Contents

1 Introduction ................................................................. 1
  1.1 An Apologia ............................................................. 3
References ................................................................. 4

Part I Predestination

2 Cleveland State University, Cleveland 1959–1964 ................. 7
  2.1 Elmore S. Pettyjohn, Former Director of the Institute of Gas
      Technology, is on the Faculty of the Fenn College Chemical
      Engineering Department ........................................ 13
References ................................................................. 18

3 Illinois Institute of Technology (IIT), Chicago 1964–1970 ....... 21
  3.1 Professor Gidaspow Is on the Faculty of the Gas Technology
      Department ....................................................... 25
  3.2 Charlie Solbrig Is on the Faculty of the Gas Technology
      Department ....................................................... 29
References ................................................................. 31

Part II In a State Far Away 1970–1977

4 The Seeds Are Sown by Larry Ybarrondo and Charlie Solbrig
   in a State Far Away, Idaho Falls, Idaho .......................... 35
  4.1 The “Loss-of-Coolant Accident” and the RELAP Series of
      Codes ............................................................. 39
  4.2 A Mysterious Stranger Points the Way Forward ................. 43
  4.3 The Development of a Totally New Set of Two-Phase
      Equations ....................................................... 44
References ................................................................. 48
5 Project Development Begins ............................................. 51
  5.1 I Am Hired by Charlie Solbrig to Work on the SLOOP
         (Seriated Loop) Code at Aerojet Nuclear Company (ANC) ..... 55
     References ..................................................................... 64

6 Characteristics Analysis of the One-Dimensional, Two-Fluid
Partial Differential Equations (PDE’s) Developed by Charlie
Solbrig and Dan Hughes .......................................................... 67
  6.1 Dimitri’s Sabbatical and the Discovery of Ill-Posedness
         (Complex Characteristics) of the PDE’s .......................... 72
  6.2 Characteristics Analyses Using FORMAC .......................... 77
     References ..................................................................... 82

7 The SLOOP Code Development .............................................. 85
  7.1 Dimitri’s Contract Is Extended ......................................... 89
  7.2 Comparison of Prototype Two-Phase SLOOP Code with
         Analytical Solutions ..................................................... 89
  7.3 Attempts to Develop Two-Pressure Models Having Real
         Characteristics ............................................................... 93
  7.4 Summary of SCORE, SPLEN, Executive, ZVUT, EVET,
         UVET, ADF, SSUVET, and UVUT Codes ......................... 96
  7.5 Investigations into Why the Pressure Kept Going to Zero
         for Standard Problem 1 ................................................... 99
  7.6 The Los Alamos/Aerojet Meeting of August 27, 1974 .......... 105
  7.7 SLOOP Code Development Implodes Scattering Most
         of the Participants ..................................................... 113
     References ..................................................................... 114

8 The Characteristics Paper Caper .......................................... 119
  8.1 The Journal of Fluid Mechanics Paper ................................. 120
  8.2 The 1975 ASME Winter Annual Meeting Paper
         and Presentation ......................................................... 121
  8.3 The Nuclear Science and Engineering Paper ......................... 128
     References ..................................................................... 133

Part III The Rise of CFD Codes

9 RETRAN Is Initiated at Energy Incorporated for EPRI Hiring
   the Core SLOOP Code Participants ....................................... 137
     References ..................................................................... 145

10 RELAP5 is Initiated by Vic Ransom and Dick Wagner Funded
     by Larry Ybarondo ........................................................... 149
    References ..................................................................... 155
11 DOE Starts Code Development at Systems, Science and Software and JAYCOR to Address the Energy Crisis Caused by the Oil Embargos ................................................................. 157
References ....................................................................... 159

12 IIT Code Begins Using Los Alamos’ K-FIX Code ................. 161
12.1 K-FIX Code Obtained from Bill Rivard to Start IIT Code . . . 164
References ....................................................................... 172

13 METC Starts Erosion R&D Cooperative Venture and MFIX Code Development Using FLUFIX Code ...................... 175
13.1 The METC Cooperative R&D Venture .................................. 175
13.2 METC Starts the MFIX Code Development ......................... 181
References ....................................................................... 182

14 The Rise of the First Commercial CFD Codes: PHOENICS, FLUENT, FIDAP, CFX, FLOW-3D, and STAR-CD .......... 185
14.1 PHOENICS Code ............................................................... 185
14.2 FLUENT, FIDAP, CFX, and FLOW-3D Codes .................... 185
14.3 STAR-CD ....................................................................... 186
References ....................................................................... 187

Part IV Attempts to Establish a National Program for Multiphase Flow Research

15 The Failure of Argonne National Laboratory to Establish the Multiphase Flow Research Institute ........................................... 191
References ....................................................................... 195

16 DOE OIT Virtual Center for Multiphase Dynamics Effort Begins—Becomes the Multiphase Fluid Dynamics Research Consortium ................................................................. 197
16.1 Computational Fluid Dynamics Technology Roadmap Published as Part of VISION 2020 ............................................. 199
16.2 The Attempt to Establish a Virtual Technology Multiphase Laboratory ................................................................. 200
16.2.1 First VTC “Kickoff” Meeting November 28, 1995 .... 201
16.2.2 Laboratory Coordinating Council Meeting December 6, 1995 ................................................................. 202
16.2.3 Second VTC Meeting December 13, 1995 ............. 203
16.2.4 Third VTC Meeting February 21, 1996 .................. 205
16.2.5 National Workshop on Computational Fluid Dynamics and Multiphase Flow Modeling October 30–31, 1996 .......... 208
16.3 The Four-Year Multiphase Fluid Dynamics Research Consortium (MFDRC) is Formed ............................................. 209
16.4 Vision 2020 Contributes to Commercial Success .................. 215
16.4.1 Collaboration Pays Off—MFDRC Pushes the Frontier of Modeling of Materials Transport ................ 215
16.5 Return on Investment Template .................................. 217
References ............................................................ 220

17 NETL Initiates Workshops on Multiphase Flow Research
Later Called Multiphase Flow Science ................................. 221
References ............................................................ 222

Part V Muliphase Conferences and Gidaspow’s Books

18 Conferences and Workshops Addressing Multiphase Needs and Problems Begin Due to Professor Dimitri Gidaspow’s Initiatives .......................................................... 227
References ............................................................ 228

19 Gidaspow Publishes His Two Multiphase Books ................... 231
19.1 Multiphase Flow and Fluidization Continuum and Kinetic Theory Descriptions .................................. 231
19.2 Computational Techniques: The Multiphase CFD Approach and Green Energy Technologies .................. 232
References ............................................................ 233

20 Conclusion—What Does the Future Hold? ............................. 235
References ............................................................ 239

Appendices ............................................................ 241

Appendix A: Acronyms and Abbreviations ......................... 241

Appendix B: Herbert Kouts’ 26th Water Reactor Safety Information Meeting Speech, 1998 .................. 245

Appendix C: Reviews for the Journal of Fluid Mechanics Manuscript “One-Dimensional Two-Phase Flow Equations and Their Characteristics” ......................... 251

Appendix D: Extracts from reviews of the manuscript “Characteristics and Stability Analysis of Transient One-Dimensional Two-Phase Equations and Their Finite Difference Approximations” by D. Gidaspow, R.W. Lyczkowski, C.W. Solbrig and E.D. Hughes for the session Fundamentals of Two-Phase Flow at the 1975 Winter Annual ASME Meeting, Houston, Nov. 30-Dec. 4, 1975 .................. 257
Appendix E: Discussion on the ASME paper 75-WA/HT-25

Appendix F: John Ramshaw’s Unpublished Commentary on his Paper with John Trapp .................................................. 271

Appendix G: Carl Hocevar’s letter of Resignation on September 21, 1974 to Dixie Lee Ray, Chair of the Atomic Energy Commission .................................................. 275

Appendix H: Chemical Process CFD Users Group Charter ............ 277

Appendix I: Memorandum of Cooperation for the DOE Virtual Technology Center for Multiphase Dynamics (VCMD). . . . 279

Appendix J: Review and Comments on the 2006 NETL Technology Roadmap .................................................. 283

Notes ................................................................. 323

Index ................................................................. 329
The History of Multiphase Science and Computational Fluid Dynamics
A Personal Memoir
Lyczkowski, R.W.
2018, XVII, 334 p. 19 illus., 4 illus. in color., Hardcover
ISBN: 978-3-319-66501-6