

and (2) an apparatus that operates under computer control to generate the required motions. Optimally, the stresses should mimic those to which the anterior cruciate ligament is subjected *in vivo* during normal activity. The bioengineered ligament produced by this method is characterized by a cellular orientation and/or matrix crimp pattern in the direction of the applied mechanical forces, and by the production of collagen type I, collagen type III, and fi-

bronectin proteins along the axis of mechanical loading. Optimally, the ligament thus produced contains fiber bundles arranged in a helical pattern.

This work was done by Gregory Altman, David L. Kaplan, Ivan Martin, and Gordana Vunjak-Novakovic of Massachusetts Institute of Technology for Johnson Space Center.

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Refer to MSC-23351, volume and number of this NASA Tech Briefs issue, and the page number.

Stroboscopic Goggles for Reduction of Motion Sickness

The view is presented to wearer in snapshots to suppress retinal slip.

Lyndon B. Johnson Space Center, Houston, Texas

A device built around a pair of electronic shutters has been demonstrated to be effective as a prototype of stroboscopic goggles or eyeglasses for preventing or reducing motion sickness. The momentary opening of the shutters helps to suppress a phenomenon that is known in the art as retinal slip and is described more fully below.

While a number of different environmental factors can induce motion sickness, a common factor associated with every known motion environment is sensory confusion or sensory mismatch. Motion sickness is a product of misinformation arriving at a central point in the nervous system from the senses from which one determines one's spatial orientation. When information from the eyes, ears, joints, and pressure receptors are all in agreement as to one's orientation, there is no motion sickness. When one or more sensory input(s) to the

brain is not expected, or conflicts with what is anticipated, the end product is motion sickness.

Normally, an observer's eye moves, compensating for the anticipated effect of motion, in such a manner that the image of an object moving relatively to an observer is held stationary on the retina. In almost every known environment that induces motion sickness, a change in the gain (in the signal-processing sense of "gain") of the vestibular system causes the motion of the eye to fail to hold images stationary on the retina, and the resulting motion of the images is termed retinal slip.

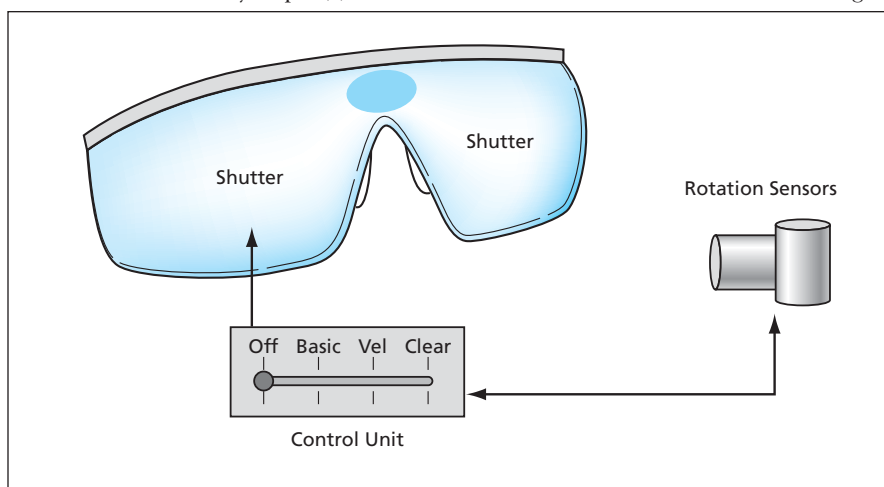
The present concept of stroboscopic goggles or eyeglasses (see figure) is based on the proposition that prevention of retinal slip, and hence, the prevention of sensory mismatch, can be expected to reduce the tendency toward motion sickness. A device according to

this concept helps to prevent retinal slip by providing snapshots of the visual environment through electronic shutters that are brief enough that each snapshot freezes the image on each retina. The exposure time for each snapshot is less than 5 ms. In the event that a higher rate of strobing is necessary for adequate viewing of the changing scene during rapid head movements, the rate of strobing (but not the exposure time) can be controlled in response to the readings of rate-of-rotation sensors attached to the device.

The shutters are compact, fast-acting, low-voltage, low-current liquid-crystal display devices of the polymer-dispersed liquid-crystal type. The shutters are installed in the lens spaces in the goggle or eyeglass frame. Sensors that measure the rates of rotation about the yaw and pitch axis are attached to the frame. Also included is a controller unit that contains a low-frequency oscillator and a switchable driver that receives the rotation-sensor readings. As now envisioned, a user of a production version of the device could select any of at least four basic modes of operation:

- Mode 1: The device would be turned off.
- Mode 2: The shutters would be held transparent, allowing ordinary vision.
- Mode 3: The shutters would open at a standard stroboscopic flash rate of 4 Hz.
- Mode 4: The flash rate would be adjusted according to the sensed rates of rotation. The maximum flash rate would be 40 Hz.

The standard flash rate of 4 Hz was chosen partly on the basis of effectiveness in suppressing motion sickness and



A Pair of Goggles or Eyeglasses contains electronic shutters in place of or in addition to lenses. The shutters can be strobed at either a constant rate or a rate that depends on the rates of yaw and pitch of the wearer's head.

partly because it is low enough not to trigger seizures in most individuals afflicted with photosensitive epilepsy. (Approximately one person in 10,000 has photosensitive epilepsy, which is triggered by a number of visual phenomena, including, in most cases, lights flashing

at rates between 15 and 20 Hz.) Preferably, individuals who have any form of epilepsy or any of a number of related disorders should not use this device.

This work was done by M. F. Reschke of Johnson Space Center and Jeffrey T. Somers of Wyle Laboratories.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23444.

Articulating Support for Horizontal Resistive Exercise

Supports can be optimized for a variety of prescribed exercises.

Lyndon B. Johnson Space Center, Houston, Texas

A versatile mechanical device provides support for a user engaged in any of a variety of resistive exercises in a substantially horizontal orientation. The unique features and versatility of the device promise to be useful in bed-rest studies, rehabilitation, and specialized strength training. The device affords a capability for selectively loading and unloading of portions of the user's body through its support mechanisms, so that specific parts of the body can be trained with little or no effect on other parts that may be disabled or in the process of recovery from injury. Thus, the device is ideal for rehabilitation exercise programs prescribed by physicians and physical therapists. The capability for selective loading and support also offers potential benefits to strength and conditioning trainers and athletes who wish to selectively strengthen selected parts.

The principal innovative aspect of the device is that it supports the subject's weight while enabling the subject, lying substantially horizontally, to perform an exercise that closely approximates a full

standing squat. The device includes mechanisms that support the subject in such a way that the hips are free to translate both horizontally and vertically and are free to rotate about the line connecting the hips. At the same time, the shoulders are free to translate horizontally while the upper back is free to rotate about the line connecting the shoulders.

Among the mechanisms for hip motion and support is a counterbalance that offsets the weight of the subject as the subject's pelvis translates horizontally and vertically and rotates the pelvis about the line connecting the hips. The counterbalance is connected to a pelvic support system that allows these pelvic movements. The subject is also supported at the shoulder by a mechanism that can tilt to provide continuous support of the upper back while allowing the rotation required for arching the back as the pelvis is displaced. The shoulder support also affords a capability for horizontal motion, and acts as the point of attachment of a load that is provided for squat and heel-raise exercises. The

device is compatible with any resistive-exercise machine that provides bilateral loading via a moving cable or other mechanical linkage.

The hip-translation and shoulder-translation and -rotation degrees of freedom of the supports can be locked individually or in combination in order to support the subject as necessary for exercises other than the standing squat. If necessary, for such exercises, the load can be applied directly to the subject by use of various attachments. In addition to the aforementioned heel raise, such exercises include the upright row, leg press, curls, extension of the triceps, front raise, lateral raise, and rear raise.

This work was done by Daniel Gundo of Ames Research Center and Grant Schaffner, Jason Bentley, and James A. Loehr of Wyle Laboratories for Johnson Space Center.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23594.