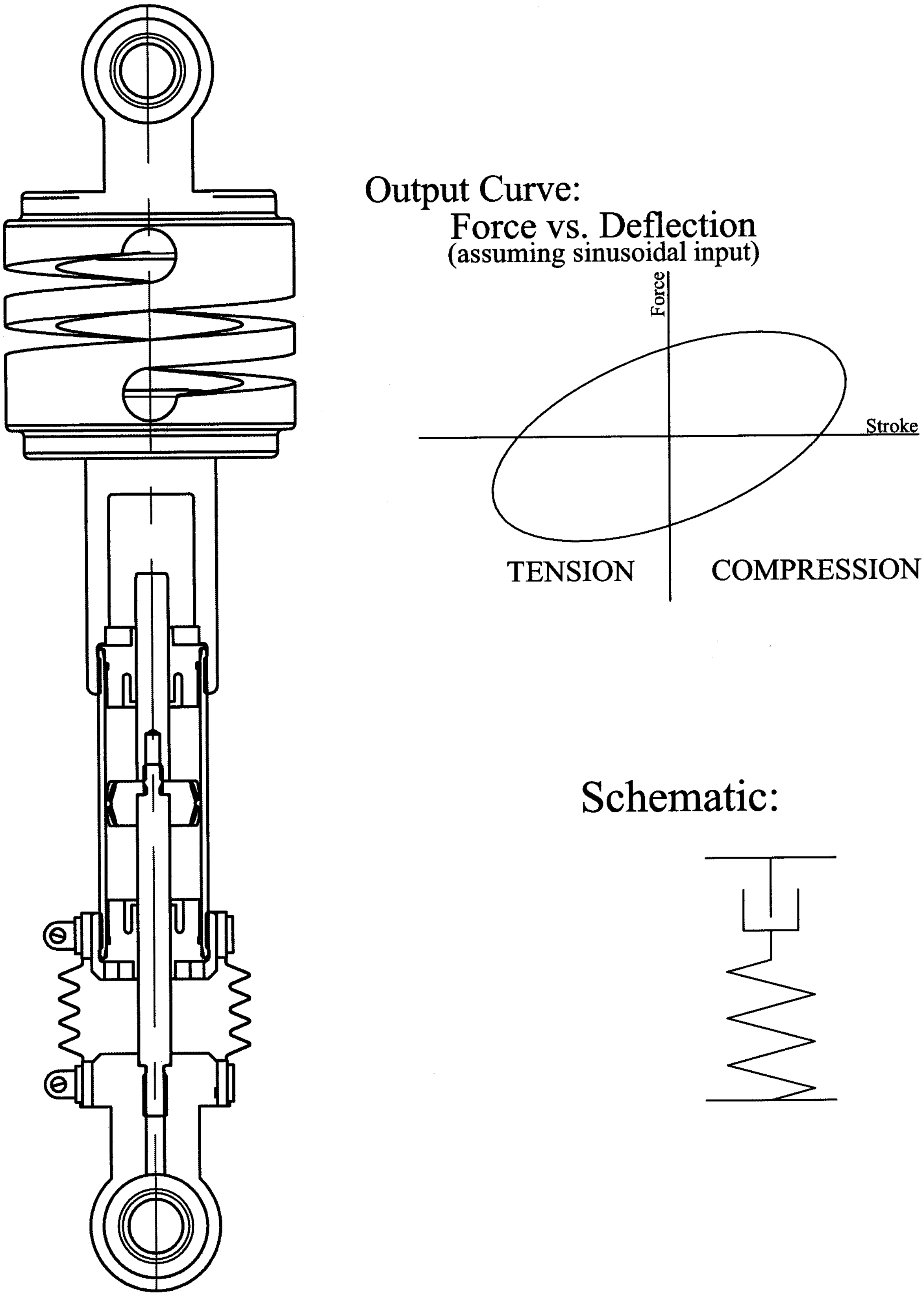

FIGURE 5
Damper with In-Series (In-Line) Spring

2 ISOLATOR TYPES

Four distinct isolator types are presented. Each of these types have been manufactured previously by Taylor Devices.

2.1 Double Acting Elastomer Spring Isolator with Parallel Fluidic Damper

A concept drawing of this isolator type is provided in Figure 6, along with representative output curves.

2.2 Double Acting Machined Spring Isolator with a Fluidic Damper in Parallel

When large sizes of conventional coil springs are needed, the springs cannot always be easily manufactured. An alternative approach with coil springs is to use a large number of much smaller springs, but this can waste valuable space.

To solve these problems, Taylor Devices manufacturers a modular machined spring, made from a single large bar of steel. This product can be made in virtually any load and stroke combination. Because it is made from a single piece of steel, it is virtually noiseless in operation. It is necessary to address so-called “ringing” or surge frequencies occurring from the different sections of the spring during vibration. This is done by coating the finished spring with a visco-elastic acoustic damping material. This spring has been used in military systems attenuating vibration in the D.C.–10,000 Hz bandwidth with great success. This spring exhibits no dynamic increases in spring rate at high frequencies.

Typical modular machined springs (prior to coating with the visco-elastic layer) are shown in Figure 7. The isolation configuration places the machined spring in parallel with a damper. This is depicted in Figure 8.

2.3 Double Acting Machined Spring Isolator with Additional Machined Spring for the Compression Direction and a Fluidic Damper in Parallel, all with Acoustic Mounts

This concept is the same as described in Section 2.2, except a second modular machined spring is used that tends to stabilize and center the equipment into a normal position at the mid-point of isolator stroke. Figure 9 shows this concept in detail. The balance of the system operation is the same as Section 2.2.

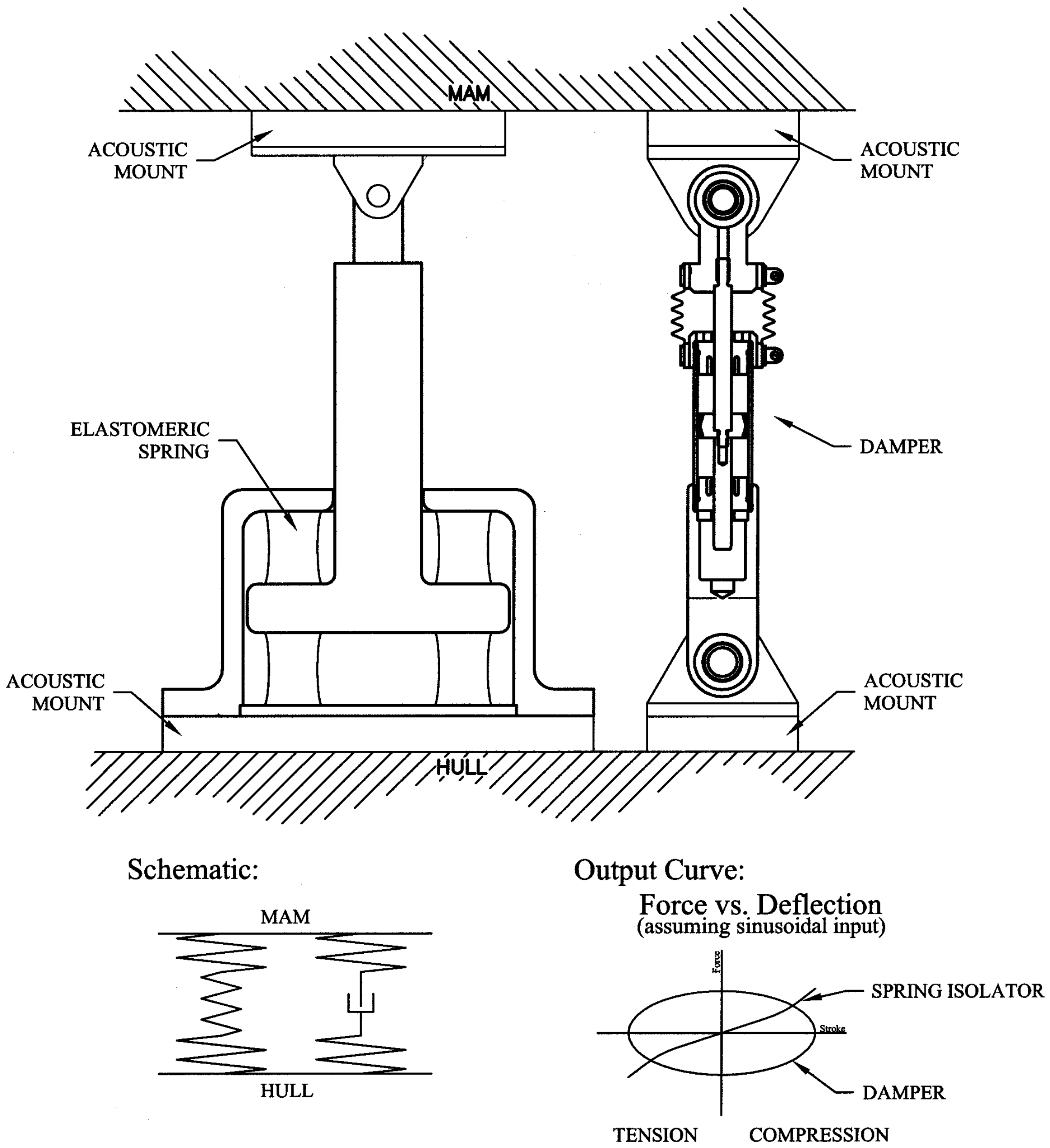

FIGURE 6

Double Acting Elastomer Spring Isolator with Parallel Fluidic Damper

FIGURE 7
Typical Modular Machined Springs

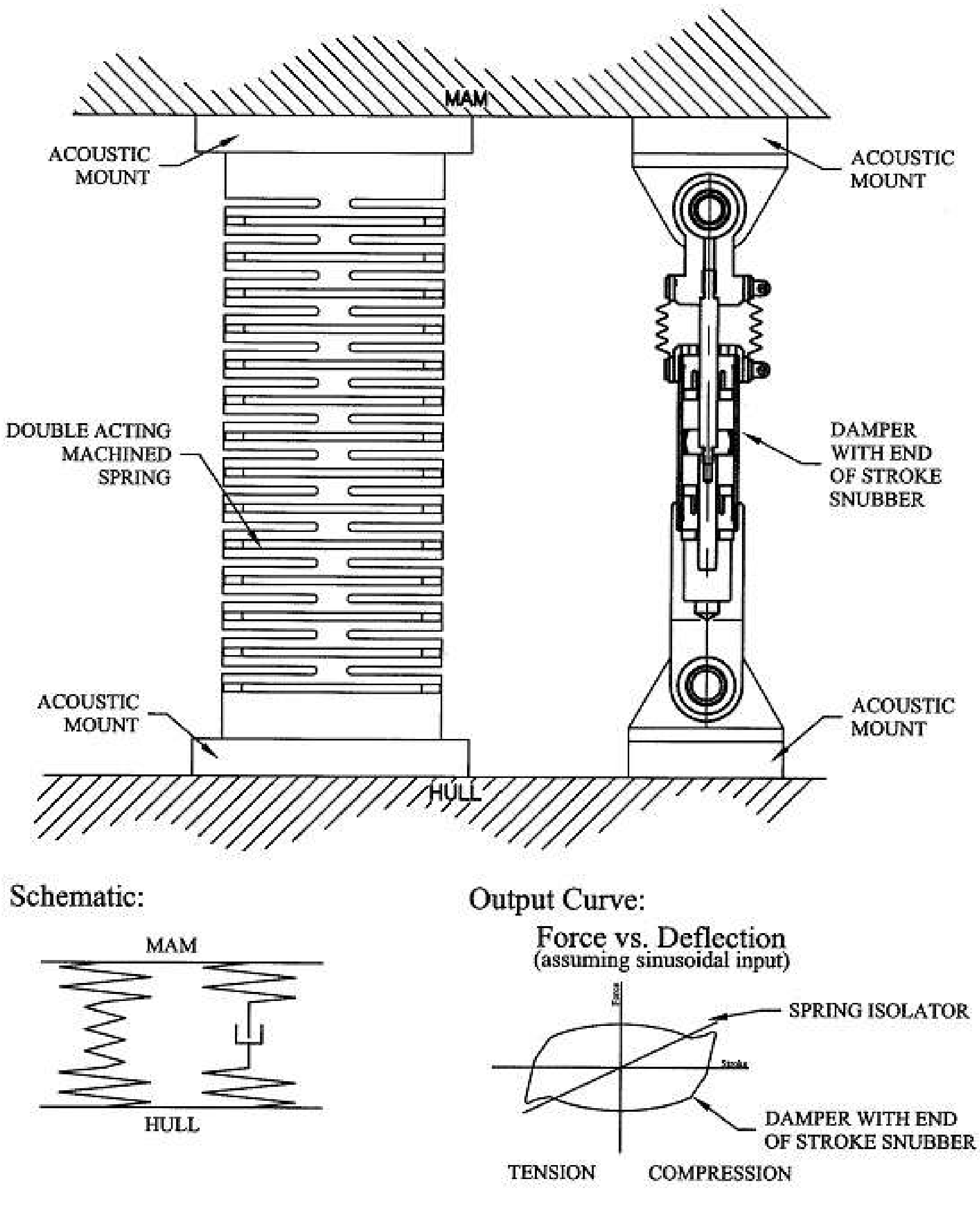

FIGURE 8
Double Acting Machined Spring Isolator with Fluidic Damper in Parallel

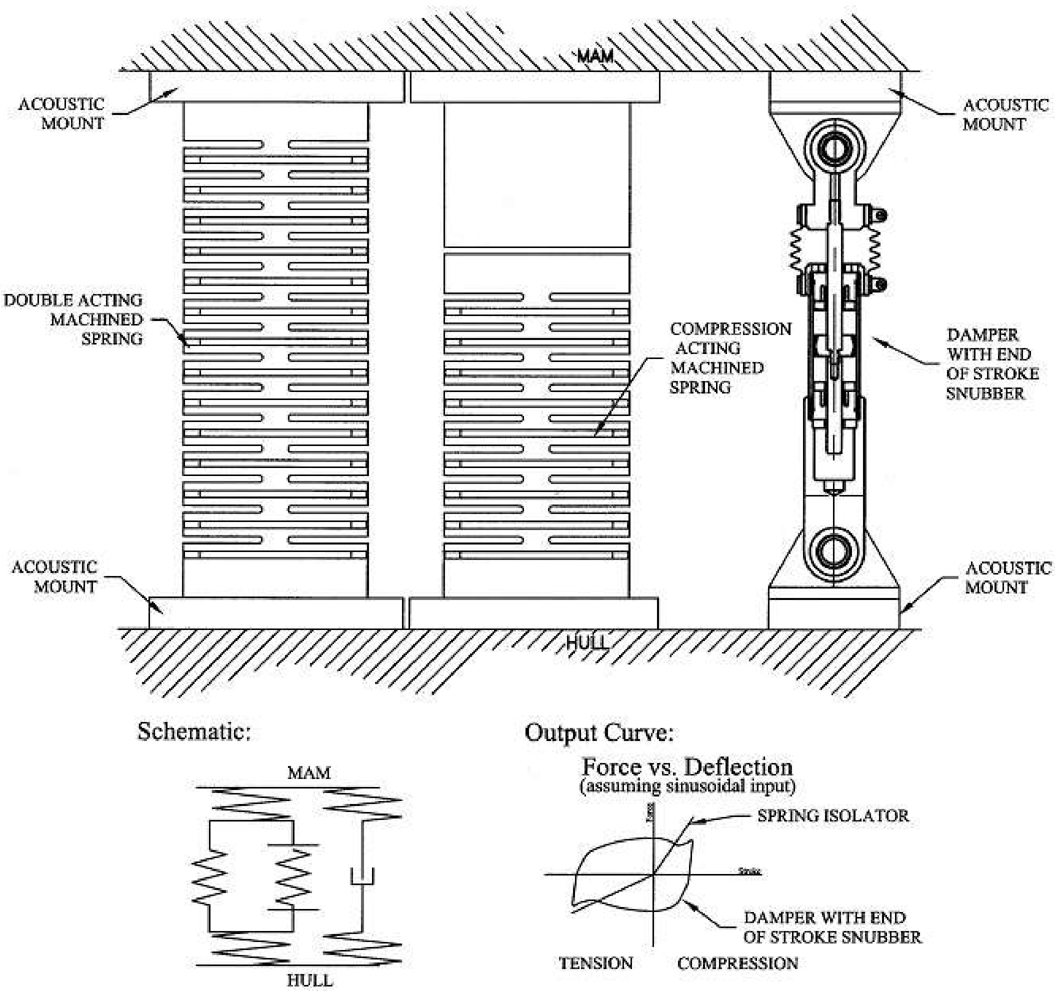

FIGURE 9

Double Acting Machined Spring Isolator with an Additional Machined Spring for the Compression Direction and a Fluidic Damper in Parallel

2.4 Hard Centering Tension-Compression Liquid Spring Shock Isolator with Acoustic Mounts

This isolator has been widely used for equipment subjected to weapons detonation shock. It combines a compressible fluid spring with an integral damping system. A mechanism is used to allow motion of the isolator in compression or extension about a center position. The mechanism is pre-stressed by the initial compression of the fluid to provide a firm centering force. Thus, the isolator acts like a rigid steel connection until the pre-stress force is exceeded. On small systems, particularly navigation systems, the pre-stress forces may be as much as 5 G, with attenuation to 25-30 G under shock testing. For larger systems, pres-stress may be as low as 0.2 G, with attenuation to 8-10 G under shock testing.

Figure 11 is a photograph of three different isolators of this type.

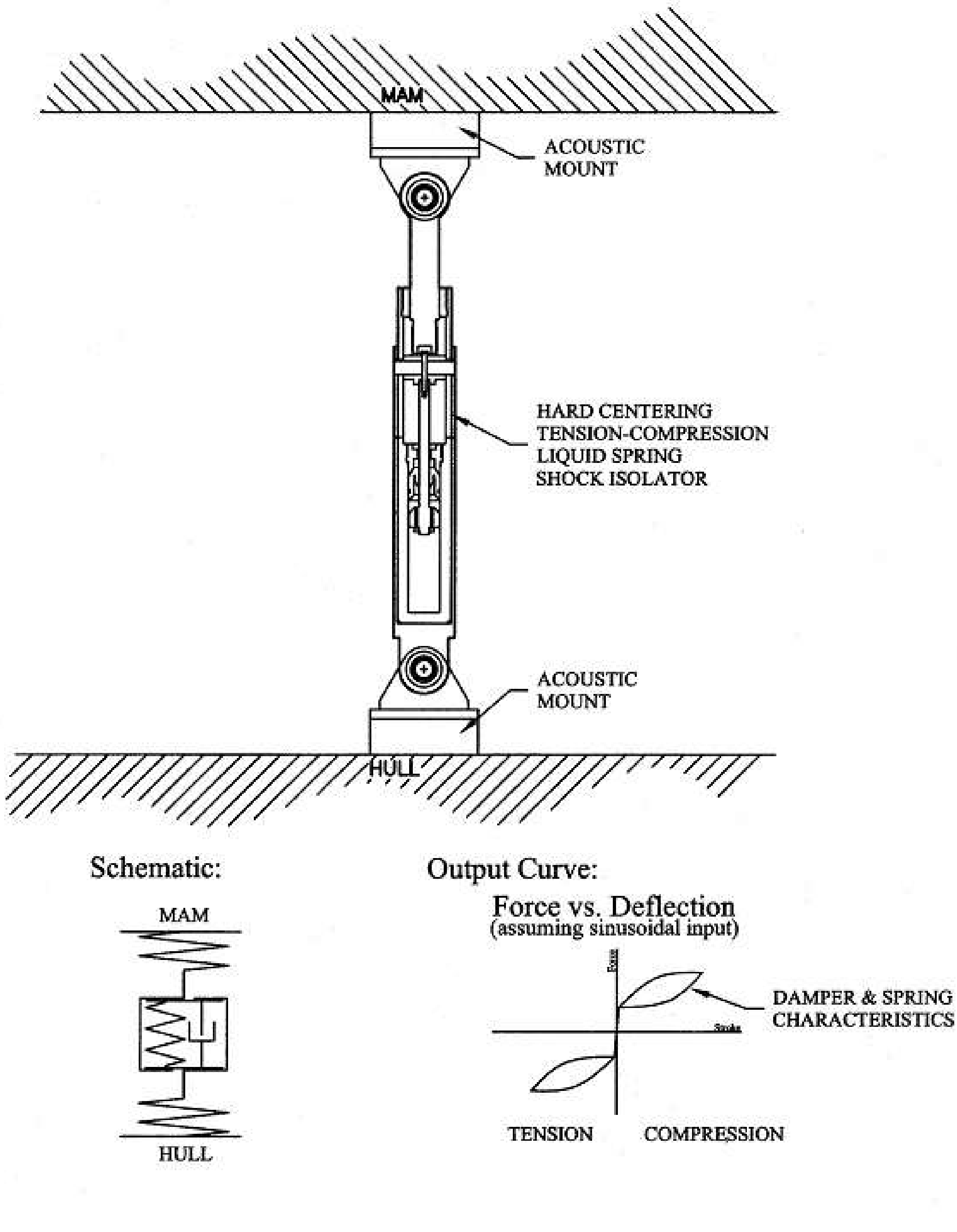

FIGURE 10

Hard Centering Tension-Compression Liquid Spring Shock Isolator

FIGURE 11
Tension-Compression Isolators