

Exhibit No.:
Issues: Electromagnetic Fields
(EMF)
Witness: Walter Gajda, Ph.D.
Sponsoring Party: Union Electric Company
Type of Exhibit: Surrebuttal Testimony
Case No.: EO-2002-351
Date Testimony Prepared: September 4, 2002

MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. EO-2002-351

SURREBUTTAL TESTIMONY

OF

WALTER GAJDA, Ph.D.

ON

BEHALF OF

**UNION ELECTRIC COMPANY
d/b/a AmerenUE**

**Rolla, Missouri
September, 2002**

**BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI**

Application of Union Electric Company)
for Permission and Authority to Construct,)
Operate, Own and Maintain a 345 kilovolt)
Transmission Line in Maries, Osage and)
Pulaski Counties, Missouri)
("Callaway-Franks Line"))

Case No. EO-2002-351

AFFIDAVIT OF WALTER GAJDA

STATE OF MISSOURI)
) ss
COUNTY OF PHELPS)

Walter Gajda, being first duly sworn on his oath, states:

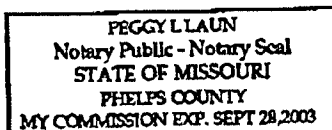
1. My name is Walter Gajda, Ph.D. I work in Rolla, Missouri and I am employed by the University of Missouri-Rolla as a Professor of Electrical and Computer Engineering.
2. Attached hereto and made a part hereof for all purposes is my Surrebuttal Testimony on behalf of Union Electric Company d/b/a AmerenUE consisting of 3 pages, which has been prepared in written form for introduction into evidence in the above-referenced docket.
3. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded are true and correct.

Walter Gajda
Walter Gajda

Subscribed and sworn to before me this 4th day of September, 2002.

Peggy L. Laun
Notary Public

My commission expires:



1 **MISSOURI PUBLIC SERVICE COMMISSION**

2 **CASE NO. EO-2002-351**

3 **SURREBUTTAL TESTIMONY OF**

4 **WALTER GAJDA**

5 **Q. Please state your name and business address.**

6 A. My name is Walter Gajda. My business address is 214 Emerson Hall,
7 University of Missouri-Rolla, Rolla, Missouri 65409-0040.

8 **Q. By whom are you employed, and in what capacity?**

9 A. I am employed by the University of Missouri-Rolla as a Professor of
10 Electrical and Computer Engineering.

11 **Q. What are your responsibilities and duties as a Professor of Electrical and**
12 **Computer Engineering?**

13 A. I am responsible for teaching, carrying out scholarly activities including
14 research, and providing service to appropriate organizations.

15 **Q. Please describe your educational and professional background.**

16 A. Please see my Curriculum Vitae attached to my testimony as Schedule 1.

17 **Q. What is the purpose of your Surrebuttal Testimony in this proceeding?**

18 A. I will respond to the testimony submitted by the Concerned Citizens of Family
19 Farms and Heritage (Intervenors) concerning the issue of electromagnetic fields (EMF).

20 **Q. In their testimony, the Intervenors contend that it is ingrained in the**
21 **popular mentality that power lines are a health hazard. (See, e.g., testimony of Darin**
22 **Arbis, pp. 2-3). One Intervenor, Ms. Claire Kramer, expresses concerns about the**
23 **safety of human beings living near the line due to EMF (pp. 4-5). Please respond.**

1 A. I have conducted research, in conjunction with Biology faculty, into the
2 effects of electromagnetic fields on insects, plants, and seeds. Despite working in proximity
3 to a 2.25 million volt (approximately 6 times the voltage in a 345 kV line), prototype
4 transmission line for three years, my co-workers and I observed no statistically significant
5 effects resulting from electromagnetic field exposure.

6 **Q. What is EMF?**

7 A. EMF is simply the electrical and magnetic effects associated with the
8 transmission of electricity which exert forces on other electrical charges.

9 **Q. Describe what you have done to study this topic.**

10 A. I conducted the research described above and have maintained an active
11 professional interest in the topic by reviewing published research results and findings from
12 other research projects.

13 **Q. What has the scientific community concluded on this topic?**

14 A. The most comprehensive and credible study to-date was conducted by the
15 National Institute of Environmental Health Sciences (NIEHS), a part of the National
16 Institutes of Health, pursuant to legislation enacted by the Congress. See NIH Publication
17 No. 99-4493. A good summary of the NIEHS's conclusion, that there is insufficient
18 evidence of negative health effects from EMF to warrant concern, is illustrated by the
19 following statement in the Executive Summary from the NIEHS report: "The NIEHS does
20 not believe that other cancers or non-cancer health outcomes provide evidence of a risk [from
21 EMF] to currently warrant concern."

1 **Q. Please describe your own beliefs and conclusions about EMF and 345 kV**
2 **transmission lines.**

3 A. EMF associated with 345 kV lines has no impact on the health of living
4 organisms, including humans.

5 **Q. Does this conclude your Surrebuttal Testimony?**

6 A. Yes, it does.

RESUME

NAME: Walter J. Gajda, Jr.
Rutledge - Emerson Distinguished Professor
Vice-Chancellor for Academic Affairs
University of Missouri-Rolla

BIRTH PLACE: Adams, Massachusetts

OFFICE: 204 Parker Hall
University of Missouri-Rolla
Rolla, Missouri 65401
Telephone: (314) 341-4138
FAX: (314) 341-6306
electronic mail gajda@ee.umsr.edu

HOME: 800 West 13th Street
Rolla, MO 65401
Telephone: (314) 368-3197

DEGREES: Ph.D., Massachusetts Institute of Technology, 1970
S.M.E.E., Massachusetts Institute of Technology, 1965
B.S.E.E., University of Notre Dame, 1964

DISSERTATION AND THESIS TITLES:

Ph.D., "X-Ray Scattering from Strained Crystal Lattices"
S.M.E.E., "Hole Conduction in Thin Films of CdS"

TECHNICAL AREAS OF INTEREST:
Semiconductor devices and materials; composites;
transit technology; organic semiconductors; sensors.

ACADEMIC EXPERIENCE:

- 1993- Vice-Chancellor for Academic Affairs
University of Missouri-Rolla
- 1987- Rutledge-Emerson Electric Distinguished Professor
Department of Electrical Engineering
University of Missouri-Rolla
- 1986-93 Chairman, Department of Electrical Engineering
University of Missouri-Rolla
- 1991-92 Interim Director, UMR/UMSL Cooperative
Engineering Program
Department of Electrical Engineering,
University of Missouri-Rolla
- 1986-87 Professor and Chairman, Department of Electrical Engineering,
University of Missouri-Rolla
- 1976-86 Assistant Chairman, Department of Electrical Engineering,
University of Notre Dame
- 1970-86 Department of Electrical Engineering
University of Notre Dame

PROFESSIONAL ACTIVITIES:

President, Michiana Section of IEEE (1974), other offices, 1972-74
Member, IEEE Region IV Committee, 1974-76
Delegate, ASEE Conference, Troy, NY, 1974

Professional Activities Chairman, IEEE, 1975-76
Region IV Delegate, IEEE PAC Meeting, Atlanta, GA, 1975
General Chairman, Sixth Annual Midwest Electronic
Material Symposium, Notre Dame, Indiana, 1976

Fundamental Session Co-Chairman, Seventh Annual Midwest
Electronic Materials Symposium, Evanston, Illinois, 1977-
Composites Contract Reviewer, Wright-Patterson Air Force Base,
Dayton, OH, 1984
Member, Composite Subcommittee of the Joint Technical Committee
on Nuclear Pulse Effects, Department of Defense, 1978-
1990

Member of the following organizations:

Institute of Electrical and Electronic Engineers
American Society for Engineering Education
Sigma Xi
Eta Kappa Nu
Tau Beta Pi
Phi Kappa Phi

Session Organizer, Rapid Transit Conference, Pittsburgh, PA, 1983
Textbook Manuscript Reviewer for MacMillan, Holt-Rinehart-
Winston

Reviewer for Solid State Electronics, Physica Status Solidi, IEEE
Transactions on Education, IEEE Transactions on Electron
Devices, Journal of the Electrochemical Society

Chairman, Materials Subcommittee of the Microelectronics
Committee of the Indiana Corporation for Science and
Technology, 1983-86

Member, Indiana Corporation for Science and Technology, 1982-1990
Executive Committee, Midwest Electronics Materials Symposium,
1983

PROFESSIONAL ACTIVITIES (continued)

Proposal Reviewer, Army Research Office, Air Force Materials Lab,
1976-86

National Science Foundation Graduate Fellowship Evaluation
Panel, 1986-1989

Member, ASEE Continuing Education Program for Engineering Faculty
Steering Committee, 1987-1992

Member, Department of Energy Power Semiconductor Committee,
1986 - 1990

IEEE Engineering Research and Development Committee
(national IEEE committee charged with formulating IEEE
positions on research priorities and conveying those positions
to the National Science Foundation, the National Institute of
Standards and Technology, NASA, other executive branch
agencies and the U. S. Congress)
chairman, 1987-1989
member, 1986 - 1992

Member, IEEE Technical Activities Council, 1987-1993

Member, IEEE Technology Issues Committee, 1988-1994

Chair, IEEE Symposium on Government Relations, Washington, D.C.
December 1990.

Liaison, IEEE and the National Electrical Engineering Department
Heads Association, 1991-

Agency for International Development Delegation Member, visited
Polish universities in Warsaw, Krakow, Wroclaw, Posnan and
Gdansk, June, 1992

UNIVERSITY SERVICE:

Faculty Advisor, Student Section of IEEE, 1973-76, 1981-83

Faculty Senate, 1972-75

University Graduate Council, 1974-77

Faculty Advisor, Technical Review, 1973-76

Graduate Counselor, 1974-77, 1979-84

Faculty Advisor, Society of Women Engineers, 1975-77

College Council, 1980-86

Academic Council, 1980-83

University Teacher-Course Evaluation Committee, 1980-81

College Physical Facilities Committee, 1981-82

College Graduate Studies Committee, 1971-78

Department Graduate Committee, 1972-75, 1978-81, 1983-85

College Committee on Freshman Courses, 1974

EG 120 Course Director, 1974-78

University Committee for the Freshman Year, 1977-80

Organizer, Summer "Intro to Engineering" Course for high school women, 1976

Department Committee on Appointments and Promotions, 1980-84

University Traffic Appeals Board, 1976-79

Doctoral Faculty, UMR, 1986

School of Engineering Planning and Advisory Committee, 1986-

School of Engineering Executive Committee, 1986-

Materials Research Center Steering Committee, 1986-

Intelligent Industrial Systems Center Steering Committee, 1987-

Member, Search Committee for Vice Chancellor of Alumni Relations and Development, 1987-88

Partners of the Americas representative, two-week sponsored trip to the Federal University of Para, Belem, Para, Brazil, assisted in development of an MSEE program and various research activities, 1987

UNIVERSITY SERVICE (continued):

Faculty Advisory Committee for Institutional Development, 1987
Committee for Non-Traditional Student Degree Programs,
1988-1990

EE Building Addition Advisory Committee, 1988-
Chancellor's Council, 1988-
Faculty Excellence Awards Selection Committee, 1988-92

Teaching Evaluation Committee, 1988-1989
Budgetary Affairs Committee, 1988-1990
Minority Student Scholarship Committee, 1988-

Retention Committee, 1989-90
Search Committee, Associate Dean of Engineering for Research,
1989
Chair, Committee of Department Chairs (university-wide), 1989-90

Weldon-Springs InterCampus Research Proposal Review Committee,
1989

Chair, Committee on Advanced Numerical Computing, 1990
Chair, Chancellor Search Committee, 1991

Civil Engineering Chair Review Committee, member, 1992-93

HONORS:

Sprague Electric Scholarship, 1960-64
Douglas Aircraft Scholarship, 1963-64
B.S.E.E. degree awarded magna cum laude,
University of Notre Dame, 1964

National Science Foundation Fellow, 1964-68
NASA-ASEE Summer Faculty Fellow,
Langley Research Center, 1972-73
Outstanding Teacher Award, University of Notre Dame,
College of Engineering, 1979

Thomas Madden Award for Excellence in Teaching,
University of Notre Dame, 1980
Paul Fenlon Award for Outstanding Teaching,
University of Notre Dame, 1981
Inaugural Lecturer-Hesburgh Alumni Lectures,
one of six ND faculty chosen by the Deans and Provost, 1985-

Member of Phi Kappa Phi, 1987
Citation from Robert D. Orr, Governor of the State of Indiana,
"for outstanding leadership in strengthening the Indiana economy
through active participation in the programs and activities of the
Corporation for Science and Technology," 1987
Appointed to the William Rutledge-Emerson Electric Distinguished
Professorship, University of Missouri-Rolla, 1987

Member, Technical Advisory Committee, Emerson Electric Co., 1987-
Fellowship, Jefferson Smurfit Foundation, travel to lecture
University College, Dublin, Ireland, 1988
Blue Key National Honor Society, honorary member, 1989

Phi Eta Sigma Freshman Honor Society, honorary member, 1992

PUBLICATIONS - PAPERS:

1. "A Re-interpretation of X-Ray Topographic Contrast," Proc. National Electronics Conf., 26, pp 254-258, 1969.
2. "On Solutions to the Diffusion Equation," *Solid State Electronics*, 13, pp 1427-1428, 1970.
3. "Topographic Examination of Ion Implanted Silicon," Proc. National Electronics Conf., 27, pp 229-237, 1970.
4. "The Gaussian Planar PN Junction," with J.H. Jackson, Proc. National Electronics Conf., 27, pp 234-237, 1970.
5. "Area and Mixed Contrast in X-Ray Topographs of Silicon Crystals Strained by Silicon Dioxide Films," *Physica Status Solidi* (a) 5, pp K143-146, 1971.
6. "A Real-time Holographic Determination of Changes in Semiconductor Wafer Thickness," with G.T. Welch, Proceedings of the IEEE Fall Electronics Conference, 71C64, pp 170-174, 1971.
7. "X-Ray Topography and Device Performance," Proceedings of the IEEE Fall Electronics Conference, 71C64, pp 163-169, 1971.
8. "Dependence of CdS Thin Film Conductivity on Ambient Oxygen," with W.B. Berry and H.G. Henry, Proc. National Electronics Conf., 29, pp 181-186, 1972.
9. "Optical Properties of Polysilicon as Determined by Photoconductance Measurements," IEEE International Electron Devices Meeting, Washington, DC, 1973.
10. "New Directions in Surface Acoustic Wave Devices," IEEE Microelectronics Symposium, Tampa, Florida, 1975.
11. "Acoustic Conversion Efficiency in PCT Layered Transducers," Midwest Electronic Materials Symposium, Milwaukee, Wisconsin, 1975.

PUBLICATIONS - PAPERS (continued)

12. "A Three-Week Resident "Introduction to Engineering" course for High School Women, Proceedings Fifth Annual Frontiers in Education Conference, pp 139-144, 1975.
13. "Low Frequency Conductivity of Graphite-Epoxy Composites," with L.A. Scruggs, Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, pp 147-151, 1977.
14. "DC Electrical Behavior of Graphite Fibers," with T.C. Holzschuh, Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, pp 182-185, 1977.
15. "Sensors and Sensor Physics," Midwest Electronics Material Symposium, Evanston, Illinois, 1977.
16. "Modification and Modeling of the Electrical Conductivity of Fiber Reinforced Composites," Proceedings of the 23rd National SAMPE Symposium, pp 75-80, 1978.
17. "Design Implications of the Electromagnetic Properties of Advanced Composites," Proceedings of the Fourth Conference on Fibrous Composites in Structural Design, pp 245-262, 1978.
18. "Temperature Sensing via Metal-Semiconductor Transitions in Doped, Single Crystal Vanadium Oxide," with H.G. Henry, Proceedings of the National Electronics Conference, 37, pp 182-185, 1980.
19. "Impurity Distribution in Doped, Single Crystal Vanadium Oxide Temperature Sensors," with H.G. Henry, Proceedings of the National Electronics Conference, 38, pp 431-435, 1981.
20. "Faculty Research and Its Role in Undergraduate Engineering Education," with P.K. Ajmera, Proceedings of the Twelve Annual Frontiers in Education Conference, 12, pp 35-40, 1982.
21. "A Mathematical Model of Transmission Line Audible Noise," with H. Kirkham, IEEE Power Engineering Society Summer Meeting, San Francisco, CA, 1982.

PUBLICATIONS - PAPERS (continued)

22. "A Mathematical Model of Transmission Line Audible Noise - Part 1: Background and Model Development," with H. Kirkham, *IEEE Transactions on Power Apparatus and Systems*, PAS-102, pp 710-718, 1982.
23. "A Mathematical Model of Transmission Line Audible Noise - Part 2: Comparison with Experiment," with H. Kirkham, *IEEE Transactions on Power Apparatus and Systems*, PAS-102, pp 719-728, 1982.
24. "Electrical Characteristics of Joints in Graphite/Epoxy Composites," IEEE Electromagnetic Compatibility Symposium, Denver, CO, 1982.
25. "The Cold Weather Transit Technology Program," with W. Albach, Rapid Transit Conference, Pittsburgh, PA, 1983.
26. "Incoherent Light Annealing of Ion Implanted Polysilicon," with D.L. Kwong, Materials Research Society Annual Meeting, Boston, MA, 1983.
27. "The Dependence of Audible Noise Upon Rain Rate," with H. Kirkham, 1984 Electric Utility Research Conference, Chicago, IL, 1984.
28. "The Statistical Relationship between Transmission Line Audible Noise and Rain Rate," with H. Kirkham, in Trends in Electric Utility Research, C.W. Bullard and P.J. Womeldorff editors, Pergamon Press, pp 85-94, 1984.
29. "The Statistical Properties of the Residual in System Identification," with J. Flentz and Y.F. Huang, Proceedings of the Twenty First Annual Allerton Conference, pp 712-721, 1983
30. "Discussion of 'Methods for Predicting AC Transmission Line Audible Noise'," with H. Kirkham, *IEEE Transactions on Power Apparatus and Systems*, PAS-103, pp 292-293, 1984.

PUBLICATIONS - PAPERS (continued)

31. "Conditions and Kinetics for the Growth of Polypyrrole on Au and Si," with S.J. Hahn, W.E. Stanchina and P.O. Vogelhut, 1984 Electronic Materials Conference Digest, pp 167-168, Santa Barbara, 1984.
32. "Auger and Infrared Study of Polypyrrole Films," with S.J. Hahn, P.O. Vogelhut and M.V. Zeller, *Synthetic Metals*, 14, pp 89-96, 1986.
33. "Dependence of the Electrical Conductivity of Polypyrrole Upon Anion Species," with S.J. Hahn, 1985 Electronic Materials Conference Digest, pp 196-197, Boulder, 1985.
34. "The Effect of Growth Rate Variation on the Conductivity and Morphology of Polypyrrole Thin Films," with S.J. Hahn, W.E. Stanchina and P.O. Vogelhut, *J. Electronic Materials*, 13, pp 124-132, 1986.
35. "Transmission Line Audible Noise: An Extended Model Including Effects of the Size and Number of Subconductors," with H. Kirkham, invited paper, Proceedings of the International Congress on Acoustics, pp 384-354, 1986.
36. "Prediction of Audible Noise Produced by Ultra High Voltage Transmission Lines," invited lecture, with H. Kirkham, IEEE Winter Power Meeting, New York, 1986.
37. "Deicing Coil Coupling to Thin Plates," Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, with J. Veedock, pp 243-247, 1986.
38. "ESCA Studies of Electrochemically Prepared Polypyrrole," with S.J. Hahn and M.V. Zeller, 1986 Electronic Materials Conference Digest, pp 181-182, 1986.
39. "Effect of Anion Species Upon Polypyrrole Conductivity," with S.J. Hahn, *J. Electronic Materials*, pp. 295-304, 1987.
40. "Long Term Stability of Polypyrrole Conductivity," with S.J. Hahn, *J. Electronic Materials*, 15, pp. 76-85, 1988.

41. "Doping of Electrochemically Grown Polypyrrole," with S. J. Hahn, *J. Electronic Materials*, 14, pp. 229-233, 1987.
42. "Electromagnetic Coupling to Thin Plates," Proc. of the IEEE Symposium on Electromagnetic Compatibility, 27, pp. 261-264, 1988.
43. "Review of 'Solid State Devices - A Quantum Physics Approach'", IEEE Circuits and Devices Magazine, March 1989.
44. "Conductivity Models of Organic Polymers," *J. Elec. Polymers*, 3, pp 41-47, 1989.
45. "Conductivity Decay in Polypyrrole Films," with S. J. Hahn, *J. Elec. Polymers*, 3, pp 187-193, 1989.
46. "Bond Shifts in Polypyrrole," *J. Elec. Polymers*, 4, pp 64-68, 1990.

PUBLICATIONS - REPORTS:

1. "Interferometric Measurements of Thin Film Thickness," Sprague Electric Company Research Report 64-19, 1964.
2. "Hole Conduction in Thin Films of CdS," SMEE Thesis, Massachusetts Institute of Technology, Electrical Engineering Department, 1965.
3. "Feasibility Study of Metal Base Transistors," with J. Casey R. Granache et al., Sprague Electric Company Research Report 65-6, 1965.
4. "Kerr Effect in Thin Films of CdS," Technical Report, Lincoln Laboratories,
5. "X-Ray Scattering from Strained Crystal Lattices," Ph.D. Thesis, Massachusetts Institute of Technology, Electrical Engineering Department, 1970.
6. "Electrode Materials for Charge Coupled Devices," NASA Contractor Report, 132348, 1973.
7. "RF Absorption Properties of Composite Insulators," Final Report to Ristanc, 1975.
8. "Radiation Damage of Transformer Materials," Final Report to General Electric Company, 1975.
9. "A Technology Plan for Electromagnetic Characteristics of Advanced Composite Materials," Rome Air Development Center RADC-TR-76-206, with L. Allen, W. Walker, Harrington, J. Lyon, R. Heintz, E. Joy, and D. Griffin, 1976.
10. "Low Frequency Electrical Properties of Advanced Composite Materials," Rome Air Development Center, RADC-SU 1229ND, 1977.
11. "A Fundamental Study of the Electromagnetic Properties of Advanced Composite Materials," Rome Air Development Center, RADC-TR-78-158, 1978.
12. "Electromagnetic Effects of Advanced Composite Materials," with A. T. Adair, Rome Air Development Center, RADC-TR-78-156, 1978.
13. "Measurement of the Electrical Properties of Composite Materials in the Frequency Range of DC to 30 MHz," Rome Air Development Center, RADC-TR-78-203, 1979.

PUBLICATIONS - REPORTS (continued)

14. "Modeling and Modification of the Electromagnetic Properties of Advanced Composite Materials," with P.K. Ajmera, W. Strieder, Air Force Office of Scientific Research, Final Report under Grant AFOSR 77-3453, 1979.
15. "Preliminary Screening for Biological Effects of UHV Transmission Line Electric Fields," with R.W. Greene, Final Report to American Electric Power Service Company, 1979.
16. "Temperature Sensitive Switching in Doped Vanadium Oxides," with H.G. I. Final Report to the Whirlpool Corporation, 1980.
17. "Fabrication and Electrical Characterization of Joints in Advanced Composite Materials," Naval Air Systems Command, Final Report under Contract NASC N00019-77-C-0460, 1981.
18. "Study of Laser Deicing," Department of Transportation, Cold Weather Transit Technology Program, UMTA-IN-06-0009-83-12, 1983.
19. "RF Coupling to Complex Geometric Shapes," Department of Transportation, Weather Transit Technology Program, UMTA-IN-06-0009-83-19, 1983.
20. "Growth and Properties of Polypyrrole," with S.J. Hahn, Miles Corporation Internal Report, 1984.
21. "RF Deicing Theory and Technology," Department of Transportation, Cold Weather Transit Technology Program, UMTA-IN-06-0009-85-01, 1985.
22. "VLSI Course Development," Westinghouse Foundation, 1986.
23. "Program Summary and Recommendations," with W.B. Berry, Department of Transportation, Cold Weather Transit Technology Program, UMTA-IN-06-86-01, 1986.

CONSULTING ACTIVITIES:

U.S. Naval Research Laboratory: X-ray scattering, 1971
NASA Langley Research Center: charge coupled devices, electrical properties of advanced composites, 1972, 1977
Intertec: ion generator evaluation, 1974-77

Bendix Corporation: high temperature furnace design, 1974-75
Rome Air Development Center: electrical properties of advanced composite materials, 1975-77
Abcom: composite insulating coatings, 1976-7

Boeing: advanced composite materials, 1978-1993
Cabot Corporation: electromagnetic compatibility, 1982-1986
McDonnell-Douglas: advanced composite materials, 1982-1988

Emerson Electric: sensor physics, 1988-present
American-National Can Company: microwave coupling, 1988-1992
Aslin-Gajda, strategic planning for academic organizations, 1991-92

COURSES TAUGHT:

Engineering Concepts - a first course in modeling and computation for freshman.

Circuits I and II - two semester sequence in networks for sophomores

Electrophysics I - junior course in semiconductor devices.

Electrophysics II - junior course in quantum and statistical mechanics

Electromechanical Devices - junior course in magnetic circuits, transformers and motors.

Integrated Circuits - senior elective course in processing, circuit elements and design, separate digital and analog courses.

Semiconductor Physics - graduate course in the theory of solids.

Solid State Devices - graduate course covering junction diodes and transistors, MOS physics, CCDs, SAWs, transit time devices.

Advanced Semiconductor Theory - graduate course in irreversible thermodynamics and the effects of crystal symmetry on transport properties.

AC Power Systems - senior elective course covering synchronous generators, transformers, three phase concepts, one line diagrams, load flow, fault analysis and stability.

VLSI Design - senior/graduate elective course, MOS, CMOS Physics, layout scaling, floorplanning, and design of logic families.

Optical Propagation, Sources and Detectors - graduate course covering mechanisms of propagation, semiconductor lasers, photodetectors, coupling,