

Index

A

- Abnormality:
 measurement scale for, 398. *See also*
 Mahalanobis–Taguchi System
 methods for identifying, 417
- Active dynamic SN ratio, 132–133
- Active signal factors, 39, 97
- Active SN ratios, 236
- Additive model (Taguchi), 1488
- Additivity:
 of factorial effects, 592
 and noise level, 586
 with particle size data, 588
 and physical condition, 585
- Adhesion condition of resin board and copper
 plate, 890–894
- Adjustability, 225
- Adjusting factors, 60. *See also* Control factors
- Adjustment, 60, 319. *See also* Tuning
 basic equations for, 1601
 in feedback control:
 based on product characteristics, 455–459
 of process condition, 468–473
 linearity in, 227–228
 in on-line quality engineering, 116
 process, 439
- Adjustment cost, 441
- Advanced Machining Tool Technology
 Promotion Association, 137
- Airflow noise reduction of intercoolers, 1100–
 1105
- Akao, Yoji, 1427, 1430
- Algorithms case studies (software):
 optimization of a diesel engine software
 control strategy, 1301–1309
 video compression optimization, 1310–1323
- Altshuller, Genrich, 1452–1453, 1489
- American Society for Quality Control, 1443,
 1444
- American Statistical Association, 1435
- American Supplier Institute (ASI), 134, 144,
 158, 160, 162–164, 168, 1494
- American Supplier Institute Consulting Group
 (ASI CG), 1498
- Amplifier stabilization, design for, 717–731
- Analysis of variance (ANOVA), 515–522
 and decomposition of variation, 515–521
 and spectrum analysis, 560
 table, 521–522
 in tolerance design, 342–346
 for two-way layout, 555–562
- Analysis stage, 40
- Analytical models, 1475–1476
- Analytical stage (TRIZ), 1453
- ANNs, *see* Artificial neural networks
- ANOVA, *see* Analysis of variance
- Aoyama Gakuin University, 155
- Approximation:
 sequential, 610, 613–616
 in experimental regression analysis, 490,
 492–496
 with incomplete data, 613–616
 zero, 613
- ARIZ, 1453–1454
- Articulated robots, functionality evaluation of,
 1059–1068
- Artificial environment, 14
- Artificial neural networks (ANNs), 417–418
 The Asahi, 181

- ASI, *see* American Supplier Institute
- ASI CG (American Supplier Institute Consulting Group), 1498
- Assignment (layout) to an orthogonal array, 490
- Attributes:
- classified, 234, 587
 - signal-to-noise ratios for, 234–236, 290–308
 - value of continuous variables vs., 239
 - customer, 1482
- Attribute data, disadvantages of using, 234–235
- Automated process management, 31–33
- Automatic inspection of solder joints, Mahalanobis distance in, 1189–1195
- Automatic transmissions, friction material for, 841–847
- Automotive industry, 7–8, 419. *See also specific companies*
- Automotive industry case studies:
- airflow noise reduction of intercoolers, 1100–1105
 - brake boosters, reduction of boosting force variation of, 1106–1111
 - casting conditions for camshafts, simulation of, 900–903
 - clear vision by robust design, 882–889
 - clutch disk torsional damping system design, 973–983
 - DC motor, optimal design for, 1122–1127
 - diesel engine software control strategy, 1301–1309
 - direct-injection diesel injector optimization, 984–1004
 - exhaust sensor output characterization with MTS, 1220–1232
 - friction material for automatic transmissions, 841–847
 - linear proportional purge solenoids, 1032–1049
 - minivan rear window latching improvement, 1025–1031
 - on-line quality engineering in, 1367–1375
 - product development challenge in, 1478–1479
 - steering system on-center robustness, 1128–1140
 - two-piece gear brazing conditions, optimization of, 858–862
 - wiper system chatter reduction, 1148–1156
- Axiomatic design, 1454–1458
- comparison of TRIZ, robust design, and, 1454–1458
 - function in, 1456
 - and structure thinking, 1487–1489
- B**
- Baba, Ikuo, 140
- Banks, 10, 11
- Base space, 143
- Batch production, 459
- Bean sprouting conditions, optimization of, 631–636
- Bebb, Barry, 158
- Becker technique, 795
- Bell Laboratories, 41, 57, 60, 154–157, 1501
- Benchmarking, 10, 30, 96
- Between-product noise, 176, 319
- Biochemistry case studies:
- bean sprouting conditions, optimization of, 631–636
 - small algae production, optimization of, 637–642
- Biomechanical case study, 795–805
- Block factors, 603
- Blow-off charge measurement systems, optimization of, 746–752
- Bobcat Division, Ingersoll-Rand, 161
- Boosting force variation in brake boosters, reduction of, 1106–1111
- Bossidy, Larry, 161
- Box, George, 1479
- Brain disease, urinary continence recovery in patients with, 1258–1266
- Brake boosters, reduction of boosting force variation of, 1106–1111
- Brazing conditions for two-piece gear, 858–862
- Bucket elevator, preventive maintenance design for, 1376–1382
- Build-test-fix cycles, 1480
- Business applications of MTS, 419–420
- Business readiness, 1505
- C**
- CAE, *see* Computer-aided engineering
- Calibration, 116, 177
- linearity in, 227–228
 - point, 247–250
 - reference-point, 247–250
 - slope, 228, 247

- zero-point, 228
- Cameras, single-use, stability design of shutter mechanisms for, 965–972
- CAMPS (Computer-Aided Measurement and Process Design and Control System), 140
- Camshafts, simulation of casting conditions for, 900–903
- Cannon, 1084
- CAs (customer attributes), 1482
- Casting conditions for camshafts, simulation of, 900–903
- Cause, special vs. common, 1446–1447
- Cause-and-effect diagrams, 1429
- Cause parameters, 340. *See also* Low-rank characteristics
- Central Japan Quality Control Association (CJQCA), 148, 155
- Central Japan Quality Management Association, 144
- Ceramic oscillation circuits, parameter design of, 732–734
- CF, *see* Correction factor
- Champion, corporate, 390
- Change management, 390–391
- Character recognition, Mahalanobis distance in, 1288–1292
- Chebyshev, P. C., 543
- Chebyshev's orthogonal polynomial equation, 254–257, 543
- Checking interval:
 - feedback control based on product characteristics, 455–459
 - feedback control of process condition, 468–473
- Check sheets, 1429
- Checkup interval, 117
- Chemical applications. *See also* Chemical reactions
 - for on and off conditions, 83–85
 - pharmacology, 686–694
- Chemical applications case studies, 629–714
 - biochemistry:
 - bean sprouting conditions, optimization of, 631–636
 - small algae production, optimization of, 637–642
 - dynamic operating window:
 - component separation, evaluation of, 666–671
 - herbal medicine granulation, use of, 695–704
 - photographic systems, evaluation of, 651–658
 - measurement:
 - dynamic operating window, evaluation of component separation with, 666–671
 - granule strength, optimization of measuring method for, 672–678
 - thermoresistant bacteria, detection method for, 679–685
 - ultra trace analysis, dynamic optimization in, 659–665
 - separation:
 - developer, particle-size adjustment in fine grinding process for, 705–714
 - herbal medicine granulation, use of dynamic operating window for, 695–704
 - in vitro percutaneous permeation, optimization of model ointment prescriptions for, 686–694
- Chemical engineering, Taguchi method in, 85–93
 - evaluation of images, 88–91
 - functionality, such as granulation or polymerization distribution, 91
 - function of an engine, 86–87
 - general chemical reactions, 87–88
 - separation system, 91–93
- Chemical reactions:
 - basic function of, 296–298
 - general, 87–88
 - ideal functions of, 230–232
 - and pharmacy, 142
 - with side reactions:
 - reaction speed difference method, 298–301
 - reaction speed ratio method, 301–308
 - without side reactions, 296–298
- Chemical reactions case studies:
 - evaluation of photographic systems with dynamic operating window, 651–658
 - polymerization reactions, optimization of, 643–650
- Chowdhury, Subir, 168, 1493, 1496
- Circuits case studies:
 - design for amplifier stabilization, 717–731
 - evaluation of electric waveforms by momentary values, 735–740

- Circuits case studies (*continued*)
 - parameter design of ceramic oscillation circuits, 732–734
 - robust design for frequency-modulation circuits, 741–745
- CJQCA, *see* Central Japan Quality Control Association
- Clarion, 133, 141
- Classified attributes, 587
 - signal-to-noise ratios for, 234–236, 290–308
 - for chemical reactions without side reactions, 296–298
 - for chemical reactions with side reactions, 298–308
 - for two classes, one type of mistake, 291–293
 - for two classes, two types of mistake, 293–296
 - three-or-more-class, 234
 - two-class, 234
 - value of continuous variables vs., 239
- Clausing, Don, 158
- Clear vision by robust design, 882–889
- Clutch disk torsional damping system design optimization, 973–983
- Common cause, 1446–1447
- Communication (in robust engineering implementation), 391–392
- Comparison, 529, 542–543
- Computer-aided engineering (CAE), 1475–1476
- Computer-Aided Measurement and Process Design and Control System (CAMPS), 140
- Computer systems case study, 1324–1334. *See also* Software testing and application case studies
- Concepts:
 - creation of, 39
 - optimization of, 1497, 1512–1514
 - selection of, 26–28, 40
- Concept design, 1496, 1497. *See also* System design
- Concept optimization phase, 1503, 1504
- Concept phase, 1503, 1504
- Concurrent engineering, 276, 1451
- Conformance to specifications, quality as, 171
- Consumer loss, quality level and, 17–18
- Continuous improvement cycle, 1447
- Continuous variables:
 - signal-to-noise ratios for, 234–236, 239–289
 - double signals, 275–284
 - estimation of error, 271–275
 - with known signal factor level interval, 256–260
 - with known signal factor level ratio, 262–263
 - linear equation, 250–254
 - linear equation using tabular display of orthogonal polynomial equation, 254–256
 - with no noise, 284–289
 - with no signal factor, 264–271
 - reference-point proportional equation, 247–250
 - split analysis, 284–289
 - with unknown true values of signal factor levels, 264
 - when signal factor levels can be set up, 260–262
 - zero-point proportional equation, 241–247
 - in two-way layout experiments, 563–572
 - value of classified attributes vs., 239
- Contradiction table, 1454
- Contrast, 529, 542
- Contribution, 107
- Control charts, 1429
- Control costs, 17
- Control factors, 30, 603, 1435. *See also* Adjusting factors; Indicative factors
 - avoiding interactions between, 290, 356
 - definition of, 74
 - interactions of noise factors and, 227
 - optimum levels for, 212
 - in two-stage optimization, 40, 41
- Copper, separation system for, 91–93
- Copper plate, adhesion condition of resin board and, 890–894
- Corporate leader/corporate team, 390–391
- Corporate strategy, R&D investment in, 26
- Correction factor (CF, CT), 510–511
- Correction (in on-line quality engineering), 116
- Cost(s):
 - adjustment, 441
 - balance of quality and, 18–22, 440–441
 - control, 17
 - and DFSS, 1516–1517
 - for loss of quality, 171
 - process control, 441
 - production, 17, 442

- of quality control systems during production, 474–477
 - and quality level, 18–22
 - and quality loss function, 380
 - unit manufacturing cost, 18, 121, 439, 441
 - Coupled design, 1455
 - Covariance, 536
 - Credit, 10–11
 - Criminal noises, 15–16
 - Cross-functional team, 390–392
 - CT, *see* Correction factor
 - Customers' tolerance, 182
 - Customer attributes (CAs), 1482
 - Customer loss, 193
 - Customer quality, *see* Downstream quality
 - Customer satisfaction, 134
 - Cycle for continuous improvement, 1447
 - Cycle time reduction, 39–40, 228
- D**
- Data analysis, 506–514
 - deviation, 507–508
 - with incomplete data, 609–616
 - sequential approximation, 613–616
 - treatment, 611–613
 - sum and mean, 506–507
 - variation and variance, 509–514
 - Data transformation, 507
 - DC motor, optimal design for, 1122–1127
 - Debugging software, streamlining of, 1360–1364
 - Debug model, 1435
 - Decibel value of the SN ratio, 1438
 - Decomposition, 64. *See also* Decomposition of variation
 - of degrees of contribution, 520–521
 - of degrees of freedom, 518
 - of indicative factors, 563–565
 - two-way layout with, 563–572
 - one continuous variable, 563–567
 - two continuous variables, 567–572
 - Decomposition of variation, 505, 513
 - and analysis of variance, 515–521
 - to components with unit degree of freedom, 528–551
 - comparison and its variation, 528–534
 - linear regression equation, 534–543
 - orthogonal polynomials, application of, 542–551
 - between experiments, 574–575
 - Decoupled design, 1455
 - Deep-drawing process, optimization of, 911–915
 - Defect detection, MTS in, 1233–1237
 - Defective items, 445
 - Degrees of contribution:
 - calculation of, 521–522
 - decomposition of, 520–521
 - explanation of, 560
 - Degrees of freedom, 509–510, 618
 - decomposition of, 518
 - decomposition of components with, 528–551
 - comparison and its variation, 528–534
 - linear regression equation, 534–543
 - orthogonal polynomials, application of, 542–551
 - Delphi, 161
 - Delphi Automotive Systems, 984, 1220
 - Deming, Pluma Irene, 1442–1443
 - Deming, William Albert, 1442–1443
 - Deming, William Edwards, 1424, 1442–1448
 - biographical background, 1442–1444
 - continuous improvement cycle, 1447
 - as father of quality in Japan, 157
 - at Ford Motor Company, 157
 - 14 points for management, 1445–1446
 - on making excellent products, 1491
 - and pattern-level thinking, 1481
 - quality principles of, 1444–1447
 - seven deadly diseases, 1446
 - Taguchi methods vs. teachings of, 1447–1448
 - Deming cycle, 1424, 1426, 1443
 - Deming Prize, 1424, 1428
 - Derivation(s):
 - of quality loss function, 440
 - of safety factors, 443–448
 - with Youden squares, 623–625
 - Design. *See also specific topics*
 - interaction between signals/noises and, 57
 - management for quality engineering in, 30–31
 - Design-build/simulate-test-fix cycle, 164
 - Design constants:
 - selection of, 40
 - tuning as alteration of, 57
 - Design for assembly (DFA), 1482
 - Design for manufacturing (DFM), 1482
 - Design for six sigma (DFSS, IDDOV), 161–163, 1492–1520
 - aligning NPD process with, 1498–1507

- Design for six sigma (*continued*)
 - financial benefits, 1515–1517
 - IDDOV structure, 1494–1496
 - and intersection of six sigma and robust engineering, 1517–1519
 - and NPD, 1501–1507
 - and quality engineering, 1498
 - Taguchi methods as foundation for, 1493–1494
 - technical benefits, 1507–1515
 - Design for Six Sigma* (Subir Chowdhury), 1493
 - Design life, 57
 - Design method for preventive maintenance, 463–467
 - Design of experiments (DoE), 503–505
 - decomposition of variation, 505
 - definition of, 503–504
 - development of, 154
 - at Ford Motor Company, 158
 - functionality, evaluation of, 504
 - in Japan, 1431–1435
 - objective of, 178, 356
 - quality engineering vs., 356
 - and reproducibility, 504–505
 - in United States, 159
 - Design of Experiments* (Genichi Taguchi), 131, 515, 523, 552, 563, 573, 597
 - Design process:
 - analysis stage of, 40
 - stages of, 40
 - synthesis stage of, 40
 - tools for, 30
 - Design quality, 438
 - Design quality test, 38
 - Design review, 1427
 - Design-test-fix cycle, 1471
 - Detector switch characterization with MTS, 1208–1219
 - Deteriorating characteristics, 205–207
 - Developer:
 - high-quality, development of, 780–787
 - particle-size adjustment in fine grinding process for, 705–714
 - Deviation, 507–508
 - estimate of, 512
 - magnitude of, 509
 - from main effect curve, 557
 - from mean, 507, 508
 - from objective value, 507–508
 - standard, 517
 - in variance, 511–514
 - in variation, 509
 - DFA (design for assembly), 1482
 - DFM (design for manufacturing), 1482
 - DFSS, *see* Design for six sigma
 - Diagnosis. *See also* Medical diagnosis
 - basic equations for, 1601
 - MTS for, 398
 - to prevent recalls, 33–38
 - process, 439, 477–479
 - Diagnosis interval, 117
 - Diesel engine software control strategy, 1301–1309
 - Direct-injection diesel injector optimization, 984–1004
 - Direct product design, 227
 - Direct product layout, 323
 - Discrimination and classification method, 417
 - Disk blade mobile cutters, optimization of, 1005–1010
 - Distribution of tolerance, 204–205
 - DMAIC (six sigma), 1517–1519
 - Documentation of testing, 1477
 - DoE, *see* Design of experiments
 - Dole, 1208
 - Domain model of product development, 1479–1480
 - Double signals, 275–284
 - Downstream quality, 269, 354, 355
 - Drug efficacy, Mahalanobis distance in measurement of, 1238–1243
 - Dummy treatment, 427, 428, 605
 - D-VHS tape travel stability, 1011–1017
 - Dynamic operating window method, 142
 - for chemical reactions with side reactions, 298–308
 - for component separation evaluation, 666–671
 - for herbal medicine granulation, 695–704
 - for photographic systems evaluation, 651–658
 - Dynamic SN ratio, 139, 225
 - nondynamic vs., 139, 225
 - for origin quality, 354–355
 - in U.S. applications, 160
 - uses of, 139, 236
- E**
- Earthquake forecasting, MTS in, 419

- ECL, *see* Electrical Communication Laboratory
- Economy:
 direct relationship of SN ratio and, 225
 and productivity, 5–7
- ECs (engineering characteristics), 1482
- Education (in robust engineering implementation), 392
- Effective power, 61
- Effect of the average curve, 558–559
- Elderly:
 improving standard of living for, 12
 predicting health of, 15
- Electrical applications case studies, 715–792
 circuits:
 amplifier stabilization, design for, 717–731
 ceramic oscillation circuits, parameter design of, 732–734
 electric waveforms, evaluation of, 735–740
 frequency-modulation circuits, robust design for, 741–745
 electronics devices:
 back contact of power MOSFETs, optimization of, 771–779
 blow-off charge measurement systems, optimization of, 746–752
 fine-line patterning for IC fabrication, parameter design of, 758–763
 generic function of film capacitors, evaluation of, 753–757
 pot core transformer processing, minimizing variation in, 764–770
 electrophotography:
 functional evaluation of process, 788–792
 high-quality developer, development of, 780–787
- Electrical Communication Laboratory (ECL), 154–156
- Electrical connector insulator contact housing, optimization of, 1084–1099
- Electrical encapsulants:
 ideal function for, 234
 optimization of process, 950–956
 robust technology development of process, 916–925
- Electric waveforms, momentary value in evaluation of, 735–740
- Electro-deposited process for magnet production, 945–949
- Electronic and electrical engineering, Taguchi method in, 59–73
 functionality evaluation of system using power, 61–65
 quality engineering of system using frequency, 65–73
- Electronic components:
 adhesion condition of resin board and copper plate, 890–894
 on and off conditions, 83–85
 resistance welding conditions for, 863–868
- Electronic devices case studies:
 back contact of power MOSFETs, optimization of, 771–779
 blow-off charge measurement systems, optimization of, 746–752
 fine-line patterning for IC fabrication, parameter design of, 758–763
 generic function of film capacitors, evaluation of, 753–757
 variation in pot core transformer processing, minimizing, 764–770
- Electronic warfare systems, robust testing of, 1351–1359
- Electrophotography case studies:
 functional evaluation of an electrophotographic process, 788–792
 high-quality developer, 780–787
 toner charging function measuring system, 875–881
- Emission control systems, 1032–1049
- Employment, productivity and, 6
- Engines:
 function of, 86–87
 idle quality, ideal function of, 230
- Engineering and the Mind's Eye* (Eugene S. Ferguson), 1476
- Engineering characteristics (ECs), 1482
- Engineering quality, 10
- Engineering systems, laws of evolution of, 1454
- Enhanced plastic ball grid array (EPBGA) package, 916–925
- Environmental noises, 14–15
- EPBGA package, *see* Enhanced plastic ball grid array package
- Equalizer design, ideal function in, 233
- Error, human, 13–14
- Error factors, 1434, 1436
- Error variance, 240, 420, 511
- Error variation, 513, 517, 518, 559
- Estimated values, 492, 494–499

Estimate of deviation, 512
 Estimation of error, 271–275
 Europe, paradigm shift in, 29
 Evaluation technologies, 26
 Event thinking, 1480–1481, 1490
 Evolution of engineering systems, laws of, 1454
 Exchange rates, 7
 Exhaust sensor output characterization with
 MTS, 1220–1232
 Experimental regression analysis, 149, 484, 488–
 499
 estimated values, selection of, 492, 494–499
 initial values, setting of, 488–489
 orthogonal array, selection and calculation of,
 489–494
 parameter estimation with, 484, 488–499
 sequential approximation, 490, 492–496
 Experimentation:
 confirmatory, 361
 development of experimental design, 1472–
 1473
 orthogonal array L_{18} for, 357
 successful use of orthogonal arrays for, 358
 Experts, internal, 392
 External noise, 1512
 External test facilities, 1476–1477

F

Fabrication line capacity planning using a
 robust design dynamic model, 1157–1167
 Factors. *See also specific types, e.g.*, Control factors
 classification of, 1434–1435
 definition of, 552
 Failure mode and effects analysis (FMEA), 392,
 1427, 1482
 Failure rates, 1514–1515
 FDI (Ford Design Institute), 161
 Feedback control, 32, 79, 439
 based on process condition, 468–473
 temperature control, 471–473
 viscosity control, 469–470
 based on product characteristics, 454–467
 batch production process, 459–462
 process control gauge design, 462–467
 system design, 454–459
 designing system of, 118–120
 measurement error in, 459
 by quality characteristics, 1383–1388
 Feeder valves, reduction of chattering noise in,
 1112–1121
 Feedforward control, 32, 79, 439
 Felt-resist paste formula, optimization of, 836–
 840
 FEM (finite-element method) analysis, 1050
 Ferguson, Eugene S., 1476
 Film capacitors, generic function of, 753–757
 Financial system product design, 10–11
 Find-and-fix improvement efforts, 1515
 Fine-line patterning for IC fabrication, 758–763
 Finite-element method (FEM) analysis, 1050
 Fire detection, MTS in, 419
 Firefighting, 159, 167, 318
 Fire prevention, 167, 168
 Fisher, Ronald A., 503, 1424, 1431–1434
 Fixed targets, signal-to-noise ratios for, 236
 Flexible manufacturing systems (FMSs), 12
 Flexor tendon repairs, biomechanical
 comparison of, 795–805
 Flex Technology, 160
 FMEA, *see* Failure mode and effects analysis
 FMSs (flexible manufacturing systems), 12
 Ford Design Institute (FDI), 161
 Ford Motor Company, 16, 81, 157–158, 160,
 161, 229, 230, 1431
 Ford Supplier Institute (FSI), 157, 158
 Forecasting. *See also* Prediction
 of earthquakes, 419
 of future health, 1277–1287
 MTS for, 398
 of weather, 419
 Foundry process using green sand, 848–851
 Four “P’s” of testing, 1470
 personnel, 1470–1472
 preparation, 1472–1473
 procedures, 1473–1474
 product, 1474–1475
 14 points for management, 1445–1446
 Freedoms, individual, 9, 11
 Frequency modulation, 67–69, 741–745
 Friction material for automatic transmissions,
 841–847
 FSI, *see* Ford Supplier Institute
 Fuel delivery system, ideal function in, 229–230
 Fuji Film, 24, 135, 1439
 Fujimoto, Kenji, 84
 Fuji Steel, 1424
 Fuji Xerox, 149, 158, 428, 1439
 Function(s):
 definitions of, 1456

- in design, 1456
 - generic, 8
 - definition of, 85, 229, 355
 - determining evaluation scale of, 148
 - identification of, 360
 - machining, 80–83
 - objective function vs., in robust technology development, 355
 - optimization of, 352
 - robustness of, 352
 - selecting, 313–314
 - SN ratio for, 133
 - technological, 1440
 - ideal, 60, 229–234
 - actual function vs., 1508–1509
 - based on signal-to-noise ratios, 228–234
 - chemical reactions, 230–232
 - definition of, 1450, 1508
 - with double signals, 279
 - electrical encapsulant, 234
 - engine idle quality, 230
 - equalizer design, 233
 - fuel delivery system, 229–230
 - grinding process, 232
 - harmful part of, 1509
 - identifying, 377–378
 - injection molding process, 229
 - intercoolers, 232
 - low-pass filters, 233–234
 - machining, 229
 - magneto-optical disk, 233
 - power MOSFET, 234
 - printer ink, 234
 - specifying, 1472
 - transparent conducting thin films, 233
 - useful part of, 1509
 - voltage-controlled oscillators, 234
 - wave soldering, 233
 - welding, 230
 - wiper systems, 230
 - loss, 1452, 1488
 - modulation, 67–69
 - objective, 10
 - definition of, 229, 355
 - and design of product quality, 26
 - generic function vs., 355
 - standard conditions for, 40
 - of subsystems, 313
 - transformability as, 140
 - tuning as, 57
 - on and off, 138
 - orthogonal, 543
 - phase modulation, 68–72
 - quality loss function, 133–134, 171–179, 380
 - classification of quality characteristics, 180
 - derivation of, 440
 - equations for, 1598–1601
 - justice-related aspect of, 175–176
 - for larger-the-better characteristic, 188, 191
 - for nominal-the-best characteristic, 180–186, 190, 445
 - and process capability, 173–176
 - quadratic representation of, 174
 - quality aspect of, 176
 - for smaller-the-better characteristic, 186–188, 190
 - and steps in product design, 176–179
 - for tolerance design optimization, 386
 - in TRIZ, 1456
 - Functional analysis and trimming (TRIZ), 1454
 - Functional evaluation:
 - of electrophotographic process, 788–792
 - SN ratio for, 133
 - Functional independence, 1488
 - Functionality(-ies):
 - evaluation, functionality, 28–30, 147, 504
 - of articulated robots, 1059–1068
 - of spindles, 1018–1024
 - standardization draft for, 148
 - in trading, 148
 - improvement of, 27
 - and system design, 314–317
 - Functionality design, 11, 73
 - Functional limit, 443
 - Functional quality, *see* Origin quality
 - Functional risk, 11
 - Functional tolerance, 193
 - Function limit, 196–201
- G**
- Gain, 79
 - Gas-arc stud weld process parameter optimization, 926–939
 - Gauss, K. F., 535
 - GDP, *see* Gross domestic product
 - General Electric (GE), 161, 1481
 - Generic function(s), 8
 - definition of, 85, 229, 355

Generic function(s) (*continued*)
 determining evaluation scale of, 148
 identification of, 360
 machining, 80–83
 objective function vs., in robust technology
 development, 355
 optimization of, 352
 robustness of, 352
 selecting, 313–314
 SN ratio for, 133
 technological, 1440

Generic technology, 26, 39, 59

Global Standard Creation Research and
 Development Program, 148

GNP (gross national product), 6

GOOD START model, 1505–1507

Gram–Schmidt orthogonalization process
 (GSP), 400, 415–418. *See also* Mahalanobis–
 Taguchi Gram–Schmidt process

Granule strength, optimization of measuring
 method for, 672–678

Graphs, 1429. *See also* Linear graphs

Greco Latin square, 1432

Green sand, foundry process using, 848–851

Grinding process:
 for developer, particle-size adjustment in,
 705–714
 ideal function of, 232

Gross domestic product (GDP), 11, 12

Gross national product (GNP), 6

GSP, *see* Gram–Schmidt orthogonalization
 process

H

Hackers, 15

Handwriting recognition, 1288–1292

Hara, Kazuhiko, 141

Hardware design, downstream reproducibility
 in, 58–59

Harmful effects (TRIZ), 1453

Harmful part (ideal functions), 1509

Harry, Mikel, 161, 1517

Hazama, 1427

Health. *See also* Medical diagnosis
 of elderly, 12, 15
 forecasting, 1277–1287
 MT method for representing, 102–104

Herbal medicine granulation, dynamic
 operating window method for, 695–704

Hermitian form, 62–64. *See also* Decomposition
 of variation

Hewlett-Packard, 27–29, 73

Hicks, Wayland, 158

Higashihara, Kazuyuki, 84

High-performance liquid chromatograph
 (HPLC), 666–671

High-performance steel, machining technology
 for, 819–826

High-rank characteristics, 201
 definition of, 340
 relationship between low-rank characteristics
 and, 203–204
 tolerance for, 205

Histograms, 1429

History of quality engineering, 127–168
 in Japan, 127–152
 application of simulation, 144–147
 chemical reaction and pharmacy, 142
 conceptual transition of SN ratio, 131–133
 design of experiments, 1431–1435
 development of MTS, 142–143
 electric characteristics, SN ratio in, 140–
 141
 evaluation using electric power in
 machining, 138–139
 machining, SN ratio in, 135–137
 on-line quality engineering and loss
 function, 133–135
 origin of quality engineering, 127–131
 QFD for customers' needs, 1430–1431
 seven QC tools and QC story, 1428–1430
 since 1950s, 1435–1440
 transformability, SN ratio of, 139–140
 in United States, 153–168
 from 1980 to 1984, 156–158
 from 1984 to 1992, 158–160
 from 1992 to 2000, 161–164
 from 2000 to present, 164–168
 and history of Taguchi's work, 153–156

Holmes, Maurice, 158

Hosokawa, Tetsuo, 27, 28

House of quality, 164–166

HPLC, *see* High-performance liquid
 chromatograph

Human errors, 13–14

Human performance case studies:
 evaluation of programming ability, 1178–1188
 prediction of programming ability, 1171–1177

I

- ICP-MS (inductively coupled plasma mass spectrometer), 659
- IDDOV, *see* Design for six sigma
- Ideal function(s), 60, 229–234
 - actual function vs., 1508–1509
 - based on signal-to-noise ratios, 228–234
 - chemical reactions, 230–232
 - definition of, 1450, 1508
 - with double signals, 279
 - electrical encapsulant, 234
 - engine idle quality, 230
 - equalizer design, 233
 - fuel delivery system, 229–230
 - grinding process, 232
 - harmful part of, 1509
 - identifying, 377–378
 - injection molding process, 229
 - intercoolers, 232
 - low-pass filters, 233–234
 - machining, 229
 - magneto-optical disk, 233
 - power MOSFET, 234
 - printer ink, 234
 - specifying, 1472
 - transparent conducting thin films, 233
 - useful part of, 1509
 - voltage-controlled oscillators, 234
 - wave soldering, 233
 - welding, 230
 - wiper systems, 230
- Ideality:
 - concept of, 1453
 - principle of, 1489
- Ideation, 1301
- IHI, *see* Ishikawajima–Harima Heavy Industries
- IIN/ACD, *see* ITT Industries Aerospace/Communications Division
- Image, definition of, 88
- IMEP (indicated mean effective pressure), 230
- Implementation of robust engineering, 389–393
 - and bottom-line performance, 393
 - corporate leader/corporate team in, 390–391
 - critical components in, 389–390
 - education and training in, 392
 - effective communication in, 391–392
 - and integration strategy, 392–393
 - management commitment in, 390
- Ina, Masao, 1433
- Inao, Takeshi, 131
- Ina Seito Company, 155, 589, 1433, 1434
- Incomplete data, 609–616
 - sequential approximation with, 613–616
 - treatment of, 611–613
- Incomplete Latin squares, 617. *See also* Youden squares
- Independence axiom, 1454, 1487–1488
- Indian Statistical Institute, 155, 398
- Indicated mean effective pressure (IMEP), 230
- Indicative factors, 30, 68, 563, 603, 1434, 1436.
 - See also* Control factors
- Individual freedoms, 9, 11
- Inductively coupled plasma mass spectrometer (ICP-MS), 659
- Industrial Revolution, 9. *See also* Second Industrial Revolution
- Industrial waste, tile manufacturing using, 869–874
- Information axiom, 1454
- Information technology, 10–11
- Ingersoll-Rand, 161
- Initial values (experimental regression analysis), 488–489
- Injection molding process. *See also* Plastic injection molding
 - ideal function in, 229
 - thick-walled products, 940–944
- Ink, printer:
 - ideal function for, 234
 - MTS in thermal ink jet image quality inspection, 1196–1207
- Inner noise, 176, 319
- Inner orthogonal arrays, 322–323
- Input, signal-to-noise ratios based on, 236–237
- Inspection, traditional approach to, 378–379
- Inspection case studies:
 - automatic inspection of solder joints, Mahalanobis distance in, 1189–1195
 - defect detection, 1233–1237
 - detector switch characterization, 1208–1219
 - exhaust sensor output characterization, 1220–1232
 - printed letter inspection technique, 1293–1297
 - thermal ink jet image quality inspection, 1196–1207
- Inspection design, 32–33, 80, 463–467
- Inspection interval, 117

Integration strategy (robust engineering), 392–393
 Intention, signal-to-noise ratios based on, 236
 Interaction(s), 579
 and choice of functional output, 1451
 software diagnosis using, 98–102
 Intercoolers:
 airflow noise reduction of, 1100–1105
 ideal function of, 232
 Internal experts, 392
 Internal noise, 1512
 International Society for Robust Engineering Professionals, 168
 Inventive principles, 1454
 Inverted matrix (for MD computation), 400
 In vitro percutaneous permeation, model ointment prescriptions for, 686–694
 Ishikawa, Ichiro, 1481
 Ishikawa, Kaoru, 1481, 1482
 Ishikawajima–Harima Heavy Industries (IHI), 83–85, 137, 138, 141, 148
 Isuzu Motors, 131–132
 ITT, 161, 162
 ITT Cannon, 144, 1069
 ITT Defense Electronics, 433
 ITT Industries Aerospace/Communications Division (IIN/ACD), 1310, 1324

J

Japan:
 fire loss in, 14
 functional evaluation of systems in, 11
 history of quality engineering in, 127–152, 1428–1440
 application of simulation, 144–147
 chemical reaction and pharmacy, 142
 conceptual transition of SN ratio, 131–133
 design of experiments, 1431–1435
 development of MTS, 142–143
 electric characteristics, SN ratio in, 140–141
 electric power in machining, evaluation using, 138–139
 machining, SN ratio in, 135–137
 on-line quality engineering and loss function, 133–135
 origin of quality engineering, 127–131
 QFD for customers' needs, 1430–1431
 seven QC tools and QC story, 1428–1430

 since 1950s, 1435–1440
 transformability, SN ratio of, 139–140
 quality management in, 1423–1440
 design of experiments, 1431–1435
 history of, 1423–1428
 quality engineering, 1435–1440
 quality function deployment, 1430–1431
 R&D investment in, 26
 standard of living and income in, 7
 statistical process control in, 1481
 Japanese Society for Quality Control, 1428
 Japanese Standards Association (JSA), 148–149, 155, 1432
 Japanese Union of Scientists, 1432
 Japanese Union of Scientists and Engineers (JUSE), 157, 1335, 1427, 1443, 1481
 Japan Industry Standards (JIS), 196, 1424
 Japan Society for Seikigakkai, 136
 Japan Society of Plastic Technology, 140
 JIS, *see* Japan Industry Standards
 Joban Hawaiian Center, 1428
 JR (Japan Railroad), 199
 JSA, *see* Japanese Standards Association
 Juran, J. M., 1426, 1481
 Juran's trilogy, 1511
 JUSE, *see* Japanese Union of Scientists and Engineers

K

Kajima Corp., 1427
 Kakar, Rague, 156
 Kanemoto, Yoshishige, 133, 141
 Kanetaka, Tatsuji, 104–106, 143
 Kansai Electric Power, 1428
 Kawamura, Masanobu, 131
 Kessler technique, 795
 Kitagawa, Toshio, 1424
 Kodak, 161
 Kokai, Tomi, 153
 Komatsu, 1429
 Konica, 133

L

Larger-the-better characteristic, 17, 180
 quality level at factories for, 451–453
 quality level calculation for, 19, 21–22
 quality loss function for, 188, 191
 safety factor for, 447
 tolerance design for, 210–211
 Larger-the-better SN ratio, 95, 139

- Latent defects, 1498
- Latin squares, 617, 1432
- Laws of evolution of engineering systems, 1454
- Layout to an orthogonal array, 490
- LC (liquid chromatographic) analysis, 666
- Leadership for robust engineering, 390–391
- Least squares, 60, 535
 for estimation of operation time, 485–486
 parameter estimation with, 485–489
- LIMDOW disk, 27, 28
- Limits, 379
- Linear actuator optimization using simulation, 1050–1058
- Linear equations, 240, 241
 number of units in, 559
 for signal-to-noise ratios for continuous variables, 250–256
 zero-point proportionality as replacement for, 137
- Linear graphs, 597–608, 1433, 1527–1528
 combination design, 606–608
 dummy treatment, 605
 for L_4 , 1530
 for L_8 , 597–600, 602, 604, 1530, 1603
 for L_9 , 1564, 1609
 for L_{16} , 1532–1535, 1586, 1606–1608
 for L_{18} , 1564, 1610
 for L_{25} , 1591
 for L_{27} , 1567, 1613
 for L'_{27} , 1597
 for L_{32} , 1538–1549, 1587
 for L_{36} , 1594
 for L_{50} , 1592
 for L_{59} , 1568
 for L_{64} , 1554–1563, 1590
 for L_{81} , 1572–1585
 for multilevel factors, 599–606
- Linearity (SN ratios), 225, 226
 in adjustment and calibration, 227–228
 dynamic, 236
- Linear proportional purge solenoids, 1032–1049
- Linear regression equations, 1406–1419
- Liquid chromatographic (LC) analysis, 666
- Liver disease diagnosis case studies, 401–415, 1244–1257
- Loss:
 definition of, 171
 due to evil effects, 18
 due to functional variability, 18–19, 440–442
 due to harmful quality items, 440–441
 to society, 1516–1517
- Loss function, 1452, 1488. *See also* Quality loss function
- Low-pass filters, ideal function for, 233–234
- Low-rank characteristics. *See also* Parameter design; Tolerance design
 definition of, 340
 deterioration of, 205–207
 determination of, 201–204
 and high-rank characteristics, 203–204
 specification tolerancing with known value of, 201–204
- M**
- MACH, *see* Minolta advanced cylindrical heater
- Machine and Tool*, 136
- Machine Technology*, 136
- Machining, 80–83
 analysis of cutting performance, 81, 82
 ideal function, 229
 improvement of work efficiency, 82–83
- Machining case studies:
 development of machining technology for high-performance steel by transformability, 819–826
 optimization of machining conditions by electrical power, 806–818
 spindles, functionality evaluation of, 1018–1024
 transformability of plastic injection-molded gear, 827–835
- Maeda, 1428
- Magnetic circuits, optimization of linear actuator using simulation, 1050–1058
- Magneto-optical disk, ideal function for, 233
- Magnet production, electro-deposited process for, 945–949
- Mahalanobis, P. C., 103, 155, 398, 1440
- Mahalanobis distance (MD), 102–103, 114–116, 398, 1440
 applications of, 398
 in automatic inspection of solder joints, 1189–1195
 in character recognition, 1288–1292
 computing methods for, 400
 Gram–Schmidt process for calculation of, 416
 for health examination and treatment of missing data, 1267–1276

- Mahalanobis distance (*continued*)
- in measurement of drug efficacy, 1238–1243
 - in medical diagnosis, 1244–1257
 - in prediction:
 - of earthquake activity, 14
 - of urinary continence recovery in patients with brain disease, 1258–1266
 - and Taguchi method, 114–116
- Mahalanobis space, 114–116
- in predicting health of elderly, 15
 - in prediction of earthquake activity, 14
 - and Taguchi method, 114–116
- Mahalanobis–Taguchi Gram–Schmidt (MTGS) process, 415–418
- Mahalanobis–Taguchi (MT) method, 102–109
- general pattern recognition and evaluation procedure, 108–109
 - and Mahalanobis distance/space, 114–116
 - for medical diagnosis, 104–108
- Mahalanobis–Taguchi System (MTS), 102–103, 109–116, 397–421
- applications, 418–420
 - in automotive industry:
 - accident avoidance systems, 419
 - air bag deployment, 419
 - base space creation in, 143
 - in business, 419–420
 - definition of, 398
 - discriminant analysis vs., 143
 - early criticism/misunderstanding of, 142–143
 - in earthquake forecasting, 419
 - in fire detection, 419
 - general pattern recognition and evaluation procedure, 109–114
 - and Gram–Schmidt orthogonalization process, 415–418
 - liver disease diagnosis case study, 401–415
 - and Mahalanobis distance/space, 114–116
 - in manufacturing, 418
 - in medical diagnosis, 418
 - other methods vs., 417–418
 - in prediction, 15, 419
 - sample applications of, 398–400
 - for study of elderly health, 12
 - in weather forecasting, 419
- Mahalanobis–Taguchi System (MTS) case studies, 1169–1297
- human performance:
 - evaluation of programming ability, 1178–1188
 - prediction of programming ability, 1171–1177
- inspection:
- automatic inspection of solder joints, Mahalanobis distance in, 1189–1195
 - defect detection, 1233–1237
 - detector switch characterization, 1208–1219
 - exhaust sensor output characterization, 1220–1232
 - thermal ink jet image quality inspection, 1196–1207
- medical diagnosis:
- future health, forecasting of, 1277–1287
 - health examination and treatment of missing data, 1267–1276
 - liver disease, 401–415
 - measurement of drug efficacy, Mahalanobis distance for, 1238–1243
 - urinary continence recovery among patients with brain disease, prediction of, 1258–1266
 - use of Mahalanobis distance in, 1244–1257, 1267–1276
- products:
- character recognition, Mahalanobis distance for, 1288–1292
 - printed letter inspection technique, 1293–1297
- Main effect curve, 557
- Maintenance design, 439. *See also* Preventive maintenance
- Maintenance system design, 33
- Management:
- commitment to robust engineering by, 390
 - general role of, 23
 - for leadership in robust engineering, 390–391
 - major role of, 10
 - in manufacturing, 16–22, 120–123
 - consumer loss, evaluation of quality level and, 17–18
 - cost vs. quality level, 18–22
 - at Ford Motor Company, 16
 - tolerance, determination of, 16–17
 - for quality engineering, 25–38
 - automated process management, 31–33
 - design process, 30–31
 - functionality, evaluation of, 28–30
 - recalls, diagnosis to prevent, 33–38

- research and development, 25–28, 39–40
- and robust engineering, 377–388
- parameter design, 382–386
- tolerance design, 386–388
- strategic planning in, 13
- Management by total results, 149
- Management reviews, 1507
- Manufacturing. *See also* Manufacturing processes
 - management in, 16–22
 - balance of cost and quality level, 18–22
 - determining tolerance, 16–17
 - evaluation of quality level and consumer loss, 17–18
 - at Ford Motor Company, 16
 - MTS in, 418
 - of semiconductor rectifier, 1395–1398
- Manufacturing case studies. *See also* Processing case studies
 - control of mechanical component parts, 1389–1394
 - on-line quality engineering in automobile industry, 1367–1375
 - semiconductor rectifier manufacturing, 1395–1398
- Manufacturing processes:
 - automated, 31–33
 - on-line quality engineering for design of, 1497–1498
 - quality management of, 1498
 - stages of, 441
- Manufacturing tolerance, 194–195
- Market noises, 13
- Market quality, items in, 18
- Martin, Billy, 387
- Masuyama, Motosaburo, 1431
- Material design case studies:
 - felt-resist paste formula used in partial felting, optimization of, 836–840
 - foundry process using green sand, parameter design for, 848–851
 - friction material for automatic transmissions, 841–847
 - functional material by plasma spraying, 852–857
- Material strength case studies:
 - resistance welding conditions for electronic components, optimization of, 863–868
 - tile manufacturing using industrial waste, 869–874
 - two-piece gear brazing conditions, optimization of, 858–862
- Matsuura Machinery Corp., 138
- Maxell, Hitachi, 27
- McDonnell & Miller Company, 330–337
- MD, *see* Mahalanobis distance
- Mean, 506–507
 - deviation from, 507, 508
 - as variance, 509
 - variation from, 510
 - working, 506–507
- Mean-squared deviation (MSD), 183–184
- Measurement. *See also* Measurement systems
 - of abnormality, 398
 - on continuous scale vs. pass/fail, 474
 - establishing procedures for, 1473–1474
 - in on-line quality engineering, 116
 - technologies for, 26
- Measurement case studies:
 - clear vision by robust design, 882–889
 - component separation using a dynamic operating window, 666–671
 - drug efficacy, Mahalanobis distance in measurement of, 1238–1243
 - electrophotographic toner charging function measuring system, 875–881
 - granule strength, optimization of measuring method for, 672–678
 - thermo-resistant bacteria, detection method for, 679–685
 - ultra trace analysis, dynamic optimization in, 659–665
- Measurement error, 459
- Measurement interval, 117
- Measurement systems:
 - efficiency of, 228
 - for electrophotographic toner charging function, 875–881
 - in MTS, 420. *See also* Mahalanobis–Taguchi System
 - SN ratio evaluation of, 225
 - types of calibration in, 247
- Mechanical applications case studies, 793–1167
 - control of mechanical component parts in manufacturing, 1389–1394
 - fabrication line capacity planning, 1157–1167
 - flexor tendon repairs, biomechanical comparison of, 795–805

Mechanical applications case studies (*continued*)

machining:

- electric power, optimization of machining conditions by, 806–818
- high-performance steel by transformability, technology for, 819–826
- plastic injection-molded gear, transformability of, 827–835

material design:

- automatic transmissions, friction material for, 841–847
- felt-resist paste formula used in partial felting, optimization of, 836–840
- foundry process using green sand, 848–851
- plasma spraying, development of functional material by, 852–857

material strength:

- resistance welding conditions for electronic components, optimization of, 863–868
- tile manufacturing using industrial waste, 869–874
- two-piece gear brazing conditions, optimization of, 858–862

measurement:

- clear vision of steering wheel by robust design, 882–889
- electrophotographic toner charging function measuring system, development of, 875–881

processing:

- adhesion condition of resin board and copper plate, optimization of, 890–894
- casting conditions for camshafts, optimization of, 900–903
- deep-drawing process, optimization of, 911–915
- electrical encapsulation process, optimization of, 950–956
- electro-deposited process for magnet production, quality improvement of, 945–949
- encapsulation process, development of, 916–925
- gas-arc stud weld process parameter optimization, 926–939
- molding conditions of thick-walled products, optimization of, 940–944
- photoresist profile, optimization of, 904–910

plastic injection molding technology,

development of, 957–964

wave soldering process, optimization of,

895–899

product development:

- airflow noise reduction of intercoolers, 1100–1105
 - articulated robots, functionality evaluation of, 1059–1068
 - brake boosters, reduction of boosting force variation of, 1106–1111
 - chattering noise in Series 47 feeder valves, reduction of, 1112–1121
 - clutch disk torsional damping system design, optimization of, 973–983
 - DC motor, optimal design for, 1122–1127
 - direct-injection diesel injector optimization, 984–1004
 - disk blade mobile cutters, optimization of, 1005–1010
 - D-VHS tape travel stability, 1011–1017
 - electrical connector insulator contact housing, optimization of, 1084–1099
 - linear actuator using simulation, 1050–1058
 - linear proportional purge solenoids, 1032–1049
 - minivan rear window latching, improvement of, 1025–1031
 - omelets, improvement in the taste of, 1141–1147
 - shutter mechanisms of single-use cameras by simulation, 965–972
 - spindles, functionality evaluation of, 1018–1024
 - steering system on-center robustness, 1128–1140
 - ultraminiature KMS tact switch optimization, 1069–1083
 - wiper system chatter reduction, 1148–1156
- Mechanical engineering, Taguchi method in, 73–85
- conventional meaning of robust design, 73–74
 - functionality design method, 74–79
 - generic function of machining, 80–83
 - problem solving and quality engineering, 79–80
 - signal and output, 80

- when on and off conditions exist, 83–85
 - Medical diagnosis:
 - Mahalanobis–Taguchi method for, 104–108
 - MTS in, 418
 - Medical diagnosis case studies:
 - future health, forecasting of, 1277–1287
 - health examination and treatment of missing data, Mahalanobis distance for, 1267–1276
 - liver disease, 401–415, 1244–1257
 - measurement of drug efficacy, Mahalanobis distance for, 1238–1243
 - urinary continence recovery among patients with brain disease, prediction of, 1258–1266
 - use of Mahalanobis distance in, 1244–1257
 - Medical treatment and efficacy
 - experimentation, Taguchi method in, 93–97
 - Metrology Management Association, 134, 140–141
 - Midstream quality (specified quality), 354, 355
 - Minivan rear window latching improvement, 1025–1031
 - Minolta advanced cylindrical heater (MACH), 361–376
 - functions of, 362, 363
 - heat generating function, 365, 367–370
 - peel-off function, 367, 369, 371–373
 - power supply function, 362–366
 - temperature measuring function, 369, 374–376
 - traditional fixing system vs., 361–362
 - Minolta Camera Company, 232
 - Mitsubishi Heavy Industries, 1482
 - Mitsubishi Research Institute, 26
 - Mixed-level orthogonal arrays, 596
 - Miyamoto, Katsumi, 136
 - Mizuno, Shigeru, 1427, 1430
 - Modification, 177, 319
 - Modulation function, 67–69
 - Momentary values, evaluation of electric waveforms by, 735–740
 - Monotonicity property, 1451
 - Monte Carlo method, 442
 - Moore, Willie, 16, 158
 - Morinaga Pharmaceutical, 1431
 - Moritomo, Sadao, 136
 - Motorola, 1517
 - MSD, *see* Mean-squared deviation
 - MTGS process, *see* Mahalanobis–Taguchi Gram–Schmidt process
 - MT method, *see* Mahalanobis–Taguchi method
 - MTS, *see* Mahalanobis–Taguchi System
 - Multilevel assignment, 618, 1433
 - Multiple factors, tolerance design for, 212–220
 - Multiple targets, signal-to-noise ratios for, 236
 - Multivariate charts, MTS/MTGS vs., 417
 - Musashino Telecommunication Laboratory, 127–129
 - My Way of Thinking* (Genichi Taguchi), 127–129
- N**
- Nachi-Fujikoshi Corp., 137, 138, 141
 - NASA, 1427
 - NASDA (National Space Development Agency), 1427
 - National Railway, 81, 83, 1427
 - National Research Laboratory of Metrology, 140
 - National Space Development Agency (NASDA), 1427
 - Natural environment, 14
 - Natural logarithms, 142
 - New product development (NPD), 1498–1507
 - and design for six sigma, 1498–1507
 - and IDDOV, 1496, 1501–1507
 - leveraging of DFSS by, 1493–1494
 - phase gate process, 1505–1506
 - phase-phase gate structure, 1501–1503
 - phase processes, 1503–1505
 - project review process, 1506–1507
 - structure thinking in, 1486–1490
 - Suh/Senge model of, 1479–1480
 - synthesized case study, 1499–1500
 - New robust product development (NRPD), 1499, 1502–1503, 1507
 - Night-vision image-intensifier tube, 950
 - Nikkei Mechanical*, 27, 28
 - Nikon Corp., 27, 28
 - Nippon Denso, 135, 157, 1439
 - Nippon Electric, 1439
 - Nippon Telegraph and Telephone Public Corporation (NTT), 15, 73, 127–129, 199
 - Noise(s), 13. *See also* Signal-to-noise ratio
 - between-product, 319
 - criminal, 15–16
 - definition of, 319, 381
 - environmental, 14–15

- Noise(s) (*continued*)
- external, 1512
 - human errors, 13–14
 - inner, 319
 - interaction between design and, 57
 - internal, 1512
 - outer, 319
 - parameter design for minimization of, 319–320
 - types of, 319
 - and types of variability, 224
- Noise factors, 29, 30, 381–382, 1434
- compounded, 40–41, 360–361
 - indicative, 30
 - interactions of control factors and, 227
 - in robust design, 353
 - testing personnel in selection of, 1473
 - in tolerance design, 208–210
 - true, 30
 - in two-stage optimization, 40, 41
 - variation caused by repetitions, 242
- Noise level, additivity for, 586–587
- Noise variables, 176
- Nominal system parameters, 40
- Nominal-the-best characteristic, 17, 180
- definition of, 442
 - quality level at factories for, 448–450
 - quality level calculation for, 19–21
 - quality loss function for, 180–186, 190, 445
 - tolerance design for, 208–210
- Nominal-the-best scale, 1439
- Nominal-the-best SN ratio, 139
- Nomura Research Institute, 26
- Nondynamic characteristics, 236
- Nondynamic SN ratio, 139, 225, 264–271
- dynamic vs., 139, 225
 - larger-the-better applications, 269
 - nominal-the-best applications, 265–268
 - operating window, 269–271
 - smaller-the-better applications, 268
 - for upstream quality, 243
 - uses of, 236
- Nonlinear regression equations, 1406–1419
- Normalization, 103
- Normal state, 196
- NPD, *see* New product development
- NRPD, *see* New robust product development
- NTT, *see* Nippon Telegraph and Telephone Public Corporation
- Number of workers, optimal, 469–471
- O**
- Objective function(s), 10
- definition of, 229, 355
 - and design of product quality, 26
 - generic function vs., 355
 - standard conditions for, 40
 - of subsystems, 313
 - transformability as, 140
 - tuning as, 57
- Objective value, deviation from, 507–508
- Observational equation, 535
- Off functions, 138
- Off-line quality engineering, 135, 504, 1496–1497. *See also* Robust engineering
- for product design, 1497
 - role of, 1493
 - steps in, 504
 - for technology development, 1496
- Ohm's law, 508
- Oken, 143
- Oki Electric Industry, 44–55, 144
- Omega transformation, 292–293
- Omelets, improvement in taste of, 1141–1147
- On and off conditions, 83–85
- One-factor-at-a-time approach, 291, 357
- One-factor-by-one method, orthogonal arrays vs., 594–595
- One-way layout, 523–527
- with equal number of repetitions, 523–527
 - with unequal number of repetitions, 527
- On functions, 138
- On-line process control:
- equations for, 1598–1601
 - feedback control:
 - of process conditions, 1600–1601
 - by quality characteristics, 1598–1600
 - process diagnosis and adjustment, 1601
- On-line quality engineering (OQE), 504, 1497–1498
- applications of, 135
 - definition of, 14, 79, 116
 - feedback control:
 - process condition, based on, 468–473
 - product characteristics, based on, 454–467
 - major concept in, 135
 - for manufacturing process design, 1497–1498
 - origin of field, 135
 - parameter design vs., 437
 - process condition, feedback control based on, 468–473

- temperature control, 471–473
- viscosity control, 469–470
- process diagnosis and adjustment, 474–481
 - and cost of quality control systems during production, 474–477
 - diagnostic interval, optimal, 477–479
 - number of workers, optimal, 469–471
- product characteristics, feedback control
 - based on, 454–467
 - batch production process, 459–462
 - process control gauge design, 462–467
 - system design, 454–459
- role of, 1493
- Taguchi method in, 116–123
- tolerancing and quality level in, 437–453
 - determination of tolerance, 442–448
 - larger-the-better characteristics, quality level at factories for, 451–453
 - nominal-the-best characteristics, quality level at factories for, 448–450
 - product cost analysis, 440
 - production division responsibilities, 440–441
 - related issues, 437–439
 - and role of production in quality evaluation, 441–442
 - smaller-the-better characteristics, quality level at factories for, 450–451
- On-line quality engineering case studies, 1365–1398
 - automobile manufacturing process, application to, 1367–1375
 - feedback control by quality characteristics, 1383–1388
 - manufacturing process, control of mechanical component parts in, 1389–1394
 - preventive maintenance of bucket elevator, 1376–1382
 - semiconductor rectifier manufacturing, 1395–1398
- Op-amp, 27
- Operating cost, 18, 440
- Operating window:
 - dynamic, 142, 298–308
 - for chemical reactions with side reactions, 298–308
 - for component separation evaluation, 666–671
 - for herbal medicine granulation, 695–704
 - for photographic systems evaluation, 651–658
 - nondynamic, 269–271
- Optimal diagnostic interval, 477–479
- Optimization. *See also specific case studies*
 - of concept/technology sets, 1497, 1512–1514
 - evaluation technique for, 148
 - of generic functions, 352
 - in research and development, 1502, 1515
 - robust, 1497, 1501, 1502. *See also* parameter design
 - improvement in, 1508
 - and innovation, 1515
 - for reliability improvement, 1515
 - in robust technology development, 361
 - stage, 40–55
 - example of, 44–55
 - formula of orthogonal expansion, 43–44
 - orthogonal expansion, 40–41
 - testing method and data analysis, 42–43
 - variability improvement, 41–55
 - of technology, 1497, 1512–1514
 - of tolerance design, 386
 - two-stage:
 - control factors in, 40, 41
 - noise factors in, 40, 41
 - two-step, 178, 353–354, 377, 1502. *See also* Parameter design
 - concept step in, 1504
 - definition of, 60
 - in new product development, 1501–1502
 - in product design, 1439, 1497
 - in robust technology development, 353–354
 - in technological development, 1440
- Optimum performance, exceeding, 379–380
- OQE, *see* On-line quality engineering
- Origin quality (functional quality), 354–355
- Orthogonal arrays, 30, 356–358, 584–596, 1526–1527
 - assignment (layout) to, 490
 - inner, 322–323
 - Japanese experimentation using, 1432–1433
 - L_4 , 1530, 1602
 - L_8 , 597–600, 602, 604, 1530, 1603
 - L_9 , 1564, 1609
 - L'_9 , 1595
 - L_{12} , 589, 1531, 1604
 - L_{16} , 1532, 1586, 1605

Orthogonal arrays (*continued*)

- L_{18} , 74, 589–594, 1564, 1610
 - L_{25} , 1591
 - L_{27} , 1565–1566, 1611–1612
 - L_{27}^2 , 1596
 - L_{32} , 1536–1537, 1587
 - L_{36} , 491–492, 589, 1593, 1614–1617
 - L_{50} , 1592
 - L_{54} , 1568
 - L_{64} , 1550–1553, 1588–1589
 - L_{81} , 1570–1571
 - layout of signal factors in, 97–98
 - linear graphs of, *see* Linear graphs
 - mixed, 286–289
 - objective of using, 357
 - one-factor-by-one method vs., 594–595
 - outer, 322–323
 - quality characteristics and additivity, 584–588
 - for reproducibility assessment, 30
 - split analysis for:
 - mixed, 286–289
 - two-level, 284–286
 - two-level, 284–286
 - types of, 596
- Orthogonal expansion:
- formula of, 43–44
 - meaning of, 537
 - for standard SN ratios and tuning robustness, 40–41
- Orthogonal function, 543
- Orthogonal polynomial equation, 254–257
- Outer noise, 176, 319
- Outer orthogonal arrays, 73, 322–323
- Out of the Crisis* (W. Edwards Deming), 1448
- Output, signal-to-noise ratios based on, 236–237
- Output characteristics, 1449–1450

P

- Panasonic, 1427
- Paradigm shift, 29
- Parameter design, 318–338, 1439–1440. *See also*
 - Two-step optimization
 - applied to semiconductors, 141
 - control-factor-level intervals in, 609
 - definition of, 40, 177, 314, 1452
 - evaluation for, 39
 - history of, 140–141
 - initial example of, 140
 - key steps of, 387

- management perspective on, 382–386
 - for manufacturing process design, 1498
 - for noise minimization, 319–320
 - objective of, 284, 438–439
 - on-line quality engineering vs., 437
 - optimum control factor levels in, 212
 - origin of, 1435–1436
 - primary uses of, 356
 - for product design, 18, 177–178, 1497
 - purpose of, 504
 - and quality loss function, 177–178
 - research on, 177
 - and robust design, 382, 1435, 1452. *See also*
 - Robust design
 - in robust engineering, 382–386
 - for selected system, 40
 - in simulation, 144
 - systematization of, 1439
 - systems for, 39
 - for technology development, 1496
 - transition to technological development, 1439–1440
 - of water feeder valve, 330–338
 - of Wheatstone Bridge, 320–330, 349–350
- Parameter Design for New Product Development* (Genichi Taguchi), 140–141
- Parameter estimation:
- with experimental regression analysis, 484, 488–499
 - with least squares method, 485–489
- Pareto charts, 1429
- Particle size distribution, data showing, 587–588
- Pass/fail criteria, specification limits vs., 181–182
- Passive dynamic SN ratio, 132
- Passive signal factors, 39, 97
- Passive SN ratios, 236
- Patterning:
- fine-line patterning for IC fabrication, 758–763
 - transformability, patterning, 141
- Pattern recognition, 397–398
- design of general procedure for, 108–114
 - in earthquake-proof design, 14
 - in manufacturing, 418
 - with MT method, 108–109
 - with MTS, 109–114, 398
 - MTS/MTGS vs. other techniques for, 417
- Pattern thinking, 1480–1485, 1490

- PCA (principal component analysis), 417
- PDCA (plan, do, check, action) cycle, 1426, 1427
- P-diagrams, 1472
- Pearson, Carl, 1424
- Performance, 393. *See also* Functionality(-ies)
- Personnel (for testing), 1470–1472
- Peterson, Don, 157
- Phadke, Madhava, 156, 1519
- Pharmacology case studies:
 - drug efficacy, Mahalanobis distance in measurement of, 1238–1243
 - optimization of model ointment prescriptions for in vitro percutaneous permeation, 686–694
- Phase gate process, 1505–1506
- Phase modulation function, 68–72
- Phase-phase gate structure, 1501–1503
- Phase processes, 1503–1505
- Photography:
 - evaluation of photographic systems with dynamic operating window, 651–658
 - photographic film, 28, 88–91
 - stability design of shutter mechanisms of single-use cameras, 965–972
- Photoresist profile using simulation, 904–910
- Physical condition:
 - additivity with, 585
 - data showing, 584–585
- Physics, quality engineering vs., 31
- Plan, do, check, action cycle, 1426, 1427
- Plan-do-study-act cycle, 1481
- Plasma spraying, development of functional material by, 852–857
- Plastic injection molding:
 - development of technology by transformability, 857–864, 957–964
 - electrical connector insulator contact housing, optimization of, 1084–1099
 - gear, transformability of, 827–835
- Point calibration, 247–250
- Pollution:
 - monitoring, 24
 - post-World War II, 23–24
 - and quality improvement, 7–9
- Polymerization reactions, optimization of, 643–650
- Pot core transformer processing, variation in, 764–770
- Power factor, 61
- Power MOSFET:
 - ideal function for, 234
 - optimizing back contact of, 771–779
- Power spectrum analysis, 513
- Preconcept phase, 1503, 1504
- Prediction. *See also* Forecasting
 - MTS for, 398
 - of urinary continence recovery in patients with brain disease, 1258–1266
- Premature failures, 1498
- Preparation (for testing), 1472–1473
- Preventive maintenance, 79
 - for bucket elevator, simultaneous use of periodic maintenance and checkup, 1376–1382
 - design method for, 463–467
- Price:
 - and production quality, 439
 - and total cost, 121
 - and unit manufacturing cost, 18, 439, 441
- Primary error variation, 574–576, 580
- Princeton University, 155
- Principal component analysis (PCA), 417
- Principle of ideality, 1489
- Printed letter inspection, MTS for, 1293–1297
- Procedures, testing, 1473–1474
- Process capability, quality loss function and, 173–176
- Process capability index, 173
- Process condition control, 468–473
- Process control, 32, 441
- Process design:
 - robust, 58
 - steps in, 314. *See also specific steps*
 - value of SN ratios in, 227
- Process development, SN ratio and reduction of cycle time, 228
- Process diagnosis and adjustment, 474–481
 - and cost of quality control systems during production, 474–477
 - optimal diagnostic interval, 477–479
 - optimal number of workers, 469–471
- Processing case studies:
 - adhesion condition of resin board and copper plate, optimization of, 890–894
 - casting conditions for camshafts by simulation, 900–903
 - deep-drawing process, optimization of, 911–915

- Processing case studies (*continued*)
 - electro-deposited process for magnet production, improvement of, 945–949
 - encapsulation process:
 - optimization of, 950–956
 - robust technology development of, 916–925
 - gas-arc stud weld process parameter optimization, 926–939
 - molding conditions of thick-walled products, optimization of, 940–944
 - photoresist profile using simulation, 904–910
 - plastic injection molding technology by transformability, 957–964
 - wave soldering process, optimization of, 895–899
- Process maintenance design, 32
- Product(s):
 - product planning:
 - definition of, 108
 - design life in, 57
 - and production engineering, 12–13
 - product quality, 10, 171
 - definition of, 442
 - design of, 26
 - quantitative evaluation of, 32, 438–439
 - standards for, 32
 - product species, 171
 - for testing, 1474–1475
- Product case studies:
 - character recognition, Mahalanobis distance for, 1288–1292
 - printed letter inspection technique, 1293–1297
- Product costs, 1516
- Product cost analysis, 440
- Product design:
 - direct, 227
 - for financial systems, 10–11
 - focus of, 18
 - off-line quality engineering for, 1497
 - orthogonal array for modification in, 74
 - paradigm shift for, 359–360
 - parameter design in, 177–178. *See also* Parameter design
 - quality loss function and steps in, 176–179
 - robust, 58
 - robustness in, 318
 - steps in, 314. *See also specific steps*
 - system design in, 176–177. *See also* System design
 - tolerance design in, 179. *See also* Tolerance design
 - value of SN ratios in, 227
- Product development, 1478–1491. *See also* New product development; Robust technology development
 - control-factor-level intervals in, 609–610
 - event thinking in, 1480–1481
 - paradigm shift for, 359–360
 - pattern thinking in, 1481–1485
 - product vs. engineering quality in, 10
 - with robust engineering, 167
 - SN ratio and reduction of cycle time, 228
 - structure thinking in, 1486–1490
 - Suh/Senge model of, 1479–1480
 - synergistic, 1490–1491
 - Taguchi system for, 1485–1486
- Product development case studies:
 - airflow noise reduction of intercoolers, 1100–1105
 - articulated robots, functionality evaluation of, 1059–1068
 - brake boosters, reduction of boosting force variation of, 1106–1111
 - chattering noise in Series 47 feeder valves, reduction of, 1112–1121
 - clutch disk torsional damping system design, optimization of, 973–983
 - DC motor, optimal design for, 1122–1127
 - direct-injection diesel injector optimization, 984–1004
 - disk blade mobile cutters, optimization of, 1005–1010
 - D-VHS tape travel stability, 1011–1017
 - electrical connector insulator contact housing, optimization of, 1084–1099
 - linear actuator, simulation for optimization of, 1050–1058
 - linear proportional purge solenoids, 1032–1049
 - minivan rear window latching, improvement in, 1025–1031
 - new ultraminiature KMS tact switch optimization, 1069–1083
 - omelets, improvement in the taste of, 1141–1147
 - spindles, functionality evaluation of, 1018–1024

stability design of shutter mechanisms of
 single-use cameras by simulation, 965–
 972
 steering system on-center robustness, 1128–
 1140
 wiper system chatter reduction, 1148–1156
 Production control, 439
 Production control costs, 17
 Production cost, 17, 18, 442
 Production division responsibilities:
 in quality evaluation, 441–442
 for tolerancing in testing, 440–441
 Production engineering, 12–13
 for reduction of corporate costs, 18
 responsibilities of, 17
 Production processes, 18
 Production quality, 438
 Productivity:
 definition of, 11
 developing, 10–13
 and economy, 5–7
 improvement in, 6–7
 and individual freedom, 9
 and quality, 7–8
 Profound knowledge, 1444
 Programming ability:
 evaluation of, 1343–1350
 evaluation of capability and error in, 1335–
 1342
 MTS evaluation technique for, 1178–1188
 questionnaire for prediction of, 1171–1177
 Project leaders, 391
 Project review process, 1505–1507
 Proportional equation:
 reference-point, 247–250
 zero-point, 241–247
 Proseanic, Vladimir, 1301
 Prototypes, 318
 Pugh, Stuart, 164, 1482, 1495
 Pugh analysis, 392
 Pugh concept, 1495
 Pure variation, 518, 559

Q

QC circle, 1427
 QCRGs, *see* Quality Control Research Groups
 QC story, 1428–1430
 QE, *see* Quality engineering
 QFD, *see* Quality function deployment
 QFP, *see* Quad flat package
 QLF, *see* Quality loss function
 Quad flat package (QFP), 1189, 1190
 Quadratic planning, 488
 Quality. *See also specific topics*
 as conformance to specifications, 171
 and corporate organization, 10
 and cost, 16, 440–441
 definition of, 171, 314, 442
 Deming's key principles of, 1444–1447
 design, 438
 downstream, 354, 355
 engineering, 10
 expressing, through loss function, 133–134
 four levels of, 354
 as generic term, 57
 measurement of, 138
 midstream, 354, 355
 origin, 354–355
 product, 10, 171
 in product design for financial systems, 10–11
 production, 438
 and productivity, 7–8
 risks to, 13–16
 Taguchi's definition of, 171, 193
 and taxation, 8–9
 as "tested in," 1471
 types of, 10
 upstream, 354, 355
 Quality assurance department, 23–24, 38
 Quality assurance (in Japan), 1427. *See also*
 Quality control
 Quality characteristics, 16–17. *See also specific*
 types
 and additivity, 584–588
 classification of, 180
 downstream, 269
 high-rank, 340
 larger-the-better, 17
 low-rank, 340
 nominal-the-best, 17
 quality loss function and classification of, 180
 smaller-the-better, 17
 true, 1482
 Quality control:
 cost of, during production, 474–477
 paradigm shift for, 359–360
 specification limits vs., 182
 traditional method of, 378–379

- Quality control costs, 17
 - Quality Control* (Ina Seito), 1433, 1434
 - Quality control in process, 116. *See also* On-line quality engineering
 - Quality Control Research Groups (QCRGs), 148–149
 - Quality Engineering for Technological Development* (Genichi Taguchi), 133, 147
 - Quality engineering (QE). *See also* Robust design; Taguchi method
 - conventional research and design vs., 77, 78
 - definition of, 314
 - and design for six sigma, 1498
 - at Ford Motor Company, 16
 - functionality design in, 11
 - generic (essential) functions in, 8
 - history of, 127–168
 - in Japan, 127–152, 1428–1440
 - in United States, 153–168
 - in Japan, 1427, 1435–1440
 - main objective of, 23
 - management for, 25–38
 - automated process management, 31–33
 - in design process, 30–31
 - diagnosis to prevent recalls, 33–38
 - evaluation of functionality, 28–30
 - management role in research and development, 25–28, 39–40
 - off-line, 1496–1497. *See also* Off-line quality engineering
 - on-line, 1497–1498. *See also* On-line quality engineering
 - physics vs., 31
 - in research and development, 13
 - research and development strategy in, 39–55
 - cycle time reduction, 39–40
 - stage optimization, 40–55
 - responsibilities of, 23–24
 - as robust design, 58
 - standardization of, 148
 - Taguchi method vs., 58
 - timeline of, 129–130
 - transition and development of, 135
 - tuning in, 57–58
 - U.S. Taguchi method vs., 58
 - Quality Engineering Series*, 133
 - Quality Engineering Society (Japan), 147, 149, 161, 162, 168, 1435, 1440
 - Quality function deployment (QFD), 164, 392
 - and DFSS process, 1494
 - in Japan, 1427, 1430–1431
 - origin of, 1482
 - Quality improvement, 7–9
 - Quality level:
 - and consumer loss, 17–18
 - and cost, 18–22
 - for larger-the-better characteristic, 19, 21–22, 451–453
 - for nominal-the-best characteristic, 19–21, 448–450
 - for smaller-the-better characteristic, 19, 21, 450–451
 - in tolerance design, 437–453
 - Quality loss function (QLF), 133–134, 171–179, 380
 - and classification of quality characteristics, 180
 - derivation of, 440
 - equations for, 1598–1601
 - justice-related aspect of, 175–176
 - for larger-the-better characteristic, 188, 191
 - for nominal-the-best characteristic, 180–186, 190, 445
 - and process capability, 173–176
 - quadratic representation of, 174
 - quality aspect of, 176
 - for smaller-the-better characteristic, 186–188, 190
 - and steps in product design, 176–179
 - parameter design, 177–178
 - system design, 176–177
 - tolerance design, 179
 - for tolerance design optimization, 386
 - Quality management:
 - design of experiments, 1431–1435
 - history of, 1423–1428
 - in Japan, 1423–1440
 - of manufacturing processes, 1498
 - quality engineering, 1435–1440
 - quality function deployment, 1430–1431
 - seven QC tools and QC story, 1428–1430
 - Quality programs, 392
 - Quality tables, 1482
 - Quality target, 438
- R**
- Radio waves, 65
 - RCA Victor Company, 397
 - R&D, *see* Research and development

- Reactive power, 61
- Reagan, Ronald, 1444
- Real-time operating system optimization, 1324–1334
- Recalls, prevention of, 33–38
- Reference-point calibration, 247–250
- Reference-point proportional equation, 240, 241, 247–250
- Regression analysis:
 - experimental, 149, 484, 486, 488–499
 - estimated values, selection of, 492, 494–499
 - initial values, setting of, 488–489
 - orthogonal array, selection and calculation of, 489–494
 - parameter estimation with, 484, 488–499
 - sequential approximation, 490, 492–496
- MTS/MTGS vs., 417
- Regression equations, parameter estimation in, 485–489
- Reliability, 40. *See also* Functionality
- Reliability analysis, 392
- Reliability and Maintainability 2000 Program* (U.S. Air Force), 159
- Reliability design, Monte Carlo method in, 442
- Reliability management, 1427
- Repeatability, definition of, 224
- Repetition, 1436
- Reproducibility, 504–505
 - definition of, 224
 - in design of experiments, 504–505
 - evaluation of, 30–31
 - for hardware design, 58–59
 - meaning of term, 356–357
 - with orthogonal arrays, 594
- Research and development (R&D), 6
 - application of quality engineering to, 1496
 - in banks, 11
 - cycle time reduction, 39–40
 - functionality prediction in, 28–30
 - management of, 10, 25–28, 39–40
 - need for, in Japan, 7
 - quality engineering strategy in, 39–55
 - cycle time reduction, 39–40
 - stage optimization, 40–55
 - robust optimization in, 1515
 - stage optimization, 40–55
 - orthogonal expansion for standard SN ratios and tuning robustness, 40–41
 - variability improvement, 41–55
 - strategy in, 13
 - two-step optimization in, 1502
- research and development (R&D):
 - management role in, 39–40
- Research Institute of Electrical Communication, 57
- Resin board, adhesion condition of copper plate and, 890–894
- Resistance welding conditions for electronic components, 863–868
- Resource constraints, 1472
- Responses, 228, 503
- Response tables, 361
- Ringer Hut, 1428
- Risk(s):
 - countermeasures against, 13–16
 - functional, 11
 - to quality, 13–16
 - as signals vs. noises, 13
- Robots, articulated, 1059–1068
- Robust design. *See also* Quality engineering;
Robust engineering; Robust technology development
 - conventional meaning of, 73–74
 - function in, 1456
 - noise conditions in, 353
 - objective of, 58
 - origin of, 154, 155
 - as parameter design, 382. *See also* Parameter design
 - quality engineering as, 58
 - Taguchi method for, 1451–1452
 - as term, 57
- TRIZ and axiomatic design for enhancement of, 1449–1468
 - comparison of disciplines, 1451–1458
 - further research, possibilities for, 1466–1468
 - limitations of proposed approach, 1465–1466
 - system output response, identification of, 1456, 1459–1465
 - two-step process for, 377
 - using Taguchi methods, 1451–1452
 - value of SN ratios in, 227
- Robust engineering. *See also* Off-line quality engineering
 - development of, in U.S., 161, 162
 - implementation strategies for, 389–393

- Robust engineering (*continued*)
- and bottom-line performance, 393
 - corporate leader/corporate team in, 390–391
 - critical components in, 389–390
 - education and training in, 392
 - effective communication in, 391–392
 - and integration strategy, 392–393
 - management commitment in, 390
 - institutionalization of, 164–168
 - manager's perspective on, 377–388
 - parameter design, 382–386
 - tolerance design, 386–388
 - misconceptions about, 1471
 - parameter design in, 382–386
 - product development with, 167
 - purpose of, 1496
 - and six sigma, 1517–1519
 - steps in, 387, 388
 - thinking approach in, 392
 - tolerance design in, 386–388
- Robust engineering case studies:
- chemical applications, 629–714
 - biochemistry, 631–642
 - chemical reaction, 643–658
 - measurement, 659–685
 - pharmacology, 686–694
 - separation, 695–714
 - electrical applications, 715–792
 - circuits, 717–745
 - electronics devices, 746–779
 - electrophoto, 780–792
 - mechanical applications, 793–1167
 - biomechanical, 795–805
 - fabrication line capacity planning using a robust design dynamic model, 1157–1167
 - machining, 806–835
 - material design, 836–857
 - material strength, 858–874
 - measurement, 875–889
 - processing, 890–964
 - product development, 965–1156
- Robust Engineering* (Genichi Taguchi, Subir Chowdhury, and Shin Taguchi), 1493
- Robust optimization, 1497, 1501, 1502. *See also* parameter design
- improvement in, 1508
 - and innovation, 1515
 - for reliability improvement, 1515
 - in research and development, 1515
- Robust quality, *see* Upstream quality
- Robust technology development, 352–376
- advantages of, 358–359
 - encapsulation process, 916–925
 - guidelines for application of, 359–361
 - key concepts in, 353
 - Minolta advanced cylindrical heater, 361–376
 - objective function vs. generic function, 355
 - orthogonal array, 356–358
 - selection of what to measure, 354–355
 - SN ratio, 228, 355–356
 - two-step optimization, 353–354
- Rolls-Royce, 33–35
- Ross, Louis, 1479
- Rules of Dimensional Tolerances of a Plastic Part* (JIS K-7109), 140
- S**
- Safety design, 199–201
- Safety factor(s), 32
 - derivation of, 443–448
 - equation for, 197–198
 - for larger-the-better characteristic, 447
 - for smaller-the-better characteristic, 446
 - in specification tolerancing, 195–201
- Scatter diagrams, 1429
- Scoping of project, 1472
- Second Industrial Revolution, 5–24
 - automated management operations in, 31–32
 - elements of productivity in, 5–9
 - and management in manufacturing, 16–22
 - productivity development in, 10–13
 - and quality assurance departments, 23–24
 - risks to quality in, 13–16
- Seed technology, 164
- Seiki, Sanjo, 137
- Seiko Epson, 433
- Sekisui Chemical, 1427
- Semiconductor rectifier manufacturing, 1395–1398
- Senge, Peter, 1479, 1480
- Sensitivity (SN ratios), 225, 226, 236, 360
- Separation case studies:
 - herbal medicine granulation, dynamic operating window for, 695–704
 - particle-size adjustment in a fine grinding process for a developer, 705–714

- Separation principles, 1454
- Sequential approximation, 610, 613–616
 - in experimental regression analysis, 490, 492–496
 - with incomplete data, 613–616
- Service costs, 1516
- Seven deadly diseases (Deming), 1446
- Seven QC tools, 1428–1430
- S-F analysis, *see* Substance-field analysis
- S-field analysis, 1461–1468
- Sharp Corp., 141
- Shewhart, Walter, 155, 1424, 1443, 1446, 1481
- Shewhart control charts, 1424–1426
- Shimizu Corp., 1427
- Shoemaker, Anne, 156
- Showa Denko, 1424
- Sigma level, 1510, 1511
- Signals, 13, 57
- Signal factors, 29–30
 - active vs. passive, 29, 97
 - for degree of disease, 143
 - in orthogonal array, 97–98
 - in software testing, 97–98
 - testing personnel in selection of, 1473
- Signal-to-noise (SN) ratio, 13, 223–237
 - active, 236
 - active dynamic, 132–133
 - based on input and output, 236–237
 - based on intention, 236
 - benefits to using, 225, 227–228
 - classifications of, 234–237
 - for classified attributes, 234–236, 290–308
 - chemical reactions without side reactions, 296–298
 - chemical reactions with side reactions, 298–308
 - two classes, one type of mistake, 291–293
 - two classes, two types of mistake, 293–296
 - conceptual transition of, 131–133
 - for continuous variables, 234–236, 239–289
 - double signals, 275–284
 - estimation of error, 271–275
 - with known signal factor level interval, 256–260
 - with known signal factor level ratio, 262–263
 - linear equation, 250–254
 - linear equation using tabular display of orthogonal polynomial equation, 254–256
 - with no noise, 284–289
 - with no signal factor, 264–271
 - reference-point proportional equation, 247–250
 - split analysis, 284–289
 - with unknown true values of signal factor levels, 264
 - when signal factor levels can be set up, 260–262
 - zero-point proportional equation, 241–247
- correspondence course on, 132
- decibel value of, 1438
- definition of, 224, 225, 314
- determining evaluation scale of, 148
- differences in (gain), 79
- direct relationship of economy and, 225
- dynamic, 139, 225
 - nondynamic vs., 139, 225
 - for origin quality, 354–355
 - in U.S. applications, 160
 - uses of, 139, 236
- in electric characteristics, 140–141
- elements of, 224–226
- fixed vs. multiple targets, 236
- functional evaluation, 133
- generic function, 133
- ideal functions based on, 228–234
- improving, 41–55
- larger-the-better, 95, 139
- in machining, 135–137
- in measurement systems evaluation, 225
- in metrology field, 132
- in MTS, 398
- new method of calculating, 144–147
- nominal-the-best, 139
- nondynamic, 139, 225, 264–271
 - dynamic vs., 139, 225
 - larger-the-better applications, 269
 - nominal-the-best applications, 265–268
 - operating window, 269–271
 - smaller-the-better applications, 268
 - for upstream quality, 243
 - uses of, 236
- origin of, 1436, 1438–1439
- orthogonal expansion for, 40–41
- passive, 236
- passive dynamic, 132
- in process design, 227
- in product design, 227

- Signal-to-noise (SN) ratio (*continued*)
 for reactions without side reactions, 296–298
 for reactions with side reactions, 298–308
 and reduction of process/product
 development cycle time, 228
 and reproducibility, 505
 in robust design, 227
 in robust technology development, 355–356
 selection of, 240
 for shape retention, 140
 in simulations, 144
 smaller-the-better, 95, 139
 standard, orthogonal expansion and tuning
 robustness for, 40–41
 in technology development, 225
 and traditional approach for variability, 224
 of transformability, 139–140
- Significance test, 521
- Significant factorial effects, 521
- Simulation(s), 1475–1476
 casting conditions for camshafts, 900–903
 design, 40, 72–73
 linear actuator, optimization of, 1050–1058
 orthogonal array L_{36} for, 357
 parameter design in, 144
 photoresist profile, optimization of, 904–910
 SN ratio applied to, 144
 stability design of shutter mechanisms of
 single-use cameras, 965–972
 technological development using, 148
- Simultaneous engineering, 276
- Single-use cameras, stability design of shutter
 mechanisms of, 965–972
- Six sigma, 161, 162. *See also* Design for six
 sigma
 improvement in, 1508
 and robust engineering, 1517–1519
 thinking levels used in, 1490
 and whack-a-mole engineering, 1508
- Slope calibration, 228, 247
- Small algae production, optimization of, 637–
 642
- Smaller-the-better characteristic, 17, 180
 quality level at factories for, 450–451
 quality level calculation for, 19, 21
 quality loss function for, 186–188, 190
 safety factor for, 446
 tolerance design for, 208–210
- Smaller-the-better SN ratio, 95, 139
- Smart Cards, 1084
- Smith, Larry R., 1519
- SN ratio, *see* Signal-to-noise ratio
- SN Ratio Manual* (Genichi Taguchi), 131
- Software:
 simulation, 1475–1476
 for test results analysis, 1475
- Software testing, 425–433
 main difficulty in, 425–426
 Taguchi method in, 97–102, 425–433
 layout of signal factors in orthogonal array,
 97–98
 software diagnosis using interaction, 98–
 102
 system decomposition, 102
 two types of signal factor and software, 97
 typical procedures for, 426–433
- Software testing and application case studies,
 1299–1364
 algorithms:
 diesel engine software control strategy,
 optimization of, 1301–1309
 video compression, optimization of, 1310–
 1323
 debugging, streamlining of, 1360–1364
 electronic warfare systems, robust testing of,
 1351–1359
 prediction of programming ability from
 questionnaire, 1171–1177
 programmer ability in software production,
 evaluation of, 1343–1350
 programming, evaluation of capability and
 error in, 1335–1342
 real-time operating system, robust
 optimization of, 1324–1334
- Soldering:
 automatic inspection of joints, Mahalanobis
 distance in, 1189–1195
 optimization of wave soldering process, 895–
 899
- Sony, 134, 1427
- SPC, *see* Statistical process control
- Special cause, 1446–1447
- Specifications, conformance to, 171
- Specification limits:
 pass/fail criteria vs., 181–182
 quality control vs., 182
- Specification tolerancing, 192–207
 deteriorating characteristics in, 205–207

- distribution of tolerance, 204–205
 - safety factor in, 195–201
 - when central value of low-rank characteristics has been determined, 201–204
 - Specified quality, *see* Midstream quality
 - Spectrum analysis, ANOVA and, 560
 - Speed difference method, 142, 299
 - Speed ratio method, 142, 302
 - Spindles, functionality evaluation of, 1018–1024
 - Split analysis, 284–289
 - SQC, *see* Statistical quality control
 - Stability, definition of, 224
 - Stage optimization, 40–55
 - example of, 44–55
 - formula of orthogonal expansion, 43–44
 - orthogonal expansion, 40–41
 - testing method and data analysis, 42–43
 - variability improvement, 41–55
 - Standards, quality, 32
 - Standard deviation, 517
 - Standardization and Quality Control*, 133, 147, 156
 - Standardization and Quality Management*, 147
 - Standard of living, 7, 12
 - Statistical Methods for Research Workers* (Ronald A. Fisher), 1431
 - Statistical process control (SPC), 135, 1481. *See also* On-line quality engineering
 - Statistical quality control (SQC), 157, 1425, 1426
 - Steel, high-performance, machining technology for, 819–826
 - Steering system on-center robustness, 1128–1140
 - Stepwise regression, MTS/MTGS vs., 417
 - Strategic planning, 13
 - Strategic planning team, 391, 392
 - Strategy, 13
 - definition of, 23
 - for R&D, 25, 26
 - Sun Tzu on the Art of War* as, 25
 - technological, 39
 - Structure thinking, 1480, 1486–1490
 - Substance field model, 1453
 - Substance-field (S-F) analysis, 1453, 1459, 1462
 - Subsystems, 313
 - Suh, Nam P., 1454–1456, 1479–1480, 1487
 - Suh/Senge model, 1479–1480
 - Sullivan, Larry, 157
 - Sum, 506–507
 - Sumitomo Electric Industries, 141
 - Sum of squares, 509
 - Sun Tzu on the Art of War*, 25
 - Synergistic product development, 1490–1491
 - Synthesis stage, 40, 1453
 - System(s), 102
 - creation of, 39
 - optimization of, 30
 - of profound knowledge, 1444
 - selection of, 26–28, 40, 176–177, 313
 - System design, 313–317, 387–388, 504
 - definition of, 313, 1452
 - and functionality of selected system, 314–317
 - manufacturing process design, 1497
 - product design, 176–177, 1497
 - and quality loss function, 176–177
 - robust design, 1452
 - and selection of system, 313
 - technology development, 1496
 - System engineering, 1482
 - System output responses, 1449–1451, 1456, 1459–1465
 - System testing, 425. *See also* Software testing
- T**
- Tactics, 13
 - management systems as, 23
 - technology as, 25
 - Taguchi, Fusaji, 153
 - Taguchi, Genichi. *See also* Taguchi method
 - on American quality management, 1498
 - at Bell Labs, 156–157
 - biography of, 153–156
 - on bridging MTS methods, 143
 - and cells in studying main/side effects, 142
 - and cost vs. quality, 138
 - and design of experiments, 149, 1431, 1432, 1434–1436
 - and development of quality engineering, 127–131
 - at Ford Motor Company, 157
 - foresight of, 131
 - on function in plastic injection molding, 140
 - history of work, 153–156
 - honors received by, 162
 - impact of work, 148
 - at Konica, 133
 - and Mahalanobis distance, 1440
 - and management by total results, 149

- Taguchi, Genichi (*continued*)
- and MTS application to fire alarm, 143
 - and natural logarithms, 142
 - and on/off functions, 138
 - and origin of parameter design, 1434
 - and output characteristic identification, 1449–1450
 - and parameter design, 141
 - and pattern level of thinking, 1482
 - publications by, 1625–1628
 - in Quality Engineering Society, 161
 - quality engineering's reliance on, 144
 - and relationships between time/work and electric power, 137
 - and selection of interactions for experiments, 1433
 - semiannual U.S. visits by, 160
 - and sensor welding study, 141
 - and signal and noise factors as consumer conditions, 138
 - and simulation, 144
 - and two-step optimization, 1439, 1440
 - at Xerox, 158
- Taguchi, Shin, 157, 158, 1493
- Taguchi method, 56–133. *See also* Quality engineering
- in chemical engineering, 85–93
 - evaluation of images, 88–91
 - functionality such as granulation or polymerization distribution, 91
 - function of an engine, 86–87
 - general chemical reactions, 87–88
 - separation system, 91–93
 - and Deming's teachings, 1447–1448
 - in design for six sigma, 1493–1494
 - in electronic and electrical engineering, 59–73
 - functionality evaluation of system using power, 61–65
 - quality engineering of system using frequency, 65–73
 - essence of, 58
 - five principles of, 1452
 - and leveraging of DFSS, 1493–1494
 - and Mahalanobis distance/space, 114–116
 - and Mahalanobis–Taguchi method, 102–109
 - and Mahalanobis–Taguchi System, 102–103, 109–116
 - in mechanical engineering, 73–85
 - conventional meaning of robust design, 73–74
 - functionality design method, 74–79
 - generic function of machining, 80–83
 - problem solving and quality engineering, 79–80
 - signal and output, 80
 - when on and off conditions exist, 83–85
 - in medical treatment and efficacy
 - experimentation, 93–97
 - misconceptions of, 163, 164
 - naming of, 158
 - in on-line quality engineering, 116–123
 - in product development, 1485–1486
 - quality engineering vs., 58
 - for robust design, 1451–1452
 - in software testing, 97–102, 425–433
 - layout of signal factors in orthogonal array, 97–98
 - software diagnosis using interaction, 98–102
 - system decomposition, 102
 - two types of signal factor and software, 97
- Taguchi Methods for Robust Design* (Yuin Wu and Alan Wu), 1493
- Taguchi paradigm, *see* Taguchi method
- Taguchi quality engineering, 1482. *See also* Taguchi method
- Takahaski, Kazuhito, 84
- Takenaka Corp., 1427
- Takeyama, Hidehiko, 136
- Tanabe Seiyaku, 1424
- Tananko, Dmitry, 1301
- Target value/curve, 60–61
- Taxation:
- and quality, 8–9
 - for quality improvement, 8–9
- Teams:
- familiarity with robust design methods, 1471
 - for robust engineering implementation, 390–392
 - self-assessment of, 1506
 - and strategic planning, 391, 392
 - testing considerations for, *see* Testing
- Technical Committee of the Quality Engineering Society, 149
- Technical readiness, 1505

- Technological Development in Electric and Electronic Engineering* (Kazuhiko Hara), 141
- Technological development methodology, 147
- Technological Development of Transformability* (Ikuro Baba), 140
- Technological strategy, 39. *See also* Generic technology
- Technology(-ies):
- generic, 26
 - optimization of, 1497, 1512–1514
 - as tactics, 25
- Technology development. *See also* Robust technology development
- dynamic SN ratios in, 225
 - off-line quality engineering for, 1496
 - transition of parameter design to, 1439–1440
 - using simulation, 148
- Technometrics*, 1435
- Temperature control, 471–473
- Test for additional information, MTS/MTGS vs., 417
- Testing, 1470–1477
- analysis of results, 1475
 - design quality test, 38
 - during development, 360
 - documentation of, 1477
 - by external service providers, 1476–1477
 - four “P’s” of, 1470
 - measurement and evaluation technologies, 26
 - personnel for, 1470–1472
 - preparation for, 1472–1473
 - procedures for, 1473–1474
 - product for, 1474–1475
 - simulation, 1475–1476
 - of software, *see* Software testing
 - of systems, 425
 - tolerancing in, 437–453
 - determination of tolerance, 442–448
 - issues related to, 437–439
 - product cost analysis, 440
 - production division responsibilities for, 440–441
 - quality level at factories for larger-the-better characteristics, 451–453
 - quality level at factories for nominal-the-best characteristics, 448–450
 - quality level at factories for smaller-the-better characteristics, 450–451
 - role of production in quality evaluation, 441–442
- Test planning, 392
- Theory of inventive problem solving, *see* TRIZ
- Thermal ink jet image quality, 1196–1207
- Thermoresistant bacteria, detection method for, 679–685
- Thermotherapy, 96, 97
- Thick-walled products, optimization of molding conditions for, 940–944
- Thinking, Senge’s levels of, 1480
- event thinking, 1480–1481
 - pattern thinking, 1480–1485
 - structural thinking, 1480, 1486–1490
- Three-level orthogonal arrays, 596
- Three-or-more-class classified attributes, 234
- Tile manufacturing using industrial waste, 869–874
- Toagosei and Tsumura & Co., 133, 142
- Toa Gosei Chemical Company, 232
- Tokumaru, Soya, 132
- Tolerance, 192–193
- definition of, 193
 - determination of, 16–17, 442–448
 - functional, 193
 - manufacturing, 194–195
- Tolerance design, 208–220, 340–351. *See also* Specification tolerancing
- after parameter design, 318
 - analysis of variance in, 342–346
 - definition of, 79, 340
 - for larger-the-better characteristics, 210–211
 - management perspective on, 386–388
 - for manufacturing process design, 1498
 - for multiple factors, 212–220
 - for nominal-the-best characteristics, 208–210
 - optimization of, 386
 - for product design, 179, 1497
 - purpose of, 504
 - quality and cost balanced by, 16
 - and quality characteristics, 16–17
 - and quality loss function, 179
 - in robust design, 1452
 - in robust engineering, 386–388
 - for smaller-the-better characteristics, 208–210
 - steps in, 212–220, 386–387
 - for technology development, 1496

- Tolerance design (*continued*)
 - two methods for, 442
 - of Wheatstone bridge, 346–351
 - Tolerance specification, 1497. *See also*
 - Specification tolerancing
 - Tolerancing, 439
 - Toner charge measurement, 746–752
 - Tools:
 - design, 30
 - preparation of, 39
 - Tosco and Sampo Chemical, 133
 - Total output, 314
 - Total quality control (TQC), 1426–1428
 - Total quality management (TQM), 1426, 1428, 1435
 - Total social productivity, 11–12
 - Total sum squared, 509
 - Total variation, 509
 - Toyota Motor Company, 12, 26, 135, 155
 - TQC, *see* Total quality control
 - TQM, *see* Total quality management
 - Trading, functionality evaluation in, 148
 - Training (in robust engineering implementation), 392
 - Transformability, 229
 - machining technology for high-performance steel by, 819–826
 - as objective function, 140
 - origin of, 137
 - of plastic injection-molded gear, 827–835
 - plastic injection molding technology development by, 957–964
 - Transmitting wave, stability of, 65–67
 - Transparent conducting thin films, ideal function for, 233
 - TRIZ (theory of inventive problem solving), 1452–1454, 1456–1458
 - comparison of axiomatic design, robust design, and, 1456
 - function in, 1456
 - and pattern-level thinking, 1490
 - and structure thinking, 1489–1490
 - True noise factors, 30
 - True quality characteristics, 1482
 - Tuning, 57–58, 319
 - cause-and-effect relationship in, 41
 - orthogonal expansion for robustness in, 40–41
 - in quality engineering, 57–58
 - in two-stage optimization, 60
 - Two-class classified attributes, 234
 - Two-level control factors, 357
 - Two-level orthogonal arrays, 596
 - Two-piece gear brazing conditions, optimization of, 858–862
 - Two-stage optimization, 40–41
 - Two-step optimization, 178, 353–354, 377. *See also* Parameter design
 - concept step in, 1504
 - definition of, 60
 - in new product development, 1501–1502
 - in product design, 1439, 1497
 - in robust technology development, 353–354
 - in technological development, 1440
 - Two-way layout, 552–562
 - analysis of variance for, 555–562
 - with decomposition, 563–572
 - one continuous variable, 563–567
 - two continuous variables, 567–572
 - factors and levels in, 552–555
 - with repetitions, 573–583
 - different number of, 578–583
 - same number of, 573–578
- U**
- Uehara, Yoshito, 136
 - Ueno, Kenzo, 139, 140
 - Ultraminiature KMS tact switch optimization, 1069–1083
 - Ultra trace analysis, dynamic optimization in, 659–665
 - UMC, *see* Unit manufacturing cost
 - Uncoupled design, 1454, 1455
 - Unemployment:
 - and productivity improvement, 6
 - and quality improvement, 8
 - Union of Japanese Scientists and Engineers, *see* Japanese Union of Scientists and Engineers
 - United States:
 - history of quality engineering in, 153–168
 - from 1980 to 1984, 156–158
 - from 1984 to 1992, 158–160
 - from 1992 to 2000, 161–164
 - from 2000 to present, 164–168
 - and history of Taguchi's work, 153–156
 - paradigm shift in, 29
 - productivity improvement in, 6
 - quality engineering in, 58

quality targets in, 16
 U.S. Air Force, 159
 U.S. Census Bureau, 1443
 U.S. Department of Agriculture, 1443
 U.S. Department of Defense, 159
 Unit manufacturing cost (UMC), 18, 121, 439, 441
 University of Electro-Communications, 133, 137, 138, 141, 143
 Upstream quality (robust quality), 354, 355
 Urinary continence recovery in patients with brain disease, prediction of, 1258–1266
 Useful effects (TRIZ), 1453
 Useful part (ideal functions), 1509
 User friendly design, 14
 Utilization of interaction between control and noise factors, *see* Parameter design
 Utilization of nonlinearity, *see* Parameter design

V

Values, objective, 507–508
 Value analysis (VA), 1482
 Value engineering (VE), 1482
 Variability, 225, 226
 dynamic, 236
 improving, 41–55
 nondynamic, 236
 reducing, 40
 repeatability as, 224
 reproducibility as, 224
 SN ratios and traditional approach for, 224
 stability as, 224
 Variables:
 continuous:
 signal-to-noise ratios for, 234–236, 239–289
 in two-way layout experiments, 563–572
 value of classified attributes vs., 239
 noise, 176
 Variance, 509–514. *See also* Analysis of variance
 definition of, 509
 error, 511. *See also* Error variance
 Variation, 509–514
 decomposition of, *see* Decomposition of variation
 definition of, 509
 error, 513, 517, 518, 559
 between experiments, 574
 of primary error, 574–576
 between primary units, 574

 pure, 518, 559
 range of, 1510–1513
 within repetitions, 575–576, 581
 of the secondary error, 575–576, 581
 total, 509
 Variation of the general mean, 520
 VE (value engineering), 1482
 Video compression, optimization of, 1310
 Virtual testing, 1475–1476
 Viscosity control, 469–470
 Vision, project, 391
 Visnepolschi, Svetlana, 1301
 Visual pattern recognition, 397–398
 Voltage-controlled oscillators, ideal function for, 234

W

Wakabayashi, Kimihiro, 137
 Warranty costs, 1516
 Water feeder valve, parameter design of, 330–338
 Wave soldering:
 ideal function for, 233
 optimization of process, 895–899
 Weather forecasting, MTS in, 419
 Welch, Jack, 161
 Welding:
 gas-arc stud weld process parameter optimization, 926–939
 ideal function of, 230
 resistance welding conditions for electronic components, 863–868
 Whack-a-mole engineering, 1508
 Whack-a-mole research, 73, 74
 Wheatstone bridge:
 parameter design of, 320–330, 349–350
 purpose of, 320
 tolerance design of, 346–351
 Window latching, minivans, 1025–1031
 Wiper systems:
 chatter reduction in, 1148–1156
 ideal function of, 230
 Working hours, estimation of, 1401–1405
 Working mean, 506–507
 Wu, Alan, 1493
 Wu, Yuin, 157–158, 1493

X

Xerox Corporation, 18, 158, 161, 433, 441, 1439, 1503, 1505

Y

Yaesu Book Center, 1428
Yahata Steel, 1424
Yano, Hiroshi, 132–133, 136, 140, 161
Yano Laboratory, 133
Yield, 235, 293
Yokogawa Hewlett-Packard, 141, 313
Yoshino, Fushimi, 142
Youden squares, 617–625
 calculations with, 620–623

derivations with, 623–625
objective of using, 617–619

Z

Zero approximation, 613
Zero operating window, 269, 270
Zero-point calibration, 228
Zero-point proportional equation, 240–247
Zero-point proportionality, 137
Zlotin, Boris, 1301
Zusman, Alla, 1301