

## PART I INDEX

- Abrasion, by suspensions, 133
- Adsorber system, design of, 316
- Adsorbers, adsorptive capacity of, 314
- Advanced Engineering Test Reactor (AETR), discussion, 486
  - key design specifications, 487
- Aqueous fuel systems, principal advantages of, 14
- Armour Research Foundation Research Reactor, 348
  - schematic, 347
- Atomics International Reactors, 347
- Austenitic stainless steels, corrosion of, out of pile by uranyl carbonate, 213
  - homogeneous reactor metallurgy of, 262
  - slurry corrosion rates, discussion, 249
- Autoclaves, in pile, sketch of, 204
  - irradiation corrosion tests on Zircaloy-2, discussion of, 237
- Autoignition (pyrophoricity), of titanium, 276
  - of zirconium, 276
- Barium sulfate, temperature dependence of solubility, 305
- Bingham plastics, fluid flow of, mathematical relationship for circular pipes, 168
  - heat transfer for laminar flow through tubes, discussion of, 173
  - sediment movement in, discussion and mathematical treatment, 170
  - slurries, friction factor vs Reynolds number for smooth pipes, 169
- Biological hazards, homogeneous reactors, discussion, 302
- Biological shield, HRE-2, 396
- Blanket processing, plutonium producer, discussion of, 326
  - removal of Np, chemistry of Np in uranyl sulfate solutions, 327
  - removal of Pu, alternative methods, 330
    - behavior in uranyl sulfate solutions under dynamic conditions, 329
    - chemistry of plutonium in uranyl sulfate solutions, 326
    - solubility of tetravalent Pu in uranyl sulfate solution at 250°C, 327
- Blanket-vessel design, discussion for two-region reactors, 409
- Blast shield, HRE-2, for containment of missiles, 395
- Boiler feed water, treatment of, 472
- Boiling Reactor Experiment (BRE), conceptual design studies for, 8
  - definition of, 13
  - discussion of, 21
  - homogeneous, discussion of, 22
    - general discussion of, 22
  - slurry, 23
- Breeder reactors, definition of, 13
- Breeding, importance of, 19
- Breeding ratio (BR), as function of pressure vessel size, etc., 53
  - and fuel concentrations (unsteady-state), calculations relative to HRE-3 conceptual design, 59
  - comparison of values for one- and two-region reactors, 46
  - definition of for criticality calculations, spherical reactors, 31
  - dependence of on value of  $\eta$   $U^{233}$  spherical reactors, 37
  - effect of blanket  $U^{233}$  concentration on, for spherical homogeneous reactors, 47
  - effect of copper addition on, 55
  - effect of core poison fraction on, 54
  - effect of  $H_2O$  concentration on, 55
  - for cylindrical reactors of various heights, 51
  - homogeneous spherical reactors, 35
  - spherical homogeneous reactors, two-region, effect of core

- thorium concentration and wall power density on, 45
- results of calculations for, 45
- Bubble problem, homogeneous reactors, 7
- Burner reactors, definition of, 13
- homogeneous, discussion of, 17
- Capital costs, as a function of power level, 550
- bases for calculations, 521
- breakdown for large scale reactors, 546
- HRE-1, 357
- HRE-2, 398
- large-scale aqueous plutonium-power producers, 494
- large-scale plants, 545
- Nuclear Power Group Two-Region Breeder, 499
- one-region power producers, 495
- turbogenerator plants, 548
- Wolverine Reactor, 476
- Carbon adsorption beds, HRE-2, 366
- Carbon beds, HRE-1, 353
- Carbon steel, homogeneous reactor metallurgy of, 262
- physical metallurgical properties, effect of neutron irradiation, 279
- effect of neutron irradiation on yield and tensile strengths, 280
- selection for service under irradiation, 282
- slurry corrosion rates of, discussion, 249
- slurry corrosion resistance of, effect of hydrogen atmosphere, 259
- see also* Pressure vessel steels
- Catalytic recombination of radiolytic gases, effect of variables (firing time, etc.) on, in thorium oxide slurries, 186
- thorium oxide, molybdenum oxide experiments, 186
- Centrifugal pump—HRE-2 mock-up, 380
- Charcoal adsorbers, purpose in homogeneous reactors, 440
- Chemical conversion, costs for, 518
- Chemical processing, blanket material of two-region breeder, conceptual flow diagram, 302
- blanket removal of Np, solubility of Np in uranyl sulfate solutions, 327
- blanket removal of Pu, alternative methods, 330
- behavior in uranyl sulfate solutions under dynamic conditions, 329
- chemistry of Pu in uranyl sulfate solutions, 326
- solubility of tetravalent Pu in uranyl sulfate solution at 250°C, 327
- costs for, 517
- disposal of gaseous fission products, 312
- adsorption of Kr on several adsorbents, 313
- capacity of several adsorbents, 314
- design of adsorber system, 316
- discussion of HRE-2 adsorber system, 316
- homogeneous fuels, discussion of neutron poisons, 301
- plutonium-producer, conceptual flow diagram, 303
- removal of iodine, discussion of chemistry of iodine, 319
- discussion in terms of HRE-2, 324
- oxidation state at high temperature and pressure, 322
- oxidation state at low temperature, 323
- proposed system for HRE-3, 325
- vapor-liquid distribution, 320
- volatility under reactor conditions, 320
- removal of solids, 304
- removal of solubles, by solvent extraction, 368
- by uranyl peroxide precipitation, 318
- by uranyl peroxide precipitation, schematic flow diagram, 319
- discussion, 317
- thorium oxide blanket, adaptability of the flowsheet, 335
- alternative processes for, 335

- average decontamination factors
  - of the Thorex pilot plant, 334
- discussion, 332
- feed preparation flowsheet, 331
- solvent extraction
  - codecontamination flowsheet, 331
  - solvent extraction step, 333
  - uranium isolation and third cycle flowsheet, 332
- two-region breeder, conceptual flow diagram, 302
- Chloride ion, effect of concentration
  - on stress-corrosion cracking of type-347 stainless steel, 284
- effect on stress-corrosion in fuel solutions, 284
- effect on stress-corrosion in fuel solutions, discussion of 100-gpm dynamic loop experiments, 287
- Circulating pumps, discussion, 413
  - HRE-1, discussion, 350
  - HRE-2 blanket, discussion, 413
  - hydraulic parts for wear resistance, 416
  - large scale, 498
    - discussion in terms of remote maintenance, 468
  - PAR reactor, maintenance of, 490
  - Westinghouse 400A for HRE-2 fuel, 415
    - for slurries, discussion of wear, 416
- Cold traps, purpose in homogeneous reactors, 439
- Condenser, purpose in aqueous low-pressure systems, 439
- Containment, cost of, in HRE-2, 398
  - discussion of the containment vessel, 471
  - methods, HRE-2, 391
    - Wolverine Reactor Design, 478
    - NPG and B & W Breeder, 501
    - NPG breeder reactor, 499
- Control panel, HRE-2, 384
- Converter reactors, definition of, 13
- Core- and blanket-vessel design, conceptual, 409
- Core and pressure vessel, HRE-2, discussion, 412
  - illustrated, 412
- Core pressure rise, homogeneous reactors, safety of, calculation for, 74
- Core processing, disposal of gaseous fission products, 312
  - adsorption of Kr on several adsorbents, 313
- removal of iodine, discussion, 323
  - discussion in terms of HRE-2, 324
  - discussion of chemistry of iodine, 319
  - oxidation state at high temperature and pressure, 322
  - oxidation state at low temperature, 323
  - proposed system for HRE-3, 325
  - vapor-liquid distribution of, 320
  - volatility under reactor conditions, 320
- removal of solids, 304
  - dimensions of three sizes of hydroclones, 311
  - discussion of HRE-2 processing plant, 309
  - drawing of HRE-2 chemical plant hydroclone container, 311
  - factors influencing design of hydroclones, 306
  - schematic diagram of hydroclone, 307
  - solubilities of selected fission- and corrosion products, general discussion, 305
  - solubility of lanthanum sulfate, 304
  - solubility of neodymium sulfate as affected by uranyl sulfate concentration, 305
  - solubility of rare earth sulfates at 280°C, 305
  - temperature dependence of solubility of barium sulfate in core solutions, 305
  - temperature dependence of solubility of strontium sulfate in core solutions, 305
  - use of hydroclones, 306
- removal of solubles, by solvent extraction, 318
  - discussion, 317

- schematic flow diagram for
  - uranyl peroxide method, 319
  - uranyl peroxide precipitation, 318
- Core-vessel design, discussion for
  - two-region reactors, 409
- HRE-1, dimension and material of construction, 350
- hydrodynamics, discussion for
  - two-region reactors, 402
- Corrosion products, chemistry of, 304
- neutron poisoning by, 302
- Cost calculations, bases for, 516
- Cost studies, capital costs, for a
  - 3-reactor station operating at 1350 thermal mw (315 electrical mw), 546
  - for large-scale plants, 545
  - of a homogeneous reactor power station as a function of station size, 550
  - of two-region aqueous homogeneous reactors, 548
- chemical conversion costs, 518
- chemical processing costs for aqueous homogeneous reactors, 517
- discussion of, 515
- effect of design variables on fuel costs, 521
- for fuel processing cycle, 521
- for investment, operating, and maintenance costs, 521
- fuel, comparison of fuel costs for one- and two-region reactors, 539
  - cost breakdown for batch-operated homogeneous reactors (no hydroclone), 536
  - effect of blanket thickness and thorium concentration, 524
    - for a two-region breeder, 524
  - effect of core diameter and core thorium concentration, 525
  - effect of core thorium concentration and diameter, 524
  - effect of design variables for uranium-plutonium systems, 530
  - effect of fuel-processing rate and charge and poisoning on fuel cost for  $\text{UO}_3\text{-ThO}_2\text{-D}_2\text{O}$  reactors, 544
  - effect of  $\text{Li}_2\text{SO}_4$  on the fuel cost of a plutonium-producer—power reactor, 540
  - effect of nuclear parameters, 527
  - effect of power level, 527
    - on fuel costs for one-region reactors, 543
  - effect of reactor power in one-region reactors, 529
  - effect of thorium concentration in one-region reactors, 528
  - effect of  $\text{U}^{233}$  concentration (blanket) or core poison fraction on fuel cost, 523
  - effect of uranium concentration and reactor diameter, 532
  - effect of xenon poison, 528
  - effect of xenon removal, 527
  - equilibrium fuel concentrations and reactor dimensions for homogeneous reactors operating at 280°C and producing 125 mw electrical power, 551
  - for batch-operated homogeneous  $\text{UO}_2\text{SO}_4\text{-Li}_2\text{SO}_4$  reactors, 534
  - for dual-purpose plutonium-power reactors, 537
  - for one-region  $\text{PuO}_2\text{-UO}_3\text{-D}_2\text{O}$  reactors of 12-ft diameter, 531
  - for one-region  $\text{UO}_2\text{SO}_4\text{-Li}_2\text{SO}_4\text{-D}_2\text{O}$  power reactors, 532
  - for two-region reactor having a 6-ft core and 10-ft diameter, 537
  - for two-region  $\text{UO}_3\text{-PuO}_2\text{-D}_2\text{O}$  reactors, 535
  - for  $\text{U}^{235}$  burner reactors, 539
  - isotope concentrations and fuel cost-breakdown for some  $\text{U}^{235}$  burner reactors, 541
  - one-region  $\text{PuO}_2\text{-UO}_3\text{-D}_2\text{O}$  reactors, 530
  - one-region spherical reactors, 527
  - one-region  $\text{UO}_2\text{SO}_4\text{-D}_2\text{O}$  and  $\text{UO}_2\text{SO}_4\text{-Li}_2\text{SO}_4\text{-D}_2\text{O}$  reactors, 538
  - one-region U-Pu reactor, 530
  - results for several one-region reactors near optimal conditions, 533
  - shape-effect comparison for cylindrical and spherical reactors, 529

- shape-effect of cylindrical reactors, 529
- summary of fuel costs for different reactors, 542
- two-region reactor fuel cycle, 537
- two-region U-Pu reactor fuel costs, 538
- cycle, 537
- influence of reactor variables, discussion, 523
- operating and maintenance, large scale plants, 549
- power, summary of estimated costs, 553
- power costs, for large scale aqueous homogeneous reactors (125 electrical mw, 80% load factor, 280°C), 552
- influence of power level on "present" power costs in U<sup>235</sup> burners, 553
- price of high-purity U<sup>233</sup>, 518
- Purex process, 519
- relation to reactor design factors, 514
- schematic flow sheet for two-region homogeneous thorium breeder reactor, 522
- slurry reactors, core and blanket specifications, 524
- Thorex process, 519
- turbine plant cost and net station efficiency vs steam temperature, 548
- USAEC official price schedules for nuclear materials, 518
- Critical concentration, cylindrical reactors, evaluation for, 49
- Critical mass, homogeneous reactors, effect of thorium slurry settling on, 75
- Critical velocity, definition in terms of corrosion studies, 222
- Criticality calculations, aqueous-homogeneous reactors, factors in, 29
- spherical, nuclear constants used in, 39
- spherical, nuclear data for, 41
- spherical, resonance integrals, 43
- Cylindrical reactors, breeding ratios for, at various heights, 51
- Cylindrical reactors, fuel costs in, 529
- Decontamination, HRE-1 equipment, discussion of, 358
- HRE-2 equipment, 379
- Diaphragm pumps, check-valve materials, 444
- construction for HRE-2 use, 442
- discussion of developmental work, 443
- durability of, 442
- HRE-1, fuel concentration control, 353
- HRE-2, for return of condensate, 364
- HRE-2 mock-up, for fuel feed, 380
- purpose in homogeneous reactors, 441
- sketch, 441
- slurry, discussion of methods under test, 444
- Diffusion equations, two-group, for criticality calculations, spherical reactors, 32
- Dump tank—HRE-2 mock-up, 380
- Dynamic corrosion test loop, determining corrosion rates by, diagram, 201, 203
- discussion, 201
- discussion of equipment, 203
- Eddy corrosion, a feature of slurry corrosion, discussion, 251
- photo of effect on stainless steel impeller, 252
- Electrical wiring and accessories, HRE-2, discussion, 460
- Elgiloy, corrosion rate in uranyl sulfate solution at high temperature, 217
- Entrainment separator, discussion of HRE-2 design, 436
- Eta-U<sup>233</sup>, value for in resonance region, homogeneous spherical reactors, 34
- Evaporator, purpose in HRE-2, 435
- "Fast fission factor," definition of for criticality calculations, spherical reactors, 31
- Feed pumps: *see* Diaphragm pumps

- Ferritic and martensitic stainless steels, slurry corrosion rates of, discussion, 249
- Ferritic stainless steels, corrosion of, out of pile, by uranyl carbonate, 213
- Fission and corrosion products, general discussion of solubilities, 305
- Fission product iodine, chemistry in fuel solutions, 319
  - oxidation state at high temperature and pressure, 322
  - oxidation state at low temperature, 323
  - proposed removal system for HRE-3, 325
  - removal from aqueous homogeneous reactors, 323
  - removal from HRE-2, 324
  - vapor-liquid distribution of, 320
  - vitro iodine test loop, 321
  - volatility under reactor conditions, 320
- Fission products, chemistry of, 304
  - gaseous, adsorptive capacity of several adsorbents, 314
    - design of adsorber system, 316
    - disposal of, 312
      - adsorption of Kr on several adsorbents, 313
- Fissionable isotopes, production of in terms of neutron economy, 29
- Fissionable material, annual requirement of, 20
- Flame recombiner, HRE-1, 352
- Flange closures, discussion, 429
- Flange joints, bi-metallic, discussion, 431
  - Vickers-Anderson, discussion, 431
- Flow delay tanks, purpose of, 472
- Fluidized-bed reactors, discussion of, 24
- Fluidized suspension reactors, definition of, 13
  - discussion of, 24
- Freeze plugs, purpose and discussion in terms of homogeneous reactors, 451
- Fuel concentrations and breeding ratios for two-region
  - homogeneous reactors, estimation of minimum fuel costs, 44
  - evaluation under initial conditions, 44
  - initial and steady-state conditions, 43
- Fuel costs, bases for calculations, 516
  - comparison of in various reactors, 542
  - cylindrical reactors, discussion, 529
  - effect of power level, 527
  - effect of xenon removal, 527
  - homogeneous reactors, 526
  - in  $\text{ThO}_2\text{-UO}_3\text{-D}_2\text{O}$  systems, 521
  - one-region power reactors with  $\text{Li}_2\text{SO}_4$  added, 532
  - one-region spherical reactors, 528
    - discussion, 527
    - effect of xenon removal, 528
  - two-region breeders, effect of blanket thickness, 524
    - effect of core diameter, 525
    - spherical systems, 523
  - $\text{U}^{235}$  burner reactors, 539
- Fuel inventory, HRE-2, system for, 386
- Fuel processing, costs for, 519
  - discussion of chemistry of Pu in uranyl sulfate solutions, 326
  - disposal of gaseous fission products, 312
    - adsorption of Kr on several adsorbents, 313
    - adsorptive capacity of several adsorbents, 314
    - design of adsorber system, 316
    - discussion of HRE-2 adsorber system, 316
  - flowsheet for, 522
  - removal of iodine, discussion, 323
    - discussion of chemistry of iodine, 319
    - discussion in terms of HRE-2, 42
    - oxidation state at high temperature and pressure, 322
    - oxidation state at low temperature, 323
    - proposed system for HRE-3, 325
    - vapor-liquid distribution of, 320
    - volatility under reactor conditions, 320

- removal of Np, solubility of Np in uranyl sulfate solutions, 327
- removal of Pu, alternative methods, 330
  - behavior in uranyl sulfate solutions under dynamic conditions, 329
  - solubility of tetravalent Pu in uranyl sulfate solution at 250°C, 327
- removal of solubles, discussion, 317
  - schematic flow diagram for uranyl peroxide method, 319
  - solvent extraction, 318
  - uranyl peroxide precipitation, 318
- two-region breeder, conceptual flow diagram, 302
- Fuel systems, aqueous, for enriched-fuel burner reactors, 17
  - high temperature, solution-type reactors, 17
- Gamma heating, discussion, 411
- Gamma ionization chamber, 460
- Gamma radiation measurement, 459
- Gas adsorber, disposal of gaseous fission products, adsorptive capacity of several adsorbents, 314
  - design of adsorber system, 316
  - discussion of HRE-2 gas adsorber system, 316
  - evaluation of adsorbents, 314
- Gas handling, carbon adsorption beds for HRE-2 fission gases, 366
  - catalytic recombiner for HRE-2, 364
  - oxygen injection to prevent hydrolytic precipitation of uranium, 362
  - recombination of radiolytic gases in HRE-2, 362
- Gas separators, discussion of HRE-2 type, 432
- Gases, reaction limits and pressures, discussion, 120
  - solubility in water and reactor solutions, 120
  - steam-oxygen and steam-helium, P-V-T relationships, 120
- Gold, corrosion rates in uranyl fluoride solution, 215
- Heat exchanger, design data for HRE-2, 420
- Heat transfer, of thorium oxide slurries, 174
- Heavy water, costs of, 517
  - densities of liquid and vapor at elevated temperatures, 112
  - density of, discussion, 113
  - viscosity at elevated temperatures, 114
- Homogeneous catalysts, thermal recombination of H<sub>2</sub> and O<sub>2</sub> in aqueous uranium solutions, discussion, 107
- Homogeneous reactor development, levels of effort expended on, 9
- Homogeneous reactors, biological hazards, 302
  - characteristics of large scale, 526
  - large scale, fuel costs in, 526
- HRE-1 (Homogeneous Reactor Experiment No. 1), 341
  - beginning of construction of, 8
  - capital cost, 357
  - circulating pump, discussion of, 350
  - core vessel, design features, 350
  - critique, 358
  - dependence of critical concentration on temperature, 354
  - design, 350
  - discussion, 348
  - dismantling of, discussion, 358
  - equipment decontamination, discussion, 358
  - fuel concentration control, diaphragm pump for, 353
  - fuel system, 348
  - internal gas-recombination experiments, description, 355
  - leak detection device, discussion, 357
  - leak prevention, discussion, 356
  - maintenance, discussion, 357
  - nuclear safety, discussion, 355
  - off-gas system, activated carbon beds, 353
    - discussion of, 352
    - flame-recombiner, 352
  - power density, 350
  - power response during reactivity increase, 357
  - pressure vessel, discussion of, 350

- reflector system, 350
- schematic flow diagram of, 351
- shielding, 350
  - discussion, 357
- summary of results of operation, 359
- HRE-2 (Homogeneous Reactor Experiment No. 2), 341
  - biological shield, 396
  - blast shield, 395
  - capital cost (tabulation), 398
  - carbon adsorption beds for fission gases, 366
  - catalytic recombiner, 364
  - chemical plant, tests of solids removal in, 312
  - chemical processing plant, diagram of hydroclone container, 311
    - dimensions of hydroclones, 308
    - discussion of experimental hydroclone work, 309
  - disposal of gaseous fission products, discussion, 316
  - flow diagram for, 307
  - photo, 310
  - components for, charcoal adsorbers, 440
    - circulating pumps, 413
    - cold traps, 440
    - condenser, 439
    - construction of diaphragm pump, 442
    - core and pressure vessel, 412
      - illustrated, 412
    - diaphragm pump check-valve materials, 444
    - diaphragm pumps for feed, 441
    - differential-pressure cells, 458
    - discussion of instrumentation and controls, 454
    - durability of diaphragm pumps, 442
    - effect of thermal cycling with diphenyl on steam generators, 420
    - electrical wiring and accessories, 460
    - entrainment separator, 436
      - drawing, 436
    - evaporator, 435
    - float transmitter for pressurizer level, 456
    - flow transmitters, 459
    - freeze plugs, 451
    - gas-metering valve to regulate O<sub>2</sub> flow to high-pressure system, 448
    - gas recombiner and condenser sketch, 437
    - gas recombiners, 436
    - gas separator, 432
    - heat-exchanger design data, 420
    - importance of valves, 445
    - letdown heat exchanger, 450
    - nuclear instrumentation, 459
    - oxygen injection equipment, 452
    - pressurizers, 423
      - reason for construction, 8
    - refrigeration system, 452
    - sampling equipment, 448
    - sketch of flame recombiner for off-gas after shutdown, 438
    - sketch of gas-metering valve, 448
    - sketch of letdown and low-pressure valves, 446
    - sketch of liquid level transmitter for pressurizer, 455
    - sketch of sampling equipment, 449
    - slurry steam generator, 423
    - spare steam generator, 422
    - steam generators, 419
    - steam pressurizer for the core, 425
    - storage tank (fuel), 434
      - sketch, 434
    - storage tank (slurry), 435
    - valve actuators, 445
    - valve designs, 445
    - weigh systems for inventory purposes, 456
    - Westinghouse 400A pump for fuel, 415
    - Zircaloy-stainless steel joint, 413
  - conditions necessary for hydrogen-oxygen explosions, 394
  - containment methods, 391
  - control panel, 384
  - control room and instrument panel, photo, 385
  - core tank, fabrication of, inverse pole figures of Zircaloy-2 before and after refabrication, 265
    - discussion of welding method, 273



- joint configuration of Zircaloy-2 trailer and titanium air weldments, 272
- welding set-up, 272
- metallurgy of, discussion of Zircaloy-2 physical metallurgy and fabrication, 263
- microstructures of Zircaloy-2 plates fabricated by different schedules, 264
- core vessel, fabrication of, non-destructive testing, 278
- corrosion minimization, 394
- critical concentration, 376
- critical concentration as a function of temperature, 377
- decontamination of equipment, 379
- design specifications, 360, 361
- diaphragm pump for return of condensate, 364
- flowsheet, 363
- fuel inventory systems, 386
- heating and cooling rates in terms of stresses, 393
- instrument and control system, 381
- key control loops using pneumatic and electric transmission, 382
- leak detection system, 371
- leak tests, 374
- maintenance concepts, 388
- maximum pressure during nuclear accident, 394
- oxygen injection to prevent hydrolytic precipitation of uranium, 362
- radiation dosage through shield, 366
- nonnuclear testing and operation, 371
- nuclear-instrument thimble, 383
- nuclear instrumentation, 383
- nuclear operation, 375
- objectives of the reactor, 359
- operation of pressure-vessel mockup system, 177
- operational techniques and special procedures, 376
- photo of container at 50% completion, 368
- piping joints for remote maintenance, 388
- radiation dosages in remote maintenance work, 388
- recombination of radiolytic gases, 362
- remote maintenance, 387
- remotely operable tools, 389
- safety, in terms of hydrogen-oxygen explosions, 395
  - in terms of missiles, 395
- samplers for fuel and blanket liquids, 366
- schedule of construction, 369
- shield, discussion, 366
  - and vapor-container, sketch, 367
- slurry blanket, flowsheet, 177
  - operating experience with, 176
- specifications and description, 359
- stress cracking, 373
- summary of design and construction experience, 396
- summary of nonnuclear operation, 372
- HRE-2 mock-up, diaphragm feed-pumps used in, 380
  - discussion, 380
  - dump tank used in, 380
  - letdown heat exchanger used in, 380
  - letdown valve used in, 380
  - liquid-level controller used in, 380
  - one-eighth-scale steam generator used in, 380
  - oxygen-feed system used in, 380
  - pulsafeeder (diaphragm pump) used in, 380
  - summary of experience, 381
  - Westinghouse canned-rotor centrifugal pump used in, 380
- HRE-3, aqueous thorium breeder reactor, 9
  - breeding ratio and certain isotope concentrations vs time, graphs of, 64
  - comparison of breeding ratios and  $U^{233}$  core concentrations for various cores and core concentrations, graphs of, 66
  - conceptual design calculations for unsteady-state fuel concentrations and breeding ratios, 59
  - design criteria, 510

- discussion, 509
- iodine removal system, 325
- two-region reactor, intermediate scale, design characteristics of at equilibrium conditions, 52
- HRR (Homogeneous Research Reactor), feasibility study, 479
  - key design specifications, 481
  - layout plan view, 483
  - layout sectional elevation, 484
  - maintenance concept, 484
  - maintenance equipment, 485
  - plan view, 485
  - steam-generator specifications, 480
- Hydroclone, container for in HRE-2
  - chemical plant, 311
  - dimensions of three sizes, HRE-2 chemical plant, 311
  - factors influencing design, 306
  - schematic diagram of, 307
  - use in core processing, 306
- Hydrogen and oxygen explosions, conditions for in HRE-2, 394
- Hydrogen peroxide decomposition, aqueous reactors, mechanisms for, 108
- HYPO (High Power Water Boiler), 5, 341
  - description of, 341
- In-pile autoclaves, for irradiation of thorium oxide slurries, 180
- In-pile loops, approximate operating conditions for, 235
  - determining corrosion rates by, exterior view of dismantling facility, 208
    - assembly drawing, 207
    - discussion, 205
    - interior view of dismantling facility, 210
    - physical data, 206
  - methods and procedures employed, 234
- Instrument and control system, HRE-2, 381
- Instrument thimble, HRE-2, 383
- Instrumentation, nuclear, HRE-2, 383
- Instrumentation and controls, differential pressure (D/P) cells as level transmitters, 456
  - differential pressure cells for HRE-2 use, 458
  - differential-transformer type of float transmitter, 456
  - float-type liquid-level transmitters, 456
  - flow transmitters for HRE-2, 459
  - fluid damping transmitters (Dynatrol), discussion, 458
  - heated thermocouple wells for liquid-level alarm or control, 457
  - liquid-level transmitters discussion, 455
  - nuclear instrumentation in the HRE-2, 459
  - pneumatic signal transmitter, discussion, 454
  - pressure transmitters, 458
  - pressure transmitter in safety housing, sketch, 457
  - weigh systems for tank inventories in HRE-2, 456
- Instrumentation and controls systems, discussion in terms of homogeneous reactors, 454
  - electric signal transmitter, discussion, 454
- Intermediate-Scale Homogeneous Reactor (ISHR), conceptual design studies for, 8
  - discussion and description, 504
- Iodine, chemistry in reactor fuel solutions, discussion, 319
  - oxidation state at high temperature and pressure, 322
  - oxidation state at low temperature, 323
  - proposed removal system for HRE-3, 325
  - removal bed, efficiency of in HRE-2, 324
  - removal from aqueous homogeneous reactors, 323
  - removal from high pressure system, 322
  - removal from HRE-2, 324
  - vapor-liquid distribution of, 320
  - vitro iodine test loop, schematic, 327
  - volatility under reactor conditions, 320
- Isotopes, core concentrations of, for  $U^{233}$  fuel, table of, 63