The **Cable Shield Is Terminated on the Outside** of the backshell instead of on the inside as in a traditional design. The mechanical and electrical integrity of the shield termination is ensured by squeezing of the shield between the cover and the band clamp.

place when the band clamp is tightened.

The procedure for assembling the cable, the backshell, and the rest of the connector is the following: The cable is placed through the coupling nut on the backshell body, the insulation on the cable wires is stripped back, and each wire is crimped to a connector pin. The pins are inserted in the connector. The coupling nut is threaded onto the connector. The shield (assumed to made of braided wire) pulled through the hole on the cover. Tape is wound around the cable near the left end of the backshell to provide strain relief. The cover is latched in place on the backshell body. The band clamp is tightened around the cover/backshell-body assembly with the shield squeezed between the cover and the band clamp. Once electrical continuity between the shield and the backshell has been verified, the shield is trimmed and the cable is examined for proper strain relief.

If the cable is unshielded or if termination of the shield is not needed, then except for omission of the steps involving the cable shield, the assembly procedure remains as described above. The design of the backshell for such a case can also remain the same, except that optionally, the hole near the left end of the cover can be eliminated because it is not needed.

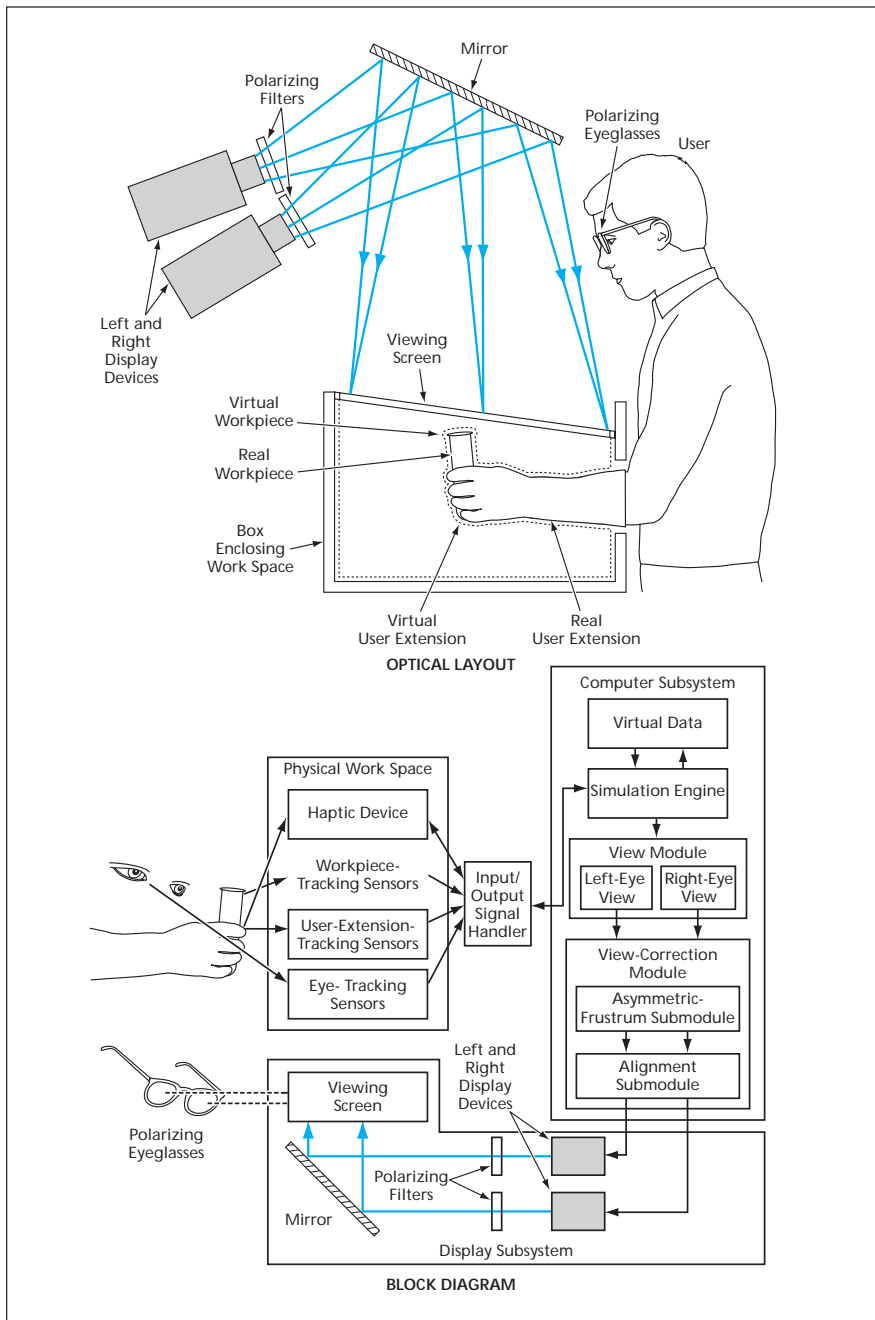# Glove-Box or Desktop Virtual-Reality System

Multiple remote users can participate in a realistic simulation of a work space.

Ames Research Center, Moffett Field, California

The figure depicts salient features of the optical layout of a desktop-scale virtual-reality system that is specialized for simulating a glove-box work space. The system generates stereoscopic left- and right-eye images of the interior of the work space that show (1) a user extension (defined here as an arm, hand, and/or one or more of the fingers on the hand of a user) and (2) either a real or a virtual workpiece to be manipulated by the user extension. The positions and orientations of the user extension and workpiece in the virtual images coincide substantially with those of the real user extension and of the real

Labels in optical layout: Polarizing Filters, Mirror, Polarizing Eyeglasses, User, Left and Right Display Devices, Viewing Screen, Virtual Workpiece, Real Workpiece, Box Enclosing Work Space, Virtual User Extension, Real User Extension

OPTICAL LAYOUT

Labels in block diagram: Computer Subsystem, Virtual Data, Simulation Engine, View Module, Left-Eye View, Right-Eye View, View-Correction Module, Asymmetric-Frustrum Submodule, Alignment Submodule, Physical Work Space, Haptic Device, Workpiece-Tracking Sensors, User-Extension-Tracking Sensors, Eye- Tracking Sensors, Input/Output Signal Handler, Left and Right Display Devices, Viewing Screen, Polarizing Eyeglasses, Polarizing Filters, Mirror, Display Subsystem

BLOCK DIAGRAM

This **Virtual-Reality System** simulates a work space immediately in front of the user, as in a glove box. The system generates stereoscopic images that are compensated for changing positions of the user's eyes.

workpiece if one exists. The images are compensated for the non-central positions of the user's eyes relative to a viewing screen on which they are presented.

The system consists of three major parts: the physical work space, a computer subsystem, and a display subsystem. In addition to the user extension, the physical work space contains sensors that track the position and orientation of the user extension, sensors that track the positions of the user's eyes, and sensors that track the position and orientation of the workpiece (if any). Option-

ally, attached to the user extension is a pen-style haptic device — an assembly that can include actuators that apply forces to the end of a pen stylus held by a user to simulate contact between the stylus and a virtual workpiece. The sensor readings are digitized in real-time and sent to the computer subsystem.

The computer subsystem runs software, denoted a simulation engine, that simulates the manipulation of the workpiece by the user extension. The simulation engine includes mathematical models of all relevant aspects of the

three-dimensional geometry and physical properties of the user extension and the workpiece, and calculates interactions between objects using a physics based force model. The simulation utilizes the tracking data provided by the sensors plus stored data (denoted virtual data) on the dimensions and physical properties of the user extension and the workpiece. The simulation can include such details as the positions and orientations of finger segments, contact forces with the stylus, and even deflections of the workpiece if the workpiece is a deformable body.

The output of the simulation engine is fed to a software module that generates nominal left- and right-eye views for eyes that are spaced apart by an amount that can be adjusted to match the inter-pupillary distance of the user. The views are then processed by a software module that uses the eye-tracking sensory data to correct for the deviation of the user's eye positions from nominal viewing positions. An important part of the view-correction module is a submodule in which the geometry of the viewing screen and the user's eyes is represented by means of an asymmetric frustum that is repeatedly updated in response to the eye-tracking data.

The outputs of the view-correction module are synchronized by an alignment submodule, then fed to the display subsystem, wherein two display devices generate the left- and right-eye images. The images are projected onto the viewing screen through circularly polarizing filters, such that the left and right images are polarized orthogonally to each other. The user wears a pair of correspondingly polarized eyeglasses so that the left or right eye sees only the left or right image, respectively.

A somewhat more complex version of the system can include two or more physical-work-space/display subsystem assemblies, possibly at different locations. The simulation engine from each work-space is connected via a network to the other simulation engines. This system would make it possible for multiple remote users to work together, or simulate working together, on the same workpiece.