Index

• A •

AC (alternating current), 91, 115, 319
acetone, 25, 319
acetylene, 319
acetylene cylinders, 188, 192
acid, in cleaning steel, 25
advancement, welding career, 287
air compressors
cost, 68
maintenance, 316
with plasma arc cutting, 174
uses, 277
air-acetylene, 319
air-arc cutting, 319
alcohol, in cleaning steel, 25
alloys, 261, 319
alternating current (AC), 91, 115, 319
aluminum. See also metals
alloy 3003, 30
alloys, 29
butt joint, 130
characteristics, 14
color test, 261
lap joint, 131
mig welding, 30
plasma arc cutting, 175–176
properties, 29–30
pure, 29, 30
repairs, 262
stick welding, 30
T joint, 132
tig welding, 30, 108, 125
welding process decision, 264
welding techniques, 30
working with, 29–30
American Welding Society (AWS)
certifications. See also certified welder
advantages, 286–290
defined, 285
as national organization, 288
pursuing, 285
skill demonstration, 286
in specific welding areas, 289
as traveling certification, 288
ammeters, 319
amperage
adjusting after starting, 92
defined, 90
high, as defect cause, 294
low, as defect cause, 292, 293, 295
setting, 90, 91–92, 97
stick welding, 75, 90, 91–92
tig welding, 115
angle grinders, 24
angle irons
campfire grill project, 252
portable welding table project, 245, 247
torch cart project, 237–238
annealing, 187, 319
anvils, 68
arc blow, 81, 319
arc brazing, 319
arc cutting, 319
arc eye, 46
arc length, 75, 94, 319
arc striking, 93–95, 319
arc welding, 319
argon, 114, 142
austenite, 320
auto-darkening lenses, 35
autogenous welds, 116
AWS. See American Welding Society
certifications

• B •

back pass, 320
back up, 320
back welds, 320
backfire, 180, 320
backhand welding, 320
backing rings, 208, 320
backing strips, 320
backstep, 320
back-up strips, 267
ball-peen hammers, 58, 60
base metal arc welding, 320
base metals
  brazing, 195
  defined, 320
  postheating, 271
  preheating, 271
  in repairs, 265
bead welds, 320
beads, 320, 340
beanies, 38
bench grinders. See also grinders
  abrasive wheels, 281
  defined, 281
  gloves and, 282
  illustrated, 281
  sharpening tools with, 282
bevels
  defined, 321
  oxyfuel cutting, 184–185
  plasma arc cutting, 177–178
billets, 321
birds’ nest
  defined, 312
  fixing, 314
  illustrated, 313
bleeding wound/injuries, 49
bonds, 321
bones, broken, 49
boots, 38
bottle jacks, 282, 309
box-end wrenches, 278
brass/bronze, color test, 261
brazing
  base metals, 195
  block, 321
  butt joint, 195
  cast iron, 226
  corncob, 195, 197
  defined, 17, 195, 321
  dip, 324
  filler rods, 195, 196
  fire bricks, 196
  flux inclusions, 295
  furnace, 327
  induction, 329
  lap joint, 195
  passes, 196–197
  process, 196–197
  quenching metal, 196
  resistance, 334
  rules, 195
  torches, 196, 197, 339
  bridging, 321
  buckling, 321
  build-up sequence, 321
burns
  chemical, 52
  first-degree, 50, 51
  flash, 46, 326
  heat, 50–51
  risk, reducing, 47
  second-degree, 50, 51
  third-degree, 50, 51
butt joints. See also joints
  brazing, 195
  defined, 129, 321
  fusion welding, 198
  illustrated, 130
  pipe welding, 207
  tig welding process, 130
  butt welds, 321
  butter welds, 321

• C •
cable holders, 67
campfire grill
  angle irons, 252
  characteristics, 249
  fabricating, 249–256
  grill grate, premade, 251
  grill grate assembly, 255
  grill grate pieces, 253
  illustrated, 250
  paint, 256
  partially constructed, 255
  seasoning, 256
  steel pieces, 250–251
  tack welds, 253
  tools for, 249–250
  welding, 253–256
capillary action, 321
carbide precipitation, 321
carbon, in steel, 13
carbon dioxide, 142
Index

carburizing flame, gas torch, 193, 322
cascade sequence, 322
case hardening, 322
cast iron
  brazing, 226
  carbon content, 217
  color test, 260
defined, 217
  filler rods, 225
  graphite, 218
  gray, 218
  malleable, 218–219
  mig welding, 227–228
  nodular, 219
  oxyfuel welding, 224–226
  repair welds, 263
  repairs on, 262
  stick welding, 221–223
  welding process decision, 264
  working with, 217–228
C-clamps, 309
CDA (Copper Development Association), 262
center punches
  in punching measurement lines, 236
  in punching soapstone marks, 241
  for repairs, 268
certified welder
  advancement, 287
  AWS database listing, 290
  becoming, 285–286
  job opportunities, 286
  pay, 286–287
  skill confidence, 289
  in specific areas, 289
chamfering, 322
chemicals
  burns, 52
  cleaning steel with, 25
  MSDS for, 25, 39
chipping, with stick welding, 75
chipping hammers, 58, 60, 308
chisels, 308
circles
  oxyfuel cutting, 183–184
  plasma arc cutting, 176–177
cleaning
  steel, 23–25
  with stick welding, 74, 75
  work space, 41
clothing, protective, 38–39
coalescence, 322
cold cracks, 297
cold rolled steel, 21
color test, 260–261
combination squares, 83
concavity, 322
concurrent heating, 322
cone, 322
contaminated tungsten, 121–122
conventions, this book, 2
convexity, 323
copper
  color test, 260
  repairs, 262
  tig welding, 108
  uses, 31
  welding process, 31
  welding process decision, 264
Copper Development Association (CDA), 262
corncob, 195, 197
corner joints, 323
corrosion
  aluminum and, 14
  defined, 323
  stainless steel and, 13
  steel and, 13
coveralls, 81
covered electrodes, 93
cracking the cylinders, 191
cracks. See also defects
cold, 297
  crater, 297, 323
defined, 323
  fixing, 271
  hot, 297
illustrated, 270, 297
prevent, 271
reasons for, 270
in repair welding, 269–271
root, 334
stainless steel tig welds, 108
subsurface, 269
toe, 339
underbead, 340
  crater cracks, 297, 323
creepers, 68
...
crescent wrenches, 58, 60

cup holders, 67
current, welding machines, 62, 115

cutoff saws, 280–281

• D •

direct current (DC), 91, 115, 324
defects
   cracks, 269–271, 297
defined, 323
   flux inclusions, 295–296
   incomplete fusion, 156, 215, 292–293
   incomplete penetration, 156, 215, 291–292
   mig welding, 155–156
   pipe welding, 214–215
   porosity, 296
   slag inclusions, 294–295
   spatter, 15, 152, 208, 299
   undercutting, 293–294
   warpage, 298
deoxidizers, 109
deposited material, 323
deposition efficiency, 323
die, 324
die welding, 324
direct current (DC), 91, 115, 324
distortion, 236
downhill vertical mig welds, 154
drill presses, 69, 316–317
dross, 182
ductile iron. See nodular cast iron
ductile joints, 107
ductility, 12, 22, 324
duty cycle
defined, 62, 324
   stick welding machines, 77
dye-penetrating test, 324

• E •

edge joints, 325
electric drills, 277–278
electric shock
safety, 45–46
   victims, 50
electrical conductivity, 12, 22
electrical setback, 164
electrode holders, 82, 92, 325
electrode stubs
defined, 45
   safety, 45
   stick welding, 75
electrode wire. See also mig welding
carbon steel classifications, 144
cutting end of, 148
defined, 143
   feed speed, 150–151
   feeders, 141
   liner, 148
   purchasing, 144
   selection, 151
   size, 143
   stub off, 153
electrodes
   bare, 320
   coated, 322
   composite, 322
   consumable, 322
defined, 325
dirty, 270
   low hydrogen, 268–269
   for repairs, 267
   stick welding, 16, 74, 75, 80–81, 87–90
tig welding, 106, 112, 117, 120–122
equal pressure torches, 189
equipment. See also welding shops
   air compressor, 68, 174, 277, 316
   anvil, 68
   ball-peen hammer, 58, 60
   checking, 47
   chipping hammer, 58, 60
   creeper, 68
   crescent wrench, 58, 60
   drill press, 69
   grinder, 69, 222, 247, 276, 281–282
   hacksaw, 69, 276, 308
   hand tools, 58–60
   level, 58, 60
   maintaining, 47–48
   mig welding, 139–141
   options, 57
   pliers, 59
portable welding curtain, 69
soapstone/silver pencils, 59
steel square, 59, 60
stick welding, 76–83
straightedge, 59, 60
tape measure, 59, 267, 307
tig welding, 110–117
types of, 56–69
used, 58
vise, 69
vise grips, 59, 308
welding machine, 62–67
welding table, 61–62
wire brush, 60, 241, 308
etching, 325
eye injuries, 52
eye protection. See also gear, safety; safety for bystanders, 35
welding helmet, 34–35

• F •
fabricating
  campfire grill, 249–256
defined, 10
  metal products, 10
  portable welding table, 242–248
  torch cart, 231–242
fast fill electrodes, 268
fast freeze electrodes, 268
faying surface, 325
FCAW (flux core arc welding), 135, 326
ferrite, 325
ferrous metal, 261
field welds, 325
filler metal, 116–117
filler rods
  brazing, 195, 196
  cast iron, 225
  common, 123
defined, 116, 123, 190, 341
fusion welding, 197, 199
gas welding with, 190, 194, 269
illustrated, 116
nonferrous, 195
for repairs, 267, 269
RG-45, 269
RG-60, 269
RG-65, 269
tig welding with, 123
fillet welds, 325
fire bricks, 196
fire extinguishers. See also gear, safety; safety
classes, 36, 37
  cutting down on need for, 36
  illustrated, 37
fires, clothing, 50
first-aid kits, 48–49
flame hardening/softening, 326
flammable gases, 44
flammable liquids, 43–44
flash burns, 46, 326
flash welding, 326
flashback, 180, 326
flashback arrestor, 315
flat position, 326
flat steel, 20, 21
flat surface
  pipe welding on, 212–213
  stick welding on, 96–97
flow meters, 113, 148
flow welding, 326
flux
correct, using, 201
defined, 93, 201, 202, 326
on electrodes, 93
illustrated, 202
in oxyfuel cast iron welding, 225
in soldering, 201, 202
soldering paste, 201, 202
flux core arc welding (FCAW), 135, 326
flux inclusions. See also defects
  avoiding, 296
defined, 295
  illustrated, 295
forehand method
defined, 326
fusion welding, 198
gas welding, 194
forge welding, 326
friction lighters, 190
fuel gases, 165
full feeders, 141
fusion, 327
fusion welding
  butt joint, 198
defined, 197
filler rods, 197, 199
forehand method, 198
illustrated, 198
process, 198–199
torch, 198
welds, 199
with/without filler rods, 197

• G •
gas cylinders. See also oxyfuel cutting
  acetylene, 188, 192
caps, 191
defined, 168, 323
gas welding, 188
large size, 170
leaking, 188
left-handed fittings, 188
moving, 188
oxyfuel cutting, 168, 169–170
oxygen, 188, 191
right-handed fittings, 188
selecting, 169–170
setting up, 170–171
shielding gas, 112
small size, 170
in torch cart, 232
valves, opening/closing, 191
gas metal arc welding (GMAW).
  See mig welding
gas torches
  acetylene valve, 194
  for annealing, 187
  body, 189
carburizing flame, 193, 322
equal pressure, 189
fuel valve, 192
lighting, 192–193
neutral flame, 192–193, 330
oxidizing flame, 193, 331
oxygen valve, 192
processes with, 187
setting up, 191–192
soldering with, 202
tips, 190
gas tungsten arc welding (GTAW). See tig welding
gas welding
  acetylene cylinder, 188
defined, 187, 327
equipment leaks, 42
filler rods, 190, 194, 269
finishing up, 194
forehand method, 194
friction lighter, 190
gas cylinders, 188, 191
gases, 187
goggles, 190
hoses, 190
oil/grease and, 190
oxyacetylene gas, 187
oxygen cylinder, 188
oxymapp, 187
position, 194
propane, 187
regulators, 190, 191
welds, 194
working with, 191–194
gases
  fuel, 165
  inert, 329
  inhalation, 50
  oxyacetylene, 187
  oxymapp, 187
  safety, 43–44
  shielding (mig welding), 142–143
  shielding (tig welding), 106, 109, 112–115, 122–123
gear, safety
  eye protection, 34–35
  fire extinguishers, 36–37
  Material Safety Data Sheets (MSDS) and, 39
  protective clothing, 38–39
  respirators, 39–40
generators, stick welding machine, 77, 78
globular transfer, 137, 327
gloves, 38, 82
GMAW (gas metal arc welding). See mig welding
goggles, 190, 327
grapes, 210
gray cast iron
  defined, 218
determination, 219
mig welding, 227–228
oxyfuel welding, 224–226
repairs on, 262
stick welding, 221–224
welding, 221–228
grill grate. See also campfi re grill
assembly, 255
pieces, 253
premade, 251
seasoning, 256
welds, 254
grinders
bench, 281–282
cost of, 276
defined, 69
as dynamic tools, 276
4½-inch, 276
for repairs, 267
sanding discs, 247
for V-shaped grooves, 222
grinding
pipe, 208
portable welding table, 247
torch cart welds, 241
tungsten electrodes, 121
groove welds, 327
grooves, 222, 292, 327
ground clamps, 82, 175, 176, 177
GTAW (gas tungsten arc welding). See tig
welding
guided bend test, 328
• H •
hacksaws, 69, 276, 308
hammers, 307
hand tools, 58–60
hardfacing, 263, 328
hardness, 22
hats, 38
heart attack, 50
heat burns, 50–51
heat sink, 328
heat sparks, 74
heat treating, 328
heating gate, 328
helium, 114, 142
helmets, welding
comfort, 35
lenses, 35
maintenance, 35, 310–311
need for, 34–35
in oxyfuel cutting, 179, 181
shade number, 35
stick welding, 81
high carbon steel, 20
high pressure pipes, 206
history, welding, 11
horizontal position, vertical pipe welding
in, 213
horizontal stick welding
defined, 101
flat surface welding versus, 101
illustrated, 102
starting, 101
hoses
as leak source, 42
oxyacetylene, 179, 190
oxyfuel cutting, 168
hot cracks, 297
hot pass, 213
hot rolled steel, 21
hot short, 328
hydrogen, in welds, 270
• I •
icicles, 210
icons, this book, 5
impact test, 329
impregnated tape metal arc welding, 329
incomplete fusion. See also defects
causes, 293
defined, 292
illustrated, 293
mig welding, 156
pipe welding, 215
incomplete penetration. See also defects
causes, 292
defined, 291
illustrated, 292
mig welding, 156
pipe welding, 215
indoor welding, 55–56
induction welding, 329
injuries. See also safety
bleeding/wounds, 49
broken bones, 49
burns, 50–52
clothing fires, 50
electric shock, 50
eye, 52
first-aid kits, 48–49
gas inhalation, 50
handling, 49–52
heart attack, 50
plume poisoning, 52
poisons, 50
stick welding, 87
inverters, 79
iron powder, 88

• J •
job opportunities, certified welder, 286
joints
butt, 129, 130, 195, 198, 207
composite, 322
corner, 323
defined, 329
ductile, 107
dge, 325
lap, 130–131, 155, 195, 329
lateral, 214
repair, 265–266
root of, 335
socket, 214
T, 131–132, 214, 338
Y, 214

• K •
kerf, 235, 329
keyholes, 211, 213, 329

• L •
lap joints. See also joints
brazing, 195
defined, 130, 329
illustrated, 131
mig welding sheet metal, 155
tig welding process, 131
lateral T and Y joints, 214
layers, 212, 329
lead, color test, 261
leaks
checking for, 42
gas cylinders, 188
hose, 42
leather aprons, 39
leather jackets, 38
left-handed fittings, gas cylinders, 188
levels, 58, 60
lighting, for repairs, 267
liquidus, 329
local preheating, 330
low carbon (mild) steel, 20
low hydrogen electrodes, 268–269
low pressure pipes, 206

• M •
magnesium
tig welding, 108
uses, 31
welding process, 31
magnetism, 22
magnetism check, 261
maintenance tips
air compressor, 316
drill press, 316–317
hand tools, 307–309
mig welding machines, 312–314
oxyfuel equipment, 315
power tools, 309–310
shop housekeeping, 310
malleable cast iron. See also cast iron
color test, 260
defined, 218
determination, 219
depense, 219
manifolds, 330
martensite, 330
mash seam welding, 330
Material Safety Data Sheets (MSDS) for hazardous materials, 39
reading and understanding, 25
measurement
lines, center punching, 236
marks, drawing, 236
for torch cart project, 235–236
medium carbon steel, 20
medium pressure pipes, 206
melting point, 22, 330
melting range, 330
melting rate, 330
metal identification
aluminum, 262
cast iron, 262
with color chart, 260–261
copper, 262
kit, 261
magnetism check, 261
spark test, 220, 261
metallizing, 330
metals. See also specific metals
brazing, 195
cast iron, 262
ductility, 12, 22
electrical conductivity, 12, 22
ferrous, 261
filler, 116–117, 325
hardness, 22
hot, handling, 47
magnetism, 22
melting point, 22
nickel-based alloys, 31
nonferrous, 261, 331
for oxyfuel cutting, 165
parent, 293
for plasma arc cutting, 160
precious, 31
properties, 12, 22
quenching, 196
resistance to oxidation, 22
strength, 12, 22
for tig welding, 108–109
mig welding
advantages, 138–139
aluminum, 30
beads, 152, 153
benefits, 16
defects, 155–156
defined, 16, 135, 330
drawbacks, 16, 139
electrode wire feeders, 141
equipment, 139–141
equipment, readying, 148–149
feed speed, 145, 150–151
globular transfer, 137, 327
how it works, 16–17, 136–137
joining pieces of sheet metal, 155
penetration, 139
practicing, 147–156
preparing for, 147–151
pulse transfer, 137
robotic, 137
settings, experimenting with, 153–154
setup, 140
shielding gases, 142–143
short circuit transfer, 136, 150
spray arc transfer, 136–137, 150–151
stainless steel, 28, 150, 151
steel, 26
voltage, 145, 150–151
mig welding (cast iron)
on cracked cast iron, 227
illustrated, 228
mig gun, 228
process, 227–228
shielding gas, 227
weld backing, 227
mig welding guns
defined, 140–141
liner, 312, 313
moving, 152
mig welding machines
birds’ nest, 312, 313, 314
DC option, 140
defined, 65
design, 65
illustrated, 66
liner, 312, 313
maintenance, 312–314
power needs, 66
prices, 140
types of, 140
mixing chamber, 330
monel metal, color test, 261
MSDS. See Material Safety Data Sheets
multi-impulse welding, 330

- N -
neutral flame, gas torch, 192–193, 330
new welding machines, 63
nick break test, 330
nickel, color test, 261
nickel-based alloys, 31
nitriding, 330
nodular cast iron, 219
nonferrous filler rods, 195
nonferrous metal, 261, 331
normalizing, 331
nozzle tip, plasma cutting torch, 164
nugget, 331

- O -
Occupational Outlook Handbook (OOH), 286
1G horizontal rolled open root pipe weld, 212
open circuit voltage, 331
open-end wrenches, 278
organization, this book, 3–5
OSHA (Occupational Safety and Health Administration) Web site, 43
outdoor welding, 56
output rating, stick welding machines, 77
overhead stick welding, See also stick welding checking clothes and, 104
defined, 102, 331
illustrated, 103
process, 102–103
oxidizing flame, gas torch, 193, 331
oxyacetylene cutting/welding, 331
oxyacetylene gas, 187
oxy-arc cutting, 331
oxyfuel cutting
acetylene levels, 181
actions to avoid, 179
advantages, 166
beveled edges, 184–185
circles, 183–184
cutting tip, 169
defined, 18, 165
drawbacks, 166
dross, 182
equipment, 166–171
equipment setup, 170–171
friction lighter, 168
fuel gas, 165
gas cylinders, 168, 169–170
hoses, 168
ignition temperature, 165
metals, 165
oxygen levels, 181
practicing, 178–185
regulators, 168, 171
safety, 179
setup illustration, 167
straight lines, 181–182
welding helmet, 179, 181
oxyfuel cutting torches
backfire, 180, 320
flashback, 180
illustrated, 168, 180
lighting, 179–180
maintenance, 315
operating, 180–181
shutting off, 181
oxyfuel welding (cast iron)
choice of, 224
filler rods, 225
flux, 225
items needed for, 224
process, 225–226
setup, 224
torch tip, 225
oxygen cutting, 331
oxygen cylinders, 188, 191
oxygen gouging, 331
oxy-hydrogen cutting/welding, 331–332
oxymapp, 187
oxy-natural gas cutting, 332
oxy-propane cutting, 332
paint
  campfire grill project, 256
  portable welding table project, 248
  for repairs, 268
  torch cart project, 242
pants, 38
parent metal, 293
parts cart. See portable welding table
passes, 332
passive lenses, 35
pay, certified welder, 286–287
peening, 332
penetration
  defined, 304
  full, 304
  incomplete, 156, 215, 291–292
  joint, 329
  root, 335
percussive welding, 332
perlite, 332
piece failure. See also repairs
  improving pieces to avoid, 265
  mechanical failures causing, 265
  reasons for, 258
pipe clamps, 209
pipe welding
  backing rings, 208, 320
  butt joint, 207
  defects, 214–215
  in flat position, 212–213
  grapes, 210
  hot pass, 213
  incomplete fusion, 215
  incomplete joint penetration, 215
  keyholes, 211, 213, 329
  lateral T and Y joints, 214
  movement in, 212
  pipe types and, 205, 206
  process, 210–212
  root pass, 210–211, 213
  side-to-side motion, 212
  socket joints, 214
  standards, 215
  tacks, 209–210
undercutting, 211
vertical, in horizontal position, 213
pipes
  aligning, 208
diameter, 209
grinding, 208
high pressure, 206
low pressure, 206
medium pressure, 206
Schedule 40, 207
setting up and preparing, 207–209
steel, 205
tacked, 213
wall, 209
plasma arc cutters
  illustrated, 163
  regulatory assembly, 163
  setting up, 164
torch connection, 163
types of, 174
plasma arc cutting
  advantages, 161
  air flow, 174
  aluminum, 175–176
  bevels, 177–178
  characteristics, 160
  circles, 176–177
  defined, 159–160
diagram, 162
drawbacks, 161
equipment setup, 164
materials, 160
pilot arc, 175
preparing for, 162–164, 174
regulator, 174
straight lines, 174–176
plasma cutting torches
  angling, 177–178
  connection, 163
electrode tip, 164
nozzle, 193
nozzle insulator, 164
nozzle tip, 164
trigger, 175, 176, 177
plating, 332
platinum, welding, 31
pliers, 59, 308
plug welds, 332
plume poisoning, 52
poisons swallowed, 50
poke welding, 332
polarity
alternating current (AC), 91
defined, 333
direct current electrode negative
(DC- or DCEN), 91
direct current electrode positive
(DC+ or DCEP), 91
reverse, 334
setting, 90, 91
stick welding machines, 64, 76–77
straight, 337
porosity, 109, 296, 312
portable welding curtains, 69
portable welding table
angle irons, 245, 247
assembly, 244–247
castors, 244, 248
defined, 242
dimensions, 242
edges, smooth, 247
fabricating, 242–248
illustrated, 243
paint, 248
partial construction illustration, 246
parts, 243–244
parts illustration, 245
tack welds, 244
tools for, 243
washer welding position, 246
post-flow timers, 112
postheating, 333
power source
defined, 62
stick welding machine, 77–79
power tool maintenance, 309–310
precious metals, 31
pre-flow timers, 112
preheating, 333
pressure controlled welding, 333
pressure welding, 333
preweld intervals, 333
projection welding, 333
projects
campfire grill, 249–256
portable welding table, 242–248
torch cart, 231–242
propane, gas welding and, 187
protective clothing, 38–39
puddles, 94, 333
pulsation welding, 334
pulse transfer, 137
push feeders, 141
push welding, 334
push-pull feeders, 141

• Q •
quenching, 196, 334

• R •
reaction stress, 334
reader assumptions, this book, 3
regulators
acetylene, 192, 194
defined, 334
gas welding, 190, 191
gauge, standing away from, 191
oxyfuel cutting, 168, 171
oxygen, 191
plasma arc cutting, 174
reinforced welds, 334
repairs. See also piece failure
aluminum, 262, 264
base metal condition, 265
base metal strength, 265
cast iron, 262, 264
compromise of other pieces and, 259
copper, 262, 264
cost versus new piece, 258–259
cracks and, 269–271
defined, 10
determination if fixable, 258–259
electrodes for, 267, 268–269
equipment and tools for, 267–268
equipment failure and, 258
filler rods for, 267, 269
first step for, 258
hardfacing, 263
joints, 265–266
magnetism check, 261
metal color identification chart for, 260–261
metal identification, 260–262
metal identification kit and, 261
piece preparation, 266–267
plan, making/following, 265–266
skill level for, 265
spark test, 261
strategy, planning, 259–266
time for, 264
weld aesthetic, 264
weld preparation, 266–269
weld strength, 259
welding process decision, 264–265
as welding use, 10–11
work area preparation, 266–267
residual stress, 334
resistance butt welding, 334
resistance to oxidation, 22
resistance welding, 334
respirators
filters, 40
illustrated, 40
for repairs, 268
in stick welding, 82
types of, 39
right-handed fittings, gas cylinders, 188
robotic mig welding, 137
Rockwell hardness test, 334
root edge, 335
root face, 335
root pass, 210–211, 213, 335

safety. See also injuries
burns, 46–47, 50–52
cleaning, 25
electric shock, 45–46
equipment, 47–48
first-aid kit, 48–49
flammable liquids/gases and, 43–44
gear, 34–40
importance of, 14
leaks, 42
oxyfuel cutting, 179
precautions, talking, 33
rules, 40–48
smells and sounds, 45
soldering, 201
surroundings, 44–45
tips, 41
ventilation, 42–43
work space, 41
sandblasting, 335
SAW (submerged arc welding), 338
sawhorses, steel, 278–280
scaling, 13
scarf, 335
scarfing, 335
Schedule 40 pipe, 207
scrap metal safety, 45
scratching method, stick welding, 95
screwdrivers, 308
seal welds, 335
seam welding, 335
selective block sequence, 335
series welding, 335
shade number, 35
sheet metal, mig welding on, 155
sheet separation, 335
shielded metal arc welding (SMAW). See stick welding
shielding gases (mig welding)
argon/argon mixes, 142
carbon dioxide, 142
cast iron, 227
defined, 336
flow rate, 149
helium/helium mixes, 142
suggestions, 143
supply chamber installation, 148
shielding gases (tig welding)
argon, 114–115
cylinders, 112
defined, 106, 109, 336
flow meters, 113, 122
flow rate, 113
helium, 114
hook up, checking, 122
selecting and managing, 112–115
setting up, 122–123
solenoid and, 122–123
<table>
<thead>
<tr>
<th>Term</th>
<th>Page References</th>
</tr>
</thead>
<tbody>
<tr>
<td>shirts</td>
<td>38</td>
</tr>
<tr>
<td>shoes</td>
<td>38</td>
</tr>
<tr>
<td>shop welds</td>
<td>336</td>
</tr>
<tr>
<td>short circuit transfer</td>
<td>136, 150</td>
</tr>
<tr>
<td>sidebars, this book</td>
<td>2</td>
</tr>
<tr>
<td>single impulse welding</td>
<td>336</td>
</tr>
<tr>
<td>slag</td>
<td></td>
</tr>
<tr>
<td>defined</td>
<td>336</td>
</tr>
<tr>
<td>not sticking to weld</td>
<td>302</td>
</tr>
<tr>
<td>in pipe welding</td>
<td>208</td>
</tr>
<tr>
<td>in stick welding</td>
<td>15</td>
</tr>
<tr>
<td>slag inclusions</td>
<td></td>
</tr>
<tr>
<td>See also defects</td>
<td></td>
</tr>
<tr>
<td>causes</td>
<td>295</td>
</tr>
<tr>
<td>defined</td>
<td>294, 336</td>
</tr>
<tr>
<td>illustrated</td>
<td>295</td>
</tr>
<tr>
<td>slot welds</td>
<td>336</td>
</tr>
<tr>
<td>slugging</td>
<td>336</td>
</tr>
<tr>
<td>SMAW (shielded metal arc welding)</td>
<td></td>
</tr>
<tr>
<td>See stick welding</td>
<td></td>
</tr>
<tr>
<td>soapstones</td>
<td></td>
</tr>
<tr>
<td>circles</td>
<td>176, 183</td>
</tr>
<tr>
<td>defined</td>
<td>59, 96, 175</td>
</tr>
<tr>
<td>in oxyfuel cutting</td>
<td>181, 183</td>
</tr>
<tr>
<td>in plasma arc cutting</td>
<td>175, 176</td>
</tr>
<tr>
<td>as repair tool</td>
<td>267</td>
</tr>
<tr>
<td>sharpening</td>
<td>83</td>
</tr>
<tr>
<td>straight lines</td>
<td>175, 181</td>
</tr>
<tr>
<td>in torch cart project</td>
<td>241</td>
</tr>
<tr>
<td>uses</td>
<td>59, 83</td>
</tr>
<tr>
<td>socket joints</td>
<td>214</td>
</tr>
<tr>
<td>soft arc electrodes</td>
<td>88</td>
</tr>
<tr>
<td>solder</td>
<td></td>
</tr>
<tr>
<td>applying</td>
<td>203</td>
</tr>
<tr>
<td>cooling/hardening</td>
<td>201</td>
</tr>
<tr>
<td>correct, using</td>
<td>201</td>
</tr>
<tr>
<td>defined</td>
<td>199</td>
</tr>
<tr>
<td>lead-free</td>
<td>201, 202</td>
</tr>
<tr>
<td>rosin core</td>
<td>201, 202</td>
</tr>
<tr>
<td>soldering</td>
<td></td>
</tr>
<tr>
<td>cleanup after</td>
<td>203</td>
</tr>
<tr>
<td>defined</td>
<td>18, 199, 336</td>
</tr>
<tr>
<td>drawbacks</td>
<td>199, 200</td>
</tr>
<tr>
<td>flux</td>
<td>201</td>
</tr>
<tr>
<td>flux inclusions</td>
<td>295</td>
</tr>
<tr>
<td>with gas torch</td>
<td>202, 203</td>
</tr>
<tr>
<td>heat application</td>
<td>201</td>
</tr>
<tr>
<td>joint fit</td>
<td>200</td>
</tr>
<tr>
<td>joint illustration</td>
<td>200</td>
</tr>
<tr>
<td>joint strength</td>
<td>199</td>
</tr>
<tr>
<td>materials</td>
<td>201</td>
</tr>
<tr>
<td>materials illustration</td>
<td>202</td>
</tr>
<tr>
<td>metal cleanliness</td>
<td>200</td>
</tr>
<tr>
<td>process</td>
<td>202–203</td>
</tr>
<tr>
<td>rules</td>
<td>200–201</td>
</tr>
<tr>
<td>safety</td>
<td>201</td>
</tr>
<tr>
<td>soft</td>
<td>201</td>
</tr>
<tr>
<td>with soldering iron</td>
<td>202, 203</td>
</tr>
<tr>
<td>torch</td>
<td>201, 202</td>
</tr>
<tr>
<td>types</td>
<td>202</td>
</tr>
<tr>
<td>uses</td>
<td>199</td>
</tr>
<tr>
<td>solenoids</td>
<td>122–123</td>
</tr>
<tr>
<td>spacer strips</td>
<td>336</td>
</tr>
<tr>
<td>spall</td>
<td>336</td>
</tr>
<tr>
<td>spark test</td>
<td>220, 261</td>
</tr>
<tr>
<td>spats</td>
<td>39</td>
</tr>
<tr>
<td>spatter</td>
<td></td>
</tr>
<tr>
<td>defined</td>
<td>299, 336</td>
</tr>
<tr>
<td>illustrated</td>
<td>152</td>
</tr>
<tr>
<td>minimizing</td>
<td>299</td>
</tr>
<tr>
<td>in pipe welding</td>
<td>208</td>
</tr>
<tr>
<td>in stick welding</td>
<td>15</td>
</tr>
<tr>
<td>speed of travel</td>
<td></td>
</tr>
<tr>
<td>as incomplete penetration cause</td>
<td>292</td>
</tr>
<tr>
<td>stick welding</td>
<td>75, 95</td>
</tr>
<tr>
<td>weld size control with</td>
<td>301</td>
</tr>
<tr>
<td>spool guns</td>
<td>141</td>
</tr>
<tr>
<td>spot welding</td>
<td>336–337</td>
</tr>
<tr>
<td>spray arc transfer</td>
<td>136–137, 150–151, 337</td>
</tr>
<tr>
<td>stainless steel</td>
<td></td>
</tr>
<tr>
<td>See also metals</td>
<td></td>
</tr>
<tr>
<td>butt joint</td>
<td>130</td>
</tr>
<tr>
<td>characteristics</td>
<td>13</td>
</tr>
<tr>
<td>color test</td>
<td>260</td>
</tr>
<tr>
<td>400 series</td>
<td>27</td>
</tr>
<tr>
<td>lap joint</td>
<td>131</td>
</tr>
<tr>
<td>mig welding</td>
<td>28</td>
</tr>
<tr>
<td>steel versus</td>
<td>27</td>
</tr>
<tr>
<td>stick welding</td>
<td>28</td>
</tr>
<tr>
<td>T joint</td>
<td>132</td>
</tr>
<tr>
<td>tig welding</td>
<td>28, 108, 125</td>
</tr>
<tr>
<td>200 to 300 series</td>
<td>27</td>
</tr>
<tr>
<td>use decision</td>
<td>27–28</td>
</tr>
<tr>
<td>welding decision</td>
<td>27–28</td>
</tr>
<tr>
<td>working with</td>
<td>27–28</td>
</tr>
</tbody>
</table>
steel. See also metals
bars, 20
butt joint, 130
carbon, 13
characteristics, 13
cleaning, with chemicals, 25
cleaning, with mechanical methods, 23–25
cold rolled, 21
color test, 260
decision to use, 21–22
defined, 20
flat, 20
forms, 20–21
heat treating, 337
high carbon, 20
hot rolled, 21
information resource, 22
lap joint, 131
low carbon (mild), 20
medium carbon, 20
mig welding, 26, 150–151
preparing for welding, 23–25
stainless steel versus, 27
stick welding, 26
T' joint, 132
tig welding, 26, 109, 124
weathered, 23
welding methods, 26
steel pieces
  campfire grill project, 250–251
  portable welding table, 243–244
  steel pieces, cutting, 251–253
  torch cart project, 233–234
steel pipes. See also pipe welding
  high pressure, 206
  low pressure, 206
  medium pressure, 206
  with stick welding, 205, 206
  welding, 206–215
steel sawhorses, 278–280
steel squares, 59, 60
stick welding
  advantages, 74
  aluminum, 30
  arc length, 75, 94, 319
  arcs, striking and maintaining, 93–95
  combination square, 83
  coveralls, 81
defined, 15, 337
drawbacks, 15–16, 74–75
electrode holder, 82, 92, 325
equipment, 76–83
factors influencing, 75–76
flat surface, 96–97
gloves, 82
ground clamps, 82
horizontal, 101–102
how it works, 16
injuries, 87
overhead, 102–104
in pipe welding, 205, 206
popularity, 15, 64
positions, 95–104
preparation, 86–90, 92–93
respirator, 82
slowness, 75
soapstones, 83
speed of travel, 75, 95
stainless steel, 28
steel, 26
success factors, 94–95
tig welding machines for, 111
tools and supplies, 81–83
vertical, 97–100
welding cables, 83
welding helmet, 81
work area setup, 86–87
working with, 85–104
stick welding (cast iron)
  components for, 222
  cracked cast iron, 221, 223
drill/drill bit, 222
  electrodes, 222
  grinder, 222
  illustrated, 224
  oxyacetylene torch, 222
  process, 223–224
temperature indicating crayon, 223
stick welding electrodes
  amperage, setting, 90, 91–92
  angle, 75, 94
  arc blow, 81
stick welding electrodes (continued)
burning too fast on one side, 81
for cast iron, 222
characteristics, 87–88
classifications, 89–90
covered, 93
defined, 87
exposure to moisture/air, 89
fast fill and fast freeze, 268
in flat surface welding, 97
flux, 16, 93
handling, 80
iron powder, 88
keeping dry, 80
material matching, 88
7018 and 7028, 268–269
6010 and 6011, 268
sizes, 88
soft arc designation, 88
storage oven, 90
strength, 88
stubs, 75
types of, 87
understanding, 87–90
in vertical-down welding, 100
wasting, 74
welding positions and, 88
stick welding machines. See also welding machines
AC versus DC, 64, 76–77
in cast iron welding, 223
defined, 64
differences, 76–80
duty cycle, 77
generators, 77, 78
illustrated, 65
inspecting, 90
inverter, 79
maintenance, 311–312
output rating, 77
polarity, 64, 76–77
power source, 77–79
setting, 90–93
setting up, 79–80
transformer, 77, 78, 341
stitch welds, 337
storage, 67
stored energy welding, 337
straight lines
oxyfuel cutting, 181–182
plasma arc cutting, 173–176
straightedges, 59, 60
strength
base metal, 265
defined, 12, 22
repair weld, 259
requirements, weld meeting, 305
tensile, 88, 218, 338
yield, 219
striking an arc (stick welding)
defined, 93–94
scratching method, 95
success factors and, 94–95
tapping method, 95
striking the arc (tig welding)
with DC, 127
preparation, 126
remote control device, 126–127
scratch starting, 126
string bead welding, 337
stud welding, 338
submerged arc welding (SAW), 338
subsurface cracks, 269
sugar, 338

T joints. See also joints
defined, 131
illustrated, 132
lateral, 214
pipe welding, 214
tig welding process, 132
tack welding
campfire grill, 253
defined, 99, 338
portable welding cart, 244
torch cart project, 236–237
tape measures, 59, 267, 307
tapping method, stick welding, 95
temper colors, 338
temperature indicating crayon, 223
tempering, 338
tensile strength, 88, 218, 338
tension test, 338
thermit mixture, 339
thermit mold, 339
thermit reaction, 339
thermit welding, 339
thick plates, 270
thoriated electrodes, 117
thoriated tungsten, 339
\(\frac{3}{8}\)-inch electric drills, 277–278
throat depth, 339
tig torches
  defined, 112
  holding, 127
  illustrated, 113
  striking the arc, 126–127
  using, 125–127
tig welding
  advantages, 17, 106–107
  aluminum, 30, 125
  amperage control, 115
  butt joints, 129–130
  characteristics, 105
  components, 106
  current control, 115
  defined, 17, 339
  disadvantages, 107
  drawbacks, 17
  electrical current selection, 125–126
  equipment, 110–117
  filler metal, 116–117
  filler rods for, 116
  first weld, 128–129
  how it works, 17
  lap joints, 130–131
  metals for, 108–109
  practicing, 119–132
  quality welds, 109
  setting up for, 119–123
  setup, 110
  shielding gas, 106, 109, 112–115, 122–123
  stainless steel, 28, 125
  steel, 26, 124
  striking the arc, 126–127
  T joints, 131–132
  wind and, 114

tig welding machines
  defined, 66
  features and controls, 111–112
  fully equipped, 111–112
  illustrated, 67, 114
  maintenance, 314–315
  polarity, 66
  starting modes, 111
  for stick welding, 111
  timers, 112
tig welding tungsten electrodes, 106, 112
  breaking, 121
  contamination, 121–122
  diameters, 117
  green, 117
  grinding, 121
  as non-consumable, 120
  red, 117
  shaping tip of, 117
  thorium alloy, 117
  types and applications, 120–121
toe, weld, 339
toolboxes
  illustrated, 283
  sizes, 283
  as top tool, 282
tools, most wanted
  air compressor, 277
  bench grinder, 281–282
  bottle jack, 282
  cutoff saw, 280–281
  4 \(\frac{1}{2}\)-inch grinder, 276
  hacksaw, 276
  steel sawhorses, 278–280
  \(\frac{3}{8}\)-inch electric drill, 277–278
  toolbox, 282–283
  wrench set, 278
torch cart. See also projects
  angle irons, 237–238
  base and handle welds, 237–238
  base pieces, 234
  benefits, 231
  box, 238–240
  box pieces, 234
  creating, 231–242
design, 232
distortion, 236
torch cart (continued)
gas cylinders, 232
illustrated, 232
materials, 233
paint, 242
partially welded, 239
pieces, cutting, 236
pieces, measuring, 235–236
steel pieces, 233–234
steel pieces illustration, 235
tack welding, 236
welds, 236–240
welds, checking, 241
wheels, 234, 240–241
torches
brazing, 196, 197
defined, 323, 341
fusion welding, 198
gas, 187, 189, 191–193
oxyfuel, 168, 179–181
plasma cutting, 163–164, 175, 176, 177–178
soldering, 201, 202
tig, 112–113, 125–127
transformers, stick welding machines, 77, 78, 341
traverse seam welding, 339
tungsten electrodes. See tig welding
tungsten electrodes
2G vertical fixed position open root pipe weld, 213

• V •

ventilation
importance, 43
need for, 42–43
for repairs, 268
in welding shop location selection, 54
vertical stick welding
types of, 97–98
vertical-down, 98, 100
vertical-up, 98–99
vertical welding
defined, 340
mig welding, 154
pipe welding, 213
vise grips, 59, 308
vises, 69
voltage, for mig welds, 145, 150–151
V-shaped grooves, 222, 292

• W •

wall clocks, 69
wandering block sequence, 340
wandering sequence, 340
warpage, 298
weathered steel, 23
weaving, 340
weld gauge, 341
weld metal, 341
weldability, 341
welding. See also mig welding; stick welding; tig welding
braze, 195–197
cast iron, 221–228
defined, 10
fusion, 197–199
future of, 18
gas, 187–194
history, 11
importance of, 10
methods, 15–18
oxyfuel/oxyacetylene, 18
pipe, 205–215
Index

safety, 14, 33–52

welding technique, 341

welding uses, 10–11

welding cables, 83

welding curtains, 69

welding educators, 287

welding engineers, 287

welding helmets. See helmets, welding

welding inspectors, 287

welding machines

  carriage, 68
  current, 62
  defined, 62
  duty cycle, 62, 77
  material type/size and, 63
  mig, 65–66
  new, 63
  plasma arc cutting, 161, 163–164
  power source, 62
  for repairs, 267
  stick, 64–65, 76–80
  tig, 66–67, 111–112
  used, 63–64

welding pressure, 341

welding procedure qualification record
  (WPQR), 215

welding procedure specifications (WPS), 215

welding shops

  accessories, 67–69
  doors, 54
  electrical service, 54
  equipment, 56–69
  flame retardant floors and walls, 54
  housekeeping, 310
  indoor versus outdoor, 55–56
  lighting, 54
  location selection, 53–56
  setting up, 53–69
  space needs, 54–55
  storage, 67
  ventilation, 54

welding supervisors, 287

welding symbols, 341

welding tables, 61–62

welding technicians, 287

welding torches. See torches

welding transformer, 77, 78, 341

weldment, 341

welds

  axis of, 320
  back, 320
  backing, 227, 320
  bead, 320
  butt, 321
  butter, 321
  campfire grill, 253, 254
  chain intermittent fillet, 322
  cold, 322
  defined, 340
  distributed equally between parts, 301–302
  effective length of, 325
  face of, 325
  field, 325
  fillet, 326
  full fillet, 326
  full penetration, 304
  fusion welding, 199
  gas welding, 194
  good, signs of, 301–305
  groove, 327
  horizontal, 328
  leakproof, 303
  loose, 303
  no overlap, 304
  no undercutting, 304
  plug, 332
  portable welding cart, 244
  reinforced, 334
  root of, 335
  seal, 335
  shop, 336
  size control, 301
  slag/shielding material not sticking
to, 302
  slot, 336
  staggered intermittent fillet, 337
  stitch, 337
  strength requirements and, 305
  surface, no irregularities on, 302
  tight, 303
  toe of, 339
welds (mig welding)
beads, 152, 153
depth, 139
excessive penetration, 156
feed speed setting, 145, 150
incomplete fusion, 156
incomplete penetration, 156
tack, 154
vertical, 154
voltage setting, 145
whiskers, 156
welds (pipe welding)
location, 210
1G horizontal rolled open root, 212
penetration, 208
tack, 209, 210
2G vertical fixed position open root, 213
welds (repair)
aesthetic, 264
cast iron, 263
strength, 259
welds (stick welding)
goal, 95
illustrated examples, 96
width, 75
welds (tig welding)
autogenous, 116
butt joint, 129–130
first, 128–129
lap joint, 130–131
porosity, 109
quality, 109–110
stainless steel, cracking, 108
T joints, 131–132
variables affecting, 111
welds (torch cart project)
base and handle, 237–238
box, 238–240
checking, 241
finalizing, 238–240
grinding, 241
making, 236–240
tack, 236–237
wire brush on, 241
wheels
portable welding table project, 244, 248
torch cart project, 234, 240–241
whiskers, 156
wire brushes, 60, 308
wire feed speed, for mig welds, 145, 150–151, 341
work space
cleaning, 41
stick welding, setting up, 86–87
WPQR (welding procedure qualification record), 215
WPS (welding procedure specifications), 215
wrenches
box-end, 278
crescent, 58, 60
maintenance, 308
open-end, 278
sets, 278, 279
wrought iron, color test, 260

Y

Y joints, lateral, 214
yield point, 341