SUBJECT INDEX

Absorption coefficient 37
Accordion mode vibrations 98-101
Acoustic arrays 22, 81-89, 93-94
Acoustic assumption 23
Acoustic cavitation 202
Acoustic continuity equation 26
Acoustic conversion efficiency 2-3, 278
Acoustic feedback 308
Acoustic intensity 5-7, 32-33, 35-36, 58
Acoustic Mach number 32, 43
Acoustic momentum equation 28-30
Acoustic particle speed 31-34
Acoustic potential 30-33
Acoustic reciprocity principle 180
Acoustic wave equation 23-31, 47-50
Active dampers 150
Actuator-disk propeller 262-264, 268
Advance ratio 262, 265, 269
Aeolian tones 300
Aerodynamic noise 51-56
Air-to-air transmission 181-184
Air-to-water transmission 40-42, 182
Airfoil in a sinusoidal gust 295-298
Airfoil vortex wakes 311-312
Ambient noise 3-4, 69-72, 243, 280-285
American Standards Association 3, 6
Anomalous depth effect 259-260, 272
Anti-singing trailing edges 318
Applied damping 145-149
Array signal-to-noise gain 10, 88
Arrays 22, 81-89, 93-94
Arrays as spatial filters 88-89
Arrays of directional sources 88
Arrays of flush-mounted hydrophones 194
Asymmetrical bubble collapse 215
Attenuation of structural vibrations 143-150
Axial-flow fans 313-315

Ball bearings 345
Bars, vibrations of 106-108
Beams, flexural vibrations of 100-101, 106-153, 183-184
Beam bending equations 110-116
Beam-plate systems 176-180
Bearings 345-346
Bending equations 110-116, 158-159
Bending rigidity 113, 158
Bending stiffness 113, 158
Bending vibrations of ship hulls 106, 150-153
Bernoulli's equation 224, 241
Bessel's equation 160-161
Bessel functions 50, 90-92, 95, 160-161, 296
Blade-element theory 260-262
Blade frequency 269-270, 293-299
Blade-rate modulation 269, 278-279
Blade-slap 298
Blade-surface cavitation 253-260, 264, 269
Blade tones 269-270, 293-299, 327
Blade-turbulence interaction 299
Blade-vortex interaction 298
Blending region of boundary layer 188
Blowers 288, 313-316
Bodies of revolution 98-99
Body cavitation 202, 223-229
Boiler explosions 203
Boiling 202-203
Boundary cavitation 203
Boundary layers 184-196, 299
Boundary-layer friction 286-290
Boundary-layer turbulence 187-193, 299
Boundary-layer velocity profiles 185-188
Breaking waves 68-71
Broadband noise 142-143, 299, 313
Bubble collapse 205-220
Bubble dynamics 205-215
Bubble growth 205-208
Bubble pulse frequency 244
Bubble sounds 62-69
Bubble temperatures 211
Bulk modulus 29, 107-108
Bulk waves in solids 107-108
Buoyant bodies 195

Camber of airfoils 233-235
Cartesian coordinates 11-14, 20-22
Cavitation 202-242, 269-279, 317
Cavitation blade rates 270
Cavitation damage 223
Cavitation dynamics 205-215
Cavitation erosion 223
Cavitation hysteresis 224
Cavitation in uniform inflows 264-265
Cavitation inception 203-205, 224, 227-229, 265, 269-270, 272
Cavitation inception scaling 227-229
Cavitation noise 202-203, 215-222, 269-279
Cavitation noise modulation 278-279
Cavitation nuclei 203-205, 228
Cavitation of hydrofoils 202, 223, 231-240
Cavitation of marine propellers 253-259, 270-273

Cavitation of submarine propellers 270-273
Cavitation parameters 224-226, 269-272
Cavitation tonals 270
Cavity resonances 96-97, 318-319
Centrifugal blowers and fans 313-315
Characteristic impedance 32, 162
Chemical reactions 222
Chevron London (tanker) 279
Circumferential wake variations 265-270
Clamped beams vibrations 123-130
Coastal region enhancement effect 283
Coastal shipping 283-284
Coefficient of relative rotatory inertia 114
Coincidence 163-169, 175, 181
Coincidence frequency 163-168, 176
Complex quantities 15-16
Compressibility 29, 209
Compressors 288, 299-300
Constrained-layer damping treatments 147-149
Continuity equation 24-26, 47
Continuous line radiators 83-88
Continuous spectra 9
Contour integrals 15
Contrails 231
Cosine radiation pattern 288-291
Critical angle 40
Critical cavitation index 224
Cruiser *Cardiff* 274
Curl of a vector 13
Curved plates 178
Cylinders 99
Cylindrical shells 178

Damped beam structures 149
Damped oscillation of a gas bubble 63-68
Damped sound waves 37
Damping 139-142, 145-149, 176, 317, 331
Damping of bubble motions 66-68
Damping treatments for plates 145-149
Decibels defined 4, 8
Decibel arithmetic 8, 360-362
Dependence of cavitation noise on depth 259-260
Desinent cavitation 224
Detection threshold 10
Diesel engines 315, 332-345
Dipoles 45-53, 76-81, 171, 195, 288-293
Dipole strength 77, 292
Direction cosines 20-22
Directional radiation 75-77, 82-93, 171-173, 195
Directivity factor 85-87, 93
Directivity function 75-77, 82-88, 90-91, 93
Directivity index 86-88
Displacement thickness of boundary layer 185
Dissipation coefficient 63-64
Dissolved gases 209-215
Divergence operator 13
Domed sonar self-noise 196
Doppler shift 55
Double-layer damping treatment 149

Drag force 233-234, 237
Droplets 68
Dyadics 11
Dynamic tensile strength 205
Dynamic unbalance 326-327

Edge tones 308
Eggbeater-type rotating blade apparatus 255-260
Eigen-frequencies 140
Electric motors 328-329
Electrical analogy methods 100, 131
Electrical steering of arrays 75
Electromagnetic force fluctuations 328-329
Electromechanical feedback vibration suppressors 150
Elementary force dipole 288-292
Elementary pistons 89-90
Entrained mass 60-63, 113, 150-151, 164-166
Equation of continuity 24-26, 47
Equation of motion 26-28
Equation of state 24
Equilibrium boundary layers 188, 191
Equivalent spectrum level 8
Erosion damage 222-223
Erosion of marine propellers 202, 222-223
Euler-Bernoulli equation 115-123
Exhaust systems 97
Explosions 242-245
Explosion-like impulsive sources 242

Fans 288, 299-300, 313-315, 327
Far acoustic field 34, 74-75, 91
Filter bandwidth 8
Finite-amplitude effects 43-44
Finite-element methods 99-100, 130-131
Fleet submarines 270-272
Flexural resonances 123-134, 150-153
Flexural resonances of ship hulls 150-153
Flexural vibrations 106-153, 158-184
Flexural waves 100-101, 110-153, 158-184
Flexural-wave Mach number 164-169
Flexural wave speed 116-122, 159-160
Flow noise 54-55, 184-196
Flow past a piston 95
Flow-excited resonances 96-97, 318-319
Fluctuating forces 45-46, 48-50, 52-53, 288-299, 304-307
Fluctuating inflow velocity 266
Fluctuating thrust 269, 294-297
Fluctuating turbulent shear stresses 45-48, 50-53, 55, 190, 195
Fluctuating volumes 45-46, 49-52, 57-102
Fluid loading 150-151, 162-171
Fluid mechanics 23-28
Flush-mounted hydrophones 192-194
Forced flexural vibrations 135-143
Form drag 302
Fourier analysis 17-18, 169, 330
Fourier transform methods 17-18, 169
Free-free beams 123-130

Frequency of bubble oscillation 65
Frequency regimes for hull vibration 100-102
Friction velocity 186
Fuel-injection equipment 345

Garfield Thomas Water Tunnel 254, 268
Gas bubbles 62-69
Gas diffusion 215
Gas jet in water 68
Gaseous cavitation 203
Gauss' divergence theorem 25
Gauss' gradient theorem 27
Gears 327, 331-332
Geographical variability of ambient noise 281-283
Gradient operator 13-14
Gravitational force 27-28
Green's theorem 98
Guppy submarines 270
Gutin sound 56, 293

Hamburg Shipbuilding Research Establishment 317
Harmonic representation of waves 20-22, 30-35
Helical gears 331
Helicopter blade-slap noise 298
Helmholtz equation 21-22, 30-31, 33, 97-98
Helmholtz integral 151
Helmholtz integral equation 98-100
Helmholtz resonators 96-97
History effect 187
Hobbing error 331-332
Homogeneous damping treatments 145-147
Horizontal directionality of ambient noise 283
Horseshoe vortex 239-240
Hub-vortex cavitation 253-254, 269
Hull openings 95-97
Hull radiation 97
Hull vibration 106, 150-153, 295-298
Hydraulic cavitation 202, 223, 228, 240-242
Hydraulic machinery 242, 288, 299-300, 327
Hydrodynamic cavitation 223-242
Hydrodynamic damping 151
Hydrodynamic noise sources 51-55
Hydrofoil cavitation 202, 223, 231-240

Ideal vortex 229-231
Image interference 78-81
Image sources 42
Image vortex 304-307
Imaginary quantities 15-16
Impact sounds 68, 329-345
Impedance mismatches 148-150
Inception cavitation index 224, 269
Incipient cavitation index 224
Induction motors 329
Inductive pressure field 290-291, 298
Infinite beam impedance 138-140
Injector noise 345
Inner region of boundary layer 185-189
Input impedance 135-138, 162
Insertion loss 143-145
Integral equation methods 97-100, 151
Intensity 5-7, 32-33, 35-36, 58
Intensity levels 5-7
Interference patterns 79-81
Intermittency effects 191-192
Inverse-square spreading 36
Involute helical gears 331
Irrotational fields 13
Isolation mounts 143-145

Jet cavitation 223, 231
Jet noise 53-54

Karman vortex street 301-308
Knudsen ambient noise curves 69-71
Kronecker delta 12

Lamb waves 109
Laminar sublayer 185-186
Laplace's equation 20-29, 97
Laplacian operator 14, 160
Laser beams 45
Law of the wake 187
Law of the wall 187
Legendre functions 50, 95
Levels 5-8
Lift force 233-235, 239, 288
Lifting surfaces 288
Lighthill's equation 47-50, 309
Limp walls 184
Line integrals 14-15
Linear arrays 81-89
Linear bubble pulsations 62-66
Logarithmic decrement 64
Long term ambient noise trends 285
Longitudinal waves 107-109
Loss factor 63-68, 139-140
Low-frequency ambient noise 280-285
Low-frequency cavitation tonals 270

Mach number 2-3, 51-56
Magnetic force variations 328-329
Magnetostrictive hum 328
Marine diesel engines 333-345
Mass law 182-184
Mass moment of rotatory inertia 113
Material derivative 24-25
Mathematical concepts 11-18
Mechanical impedances 135-139
Mechanical unbalances 326-328
Media interfaces 38-42
Megaphone effect 283
Merchant ships 258, 266, 272-280, 298
Merchant ship trends 279-280
Micropascal 6
Microstreaming 222
Mindlin-Timoshenko thick plate equation 158-159, 161, 171-173

Mixing length 190
MKS system 5-6
Mobility 135
Modal analysis 141-143, 175-178
Modal densities 142, 178
Modal densities of cylindrical shells 178
Modulation at shaft rate 269, 298-299
Modulation of cavitation noise 269
Moment of inertia 113
Momentum equation 26-28, 47-49
Momentum theory 262-264, 268
Momentum thickness of boundary layer 185, 189
Momentum-thickness Reynolds number 189
Monopoles 45-52, 57-62, 97
Motors 328-329
Mount effectiveness 143-145
Multiply resonant systems 140-143

N.A.C.A. 233-238, 360
NACA airfoil families 233-238
NACA 4412 hydrofoils 233-238
N.A.S.A. 235, 360
N-element arrays 81-83, 87-88
Naval architecture 150-153
Navier-Stokes equations 190, 209
Near acoustic field 34, 79, 91-92
Near field of a piston radiator 91-92
Near surface sources 78-81
Noise control 3, 176
Noise measurements 81
Noltingk-Neppiras equation 210-220
Non-linear effects 43-44
Non-uniform beams 115, 130-134
Novikov gears 331
Nozzles 223
Nuclear submarines 272

Oil tankers 277, 279-280, 283
Orthotropic plates 176-178
Oscillating lift 295-298
Oscillating motion of a rigid body 288
Oscillating rigid sphere 289-292
Oscillating thrust coefficient 294
Out-of-phase sources 76-78
Outer turbulent region of boundary layer 185-188

Pancake diesels 333, 342
Partially baffled pistons 94-95
Particle velocity 31-34
Passenger ship *Astrid* 275
Passive sonar 9-11
Pennsylvania State University 254, 268
Periodic motions 55-56
Periodic structures 177-178
Permanent gases in cavitation bubbles 209-214
Pipes 97, 223, 241-242
Pipe bends 223, 242
Pipe cavitation 241-242
Pistons 89-95
Piston in a baffle 90-94
Piston in a non-rigid baffle 94
Piston in a non-planar baffle 95
Piston set in a cylinder 95
Piston slap 332-345
Planar arrays 93-94
Plane sound waves 31-33, 37-38
Plane waves 20-22
Planetary gear systems 331
Plates 106-108, 158-172
Plate flexural vibrations 158-169
Plate flexural wave radiation 158-184
Platform noise 4
Point-excited infinite plates 169-172
Poisson's ratio 108
Polar coordinates 160
Positive displacement blowers 315-316
Power level 7
Prolate spheroids 98, 298
Propellers 203, 253-273, 288, 297-300, 316-318
Propeller blade-element analysis 260-262
Propeller blade tonals 293-299
Propeller cavitation 203, 253-260, 264-265, 269-273
Propeller induced hull forces 297-298
Propeller operation in uniform flows 260-265
Propeller singing 316-318
Propulsive efficiency 262
Pseudo sound 55
Pulsating fluid motions in hole openings 95
Pulsating spheres 57-68
Pulse jets 97
Pumps 242, 288, 299-300, 327
Pump cavitation 242

Quadrupoles 45-55, 195

Radiation, of sound (see specific sources)
Radiation below coincidence 169-171
Radiation efficiency 3, 46-47, 50-51, 53-54, 60-61, 66, 92, 94, 167, 171, 289-291
Radiation from arbitrary bodies 97-100
Radiation from collapsing bubbles 215-220
Radiation from cylinders 99
Radiation from exhaust pipes 97
Radiation from finite plates 173-180
Radiation from fluctuating forces 45-46, 48-50, 52-53, 288-299, 304-309
Radiation from fluctuating volumes 45-46, 49-52, 57-102
Radiation from hulls 98-102, 178-180
Radiation from hull openings 95-97
Radiation from pipe ends 95-96
Radiation from plate flexural vibrations 158-184
Radiation from rigid pistons 89-95
Radiation from tank resonances 96-97
Radiation from two monopoles 72-81
Radiation impedance 59-62
Radiation load factor 167-169, 171
Radiation loss factor 46-47
Radiation reactance 45-46, 50, 166, 291

Radiation resistance 45-46, 50, 92, 177
Radius of gyration 113
Rain noise 71-72
Random forces 142-143
Rayleigh waves 109
Rayls 32
Real quantities 15-16
Reciprocating compressors 333
Reciprocating machinery 327-328, 332-345
Reciprocating unbalances 327-328
Recognition differential 10
Rectangular cutouts 318-319
Rectangular pistons 93
Rectilinear vortices 229-231
Reduced frequency 295-297
Reference pressures 5-7, 361
Reflection by ocean surfaces 42
Reflection of sound 39-42
Resonance frequencies of gas bubbles 65
Resonances of non-uniform beams 130-134
Resonant structures 140-143
Response of structures to sound waves 180-181
Retarded time 20
Reverberant modes 175-178, 183
Reverberant sound 2, 281-282
Reynolds number 53, 227-229, 240, 300-303, 307
Rhombic drive 333
Roots blowers 315-316
Rotary positive displacement blowers 313, 315-316
Rotating blade experiments 253-260
Rotating rods 311
Rotational unbalances 326-327
Rotor-slot motor noise 329
Rotor-stator interactions 299
Rough walls 189-190
Roughness effects on cavitation 228-229

Scalars 11-12
Scalar potentials 13-14
Scale effects 227-229, 237
Sear's function 295-297, 299
Second law of thermodynamics 1-2
Seismic profiling 242-243
Self-noise 4, 184, 193-194, 196
Semi-infinite beams 135-136
Shaft-rate modulation 269, 278-279, 298-299
Shaft-rate tonals 298-299
Shear modulus 107
Shear parameter 114, 159
Shear waves 107, 118
Ships 152-153, 280-285
Ship-generated ambient noise 280-285
Ship resonances 152-153
Side lobes 84-85
Signal excess 10
Signal-to-noise ratio 10
Simply-supported beams 123-130
Singing blades 300, 308, 316-318
Single bubble cavitation noise 215-220
Single bubble growth and collapse 205-220
Skewed propellers 297
Skin-friction coefficient 228
Slender body theory 98-99
Snell's law 38-39, 148, 162, 177
Solid rectangular bars 119-122
Sonar background noise 4
Sonar domes 196
Sonar equation 9-11
Sonar self-noise 4, 184, 193-194, 196
Sonoluminescence 222
Sound (see also radiation)
Sound isolation by walls 184
Sound pressure levels 5-8
Sound radiated by cavitation bubbles 215-220
Sound speed in solids 107-109
Sound waves 19-44, 107-109
Sounds from gas bubbles 62-69
Sounds from rotating rods 311
Sounds from splashes 68-71
Sounds from surface impacts 68-69
Sounds of running water 62-68
Source level 7
Source stability 9
Sources in motion 55-56
Space-rate-of-decay of vibration 140
Spatial filters 88-89
Specific acoustic impedance 32-35, 46, 169, 290
Specific radiation reactance 46
Specific radiation resistance 46, 169, 290
Spectral analysis 9, 18
Spectral width 9
Spectrum level 8
Spectrum of cavitation noise 220-222
Speed of sound 29, 107-109
Spheres pulsating out of phase 292
Spherical coordinates 14, 33, 50-51
Spherical sources 50-51
Spherical symmetry 14
Spherical waves 33-38
Spheroidal wave functions 98
Splash noise 68-72
Spur gears 331
Standing waves 33, 35
Static tensile strength of liquids 203-205
Static unbalance 326
Stirling engine 333
Stress tensor 48-50
Strouhal number 300-304, 318
Structural damping 145-149, 331
Structural vibrations 106-153
Structure-borne sound 106-151, 158-184
Strut cavitation 231-233
Strut oscillating forces 298
Submarines 253, 266, 270-273
Submarine propeller cavitation 270-273
Submicroscopic nuclei in liquids 203-205
Substantial 24-25
Supercavitating hydrofoils 240

Supertankers 277, 279, 283
Surface cavitation 203
Surface image interference 78-81
Surface integrals 15
Surface roughness on cavitation 228-229
Surface ships 253, 272-280
Surface tension 204, 208-209, 228
Surface waves 109

Tankers 277, 279-280, 283
Tapered cantilever beams 133-134
Temporal fluctuations 283-285
Tensile strength of liquids 203-205, 209
Tensors 11-13
Tensor notation 11-12
Thermal sources of sound 45-46
Three-dimensional body cavitation 224-229
Thrust coefficient 262
Thrust loading factor 263
Time-rate-of-decay of vibration 140
Timoshenko beam equation 115-117, 125, 130, 158-159
Tip-cavitation parameter 256, 264, 272
Tip-vortex cavitation 253, 269
TNT charges 243-245
Tonal radiation from rotating propellers 56, 269-270, 293-299, 327
Tooth impacts of gears 331
Torpedoes 253, 266, 287
Torque coefficient 262
Traffic noise 280-285
Trailing edge shape 311-312, 316-318
Transducer size effects 192-194
Transfer impedance 135
Transformer hum 328
Transient cavitation 256-257
Transmission anomaly 36-37
Transmission at boundaries 38-42
Transmission loss 5, 9-11, 35-37, 40-42, 181-184
Transmission ratio 181-184
Transmission through a plane boundary 40-42
Transmission through wall structures 180-184
Transport theorem 25
Turbines 288, 299, 316
Turbulence noise 45-46, 49-50, 53-55
Turbulent boundary layers 184-196
Turbulent pressure fluctuations 184, 192-196
Turbulent stresses 45-46, 49-52, 57-102, 190, 195
Two-element array (two-pole) 72-83

U.S. Naval Oceanographic Office (N.O.O.) 279
U.S. Navy Bureau of Ships 6
U.S. Office of Scientific Research and Development (O.S.R.D.) 273
Ultrasonics applications 202, 222
Unbaffled pistons 94-95
Unbalance forces 326-328
Underwater explosions 242-245
Uniform beams vibrations 115-130
Unsteady airfoil theory 295-297

Valves 223, 242
Valve cavitation 242
Van der Waals' equation of state 203
Vapor cavitation 203
Vectors 11-15
Vector arithmetic 12
Vector differentiation 12-13
Vector operations 12-13
Vector operators 13-14
Velocity potential 30
Venturis 223, 241
Vertical directionality of ambient noise 283
Vibration absorbers 150
Vibration damping 139-142, 145-149, 176, 317
Vibration suppressors 150
Viscoelastic materials 145-149
Volume cavitation 203
Volume integrals 15
Volume pulsations of gas bubbles 62-68
Vortex cavitation 223, 228-231, 239-240, 253-254
Vortex shedding sounds 299-319
Vortex sounds from rotating blades 312-313
Vortex streets 301-308
Vortex wakes 299-312

Wake cavitation 231
Wake diagrams 266-268
Wake operation of propellers 265-270, 294-299
Wake turbulence 54, 223
Wake turbulence cavitation 223
Wake vortices 299-312
Wall pressure fluctuations 192-196
Wall shear stress 185-191, 228
Wall-shear-stress velocity 186
Water-to-air transmission 41-42, 182
Water-to-water transmission 181-182
Wave approach to resonance calculation 128-132, 152-153
Wave equation 19-31, 47-50
Wave motion 19, 106
Wave motions in solids 106-110
Wave number 21-22
Wave speeds 19-22, 107-109
Wave vectors 22
Wave-vector filters 27, 194
Waves in plates 108-109
Weber number 228
Whipping modes 100-101, 106
Wind-generated ambient sea noise 69-71
Wing-tip vortex cavitation 239-240, 253
Wing-tip vortices 239-240

Young's modulus 107