

# Index

Note: Page numbers in *italics> designate illustrations and captions.*

- A**  
A-1 camera, 66  
Abbe, Ernst, 9, 14, 23, 35  
Abbe number, 266  
Abelès, Florin, 72  
Abella, Isaac, 82, 84  
achromatic lens, 13  
achromatic optics, 14  
Acrysof Toric, 264  
Adams, Ansel, 35  
Adams, E.Q., 43  
Adams, Paul, 149  
adaptive optics, 29, 151, 178, 184, 247, 248, 248, 329  
additive-pulse mode locking (APM), 241, 242  
Advanced LIGO (Laser Interferometer Gravitational-wave Observatory), 12  
Advanced Research Projects Agency (ARPA), 82, 100, 149, 150, 185–187, 282  
Advanced X-Ray Astrophysics Facility (AXAF), 249  
AEC (Atomic Energy Commission), 29, 161  
aerial cameras, 24, 25, 66  
aerial reconnaissance. *See* spy satellites; surveillance imaging  
AFCRL (Air Force Cambridge Research Laboratory), 186, 187  
AFM (atomic force microscopy), 225–226  
AFWL (Air Force Weapons Laboratory), 185, 186  
Agrawal, Govind, 277  
Aigran, Pierre, 107  
Air Force Cambridge Research Laboratory (AFCRL), 186, 187  
Air Force Office of Scientific Research, 29  
Air Force Weapons Laboratory (AFWL), 185, 186  
Airborne laser, 151  
Airborne Laser Laboratory, 93, 150  
Airy, George, 15  
Akhmanov, Sergey A., 116  
Alcatel, 197, 285  
Alcatel Thomson Gigadisc, 139  
Alcon, 263, 264  
Alflight Inc., 230, 231  
Alfano, R.R., 117, 238  
Alferness, Rod C., 277, 287  
Alferov, Zh. I., 110, 111, 111, 201  
AlGaAs, 110, 200  
AlGaAs/GaAs, 110–111  
AlGaAs lasers, 202, 228  
Allen, Lew, 143, 250  
Alpha laser, 151  
Alvan Clark and Sons, 14  
Alvarez lenses, 267  
American Cystoscope Makers, 56  
American Film, 31  
American Marconi Co., 26, 175  
American Optical Co., 10, 15, 51, 55, 56, 100, 101–102, 104, 150, 185, 186, 187, 280  
American Physical Society, 86, 107, 178  
American Telephone & Telegraph Co. (AT&T), 25, 26, 100, 197, 278, 279, 281, 282, 283, 297  
ammonia maser, 50, 81, 82  
AMO, 263, 264  
Ampex Corp., 140  
Anastigmat lens, 33, 35  
Anderson, Jim, 177  
Anderson, Rox, 334  
Ando, 305  
Andreev, Vyacheslev M., 111, 111  
Andrus, J., 50  
Angel, Roger, 246, 248, 250  
Ångstrom, Anders, 12, 13  
Antares project, 167, 168  
anti-reflection coatings, 3, 49, 69, 70, 71–72, 73, 266  
anti-resonant reflecting optical waveguiding (ARROW), 297  
APDs (avalanche photodiodes), 288  
APM (additive-pulse mode locking), 241, 242  
“apochromat” objective, 14  
Apple Computer, 140  
Applied Energetics, 305  
applied nonlinear optics, 213–217, 214–217  
*Applied Optics* (journal), 195, 312  
*Applied Physics Letters* (journal), 84, 95, 191  
applied spectroscopy, 20, 49–50  
argon-fluoride laser, 92  
argon-ion lasers, 91, 91, 95, 96, 98, 196, 225, 234  
argon-mercury discharge, 91  
Argonne National Laboratory, 29  
Argyros, Alex, 299  
Armand, M., 90  
Armstrong, John, 115, 219  
Army Research Office (ARO), 29, 178  
Arnold, George, 163  
ARO (Army Research Office), 29, 178  
ARPA (Advanced Research Projects Agency), 82, 100, 149, 150, 185–187, 282  
ARPANET, 279  
arrayed waveguide grating (AWG), 293, 294  
ARROW (anti-resonant reflecting optical waveguiding), 297  
Artal, Pablo, 263  
Arzamas-16, 166  
Asai, Kazuhiro, 175, 179  
Aschenbrenner, Claus, 159–160  
Ashkin, Arthur, 119, 220, 222, 223–226, 311, 312  
Ashura laser system, 167  
Asterix laser system, 166  
astigmatism, 15, 253, 262, 264, 266, 267  
astronomical spectroscopy, 13, 13  
astronomy, 4, 9, 71, 184  
    Cat’s Eye Nebula, 18  
    fiber-based astronomy, 301  
    gravity-wave astronomy, 329  
    ground-based telescopes, 244–248, 245–248  
    Hubble Space Telescope (HST), 4, 13, 143, 184, 247, 249–250, 250, 251, 252  
    laser guide star, 4, 29, 178, 247, 248, 248  
    mirrors, 69, 245, 247, 251, 252  
    optical astronomy, 184, 247, 248, 249, 252  
Orbiting Astronomical Observatory (OAO), 247, 249  
refractors, 14  
space telescopes, 249–252, 250, 251  
spectroscopy and, 13, 13, 18–19  
stellar interferometers, 247  
stellar spectra, 13  
*See also* telescopes  
AT&T (American Telephone and Telegraph Co.), 25, 26, 100, 197, 278, 279, 281, 282, 283, 297  
AT&T Bell Laboratories, 197  
Atchison, David, 263  
atom interferometers, 329  
atom trapping, 224, 225  
atom-wave gravity gradiometers, 330  
*Atombau und Spektrallinien* (Sommerfeld), 17  
atomic clocks, 226  
Atomic Energy Commission (AEC), 29, 161  
atomic force microscopy (AFM), 225–226  
atomic physics, spectroscopy and, 12–13, 13  
atomic structure  
    quantum theory, 3  
    subshells, 17  
*Atomic Structure and Spectral Lines* (Sommerfeld), 17  
Atomic-Vapor Laser Isotope Separation (AVLIS) program, 162, 163, 163, 164  
Auston, D., 221  
auto industry, 51  
autochrome plates, 34  
automatic exposure (AE) control, 36  
automatic tristimulus integrator, 43  
avalanche photodiodes (APDs), 288  
AVCO Everett Research Laboratory, 92, 150, 161, 187  
AVLIS program, 162, 163, 163, 164  
AWG (arrayed waveguide grating), 293, 294  
AXAF (Advanced X-Ray Astrophysics Facility), 249  
azimuthal quantum number, 1, 7
- B**  
Babinet, Jacques, 53  
Baird, John Logie, 53  
Baker, James G., 49, 64–67, 245  
Baker–Nunn camera, 245  
Ball Aerospace, 250, 252  
“ballistic” photons, 308  
Balmer, Johann, 13  
Balmer formula, 13  
bandwidth, 4, 191–192, 211, 280, 291  
Banning, Mary, 71  
*The Bar Code Book* (Palmer), 133  
barcode scanners, 128, 129–133, 130–132  
barcodes, 128–133  
    scanners, 128, 129–133, 131, 132  
    symbolologies, 128–129, 129, 130  
Bardeen, John, 62  
Barger, R.L., 219  
Barnack, Oskar, 34–35  
Barnack camera, 35  
Basov, N.G., 107, 218

- Bass, Michael, 183, 218, 219  
 Bates, Frederick J., 27  
 Battelle Memorial Institute, 57, 60–61  
 Battista, Albert, 102  
 Baumeister, Philip, 73  
 Bausch, John Jacob, 15  
 Bausch & Lomb, 10, 15, 23, 24, 25, 33, 70, 71, 72, 185, 253, 254, 256  
 BBO (beta barium borate), 215  
 BEACON HILL Report, 65  
 BEACON HILL Study Group, 64  
 Beckman, 50  
 Beecher, William, 15  
 Belforte, David A., 124  
 Bell, Earl, 89, 90, 97, 98  
 Bell and Howell, 15  
 Bell Holmdel Laboratory, 185, 186, 224  
 Bell inequalities, 320  
 Bell Telephone Laboratories, 25, 50, 81, 82, 84, 88, 89, 91, 92, 96, 100, 104, 105, 114, 116, 177, 185, 186, 196, 199, 201, 204, 205, 215, 218, 223, 227, 232–233, 239, 240, 278, 284, 297, 304  
 Bennett, William, 82, 84, 88, 89, 89, 91  
 Benton, Steve, 122  
 Berg, Howard, 225  
 Bernard, M.G., 107  
 Berns, Roy S., 10, 43  
 beta barium borate (BBO), 215  
 Bevacqua, S.F., 109  
 Biacore, 312  
 bifocals, 14, 184, 253, 254, 263, 265, 266, 268  
 “Big Bird,” 156, 158  
 Big Demonstration Laser, 150  
 binary phase shift keying (BPSK) modulation, 294–295  
 binoculars, 14, 24, 71  
 bioluminescence, 311  
 BIOMED meeting, 313  
 biomedical optics, 277, 308–313, 309–312, 334–335  
   *See also* ophthalmic surgery; vision correction  
*Biomedical Optics Express* (journal), 313  
 BioRad/Spectra-Physics, 305  
 Birks, Tim, 299, 300  
 “Bison” (Soviet bomber), 65  
 Bissell, Richard, 65, 157, 158  
 Bjorkholm, John, 224, 225, 226  
 blackbody radiation, 3, 12  
 BlazePhotonics, 300  
 Blikken, Wendell, 119  
 Block, Steven, 225  
 Blodgett, Katharine, 70  
 Bloembergen, Nicolaas, 115, 115, 213, 214, 221  
 Bloom, Arnold, 89, 90, 97  
 Blu-Ray, 142, 142  
 Blum, Samuel E., 257, 258, 259, 260, 261  
 Boeing, 150, 151, 185  
 Bohr, Niels, 3, 13, 17, 329  
 Bohr atom, 3, 13, 17  
 Boll, Franz Christian, 41  
 BOMEX project, 98  
 Bond, W.L., 6  
 Borde, C., 220  
 Bortfeld, Dave, 95  
 Bose–Einstein condensation, 219, 221, 225  
 Boston University, 85  
 Boston University Optical Research Laboratory (BUORL), 65  
 Botez, Dan, 227, 231, 231  
 Bowen, Ira S., 18, 18, 20, 245  
 Boyd, Robert, 117  
 BPSK modulation (binary phase shift keying modulation), 294–295  
 Brackett, Frederick Sumner, 18  
 Bradbury, Rudolph, 186  
 Bragg fibers, 297, 298  
 Brandeis University, 186  
 Braren, Bodil, 260  
 Braunstein, Maurice, 187  
 Brazier, Pam, 122, 122  
 Breckinridge, James, 244, 246, 249, 250  
 Brewster, David, 11  
 Brewster’s angle, 91, 97, 169  
 Brewster’s angle slab amplifier, 168–169, 169  
 Bridges, William B., 88–93, 91, 98, 187  
 Brillouin scattering, 116  
 British Telecom Research Laboratories, 197, 278, 280  
 Brody, Peter, 270  
 Bromberg, Joan Lisa, 103  
 Browell, Ed, 175  
 Brown, Gordon, 145  
 Brown University, 186  
 Brownell, Frank A., 32  
 Brownie camera, 10, 31–32, 32  
 Buccini, John, 143  
 Bufton, Jack, 175, 179, 180  
 Bunsen, Robert, 13  
 BUORL (Boston University Optical Research Laboratory), 65  
 Burbank Skunk Works, 157  
 Bureau of Standards, 20, 24, 25, 26, 27, 43, 185  
 Burnham, R.W., 44  
 Burns, Gerald, 108, 108  
 Burns, Keivan, 20  
 Bush, Vannevar, 27, 28, 28, 29, 185  
 Byer, Robert L., 103, 213, 214, 336
- C**  
 C-camera, 66, 67  
 C-series contact lenses, 253  
 Cabellero, Doris, 72  
 cadmium selenide, 270  
 calcium, spectrum, 18  
 Caltech, 86, 297  
 Cambridge Research Laboratory, 185, 186  
 camera lenses, 3, 33, 35  
 cameras, 10, 15, 33–36, 36, 37  
   A-1 camera, 66  
   aerial cameras, 24, 25, 66  
   automatic exposure (AE) control, 36  
   Baker–Nunn camera, 245  
   Barnack camera, 35  
   Brownie camera, 31–32, 32  
   C-camera, 66, 67  
   Contax I, 33, 35–36, 36  
   Deckrullo focal plane shutter cameras, 35  
   Faint Object Camera (FOC), 250  
   Fairchild K-19, 66  
   film, 10, 15, 34, 39, 51, 52  
   folding Pocket Kodak (FPK), 32–33, 32  
   Homéos stereo camera, 34  
   K-19 camera, 66  
   Kodak Retina camera, 36  
   Leicas, 33–35, 35  
   lenses, 3, 33, 35  
   Miroflex reflex camera, 35  
   Model A, 35  
   Pocket Kodak, 32  
   Polaroid process, 49, 52, 158  
   Polaroid SX70 camera, 64  
   reconnaissance cameras, 64–67  
   Schmidt camera, 4, 244, 245  
   Simplex camera, 34  
   Super Kodak Six-20, 36–37, 36  
   35-mm precision cameras, 34  
   Tourist Multiple camera, 34  
 Universal Jewel professional folding dry plate camera, 35  
 Wide-Field Planetary camera (WF/PC), 250  
   *See also* photography; surveillance imaging  
 Campillo, Anthony, 299  
 Canon, 62, 63  
 carbon dioxide lasers, 92–93, 92, 102, 124, 150, 163, 167, 168, 186, 187  
 carbon monoxide lasers, 92  
 carbon nanotubes, 315  
 Carl Zeiss Co., 69  
 Carl Zeiss Foundation, 35  
 Carl-Zeiss Stiftung, 23  
 Carlson, Chester, 50, 57, 58, 59–60, 61, 61, 62, 134  
 Carlson, R.O., 108  
 Carnegie, Andrew, 244, 246  
 carotenoids, 41  
 carrier frequency sweep, 215  
 carrier leakage, 229  
 Carritol, Dick, 154  
 CARS spectroscopy (coherent anti-Stokes Raman spectroscopy), 219, 308  
 Carswell, Alan, 177  
 Cartwright, Charles Hawley, 69, 70, 71  
 Case Western Reserve University, 244  
 Catalán, Miguel A., 17  
 cataract surgery, 124, 184, 262–264, 312  
 cathode ray tubes (CRTs), 269  
 Cat’s Eye Nebula, 18  
 Caves, Carlton, 277, 320  
 CDs (compact discs), 138, 140, 141, 141, 142  
 cellular control, 312  
 cellulose nitrate film, 15  
 Central Intelligence Agency (CIA), 55, 65, 153, 157  
 Central Laser Facility, 235  
 Centre National de la Recherche Scientifique, 72  
 ceramic fabrication processes, 316  
 ceramics, 97, 124, 171, 221, 234, 316  
 CERIN (European Center for Nuclear Research), 279  
 CGHs (computer generated holograms), 145  
 CGRO (Compton Gamma Ray Observatory), 249  
 chalcogenide fibers, 317  
 chalcogenides, 317  
 Chan, Kin Pui, 180  
 Chance, Britton, 309, 309  
 Chandra X-ray Observatory, 249, 251, 251  
 Chanin, Marie, 177–178  
 Charles Stark Draper Laboratory, 86  
 Charman, William, 265  
 Chebotayev, V., 220  
 chemical elements, 19, 21  
 chemical lasers, 93, 150, 151  
 chemical oxygen-iodine laser (COIL), 151  
 Chemla, Daniel S., 304  
 Chen, Chuangtian, 214, 215  
 Chiao, Ray, 116  
 “chirp,” 117, 171, 215, 224, 238, 288  
 chirp-pulse amplified femtosecond lasers, 305  
 chirped-pulse amplification, 235, 242, 304  
 Chraplyvy, Andrew, 211  
 chromatic dispersion, 211, 280, 283, 288  
 chromophores, 309  
 Chu, Steven, 220, 221, 221, 222, 224, 225, 329  
 Churchill, Winston, 205  
 CIA (Central Intelligence Agency), 55, 65, 153, 157  
 CIBA VISION, 254

- CIE system, 43, 44  
 CIECAM02, 44  
 CIECAM97s, 44  
 Cirac, Ignacio, 321  
 CL-282 (aircraft), 65  
 Clark, Alvan, 14  
 Clark, Harold, 57  
 Clark-MXR, 306  
 CLEO (Conference on Lasers and Electro-Optics), 178, 237, 259, 279, 285, 300, 304, 305, 313  
 climate change, 329–330  
 coatings  
   anti-reflection coatings, 3, 49, 69, 70, 71–72, 73, 266  
   interference coatings, 68–70  
   mirrors, 68, 69, 187, 245, 329  
   optical coatings, 3, 68–73, 142  
 COBE space telescope, 252  
 Coble, Robert, 234  
 Code, Art, 249  
 Cohen-Tannoudji, C., 221, 221, 225  
 coherent anti-Stokes Raman (CARS) spectroscopy, 219, 308  
 coherent anti-Stokes Raman spectroscopy (CARS) microscopy, 308  
 Coherent, Inc., 102, 305  
 Coherent Laser Radar Conference, 178  
 coherent lidar, 178  
 coherent light, 79, 88, 98, 107, 108, 114, 119, 213, 214  
 coherent optical communication, 210, 211, 294–295, 295  
 coherent phonons, 305  
 coherent population trapping, 217  
 Coherent Technologies, 178  
 coherent Raman microscopy, 310, 311  
 COIL (chemical oxygen-iodine laser), 151  
 Cold War, 49–50, 52, 85, 116, 151, 156, 157, 164, 199  
   *See also* spy satellites; surveillance imaging  
 Colladon, Daniel, 53  
 colliding-pulse mode-locked (CPM) geometry, 239–240  
 colliding pulse mode-locked lasers, 304  
 color-center lasers, 215, 241, 333  
 color-matching function data, 43  
 color measurements, standardization, 10  
 color order system, 43  
 color photography, 3, 10, 33, 34  
 color printing, 10  
 color science, 43–44  
 color television, 270  
 Colorado State University, 178  
 colorimetry, 43  
 Columbia Electronics Research Laboratory, 86  
 Columbia Radiation Laboratory, 85  
 Columbia University, 30, 40, 81, 84, 85, 86, 197, 219, 261  
 Columbia University Harkness Eye Center, 260  
 Commissariat à l’Energie Atomique, 169, 170  
 Committee on Medical Research (CMR), 27  
 communications, 327  
   bandwidth, 4, 191–192, 211, 280, 291  
   coherent optical communication, 210, 211, 294–295, 295  
   continuous-wave (CW) room-temperature diode lasers, 199–202, 200, 201  
   data transmission, 196, 215, 279–280, 279  
   erbium-doped fiber amplifier (EDFA), 195–198, 196–198, 210, 230, 277, 280, 281, 288  
   fiber-optic communications, 4, 50, 209–210, 210, 227, 230, 278–281, 279, 281  
   future trends in, 338–339  
   Internet, 4, 63, 133, 142, 191, 193, 207, 211, 277, 279, 280, 282, 283, 285, 286, 287, 333  
   low-loss fibers for, 189–193, 190–193, 241, 282  
   modems, 279, 282  
   optical communications networks, 183, 186, 189, 193, 195, 199, 205, 209–211, 215, 237, 277, 289–292, 289, 290, 338  
   quantum communications, 323  
   telecommunications industry, 282–286  
   telephony, 26, 203–207, 204, 206, 207, 279, 282  
   terabit-per-second fiber, 209–211, 210  
   World Wide Web, 279, 282  
 compact discs (CDs), 138, 140, 141, 141, 142  
 Compton, Karl, 27  
 Compton Gamma Ray Observatory (CGRO), 249  
 computer generated holograms (CGHs), 145  
 computers  
   personal computers, 135, 141, 279, 282, 331  
   quantum computers, 320–323, 329  
 Conant, James B., 27  
 condensed-matter physics, 3, 206, 323  
 Conference on Electron Device Research, 88  
 Conference on Laser Radar Studies of the Atmosphere, 178  
 Conference on Lasers and Electro-Optics (CLEO), 178, 237, 259, 279, 285, 300, 304, 305, 313  
 Conrady, Alexander Eugen, 33  
 contact lenses, 183, 184, 253–256, 254, 255, 260, 262, 333  
 Contax I camera, 33, 35–36, 36  
 Contessa Nettel, 36  
 continuous-stream inkjet, 62  
 continuous-wave argon-ion laser, 98  
 continuous-wave (CW) dye lasers, 95–96, 103, 161  
 continuous-wave femtosecond laser systems, 239–242, 241  
 continuous-wave (CW) room-temperature diode lasers, 199–202, 200, 201  
 continuous wear contact lenses, 254–255, 256  
 Convert, G., 90  
 Coolidge, William, 24  
 Copernicus mission, 249  
 copiers, 57, 62–63, 134  
   xerography, 57–63, 58–61, 134–137, 136, 137  
 copper-vapor lasers, 96, 163, 240  
 copper-vapor pumped dye lasers, 163, 164  
 Cornell, Eric, 221, 225  
 Cornell University, 186  
 Corning, 189, 190, 191, 199, 267, 277, 278, 280, 284, 300  
 Corning Glass Works, 24, 245, 248  
 CORONA program, 52, 65, 79, 153, 157–160, 159  
 “coronium,” 19  
 COSTAR optical system, 250  
 couching, 262  
 Cox, Ian, 253  
 Cox, Palmer, 32  
 CPM (colliding-pulse mode-locked geometry), 239–240  
 Cross, Lee, 100  
 Cross, Lloyd, 122  
 Cross, Lowell, 100  
 Crosswhite, H., 218  
 CRTs (cathode ray tubes), 269  
 CRU International, 280  
 Crystalens, 264  
 CSF, 90, 91  
 Cummings, Stuart, 264  
 Cummins, Herman, 82  
 Currie, Mal, 88, 89  
 Curtiss, Lawrence E., 50, 55, 56  
 “custom wavefront-guided” laser refractive surgery, 261  
 Cyclops laser, 168
- D**  
 Dagor lens, 33  
 Daguerre, Louis Jacques Mandé, 31  
 Dàlibard, J., 221  
 Danalens, 255, 255  
 Danielmeyer, H.G., 105  
 dark-field microscope, 312  
 dark-line defects (DLDs), 203  
 DARPA (Defense Advanced Research Projects Agency), 29, 151, 282  
 D’Asaro, Art, 201  
 DAST (4-dimethylamino-N-methyl-4-stilbazolium), 215  
 data transmission, 196, 215, 279–280, 279  
 Daukantas, Patricia, 9, 10, 17, 38  
 Davidson, Gil, 179  
 Davis, Doug, 177  
 Day, Clive, 298, 299  
 Day, D.A., 157  
 Dayton, Russell, 60  
 DCFs (dispersion-compensation fibers), 211  
 “death ray,” 149  
 Deckrullo focal plane shutter cameras, 35  
 Defense Advanced Research Projects Agency (DARPA), 29, 151, 282  
 Dehmelt, H.G., 220  
 Del’fin laser system, 167  
 Delfyett, P.J., 241  
 DeLoach, B.C., 207  
 Delta laser, 168  
 DeMaria, Tony, 186, 237  
 dementia, advances in treatment, 329  
 Denisyuk, Yuri, 121  
 Denton, Richard, 70  
 Department of Energy (DOE), 29, 164  
 Depot of Charts and Instruments, 26  
 Derr, Vernon, 178  
 designer optical interfaces, 334  
 Dessauer, John, 57, 61–62, 61  
 Desurvive, Emmanuel, 197, 210  
 Detch, J.L., 91  
 Deutsch, David, 320  
 Devlin, G.E., 104  
 Dexeimer, John, 285  
 DFB (distributed feedback) lasers, 288, 293  
 D’Haeens, Irnee, 79, 83  
 DIAL system (Differential-Absorption Lidar system), 175  
 Dieke, G., 218  
 Dietz, R.E., 105  
 Differential-Absorption Lidar (DIAL) system, 175  
 diffraction, 69  
 diffraction grating, 12  
 diffuse optical imaging in vivo, 309  
 digital holographic microscopy, 311  
 digital signal processing (DSP), 211  
 Digonnet, Michel, 195  
 Dill, Frederick H., Jr., 108, 108, 109  
 4-dimethylamino-N-methyl-4-stilbazolium (DAST), 215

- diode-laser bars, 229  
diode laser-pumped solid-state lasers, 105–106  
diode lasers, 105  
  continuous-wave room-temperature diode lasers, 199–202, 200, 201  
  high-power diode lasers, 227–231, 228–230  
  InGaAsP diode lasers, 197  
  long-lived diode lasers, 206–207  
  mirror damage in, 227  
  semiconductor diode lasers, 4, 107–111, 199, 209, 210, 240–241  
diode-pumped neodymium-slab laser, 151  
diods, LEDs, 4, 26, 105, 133, 178, 199, 203, 271, 272, 318  
Dirac, Paul, 9  
direct-detection lidar, 178  
DiscoVision, 138  
dispersion-compensation fibers (DCFs), 211  
display technology, future trends in, 333  
disposable contact lenses, 255  
distributed Bragg reflector lasers, 293  
distributed feedback (DFB) lasers, 288, 293  
Dixon, Richard W., 203, 205, 207, 207  
DLs (dark-line defects), 203  
DNA  
  genetic modification, 311  
  microarrays, 312  
Dobrowolski, George, 72  
DOE (Department of Energy), 29, 164  
Dollond, John, 13  
dominant designs, 62, 63  
Donders, F.G., 265  
“Doppler-free” laser spectroscopy, 220  
Dorpat Observatory, 14  
dot-com boom, 283  
double heterojunction lasers, 110, 111, 201, 201, 227, 228  
Dover printer, 136, 137, 137  
Dow Corning, 255  
drop-on-demand inkjet, 62  
DSP (digital signal processing), 211  
duality of light, 12  
Duguay, Michel, 238, 297  
Dumke, William P., 107, 108, 108  
Dupont, 24  
Durafforg, G., 107  
DVDs, 141, 141, 142  
Dwight, Herb, 97, 98  
dye lasers, 95, 304  
dye sublimation printing, 50  
dynamic grating spectroscopy, 219  
dynamic light scattering, 312  
dysprosium ions, 104  
Dziedzic, Joe, 225
- E**  
E-Tek Dynamics, 284  
Ealey, Mark, 247  
EAMs (electro-absorption modulators), 293  
EARS (Electronic Array Raster Scanner), 136  
Eastman, George, 10, 15, 25, 31, 33, 185  
Eastman, Jay, 128  
Eastman Dry Plate Co., 31  
Eastman Kodak Co., 23, 25, 31, 36, 44, 51, 95, 161  
Eastman Kodak Research Laboratory, 24, 25, 27, 33–34, 185  
Ebbers, Bernie, 286  
ECBO (European Conferences on Biomedical Optics), 313  
ECCE (extracapsular lens extraction), 262  
Eckhardt, Gisela, 115
- EDFA (erbium-doped fiber amplifier), 195–198, 196–198, 210, 230, 277, 280, 281, 288  
Edison, Thomas, 4, 15, 23, 34, 185  
Edlén, Bengt, 18  
Einstein, Albert, 3, 12, 81, 88  
Eisenhower, Dwight D., 29, 49, 52, 64, 65, 85, 148, 157, 158, 185  
EIT (electromagnetically induced transparency), 217  
Ektaprint 100 copier, 63  
El-Sum, Hussein M.A., 119  
electric power  
  laser fusion for, 171  
  solar power, 329, 332  
electricity, 11  
electro-absorption modulators (EAMs), 293  
electromagnetic radiation, 11  
electromagnetically induced transparency (EIT), 217  
electromagnetism, 11  
electron microscope, 119, 204, 336  
electron spin, 18  
Electronic Array Raster Scanner (EARS), 136  
electrophotography, 57  
  *See also* xerography  
  *Electrophotography* (Schaffert), 57  
  Electrotechnical Laboratories (Japan), 167  
  Ellerbrock, V.J., 267  
  ELT (Extremely Large Telescope), 248  
  emission lines, 12  
  Emmett, John, 161, 168  
  end-pumping, 196  
  endlessly single-mode (ESM) PCF, 299  
  endoscopy, 50, 55, 310  
  fiber-optic endoscope, 50, 55, 56  
  future trends in, 328  
energy, future trends in, 332  
Energy Star 6, 272  
engineering, post-World War II statistics, 85, 87  
Enron, 284, 286  
entangle-based quantum-key distribution, 320–321  
Epson, 270  
Epstein, Ivan, 72  
erbium, 280, 304  
erbium-doped fiber amplifier (EDFA), 195–198, 196–198, 210, 230, 277, 280, 281, 288  
erbium-doped lasers, 106  
erbium ions, 104, 196  
Ericksen, J.L., 269  
Ernst Leitz Optical Works, 33, 34  
ESM-PCF, 299  
Essilor, 266  
ether, 11  
“ether wind,” 11–12  
Ettenberg, Michael, 199  
European Center for Nuclear Research (CERN), 279  
European Conferences on Biomedical Optics (ECBO), 313  
europium ions, 104  
Evans, R.M., 44  
evaporated dielectric coatings, 70  
excimer laser, 183  
excimer laser ablation, 260, 306  
excimer laser lithography, 4  
excimer laser surgery, 257–261, 258, 259, 306  
excitation curves, 43  
exclusion principle, 18  
exobiology, 335  
exoplanets, 252  
extracapsular lens extraction (ECCE), 262  
Extremely Large Telescope (ELT), 248
- Exxon Nuclear, 161  
*Eye in the Sky: The Story of the CORONA Spy Satellite* (Day, Logsdon, & Latell), 157  
eye surgery. *See* ophthalmic surgery  
eyeglasses, 10, 11, 14–15, 265–268, 267  
  astigmatism, 15  
  bifocals, 14, 184, 253, 254, 263, 265, 266, 268  
  frames for, 15  
  lenses, 184, 265, 266  
  for low-vision patients, 267  
  polarizing sunglasses, 51
- F**  
Fabrikant, Valentin, 81  
Fabry–Perot resonator, 81  
Faint Object Camera (FOC), 250  
Faint Object Spectrograph (FOS), 250  
Fairchild K-19, 66  
Fano interference, 217  
Faraday, Michael, 11  
Faris, Gregory, 277, 308  
“fast ignition” target, 171  
Faust, W.L., 92  
Feinbloom, William, 253  
Fejer, Martin, 213  
FELs (free-electron lasers), 151, 336  
femtosecond absorption spectroscopy, 180  
femtosecond direct laser writing, 317–318  
femtosecond lasers, 147, 238, 239–242, 241, 304, 305, 306  
Fenner, G.E., 108, 109  
Ferguson, James, 270  
fermions, 18, 322  
FETs (field effect transistors), 293  
fiber amplifiers, 195–196, 288  
fiber attenuation, 280  
fiber-based astronomy, 301  
fiber-grating compressors, 216  
fiber lasers, 241–242  
fiber-optic communications, 4, 50, 209–210, 210, 227, 230, 278–281, 279, 281  
fiber-optic connectivity, 4  
fiber-optic endoscope, 50, 55, 56  
fiber-optic image scramblers, 55  
fiber-optic imaging, 53–56  
“fiber-to-the-home,” 207  
fiber-optic amplifier (FOA), 195–198, 282  
fibers  
  Bragg fibers, 297, 298  
  chalcogenide fibers, 317  
  dispersion-compensation fibers (DCFs), 211  
  fiber structure, 301  
  future trends in, 327–328  
  glass fibers, 53–54, 55, 187, 195, 209, 210, 297, 328  
  high-power fibers, 327  
  hollow-core photonic crystal fibers, 297, 299, 300, 301, 327, 328  
  low-loss fibers, 189–193, 190–193, 241, 278, 282  
  “Mercedes” fiber, 301  
  microstructured optical fibers, 277, 297–301, 298–301, 328  
  multi-core fibers, 301, 328  
  non-zero dispersion-shifted fibers, 280, 289  
  photonic bandgap fibers, 277  
  photonic crystal fiber (PCF), 298–299, 299, 317, 327  
  rod-in-tube fibers, 55, 190  
  single-mode fibers, 55–56, 191, 206, 210, 279, 301  
  terabit-per-second fiber, 209–211, 210  
  ultra-low-loss fibers, 327

- fiberscope, 50  
field effect transistors (FETs), 293  
film-based photography, 10  
film, photographic. *See* photographic film  
Fiocco, Giorgio, 175, 176  
FIREX project, 171  
first-generation lasers, 205  
Fisher, A.G., 270  
Fizeau interferometer, 144, 144  
flame-emission spectroscopy, 20  
flame hydrolysis, 190  
flashlamp-pumped picosecond systems, 237–239  
flashlamp pumping, 84, 95, 95, 103, 169, 280  
flowing gas-dynamic carbon dioxide lasers, 187  
fluorescence correlation spectroscopy, 312  
fluorescence microscope, 312  
fluorescence recovery after photobleaching (FRAP), 311  
fluorescent lamp, 4, 271  
fluorite, 103  
fluorophores, 309, 311  
FOA (fiber-optic amplifier), 195–198, 282  
FOC (Faint Object Camera), 250  
folding Pocket Kodak (FPK) camera, 32–33, 32  
Ford Motor Co. Research Laboratory, 115  
Ford Scientific Research Center, 177  
Fork, Richard L., 216, 304  
Forster, Don, 88  
Förster resonance energy transfer (FRET), 311  
Fort Belvoir, 72  
FOS (Faint Object Spectrograph), 250  
four-level lasers, 83, 104  
four-wave mixing (FWM), 211, 219  
Fowler, Alfred, 17  
Foy, P.W., 111  
Franck–Condon principle, 232  
Frank, F.C., 269  
Franken, Peter, 114, 115, 213, 218, 219, 246  
Frankford Arsenal, 70  
FRAP (fluorescence recovery after photobleaching), 311  
Fraunhofer, Joseph von, 12, 13  
free-electron lasers (FELs), 151, 336  
free-space solid-state lasers, 242  
Fréedericksz, V., 269  
Freeman, R.R., 224  
frequency combs, 4, 117, 147, 221, 300, 301, 337  
frequency-resolved optical gating (FROG), 238  
Fresnel, Augustin-Jean, 11, 12, 69  
FRET (Förster resonance energy transfer), 311  
Freulich, Rod, 180  
FROG (frequency-resolved optical gating), 238  
fuels, 332  
Fuji-Xerox, 63  
Fujimoto, James, 238, 240, 309, 310  
Fujitsu Laboratories, 281  
FULCRUM program, 154  
fullerenes, 315  
fused fiber bundles, 55, 56  
fusion research, with lasers, 166–172, 167–171  
FWM (four-wave mixing), 211, 219
- G**  
GaAlAs lasers, 197, 203, 240  
GaAs-GaAlAs heterostructure semiconductor lasers, 203, 204  
GaAs homojunction (diode) lasers, 187  
GaAs injection laser, 107–109  
Gabel, Conger, 96  
Gabor, Dennis, 119, 122  
GALEX space telescope, 252  
GAMBIT system, 160  
Gamble, Susan, 122  
GaPAs, 109  
Garbuzov, Dmitry Z., 111  
Gardner, Chet, 178, 179  
Garmire, Elsa, 116, 117  
gas-dynamic lasers, 92–93, 92, 150  
gas lasers, 88–93  
  ionized gas lasers, 90–91, 91  
GE Hitachi Nuclear Energy, 165  
Geffcken, Walter, 70  
Gekko laser, 169  
gelatin dry plates, 31  
Gemini amplifiers, 235, 235  
gene chips, 311  
gene expression, 311  
General Electric Co. (GE), 23–24, 70, 100, 108, 109, 165, 185, 187, 199  
genetics  
  genetic modification, 311  
  optogenetics, 334  
Geodolite Laser Distance Rangefinder, 98–99  
Georgia Tech, 177  
germania, 191  
germanium, 107, 110, 199  
Gerry, Ed, 150, 187  
Gestic, J.E., 104, 105, 186  
GHRF (Goddard High Resolution Spectrograph), 250  
Giant Magellan Telescope (GMT), 248  
Gilder, George, 284, 285  
Giordmaine, Joe, 114, 116, 117, 186, 214  
glass  
  anti-reflection coatings, 3, 49, 69, 70, 71–72, 73, 266  
  optical glass, 13, 23, 24, 33, 35, 101, 189, 266  
  photo-thermo-refractive (PTR) glass, 318  
  quality for lenses, 13, 14  
  rare-earth metal-doped glass fiber, 210  
  glass fibers, 53–54, 55, 187, 195, 209, 210, 297, 328  
  glass fusion lasers, 169  
  glass lasers, 101, 104, 150, 166, 167, 168, 186, 237, 238, 239  
  glass mirrors, 68, 245  
  GMT (Giant Magellan Telescope), 248  
  Goddard, George, 64  
  Goddard High Resolution Spectrograph (GHRF), 250  
  Godowsky, Leopold, Jr., 34  
  Goethe, J.W. von, 68, 69  
  Goetze, Richard, 17  
  Goldman, Jack, 62, 135  
  Goldmuntz, Lawrence, 82, 149  
  Goldsworthy, Michael, 165  
  Gordon, E.L., 91  
  Gordon, James, 7, 81, 82, 82, 215, 224  
  Goudsmit, Samuel, 18, 83  
  Gould, Gordon, 81, 82, 83, 100, 149, 150  
  governmental and industrial research laboratories. *See* industrial and governmental research laboratories  
  governmental funding agencies, 9, 185–188  
  Graham, Clarence H., 40  
  Granit, Ragnar, 41  
  Granitsis, George, 101  
  Grant, Bill, 175  
  graphene, 315  
  graphite, 315  
  gravity-wave astronomy, 329  
  Gray, George, 270  
  Great Britain, 9  
  Great Observatories, 249, 252  
  green fluorescent protein, 311  
  “green gap,” 271  
  Gregg, David P., 138  
  Grotian, Walter, 18–19  
  ground-based telescopes, 244–248, 245–248  
  group velocity dispersion (GVD), 215  
  Gschwendtner, Al, 177  
  GTE Laboratories, 117  
  Guggenheim, H.J., 105  
  Guiliano, Connie, 186  
  Guinand, Pierre Louis, 13  
  Guirao, Antonio, 263  
  Gustafson, Ken, 116  
  Gustavson, Todd, 10, 31  
  GVD (group velocity dispersion), 215
- H**  
Hagan, David J., 277, 315  
Hale, George Ellery, 244, 245, 245, 246  
half-integral quantum numbers, 18  
Hall, Charles, 153  
Hall, Freeman, 178  
Hall, Jan, 300  
Hall, J.L., 219, 222  
Hall, John, 97, 147  
Hall, Robert N., 108, 109, 187  
Haloid Co., 57, 60, 61  
Hamburg Observatory, 4  
*Handbook of Physiological Optics* (Helmholtz), 15  
handheld barcode scanners, 131–132  
Hänsch, Theodor, 94, 96, 147, 220, 220, 221, 224, 225, 300  
Hansell, C.W., 53  
Hardesty, Mike, 178, 180  
Hardwick, David, 97  
Hardy, A.C., 43, 44  
Hardy, John, 247  
Hardy spectrophotometer, 43  
Harris, Stephen E., 186, 214, 216, 217, 221  
Harrison, George, 20, 21, 28  
Hartline, Haldan Keffer, 40, 40, 41  
Hartman, R.L., 207, 207  
Hartmann–Schack wavefront sensors, 256  
Harvard College Observatory, 14, 14  
Harvard “great refractor,” 14, 14  
Harvard University, 101, 177, 186  
Harvard University Optical Research Laboratory, 65  
Hasegawa, Akira, 117, 215  
Hass, Georg, 72  
Haus, H.A., 239  
Haus, J., 213  
Hausmann, Carl, 168  
Hayashi, Izuo, 111, 201–202, 204, 293  
HBTs (hetero-junction bipolar transistors), 293  
Heaps, Bill, 175, 177  
Heard, H.G., 92  
Heavens, Oliver, 72, 84  
Hecht, Jeff, 9, 11, 51, 53, 79, 81, 85, 94, 100, 102, 114, 119, 149, 161, 277, 278, 282  
Hecht, Selig, 39–40, 40  
Heilmeyer, George, 269  
Heinz, T., 221  
Heisenberg, Werner, 18, 40  
Helfrich, Wolfgang, 270  
helium, model for neutral atom, 17  
helium-mercury ion laser, 90–91, 91  
helium-neon lasers, 4, 84, 88–89, 89, 90, 97, 98, 107, 120, 134, 135, 136, 138, 190  
Hellwarth, Robert, 115

- Helmholtz, Hermann, 15  
Henderson, Sammy, 178  
Heraeus Corp., 155  
Hercher, Michael, 116, 186  
Herriott, Donald, 84, 88, 89, 89  
Herschel, William, 11, 14  
Herschel space telescope, 252  
Herscher, Mike, 96  
Hertz, Heinrich, 11, 12  
hetero-junction bipolar transistors (HBTs), 293  
heterodyne Doppler lidar, 177  
heterodyne interferometry, 143, 247  
Hewlett-Packard, 62, 63, 98, 131  
Hexagon program, 79, 154, 158, 160  
Hexagon spy satellite, 153–156, 154–156, 158  
Heyerdahl, Thor, 98  
Hicks, Will, 55, 56  
hierarchical self-assembly, 318  
high-average-power lasers, 336  
high-power diode lasers, 227–231, 228–230  
high-power fiber lasers, 106, 126, 198  
high-power fibers, 327  
high-power gas lasers, 4  
High Speed Photometer (HSP), 250  
Hilbert, Robert S., 157, 158, 159  
Hillotype, 33  
HIORP (Hubble Independent Optical Review Panel), 250  
HiPER project, 171  
Hirschowitz, Basil I., 50, 55, 56  
Hitachi Central Research Laboratory, 165, 227  
Hochuli, Urs, 97  
Hockham, G., 189, 209  
hohlraum, 166, 170  
Holland, Leslie, 72  
hollow-core photonic crystal fibers, 297, 299, 300, 301, 327, 328  
holmium ions, 104  
holographic interferometry, 144–145  
holography, 79, 119–122  
  computer generated holograms (CGHs), 145  
  phase-shifting interferometric, 145  
  reflection holography, 121, 122  
  time-averaged holography, 145  
  two-wavelength holography, 145  
Holonyak, N., Jr., 109, 187  
Homéos stereo camera, 34  
Homer, Howard, 71  
homodyne interferometry, 143–144  
Hooker, John K., 244  
Hopkins, Harold H., 50, 54  
Hopkins, Robert, 143, 158  
HRL (Hughes Research Laboratory), 88, 91, 98, 100, 103, 115, 185, 186, 187  
HSP (High Speed Photometer), 250  
Hubble, Edwin, 244, 245, 247  
Hubble Independent Optical Review Panel (HIORP), 250  
Hubble Space Telescope (HST), 4, 13, 143, 184, 247, 249–250, 250, 251, 252  
Huffaker, Milt, 178  
Huggins, Margaret, 13  
Huggins, William, 13  
Hughes Aircraft Co., 94, 98, 100, 115  
Hughes Research Laboratories (HRL), 88, 91, 98, 100, 103, 115, 185, 186, 187  
Hull University, 270  
Hund, Friedrich, 18  
Hunter, Max, 151  
Hunter, R.S., 44  
Huygens, Christiaan, 11  
Hycon, 67  
Hycon K-38, 66  
Hyde, Frank, 189  
hydrogen, Bohr model, 13  
hydrogen-fluoride chemical lasers, 93  
hydrogen-fluoride optical parametric oscillator, 163  
hyper-contrast optical systems, 252  
hyperfine splitting, 9, 20  
hyperfine structure, 19
- I**  
IBM, 100, 108, 108, 110, 187, 199, 221  
IBM Watson Research Center, 84, 94, 103, 104, 187, 187, 257  
IBM Zurich Laboratories, 228  
Icaroscope, 114  
ICCE (intracapsular lens extraction), 262  
ICG (indocyanine green), 309  
ICLAS (International Coordination Group on Laser Atmospheric Studies), 178  
illumination  
  fluorescent lamp, 4, 271  
  incandescent light bulbs, 4, 24  
  solid-state lighting, 339  
ILRC (International Laser Radar Conference), 178, 179  
image scramblers, 55  
imaging barcode scanners, 133  
imaging machines, xerography, 57–63, 58–61, 134–137, 136, 137  
Inaba, Humio, 180  
incandescent bulbs, 4, 24  
indium-tin-oxide (ITO) film, 269  
indocyanine green (ICG), 309  
industrial and governmental research laboratories, 9, 23–30  
Infrared Astronomical Satellite (IRAS), 251–252  
infrared materials, 317  
infrared optical microscope, 203–204  
infrared spectroscopy, 3  
infrared thin film, 72  
InGaAsP diode lasers, 197  
inkjet printers, 50, 62, 63  
inner-quantum number, 17  
InP-based lasers, 206, 293, 294  
Institute of Optics (University of Rochester), 25, 33, 54, 134, 143, 158, 168, 169, 170, 185, 186, 304  
instrumental optics, 9  
integrated photonics, 277, 293–295, 294, 295  
Intel, 293  
Intelligence Systems Panel (ISP), 65  
intensity-comparison with standards method, 20  
intensity-modulation direct detection, 210  
interference coatings, 68–70  
interference phenomena, 69  
interferometers, 9, 12, 69, 70, 143–146, 144, 247, 293, 322, 329  
interferometric optical metrology, 143–147  
interferometry  
  heterodyne and homodyne interferometry, 143–144, 247  
  metrology and, 143–147  
  phase-shifting interferometry, 143, 144, 146–147  
  stellar interferometers, 247  
International Conference on Picosecond Phenomena, 237  
International Conference on Ultrafast Phenomena, 237  
International Coordination Group on Laser Atmospheric Studies (ICLAS), 178  
International Laser Radar Conference (ILRC), 178, 179
- International Quantum Electronics Conference, 82, 162, 234  
International Symposium on Remote Sensing of Environment, 178  
International Telecommunications Union, 193  
Internet, 4, 63, 133, 142, 191, 193, 207, 211, 277, 279, 280, 282, 283, 285, 286, 287, 333  
Internet of Things, 333  
intracapsular lens extraction (ICCE), 262  
intraocular lenses, 262–264  
iodoquinine sulfate, 51  
ionized gas lasers, 90–91, 91  
ionography, 62  
iPhone 6, 272, 272  
Ippen, Erich P., 96, 216, 232, 239, 240  
IRAS (Infrared Astronomical Satellite), 251–252  
IRCOM (France), 297  
Iskra laser system, 166  
isosulfan blue, 309  
isotope enrichment, 161–165, 162–164  
ISP (Intelligence Systems Panel), 65  
Itabe, Toshikazu, 179  
ITEK and the CIA (Lewis), 157  
ITEK Corp., 65, 143, 157, 158  
ITEK Optical Systems, 247  
Ito, Hiromasa, 179  
ITO film (indium-tin-oxide film), 269  
Ives, Herbert, 69  
Izatt, Joe, 313
- J**  
Jahn–Teller splitting, 234  
James Webb Space Telescope (JWST), 252  
Janes, G. Sargent, 161  
Janus laser, 168  
Javan, Ali, 82–83, 84, 88, 89, 89, 107  
JDS Uniphase, 284  
JDSU Corp., 230, 285  
Jelalian, Al, 177  
Jensen, Reed, 161  
Jersey Nuclear-Avco Isotopes, 163  
Jet Propulsion Lab (JPL), 175  
Jewett, Frank B., 27  
JHPSSL (Joint High Power Solid State Laser), 151, 151  
JILA, 97, 221  
Jobs, Steve, 140  
Johnson, A.M., 216  
Johnson, Kelly, 49, 65  
Johnson, L.F., 104, 105, 232–233  
Johnson, Roy, 149  
Johnson and Johnson, 255  
Johnston, Sean, 122  
Joint High Power Solid State Laser (JHPSSL), 151, 151  
Jones, Frank, 71  
*Journal of Applied Physics*, 84  
*Journal of Display Technology*, 271  
*Journal of Lightwave Technology*, 291–292  
*Journal of the Optical Society of America (JOSA)*, 20, 38, 40, 41, 44, 56, 69, 119, 121, 221, 265, 312, 315  
JPL (Jet Propulsion Lab), 175  
Judd, D.B., 43  
JWST (James Webb Space Telescope), 252
- K**  
K-19 camera, 66  
Kaiser, David, 86  
Kaminskii, A.A., 105  
Kantrowitz, Arthur, 150, 161  
Kao, Charles, 189, 199, 209, 339  
Kapany, Narinder, 54, 56, 100  
Karrer, Paul, 41

- Kass, Stanley, 176  
 Kay, Alan, 136  
 Kazarinov, R.F., 110  
 Keck, Donald B., 189, 190, 191, 279  
 Keck Ten-Meter-Diameter Telescope Project, 248  
 Kelley, Paul, 3, 28, 49, 116, 179  
 Kepler mission, 252  
 Kepler space telescope, 252  
 Kerr-effect lensing, 236  
 Kerr-lens mode-locked lasers, 242, 304  
 Kerr nonlinearity, 211  
 Kessler Marketing Intelligence, 280  
 Ketterle, Wolfgang, 221, 225  
 Keuffel & Esser Co., 24  
 Keyes, R.J., 105, 108, 109, 187  
 KH-7 GAMBIT, 153  
 KH-9 Hexagon spy satellite, 153–156, 154–156, 158  
 Khokhlov, Rem V., 116  
 Kidder, Ray, 161, 166  
 Kiess, C.C., 20  
 Killinger, Dennis K., 175, 177, 178, 179, 180  
 Kimmerling, L.C., 107, 110  
 Kinoscope, 34  
 King, Peter, 71  
 Kingslake, Rudolf, 33  
 Kingsley, Jack, 108, 109  
 Kirchhoff, Gustav Robert, 12–13  
 Kirkpatrick, Paul, 119  
 Kirtland Air Force Base, 248  
 Kiss, Z.J., 104  
 Kitt Peak National Observatory, 245, 246  
 Kleinman, David, 117  
 KMS Fusion, 101, 168  
 Knight, Jonathan, 299, 300  
 Knoll, Henry, 253  
 Knox, Wayne H., 96, 277, 304, 305, 306  
 Knutson, J.W., Jr., 91  
 Kobayashi, Takao, 179  
 Kodachrome film, 34  
 Kodak AG, 36  
 Kodak camera, 31  
 Kodak Co., 61, 158, 185  
 Kodak Research Laboratories. *See* Eastman Kodak Research Laboratory  
 Kodak Retina camera, 36  
 Koester, Charles, 101, 186, 195  
 Kollmorgen, Frederick, 69  
 Kompfner, Rudi, 223  
 Korad Inc., 100  
 Kornei, Otto, 59  
 Korol'kov, Vladimir I., 111  
 Korsch, Dietrich, 250  
 Kossel, Walther, 17  
 Kowalski, Robert, 134, 135  
 Krag, W.E., 109  
 Kressel, Henry, 111, 199, 200  
 Krishnan, K.S., 19  
 Kroemer, Herb, 110, 187  
 Krupke, William, 103  
 krypton fluoride lasers, 167  
 krypton-ion lasers, 91  
 Kubelka, P., 44  
 Kusch, Polykarp, 81
- L**  
 Labuda, E.F., 91  
 Lamb, Willis, 96, 114  
 Lamb shift, 220  
 Lamm, Heinrich, 50, 53–54  
 Land, Edwin, 49, 51–52, 64, 65, 158  
 Langmuir, Irving, 24  
 Lankard, Jack, 94  
 Large, Maryanne, 299  
 Large Optics Demonstration Experiment (LODE), 151  
 large-scale photonic integrated chip (LS-PIC), 293  
 Large Space Telescope (LST), 249  
 laser ablation, 92, 257, 258, 260, 306  
 laser-bars, 228  
 laser-based phase-shifting Fizeau interferometer, 144, 144  
 laser-based spectroscopy, 147, 232  
 laser cooling, 221  
 laser diode pump, 304  
 laser diodes, 105, 199, 200, 201, 202, 293, 304, 318, 327  
 laser Doppler velocimetry, 328  
*Laser Focus* (magazine), 121, 259  
 laser fusion experiments, 101  
 laser guide star, 4, 29, 178, 247, 248, 248  
 Laser Heterodyne Radiometer, 175, 177  
*The Laser in America* (Bromberg), 103  
 laser in situ keratomileusis (LASIK), 5, 183, 260, 261, 306, 308, 312  
 Laser In Space Technology Experiment (LITE), 177  
 Laser Inc., 102  
 laser-induced-breakdown spectroscopy (LIBS), 178  
 laser-induced continuum structure, 217  
 laser-induced fluorescence (LIF), 177, 178  
 Laser Interferometer Gravitational-wave Observatory (LIGO), 12  
 laser isotope enrichment, 161–165, 162–164  
 Laser Megajoule (LMJ) project, 170, 171  
 laser oscillation, 90, 91  
 laser printers, 134–137, 136, 137, 183–186  
 laser printing, 4, 62  
 laser radar, 175–178  
 laser radiation pressure, 223  
 laser spectroscopy, 218–219, 221–222  
 laser trapping, 225  
 laser unequal path interferometer (LUPI), 143, 144  
 laser video disc, 138  
 laser weapons, 149–152  
 lasers, 3, 4, 9, 50, 52, 79, 163, 209, 218  
   Airborne laser, 151  
   AlGaAs lasers, 202, 228  
   Alpha laser, 151  
   at American Optical Co., 10, 15, 51, 55, 56, 100, 101–102  
   applications, 4  
   argon-ion lasers, 91, 91, 95, 96, 98, 196, 225, 234  
   Ashura laser system, 167  
   Asterix laser system, 166  
   carbon dioxide lasers, 92–93, 92, 102, 124, 150, 163, 167, 168, 186, 187  
   chemical lasers, 93, 150, 151  
   chemical oxygen-iodine lasers (COILs), 151  
   chirp-pulse amplified femtosecond lasers, 305  
   colliding pulse mode-locked lasers, 304  
   color-center lasers, 215, 241, 333  
   continuous wave argon-ion lasers, 98  
   continuous-wave (CW) dye lasers, 95–96, 103, 161  
   continuous-wave femtosecond systems, 239–242, 241  
   copper-vapor lasers, 96, 163, 240  
   copper-vapor pumped dye lasers, 163, 164  
   Cyclops laser, 168  
   Del'fin laser system, 167  
   Delta lasers, 168  
   development, 81–84, 88–93  
   diode laser-pumped solid-state lasers, 105–106  
   diode lasers. *See* diode lasers  
   diode-pumped neodymium-slab lasers, 151  
   distributed Bragg reflector lasers, 293  
   distributed feedback (DFB) lasers, 288, 293  
   double heterojunction lasers, 110, 111, 201, 201, 227, 228  
   dye lasers, 95, 304  
   erbium-doped lasers, 106  
   excimer lasers, 183, 257–261, 258, 259  
   femtosecond direct laser writing, 317–318  
   femtosecond lasers, 147, 238, 239–242, 241, 304, 305, 306  
   fiber lasers, 241–242  
   flashlamp-pumped picosecond systems, 237–239  
   flowing gas-dynamic carbon dioxide lasers, 187  
   four-level laser action, 83, 104  
   free-electron lasers (FELs), 151, 336  
   free-space solid-state lasers, 242  
   frequency comb lasers, 147  
   fusion research with, 166–172  
   future trends in, 336–337  
   GaAlAs lasers, 197, 203, 240  
   GaAs-GaAlAs heterostructure semiconductor lasers, 203, 204  
   GaAs homojunction (diode) lasers, 187  
   GaAs injection lasers, 107–109  
   gas-dynamic lasers, 92–93, 92, 150  
   gas lasers, 88–93  
   Gekko lasers, 169  
   glass fusion lasers, 169  
   glass lasers, 101, 104, 150, 166, 167, 168, 186, 237, 238, 239  
   helium-mercury ion lasers, 90–91, 91  
   helium-neon lasers, 4, 84, 88–89, 89, 90, 97, 98, 107, 120, 134, 135, 136, 138, 190  
   high-average-power lasers, 336  
   high-power diode lasers, 227–231, 228–230  
   high-power fiber lasers, 106, 126, 198  
   holography and, 120–121  
   hydrogen-fluoride chemical lasers, 93  
   industrial growth, 100  
   industrial lasers, 124–126  
   InGaAsP diode lasers, 197  
   InP-based lasers, 206, 293, 294  
   interferometric optical metrology, 143–147  
   Iskra laser system, 166  
   for isotope enrichment, 161–165, 162–164  
   Joint High Power Solid State Laser (JHPSSL), 151, 151  
   Kerr-lens mode-locked lasers, 242, 304  
   krypton fluoride lasers, 167  
   krypton-ion lasers, 91  
   laser-based precision spectroscopy, 147  
   laser-induced-breakdown spectroscopy (LIBS), 178  
   laser isotope enrichment, 161–165, 162–164  
   Laser Megajoule (LMJ) project, 170, 171  
   laser unequal path interferometer (LUPI), 143, 144  
   Ligne d'Intégration Laser (LIL), 170  
   liquid-phase epitaxy (LPE), 200, 200, 203, 204, 206  
   live-cell lasers, 334  
   as manufacturing process tool, 124  
   materials processing with, 124–126  
   matrix-assisted laser desorption/ionization (MALDI), 312

- medical applications. *See* medical applications
- mercury-ion lasers, 91, 98
- Mid-Infrared Advanced Chemical Lasers (MIRACLs), 150, 150
- “million hour paper,” 205
- mirrors, 81, 88, 89, 90, 90, 91, 91, 94, 96, 97, 103, 130, 131, 132, 132, 143, 200, 202, 235, 336–337
- molecular gas lasers, 92–93, 92
- Navy ARPA Chemical Laser (NACL), 150
- neodymium:fiber lasers, 241
- neodymium-glass fiber lasers, 187
- neodymium-glass lasers, 104, 150, 166, 167, 186, 237–238
- neodymium-glass rod lasers, 187
- neodymium-YAG lasers, 104, 105, 124, 125, 186, 240, 242, 257, 258, 259, 301, 304
- NIF lasers, 170, 171
- Nike laser system, 167
- noble-gas ion lasers, 91
- nonlinear optics and, 114–117
- Nova lasers, 169, 170
- Omega lasers, 169
- Omega Upgrade lasers, 170, 171
- Phebus lasers, 169
- photolytically pumped iodine lasers, 166
- picosecond lasers, 237–239
- printers, 134–137, 136, 137
- for propulsion, 336–337
- pulsed argon ion lasers, 91, 98
- pulsed dye lasers, 96, 238–239
- pumped dye lasers, 95, 163, 164, 177, 234
- Q-switching ruby lasers, 94, 115, 116, 116
- quantum cascade lasers (QCLs), 176, 178, 318
- quantum-well lasers, 202, 227, 228
- radio-frequency coupling, 97
- rare earth fiber lasers, 4
- remote sensing, laser radar, and lidar, 175–178, 176, 177, 179, 180, 180
- room-temperature GaAs-AlGaAs heterostructure semiconductor lasers, 203
- ruby lasers, 83, 84, 88, 94, 95, 100, 103, 114, 115, 116, 116, 121, 124, 149, 175, 186, 218, 232, 234
- semiconductor diode lasers, 4, 107–111, 199, 209, 210, 240–241
- separate confinement heterojunction quantum well lasers, 202
- Shiva lasers, 168
- single-stripe lasers, 228, 229, 229, 231
- solid-state lasers, 4, 84, 101, 103–106, 125, 126, 131, 178, 227, 228, 231, 242, 316
- soliton lasers, 241
- at Spectra-Physics, 89, 90, 91, 97–99
- spectroscopy with, 96
- stretched-pulse lasers, 242
- stripe-geometry lasers, 111, 203
- Sun-powered lasers, 101
- in telescopes, 184, 245–248, 251, 252
- 10-J Janus lasers, 168
- three-section tunable DBR lasers, 293
- titanium:sapphire lasers, 234, 235, 236, 242, 304
- tunable dye lasers, 4, 94–96, 95, 161
- tunable quantum cascade lasers, 176
- tunable solid state lasers, 105, 232–236, 233–235
- types, 4
- ultrafast-laser technology, 304–306, 305, 306
- ultrashort lasers, 306
- ultrashort-pulse lasers, 96, 237–242, 239–242
- vibronic lasers, 233
- vision correction. *See* vision correction
- Vulcan lasers, 169
- weapons, 149–152
- Yb:fiber lasers, 242
- ytterbium-doped lasers, 106
- yttrium aluminum garnet (YAG) lasers, 104, 105, 124, 125, 186, 225, 240, 242, 257, 258, 259, 301, 304
- Zeta lasers, 168
- Laservision, 138
- Lasher, Gordon J., 108, 108
- LASIK (laser in situ keratomileusis), 5, 183, 260, 261, 306, 308, 312
- lasing without inversion (LWI), 217
- Latell, B., 157
- lateral inhibition, 40
- Lawrence, George, 250
- Lawrence Livermore National Laboratory (LLNL), 96, 101, 161, 162, 163, 164, 165, 166, 169, 170, 228, 233
- Lax, B., 109
- LBO (lithium borate), 215
- LCD TV, 272
- LCDs (liquid crystal display), 269–272, 271, 272, 318
- LDs (semiconductor laser diodes), 105, 132
- LDX (Long Distance Xerography), 134
- Lebedev Institute (Russia), 167
- Lechner, Bernard, 270
- LED lighting, 4
- LEDs (light-emitting diodes), 4, 26, 105, 133, 178, 199, 203, 271, 272, 318
- Lee, Byounggho, 333
- Leghorn, Richard, 65, 85
- Lehmann, Otto, 269
- Leica cameras, 33–35, 35
- Leith, Emmett, 119–121, 120, 122
- Leitz, Ernest, II, 35
- LeMay, Curtis, 149
- length-of-line method, 20
- lens index, 266
- lenses, 13
- achromatic lens, 13
- for cameras, 3, 33, 35
- contact lenses, 183, 184, 253–256, 254, 255, 260, 262, 333
- eyeglasses, 184, 265, 266
- intraocular lenses, 262–264
- lens index, 266
- photochromic lenses, 267
- prism lenses, 265
- lensless photography, 121
- Leonberger, Fred, 300
- Leslie, F.M., 269
- L’Esperance, Francis L., 259, 260
- Letokhov, V., 220, 224, 225
- Letz, P., 221
- “Leviathan” mirror, 14
- Levishin, Vadim L., 114
- Levison, Walter, 158
- Levy, Richard, 161
- Li, Guifang, 209
- Li, Tingye, 211
- LIBS (laser-induced-breakdown spectroscopy), 178
- Lick Telescope, 14
- lidar, 175–178
- “Lidar Pancake,” 177
- LIF (laser-induced fluorescence), 177, 178
- LIFE project, 171
- light
- coherent light, 79, 88, 98, 107, 108, 114, 119, 213, 214
- as electromagnetic radiation, 11
- illumination, 4, 24, 271, 339
- inelastic scattering, 19
- particle theory, 11
- quantization, 3
- as trigger for changes in cells, 312
- wave nature, 11–12
- wave-particle duality, 12
- wave theory, 11, 69
- light-emitting diodes (LEDs), 4, 26, 105, 133, 178, 199, 203, 271, 272, 318
- light guiding, 53, 54
- light in flight, 238, 239
- light waveguide, 201
- lighting. *See* illumination
- Ligne d’Intégration Laser (LIL), 170
- LIGO (Laser Interferometer Gravitational-wave Observatory), 12
- Lincoln Laboratory. *See* MIT Lincoln Laboratory
- linear ion trap, 322
- linear spectroscopy, 218–219
- Linker, Ralph, 258
- Linn, Doug, 100
- Lippmann, Gabriel, 69
- Lippmann emulsion, 69
- liquid crystal display (LCD), 269–272, 271, 272, 318
- liquid-phase epitaxy (LPE), 200, 200, 203, 204, 206
- Lister, Joseph (son; surgeon), 14
- Lister, Joseph Jackson (father), 14
- LITE (Laser In Space Technology Experiment), 177
- lithium borate (LBO), 215
- lithography, 4, 50, 318
- live-cell lasers, 334
- LLNL (Lawrence Livermore National Laboratory), 96, 101, 161, 162, 163, 164, 165, 166, 169, 170, 228, 233
- LMJ project (Laser Megajoule project), 170, 171
- local realism, 320
- Lockhart, Luther, 71
- Lockheed, 65
- Lockheed CL-282 (aircraft), 65
- Lockheed Sunnyvale, 249
- Lockwood, H.F., 202
- LODE (Large Optics Demonstration Experiment), 151
- Logsdon, J.M., 157
- Lohmann, Adolf, 145
- Lomb, Adolph, 25
- Lomb, Henry, 15
- long-distance telephone, 26
- Long Distance Xerography (LDX), 134
- Los Alamos Laboratory, 161–162, 163
- low-loss fibers, 189–193, 190–193, 241, 278, 282
- low-vision patients, 267
- LPE (liquid-phase epitaxy), 200, 200, 203, 204, 206
- LS coupling, 18
- LS-PIC (large-scale photonic integrated chip), 293
- LST (Large Space Telescope), 249
- Lubin, Moshe, 168
- Lucent Technologies, 283–285
- Lumière brothers, 34
- Luna-See project, 175, 176
- Lundegårdh, Henrik, 20
- Luo, Fang-Chen, 270
- LUPI (laser unequal path interferometer), 143, 144
- LWI (lasing without inversion), 217
- Lyman, John, 161
- Lyman, Theodore, 17
- Lyon, Dean, 71



- M**  
 MacAdam, David, 20, 44  
 MacAdam ellipses, 44  
 Macenka, Steve, 252  
 Macleod, Angus, 68  
 Madden, Frank, 158  
 magnesium fluoride, for anti-reflective coatings, 70–71  
 magnetism, 11  
 magneto-optic (M-O) recording, 140  
 magneto-optical trap (MOT), 220–221, 225  
 Magnuson, Warren, 29  
 Maguire, Mike, 153, 154, 156  
 Mahler, Joseph, 51  
 Maiman, Theodore, 52, 73, 79, 83–84, 84, 100, 103, 104, 107, 119, 149, 186, 189, 213, 215, 218  
 Maitenaz, 266  
 Maker, P., 219  
 MALDI (matrix-assisted laser desorption/ionization), 312  
 Malus, Etienne-Louis, 11  
 Manenkov, A.B., 297  
 Mangus, John, 250  
 Manhattan Project, 29  
 Mannes, Leopold, 34  
 Martinot-Lagarde, P., 90  
 Marzocco, B., 262  
 masers, 50, 79, 81, 82, 83, 85, 103, 107, 209, 233  
 Massoulié, M.J., 107  
 master-oscillator power amplifier (MOPA), 163, 198  
 Mather, John, 252  
 Mathias, L.E.S., 92  
 matrix-assisted laser desorption/ionization (MALDI), 312  
 matrix TFT-LCD, 270  
 Mauna Kea telescope, 4  
 Maurer, Robert, 189–190, 191  
 Max-Planck Institute for Quantum Optics, 95, 166, 300  
 Maxwell, James Clerk, 11, 33  
 Mayburg, Sumner, 107  
 Mayer, Herbert, 72  
 Mayne-Banton, Veronica, 257  
 MCA, 138  
 McCone, John, 153  
 McCormick, Pat, 176–177, 179  
 McDermid, Stuart, 175  
 McFarland, Bill, 95  
 McFarlane, R.A., 92  
 MCI Communications, 278  
 MCI Worldcom, 285, 286  
 MCVD (modified chemical vapor deposition), 297  
 McWhorter, A.L., 109  
 medical applications, 306  
 biomedical optics, 277, 308–313, 309–312, 334–335  
 excimer laser ablation, 260, 306  
 excimer laser surgery, 257–261, 258, 259, 306  
 future trends in, 328  
 imaging, 50, 309, 328  
 intraocular lenses, 262–264  
 LASIK technique, 5, 183, 260, 261, 306, 308, 312  
 medical instruments, 55, 91  
 photodynamic therapy, 183–184, 309, 312, 334  
 photorefractive keratectomy (PRK), 260, 261  
 radial keratotomy (RK), 259–260  
 medical imaging, 50, 309, 328  
 medical optics, 4  
 Mees, C.E.K., 25, 26, 33, 34, 244  
 Meggers, William F., 17, 18, 20, 20, 21  
 Mehr and Mahler, 14  
 Meinel, Aden, 245, 246, 247, 250  
 Meinel, Marjorie, 250  
 Melekhin, V.N., 297  
 Mellon Institute (University of Pittsburgh), 71  
 MEMS (micro-electro-mechanical systems), 310  
 Menyuk, Norman, 179  
 Menzies, Bob, 175, 177  
 “Mercedes” fiber, 301  
 Mercer, G.N., 91  
 mercury-ion laser, 91, 98  
 metal nanoparticles, 311  
 metallic mirrors, 68, 69–72  
 metamaterials, 316, 316  
 Metcalf, H., 220, 224  
 metrology, interferometric, 143–147  
 Meyerhof, Otro, 41  
 Michelson, Albert, 9, 12, 19, 144, 244, 246  
 Michelson interferometer, 12, 247, 329  
 Michelson–Morley experiment, 12, 12, 329  
 micro-electro-mechanical systems (MEMS), 310  
 microbots, 328  
 microfluidics, 301, 311, 318  
 micromachining, 306  
 micrometer-scale optoelectronic “microbots,” 328  
 microscopes, 3, 14, 15, 34, 35, 53, 237, 301, 309–313, 323  
 atomic force microscopy (AFM), 225–226  
 coherent anti-Stokes Raman spectroscopy (CARS) microscopy, 308  
 dark-field microscope, 312  
 digital holographic microscopy, 311  
 electron microscope, 119, 204, 336  
 fluorescence microscope, 312  
 infrared optical microscope, 203–204  
 multi-mode fiber microscope, 328  
 multi-photon microscope, 305  
 nonlinear microscope, 308  
 optical microscopes, 14, 257  
 phase-shifting interference microscope, 144, 145  
 photoacoustic microscope, 310  
 photoactivated localization microscopy (PALM), 311  
 stochastic optical reconstruction microscopy (STORM), 311  
 two-photon microscopes, 305  
 microstructured optical fibers, 277, 297–301, 298–301, 328  
 microwave masers, 81, 83  
 Mid-Infrared Advanced Chemical Laser (MIRACL), 150, 150  
 military laboratories, 186  
 military optics, 49, 55, 64, 79  
 anti-reflection coatings, 69  
 fiber-optic image scramblers, 55  
 fused fiber bundles, 55, 56  
 laser weapons, 149–152  
*See also* spy satellites; surveillance imaging  
 Millennium Project, 193  
 Miller, David A.B., 304  
 Miller, R.C., 91, 116, 186, 214  
 Miller, S., 293  
 Miller, W.C., 70  
 Millikan, Robert A., 18  
 “million hour paper,” 205  
 miniaturization, 310  
 Minogen, V.G., 224  
 MIRACL (Mid-Infrared Advanced Chemical Laser), 150, 150  
 Miroflex reflex camera, 35  
 mirrors, 151, 155  
 astronomy, 69, 245, 247, 251, 252  
 coatings, 68, 69, 245, 329  
 early history, 68  
 glass mirrors, 68, 245  
 lasers, 81, 88, 89, 90, 90, 91, 91, 94, 96, 97, 103, 130, 131, 132, 132, 143, 200, 202, 235, 336–337  
 “Leviathan” mirror, 14  
 metallic mirrors, 68, 69–72  
 in telescopes, 245  
 MIT, 86, 96, 116, 175, 186, 206, 220, 240, 241, 242  
 MIT Lincoln Laboratory, 109, 116, 175, 177, 185, 186, 187, 199, 206, 233, 304  
 MIT Ultrafast Optics Lab, 240  
 MIT *Wavelength Tables* (Harrison), 21  
 MLIS program, 164  
 M-O (magneto-optic) recording, 140  
 mobile display, 272  
 mode locking, 147, 186, 237, 238, 239  
 mode patterns, 55  
 Model A camera, 35  
 modems, 279, 282  
 modified chemical vapor deposition (MCVD), 297  
 molecular gas lasers, 92–93, 92  
 molecular imaging, 308  
 molecular laser isotope enrichment, 165  
 molecular physics, 3  
 molecular ruler, 311  
 molecular spectroscopy, 19–20  
 Mollenauer, Linn F., 214, 215, 241  
 Mooney, Robert, 71  
 Mooradian, Aram, 178  
 Moore, Duncan, 250  
 MOPA (master-oscillator power amplifier), 163, 198  
 Morley, Edward, 12  
 Mosaic Fabrications, 56  
 Moscow State University, 116  
 Moss, Steven C., 277, 315  
 MOT (magneto-optical trap), 220–221, 225  
 motion picture film, 15  
 motion pictures, 34  
 Moulton, Peter F., 105, 232, 233, 234, 304  
 Mourou, Gerard, 235, 242, 304  
 movies, 51, 52, 72, 138  
 Mt. Palomar observatory, 4, 18, 244, 245  
 Mt. Wilson observatory, 18, 244, 247  
 multi-core fibers, 301, 328  
 multi-layer dichroic reflector, 202  
 multi-megapixel arrays, 329  
 multi-mode fiber microscope, 328  
 multi-photon microscope, 305  
 Multi Speed Shutter Co., 34  
 Multi-University Research Initiatives (MURIs), 188  
 multifocal contact lenses, 254, 255  
 multiplets, 17  
 Multiplex, 122  
 Munk, F., 44  
 Munsell Value scale, 43  
 Murray, Ed, 175  
 Murray, John, 166  
 Myers, Mark B., 57  
 MZ modulator (MZM), 295  
 Møller Hansen, Holger, 54
- N**  
 NACL (Navy ARPA Chemical Laser), 150  
 Nagarajan, Radha, 277, 293  
 Nagel, August, 36  
 Nagel Werke, 36  
 nanocarbon, 315  
 nanocones, 315

- nanodiamond, 315  
nanofabrication, 5  
nanoparticles, 309, 312, 316  
  metal nanoparticles, 311  
  plasmonic nanoparticles, 315  
  quantum dots, 312, 315–316  
  semiconductor nanoparticles, 312  
nanoplasmonic materials, 316  
nanoporation, 312  
nanoscale memory, 329  
nanoscopic metal particles, 316  
nanostructuring, 315  
nanosurgery, 312  
nanotubes, 315  
narrowband interference filters, 70  
NASA (National Aeronautics and Space Administration), 29, 175, 176, 177, 249, 250, 252  
NASA Goddard, 175, 177  
NASA Langley, 175, 176  
Nasledov, D.N., 108  
Nassau, K., 104  
NASTRAN program, 154  
Nathan, Marshall I., 107, 108, 108, 110  
National Academy of Sciences, 261  
National Aeronautics and Space Administration (NASA), 29, 175, 176, 177, 249, 250, 252  
National Bureau of Standards (NBS), 20, 24, 25, 26, 27, 43, 185  
National Defense Research Committee (NDRC), 27, 28, 49  
National Ignition Facility, 170, 170, 171  
National Institute of Standards and Technology (NIST), 26, 177, 221, 225, 226, 300  
National Reconnaissance Office (NRO), 64  
National Science Foundation (NSF), 29, 245  
Naval Research Laboratory (NRL), 71, 167, 185, 298  
Navy ARPA Chemical Laser (NACL), 150  
NCR, 129  
NDRC (National Defense Research Committee), 27, 28, 49  
near-infrared optical probes, 329  
“nebulium,” 18  
negative-index metamaterials, 316  
Nelson, Herb, 111, 200  
Nelson, Jerry, 248  
neodymium-doped calcium tungstate, 104  
neodymium-doped glass fiber, 195  
neodymium-doped optical amplifier, 280  
neodymium-fiber lasers, 241  
neodymium-glass fiber lasers, 187  
neodymium-glass lasers, 104, 150, 166, 167, 186, 237–238  
neodymium-glass rod, 101  
neodymium-glass rod lasers, 187  
neodymium ion, 104  
neodymium-YAG lasers, 104, 105, 124, 125, 186, 240, 242, 257, 258, 259, 301, 304  
neon sign, 9  
Neugebauer, Gerry, 252  
New, G.H.C., 213, 239  
New Ideas Manufacturing, 34  
Newhall, S.M., 44  
Newton, Isaac, 68  
NeXT, 140  
Next Generation Space Telescope (NGST), 252  
Ng, Won, 115  
NGC 6543, 18  
NGST (Next Generation Space Telescope), 252  
NICMOS system, 250  
NIF laser, 170, 171  
Nike laser system, 167  
Nimitz, Chester, Jr., 153  
NIST (National Institute of Standards and Technology), 26, 177, 221, 225, 226, 300  
nitrogen lasers, 92  
Nixon, Richard M., 153  
nLight Inc., 230  
noble-gas ion lasers, 91  
noble metals, 312, 316  
Nomura, Akio, 179  
non-zero dispersion-shifted fibers, 280, 289  
nondestructive testing, holographic, 45  
nonlinear frequency conversion, 4  
nonlinear microscope, 308  
“Nonlinear Optical Properties of Materials,” 215  
nonlinear optics, 114–117, 183, 213–217, 219–220, 238  
  applied, 213–217, 214–217  
  lasers and, 114–117  
  parametric nonlinear optics, 218  
*Nonlinear Optics* (Bloembergen), 116  
nonlinear phenomena, 4  
nonlinear refraction, 215  
nonlinear spectroscopy, 215, 219–221  
Nordberg, Martin, 189, 190  
Norrby, Sverker, 263  
Nortel, 284, 286  
Northrop Grumman, 151  
Northwestern University, 186  
Nova laser, 169, 170  
NRL (Naval Research Laboratory), 71, 167, 185, 298  
NRO (National Reconnaissance Office), 64  
NSF (National Science Foundation), 29, 245  
NTT, 197  
nuclear structure, optical spectroscopy, 19  
nuclear technology  
  fusion research with lasers, 166–172, 167–171  
  laser isotope enrichment, 161–165, 162–164  
  Three Mile Island nuclear accident, 164  
null correctors, 143  
Nutting, Perley G., 9, 25, 25, 27, 33, 38, 39  
**O**  
O-Series Leica camera, 35, 35  
OAO (Orbiting Astronomical Observatory), 247, 249  
O’Brien, Brian, 24, 54, 55, 114  
OCT (optical coherence tomography), 5, 309  
octave frequency combs, 4  
Odlyzko, Andrew, 283  
OEICs (opto-electronic integrated circuits), 293  
OFCC (Optical Fiber Communications Conference), 211, 283–284, 283, 284, 286, 289, 291  
Office of Naval Research (ONR), 29, 82, 185  
Office of Scientific Research and Development (OSRD), 27  
Offner, Abe, 143  
OLEDs (organic light-emitting diodes), 318  
Omega laser, 169  
Omega Upgrade laser, 170, 171  
Omnifocal lenses, 266  
Omniguide, 298  
on-off keying (OOK), 294  
“On the mechanism of the eye” (Young), 14  
ONR (Office of Naval Research), 29, 82, 185  
OOK (on-off keying), 294  
Operation Paperclip, 72  
ophthalmic surgery, 306  
  biomedical optics, 277, 308–313, 309–312, 334–335  
  cataract surgery, 124, 184, 262–264, 312  
  excimer laser ablation, 260, 306  
  excimer laser surgery, 257–261, 258, 259, 306  
  intraocular lenses, 262–264  
  LASIK technique, 5, 183, 260, 261, 306, 308, 312  
  photorefractive keratectomy (PRK), 260, 261  
  radial keratotomy (RK), 259–260  
ophthalmoscope, 15  
OPNs (optical polymer nanocomposites), 316  
OPO (optical parametric oscillator), 214  
Optech Corp., 177  
optical astronomy, 184, 247, 248, 249, 252  
optical bistability, 215  
optical ceramics, 316  
“optical clock” transitions, 220  
Optical Coating Laboratory Inc., 284  
optical coatings, 3, 68–73, 142  
  anti-reflection coatings, 3, 69, 70  
  Blu-Ray, 142  
  computer-aided design, 73  
  early history, 68  
optical coherence tomography (OCT), 5, 309  
optical communications, 183, 186, 189, 193, 195, 199, 205, 209–211, 215, 237, 277, 289–292, 289, 290, 338  
  future trends in, 338  
  terabit-per-second fiber, 209–211, 210  
optical diagnostics, 334  
optical discs  
  history, 138–142, 141, 142  
  writable and re-writable discs, 139–140  
optical exobiology, 335  
Optical Fiber Communications Conference (OFCC), 211, 283–284, 283, 284, 286, 289, 291  
optical glass, 13, 23, 24, 33, 35, 101, 189, 266  
optical imaging, in vivo, 308–310  
optical instruments, 13–15, 23  
optical interferometers, 143  
optical Kerr effect, 215  
optical levitation, 223  
optical masers, 81  
optical materials, 315–318, 316, 317  
*Optical Materials Express* (journal), 315  
optical microscopes, 14, 257  
optical modulation spectroscopy, 219  
“optical molasses,” 220, 225  
optical networks, 338  
optical parametric generation, 214  
optical parametric oscillator (OPO), 214  
optical phase conjunction, 215  
optical pick-up (OPU), 138  
optical polymer nanocomposites (OPNs), 316  
optical pumping, 81  
Optical Research Associates, 157  
The Optical Society (OSA), 17, 19, 20, 25, 27, 33, 38, 40, 57, 70, 84, 120, 178, 213, 219, 222, 237, 246, 291, 304  
  areas of interest, 3  
  biomedical optics and, 312–313  
  color science, 43–44  
  Committee on Colorimetry, 43

- Committee on Needs in Optics, 86  
 membership, 3  
*The Science of Color*, 43  
 Uniform Color Scales, 43
- optical solitons, 4, 25
- optical spectroscopy, 3, 17, 19, 21, 24, 50, 175, 218, 220, 335
- optical surveillance. *See* spy satellites; surveillance imaging
- optical trapping, 223–226, 224, 311, 313
- optical tweezers, 222, 225, 226, 301, 311, 327
- optics, 277, 284  
 adaptive optics, 29, 151, 178, 184, 247, 248, 248, 329  
 biomedical optics, 277, 308–313, 309–312, 334–335  
 future trends in, 331  
 industrial and governmental research laboratories, 9, 23–30  
 microfluidics and, 301, 311, 318  
 military optics, 49, 55, 56, 64, 69, 79, 149–152  
 nonlinear optics, 114–117, 183, 213–217, 219–220, 238  
 physiological optics, 14, 15  
 quantum optics, 4, 9, 166, 222, 300, 321, 331  
 R&D funding, 9, 185–188
- optics (history), 3–5  
 pre-1800, 11  
 pre-1940, 3–4, 9–44  
 1941–1959, 49–73, 85–87  
 1960–1974, 79–180  
 1970's status, 85–87  
 1975–1990, 183–236  
 1991–present, 277–323  
 future trends in, 327–339
- Optics Express* (journal), 312, 313
- Optics in the Life Sciences (meeting), 313
- Optics Letters* (journal), 299, 312
- Optics Technology, 100
- opticon, 225
- Optiks* (Newton), 11
- opto-electronic integrated circuits (OEICs), 293
- Optoelectronics Research Center (ORC), 299
- optogenetics, 334
- optometer, 14
- Orange Book (optical discs), 140
- Orbiting Astronomical Observatory (OAO), 247, 249
- ORC (Optoelectronics Research Center), 299
- organic/inorganic composite LEDs, 318
- organic light-emitting diodes (OLEDs), 318
- organic photoreceptors, 63
- Osaka University, 169
- Osen, C.W., 269
- OSRD (Office of Scientific Research and Development), 27
- Ostermayer, F.W., 105
- Overage, Carl, 64
- Oxford University, 114
- oxide semiconductors, 270
- Ozanics, V., 253
- P**
- Paanen, Roy, 187
- Paisner, Jeffery A., 162
- Pake, George, 62
- PALM (photoactivated localization microscopy), 311
- Palmer, Roger C., 133
- Palo Alto Research Center (PARC), 135, 136
- Panish, M.B., 111, 200, 201–202, 293
- Pankove, J.L., 107
- Pappis, Jim, 187
- parametric nonlinear optics, 218
- parametric oscillators, 186
- parametric processes, 4
- Parker, J.T., 92
- Parks, Bob, 250
- Parsons, William, 14
- particle theory of light, 11
- particle tracking, 312
- Paschen, Friedrich, 17
- passive optical network (PON), 291
- Patel, C.K.N., 92, 150, 186
- Pauli, Wolfgang, 18, 19–20, 206
- Payne, David, 196, 197, 210, 280
- PBG (photonic bandgap), 297, 298
- PCF (photonic crystal fiber), 298–299, 299, 317, 327
- Pease, F.G., 246
- Pepys, Samuel, 265
- Perilli, 283
- periodically poled lithium niobate (PPLN), 213
- periscope, 53
- Perkin, Richard, 64, 66
- Perkin-Elmer Corp., 50, 66, 90, 143, 153, 155, 185, 249
- Pershan, Peter, 115
- personal computers, 135, 141, 279, 282, 331
- Peters, C. Wilbur “Pete,” 50, 55, 114
- Peterson, Otis, 95, 161
- petroleum industry, 332
- Pfund, August Hermann, 70
- PHASAR routers, 293
- phase change recording, 140
- phase-shift keying (PSK), 210, 291, 294–295, 295
- phase-shifting interference microscope, 144, 145
- phase-shifting interferometric holography, 145
- phase-shifting interferometry, 143, 144, 146–147
- phased array routers, 293
- Philips, 138, 139, 140
- Philips Audio Division, 138
- Philips Research Laboratories, 138
- Phillips, W., 220, 221, 224, 225
- Phebus laser, 169
- photo-finishing industry, 31
- photo-thermo-refractive (PTR) glass, 318
- photoablation, 261
- photoacoustic imaging, 309
- photoacoustic microscope, 310
- photoactivated localization microscopy (PALM), 311
- photoactive pigment electrography, 62
- photobiostimulation, 334
- photocathode materials, 3
- photochromic lenses, 267
- photocopiers, 50
- photodynamic therapy, 183–184, 309, 312, 334
- photoelectric effect, 3, 12
- photographic emulsions, 31
- photographic film, 10, 15, 34, 39, 51, 52
- photographic filters, 51
- photography, 3, 10, 15  
 in the 1800's, 31  
 cellulose nitrate, 15  
 color film, 34, 52  
 color photography, 3, 10, 33, 34  
 dry plates, 15  
 film, 10, 15, 34, 39, 51, 52  
 instant photography, 51  
 Kinetoscope, 34  
 lensless photography, 121
- motion pictures, 15, 34
- movies, 51, 52, 72, 138
- Polaroid process, 49, 52, 158, 186
- speckle photography, 145
- three-dimensional movies, 51  
*See also* cameras; spy satellites
- “Photography by laser” (*Scientific American*), 121
- photolithography, 4, 50, 312
- photolytically pumped iodine laser, 166
- photometry, 43
- photomodification of cells, 312
- photomultiplier tubes, 3
- photomultipliers, 26, 245
- photonic bandgap (PBG), 297, 298
- photonic bandgap fibers, 277
- photonic crystal fiber (PCF), 298–299, 299, 317, 327
- photonic integrated circuit (PIC), 293, 338
- photonic lanterns, 301
- photonic materials, 315
- photoreceptors, 40, 63, 134, 135
- photoreconnaissance. *See* spy satellites; surveillance imaging
- photorefractive keratectomy (PRK), 260, 261
- phototypesetting, 50
- Physical Review Letters* (journal), 82, 83, 114, 115, 223, 225
- physicists, post-World War II statistics, 85, 86
- physiological optics, 14, 15
- PIC (photonic integrated circuit), 293, 338
- picosecond lasers, 237–239
- “pillars of formation” (star formation), 250–251, 251
- “piplin,” 213
- Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, 50
- Pittsburgh Plate Glass, 24
- Planck, Max, 12
- Planck space telescope, 252
- plasmonic nanoparticles, 315
- plastic sheet polarizer, 51
- plutonium, laser isotope enrichment, 163–164
- PMD (polarization-mode dispersion), 211
- Pocket Kodak camera, 32
- Pohl, R., 68
- Polacolor, 49
- Polanyi, Tom, 102
- polarization, 11, 51–52, 143, 146, 169, 197, 210, 211, 241–242, 291, 294, 295
- polarization-based stereoscopy, 51
- polarization-mode dispersion (PMD), 211
- polarized reflection, 11
- polarized windshields, 51
- polarizing sheets, 51
- polarizing sunglasses, 51
- Polaroid Corp., 51, 65, 122, 158, 280
- Polaroid process, 49, 52, 136, 158
- Polaroid SX70 camera, 64
- Polavision instant movies, 52
- Pollard, Marvin, 55
- polycarbonate, 266
- PON (passive optical network), 291
- Popov, Yu. M., 107
- Porro prisms, 14
- Porter, J., 256
- Portnoi, E.L., 111
- Porto, S., 218
- Post Office Research Laboratories (UK), 298
- potassium dihydrogen phosphate, 114, 116
- PPLN (periodically poled lithium niobate), 213

- praseodymium ions, 104  
 “Preserving the Miracle of Sight: Lasers and Eye Surgery” (National Academy of Sciences), 261  
 Pressel, Phil, 79, 160  
 Pressley, R.J., 104  
 Priest, I.G., 43  
 Princeton University, 249  
 Pringsheim, P., 69  
 printers  
   inkjet printers, 50  
   laser printers, 134–137, 136, 137  
 printing technology, 50  
 prism lenses, 265  
 prisms, 12, 14, 21, 89, 120, 216, 233, 240, 241, 265, 266, 267  
 Pritchard, David, 96, 220  
 PRK (photorefractive keratectomy), 260, 261  
*Problems in Nonlinear Optics* (Khokhlov and Akhmanov), 116  
 Project 3 committee, 65  
 Project Blackeye, 150  
 Prokhorov, Alexander, 218  
 PSK (phase-shift keying), 210, 291, 294–295, 295  
 PTR glass (photo-thermo-refractive glass), 318  
 Pulkovo Observatory, 14  
 pulse compression, 216, 216  
 pulsed argon ion laser, 91, 98  
 pulsed dye lasers, 96, 238–239  
 pumped dye lasers, 95, 163, 164, 177, 234  
 pumping (lasers), 4  
 Purcell, Edward, 64  
 Purdue University, 186
- Q**  
 Q-switching ruby lasers, 94, 115, 116, 116  
 QAM (quadrature amplitude modulation), 291  
 QCLs (quantum cascade lasers), 176, 178, 318  
 QD LEDS (quantum-dot LEDs), 272  
 QIS (quantum information science), 320–323, 321, 322  
 QPM (quasi-phase-matching) technique, 213  
 quadrature amplitude modulation (QAM), 291  
 quadrature phase-shifted keying (QPSK), 291, 294  
 quadropole trap, 220  
 Quantatron, 100  
 quantization of light, 3  
 quantum algorithms, 321, 322  
 quantum cascade lasers (QCLs), 176, 178, 318  
 quantum communications, 323  
 quantum computers, 320–323, 329  
 quantum-confined semiconductors, 178, 315–316  
 quantum-dot (QD) LEDs, 272  
 quantum dots, 308, 312, 315–316, 322  
 Quantum Electronics Conference (High View, NY), 82  
 quantum error correction, 321, 321  
 quantum information, 222  
 quantum information science (QIS), 320–323, 321, 322  
 quantum-key distribution, 320  
 quantum mechanics, 3, 9, 17–18, 232, 320–323, 331  
 quantum optical sensitivity, 331  
 quantum optics, 4, 9, 166, 222, 300, 321, 331  
 quantum simulators, 329  
 quantum theory, 3, 9, 13, 17, 18, 21
- quantum-well infrared photodetectors (QWIPs), 316  
 quantum-well lasers, 202, 227, 228  
 quantum-well materials, 316  
 quantum wells, 228, 304, 315, 316  
 quantum wires, 316  
 quasi-phase-matching (QPM) technique, 213  
 qubit, 321, 321, 322, 322  
 Quist, T.M., 105, 108, 109, 187  
 QWIPs (quantum-well infrared photodetectors), 316
- R**  
 radial keratotomy (RK), 259–260  
 radiation pressure, 223  
 radio communication, 26  
 Radio Corporation of America (RCA), 26, 53, 129, 269, 270  
 radio technology, World War I, 25–26  
 radioastronomy, 50  
 Radioptics, 161  
 Raman, Chandrasekhara Venkata, 19, 19  
 Raman effect, 19  
 Raman frequency combs, 301  
 Raman spectroscopy, 19, 218, 219, 308, 310  
 Ramsey, Norman, 220  
 Rand, S.C., 28  
 rare earth fiber lasers, 4  
 rare earth ions, 104  
 rare-earth metal-doped glass fiber, 210  
 rare gas-halide excimers, 92  
 “ray guns,” 149  
 Rayleigh, Lord, 12  
 Raytheon, 100, 178, 185, 187  
 RCA (Radio Corporation of America), 26, 53, 129, 269, 270  
 RCA Laboratories, 185, 199, 201, 227  
 re-writable discs, 139–140  
 Reagan, John, 176  
 reconnaissance cameras, 64–67  
   *See also* spy satellites; surveillance imaging  
 reconnaissance satellites  
   CORONA program, 52, 65, 79, 153, 157–160, 159  
   KH-9 Hexagon spy satellite, 153–156, 154–156, 158  
   Sputnik, 52, 73, 79, 85, 157, 185  
 recording spectrophotometer, 43  
 “rectifier” lens, 159  
 Red Book (optical discs), 138–139  
 Rediker, R.H., 109, 206  
 Reeves, Will, 300  
 reflection holography, 121, 122  
 refractometer, 35  
 refractors, 14  
 Reinberg, A.R., 105  
 Reinitzer, Friedrich, 269  
 Reintjes, J., 216  
 remote sensing, 175–178  
 Rempel, Bob, 89, 99  
 Renhorn, Ingmar, 178  
 Research Institute of Experimental Physics (Russia), 166  
 residual spectrum method, 20  
 resonance radiation pressure, 223  
 resonant Raman spectroscopy, 218  
 reSTOR lens, 263  
 retina, 40, 41  
 retinal, 41  
 retinene, 41  
 ReZoom lens, 264  
 Rhees, Benjamin Rush, 33  
 rhodopsin, 39, 41  
 Richard, Jules, 34  
 Richards, A. Newton, 27
- Rider, Ron, 136  
 Ridley, Sir Harold, 262, 263  
 Rigden, J. Dane, 88, 89, 89, 90  
 Rigrod, W.W., 89  
 RIT method, 190, 190  
 Ritchey-Chretien Cassegrain wide-field design, 4  
 Ritchey, George, 244  
 Riverside Research Institute, 86  
 RK (radial keratotomy), 259–260  
 Robinson, C. Paul, 162  
 Rochester Optical Society, 25  
 Rockefeller, David, 157–158  
 Rockefeller family, 85  
 Rockefeller Foundation, 244, 245  
 rod-in-tube fibers, 55, 190  
 Rohlsberger, R., 222  
 Roman, Nancy, 249  
 room-temperature GaAs-AlGaAs heterostructure semiconductor lasers, 203  
 Roosevelt, Franklin D., 27, 28, 185  
 Rosenberg, R., 96  
 Ross, M., 105  
 Rossell, Henry Norris, 18  
 Rothe, Karl, 175  
 Rouard, Pierre, 70, 72  
 Royal Observatory (Greenwich), 26  
 rubber manufacturing, 50  
 ruby lasers, 83, 84, 88, 94, 95, 100, 103, 114, 115, 116, 116, 121, 124, 149, 175, 186, 218, 232, 234  
 ruby masers, 83  
 Ruddock, Ken, 98, 99  
 Rudolph, Paul, 35  
 Rudolph Instruments, 305  
 Runge, Peter, 96  
 Rupprecht, Hans, 110  
 Russell, Henry Norris, 18  
 Russell, James, 138  
 Russell, Phillip, 179, 277, 297, 300, 300, 327  
 Rutherford Appleton Laboratory (UK), 169, 235, 235  
 Rutz, R.F., 109  
 Ryan, John, 286  
 Rydberg, Johannes, 13  
 Rydberg constant, 220  
 Rydberg formula, 17
- S**  
 Saint-René, Henry C., 53  
 samarium-doped calcium fluoride, 104  
 samarium ions, 104  
 Sarles, L.R., 104  
 Sasano, Yasuhiro, 179  
 satellites. *See* spy satellites; surveillance imaging  
 Saunders, Frederick A., 18  
 Sanderson, J.L., 44  
 scanners, for barcodes. *See* barcode scanners  
 Schadt, Martin, 270  
 Schaefer, Fritz, 95  
 Schaffert, Roland, 57  
 Schawlow, Arthur, 50, 81–83, 92, 96, 98, 103, 104, 107, 149, 209, 220, 221, 222, 224, 225  
 Schindler, Rudolf, 53  
 Schmidt, Bernard, 244  
 Schmidt camera, 4, 244, 245  
 Schotland, Richard, 175  
 Schott, Otto, 9, 14, 23, 35  
 Schott and Sons, 14, 15, 70  
 Schott Glass, 248  
 Schrödinger, Erwin, 9, 18  
 Schroeder, Harold, 72  
 Schuda, Felix, 96

- Schulte, Dan, 250  
 Schultz, Peter, 190, 191  
 Schwartz Electro-Optics, 234  
*The Science of Color* (Optical Society of America), 43  
 Scifres, Carol, 229  
 Scifres, Donald R., 229, 229, 285  
 Scott, Rod, 66  
 SDI (Strategic Defense Initiative), 151  
 second-generation lasers, 205  
 second harmonic generation (SHG), 4, 117, 213, 214, 218, 221, 238, 316, 318  
 second order nonlinear interactions, 215  
 secret keys, 323  
 segmented telescope, 3  
 Seiko, 270  
 self-developing film, 51  
 self-phase modulation (SPM), 117, 215  
 self-trapping, 117  
 semiconductor circuits, 50  
 semiconductor diode lasers, 4, 107–111, 199, 209, 210, 240–241  
 semiconductor laser diodes (LDs), 105  
 semiconductor lasers, “million hour paper,” 205  
 semiconductor nanoparticles, 312  
 sensing “particles,” 327–328  
 sensor systems, 327–328  
 separate confinement heterojunction quantum well lasers, 202  
 SERS (surface-enhanced Raman scattering), 316  
 Shack, R.V., 246  
 Shank, Charles V., 96, 216, 239, 241, 304  
 Shannon, Claude E., 189  
 Shannon, R.R., 246, 250  
 Shannon limit, 209  
 Shapiro, S.L., 117, 238  
 Shaver, William, 189  
 She, C.Y., 178  
 Shen, Y.R., 221  
 Shenstone, Allen G., 21  
 SHG (second harmonic generation), 4, 117, 213, 214, 218, 221, 238, 316, 318  
 Shimizu, Fujio, 116  
 Shimizu, M., 197  
 Shiner, Bill, 101–102  
 Shiva laser, 168  
 Shlaer, Simon, 39  
 Shor, Peter, 321  
 short-wave radio, 26  
 Sibbett, Wilson, 242, 304  
 Sieder, Irwin, 104  
 Siegel, Keeve M., 168  
 Siegman, Anthony, 105  
 SILEX process, 165  
 Silex Systems Ltd., 165  
 silicon-on-insulator (SOI) modulator, 294  
 silicon photonics, 242, 293, 294  
 silicon TFTs, 270  
 Simplex camera, 34  
 Simpson, W.M., 217  
 SINDA program, 154  
 single-mode fibers, 55–56, 191, 206, 210, 279, 301  
 single molecular detection, 311  
 single-photon systems, 338  
 single-stripe lasers, 228, 229, 229, 231  
 SIRTf (Space Infrared Telescope Facility), 249  
 Skunk Works, 65  
 Slepian, Joseph, 24  
 Smakula, Alexander, 69, 70, 72  
 Small Business Innovative Research Program, 187  
 Smelser, G.K., 253  
 Smith, Dow, 158  
 Smith, George F., 103  
 Smith, Richard G., 205  
 smoothing by spectral dispersion (SSD), 170  
 Smullen, Louis, 175  
 Snively, Ben, 95, 161, 162, 163  
 Snitzer, Elias, 56, 101, 102, 104, 187, 195–196, 197, 280  
 Soffer, Bernard, 95  
 SOFIA telescope, 252  
 soft contact lenses, 253, 256  
 SOI modulator (silicon-on-insulator modulator), 294  
 solar cells, 332  
 solar panels, 332  
 solar power, 329, 332  
 Solarz, Richard W., 162  
 solid-state lasers, 4, 84, 101, 103–106, 125, 126, 131, 178, 227, 228, 231, 242, 316  
   diode laser-pumped solid-state lasers, 105–106  
   free-space solid-state lasers, 242  
   tunable lasers, 105, 232–236, 233–235  
 solid-state lighting, 339  
 solid-state masers, 50  
 soliton laser, 241  
 solitons, 4, 25, 117, 215, 216  
 Soltys, T.J., 108  
 Sommerfeld, Arnold, 17, 40  
 Sommerfeld–Kossel displacement, 17  
 Sony, 138, 140, 141  
 Sorokin, Peter, 94, 103, 104, 104, 107  
 Space Infrared Telescope Facility (SIRTf), 249  
 space race, 85  
 Spaeth, Mary, 94–95, 96, 96  
 special relativity, 12  
 speckle photography, 145  
 spectacles. *See* eyeglasses  
 spectra, 20–21  
   chemical elements, 21  
   infrared spectral lines, 18  
   multiplets, 17  
   singlets, doublets, and triplets, 17  
   Sommerfeld–Kossel displacement, 17  
   stellar spectra, 13  
 Spectra Diode Laboratories Inc., 228, 229  
 Spectra-Physics, 89, 90, 91, 97–99, 121, 129, 130, 131, 234, 305  
 spectral multiplexing, 308  
 spectral reflectance factor, 43  
 spectrometers, 50, 305  
 spectrophotometers, 43, 44  
 spectroscopic instruments, 20  
 spectroscopy, 9, 218  
   applied spectroscopy, 20, 49–50  
   astronomy and, 13, 13, 18–19  
   atomic physics and, 12–13, 13  
   coherent anti-Stokes Raman (CARS) spectroscopy, 219, 308  
   with continuous-wave dye lasers, 96  
   “Doppler-free” laser spectroscopy, 220  
   dynamic grating spectroscopy, 219  
   early history, 17–21  
   femtosecond absorption spectroscopy, 180  
   flame-emission spectroscopy, 20  
   fluorescence correlation spectroscopy, 312  
   laser-based spectroscopy, 147, 232  
   laser-induced-breakdown spectroscopy (LIBS), 178  
   laser spectroscopy, 218–219, 221–222  
   linear spectroscopy, 218–219  
   nonlinear spectroscopy, 215, 219–221  
   optical modulation spectroscopy, 219  
   optical spectroscopy, 3, 17, 19, 21, 24, 50, 175, 218, 220, 335  
   quantum mechanics and, 17–18  
   Raman spectroscopy, 19, 310  
   resonant Raman spectroscopy, 218  
   time-domain laser spectroscopy, 219  
   transient grating spectroscopy, 238  
 spectrum, 12  
 Spencer, William, 62  
 Spencer Lens Co., 24  
 spin-orbit coupling, 18  
 “spincasting” manufacturing technique, 253, 254  
 Spitzer, Lyman, 249, 252  
 Spitzer telescope system, 249, 251, 252  
 SPM (self-phase modulation), 117, 215  
 Sprint, 278  
 Sputnik, 52, 73, 79, 85, 157, 185  
 spy satellites, 79  
   CORONA program, 52, 65, 79, 153, 157–160, 159  
   KH-9 Hexagon spy satellite, 153–156, 154–156, 158  
   Sputnik, 52, 73, 79, 85, 157, 185  
   *See also* surveillance imaging  
 SRI International, 86  
 Srinivasan, R., 257, 258, 259, 260, 261  
 SSD (smoothing by spectral dispersion), 170  
 STAAR, 262, 264  
 Standard Oil (Indiana), 24  
 Standard Telecommunications Laboratory (STL), 199  
 Stanford Research Institute, 86  
 Stanford University, 96, 105, 186, 196, 220, 225  
 Starfire Optical Range, 29  
 Starkweather, Gary, 134, 135  
 Steane, Andrew, 321  
 STED (stimulated emission depletion microscopy), 311  
 Steinvall, Ove, 178  
 stellar spectra, 13  
 stereoscopic surveillance imaging, 51  
 Stetson, Karl, 145  
 Stevenson, Mirek, 84, 103, 104, 104, 107  
 Steward Observatory, 246  
 Stickley, C. Martin, 185, 186  
 still photography, 34  
 Stimson, F.J., 20  
 stimulated emission depletion microscopy (STED), 311  
 Stitch, Malcolm, 84  
 STL (Standard Telecommunications Laboratory), 199  
 STN (super-twisted nematic), 270  
 stochastic optical reconstruction microscopy (STORM), 311  
 Stoicheff, Boris, 115, 116, 221  
 Stokes, G.G., 19  
 Stolen, R.H., 215, 216  
 STORM (stochastic optical reconstruction microscopy), 311  
 Strategic Defense Initiative (SDI), 151  
 Stratoscope project, 249  
 Stratton, Samuel W., 27  
 Straus, Josef, 285  
 Strehl ratio, 256  
 stretched-pulse lasers, 242  
 Strickland, D., 235, 242  
 stripe-contact technology, 201, 203  
 stripe-geometry lasers, 111, 203  
 Stroke, George W., 122  
 Strong, Henry, 31  
 Strong, John, 69, 70, 71, 245  
 Stroud, Carlos, 9, 23, 96  
 “structured light” imaging, 328  
 Struve, Horst, 165  
 Struve, Wilhelm, 14  
 Stuhlmann, Otto, 69  
 sub-Doppler laser cooling, 222  
 subshells, 17  
 Sugimoto, Nobuo, 175

- Sullivan, Walter, 84  
 Sumski, S., 111  
 Sun-powered laser, 101  
 Super Kodak Six-20 camera, 36–37, 36  
 super-twisted nematic (STN), 270  
 supercontinuum, 216, 216  
 supermarket barcode scanners, 129–131  
 superresolution, 311  
 surface-enhanced Raman scattering (SERS), 316  
 surface plasmon resonance, 312  
 surgery, 306  
   biomedical optics, 277, 308–313, 309–312, 334–335  
   excimer laser surgery, 257–261, 258, 259, 306  
   intraocular lenses, 262–264  
   LASIK technique, 5, 183, 260, 261, 306, 308, 312  
   nanosurgery, 312  
   photorefractive keratectomy (PRK), 260, 261  
   radial keratotomy (RK), 259–260  
   *See also* ophthalmic surgery  
 surveillance imaging  
   1954–1974, 64–67  
   CORONA program, 52, 65, 79, 153, 157–160, 159  
   KH-9 Hexagon spy satellite, 153–156, 154–156, 158  
   Sputnik, 52, 73, 79, 85, 157, 185  
   stereoscopic surveillance imaging, 51  
   U-2 spy plane, 49, 52, 64–67, 66, 157, 158  
   *See also* spy satellites  
 Svanberg, Sune, 175  
 Sweden NDRI, 177  
 SX-70 color film, 52  
 Symbol Technology, 132  
 synthetic rubber, 49–50
- T**  
 Talanov, Vladimir, 116  
 Talon Gold, 151  
 Tanner, Howard, 71  
 Tappert, F., 117, 215  
 TAT-12, 282–283  
 TDM PON technology, 291  
 Teague, Walter Dorwin, 37  
 Technical Research Group Inc. (TRG), 82, 84, 100, 149, 186  
 TecnisIOL lens, 263  
 “telecom bubble,” 277, 304  
 telecommunications industry, 282–286  
 telephony, 26, 203–207, 204, 206, 207, 279, 282  
 teleportation, 321  
 telescopes, 4, 11, 13–14, 184, 249–252, 250, 251  
   Advanced X-Ray Astrophysics Facility (AXAF), 249  
   Chandra X-ray Observatory, 249, 251, 251  
   Compton Gamma Ray Observatory (CGRO), 249  
   Extremely Large Telescope (ELT), 248  
   Giant Magellan Telescope (GMT), 248  
   Great Observatories, 249, 252  
   ground-based telescopes, 244–248, 245–248  
   Hubble Space Telescope (HST), 4, 13, 143, 184, 247, 249–250, 250, 251, 252  
   James Webb Space Telescope (JWST), 252  
   Keck Ten-Meter-Diameter Telescope Project, 248  
   Kepler space telescope, 252  
   Kitt Peak National Observatory, 245, 246  
   Large Space Telescope (LST), 249  
   laser propulsion, 336–337  
   lasers in, 184, 245–248, 251, 252  
   Mt. Palomar observatory, 4, 18, 244, 245  
   Mt. Wilson Observatory, 18, 244, 247  
   Next Generation Space Telescope (NGST), 252  
   refractors, 14  
   SOFIA telescope, 252  
   Space Infrared Telescope Facility (SIRTF), 249  
   space telescopes, 249–252, 250, 251  
   spectroscopy and, 13, 13  
   Spitzer telescope system, 249, 251, 252  
   Thirty Meter Telescope (TMT), 248  
 television, 53, 270  
 Teller, Edward, 162  
 10-J Janus laser, 168  
 terabit-per-second fiber, 209–211, 210  
 TeraMobile project, 305  
 terbium ions, 104  
 Terhune, R., 115, 219  
 Tesla, Nikola, 23  
 Tessar lens, 32, 33, 35  
 tetrahertz radiation spectrometer, 305  
 Texas Instruments, 50, 105, 185  
 TFT LCD (thin film transistor liquid crystal display), 270–272, 271  
 Thack, Robert, 211  
 Thelen, Alfred, 70  
 theory of entanglement, 323  
 theory of special relativity, 12  
 thermal evaporation, 69  
 thin film coatings, 73  
 thin film interference, 68  
 thin film polarizers, 71  
 thin film transistor liquid crystal display (TFT LCD), 270–272, 271  
 thin films, 72  
 third-order nonlinear interactions, 215  
 35-mm precision cameras, 34  
 Thirty Meter Telescope (TMT), 248  
 Thomas, L., 178  
 Thompson, Kevin, 64, 79, 157  
 Thomson, J.J., 12  
 Thomson-CSF, 139  
 three-dimensional movies, 51  
 three-level lasers, 83  
 Three Mile Island nuclear accident, 164  
 three-section tunable DBR lasers, 293  
 ThreeFive Photonics, 293  
 thulium ions, 104  
 time-averaged holography, 145  
 time-domain laser spectroscopy, 219  
 time-domain reflectometry, 328  
 tipping furnace, 200, 200  
 titanium:sapphire laser, 234, 235, 236, 242, 304  
 TMT (Thirty Meter Telescope), 248  
 TN effect (twisted nematic effect), 270  
 Tolman, Richard C., 27  
 Tomsk Laser Institute (Russia), 178  
 Tonucci, R.J., 298  
 Topics in Biomedical Optics (BIOMED meeting), 313  
 topological quantum computation, 322  
 toric contact lenses, 255, 256  
 toric intraocular lenses, 264  
 Toschek, P.E., 220  
 Total Quality Movement, 63  
 touch panels, 271  
 Tourist Multiple camera, 34  
 Townes, Charles, 50, 79, 81, 82, 82, 85, 103, 107, 116, 149, 209, 218, 246–247  
 TPF (two-photon-induced fluorescence), 238  
 transient grating spectroscopy, 238  
 Tret'yakov, Dmitriy N., 111  
 TRG (Technical Research Group Inc.), 82, 84, 100, 149, 186  
 Trion Instruments Inc., 100, 114  
 triplet-state absorption, of dyes, 95  
 tristimulus integrator, 43  
 Trokel, Stephen, 259, 260  
 troland (unit), 38  
 Troland, Leonard Thompson, 38, 39, 43  
 Trukan, M.K., 111  
 Truman, Harry, 29  
 TRW, 150  
 Tuccio, Sam, 95, 161, 163  
 Tukey, John W., 65  
 tunable dye lasers, 4, 94–96, 95, 161  
 tunable optical parametric oscillators, 176  
 tunable quantum cascade lasers, 176  
 tunable solid state lasers, 105, 232–236, 233–235  
 Tuohy, Kevin, 253  
 Turner, Arthur Francis, 70, 72, 246  
 Twain, Mark, 335  
 twisted nematic (TN) effect, 270  
 two-photon-induced fluorescence (TPF), 238  
 two-photon microscopes, 305  
 two-wavelength holography, 145  
 Twyman–Green interferometer, 144  
 Tyndall, John, 53
- U**  
 U-2 spy plane, 49, 52, 64–67, 66, 157, 158  
 U-235, laser isotope enrichment, 161  
 Uchino, Osamu, 179  
 Uhlenbeck, George, 18  
 ultra-low-loss fibers, 327  
 ultrafast electro-optic sampling systems, 305  
 “Ultrafast Epiphany: The Rise of Ultrafast Science and Technology in the Real World” (CLEO paper), 305  
 ultrafast-laser technology, 304–306, 305, 306  
 ultrafast manufacturing systems, 306  
 ultrashort lasers, 306  
 ultrashort-pulse lasers, 96, 237–242, 239–242  
 Unar lenses, 35  
 uncertainty principle, 18  
 United States Army Signal Corps, 72  
 United States Enrichment Corp., 164, 165  
 United Technology Research Center, 186  
 Universal Jewel professional folding dry plate camera, 35  
 University of Arizona, 176, 246, 248  
 University of Arizona, Optical Sciences Center, 86  
 University of Chicago, 29, 186  
 University of Illinois, 62, 178, 186, 228  
 University of Maryland, 97, 186  
 University of Michigan, 213, 306  
 University of Michigan, Willow Run Laboratories, 86, 100, 119, 120, 122  
 University of North Carolina, 186  
 University of Pennsylvania, 186  
 University of Pittsburgh, Mellon Institute, 71  
 University of Rochester, Institute of Optics, 25, 33, 54, 134, 143, 158, 168, 169, 170, 185, 186, 304  
 University of Southampton, 196, 197, 242  
 University of Toronto, 116, 177  
 University of Wisconsin–Madison, 230  
 Univis, 266  
 up-conversion gating, 238

Upatniak, Juris, 119–120, 120  
UPC symbol, 128, 129  
UPC Symbology Committee, 128  
Ur-Leica camera, 35  
uranium, laser isotope enrichment, 161–163  
uranium-doped calcium fluoride, 104  
Urbach, John, 135  
U.S. Department of Energy (DOE), 29, 164  
U.S. National Bureau of Standards, 20, 24, 25, 26, 27, 43, 185  
U.S. Naval Observatory, 26  
U.S. Rubber, 24

**V**  
vacuum ultraviolet spectroscopy, 20  
van Driel, Henry, 297  
van Eijkelenborg, Martijn, 299  
van Heel, Abraham C.S., 50, 54  
VanderLugt, Anthony, 120  
Varian Associates, 100, 187  
Vasicek, Antonin, 71–72  
Vaughan, Art, 250  
Vavilov, Sergey, 114  
Vavilov State Optical Institute, 121  
vectograph, 51  
VHS tape, 138  
vibronic lasers, 233  
videotex, 279  
*Virtual Journal for Biomedical Optics*, 313  
visibility, 43  
vision, 38–39, 39  
vision correction, 306  
    contact lenses, 183, 184, 253–256, 254, 255, 260, 262, 333  
    excimer laser surgery, 257–261, 258, 259, 306  
    intraocular lenses, 262–264  
    LASIK (laser in situ keratomileusis), 5, 183, 260, 261, 306, 308, 312  
    photorefractive keratectomy (PRK), 260, 261  
    radial keratotomy (RK), 259–260  
    in vitro methods, 310–312  
    in vivo imaging, 308–310  
    *See also* eyeglasses; ophthalmic surgery  
vision research, 10, 38–41  
Vistakon Co., 255  
visual reception, 38–39  
vitamin A, 40, 41  
Vogel, Hermann Wilhelm, 13  
von Fraunhofer, Joseph, 12, 13  
Von Graefe, A., 265  
von Neumann, John, 107  
Vul, R.M., 107  
Vulcan laser, 169  
vulcanite, 15

**W**  
Wald, George, 40–41, 41  
Wallop, Malcolm, 151  
Walther, Herbert, 175  
Wang, Charles C., 177, 179  
Warburg, Otto, 41  
Watson, Gene, 97

Watson Research Center, 84, 94  
wave nature of light, 11–12  
wave-particle duality, 12  
wave theory of light, 11, 69  
wavefront reconstruction, 121  
wavelength-division multiplexing (WDM), 210–211, 280, 282–283, 284, 288–289, 290, 291, 293  
wavelength-division-multiplexing (WDM) coupler, 196, 210, 211  
Webb, Watt, 310, 311  
Wehrenberg, Paul J., 138, 140  
Weiman, Carl, 221, 225  
Weinreich, Gabriel, 114  
Weisner, J.B., 27  
Welch Allyn, Inc., 131  
Welford, Walter, 72  
Wenzel, Robert, 163  
Werner, Christian, 178  
Werner, Dick, 153, 154  
Western Electric Research Laboratories, 25  
Westinghouse, George, 23  
Westinghouse Research Laboratory, 24, 26, 100, 128, 150, 185, 270  
WF/PC (Wide-Field Planetary Camera), 250  
Wheelon, Albert “Bud,” 153  
White, Alan, 88, 89, 89  
White, George, 135, 136  
white-light continuum, 304  
white-light supercontinuum, 300, 300  
Whitehouse, Dave, 187  
Wichterle, Otto, 253, 254  
wide-field-of-view camera, 4  
Wide-Field Planetary Camera (WF/PC), 250  
Williams, Richard, 269  
Williams, Robert E., 39  
Willner, Alan E., 338  
Willow Run Laboratories, 86, 100, 119, 120, 122  
Wilson, Joseph C., 61, 61  
windshield polarizer, 51  
Winker, David, 176  
WIRE space telescope, 252  
WISE space telescope, 252  
WMAP space telescope, 252  
Wood, Robert, 34  
Wood, R.W., 19, 19  
Woodall, Jerry, 110  
Woodbury, Eric, 115  
Workshop on Optical and Laser Remote Sensing, 178  
World War I, 15, 24, 25, 33, 49  
World War II, 3, 26, 41, 49–50, 51, 85, 185, 245  
    aerial cameras, 66  
    optical coatings, 70–71  
World Wide Web, 279, 282  
WORM media (write-once read-many-times media), 140  
Worokin, Peter, 84  
Wratten & Wainwright, 33  
Wright, Fred E., 24, 25  
Wright Air Development Command, 65

Wright-Patterson Air Force Base, 186  
writable and re-writable discs, 139–140  
write-once read-many-times (WORM) media, 140  
Wu, Shin-Tson, 269, 271  
Wurzberg, E.L., Jr., 44  
Wyant, James C., 143, 246  
WYKO Corp., 144  
Wynne, James J., 257–261, 308

**X**  
x-ray tube, 24  
xerography, 57–63, 58–61, 134  
*Xerography and Related Processes* (Dessauer), 57  
Xerox 914, 57, 59  
Xerox 7000, 135–136  
Xerox 9700 Electronic Printing System, 137  
Xerox copiers, 50  
Xerox Corp., 50, 57, 63, 134, 135, 137  
Xerox Model A processor, 58, 58  
Xerox PARC, 227, 228

**Y**  
Yablonoitch, Eli, 332  
YAG lasers (yttrium aluminum garnet lasers), 104, 105, 124, 125, 186, 225, 240, 242, 257, 258, 259, 301, 304  
Yahashi, I., 111  
Yale University, 91  
Yamane, Tets, 225  
Yariv, A., 297  
Yeh, P., 297  
Yerkes Observatory, 14, 244  
Young, Thomas, 11, 14, 68, 69  
ytterbium-doped lasers, 106  
ytterbium fiber, 304  
ytterbium-fiber lasers, 242  
ytterbium ions, 104, 105  
yttrium aluminum garnet (YAG) lasers, 104, 105, 124, 125, 186, 225, 240, 242, 257, 258, 259, 301, 304  
Yule, J.A.C., 44

**Z**  
Zeiger, H.J., 50, 109  
Zeiss, Carl, 9, 14, 23, 35  
Zeiss, Roderich, 35  
Zeiss (company), 15, 33  
Zeiss Foundation, 35  
Zeiss Ikon AG, 35  
Zeiss/IMRA, 305  
Zel'dovich, Boris Ya., 116  
Zenker, Gabriel, 69  
Zernike, Frits, 54  
Zeta laser, 168  
Zimar, Frank, 191  
zinc germanium phosphide (ZGP), 215  
Zoller, Peter, 321  
Zuev, Vladimir, 178