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MODULATING SOUND AND MOTION:
ELECTRONIC AND PHYSICAL MEMBRANES FOR URBAN DWELLERS

BY

JAMES HORN

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

MASTER OF ARCHITECTURE

APPROVED, THESIS COMMITTEE

Michael Bell, Director
Associate Professor of Architecture
Rice University, School of Architecture

Kramer Woodard
Associate Professor of Architecture
University of New Mexico
School of Architecture and Planning

David Guthrie
Visiting Critic of Architecture
Rice University, School of Architecture

Houston, Texas
May 1999
ABSTRACT

MODULATING SOUND AND MOTION:
ELECTRONIC AND PHYSICAL MEMBRANES FOR URBAN DWELLERS

BY

JAMES HORN

Dwellings in congested urban areas are confronted with both invigorating and aggravating penetrations of proximic sound and street activity within constricted environments. Typically the physicality of a building is there to serve as SHELTER from weather, intruders, and to create an interior effect. Here building elements, both physical and electronic, are considered to serve as MODULATORS of environmental infiltration.

If the DWELLING is a holistic physiological system then it should be an extension of our physiological being and an extension of the urban landscape. Attunement of infiltrating SOUND and VISION (or MOTION) for dwellings in urban areas can provide for more appropriate environments. Contextual sound and motion can be managed into useful energies in urban habitats to provoke different sensory terrains.
ACKNOWLEDGEMENTS

Thanks to the students, friends, and family who helped and believed in the concepts and concerns which I was grappling with during this project. A smooth transfer and development of information and ideas was made possible thanks to Kramer, Michael, David G., David N., Brett D., Carmen, and Claudia, both short-distance and long-distance. Thanks to all of the local suppliers and consultants of acoustic materials, electronics, and closed circuit television equipment. Thanks to Chris S. for the support, time, and understanding given to fulfill my desires near the end, and to Carice and Ali for productive support and prep work. And thanks to the various, spontaneous critiques from faculty, students, and some thumbs in the halls and galleries of RSA along the way. Thanks to Claudia for inspiration and courage with sound experiments and constructions.
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4. MEMBRANE / MODULATOR
5. MOTION / VISION
6. SOUND from site
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8. SOUND CHARTS
PREFACE

The discovery and unrevealing of contextual, material, sonorous, and dynamic issues was the true aspect of this project. Being close to the work and the experiments provided the most direct description and experience of the work. The thesis presentation and defense was a representation of those sound and motion experiments through video playback, audio playback, graphic, and verbal description. This document is a further representation of the presentation. The full impact of this project is through direct contact and can be only partially described and dictated through documentation.
“In causing matter to vibrate, it [sound / music] generates a tone which departs from first-order materiality, and thus opens to the “theoretical sense” of hearing, in fact more ideal than sight since it moves in a dimension of pure temporality akin to the movement of the soul.” (Wallenstein)

Dwellings in congested urban areas are confronted with both invigorating and aggravating penetrations of proximic Sound and street Activity within constricted environments. Typically the physicality of a building is there to serve as Shelter from weather, intruders, and to create an interior effect, yet does not always provide an adequate buffer for sound and urban activity. “A house: a shelter against heat, cold, rain, thieves, and the inquisitive. A receptacle for light and sun. A certain number of cells appropriated to cooking, work, and personal life.” (Le Corbusier, p.114) In this design project various physical and electronic elements are considered to serve as Modulators of de-saturation and re-stimulation of persistent environmental infiltration in order to hopefully overcome the lack of control over urban environments.
If the DWELLING is a holistic physiological system then it should be an extension of our physiological being and an extension of the urban landscape.

"The Architect must keep it in mind and feel responsible for the subtle but vital preservation and satisfaction of human nerves and of life itself." (Neutra, Human Settings in An Industrial Civilization) The attunement of infiltrating SOUND and VISION (or MOTION) of dwellings in urban areas should provide more appropriate environments for living. Contextual sound and motion can be managed into useful energies in urban habitats to provoke different sensory terrains.

The dominance of buildings comprised of "compartmentalized" boxes of an unhealthy nature, a lack of connection to outside and context, continues in urban situations while urban noise, congestion, and distractions don't decrease. While one of the intents of modern architecture was to "free" buildings of constricting elements such as unnecessary inner walls and outer walls, people still deal with constricting environments in increasingly congested urban areas. According to an article in the Wall Street Journal, Weekend Journal, August 7, 1998, "In the year 2001, new homes will look more like medieval fortresses than futuristic bubbles...more rooms defined for specific purposes (Fletcher). I would hope that building and urban design is progressing with the increase in
populations and densities of civilizations, not reverting to hedging people in. As in the buildings of Richard Neutra, the Case Study Houses, and the spirit of homes in the 50's and 60's there was a desire for "...free, open, outward-looking space..." (Ford, intro). Many of Neutra’s buildings and their layouts were constructed as primitive organisms with central concealing / private cores and open, outward-looking perimeters in order to provide a healthy living environment. Dwellings in congested neighborhoods don’t have the option to have …free, open, outward-looking space, so other means of expansion and modulation of the given context needs to be exploited. “To live means being engaged in energy exchange and vital contact with the outer world” (Neutra, Survival Through Design, p.178) Context and location of dwelling is critical to understanding living in an area, but when they become caustic to human living the influx of information must be altered. “...a city should be organically limited in its population figure, but having reached a given numerical size, it still can grow in stature by maturing, articulating, evolving its organic parts and their relation and all the urban living benefits that such a process can yield.” (Neutra, Survival Through Design, p.178)

In the Case Study Houses of California in the 50’s and 60’s as well as the buildings of Richard Neutra and Albert Frey, there was a desire for an expansive
approach to living. The houses were open to the surroundings and environment, offering a strong connection to nature and weather. These primarily suburban buildings, with ample space around them, could afford this luxury and permitted a dissolving of compartmentalized living and stymied living conditions.

Moholy Nagy's idea that through the systematic use of light and shadow with motion, the peculiar dimension of film, the dimension of space-time can be revealed. (Moholy Nagy, Visions in Motion, p. 288) In this project, this concept is at work by placing CCTV cameras, slightly out of focus, in and around the apartment in order to "bring in" to the apartment the dynamic of surrounding contextual energies: automobile, pedestrians, street lights, sun, moon, etc. In dwellings where these contextual stimuli are not available, this could be a way to keep the dweller physiologically involved with their surroundings.

Bill Viola's installations and concepts deal with a concern for the correspondence of the microcosm and the macrocosm. The belief in contemporary physics that each particle of matter in space contains information is critical to the study and understanding of subtle, contextual clues for living. Viola claims that landscape is the link between our outer (body) and inner (mind) selves (Viola). The "landscapes" of our lives penetrates everywhere. Light,
sound, smells, pressure, and flavors make up our environments. So to accept
the finite nature of buildings is not appropriate to living. Testing the sounds, light,
and movement of our environments or contextual landscapes provides profound
information for dwelling and constructing. "Motion or change, and identity or rest,
are the first and second secrets of nature: Motion and Rest. The whole code of
her laws may be written on the thumbnail, or the signet of a ring. This whirling
bubble on the surface of a brook, admits us to the secret of the mechanics of the
sky." (Emerson, Nature, p. 389)

There is a combination of invigorating and aggravating consumption of
sound and motion in this neighborhood. This apartment is at the intersection of
San Jacinto and Binz in Houston, Texas. It is at the overlap and flow of the
Museum District, the Medical District, some churches, bus routes, I-59 and 288,
and residential neighborhoods. This area is a product of major automobile, bus
and van activity, day and night, and many pedestrians during the day.

It seems appropriate that residences should be built with urban noise in
mind. Yet, this is not necessarily the case. Case A apartment has many sound
gaps and moves when large automobiles pass at fast speeds. San Jacinto
Street, alone, gets an average of 10 buses per hour passing by. And the sound
level is around 96dB, which begins to be an aggravating repetition. Idling buses, construction, helicopters, jackhammers, booming cars . . . The human body takes this information and adjusts. But the adjustment can propel the body into a state of paraesthesia if exposed to high levels of annoying stimuli. The body works at half sensation, a prickling sensation, like when your leg falls asleep with "pins and needles". Partial sensibility could set-in when the body is inundated with an abundance of noise, doesn't receive normal motion, or senses too much motion.

The introduction of membranes that modulate, break-down, bend, and dissolve incoming energies could play an important role in congested urban environments. My investigations deal with using different materials to test their change under the influence of contextual sound. The sort of motion that comes from this, the types of materials, becomes part of the discovery. The discoveries or conclusions were not meant as literal buildings or designs, but rather as pathways to locating decisions for future buildings and designs. Processing contextual motion, sound, and light, into alternate energies for the urban dweller is the intent of this project. A form of spatial or psychological expansion needs to occur through the process of modulating these proximic energies, to supplement
the lack of connection to (or even isolation from) nature and open space in congested neighborhoods and the situation of over-saturation.

The experiments included taking the recorded site sounds and playing them back through containers of water, latex, and electronics. The water being a fluid membrane which can modulate the inundating sound. A gauge of motion from the influx of sound on the water was considered. The frequency of bus traffic along San Jacinto was measured from the City of Houston Metro Bus Schedule, and then mapped to demonstrate the level and amount of sound during the period of a day that passes along this location. It demonstrated the severity of repetition of noise and movement at this dwelling.

Finally, walls were built to conduct tests on absorption and transmission of sound. Different materials were used to achieve these effects. The concept of the curved wall was to provide an undulating surface of varying lengths to refract corresponding ambient and moving site frequencies. Since exact sound frequencies in a neighborhood cannot be determined precisely, a series of different can absorb them. A direct sound of a bus passing, a bus idling, and a van idling were mapped. Then the same sound was played against the different walls and tested at different frequencies. The results are then mapped onto
graphs which show the amount of absorbed sound levels and different frequencies. The curved wall was successful in refracting sound better than the flat metal surface, whereas the perforated wall served well as a sound absorber. At the reduced scale of the study the gypsum board wall worked the best at keeping sound levels down.

The discoveries and conclusions are probably quite subtle, but primarily the possibility of environments made of absorbing membranes of fluid organization, of thin drum-type skins, composite mesh constructions, curved surfaces, and suspended forms can possibly be solutions for controlling aggravating urban environments and congested habitats. These sorts of membranes of absorption and modulating transmittance might serve as layers of urban construction or as remedies to urban congestion.
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PROJECT INVESTIGATION / EXPLORATION

MODULATING SOUND AND MOTION
ELECTRONIC AND PHYSICAL MEMBRANES FOR URBAN DWELLERS
1. CASE A

site .location
DWELLING
houston medical district / museum district
850 sf
TRADITIONAL WALL

doesn't absorb urban noise / sound well
transmits sound
heavy
2. PARAESTHESIA

over-exposure
depravation
DEPRAVATION

ENJOYMENT
PARAESTHESIA

an abnormal sensation, as pricking, itching, etc.

PARTIAL SENSATION
HALF SENSED

EXTREMITIES AFFECTED
TINGLING
PINS AND NEEDLES

ANESTHESIA
loss of physical sensation, insensibility

(AESTHESI A)
sensation, feeling, perception

REMEDY / INTRODUCTION: HYPER STIMULATE OR GRADUAL / CONTINUOUS STIMULATION
3. EXPANSION

- unhindered dwelling
- continuity

supports / encourages function of physiological systems
How easily we might walk onward into the opening landscape, absorbed by new pictures, and thoughts fast succeeding each other, until degrees the recollection of home was crowded out of the mind till memory obliterated by the tyranny of the present; and we were as in triumph by nature—Emerson.

We talk of devotions from natural life as artificial; we are not the natural—Emerson.
MODEL STUDY

expansion into surroundings FUNDAMENTAL
PARTITIONS under roof
breaking-down compartmentalization
PHYSIOLOGICAL SYSTEMS

CIRCULATION

SKELETAL

RESPIRATORY
4. MEMBRANE

adjusted living / construction

modulators / devices
modulating environments
electronic / physical membranes

REAL
existing or occurring as fact actual true

PARAESTHESIA
partial loss of senses and feeling sensation

REALITY

CONTEXT
the set of circumstances

saturate

FANTASMATIC EVENT

(TRAUMA)

SOUND

LIGHT

MOTION

MEMBRANE
ea thin, pliable sheet of tissue serving as a cover or lining coating

DYNAMIC
energy, force, motion

SHIFTING
to change or transfer from one plane, position, direction to another displacement

DISOLUCTION
ALTER

DISSOLUTION
REFRACTION
change of direction of a ray of light, sound, heat, etc., in passing obliquely from one medium into another in which its speed is different

ENVIROMENT
aggregate of surrounding conditions as affecting the existence of someone

SENSORY
TERRAINS
PHYSIOLOGY
science dealing with the functions of living organisms or their parts

SYSTEMIC / SYSTEMATICAL

ORGANISM
a form of life composed of mutually dependent parts that maintain various vital processes

BIOLOGICAL NOURISHMENT
inhabitants

AESTHESIA
sensation, feeling, perception

ATTUNEMENT
adjusted pitch/tune

DETERIORATION
DECAY
the breaking up, going to pieces or weaking away of anything, so that its original wholeness is impaired

the reducing or a substance through natural change to its component elements

DEGENERATION
the breakdown of a compound

PH: the wearing of the land by the action of water, wind, or ice erosion
MODULATION / ATTUNEMENT

Adjustment of spatial packaging
Electronic transfer of energies, sound, light, motion
Listening for dynamic biomorphic nourishment

OVER-EXPOSURE - DEPRIVATION

MEMBRANE

MODULATION

ATTUNEMENT

HARMONIZE TO ADJUST TO PITCH
EXPANSION INCREASE SPREAD GROW ENLARGE
Increasing range scope volume size
Extend

REDUCTION

Dissolution

permeation of emerging reality
Extensive scope
Excessive scope
Excessive extent
Excessive excess
Excessive excess
Exposure
Exposure
Exposure
Exposure

ENVIROLOGICAL ENVIRONMENT

PARAMEDIC ENVIRONMENT
MEMBRANE

edges
dissolution
degeneration
sensory
ACTIVE NOISE COMPENSATION
FORM : arrangement
MEMBRANES / MODULATORS

01 INNER PANEL DEVICE
   - plays sound
   - plays motion
   - becomes vehicle for playing back moving images/sound
   - inhabitant can program input, rhythm, repetition, focus of sound and closed circuit tv

02 DIAPHRAGM / FELT
   - absorber

03 DEFLECTOR DEVICES
   - deflects noise
   - anti-transmitting
   - undulating surface/offset sound
   - convex
CURVED SURFACES
deflect sound
particular distant can be determined by ambient frequencies
UNEVEN SPACING
based on ambient frequencies to deflect sound around building
5. **MOTION / VISION**

dynamic dissolution from CASE A
MOTION

1. can explain the behavior of the flow of fluids, motion of objects

dynamics motion of bodies / objects

the motion-picture camera evolved from multi-image stop-action devices that recorded the parts of a continuous movement

time rate of linear motion in a given direction by a body is its velocity

for every action there is an equal and opposite reaction 3rd law of motion

wavelength x frequency = velocity

Hertz (Hz) cycles per second (cps)
Dissolution

Places around the site were photographed and then put through processes of dissolving details and surface realities in order to expose fundamental dynamic structures.
CCTV camera films
3-4 OCT 98
Intersection of CAROLINE and BINZ
6. SOUND from site
SOUND

1. transmission
   .to pass through medium of space
   .pathway

   solutions: 'discontinuous structure'
   severed transmission path
   discontinuous in density and elasticity

2. absorption
   .to drink in or suck up, as through pores
   .to take in with no reflection

   solutions: porosity
   flexibility

good sound insulation = hybrid of RIGID PARTITIONS + POROUS MATERIALS

SPEED OF SOUND
audible sound    1130 feet / second ---> mach
visible light    .06 to 60 ft. wavelengths

wavelength x frequency = velocity

1130 ft/sec / 256 cps = 4.4 feet  (middle 'C')

<table>
<thead>
<tr>
<th>Source</th>
<th>Sound Level (dB)</th>
<th>Weighting</th>
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<tbody>
<tr>
<td><strong>AMBIENT SOUND (DAYTIME)</strong></td>
<td>-60</td>
<td>A Weighting</td>
</tr>
<tr>
<td></td>
<td>-72</td>
<td>C Weighting</td>
</tr>
<tr>
<td><strong>AUTO TRAFFIC</strong></td>
<td>-60 - 76</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-74 - 92</td>
<td>C</td>
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<tr>
<td><strong>BUS passing (20’ away)</strong></td>
<td>-80 - 96</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-90 - 105</td>
<td>C</td>
</tr>
<tr>
<td><strong>BUS passing @ apartment wall</strong></td>
<td>-76 - 86</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-80 - 90</td>
<td>C</td>
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<tr>
<td><strong>DIESEL BUS idling (CLEAN)</strong></td>
<td>-80</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-90</td>
<td>C</td>
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<tr>
<td><strong>HELICOPTER</strong></td>
<td>same</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-76</td>
<td>C</td>
</tr>
<tr>
<td><strong>inside APARTMENT</strong></td>
<td>-60</td>
<td>A</td>
</tr>
<tr>
<td><strong>METRO VAN idling (10’ away)</strong></td>
<td>-76</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-86</td>
<td>C</td>
</tr>
<tr>
<td>( @ Apt Wall)</td>
<td>-54</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>-74</td>
<td>C</td>
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<td><strong>SCHOOL BUS passing</strong></td>
<td>-86</td>
<td>A</td>
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<td>dB (A weighting)</td>
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<td>10</td>
<td>20</td>
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<tr>
<td>hearing threshold</td>
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<tr>
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<td>AVERAGE RESIDENCE</td>
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<tr>
<td>CONVERSATION</td>
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<td>start of unsafe levels</td>
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<tr>
<td>50 hp SIREN</td>
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</table>

**typical sound levels**

- metro van
- auto traffic
- bus passing

**Intake apartment**

**Ambient sound**
SOUND LEVEL OF BUSES

DIESEL BUS IDLING samp effect

DIESEL BUS IDLING clean

BUS PASSING on san acinto
SOUND LEVEL OF INNER noise
VIBRATION OF BUILDING FLOOR CASE A from exterior sound and motion reverberating in water

SOUND (amplified) of bus passing on san jacinto causing water to vibrate

24 Nov 98
SOUND (amplified) of idling bus on binz causing water to vibrate
24 NOV 98
7. SOUND WALLS

  .walls

  .sound testing
SOUND NOISE
SOURCE

SOUNDWALLS
SOUNDBOX
VCR

S

10'-12'

dB meter
tape recorder
pitch shift
tape recorder

ELECTRONIC MODULATOR

see PANEL DEVICE IN MEMBRANE
DIESAL BUS IDLING IN SOUND from site "damp effect"
SOUND TESTING DISCOVERIES

GYPSUM most effective, possibly due to scale.

Next, PERFORATED / FIBERGLASS INSULATED WALL with no sound gap was most effective in reducing dB levels.

The CURVED METAL WALL was more effective at reducing general frequencies as compared to the FLAT METAL WALL, making it apparent that curving surfaces may be effective in MODULATING sounds better than FLAT surfaces.

Addition of FELT insulation absorbed higher frequencies.
perforated particle board
fiberglass panel / woodframe
low transmission connections

PERFORATED WALL
PERFORATED WALL
fiberglass panel facing OUT

BUS PASSING
- 83 dB (C)
- 72 dB (A)
zero EQ setting
- 56 dB (A)
- 40 dB (A)
straight sound 10-12".

BUS IDLING
- 70 dB (C)
- 62 dB (A)
zero EQ setting
- 55 dB (A)
- 40 dB (A)
straight sound 10-12"

METRO VAN
- 64 dB (C)
- 54 dB (A)
zero EQ setting
- 45 dB (A)
- 40 dB (A)
straight sound 10-12".
CURVE WALL

based on proportions of diaphragm wall

DEFLECTOR

rear w/o felt

rear w/felt
<table>
<thead>
<tr>
<th>FLAT METAL WALL w/ felt</th>
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<td>73 dB (A)</td>
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<tr>
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<td>67 dB (A)</td>
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<tr>
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5/8" gypsum board
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<tbody>
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<td>85 dB (A) *</td>
<td></td>
</tr>
<tr>
<td>79 dB (C) *</td>
<td></td>
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<tr>
<td>80 dB (A) *</td>
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<tr>
<td>71 dB (A) *</td>
<td></td>
</tr>
<tr>
<td>90 dB (C) *</td>
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<tr>
<td>81 dB (C) *</td>
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<table>
<thead>
<tr>
<th>BUS IDLING</th>
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<tbody>
<tr>
<td>86 dB (A) *</td>
</tr>
<tr>
<td>74 dB (C) *</td>
</tr>
<tr>
<td>55 dB (A) *</td>
</tr>
<tr>
<td>64 dB (C) *</td>
</tr>
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<table>
<thead>
<tr>
<th>METRO VAN</th>
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<tbody>
<tr>
<td>76 dB (A) *</td>
</tr>
<tr>
<td>66 dB (C) *</td>
</tr>
<tr>
<td>55 dB (A) *</td>
</tr>
<tr>
<td>64 dB (C) *</td>
</tr>
</tbody>
</table>
8. SOUND CHARTS
minimum audible threshold

A- and C- weighted response curves
piano scale frequency to wavelength
Fig. 10.1 Chart for computing the sound level resulting from the addition of two combining random noises. If $D$ is their difference in decibels, $N$ is added to the higher level to obtain the total level.

Fig. 10.6 Relation between outdoor noise and the density of vehicular traffic. (D F. Seacord)

NOISE LEVELS
Fig. 5.1 Absorption coefficient vs. frequency of air in an unheated tube and by a heated tube. The dashed line is the coefficient with the metal; the barometric pressure difference and the wind gust speed are the same as reported at 1 inch barometric pressure.

Fig. 7.1 Absorption frequency characteristics of polynomial curves. 1 heat by 9 heat polished to remove all resonances. Cross between 1 heat supports at 40°, 30°, and 2.5° at the three different polynomial curves.

F 2 above and 1° below.

ABSORPTION materials