

Exploratorium Cookbook II

A Construction Manual for Exploratorium Exhibits

by Ron Hipschman and the Exploratorium staff

(c) 2002 Exploratorium, www.exploratorium.edu

You may print this Cookbook PDF file for informational, educational, and other non-commercial purposes provided you include the above copyright notice. You may not reproduce, record, publish, modify, or distribute any Exploratorium digital asset for commercial purposes without prior written consent from the Exploratorium.

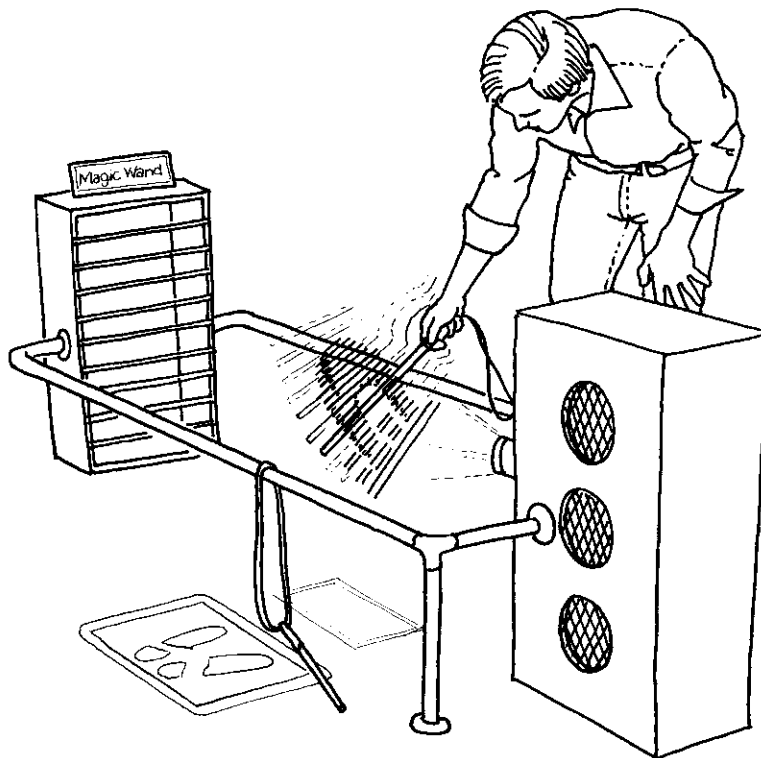
High resolution versions are available. Requests for commercial use of digital assets or questions as to whether a specific use is permissible or requires written consent should be sent to:

permissions@exploratorium.edu

Print copies of the original Exploratorium Cookbook series may be purchased online at:

www.exploratorium.edu/store

Magic Wand



Description

The visitor waves the "magic wand" rapidly up and down in an apparently dark area. A picture of the Palace of Fine Arts magically appears where the wand is waved. This exhibit works because of the persistence of vision in the eye/brain of the visitor.

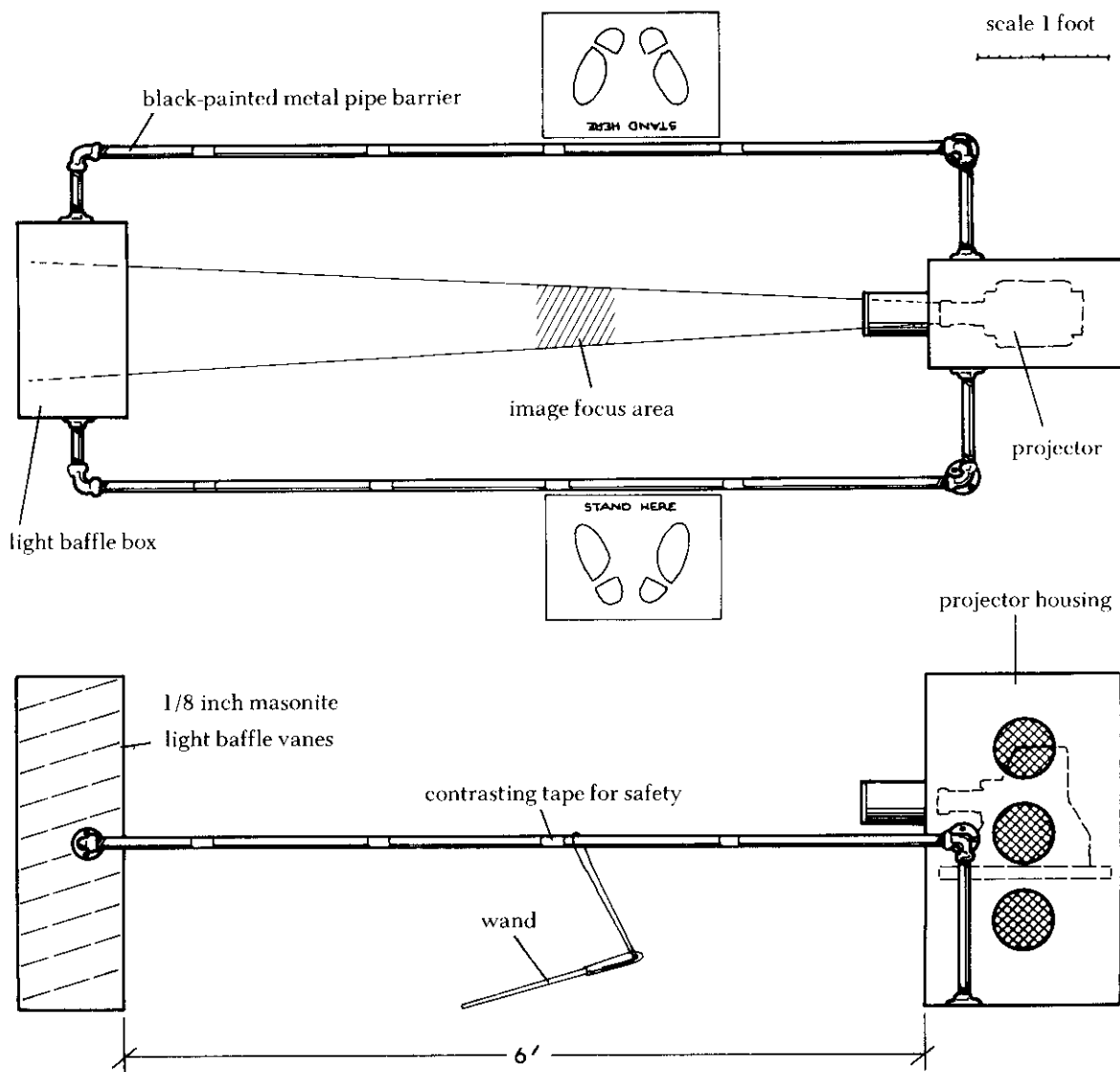
Construction

The exhibit is very simple, consisting of a non-automatic slide projector and light baffle. The slide projector is focused midway between it and the baffle. Our projector has a built in cooling fan which is necessary since it is housed in a box and would otherwise overheat. It projects through a tube in

front of the box which cuts down on the scattered light. The tube has a screen in it to keep the lens from being poked with the wand. The slide that is projected should be simple and of some recognizable object.

The wand is made of wooden doweling, 1/4" in diameter and about 12" long with a larger 1/2" dowel handle. The dowel is painted white for high reflectivity and must be kept clean since dark spots on the rod will cause streaks to appear across the picture when waved.

The wands are attached to the iron pipe barrier with nylon cord long enough to allow movement in and out of the focal plane. The barrier was constructed to keep people from walking through the projected image, and needs to be prom-



inently marked to keep people from tripping over it.

The baffle box at the end of the exhibit is painted flat black and has backward slanting wooden vanes inside of it to catch and absorb as much light as possible. This way, no clue is given of what will be seen when the wand is waved.

Additions and Changes (1990)

We no longer use wooden dowels, which tended to break and become a hazard. Instead, we use nylon rods covered with heat-shrink tubing. It is important that the wand be opaque

and white. We use the heat-shrink tubing since nylon is translucent and yellowish.

Related Exploratorium Exhibits

PERSISTENCE OF VISION

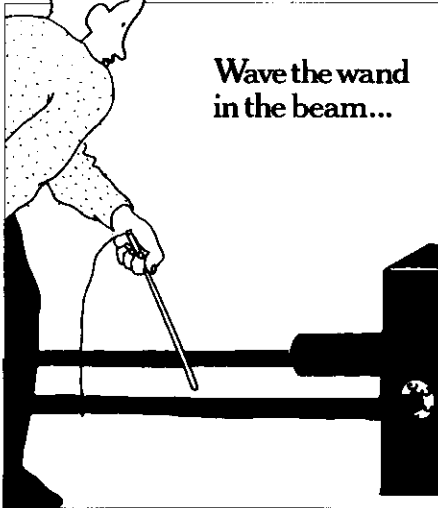
Whirling Watcher

Lightform

Persistence of Vision

LIGHT

Magic Wand



To do and notice:

- Stand on the footprints.
- Hold the stick in your left hand and wave it rapidly up and down between the railings. Lean over and look at the front of the stick.

What is going on:

The beam of light from a slide projector is focusing an image of a slide in the empty space between the railings. The image is there even when you aren't waving the wand, but you can't see it unless something reflects the light to your eyes.

When you wave the wand, the image reflects piece by piece from the moving wand. Your eye retains each of these pieces for about one-tenth of a second—long enough to let you put them together and make a composite picture.

for
left
side of
exhibit

Magic Wand

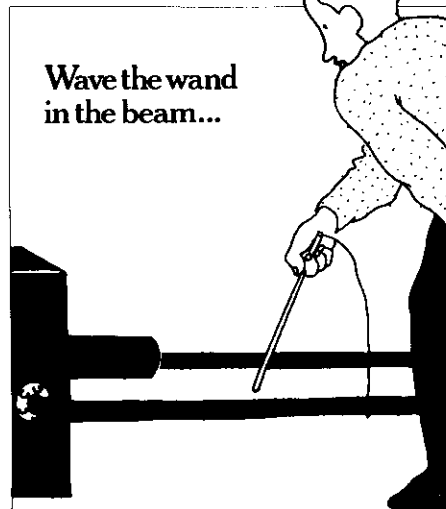
To do and notice:

- Stand on the footprints.
- Hold the stick in your right hand and wave it rapidly up and down between the railings. Lean over and look at the front of the stick.

What is going on:

The beam of light from a slide projector is focusing an image of a slide in the empty space between the railings. The image is there even when you aren't waving the wand, but you can't see it unless something reflects the light to your eyes.

When you wave the wand, the image reflects piece by piece from the moving wand. Your eye retains each of these pieces for about one-tenth of a second—long enough to let you put them together and make a composite picture.



for
right
side of
exhibit

Table of Contents for Cookbooks I, II, and III

Cookbook No.-Recipe No.

Mechanics

Balancing Stick	1-75
Bernoulli Blower	2-83
Bicycle Wheel Gyro	2-84
Descartes Diver	3-135
Downhill Race	3-136
Falling Feather	3-137
Gyroscope	3-138
Momentum Machine	1-74

Electricity and Magnetism

Black Sand	2-87
Bulbs and Batteries	2-88
Circles of Magnetism	2-89
Color TV and Magnetism	3-139
Daisy Wheel Dyno	3-140
Earth's Magnetic Field	1-80
Eddy Currents	1-82
Electrical Fleas	3-141
Energy vs. Power	3-142
Finger Tingler	3-143
Generator Effect	1-81
Giant Electroscope	2-90
Giant Meter	3-144
Glow Discharge	3-145
Hand Battery	2-91
Induction	3-146
Jacob's Ladder	2-93
Magnetic Lines of Force	2-92
Magnetic Suction	3-147
Magnetic Tighrope	1-79
Ohm's Law	3-148
Pacific Gas and Leather	3-149
Pedal Generator	3-150
Pluses and Minuses	1-78
Short Circuit	3-151
Son of Transformer	3-152
Suspense	3-153
Transformer	3-154
Very Slow Electrical Oscillations	3-155
Watt's the Difference	3-156
Zero to Sixty	3-157

Eye Physiology

After Image	1-37
Blind Spot	1-36
Blood Cells (Corpuscles of the Eye)	1-34
Blood Vessels	1-33
Eyeballs (Eyeball Machine)	1-31
Macula	1-35
Pupil	1-32

Eye Logic

Fading Dot	1-38
Floating Rings	1-47
Frozen Hand	1-21
Horse's Tail (Gray Step 1)	1-43
Mondrian (Gray Step 3)	1-45
Motion Detection	2-94
Moving Stripes	1-40
Peripheral Vision	1-42
Persistence of Vision	1-46
Rotating Gray Step (Gray Step 2)	1-44
Shimmer	1-39
Sliding Gray Step (Gray Step 4)	3-158
Three Spinners (Benham's, Depth, and Palm)	1-41
Whirling Watcher	3-159

Monocular Vision/Size and Distance

Changing Squares	3-160
Distorted Room	1-56
Far-Out Corners	1-58
Glass Camera (Perspective Window)	1-55
Impossible Triangle	1-57
Multi-Dimensional Shadows	1-60
Reverse Masks	1-59
Size and Distance	3-161
Thread the Needle	1-54
Trapezoidal Window	1-61

Stereoscopic Vision

Binocular Vision (Eyeballs)	1-48
Cheshire Cat	3-162
Delayed Vision	1-52
Lenticular Images (3-D Dots)	1-51
Reach For It	3-163
Reverse Distance	1-53
Stereo Rule	1-49
Three-D Shadows	1-50
Two As One	3-164

Color Vision

Bird in Cage	1-30
Color Reversal	1-29
Color Table	3-165
Green Tomatoes	2-106
Orange Shadows	3-166

Refraction

Chromatic Aberration (Rainbow Edges)	1-27
Critical Angle	1-2
Disappearing Glass Rods	2-104
Glass Bead Rainbow	1-4
Image Quality	3-167
Jewels (The Jewel Box)	1-5
Lens Table	1-11
Optical Bench	1-12
Rainbow Encounters	1-3
Refraction (Bathroom Window Optics)	1-6
Telescope	1-13
Water Sphere Lens	3-168

Reflection

Anti-Gravity Mirror	3-169
Corner Reflector	3-170
Duck Into Kaleidoscope	2-107
Everyone Is You and Me	3-171
Hot Spot	1-18
Look Into Infinity	2-109
Magic Wand	2-110
Mirrorly a Window	2-111
Parabolas	1-15
Shadow Kaleidoscope	1-20
Shake Hands With Yourself	1-17
Spherical Reflections (Christmas Tree Balls)	1-19
Touch the Spring	1-16
Pinhole Images	
Holes in a Wall	2-108
Pinhole Magnifier	1-14
Sophisticated Shadows	2-112

Interference

Bridge Light	1-9
Diffraction	1-7
Long Path Diffraction	1-8
Soap Bubbles	1-10
Soap Film Painting	3-172

Polarization

Blue Sky	2-95
Bone Stress	2-96
Glass Catfish	2-97
K.C.'s Window	1-24
Polarized Light Island	3-173
Polarized Radio Waves	1-26
Polarized Image Mosaic	1-25
Polarized Sunglasses	1-23
Rotating Light	2-98
String Analogy	1-22

Light and Color

Color Removal	3-174
Colored Shadows	1-28
Distilled Light	2-105
Grease Spot Photometer	2-130
Inverse Square Law	3-175
Iron Sparks	3-176
Laser Booth	3-177
Light Island	3-178
Spectra	2-131

Stored Light	2-132
Sun Painting	1-1

Heat and Temperature

Brownian Motion—Real	2-128
Brownian Motion Model	2-127
Cold Metal	3-179
Convection Currents	3-180
Curie Point	3-181
Give and Take	2-125
Heat Pump	2-129
Hot-Cold	3-182
Low Frequency Light	2-126
Skillet	3-183
Water Freezer	3-184

Sound, Waves and Resonance

Bells	1-64
Conversation Piece	3-185
Earpiece	2-113
Echo Tube	2-114
Focused Sound	2-115
Giant Guitar String	3-186
Harmonic Series Wheel	1-66
No Sound Through Empty Space	1-65
Organ Pipe	3-187
Pendulum Table	3-188
Pipes of Pan	3-189
Resonant Pendulum	2-85
Resonant Rings	2-86
Resonator	1-63
Vibrating String	2-116
Visible Effects of the Invisible	3-190
Walking Beats	2-117
Watch Dog	1-67
Wave Machine	1-62

Music

Circular Scales	1-71
Multiplied Glockenspiel	1-73
Piano Strings	1-72

Speech and Hearing

Delayed Speech	3-191
Hearing Meaning	3-192
Hearing Range	3-193
Language Wall	3-195
Selective Hearing	1-70
Stereo Hearing (Stereo Sound 1)	1-69
Tone Memory	1-68
Vocal Vowels	3-194

Animal and Plant Behavior

Brine Shrimp Ballet	2-99
Microscope Projector	2-100
Mimosa House	2-101

Neurophysiology

Crayfish Eye's Response to Light	2-118
E.M.G.	2-119
Garden of Smells	3-196
Grasshopper Leg Twitch	2-120
Heartbeat	2-121
Reaction Time	2-122
Sweat Detector	2-123
Watchful Grasshopper	2-124

Patterns

Harmonograph (Drawing Board)	1-76
Horse and Cowboy	3-197
Moiré Patterns	2-133
Non-Round Rollers	3-198
Relative Motion	1-77
Sun Dial	2-134

Mathematics

Bouncing Ball	3-199
Catenary Arch	2-102
Chaotic Pendulum	3-200
Fading Motion	2-103
Square Wheels	3-201