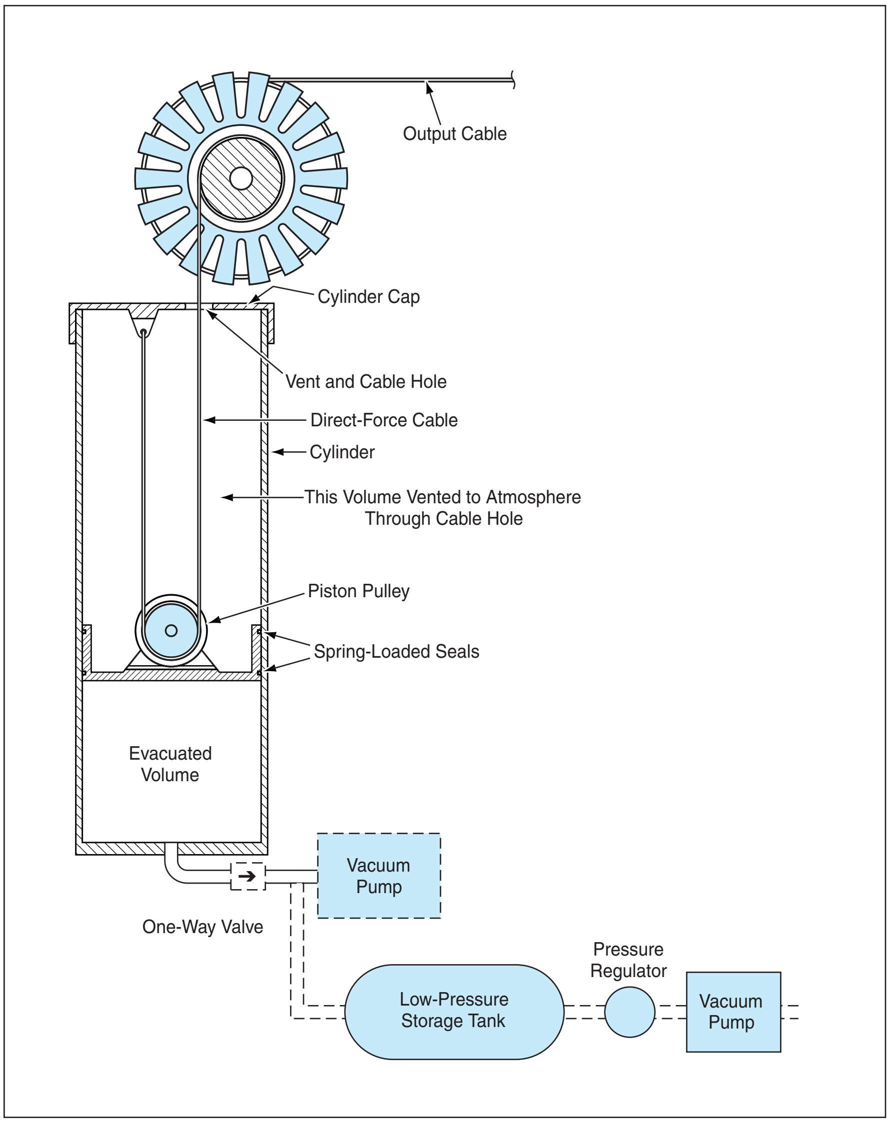
Vacuum-Assisted, Constant-Force Exercise Device

An important advantage over other exercise machines would be light weight.

Lyndon B. Johnson Space Center, Houston, Texas

The vacuum-assisted, constant-force exercise device (VAC-FED) has been proposed to fill a need for a safe, reliable exercise machine that would provide constant loads that could range from 20 to 250 lb (0.09 to 1.12 kN) with strokes that could range from 6 to 36 in. (0.15 to 0.91 m). The VAC-FED was originally intended to enable astronauts in microgravity to simulate the lifting of free weights, but it could just as well be used on Earth for simulated weight lifting and other constant-force exercises. Because the VAC-FED would utilize atmospheric/vacuum differential pressure instead of weights to generate force, it could weigh considerably less than either a set of free weights or a typical conventional exercise machine based on weights. Also, the use of atmospheric/vacuum differential pressure to generate force would render the VAC-FED inherently safer, relative to free weights and to conventional exercise machines that utilize springs to generate forces.



Atmospheric/Vacuum Differential Pressure on the piston would be utilized to generate an adjustable, nearly constant tension in the output cable.

The overall function of the VAC-FED would be to generate a constant tensile force in an output cable, which would be attached to a bar, handle, or other exercise interface. The primary force generator in the VAC-FED would be a piston in a cylinder. The piston would separate a volume vented to atmosphere at one end of the cylinder from an evacuated volume at the other end of the cylinder (see figure). Hence, neglecting friction at the piston seals, the force generated would be nearly constant — equal to the area of the piston multiplied by the atmospheric/vacuum differential pressure.

In the vented volume in the cylinder, a direct-force cable would be looped around a pulley on the piston, doubling the stroke and halving the tension. One end of the direct-force cable would be anchored to a cylinder cap; the other end of the direct-force cable would be wrapped around a variable-ratio pulley that would couple tension to the output cable. As its name suggests, the variable-ratio pulley would contain a mechanism that could be used to vary the ratio between the tension in the direct-force cable and the tension in the output cable. This mechanism could contain gears, pulleys, and/or levers, for example. By use of this mechanism, the tension in the output cable would be set to a desired fraction of the force generated by the pulley and the stroke would be multiplied by the reciprocal of that fraction.

A vacuum could be generated in several alternative ways. The way that would involve the least equipment would involve the use of a one-way valve in an outlet at the vacuum end of the cylinder (the lower end in the figure). At first, the piston would be forced all the way down in the cylinder to push out most of the air from the lower cylinder volume. Thereafter, the one-way valve would keep air from re-entering the lower cylinder volume, and the device could be used to provide nearly constant tension on the cable during exercise. Of course, air would gradually leak past the piston seals into the lower cylinder volume, so that it would eventually be necessary to repeat the initial bottoming of the piston to restore the atmospheric/vacuum differential pressure.

Alternatively, a vacuum could be generated and maintained by use of a small manual or electric vacuum pump. Still another alternative is to connect the lower cylinder volume to the combination of a low-pressure storage tank, pressure regulator, and vacuum pump. This combination could be used to maintain the lower cylinder volume at a subatmospheric pressure (partial vacuum) that could be controlled to set the differential pressure and thus the output-cable tension at a desired level.

This work was done by Christopher P. Hansen of **Johnson Space Center** *and Scott Jensen of Lockheed Martin Corp. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*

MSC-23180

Production of Tuber-Inducing Factor

This substance regulates the growth of potatoes and some other plants.

John F. Kennedy Space Center, Florida

A process for making a substance that regulates the growth of potatoes and some other economically important plants has been developed. The process also yields an economically important by-product: potatoes.

The particular growth-regulating substance, denoted tuber-inducing factor (TIF), is made naturally by, and acts naturally on, potato plants. The primary effects of TIF on potato plants are reducing the lengths of the main shoots, reducing the numbers of nodes on the main stems, reducing the total biomass, accelerating the initiation of potatoes, and increasing the edible fraction (potatoes) of the overall biomass. To some extent, these effects of TIF can override environmental effects that typically inhibit the formation of tubers. TIF can be used in the potato industry to reduce growth time and increase harvest efficiency. Other plants that have been observed to be affected by TIF include tomatoes, peppers, radishes, eggplants, marigolds, and morning glories.

In the present process, potatoes are grown with their roots and stolons immersed in a nutrient solution in a recirculating hydroponic system. From time to time, a nutrient replenishment solution is added to the recirculating nutrient solution to maintain the required nutrient concentration, water is added to replace water lost from the recirculating solution through transpiration, and an acid or base is added, as needed, to maintain the recirculating solution at a desired pH level. The growing potato plants secrete TIF into the recirculating solution. The concentration of TIF in the solution gradually increases to a range in which the TIF regulates the growth of the plants.

In a procedure for concentrating TIF, no attempt is made to separate TIF from the nutrient and other solutes in the solution. Instead, the solution is simply poured onto flat trays at a depth between 0.5 and 1.0 cm, then concentrated by drying for 12 to 24 hours in a forced-air oven at a temperature of 70 °C. The concentrated solution is stable at and below room temperature and in the presence of ultraviolet light. Optionally, one can freeze-dry the solution to remove all the water, leaving a water-soluble dry powder. The concentrated solution or dry powder is stored in a dry environment. Thereafter, one simply adds deionized water to the concentrated solution or dry powder to make a TIF-containing nutrient solution having the desired lesser concentration.

Results of laboratory tests suggest that TIF-containing solutions made in this way are suitable for use in diverse settings, including fields, green houses, and enclosed environments containing natural- and artificial-soil-based as well as hydroponic plant-growth systems. Potential commercial applications include the following:

- Hydroponic, aeroponic, or field production of seed potatoes;
- Dwarfing of bedding plants in controlled environments;
- Dwarfing of ornamental plants in fields and in controlled environments; and
- As a quasi-natural regulator (in this case, as a suppressor) of the growth of weeds.

This work was done by Gary W. Stutte and Neil C. Yorio of Dynamac Corp. for **Kennedy Space Center**.

Title to this invention, covered by U.S. Patent No. 5,992,090 has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457 (f)}. Inquiries concerning licenses for its commercial development should be addressed to:

Gary W. Stutte, Ph.D. or Neil C. Yorio
Phone Nos.: (321) 861-3493 or
(321) 861-2497
E-mail: Gary.Stutte-1@ksc.nasa.gov or
Neil.Yorio-1@ksc.nasa.gov

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