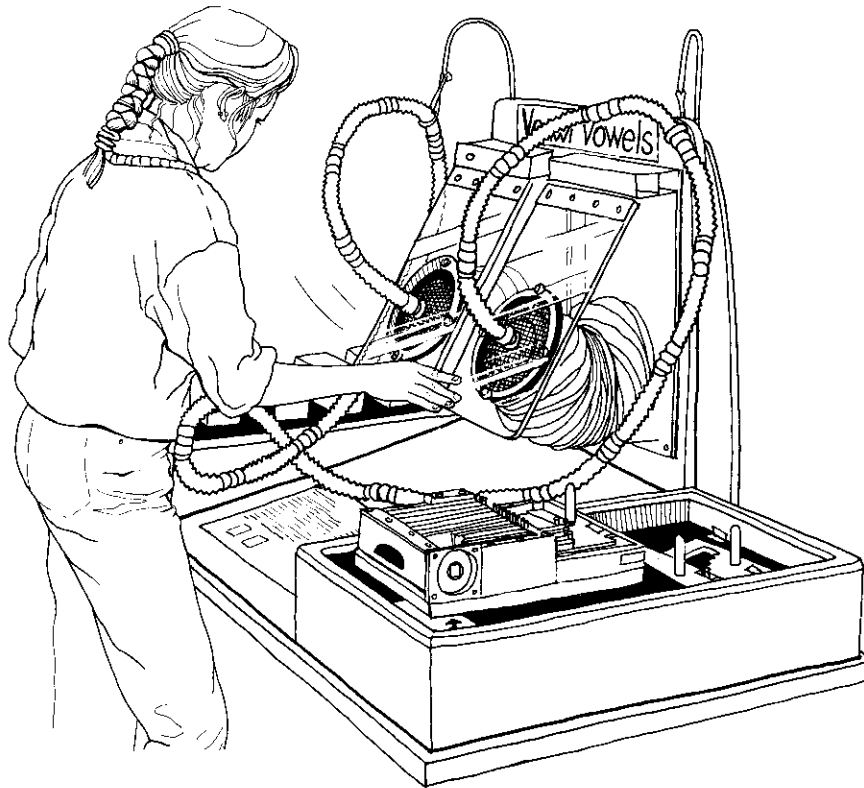


Vocal Vowels



Description

A bellows is compressed to produce a flow of air which is directed into a duck-call, making it quack—just as air from your lungs makes your vocal cords vibrate. Like your vocal cords, the reed of the duck-call produces a complex sound made up of many different frequencies. When the duck-call is placed at the end of one of five plastic models, only some of the frequencies resonate within the contours of the model, and a particular vowel sound is produced. Each of these models mimics the shape of our vocal tract when we make one of the vowel sounds ee, eh, oh, oo, or ah.

Construction

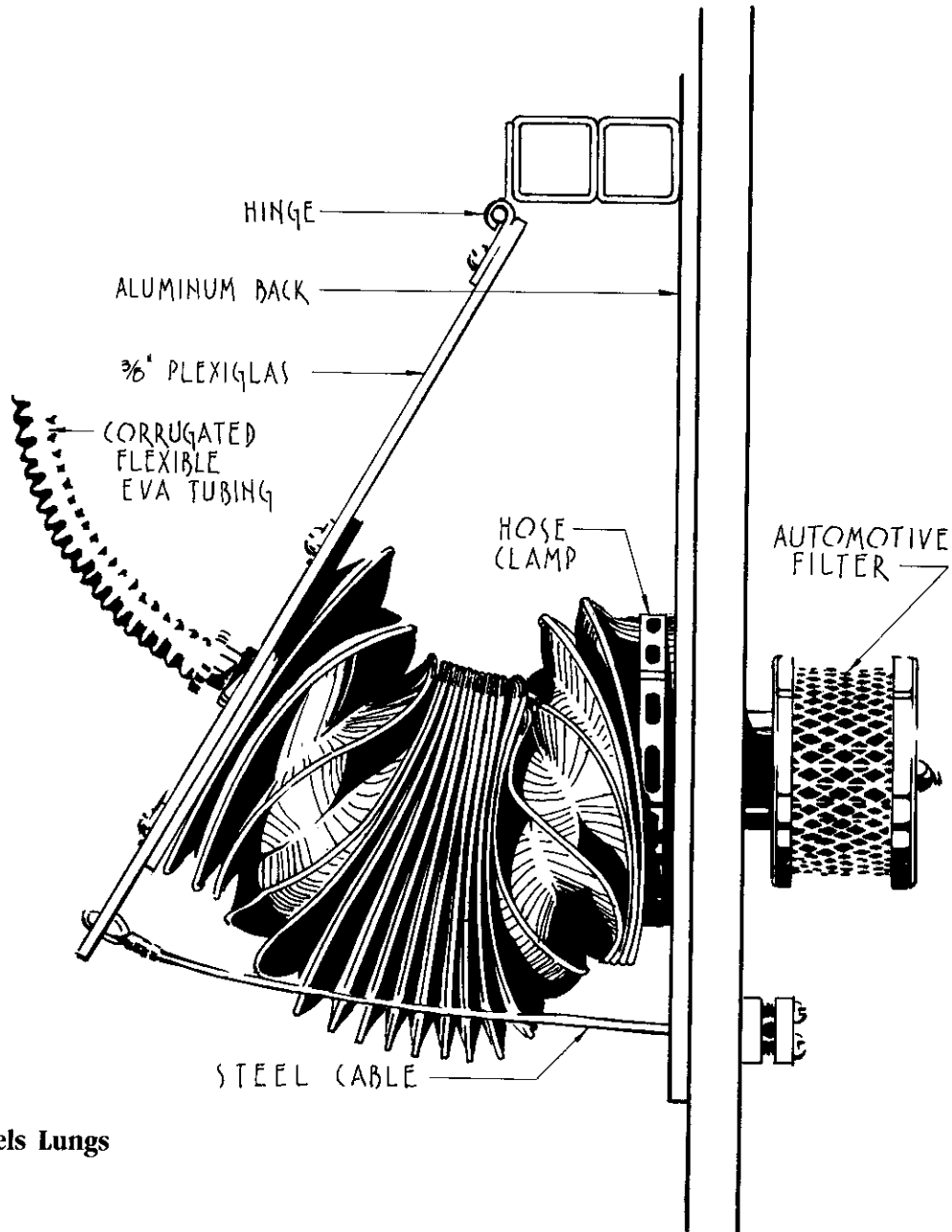
The exhibit centers around the five plastic vocal tract models. Unfortunately, these models are very difficult to make. If you have experience in casting plastics, we used the “lost wax” method of casting our blocks. If you don’t know what “lost wax” casting is and wish to try anyway, be prepared to spend several months refining your craft. (Give us a call and we’ll be happy to pass along some pointers.) We have included the cross sections of the molds if you want to make them yourself. See the Critique and Speculation section of this recipe for other methods (untested) of fabricating the models. By far the easiest way to obtain these models is to buy them from:

Miami Science Museum
 Attn: Eric Speyer, Director
 3280 South Miami Ave.
 Miami, FL 33129
 telephone: (305) 854-4242

The Miami Science Museum sells the models for \$200.00 each (\$1000.00 for the set of five).

The vocal cord end of each plastic model has a steel plate and plastic positioner into which the duck-call fits. A ring magnet on the duck-call holds it firmly in place on the steel plate.

We have mounted our models on a light-box. The top of the lightbox



Vocal Vowels Lungs

is blacked out except for the area under the models, making for a rather attractive display. The written vowel sound and a cutaway profile of the vocal tract for that vowel sound are shown next to each model.

The exhibit's lungs are a heavy rubber bellows (Gortiflex CT-6) available from:

A & A Manufacturing
 2300 South Calhoun Rd.
 New Berlin, WI 53131
 telephone: (414) 786-1500

A & A Manufacturing will make a customized bellows for your special needs at a reasonable cost. Our bellows is mounted on an aluminum back plate, with a piece of 3/8" plexiglas hinged to the aluminum and attached to the front end of the bellows for squeezing (see diagram). Air enters the bellows through a standard automotive air filter which sticks out the back of the exhibit; a simple flap-valve provides the one-way action here.

We've put a spring (hand wound from stiff 1/8" diameter wire) inside the bellows to make it bounce back after being compressed. Both ends of this spring are fixed in place with cable tie-downs. The back end of the bellows slips over a ring welded to the aluminum back plate and is hose-clamped in place. The front end of the bellows is passed through an aluminum ring which is bolted to the plexiglas plate. We have found that the life of the bellows is substantially lengthened if you coat the inside of the first few pleats at both ends with Duro "Black Plastic Rubber". This is available at most automotive supply houses. This coating keeps the bellows from cracking at these stress points. Two steel cables run from the lower corners of the plastic plate to the aluminum back, and are crimped in place, so that the bellows can't be pulled open too far.

The hose to the "quacker" fits over a machined plastic nipple on the front plastic plate and is held in place with a split-ring clamp. Our hoses are corrugated flexible E.V.A. tubing 3/4" ID and 72" long, available from:

Inspiron
Division of C. R. Bard, Inc
161 North Mountain Ave.
Upland, CA 91786

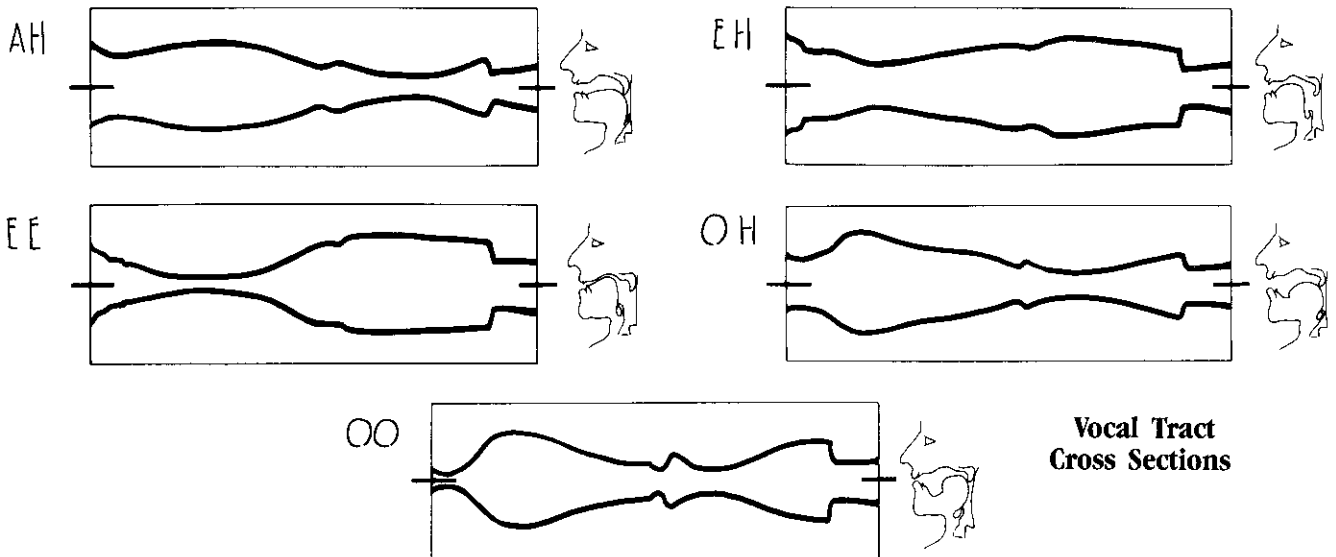
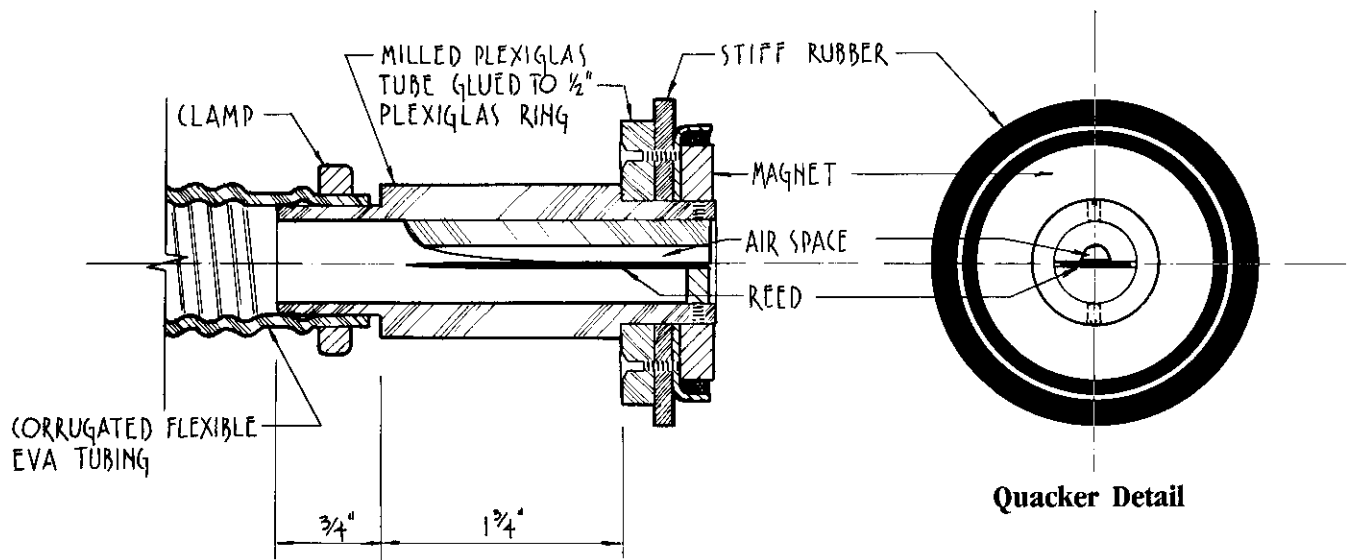
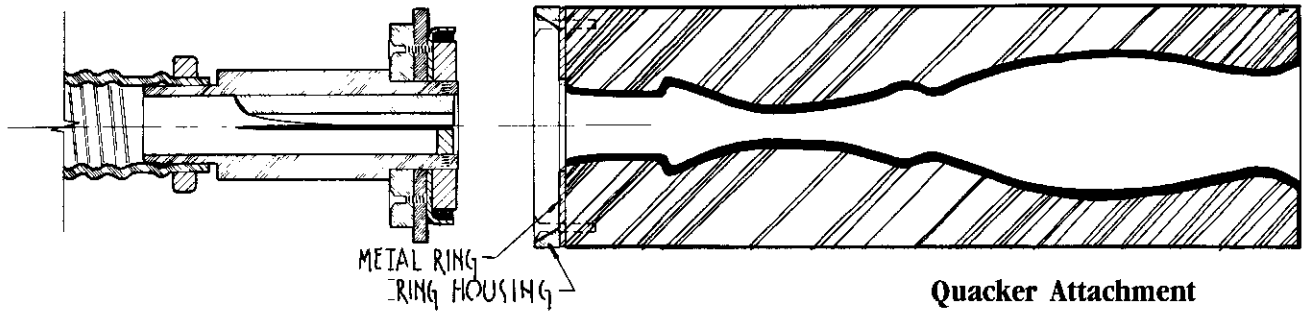
You can probably order this tubing through your local medical supply house. Order #001520.

The plastic tubing leads to a specially built duck-call (see cut-away). We buy the reeds from:

Black Duck
1737 Davis Avenue
Whiting, IN 46394
telephone: (219) 659-2997

We use the reed from the W-1010 duck call. If you wish to buy the reeds only, contact the president of the company, Mrs. Mehok. Since we have two quackers on our exhibit we made a higher (female) and lower (male) quacker.

On the right-hand side of the exhibit is a variable vocal tract. The construction details of this would be extremely difficult to describe since it is the result of many remakes and modifications. But here's the general idea: The cavity is made by sandwiching two 1/2" thick pieces of glass (the glass must be thick to keep it from radiating sound) with 2 cm. thick spacers between them. Stacked plastic slats, 1/4" thick and 2 cm. wide, are used to vary the contour of the cavity. These slats have small screws for handles at one end, and are made from strips of plexiglas and delrin, alternated to reduce friction. The vocal cord end has the same "quacker holder" as the plastic blocks. We have provided templates, made from 1/4" aluminum, which can be placed against the plastic sliders and act as guides to position the strips for various sounds. By putting a handle on the face of each template, and a notch in one corner (which matches a corresponding protrusion in the space where the template fits), we assist the user in positioning the template properly. The plastic slats can be slid against a template to match its profile; or you can move them without template guidance, testing various shapes and their corresponding sounds.



Critique and Speculation

Here are two other possible (but untested) ways to make the vocal tract models:

- 1) Clay: Using the dimensions of the vocal tracts, make a series of clay doughnuts of the appropriate diameters and assemble them into a tube of (approximately) the correct contours
- 2) Plexiglas stack: Machine a stack of 1/4" thick plexiglas squares with holes whose diameters match the varying widths of the needed profile. Solvent cement the stack together, and you've made your clear model a lot faster than we made ours.

Related Exploratorium Exhibits

Voice and Speech

Pitch Switch; Variable Speech Control; Vocal Mirror; Delayed Speech; Voice Trace; Voice Trombone; Speech Dissector.

Resonance

Coupled Pendulums; High & Low Q; Resonant Rings; Resonator; Visible Effects of the Invisible; Voice Trombone; Aeolian Harp; Sound Column; Pipes of Pan; Pendulums.

Exploratorium Exhibit Graphics

Vocal Vowels

These plastic models turn the squawk of a duck call into vowel sounds.

To do and notice

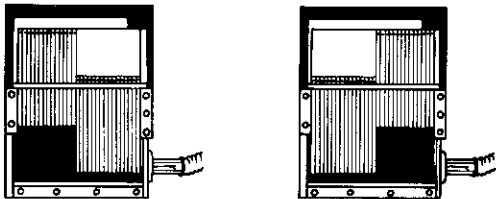
Press on the bellows. The sound you hear is made by the reed from a duck call.

Insert the end of the hose into the hole in one of the clear plastic vocal tract models. Press on the bellows again. Try the other models and compare the sounds.

Compare the shapes inside these models with the pictures at the left. The pictures show the shape of your vocal tract, the cavity formed by your mouth and throat, when you say different vowels.

You can adjust the model at the right to make different sounds. Insert the hose in the model, move the individual slats up or down, press the bellows and listen to the sound. Change the position of the slats and notice how that affects the sound.

Use the aluminum templates to arrange the slats and make specific vowel sounds. Or try shapes like these:



What is going on

The chamber of each plastic model is shaped like the human vocal tract. When you say different vowels, you change the shape of your vocal tract. That's why each model is a little different from the others.

A puff of air from the bellows makes the reed in the end of the hose vibrate, just as the air from your lungs make your vocal cords vibrate. Like your vocal cords, the vibrating reed produces a complex sound composed of many different pitches.

Like your vocal tract, the plastic models shape these complex sounds to make particular vowel sounds. When the complex sound echoes from the walls of the plastic cavity, some pitches are reinforced and some are not. The process of reinforcement and cancellation of certain pitches changes the squawk of the duck call into a recognizable vowel sound.

Exploratorium Cookbook III

A Construction Manual for Exploratorium Exhibits

by Ron Hipschman

(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

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 Slide	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 Tingles)	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
Skillets	3-183
Water Freezer	3-184

Sound, Waves and Resonance

Bells	1-64
Conversation Piece	3-185
Farpiece	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