Products of Chemistry

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The Thermobile™: A Nitinol-Based Scientific Toy

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Nitinol

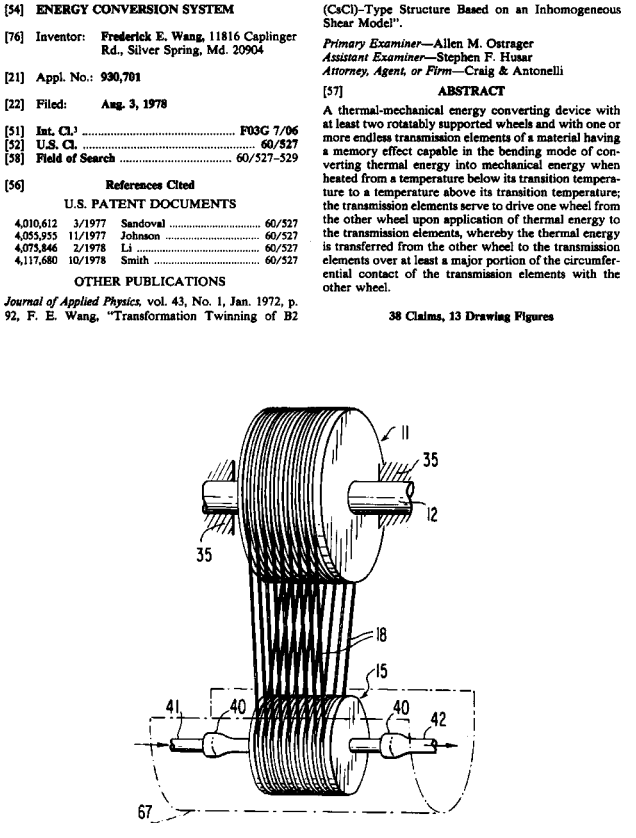
The serendipitous discovery of Nitinol, "the metal with a memory", has revolutionized manufacturing and medicine as countless products that "think" for themselves, sense changes in themselves and their surroundings, and respond appropriately enter the marketplace (*1*). Discovered in 1958 by metallurgist William J. Buehler while he was seeking an alloy for missile nose cones that could better withstand reentry, and named Nitinol for ***Ni***ckel ***Ti***tanium ***N***aval ***O***rdnance ***L***aboratory, this best-known example of a so-called "intelligent" or "smart" material undergoes changes that occur between two solid phases and involve rearrangement of atoms within a crystal lattice (*2*).

Although many materials undergo such transformations, which are less familiar than phase changes between solid and liquid or liquid and gas, Nitinol is unusual in that when it undergoes a phase transition due to a temperature change, it changes its shape as well. It "remembers" its shape because the phase change (between austenite and martensite phases) affects its structure on the atomic level only, without disturbing the arrangement of the crystals—which would be irreversible (*3–5*). Consequently, Nitinol has been used in a number of scientific demonstrations and laboratory experiments (*6–8*). The mechanism of Nitinol's action is explained in detail elsewhere (*1, 4, 5, 8*).

Taiwan-born Frederick E. Wang, an authority on crystal physics, was recruited by Buehler to explain the mechanical-memory property of Nitinol and to collaborate on its development. After leaving the Naval Ordnance Laboratory in 1980, he founded Innovative Technology International, Inc. (ITI). ITI produces and supplies Nitinol to manufacturers and has built prototypes of Nitinol-based engines that convert thermal energy to mechanical energy. Although the Nitinol engine is still years from production, other Nitinol products are already in existence and saving lives. These include sprinkler systems and automatic tap turnoffs. Nitinol-based fire sprinklers respond much more rapidly than conventional ones, while a Nitinol antiscalding device shuts off a tap whenever the temperature of the water exceeds a safe level. Other uses for Nitinol include medical and dental devices, eyeglass frames, pipe couplers for F-14 and F-16 fighter aircraft, greenhouse window hinges, and coffee-maker valves.

The Thermobile™

In 1981 ITI patented (*9*) (Fig. 1) and in 1985 began to market a scientific toy called the Thermobile (*10*), which lends itself readily to lecture demonstrations and laboratory experiments. This engine with no visible power source is designed to demonstrate the conversion of low-temperature thermal energy to mechanical energy by means of a Nitinol loop wrapped around a system of two pulleys (Fig. 2). The Nitinol wire reacts forcefully to a small change in temperature because of its memory effect, which causes it always to return to its original shape. Thus, when the smaller (brass) wheel of the Thermobile is immersed in tap water heated to between 50 °C (122 °F) and 75 °C (167 °F), the Nitinol strand straightens, and the resulting torque forces the pulleys to rotate. This causes the wheels to spin and continue to spin as long as the wire strand is heated.



[54] ENERGY CONVERSION SYSTEM

[76] Inventor: Frederick E. Wang, 11816 Caplinger Rd., Silver Spring, Md. 20904

[21] Appl. No.: 930,701

[22] Filed: Aug. 3, 1978

[51] Int. Cl.³ F03G 7/06
[52] U.S. Cl. 60/527
[58] Field of Search 60/527–529

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[57] ABSTRACT

A thermal-mechanical energy converting device with at least two rotatably supported wheels and with one or more endless transmission elements of a material having a memory effect capable in the bending mode of converting thermal energy into mechanical energy when heated from a temperature below its transition temperature to a temperature above its transition temperature; the transmission elements serve to drive one wheel from the other wheel upon application of thermal energy to the transmission elements, whereby the thermal energy is transferred from the other wheel to the transmission elements over at least a major portion of the circumferential contact of the transmission elements with the other wheel.

38 Claims, 13 Drawing Figures

Figure 1. Energy Conversion System, U.S. Patent No. 4,275,561; June 30, 1981. (Courtesy of Frederick E. Wang, Innovative Technology International, Inc.)

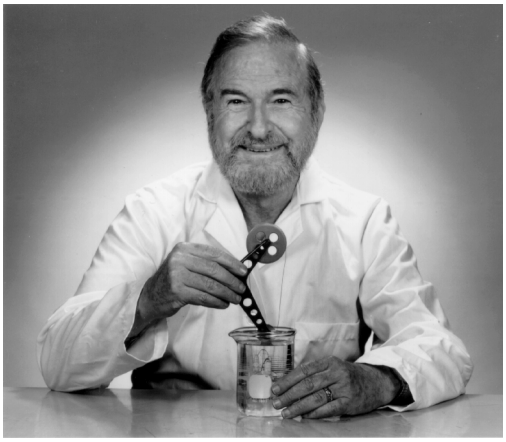

Figure 2. George B. Kauffman demonstrates the Thermobile (photograph by Randy Vaughn-Dotta, CSUF Instructional Media Center).

Alternatively, the Thermobile can be operated by using solar heat. Sunlight can be focused on the brass wheel with a magnifying glass. Because several seconds are required to heat the wheel, it may be more convenient to clamp the lens and Thermobile in a fixed position to ensure a steady stream of sunlight onto the wheel. Since the torque and force can theoretically generate electricity, turn flywheels, propel an airplane, or power an automobile, this type of system may eventually be adapted and used as a clean, nonpolluting source of power. Until then, the Thermobile provides an attractive and vivid demonstration of the possibilities inherent in the newly developed class of intelligent materials—manufactured products that have some of the properties of living things.

Wang's Creative Modus Operandi

Wang, whose most productive ideas come to him when he is alone with his thoughts, either dreaming at night or daydreaming, reports that the concept of the Thermobile occurred to him while he was flying to Europe (*11*):

> These ideas suddenly came to me, and I quickly jotted them down. When I returned home, I didn't wait for my machinist. I constructed the device with what was immediately available—my son's erector set. And it worked!

His new engine overcame the disadvantages of earlier heat engines by employing air as the cooling device instead of cold water, reducing the expenditure of energy, and by employing a simpler system of two wheels and a wire loop (*9, 10*). Although the Thermobile worked well, it wasn't quite ready for commercial use, and Wang thought that a better design was needed. The solution occurred to him about two years later (*11*):

> It was one night as I was lying in bed, just before I fell asleep, that the idea came to me clear as a bell—the "flywheel" concept.

This idea made the engine commercially viable and led to another patented system, in which a small wheel is held in a fixed position, and a large wheel rotates around it (*12*). Because the small wheel does not rotate, problems of seals and bearings were eliminated.

Sources of the Thermobile and Nitinol

The Thermobile is available for $35 postpaid from Innovative Technology International, Inc., 10747 Tucker St., Beltsville, MD 20705 (phone: 301/937-3688; fax: 301/595-5409). Nitinol products are also available from the Institute for Chemical Education, Department of Chemistry, University of Wisconsin, 1101 University Ave., Madison, WI 53706-1396 (phone: 608/262-3033; fax: 608/265-8094) and Educational Innovations, Inc., 151 River Rd., Cos Cob, CT 06807 (phone: 203/629-6049; fax: 203/629-2739).

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