Human-Powered Centrifuges and Stationary Exercise Stations

Selectable modes of operation include constant speed, constant torque, and freewheeling.

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Human-powered machines that can be operated as centrifuges or as stationary exercise stations have been invented. These machines are suitable for a variety of terrestrial and outer-space applications that involve physical therapy, maintenance of physical fitness, centrifugal simulation of gravitation or acceleration, and/or measurement of physiological responses to exercise and centrifugation. A machine of this type can be operated in any of several selectable modes, in which one or more human participant(s) can be active or passive and in which the speed of rotation (and thus the centripetal acceleration), the human-generated torque, or the human-generated power can be regulated. Although the basic concept of human-powered centrifuges for such applications is not new, older designs for machines of this type do not provide for such a variety of operating modes.

One machine of this type (see Figure 1) includes recumbent seats for two riders on a turntable, plus a stationary seat near the turntable. A bicycle-type pedal-crank mechanism is located at each seat. The turntable can be powered by either or both riders and/or by a person on the stationary seat, by use of the bicycle-type mechanisms. Each bicycle-type mechanism includes a ratchet-type clutch to provide for freewheeling when the person using the mechanism elects not to pedal.

When rotated by human power, the pedals at either rider seat impart rotation to the turntable hub through a drive train that includes sprockets and chains that drive a pinion that meshes with a bevelled crown gear on the hub. Similarly, when rotated by human power, the pedals at the stationary seat impart rotation to the turntable hub through a drive train that includes sprockets and chains that drive a pinion that meshes with another bevelled crown gear on the hub.

Optional equipment includes a video camera, physiological monitoring equipment, and data-transmission equipment. Data from the monitoring equipment can be transmitted through slip rings and wires to an external computer system.

Figure 2 depicts a different machine of this type. For clarity of illustration, only one rider station is shown on the turntable, though in general there could be more than one. Also for the sake of clarity, the seat is not shown. As before, the rider supplies power via a bicycle-type mechanism. The pedal crank drives an automatic transmission that includes a ratchet-type clutch for freewheeling. The automatic transmission adjusts the gear ratio between the rider and the turntable and maintains constant rider power demand. The power output from the automatic transmission is sent through a flywheel friction brake and through a slide collar to the output shaft connected to the turntable hub. The slide collar is used, when needed, to disengage the output shaft to enable the rider to exercise while the turntable remains stationary. The flywheel friction brake is adjustable to absorb extra energy supplied by the rider and not needed to turn the turntable. The flywheel also provides smooth pedaling, especially when the output shaft has been disconnected for stationary operation.

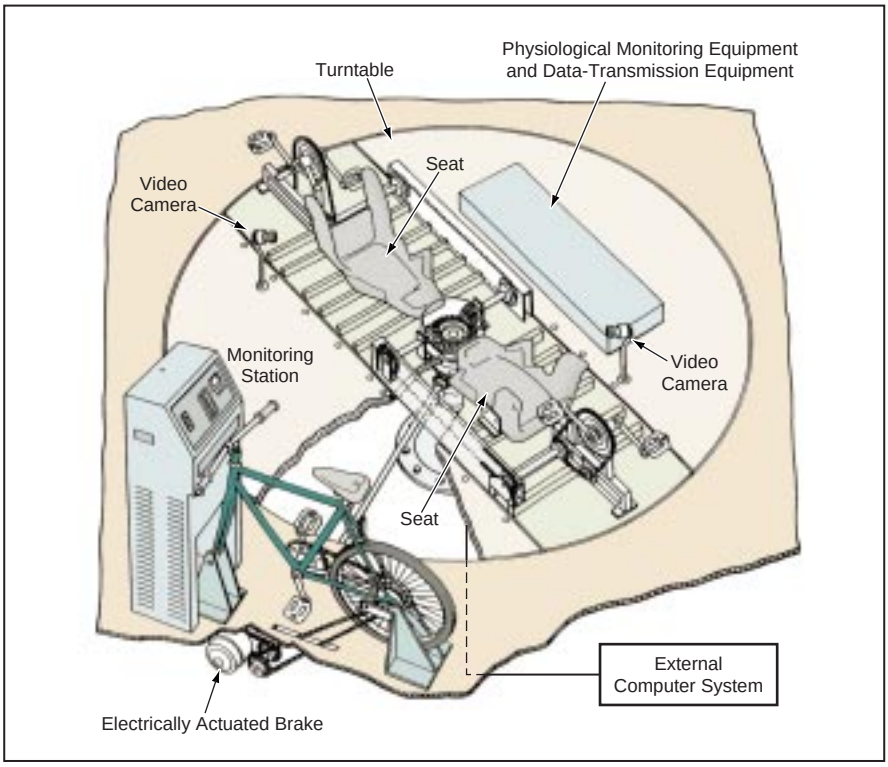

Figure 1. The **Turntable Can Be Powered** by two riders and/or by a person on a stationary bicycle-type mechanism. The electrically actuated brake resists the pedalling effort with a controlled torque.

A linear actuator changes gears in the automatic transmission in response to a command signal from a controller. Another linear actuator adjusts the tension on a strap on the flywheel, in response to another command signal from the controller. The controller is a programmable-logic control unit or other microprocessor device that is programmed to maintain a constant load on the rider, regardless of the speed of rotation. Control is maintained by using feedback from a pedal-crank torque sensor (load sensor) and a pedal-crank tachometer. The controller compares the preset commanded values (speed of rotation and load on the pedaling rider) to the actual values and responds by adjusting the tension on the strap and selecting the gear ratio on the automatic transmission.

The tension on the strap is measured and fed back to the controller, which then commands the second-mentioned linear actuator to adjust the tension. The output of a turntable tachometer is used

as a feedback signal for regulating the speed of rotation and thus the centrifugal force, which can be preset and changed as desired prior to or during operation. The workload or power output required of the rider can be preset and maintained at a constant level independent of the speed of rotation. For operation at a constant speed of rotation, the turntable can be accelerated up to the preset speed but cannot be made to turn any faster, regardless of additional rider effort: this is accomplished through a feedback subsystem that causes excess power to be diverted to storage or dissipated.

This work was done by Gerald M. Mulenburg and Joan Vernikos of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the category.*

This invention has been patented by NASA (U.S. Patent No. 5,616,104). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center [see page 20]. Refer to ARC-12058.

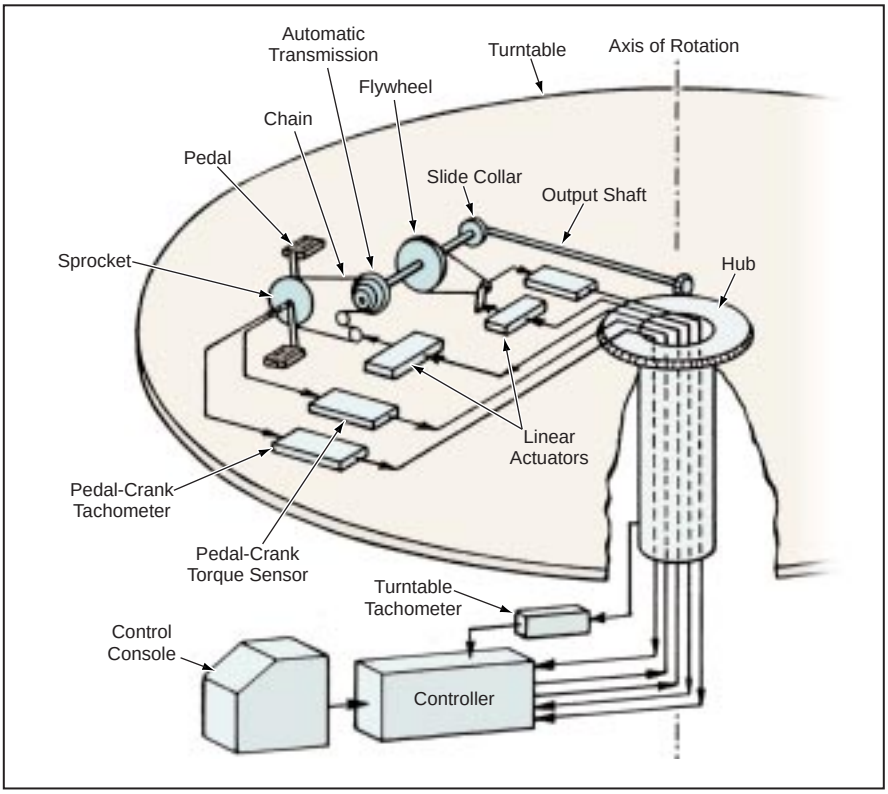

Figure 2. The **Control System of This Turntable** regulates the power demand on the rider, the torque applied by the rider, or the speed of rotation.