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 fibronectin 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.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MCR-23357, volume and number of this NASA Tech Briefs issue, and the page number.

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**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...
partly because it is low enough not to
trigger seizures in most individuals af-
flicted with photosensitive epilepsy. (Ap-
proximately one person in 10,000 has
photosensitive epilepsy, which is trig-
gered by a number of visual phenomena,
including, in most cases, lights flashing
at rates between 15 and 20 Hz.) Prefer-
ably, 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.

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 pro-
vides 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 special-
ized strength training. The device af-
forded 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 ex-
ercise programs prescribed by physi-
cians and physical therapists. The capa-
bility for selective loading and support
also offers potential benefits to strength
and conditioning trainers and athletes
who wish to selectively strengthen se-
lected 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 trans-
late both horizontally and vertically and
are free to rotate about the line connect-
ing the hips. At the same time, the shoul-
ders are free to translate horizontally
while the upper back is free to rotate
about the line connecting the shoulders.

Among the mechanisms for hip mo-
tion and support is a counterbalance
that offsets the weight of the subject as
the subject’s pelvis translates horizon-
tally 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 mecha-
nism that can tilt to provide con-
tinuous support of the upper back
while allowing the rotation required
for arching the back as the pelvis is dis-
placed. The shoulder support also af-
fords a capability for horizontal mo-
tion, 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 bilat-
eral loading via a moving cable or
other mechanical linkage.

The hip-translation and shoulder-
translation and -rotation degrees of free-
dom of the supports can be locked indi-
vidually or in combination in order to
support the subject as necessary for exer-
cises 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
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Center, (281) 483-0837. Refer to MSC-
23594.