

# Frederick Phillips Brooks, Jr.

## Biography

Frederick P. Brooks, Jr., was born in 1931 in Durham NC, and grew up in Greenville NC. He received an A.B. summa cum laude in physics from Duke and a Ph.D. in computer science from Harvard, under Howard Aiken, the inventor of the early Harvard computers.

He joined IBM, working in Poughkeepsie and Yorktown, NY, 1956-1965. He was an architect of the Stretch and Harvest computers and then was the project manager for the development of IBM's System/360 family of computers and then of the Operating System/360 software. For this work he received a National Medal of Technology jointly with Bob O. Evans and Erich Bloch

Brooks and Dura Sweeney in 1957 patented an interrupt system for the IBM Stretch computer that introduced most features of today's interrupt systems. He coined the term computer architecture. His System/360 team first achieved strict compatibility, upward and downward, in a computer family. His early concern for word processing led to his selection of the 8-bit byte and the lowercase alphabet for the System/360, engineering of many new 8-bit input/output devices, and introduction of a character-string datatype in the PL/I programming language.

In 1964 he founded the Computer Science Department at the University of North Carolina at Chapel Hill and chaired it for 20 years. Currently, he is Kenan Professor of Computer Science. His principal research is in real-time, three-dimensional, computer graphics—"virtual reality." His research has helped biochemists solve the structure of complex molecules and enabled architects to "walk through" structures still being designed. He is pioneering the use of force display to supplement visual graphics.

Brooks distilled the successes and failures of the development of Operating System/360 in *The Mythical Man-Month: Essays in Software Engineering*, (1975, 20th Anniversary Edition, 1995). He further examined software engineering in a 1986 paper, "No Silver Bullet." In 1997, he and Professor Gerrit Blaauw published a major research monograph, *Computer Architecture: Concepts and Evolution*.

Brooks has served on the National Science Board and the Defense Science Board. He is a member of the National Academy of Engineering, the National Academy of Science, and the American Academy of Arts and Sciences. He has received the ACM A.M. Turing Award, the IEEE John von Neumann Medal, the IEEE Computer Society's McDowell and Computer Pioneer Awards, the ACM Allen Newell and Distinguished Service Awards, the AFIPS Harry Goode Award, the Eckert-Mauchly Award, and an honorary Doctor of Technical Science from the Swiss Federal Institute of Technology (ETH-Zürich).

He is married to Nancy Greenwood Brooks. They have three children: Kenneth, Roger, and Barbara, and nine grandchildren. Dr. Brooks became a Christian at age 31. He chaired the Executive Committee for the Central Carolina Billy Graham Crusade in 1973. The Brookses advise a chapter of InterVarsity Christian Fellowship, and he has taught an adult Sunday School class for over twenty-five years.

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Born 19 April 1931; Durham, NC USA  
Married, three children:  
Kenneth P. Brooks, 8/14/58  
Roger G. Brooks, 12/25/61  
Barbara B. LaDine, 2/24/65

## EDUCATION

Ph.D., Harvard University, Applied Mathematics (Computer Science), 1956; Howard H. Aiken, advisor;  
dissertation: *The Analytic Design of Automatic Data Processing Systems*  
S.M., Harvard University, Applied Mathematics (Computer Science), 1955  
A.B. *summa cum laude*, Duke University, Physics, 1953. First in class of 1953.

## TEACHING EXPERIENCE

University of North Carolina at Chapel Hill, Department of Computer Science  
**Kenan Professor of Computer Science, 1975-**  
**Professor of Computer Science, 1964-75**  
**Chairman, 1964-1984; founder**  
Twente Technical University, Enschede, The Netherlands: Visiting Professor, 1970  
Columbia University: Adjunct Assistant Professor, 1960-61  
Vassar College: Visiting Instructor, 1958  
IBM Systems Research Institute, Voluntary Education Program, and Summer Student Program Teacher, 1957-59

## DEVELOPMENT EXPERIENCE

IBM Corporation  
Poughkeepsie, New York  
**Corporate Processor Manager for Development of System/360 Computer Systems, 1961-1965**  
**Manager of Operating System/360, 1964-65**  
**Manager, System/360 Hardware Development, Data Systems Division, 1961-64**  
Systems Planning Manager, Data Systems Division (8000 series *et al.*), 1960-61  
Yorktown Heights, New York: Advisory Engineer, Thomas J. Watson Research Center, 1959-60  
Poughkeepsie, New York  
Project STRETCH: Advisory Engineer, 1958-59; Staff Engineer, 1956-58; Associate Engineer, 1956  
Professional summer jobs at IBM Endicott, Bell Labs, North American Aviation, Marathon Oil Co., 1952-56

## COMPUTER DESIGNS

IBM System/360: Manager of whole project, 1961-64  
IBM 8000 Series (never produced): Manager of Architecture, 1960-61  
IBM 7950 (Harvest): Instruction set-up, adjustments, 1957-58  
IBM 7030 (Stretch): Instruction sequencing, interruption, variable-field-length arithmetic, editing, programmable console, 1956-59  
A specialized computer for payroll, Ph.D. Dissertation, 1955-56

## **PATENTS**

U.S. 2,981,020 "Alphabetical Read-Out Device"

U.S. 3,048,332 "Program Interruption System" with D.W. Sweeney; also French, German, British patents on same. Broad coverage of mask-controlled interruption, vectored interruption, etc.

## **HONORS**

National Medal of Technology, 1985

A.M. Turing Award, Association for Computing Machinery, 1999

Bower Award and Prize in Science (\$250,000), Franklin Institute, 1995

Allen Newell Award, Association for Computing Machinery, 1994

Eckert-Mauchly Award, Association for Computing Machinery and The Institute of Electrical and Electronics Engineers-Computer Society, 2004

John von Neumann Medal, The Institute of Electrical and Electronics Engineers, 1993

Harry Goode Memorial Award, American Federation of Information Processing Societies, 1989

McDowell Award for Outstanding Contribution to the Computer Art, IEEE Computer Group, 1970

Distinguished Service Award, Association for Computing Machinery, 1987

Honorary Doctor of Technical Science, Swiss Federal Institute of Technology, ETH Zurich, 1991

Distinguished Fellow, British Computer Society, 1994

Royal Academy of Engineering, (U.K.) Foreign Member, 1994

Royal Netherlands Academy of Arts and Sciences, Foreign Member, 1991

National Academy of Science, Member, 2001

National Academy of Engineering, Member, 1976

American Academy of Arts and Sciences, Fellow, 1976

Guggenheim Fellowship for studies on computer architecture and the human factors of computer systems, 1975,  
at Cambridge University, England

Computer Pioneer Award, IEEE Computer Society, 1982

Association for Computing Machinery, Fellow (initial inductee), 1994

The Institute of Electrical and Electronics Engineers, Fellow, 1968

Fellow Award, The Computer Museum History Center, 2001

Thomas Jefferson Award, University of North Carolina at Chapel Hill, 1986

Order of the Golden Fleece, University of North Carolina at Chapel Hill

Computer Sciences Distinguished Information Services Award, Information Technology Professionals, 1970

CyberEdge Journal Annual Sutherland Award, April 1997

## **SERVICE**

National Science Board, 1987-1992

Defense Science Board, 1983-86

Chairman, Military Software Task Force, 1985-87

Member, Computers in Simulation and Training Task Force, 1986-87

Member, Artificial Intelligence Task Force, 1983-84

#### NSF Advisory Committees

Computer and Information Science and Engineering Advisory Committee, 1995-January 1999  
Education and Human Resources, 1992-1995 (Chairman, 1994)

#### National Research Council

Committee to study the High Performance Computing and Communications Initiative, co-chair, 1994-95  
Produced the so-called *Brooks-Sutherland Report*  
Computer Science and Technology Advisory Board, 1977-80  
Division of Mathematical Sciences, Executive Committee, 1967-70

#### Microelectronics Center of North Carolina

Committee of Institutional Technical Representatives 1980-85 (Chairman, 1981-83); a founder  
Triangle Universities Computation Center: Board of Directors (Chairman, 1975-77), 1965-1983; a founder  
North Carolina Education Computing Service: Policy Committee, and its predecessor, 1964- ; a founder  
IBM Corporation: Science Advisory Committee, 1979-93

Teknowledge Corporation: Technical Advisory Board, 1982-87

Austek Microsystems: Technical Advisory Board, 1984-86

#### Virtus Corporation

Board of Directors, 1992-99

#### Association for Computing Machinery, 1953-

National Council, Member-at-Large, 1966-70

Special Interest Group on Computer Architecture, Board of Directors, 1973-75

University of California at Berkeley: Computer Science Visiting Committee, 1996-98

#### Carnegie-Mellon University

Advisory Committee on the Undergraduate Computer Science Curriculum, 1992-94

School of Computer Science Advisory Board, 2002-

Stanford University: Computer Science Advisory Committee (Chairman, 1976-77), 1972-79

Princeton University: Computer Center Advisory Council (Chairman, 1969-72), 1968-72

#### Organization for Economic Cooperation and Development (OECD)

Consultant Expert on Technological Gaps in the Computer Industry, 1967-68

Atomic Energy Commission: Mathematics & Computer Sciences Research Advisory Committee, 1967-72

National Institutes of Health: Various special study sections

#### Executive Office of the President

Special assignment to the President's Science Advisor (studying Soviet computer status), 1959

National Security Agency: Special 6-week assignment on cryptographic research, 1959

#### Strategic Air Command

Task Force on False Alerts, ~1972

438L Study Group on Intelligence, 1959

UNC

Chancellor's Advisory Committee, 2000-2003; Chair, 2001-2003

Search Committee for Vice-Chancellor for Research and Graduate Studies, Chair, 2000-2001

Search Committee for Vice Chancellor for Information Technology, Chair, 1996-97

Chair, Conference of Chairs, sometime in 1970's

Durham Academy: Board of Trustees, 1973-80; (President, 1977-80)

Trinity School of Durham and Chapel Hill: Advisory Committee, Chair, 1995-2003; Board of Trustees, 2003-  
(Chair, 2003-)

## BIBLIOGRAPHY

### BOOKS AND CHAPTERS

Whitton, M., B. Lok, B. Insko, F. Brooks, "Integrating Real and Virtual Objects in Virtual Environments," *Advances in Virtual Environments Technology: Musings on Design, Evaluation, & Applications*, Lawrence Erlbaum Associates. To appear.

Taylor II, R. M., D. Borland, F. P. Brooks, Jr., M. Falvo, M. Guthold, T. Hudson, K. Jeffay, G. Jones, D. Marshburn, S. J. Papadakis, L. C. Qin, A. Seeger, F. D. Smith, D. H. Sonnenwald, R. Superfine, S. Washburn, C. Weigle, M. C. Whitton, P. Williams, L. Vicci and W. Robinett, "Visualization and Natural Control Systems for Microscopy," in *Visualization Handbook*, Edited by C. Johnson and C. Hansen, Harcourt Academic Press, 2004, 875-900.

Brooks, Jr., F. P. "Foreword" in D. Luebke, M. Reddy, J. D. Cohen, A. Varshney, B. Watson, and R. Huebner, *Level of Detail for 3D Graphics*. San Francisco, CA: Morgan Kaufmann Publishers, 2003, ix.

Brooks, Jr., F. P. "The History of IBM Operating System/360," in M. Broy and E. Denert eds., *Software Pioneers: Contributions to Software Engineering*. Berlin: Springer, 2002, 170-178.

Brooks, Jr. F.P. "Aiken and the Harvard 'Comp Lab'", in I. B. Cohen and G. W. Welch (eds.), *Makin' Numbers: Howard Aiken and the Computer*. Cambridge, MA: MIT Press, 1999, 137-142.

Blaauw, G.A., F.P. Brooks, Jr. *Computer Architecture: Concepts and Evolution*. Reading, MA: Addison-Wesley, 1997 (A research monograph and text for practicing architects), 1213 pages.

Brooks, Jr. F.P. "Language Design as Design," in T.J. Bergin and R.G. Gibson, eds, *History of Programming Languages II*. New York and Reading, MA: ACM Press and Addison-Wesley, 1996, 4-16.

Brooks, Jr., F.P. *The Mythical Man-Month: Essays on Software Engineering*, 20th Anniversary Edition. Reading, MA: Addison-Wesley, 1995, 322 pages. (Also in Chinese, Dutch, French, Japanese, Polish, Russian)

Brooks, Jr., F.P. and I.E. Sutherland, co-chairs, E. Bloch, D. Estrin, J. Hennessy, B.W. Lampson, E.D. Lazowska, W.A. Lester, J. Preston, W. Sincoskie, L. Smarr, J.F. Traub. *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure*. Washington: National Academy, 1995, 119 pages.

Brooks, Jr., F.P., chm., V. Basili, B. Boehm, E. Bond, N. Eastman, D.L. Evans, A.K. Jones, M. Shaw, C.A. Zraket. *Report of the Defense Science Board Task Force on Military Software*. Washington: Dept. of Defense, 1987, 78 pages.

F.P. Brooks, Jr., Pique, M, "Computer Graphics for Molecular Studies" in *Molecular Dynamics and Protein Structure: Proceedings of a Workshop held 13-18 May 1984 at the University of North Carolina*, Jan Hermans, ed., Published by Chapel Hill, University of North Carolina, Distributed by Polycrystal Book Service, 1985, pg. 109.

Brooks, Jr., F.P. *The Mythical Man-Month: Essays on Software Engineering*. Reading, MA: Addison-Wesley, 1975. (Also in Japanese, Russian, German, and Dutch.)

Brooks, Jr., F.P., K.E. Iverson. *Automatic Data Processing, System/360 Edition*. New York: John Wiley & Sons Inc., 1969, 466 pages. (Also in Polish)

Brooks, Jr., F.P., K.E. Iverson. *Automatic Data Processing*. New York: John Wiley & Sons Inc., 1963.

Brooks, Jr., F.P. In *Planning a Computer System*. W. Buchholz, ed. New York: McGraw-Hill, 1962. Author of Chapters 2, 10; co-author with W. Buchholz, G.A. Blaauw of Chapters 4, 7.

Brooks, Jr., F.P. In *Reference Manual for the IBM 7030 Data Processing System*, IBM Form A-22-6530, 1960. Author of several chapters.

#### TECHNICAL PAPERS (Major papers marked\*)

Burns, Eric, Sharif Razzaque, Mary C. Whitton, Frederick P. Brooks, Jr. 2007: "MACBETH: Management of Avatar Conflict by Employment of a Technique Hybrid," *International Journal of Virtual Reality*, 2007, To appear.

Jerald, J, A, Fuller, A. Lastra, M. Whitton, L. Kohli, F. Brooks 2007: "Latency Compensation by Horizontal Scanline Selection for Head-Mounted Displays," *Proceedings of SPIE, Vol. 6490, Stereoscopic Displays and Virtual Reality Systems XIV* (San Jose, CA, January 28-February 1, 2007), To appear.

Burns, E., F. P. Brooks, Jr. 2006: "Perceptual sensitivity to visual/kinesthetic discrepancy in hand speed, and why we might care," *Proceedings of the ACM Symposium on Virtual Reality Software and Technology* (Limassol, Cyprus, November 01-03, 2006), 3-8, VRST '06, ACM Press, New York, NY.

Brooks, Jr., Frederick P. "Software and Systems Management—Chapter 7 Summary," *Software Engineering: The Legacy of Barry W. Boehm*, R. Selby, ed., New York: John Wiley & Sons Inc., To appear (May 2007).

Burns, E., S. Razzaque, A.T. Panter, M. C. Whitton, M. R. McCallus, F. P. Brooks, Jr. 2006: "The Hand Is More Easily Fooled than the Eye: Users Are More Sensitive to Visual Interpenetration than to Visual-Proprioceptive Discrepancy," *Journal on Presence: Teleoperators and Virtual Environments*, **15**, 1: 1-15, February 2006.

Meehan, Michael, S. Razzaque, B. Insko, M. Whitton, F. P. Brooks 2005: "Review of Four Studies on the Use of Physiological Reaction as a Measure of Presence in Stressful Virtual Environments," *Applied Psychophysiology and Biofeedback*, **30**, 3: 239-258, September 2005.

\*Brooks, Fred, J. Cannon-Bowers, H. Fuchs, L. McMillan, M. Whitton 2005: "A New VE Challenge: Immersive Experiences for Team Training," *Proceedings of HCI International 2005*, v. 9, (Las Vegas, Nevada, July 2005), CD-ROM. (Invited)

Whitton, Mary, B. Lok, B. Insko, F. Brooks 2005: "Integrating Real and Virtual Objects in Virtual Environments," *Proceedings of HCI International 2005*, (Las Vegas, Nevada, July 2005), v. 9, (Las Vegas, Nevada, July 2005), CD-ROM. (Invited)

Whitton, M., Cohn, J., Feasel, J., Zimmons, P., Razzaque, S., Poulton, S., McLeod, B., Brooks, F. 2005: "Comparing VE Locomotion Interfaces," *Proceedings of IEEE Virtual Reality 2005*, (Bonn, Germany March, 2005), 123-130, IEEE Computer Society.

Burns, E., Razzaque, S., Panter, A. T., Whitton, M. C., McCallus, M. R., & Brooks, F. P. 2005: "The Hand is Slower than the Eye: A quantitative exploration of visual dominance over proprioception," *Proceedings of IEEE Virtual Reality 2005*, (Bonn, Germany March 2005), 3-10, IEEE Computer Society.

Lok, Benjamin, Samir Naik, Mary Whitton, and Frederick Brooks 2004: "Experiences in Extemporaneous Incorporation of Real Objects in Immersive Virtual Environments," *Beyond Glove and Wand Based Interaction Workshop Manual*, 107-110, IEEE Virtual Reality 2004, Chicago, IL.

\*Lok, Benjamin, Samir Naik, Mary Whitton, and Frederick P. Brooks, Jr. 2004: "Effects of Handling Real Objects and Avatar Fidelity on Cognitive Task Performance and Sense of Presence in Virtual Environments," *Journal on Presence: Teleoperators and Virtual Environments*, **12**, 6: 615-628.

\*Lok, B., S. Naik, M.C. Whitton, F.P. Brooks, Jr. 2003: "Incorporating Dynamic Real Objects into Immersive Virtual Environments," *Proceedings of ACM SIGGRAPH 2003 Symposium on Interactive 3D Graphics* (Monterey, CA, April 28-30, 2003), 31-40, ACM, New York. Five best papers were selected for presentation at SIGGRAPH 2003. The abstract is in those proceedings, *ACM Transactions on Graphics* **22**,3: 701.

- \*Lok, B., F.P. Brooks, Jr., S. Naik, M.C. Whitton 2003: "Effects of Handling Real Objects and Self-Avatar Fidelity on Cognitive Task Performance in Virtual Environments," *Proceedings of IEEE Virtual Reality 2003* (Los Angeles, CA, March 22-26, 2003), 125-132, IEEE Computer Society.
- \*Meehan, M., S. Razzaque, M.C. Whitton, F.P. Brooks, Jr. 2003: "Effect of Latency on Presence in Stressful Environments," *Proceedings of IEEE Virtual Reality 2003* (Los Angeles, CA, March 22-26, 2003), 141-148, IEEE Computer Society.
- Brooks, Jr., F.P. 2003: "Three Great Challenges for Half-Century-Old Computer Science." *Journal of the ACM*, **50**, 1: 25-26.
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- Brooks, Jr., F.P. 2001: "The History of IBM Operating System/360," *Proceedings of SD&M Software Pioneers Conference*, Bonn, Germany.
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- Guthold, M., M.R. Falvo, W.G. Matthews, S. Paulson, S. Washburn, D. Erie, R. Superfine, F.P. Brooks, R.M. Taylor II 2000: "Controlled Manipulation of Molecular Samples with the nanoManipulator," *IEEE/ASME Transactions on Mechatronics* **5**, 2 June 2000: 189-198.
- Guthold, M., M.R. Falvo, W.G. Matthews, S. Paulson, A. Negishi, S. Washburn, R. Superfine, F.P. Brooks, Jr., R.M. Taylor II 1999: "Investigation and Modification of Molecular Structures Using the nanoManipulator," *Journal of Molecular Graphics & Modeling*, **17**, 3: 187-197.
- \*Brooks, Jr., F.P. 1999: "What's Real About Virtual Reality?" *IEEE Computer Graphics and Applications*, **19**, 6: 16-27.
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- Guthold, M., G. Matthews, A. Negishi, R.M. Taylor II, D. Erie, F.P. Brooks, Jr., R. Superfine 1999: "Quantitative Manipulation of DNA and Viruses with the nanoManipulator Scanning Force Microscope," *Surf. Interf. Analysis* **27**: 437-443.
- Brooks, Jr., F.P. 1999: "Fourteen years of interactive walkthroughs," *SIGGRAPH '99 Course #20 Notes*, pp. H1-H21.
- \*Usoh, M., K. Arthur, M.C. Whitton, R. Bastos, A. Steed, M. Slater, F.P. Brooks, Jr., 1999: "Walking>Walking-in-Place>Flying in Virtual Environments," *Proceedings of SIGGRAPH 1999* (Los Angeles, CA, August 8-13, 1999), New York, 1999, pp. 359-364.
- \*Aliaga, D., J. Cohen, A. Wilson, E. Baker, H. Zhang, C. Erikson, K. Hoff, T. Hudson, W. Stuerzlinger, R. Bastos, M. Whitton, F.P. Brooks, Jr., D. Manocha 1999: "MMR: An Interactive Massive Model Rendering System Using Geometric and Image-Based Acceleration," *Proceedings of ACM Symposium on Interactive 3D Graphics (I3D)*, April 1999: 199-206.
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\*Falvo, M.R., G. J. Clary, R.M. Taylor II, V. Chi, F.P. Brooks, Jr., S. Washburn, R. Superfine 1997: "Bending and buckling of carbon nanotubes under large strain," *Nature*, **389**, 6651: 582-584.

Falvo, M.R., S. Washburn, R. Superfine, M. Finch, F.P. Brooks, Jr., V. Chi, R.M. Taylor II 1997: "Manipulation of Individual Viruses: Friction and Mechanical Properties," *Biophysical Journal* **72** (March 1997): 1396-1403.

Superfine, R., M.R. Falvo, S. Paulson, S. Washburn, R.M. Taylor II, G.J. Clary, V. Chi, F.P. Brooks, Jr. 1997: "Manipulation of Nanometer Objects: Friction, Mechanical Properties, and Devices," *Proceedings of the International Conference on Novel Materials*, Puri, India, March 3-7, 1997.

\*Miné, Mark R., F.P. Brooks, Jr., C.H. Sequin 1997: "Moving Cows in Space: Exploiting Proprioception as a Framework for Virtual Environment Interaction," *Computer Graphics, Proceedings Annual Conference Series, ACM SIGGRAPH*, Los Angeles, CA, 19-26.

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\*Brooks, Jr., F.P. 1996: "The Computer Scientist as Toolsmith II." Keynote/Newell Award address at SIGGRAPH 94, (Orlando, FL, July 1994). *Communications of the ACM*, March 1996, Vol. **39**, No. 3: 61-68. Also *Computer Graphics (Proceedings of SIGGRAPH '94)*, **28**, 4 (November 1994): 281-287.

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Varshney, A., F.P. Brooks, Jr., D.C. Richardson, W.V. Wright, D. Manocha 1995: "Defining, Computing, and Visualizing Molecular Interfaces," *Proceedings: Visualization '95*, Atlanta, October 1995, Los Alamitos, CA: IEEE Computer Society: 36-43.

\*Varshney, A., F.P. Brooks, Jr., W.V. Wright 1994: "Computing Smooth Molecular Surfaces," *IEEE Computer Graphics and Applications*, **14**, 5 (September 1994): 19-25.

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Brooks, Jr., F.P. 1990: "Force and Volume Visualization Methods for Molecular Studies." Invited address at the Ninth Annual Conference of the Molecular Graphics Society, Uppsala, Sweden, July 2-6. Abstract in *Journal of Molecular Graphics*, **8**, 4 (December 1990): 228-229.

\*Brooks, Jr., F.P., M. Ouh-Young, J.J. Batter, P. J. Kilpatrick 1990: "Project GROPE — Haptic Displays for Scientific Visualization," *Proceedings of SIGGRAPH '90*, (Dallas, Texas, August 6-10, 1990). In *Computer Graphics*, **24**, 4 (August 1990) ACM SIGGRAPH, New York, 1990, pp. 177-185.

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